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RECONNAISSANCE REPORT

SULPHUR PROSPECTING PERMITS NOS. 184 TO 192

BITUMINOUS SAND PERMITS NOS. 82 AND 93

FORT McMURRAY AREA, ALBERTA

Prepared For

Sinclair Canada Oil Co.

November, 1968

J. C. SPROULE AND ASSOCIATES LTD.
OIL AND GAS ENGINEERING AND GEOLOGICAL CONSULTANTS

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INTRODUCTION

The following report presents the results of a field study that was undertaken by J. C. Sproule and Associates Ltd. at the request of Mr. W. P. Wilson, acting for Sinclair Canada Oil Co. The field program included a reconnaissance geological study of certain permit areas in the general area of Fort McMurray, Alberta, and the obtaining of samples from each permit to be analyzed for sulphur content. The subject permits are Sulphur Prospecting Permits Nos. 184 to 192 inclusive and leases from Bituminous Sand Permits Nos. 82 and 93. These permits are located east, northeast, north, and northwest of the town of McMurray in the general vicinities of the Clearwater River, Firebag River, Athabasca River and MacKay River, respectively. The holdings, which total approximately 900,000 acres, are distributed over a geographical area 85 miles in width by 110 miles in length.

The field work was conducted by S. R. L. Harding during the period September 7 to October 5, 1968. Use was made of both helicopter and boat services, and the operations were carried out from bases at McMurray, Fort MacKay and a field camp established at Lobstick Point on the Athabasca River about six miles upstream from the outlet of the Firebag River. The boat was very useful on the Athabasca River but was of limited use on the Clearwater River because of seasonal low water. A car was hired for one day for reconnaissance and sampling of those areas that could be reached by road. Fuel caches were placed by truck, boat and fixed-wing aircraft.

The prime purpose of the program was to locate and describe sulphur occurrences, and to obtain representative samples from each permit for subsequent analyses. The time assigned to the program did not allow for much to be achieved beyond this primary objective. It was agreed, however, in discussions with Mr. Stan Paskevitch of Sinclair Canada Oil Co. that, without attempting to summarize the voluminous geological literature for the area or to conduct any detailed field mapping, the consultant should make geological observations of a reconnaissance nature, which would add to the understanding of the regional geology of the area.

This report is illustrated by a planimetric map of the McMurray area showing Sinclair's sulphur permits and the sample locations in relation to regional geology. Analyses of 174 samples are attached as Appendix I.

REGIONAL GEOLOGY AND SULPHUR OCCURRENCE

The subject permits are in the general area of the Athabasca Oil Sands. Over a period of many years, much geological work has been conducted in this area and there are many published reports that are relevant. Various publications by the Geological Survey of Canada, the Alberta Research Council, the Oil and Gas Conservation Board of Alberta, and others include excellent bibliographies and lists of references so that they need not be included in this report.

In summary, within the general area of the subject prospecting permits, the principal outcropping bedrock formations are of Cretaceous age, but, to the north and northeast, erosion has stripped off the Cretaceous beds exposing older Devonian rocks, and beyond that the Precambrian. Erosion has also exposed the Devonian beds in the valleys of the Athabasca and Clearwater rivers, and the tributary streams, the Christina, the Muskeg, the MacKay, and the Ells. A major unconformity separates the Devonian and Cretaceous formations. The Devonian, as well as overlying Cretaceous rocks, is generally inclined gently westward toward the Alberta Syncline, and progressively younger rocks of both Paleozoic and Mesozoic ages are present in that direction.

A number of reversals to the regional structure in the Cretaceous are known to occur in the subject area. One of the most striking is evidenced by the occurrence of the basal Glauconitic sand of the Cretaceous Clearwater Formation (the formation above the oil-rich Cretaceous McMurray Formation) at the level of the Athabasca River near the mouth of Tar River about 10 miles north of Fort MacKay. This indicates a reversal of some 200 feet in four miles on Cretaceous horizons and confirms other evidence of a structurally low area in the Cretaceous. Along the same line, there is a reversal of 300 feet on the eroded surface of the Devonian.

