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ANKERTON SULPHUR PROSPECT
Central Alberta

Introduction

The presence of elemental sulphur was noted in the samples of the Banff Ankerton well in lsd 15-4-44-16W4. Yellow and greenish-yellow crystalline sulphur was recorded by the wellsite geologist over an interval of 30 feet, in the basal Wabamun. Log interpretation indicates a maximum of 14 feet of very high resistivity over this interval. Side wall cores were taken over this interval and the average analysis was 25 to 30 percent sulphur with a maximum of 60 percent. We have examined the samples and logs of the nearby wells and believe this deposit could extend over several sections. Sulphur in places, is estimated to be five to six million tons per section, using an average mineralization of 30 percent. If the sulphur mineralization extends over the area we have outlined, it will be a major deposit. We believe that it will be economical to produce by the Frasch method of mining or an adaption of this process.

Occurrence of Sulphur

Elemental sulphur is found in many volcanic districts but the main source throughout the world is from the calcium sulphate type deposits or "gypsum" type, so called because of its constant association with gypsum and limestone. There are numerous theories advanced for this association but two seem to be favoured more than the others.

(1) Bischof - Sulphur came from H_2S which resulted from reduction of calcium sulphate by carbon or methane according to the following reactions.

$$CaSO_4 + 2C — CaS + 2CO_2$$

$$CaS + CO_2 — CaCO_3 + H_2S$$

$$CaSO_4 + CH_4 — CaS + CO_2 + 2H_2O$$

$$2H_2S + O_2 — 2H_2O + 2S$$

The main drawback to this theory is the high heat (700° to $1000^\circ C$) required to reduce sulphate to sulphide with carbon compounds. Geologic time or catalyst may have replaced temperature.

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(2) Biochemical - Sulphur is the result of bacterial action. Sulphate reducing anaerobic bacteria may have converted sulphate ($CaSO_4$) to hydrogen sulphide which was subsequently converted to sulphur. Experiments by Kulp, Feely and others strongly suggest that the isotopic composition of elemental sulphur is due to bacterial reduction of sulphates.

The bacteria are believed to have consumed hydrocarbons as source of energy. Hydrogen sulphide was oxidized into elemental sulphur by

(i) Oxidation of H_2S by ground water charged with oxygen or -

(ii) Reaction between H_2S and $CaSO_4$.

The last theory is favoured. Refer to Origin of Gulf Coast Salt Dome Sulphur Deposits by Feely and Kulp, Bulletin A.A.P.G. (1957) 41, No. 8, 1802-1853.

The Wabamun in the Ankerton area has considerable anhydrite and gypsum and the presence of H_2S in the Crossfield member of the Wabamun is well known. Therefore, the materials required to produce sulphur are certainly present. Conditions to produce sulphur could have occurred at any time, either during or subsequent to the deposition of the gypsum and anhydrite.

We favour subsequent development due to the proximity of the eroded edge of the Wabamun. Several of the wells have evidence of fracturing which could have been the avenue taken by the percolating ground waters carrying anaerobic bacteria from the Cretaceous swamps which formed on the eroded Paleozoic surface.

Types of Deposits

(1) Salt Domes - Louisiana and Texas - greatly documented in the letera-ture and certainly not the source of the Ankerton deposit. However, it should be noted that, although some 200 Salt Domes have been discovered, only a few have contained enough sulphur to warrant development. These deposits differ in size, depth, shape and thickness. Sulphur content may vary from a few feet to several hundred feet ant the grade from traces to 50 percent and characterized by abrupt horizontal and vertical changes. As a result, production varies from dome to dome. The following list contains a few of the producing sulphur domes and the amount produced.

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Sulphur Dome, La. -	75 acres produced	9½ million tons
Bryan Mound, Texas -	800 acres produced	5 million tons
Palangana, Texas -	1800 acres produced	¼ million tons
Gulf, Texas -	300 acres produced	12 million tons

(2) Volcanic Deposits - The largest known deposits of this kind are in the Andes Mountains of South America. In Japan, sulphur deposits associated with a chain of volcanoes occur on the main island.

