MAR 19680095: ALBERTA

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Consulting Engineers Ltd.

PRELIMINARY STUDY

OF

ALBERTA SULPHUR PERMIT NO. 106

IN

TWPS. 114 & 115, Range 2 W, 5th

OWNED BY

CLEVELAND MINING & SMELTING CO. LTD.

CLEVELAND POWER CORPORATION LTD.,

AND

ORTEGA MINERALS LTD.

Engineering by Edward Lewis Jones, P. Engr.

[redacted]

Geology by Albert Golden, P. Geol.

[redacted] P. Geol. Feb 3, 1968.

ANNOTATED AIR PHOTO FRONTISPIECE

Sulphur permit No. 106 is well located in regards to sulphur deposits, being northeast of the Madison No. 8 permit and showing similarities on air photos to the surface deposits of sulphur on that permit.

The light areas on the air photo, marked S, signify characteristic surface sulphur, from prior experience obtained elsewhere.

Only ground inspection can tell for certain if these areas are sulphur-rich.

Sulphur Permit No. 106 is crossed by an outcrop edge of the Lower Cretaceous Shales which are exposed as small cliffs.

The contact between the underlying Devonian Grosmont and the Lower Cretaceous may be conducive to sulphur accumulations.

Township and Range lines as well as the outline of Sulphur Permit No. 106 are indicated on the air photo.

Immediately to the north, an excellent showing of surface sulphur appears to be present from other air photos, so Permit No. 106 seems well located for sulphur.

GEOLOGICAL

SULPHUR OCCURRENCE IN NORTHERN ALBERTA

GENERAL

With the rapid and expanding uses and demands for sulphur, further sources of this mineral have been diligently sought. Most recent discoveries of this mineral have been concentrated in the Northern areas of Alberta. Beds and formations containing this mineral are in evidence in this region of Alberta. Further acreages and reservations are still available to prospecting and filing for sulphur deposits in this region.

Native sulphur has been found in situ in surface deposits in the northern reaches of Alberta, north of the Peace River, west of and adjacent to the Wood Buffalo National Park. This area consists of flat woodlands intersected by small rivers, creeks, and numerous lakes. Small domes and sink holes caused by solution collapse produce a Karst typography throughout the area. The extreme, southeast limb of the large hill complex, known as the Caribou Mountains, intersects a small portion of the map area. The basal portion of the Caribou Hills consists of black shales of the Cretaceous Loon River Shales.

The geological formation in which the elemental surface deposits occur is the Upper Devonian Grosmont formation. This formation consists of vuggy petroliferous dolomites with varying amounts of thin bedded aegillaceous limestone in this area. The Vermilion Chutes or rapids on the Peace River in this area are formed by the outcrop edge of the Grosmont formation. The Grosmont thins to the northeast and east of the map area and its subcrop edge occurs east of our subject area. The Grosmont is overlain by the Cretaceous Loon River Shales and underlain by the Devonian Mottled Limestone series, known as the Beaverhill Lake (Mikkwa) formation. Following is a sequence of geological formation in this area:

	Glacial Deposits
Lower Cretaceous	Loon River Shales
Upper Devonian	Grosmont reef complex
	Beaverhill Lake: Upper Mottled Limestone
	Beaverhill Lake: Lower Mottled Limestone

The Grosmont is exposed along river and creek valleys, certain lake shores, domes and ridges and on the edges of solution sink holes. It is in this formation that native sulphur occurs at the surface as infill

to large vugs and in thin beds, covering relatively large areas. A paucity of geological mapping and drilling at present has as yet not established the thickness and depth of occurrence of these sulphur beds, or the ultimate reserves of this mineral. Aerial photographic mosaics of this area pin point exposed sulphur occurrences.

These sulphur deposits may have been deposited by the decomposition of iron sulfides (iron pyrite concretions are found in abundance immediately north of this area) or from the reduction of gypsum, which occurs in prolifacy in this area.

Sulphur has been found at 3000' depths in the Grosmont in the Athabasca area, 300 miles due south of our study area. To the north in the Great Slave Lake region, small lenticular pods of native sulphur have been mapped in Devonian formations.