A study of the Cretaceous McMurray Formation, based on outcrop data and data from over two thousand tests drilled for oil sand exploration, shows that Cretaceous beds tend to fill in the lows on the Devonian surface. Whether these lows on the Devonian surface result mainly from differential erosion or from structure within the Devonian is controversial. The possibilities of collapse structure resulting from removal of the Elk Point Salt Formation prior to, during, or after Cretaceous deposition must also be considered.

The considerable relief and lack of a regular drainage pattern on detailed maps of the Paleozoic surface suggest that collapse structure due to salt removal may be a contributing factor. The study of this subject is beyond the scope of this report. On Figure 1, we have, however, indicated the positions of a high axis and a couple of prominent lows on the eroded Devonian surface.

The bedrock, whether of Devonian or Cretaceous age, is largely overlain by a variable thickness of glacial and related sediments. The thickness of these overlying sediments is generally at a minimum in those areas where river valleys are deeply incised and greatest in the hilly portions of the area.

Sulphur occurrences in the general region of northern Alberta and the Northwest Territories may be broken into three groups, as follows:

(1) In muskeg or other poorly drained lacustrine or "dried lacustrine" areas. The most important known apparent example of this type is the discovery occurrence on Sulphur Prospecting Permit No. 8, northeast of Fort Vermilion.

(2) Deposits of elemental sulphur in connection with active springs with or without associated gas.

(3) Cretaceous shales in the area frequently contain finely disseminated sulphur. Although we know of no reported concentrations of significant size from the Cretaceous, the possibility of such economic occurrences cannot be entirely eliminated.

We are not prepared, at this time, to enter into detailed discussions of theories of the origin of the various sulphur occurrences because of the large number of presently uncertain factors. Theories of origin from Paleozoic connate waters or from bedded Devonian and other gypsum and anhydrite deposits are, however, of principal interest.

It is of general interest to the overall sulphur problem in this region that continuous flowing sulphur springs have been known for many years within a broad area along the Mesozoic-Paleozoic geological contact that extends from western Saskatchewan, through the McMurray oil sands area, across the present region of sulphur permits into the southern part of the Northwest Territories near Pine Point and westward along the Liard River. It is of further possible significance that there may be a genetic relationship between these sulphur occurrences and the McMurray oil, which has an average four to five percent sulphur content. In addition to this, there is considerable free sulphur associated with the McMurray oil sands, both within and outside of the oil saturated area. As a measure of the amount of sulphur already known to have been deposited, probably from the same type of connate waters that can be expected to have deposited the sulphur under study, we might refer to the "reserve" of sulphur in the McMurray oil sands. Recent estimates indicate that there is over 600 billion barrels of oil in place in the McMurray oil sands. This oil contains four to five percent of sulphur amounting to approximately eight to ten billion long tons.

The above and other evidence available would indicate that what is needed to produce an economic sulphur deposit in this area would be a favourable combination of faults and fractures for sulphate spring exits, sulphur supply in the connate waters and poorly drained lacustrine or other flat basin areas immediately adjacent to the spring exits. All these individual circumstances are known to exist but whether or not a proper combination of circumstances has produced commercial deposits in some location remains to be seen.

LOCAL GEOLOGY AND SULPHUR OCCURRENCE

Except for the leases from the two Bituminous Sand Permits, permits will be discussed in a clockwise sequence rather than in numerical sequence.

Permit No. 184

This permit, comprising approximately 99,840 acres, includes areas on both sides of the Clearwater River westward from the Alberta-Saskatchewan boundary for a distance of approximately 22 miles. The Clearwater River flows through a valley that is approximately 600 feet deep and two to three miles in width. High Hill River and Edwin Creek are tributary streams from the north and south respectively.

Devonian dolomite, limestone, and silty shale are exposed along the valley floor. Outcrops of dolomite of the Methy Formation and limestone and silty shale of the Firebag Member of the Waterways Formation occur in the western half of the permit. Cretaceous sands and shales are exposed in the valley walls. The surface of the area on either side of the valley is one of low relief covered with a mantle of glacial drift and some poorly drained muskeg areas.