(3) Sedimentary Deposits - Two large deposits in southeast Poland are the Tarnobrzeg deposit now being mined and the Solec-Grzybow deposit as yet undeveloped. The grade of sulphur in the Tarnobrzeg deposit is 28 to 30 percent average, with a maximum of 80 percent. The sulphur bed is 15 to 33 feet thick but is 66 feet in places. The Ankerton deposit is similar to this type.

Evidence of Sulphur in the Ankerton Area

In oral communication with the wellsite geologist, crystalline sulphur over 30 feet in the basal Wabamun was indicated at the Banff Ankerton 15-4 well. We were able to obtain copies of the original sample and sidewall core descriptions. These data are conclusive evidence of sulphur mineralization in the Banff Ankerton 15-4 well. Copies of these are attached to this report.

We examined well cuttings of the Wabamun to Nisku interval in the surrounding wells and sulphur was noted in the following wells.

(i)	Banff Ankerton 15-4-44-16W4	- good
(ii)	R.D.C. Banff Daysland 13-10-44-16W4	- probable traces
(iii)	Texaco Heisler A-2-13-43-16W4	- probable traces

The Ankerton well had the best show and only probable traces were noted in the other two wells. These probable traces in the R.D.C. Banff Daysland and Texaco Heisler wells occurred above the sulphur bearing zone. Sulphur was not noted in the equivalent sulphur beds in the R.D.C. Banff Daysland well. In the samples of the Ankerton well the sulphur occurs as a yellow amorphous coating on clusters of shale and limestone chips. There are traces of sulphur crystals (see sample descriptions). The lack of good sulphur cuttings in the samples is probably due to the washing and heating. Heating in particular, would melt the sulphur and it would flow to the bottom of the plate and solidify there when sample cooled. When the samples were bottled only the sulphur coating the limestone and shale chips would be retained.

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It should also be noted that sulphur crystals have been reported in the Wabamun in other wells some distance removed from the Ankerton occurrence. It is possible that other deposits of sulphur will be found in the Wabamun of Alberta.

Geology

The sulphur deposit occurs in the basal Wabamun, immediately above the Calmar. We were able to correlate this evaporite bed over a fairly wide area. It is approximately eight miles north-south and eleven miles east-west. The northern limit is defined by the R.D.C. Banff Daysland 13-10-44-16W4 well which did not appear to have this bed present, and also by the Calstan Daysland 11-19-44-16W4. The western limit is defined by the wells in Sections 3,9, and 11 which did not appear to have this sulphur zone developed. The southern limit is not defined.

An isopach of the Wabamun to Calmar shows a thickening to the south of the Ankerton well. The sulphur bearing beds also thicken to the south and the isopach of the sulphur zone indicates a domal shape.

The source or cause of the sulphur mineralization was mentioned previously in this report. We favour the decomposition of gypsum and/or anhydrite by anaerobic bacteria, introduced through fracturing which carried the brackish swamp waters of the basal Cretaceous to the evaporite bed. However, the possibility of a hydrogen sulphide seep during the post-Paleozoic pre-Cretaceous erosional period is a possibility. The third possibility is that of salt doming. There is salt present in the Wabamun to the south which may have been leached out of the Ankerton area. If salt was present there could have been some movement or flowage giving rise to a dome and the associated sulphur. This could account for the domal shape.

It is doubtful whether the source of the sulphur mineralization will ever be solved but if it is as extensive as shown there is no doubt it will be mined by the Frasch process or an adaption of this mining method.

Access

The area is serviced by railway and black-top highway which are only five miles north of the property. Good gravel roads traverse the property and make for easy access.

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Frasch Mining

Essentially a simple method which uses hot water to melt the sulphur. The sulphur being heavier than water, sinks and flows to the bore-hole. Compressed air then forces the liquid sulphur to the surface where it is either shipped in the molten state or allowed to solidify and then shipped at a later date.

Large quantities of hot water (330°F) are required which necessitates a cheap fuel for heating. Heat loss is a major problem. However, with new techniques and advances in technology the cost of producing a ton of sulphur should not increase.

The steam plant can supply the electricity for the surface installation and also supply some for the surrounding area, which could help defray the cost of the surface installation.

Economics

Generally, the economics vary from one deposit to another and the cost of surface installations vary greatly.