The vuggy nature of the Grosmont, the ubiquitous occurrence of iron sulphides and gypsum, the numerous rivers and creeks and sinkholes exposing the Grosmont and the shallow depth of this formation may account for a rich and thick native sulphur deposit in this area. At the present time it is not known whether sulphur occurs in the underlying Mottled Limestones.

SULPHUR-BEARING FORMATIONS PRESENT

Practically all the sulphur recovered from sour gas in Alberta originates from the Paleozoic-Mississippian and Devonian systems.

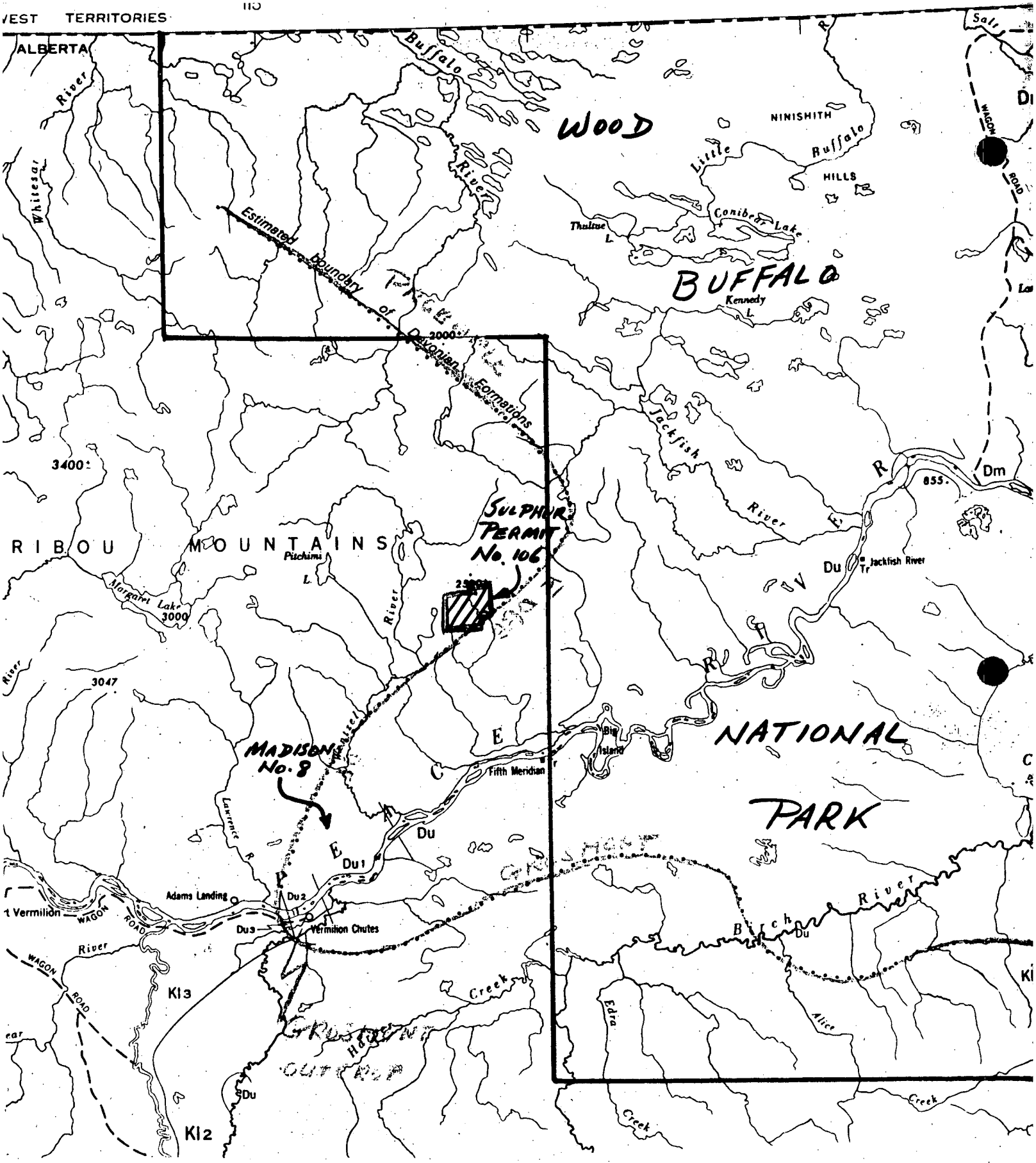
Although in the subject area the Grosmont is the underlying formation and contains native sulphur, older Devonian formations such as the Beaverhill (Mikkwa) which underlie the northeastern portion of Alberta may also contain sulphur. Subsequently, younger Devonian and Mississippian formations (Winterburn, Wabamum, Banff, etc) which subcrop successively as one proceeds west from the subject area, may also contain sulphur in situ. This is evident by the occurrence of sulphur at Great Slave Lake which is found in the Devonian Sulphur Point Formation (underlying the Beaverhill) and elsewhere in the Province, at depth.