Regional geological structure is indicated to be dipping very gently to the southwest, but this is modified by locally anomalous structures including faults.

Norris, in G.S.C. Memoir 313, places the western boundary of the Methy Formation about one mile east of the mouth of Edwin Creek. Salt casts, which we have observed in silty shale outcrops near the mouth of Edwin Creek, indicate the stratigraphic position of the Elk Point Salt Formation above the Methy Formation and might be considered to confirm the western limit of the Methy outcrops as mapped by Norris. On the other hand, evidence of faulting is present in the Devonian beds exposed in the valley of High Hill River and, on the basis of photogeological study, faulting is suspected along Edwin Creek. It is, therefore, not unreasonable to believe that the Methy Formation may be exposed locally in the area between Edwin Creek and High Hill River and that the porous dolomites, which yield sulphur springs in this area, may be rocks of the Methy Formation.

On Figure 1, we have indicated possible fault directions in the area of Permit No. 184. These are based on photo-interpretation related to field evidence and vary somewhat from the fault directions indicated by other authors.

A number of sulphur springs were observed in Permit No. 184 along the Clearwater River between High Hill River and the middle of Range 2, W. 4 M., some 10 miles to the east. The most prominent of these springs were several located at Sample Location 184-1. These emerged from porous dolomite at scattered points over a distance of 250 yards along the north shore of the river. The picture in Plate I-B shows the best developed springs in the area, which happen to be about 50 yards in from the river. Samples were taken of material in various positions with relation to the springs but only the crust deposited on the dolomite where

the springs emerged showed a significant percentage of sulphur (Appendix I, Analysis 184-1-3: 10.73%). The area did not appear to have any suitable depression that would allow for the accumulation of an appreciable volume of sulphur. This statement also applies to the locations of other sulphur springs located along the Clearwater River in Permit No. 184.

No sulphur springs were observed at Sample Locations 184-10 and 184-10A west of High Hill River. Marl deposits on a flat area adjacent to the river were, however, sampled and analyses showed sulphur to be present from traces to a maximum of 2.50 percent. Similar marl deposits at Sample Locations 184-4 and 184-4A produced analyses showing from traces to 1.05 percent sulphur. The maximum sulphur content of samples taken farther from the river was 1.40 percent at Sample Location 184-5.

Permit No. 187

This permit, comprising approximately 96,334 acres, includes the area on both sides of the Clearwater River from the western boundary of Range 8, W. 4 M., eastward to approximately the east side of Range 6, W. 4 M., but excluding areas of about 1 3/4 square miles in the vicinity of the McMurray airport and of about 3 1/2 square miles southeast of the junction of the Clearwater and Christina rivers. In the permit area the Clearwater River flows through a valley that is from 400 to 500 feet in depth and 1 1/2 to 2 miles in width. The tributary Christina River flows through a valley that is about 500 feet deep and generally about one mile in width. Beyond the walls of the valleys, the area is one of low relief and poor drainage, sloping gently toward the valleys.

Gently rolling limestone outcropping in the valley bottom and along the river has been assigned by Norris (G.S.C. Memoir 313) to the Calumet, Christina and Moberly members of the Devonian Waterways Formation (Figure 1). Above the Devonian are Cretaceous beds, including the oil sands of the McMurray Formation.

A number of sulphur springs were observed along the south bank of the Clearwater River valley immediately east of Permit No. 187 and one group of springs at Sample Location 187-14 appear to be within the subject permit. The springs at this location are well above the valley bottom and reveal sandy material at their outlets. They may, nevertheless, be emerging from the Devonian limestone or from the surface of the limestone. Sulphurous material is deposited around the spring outlets. Marl deposits are present in extensive meadows below the springs (Plate I-A). Analyses show maximum sulphur content in samples of material taken at the spring outlets to be 9.17 percent and in the marls of the meadow 2.00 percent.