The Grand Isle Mine, which is offshore in Louisiana, required an expenditure of 22 million dollars before the first ton of sulphur was produced. This mine produces 4500 tons of sulphur a day and requires five million gallons of sea water heated to 330°F by the use of 13 million cu.ft. of natural gas per day.

Onshore installations vary in cost from one to three million dollars per million gallons of hot water required. The average onshore mine requires three to five million gallons of water per day.

Each ton of sulphur mined in the last six years required from 3,000 to 10,000 gallons of hot water at 330°F.

Production costs probably vary from mine to mine and are held confidential. We have heard that one of the new automated mines produces a ton of sulphur for two dollars.

The above estimates are very general and deal with the lean deposits at one end and the rich thick deposits on the other. It requires more water per ton of sulphur in a lean deposit as there is a larger volume of rock to heat.

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The average water requirements are 5,000 gallons per ton. This water must be treated, deaerated and heated. A plant which can produce up to 100 tons of sulphur per day can be acquired for a capital outlay of $170,000. This plant is portable and can be moved as the sulphur is depleted in an area.

A large volume of cheap fuel will be necessary as it requires 1.23 MMcf/day to heat 500,000 gallons of water to a temperature of 330°F. There is natural gas in the area but it will be necessary to capture a large supply either by developing existing reservoirs or contracting for it on a long term basis.

If you consider a plant capable of producing 1,000 tons per day, the fuel requirements will be 12.3 MMcf/day or 4.5 Bcf a year.

A plant of this size will require five million gallons of water per day or 1.8 B gallons a year. It is doubtful whether the Alberta Government will allow this amount of water to be drawn from the surface reservoirs. Two possible sources have been considered: (1) basal Belly River sands or (2) the Nisku reservoir. Salt water has been used on the Gulf Coast and could be adapted to the Ankerton deposit.

There is very little recycling of the water due to the necessity of retreating it. The main reason for not recycling is that the superheated water becomes contaminated with the formation water present in the domes. This may not be a problem in the Ankerton deposit.

As a larger volume of water is required per volume of sulphur produced, the excess water must be removed from the deposit through a bleed well. This water must be treated and disposed of into a disposal pit or wells.

Production per well varies from well to well in the same deposit. There is no way of telling how large an area one well drains. A good well will produce 20 barrels an hour and a poor well three barrels. Some wells produce for years and others only one or two days and are abandoned.

There are so many variables and unknowns that any economics set down at this time must be considered as an estimate.

Production Costs

Assumptions

(1) Mineralization extends over more than 640 acres

(2) Average sulphur mineralization is 30 percent.

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(3) Average thickness is 12 feet

(4) Frasch process give 75 percent recovery

(5) Drainage is 300 feet (radius)

(6) Water required per ton is 5,000 gallons

(7) Well cost $80,000

(8) Sulphur in place/well 60,000 tons

(9) Recoverable sulphur 45,000 tons

(10) Price of gas 15¢/mcf

Gas Requirements	$1.84/ton	
Drill Costs	1.80/ton	
Fraccing	.30/ton	
Treating & Handling Water Supply (est.)	1.00/ton	
Labor & Storage (est.)	1.00/ton	
TOTAL PRODUCING COST	$5.94/ton	say $6.00/ton.

Average cost on the Gulf Coast is $8.00/ton. We therefore must assume that we could produce a ton of sulphur at $8.00/ton.

The volume of sulphur can be established by the following calculations.

(1) 43,560 sq.ft./acre x 640 x 1 = 27,578,400 cu.ft./sec.ft.

(2) 27,578,400 x 30% = 8,273,500 cu.ft./sec.ft.

(3) 1 cu.ft. of sulphur weighs 127 lb.

(4) $\frac{8,273,500 \times 127}{2,200}$ = 477,600 long. tons/sec./ft.

(5) Thickness of 12' - 477,600 x 12 = 5,731,200 tons/sec.

(6) Recovery of 75% = 4,208,000 tons

(7) Gross Value @ $25.00/ton at well head - $105.000.000.00/section

The Ankerton deposit is believed to extend over several sections and therefore, could be a major deposit and if mineable, of great economical benefit to all concerned.

Under the Canadian Tax Law, mining ventures are exempt from taxes during the first three years' operations. After the initial three years of operation, companies can then commence their write-off of expenses and depreciation which would allow a five to six year period where no taxes would be payable.