The large Elk Point Salt Basin which parallels an area lying south of the Caribou Mountains, may have on its north flanks, thin salt sections. These salt sections by solution collapse may cause certain sub-surface features favoring sulphur accumulation and deposition. Further detailed research and intensive studies of air photo mosaics may indicate certain patterns and alignments of surface features favoring sulphur deposition.

GEOLOGICAL MAP

The map shows the subject area and subcrop of the Grosmont.

It is of interest that the surface sulphur announced on the Madison Sulphur Permit No. 8 occurs along the same outcrop of the Devonian Grosmont on which Sulphur Permit No. 106 is situated, and Permit No. 106 should have similar possibilities for sulphur deposits from a geological point of view.



19680095 Figure 1 - Map showing the subject area and the subcrop of the Grosmont.

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ENGINEERING

1. Transportation

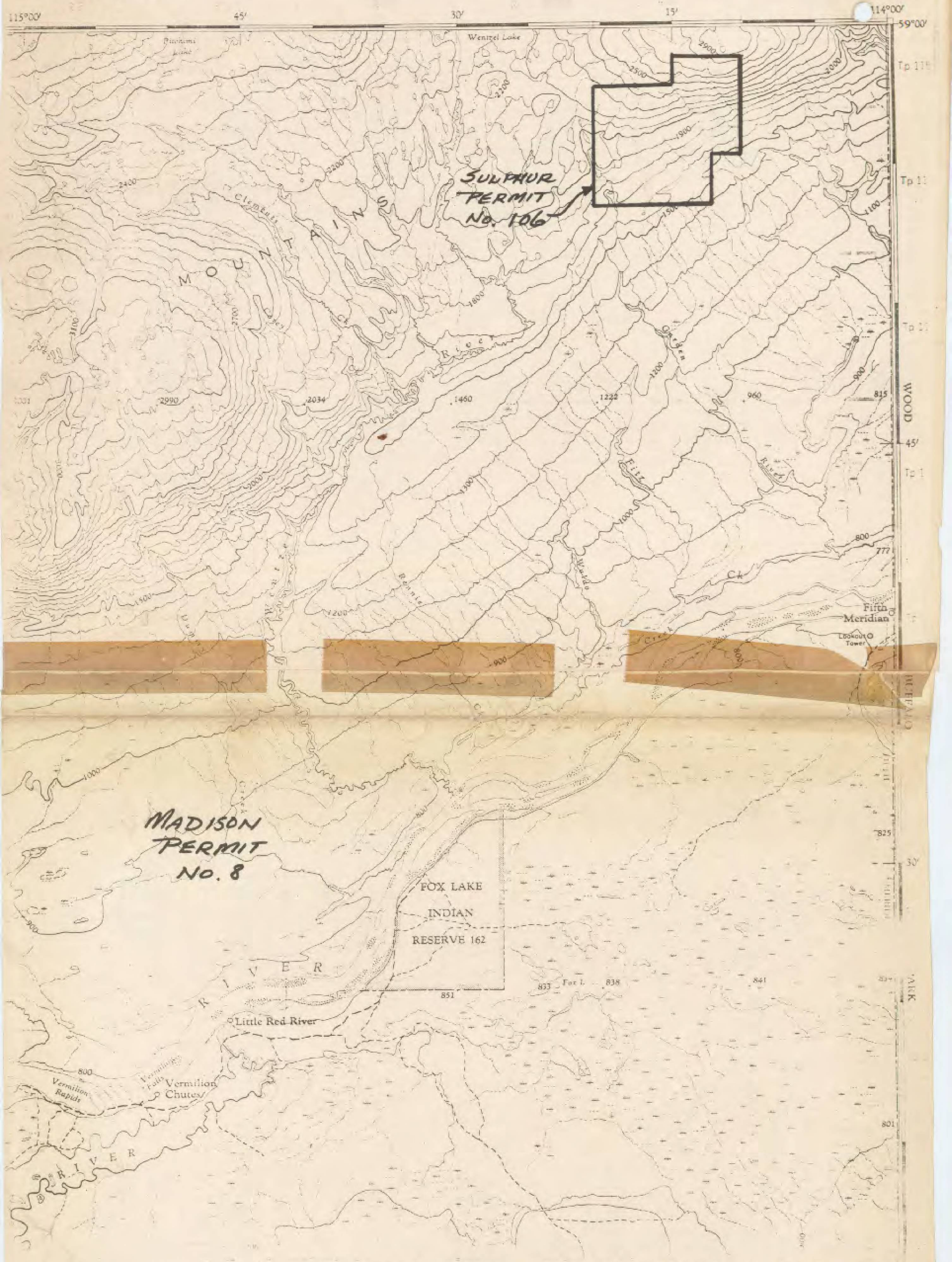
The location of Alberta Sulphur Permit No. 106 is on the same side of the Peace River (the North side), as the Madison Permit No. 8.