Sediment by a sulphur spring at Sample Location 187-23 analyzed 2.04 percent sulphur and marl deposits at Sample Location 187-22 in the same general area analyzed a maximum of 1.05 percent sulphur.

At Sample Location 187-2, a section of river-laid deposits was exposed on the north bank of the Clearwater River for a distance of one-half mile. This section may be summarized as presented on the following page.

6'	- Bedded salt.
0'-6"	- Organic material (Sample 187-2-1)
0'-6"	- Loose sand.
0'-10"±	- Organic material with yellow bloom (Sample 187-2-2).
9'-0"	- Loose sand.

----------Low water river level----------

Samples 187-1 and 187-2 at this location analyzed 1.58 percent and 2.23 percent sulphur respectively. Other samples taken from Permit No. 187 recorded analyses of nil to only 0.63 percent sulphur.

Permit No. 189

This permit, which comprises approximately 73,069 acres, straddles the Athabasca River from a point about three miles north of McMurray, northward to the general area of the Great Canadian Oil Sands plant and the mouth of the Steepbank River. Access to Permit No. 189 is by river or by the all weather road on the west side of the Athabasca River, connecting McMurray with the Great Canadian Oil Sands plant, some 18 miles to the north.

The valley of the Athabasca River in this area is about two miles wide and 200 feet deep. Areas to either side of the valley are of generally low relief and poorly drained but sloping gently toward the valley.

Well bedded, fossiliferous limestones and silty limestones of the Moberly Member of the Waterways Formation are exposed semi-continuously along the Athabasca River throughout Permit No. 189. Although the structure within the Devonian tends to be gently rolling, essentially the same stratigraphic section is exposed and identifiable along the river from McMurray to Fort MacKay. It is, therefore, correct to say that in this area the Athabasca River approximately follows the strike of the Devonian beds. In the same area, the complete McMurray Formation with its variable oil content is semi-continuously exposed along the banks of the Athabasca River.

Samples taken in Permit No. 184 include samples of oil sand. The highest sulphur values from this permit are either oil sands or concentrations of residue from the oil sands. These values vary from 6.02 to 21.36 percent. Other analyses show values up to a maximum of 7.94 percent but, in all cases, it is believed that the high sulphur readings can be directly related to the presence of oil sands.

No sulphur springs, as such, were observed in Permit No. 189, but sulphur springs are associated with salt springs on the borders of Saline Lake, on the east side of the Athabasca River about three miles north of Permit No. 189.

Permit No. 190

This permit, which comprises approximately 99,137 acres, extends on either side of the Athabasca River from Fort MacKay northward to include two-thirds of Township 98. At its widest, the permit is about 10 miles across and extends eastward almost to McClelland Lake.

The Athabasca River valley continues to be close to 200 feet in depth in this permit area but widens out more gradually away from the river level. In the direction of McClelland Lake, an area almost one township in size has very low relief and is very poorly drained.

Fossiliferous limestones of the Moberly and Christina members of the Devonian Waterways Formation outcrop along the Athabasca River as far as four miles downstream from Fort MacKay. Beyond this, the Devonian beds occur well below river level, except for an isolated outcrop of fossiliferous Calumet limestone in the N.W. 1/4 Section 30-97-10 W. 4 M. and three outcrops of fossiliferous Firebag limestone at the northern end of Permit No. 190. Outcrops of McMurray Formation oil sand are exposed intermittantly along the river throughout the permit.

Two flowing wells are present in Permit No. 190. In 1907, A. Von Hammerstein drilled a well to a depth of 615 feet on the west side of the Athabasca River at the north edge of Fort MacKay. This well, our Sample Location 190-1, has been flowing continuously since that time. There is no area suitable for the accumulation of sulphurous sediments but samples taken close to the well analyzed 4.49 percent sulphur.