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Land

Crown Permit - The Crown Sulphur Permit contains 20,000 acres. It is for one year commencing on June 29, 1966, and is renewable for a second and third term upon payment of rentals at the rate of ten cents per acre per year. Permittee shall have the right to acquire a lease of sulphur rights in areas within the permit upon consultation with the Minister. The lease will include a provision that, within one year from date of lease the leassee shall commence construction of a plant and the same must be in operation within four years from the date of the notice. Term of the lease is 21 years, renewable for further terms each of twenty-one years, so long as sulphur is being produced.

Rentals on Leases

(a) 25 cents for first five years
(b) one dollar for the balance of the term of the lease and any renewal.

Freehold Leases

3,360 acres acquired
320 acres under negotiation

The Freehold leases are for 25 years with rentals of one dollar per acre per year. If the lease is producing, no rental will be required.

Method of Exploration

(1) Drill a south and west offsetting well witnin 300 feet of the Banff Ankerton 15-4, and core the top of the Paleozoic to 10 feet into the Nisku or until sulphur mineralization is penetrated.
(2) Analyse core for sulphur content.
(3) Run Formation Density Log and Epithermal-Neutron Log and I.E.S.
(4) Depending on the results of these wells, consider a half mile step-out.
(5) Continue development drilling until sufficient sulphur tonnage has been outlined. If one section is proven then consideration should be given to constructing a pilot plant while further development drilling is being carried out.

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Conclusions

The occurrence of sulphur in the Ankerton well and the correlation of this bed in surrounding wells indicates the possibility of a major sulphur deposit.

The use of sulphur has greatly increased and there is a present shortage. A continued demand for sulphur is predicted for many years to come.

We believe that the Ankerton deposit should be explored and developed.

[redacted]

E.A. Brownless

[redacted]

F.J. Halkow

REFERENCES

Paul M. Ambrose - Sulfur and Pyrites, United States Department of the Interior - Mineral Facts and Problems- 1965 Edition.

C.M. Cockrell - The Grand Isle Sulphur Mine Heating Plant and Underwater Sulphur Line Design. A.S.M.E. Meeting Nov. 29 - Dec. 4, 1959. Atlantic City, N.J.

James Woodburn - Frasch Sulphur Mining A.S.M.E. paper 54 MEX 13.

Reis - Economic Geology - 1950 Edition

Schlumberger - Defining Evaporite Deposits with Electrical Well Logs - 1965.

3410-3435 Sandstone - clear to light grey-brown, quartzose, with trace of chert grains, well sorted, friable, porosity slight to fair, dead oil staining only.

3435-3470 Sandstone - as above, clear to light grey, porosity varies from slight to very good.

3470-3540 Sandstone - as above, showing occasional coarse rounded quartz grains, sandstone becoming friable and loose.

3540-3560 Sandstone - as above, becoming poorly sorted and tight in part, few thin black shale bands.

3560-3565 Black shale interbeds as above, numerous coarse rounded loose quartz grains.

3565-3570 Predominantly coarse quartz grains - as above, loose.

3570-3580 Shale - black, fissile, micromicaceous, silty in part, few quartz pebbles as above.

3580-3595 Limestone - light grey and light grey-buff, micro-crystalline, slightly silty, dense.

Wabamun - 3575

3595-3650 Limestone - cream to light grey-buff, finely crystalline, silty in part, showing local traces of pinpoint vuggy porosity, no staining.

3650-3660 Sulphur bed - in part bright yellow-green and crystalline and partly intermixed with white to light grey chalky soft limestone.

3660-3680 Sulphur - as above.
Siltstone - white, quartzose, calcareous to limy.

Calmar - 3662

3680-3685 Siltstone - white and pale grey, dolomitic, quartz, trace argillaceous, few chips bright green calcareous, partly silty shale.

3685-3690 Dolomite - cream to light grey-buff, mediocrystalline, silty in part, dense.

Nisku - 3682

3690-3700 Dolomite - cream, white and flesh, as above, trace white crystalline anhydrite filling vugs, very slight trace of vuggy porosity.

CORE DESCRIPTIONS

Sidewall Cores by Lowel Services - Edmonton.