It is about 20 miles from the road running from Fort Vermilion to Fort Smith. Sulphur can then be transported by truck from the permit to railhead approximately 100 miles away at High Level, where a new railroad, the Great Slave Lake Railroad, has been built.

Barge transportation of ore or sulphur may be used in the summer to Peace River, up the navigable Peace River to the town of the same name, where the above-mentioned railroad crosses the river. About 35 miles of road transport would be necessary to reach the Peace River from Permit No. 106, since the Vermilion Falls on the Peace are an effective barrier, and tonnage products like sulphur or its ore cannot be portaged easily.

CONTOUR MAP

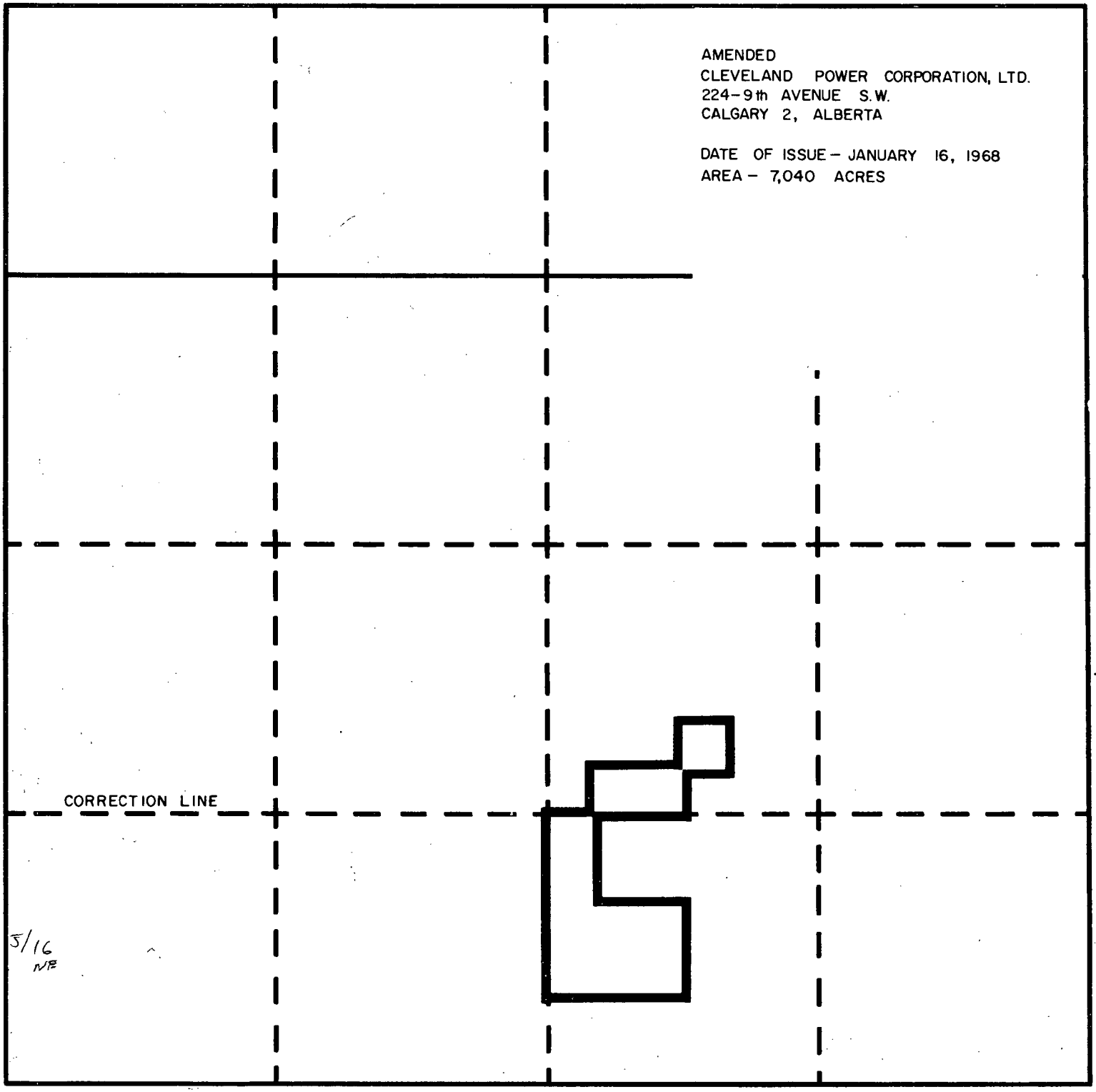
A map showing the nearness (23 miles) of the Permit No. 106 to the Madison No. 8 Permit is included. Permit No. 106 is about 1000 feet higher up the mountain on evenly sloping land, near the source of the Garden River. No transportation problems are foreseen that are abnormal. The Vermilion Rapids and the Vermilion Falls are shown on the Peace River.