The second "flowing well" was drilled by J. D. Tait in 1915 for Athabaska Oils Ltd. This well was drilled on top of the east bank of the Athabasca River across from the mouth of the Ells River, our Sample Location 190-2. This well was flowing strongly when we first visited it 12 years ago and was reported to be flowing last winter. This fall, however, there was no flow from the mouth of the well. It is possible that the water flow may have broken through to the Athabasca River at some lower level. A sample collected on the bank analyzed 75.45 percent sulphur but there is no suitable area for the accumulation of any significant quantity of sulphur.

Other samples in Permit No. 190, which show more than traces of sulphur are all samples of oil sand or are associated directly with oil sand.

Permit No. 191

This permit, which comprises approximately 98,560 acres, straddles the Athabasca River in portions of Townships 98 and 99, and extends northwestward to include the southern part of Township 101, Range 11, W. 4 M., and the southwestern corner of Township 101, Range 10, W. 4 M.

No bedrock outcrops were observed in this permit. Cretaceous beds are expected to generally underlie the drift but along the river Devonian limestones could occur under the drift in places.

The western margin of the permit rises to the top of the Birch Hills, which are nearly 2,000 feet higher than the Athabasca River.

The strongest sulphur showing reported for the permit is an analysis of 6.74 percent for a silty sample in a low-lying area in trees, about 20 feet above the river, at Sample Location 191-13.

A lake covering about 5 1/4 acres and filled with soft marl to a depth of four feet or more is present a little over one-half mile west of the Athabasca River in Lsd. 5-2-99-10 W. 4 M., in Permit No. 191 (Plate II-A). A sample taken from the surface of this lake deposit analyzed only a trace of sulphur but a sample acquired from a depth of 3 to 4 feet analyzed 6.64 percent sulphur. Repeat analyses of these samples by a second laboratory and an analysis of a third sample taken later are being obtained.

The remaining samples taken from Permit No. 191 yielded analyses varying from traces to 1.70 percent sulphur.

Permit No. 192

This most northerly permit of the Sinclair holdings along the Athabasca River is largely in Townships 101 and 102, extending westward from the river to the foot of the Birch Hills. The permit, which comprises approximately 98,906 acres, is for the most part an extensive area of muskeg.

No outcrops were observed in Permit No. 192 but it is believed that the Pleistocene and Recent sediments are underlain by Devonian rocks in about half the area and by Cretaceous in the other half.

The highest sulphur analysis, 8.99 percent, was obtained from a sample of organic material from a grassy meadow at the foot of the eastern slope of the Birch Hills (Sample Location 192-8). Another grassy meadow near the north edge of the permit (Sample Location 192-10) yielded a sample of organic material that analyzed 4.26 percent sulphur. The only other analysis for Permit No. 192, which exceeded 3 percent sulphur, was for a soil sample taken in an area of fir trees at Sample Location 192-6 on the east side of the Athabasca River. This sample analysed 6.95 percent sulphur.

Permits Nos. 188, 186 and 185

These permits, which comprise approximately 99,840 acres, 98,560 acres, and 97,280 acres, respectively, straddle the upper reaches of the Firebag River and extend from the southeast corner of Township 99, Range 7, W. 4 M., southeastward to the Saskatchewan border.

These three permits occupy an area of generally poor drainage with numerous muskegs. Elevations vary from + 1,000 feet at the northwest corner of Permit No. 188 to + 1,700 feet on the Saskatchewan border.

Sulphur springs, which emerge from the Methy dolomite, are present along the Firebag River to the northwest of Permit No. 188, but within the subject group of three Sinclair permits only Cretaceous beds are believed to underlie the glacial drift and no sulphur springs were observed.

No outcrops of bedrock were observed in Permits Nos. 186 and 185 but outcrops of McMurray oil sands are present along the Firebag River in the western part of Permit No. 188. Oil sands were also observed on the Upper Marguerite River in close proximity to outcrops of Precambrian gneisses (Plate II-B), and southeast of observed carbonate outcrops of probable Devonian age. Cliffs along the Firebag River in the eastern part of Permit No. 188 expose beds of bituminous boulder clay.