Core #1 at 3663' Recovered 6"

6" Breccia - composed of limestone, medium grey, microcrystalline, dense; siltstone - light grey, quartzose, calcareous, and sulphur - in part bright yellow-green and crystalline and in part bright grey-brownish, dull lustre, soft, partly intermixed with shaly lime? Sulphur content estimated at 20%.

Core #2 at 3661 - Run #1 Recovered 3/4"

3/4" Intermixed limestone and sulphur as above, brecciated in part. Sulphur content est. 60%.

Core #2 at 3661 - Run #2 Core recovered in fragments only Total est. - 4"?

4"? Sulphur and dark grey crystalline limestone - fragments have extremely vugular appearance - cavities (part of core dissolved)? - intermixed. Sulphur content est. 50-60%.

Core #3 at 3660 Rec. 3"

3" Limestone - as above and sulphur - predominantly grey-brown, dull lustre, intermixed, soft form, finely brecciated in part. Est. sulphur content 20-30%.

Core #4 at 3658 Rec. 8.0"

8.0" Limestone - as above, shaly in part, thinly interbedded with black, slightly calcareous shale in part, brecciated in part. Sulphur - if present, very finely disseminated and not recognizable.

Core #5 at 3656' Rec. 7.0"

7.0" Limestone - varying shale and sulphur - thinly interbedded, intermixed and brecciated in part. Sulphur present in both previously described forms - sulphur and calcite fill two prominent fractures. Sulphur content est. 5-10%.

Core #6 at 3654' Rec. 8½"

8½" Limestone and calcareous shale, thinly interbedded in part and intermixed as above. 1" section shows well-rounded quartz grains in a limy shale matrix, occasional fractures filled with secondary calcite, trace only of brown, dull, lustrous, intermixed sulphur.

Core #7 at 3652 Rec. 7½"

7½" Intermixed varying limestones and black calcareous shale, thinly interbedded in part, brecciated appearance in part, no sulphur noticeable.

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VERNE LYONS CONSULTING LTD.

415 Bentall Bldg.

Calgary 2, Alberta.

Phone: 263-1853

June 28, 1968.

MR. G. I. WHITE,
425 Bentall Bldg.,
Calgary 2, Alberta.

Dear Sir:

I attach hereto a final geological report on the Ankerton Region, which includes Sulphur prospecting permit # 5.

The cost of the studies involved in preparing the report have not been fully established, but are a minimum of $800.00. Some of these studies were conducted by Verne Lyons Consulting Ltd., as a principal in the ownership of the permits.

Yours very truly,

VERNE LYONS CONSULTING LTD.

[redacted]

J. V. Lyons.

JVL:gp
Enc.

INDEXING DOCUMENT NO. 700295

19680022

File No. 130792

SCHEDULE
to Sulphur Prospecting Permit No. 5

83A/9+16

IN TOWNSHIP FORTY-TWO (42), RANGE SIXTEEN (16), WEST OF THE FOURTH (4) MERIDIAN:

The North East quarter of Section Twenty-six (26) and Sections Twenty-eight (28), Twenty-nine (29), Thirty (30), Thirty-two (32), Thirty-four (34) and Thirty-six (36);

AND

IN TOWNSHIP FORTY-THREE (43), RANGE SIXTEEN (16), WEST OF THE FOURTH (4) MERIDIAN:

Sections Two (2), Four (4), Six (6) and Twelve (12);

AND

IN TOWNSHIP FORTY-FOUR (44), RANGE SIXTEEN (16), WEST OF THE FOURTH (4) MERIDIAN:

Sections Twenty-eight (28), Twenty-nine (29) and Thirty (30);

AND

IN TOWNSHIP FORTY-THREE (43), RANGE SEVENTEEN (17), WEST OF THE FOURTH (4) MERIDIAN:

Sections Eleven (11), Twelve (12), Fourteen (14), Twenty-two (22) and Twenty-four (24), the North East quarter of Section Twenty-six (26), Sections Twenty-eight (28) and Twenty-nine (29), the North half, the South East quarter, Legal Subdivision Three (3), the North half of Legal Subdivision Four (4) and Legal Subdivisions Five (5) and Six (6) of Section Thirty (30) and Sections Thirty-two (32), Thirty-four (34) and Thirty-six (36);

AND