CONTOUR MAP - ALBERTA SULPHUR PERMIT No. 106

19680095
Figure 2

SULPHUR PROSPECTING PERMIT No. 106



RECOMMENDATIONS

It is recommended that intensive detailed study of air photographic mosaics be undertaken to establish favorable areas of sulphur accumulation. These favorable areas, when located, should be followed up by surface mapping and shallow test hole drilling to delineate possible recoverable reserves.

The cost of such a program is estimated as follows:

Photo-geological study	$2500.00
Surface inspection in field	3500.00
Shallow test drilling up to 100 feet	7000.00
Sulphur Assays @ $4.00 each, 500 samples	2000.00
Total	$15000.00

Albert Golden, P. Geol.

ENGINEERING

2. Mining

Strip mining of surface sulphur ore may be performed economically if:

(a) A sufficient orebody near the surface is defined, the thicker the better

(b) Overburden is minimal or absent

(c) Volume production is maintained.

Strip mining of coal at a rate of 400,000 tons per year can be very reasonable, not more than $2.00 per ton. Lower costs for larger volumes.

Strip mining can be done on a long-term contract basis without owner's investment, provided long-term markets are available.

Since a section, one foot deep, of 60% sulphur contains 1,000,000 long tons of sulphur, worth $40,000,000, a deeper deposit can be quite attractive economically.

POSSIBLY FRASCH MINING

The cover of the Lower Cretaceous consists of Loon River Shales which form quite an impervious caprock perhaps suitable for Frasch mining (melting sulphur with hot water) of an underground deposit of sulphur if one is present. Deeper drilling should be done to determine this possibility as well as surface sulphur.

Frasch mining requires no process pla nt except perhaps a molten sulphur filter.

ENGINEERING

3. Processing

Several methods of recovery are available, but the one being used commercially in a California plant now, and that one experienced by the writer in Texas 15 years ago, consists of dissolving the sulphur in hot kerosene and filtering it from the gangue, and then cooling the solution so the sulphur precipitates.

This process has been written up in the attached article, along with others.

The cost of processing varies with the circumstances but is reliably reported to be not more than $15.00/long ton of sulphur, comparable to average Frasch costs.

4. Probable Costs

The cost of sulphur produced from a large deposit of 60% surface ore by strip mining and processing onsite is roughly estimated to be $20/long ton. To this must be added transportation costs to railhead, which probably range about $5.00 per long ton.

While sulphur sells for $50/long ton and up, a cost of $25/long ton is practical.