A muskeg sample at Sample Location 186-6, which analyzed 3.93 percent sulphur, was the only sample in the three Permits Nos. 188, 186 and 185, to yield more than 3 percent sulphur on analysis.

It was not possible to observe structural indications by flying over this area but photogeological studies could be useful for this purpose.

Leases from Bituminous Sand Permits Nos. 82 and 93

These leases, which together comprise approximately 48,640 acres, are located along the MacKay River approximately 12 to 24 miles west of the Great Canadian Oil Sands plant. Elevations in this area vary from about + 1,100 feet to about + 1,500 feet, and the area is generally poorly drained with numerous muskegs.

Outcrops along the MacKay River reveal the bedrock to be Cretaceous shales with some sands.

Analyses of samples from these leases revealed no sulphur higher than 0.64 percent.

CONCLUSIONS

Conclusions are as follows:

(1) The highest sulphur analysis in the Sinclair holdings was 75.45 percent, which was for Sample Location 190-2. The sample was sediment from the abandoned Devonian well drilled in 1915 and which has, until recently, been flowing since that time. The site is on the Athabasca River bank across from the mouth of the Ells River. Unfortunately, the location is not suited for the accumulation of sulphur. This location has had a strong hydrogen sulphide smell and the sulphur is believed to originate from hydrogen sulphide.

(2) Sulphur springs were observed in Permits Nos. 184, 187 and 191. With the exception of Permit No. 187, suitable catchment basins for the accumulation of sulphur were not associated with the springs. At Sample Location 187-14, on the east side of Permit No. 187, sulphur springs occur on the hillside above a meadow. Analyses of material around the springs showed a maximum 9.17 percent sulphur. Analysis of marl deposits in the meadow below showed 2.00 percent sulphur.

A second area of marl deposits with sulphur springs in the vicinity is at Sample Location 187-22 but the analyses showed a maximum 2.04 percent sulphur.

Marl deposits with 2.50 percent sulphur were present at Sample Location 104-10, in Permit No. 184, but sulphur springs were not observed in the area.

(3) Sulphur springs in the area of Sinclair holdings and in adjacent areas generally, if not always, originate in the Devonian carbonates.

(4) The marl deposit in the lake at Sample Location 191-3, in Permit No. 191, over four feet thick for an area of 5 1/4 acres, with analyses showing a maximum of 6.64 percent sulphur, is an interesting feature but it is doubtful if it is of economic interest in this relatively isolated location as there are much more readily accessible lime deposits in western Canada.

(5) Organic material from muskegs yield sulphur analyses in excess of 3 percent in Permits Nos. 189, 192, and 186. These should be indicators of sulphur in the soil and waters of the area. Sulphur springs, as such, were not in evidence in these muskeg areas.

(6) Analyses of oil sands or associated oil sand residues give readings from 0.61 percent to 21.36 percent sulphur, but the samples with high values in each instance were carefully selected from small showings.

RECOMMENDATIONS

It is recommended that consideration be given to:

(1) Dropping Sulphur Prospecting Permits Nos. 185, 186 and 188. Generally low sulphur values were obtained from these permits, which are all in areas of Cretaceous bedrock.

(2) Dropping Permits Nos. 189 and 190, unless Sinclair holds some interest in the oil sands of these areas, as all high sulphur values in these permits, except for the flowing well locations, appear to be related to the oil sands and no sulphur springs were observed along the Athabasca River within the permits.

(3) Retaining Permit No. 187 and undertaking further auger testing this winter or next summer at Sample Locations 187-14 and 187-22. These two locations are meadows with marl deposits in the vicinities of sulphur springs. A winter road from McMurray comes within approximately one mile of each of these locations.

(4) Retaining Permit No. 184 pending further work on Permit No. 187.

(5) Retaining Permit No. 191 with a view to possible further testing of the marl deposit area at Sample Location 191-3, especially if testing of the marl deposit areas in Permit No. 187 should encounter improved sulphur values.

(6) Retaining Permit No. 192 for possible further investigation next summer. Devonian beds are believed to underlie much of this permit and several encouraging sulphur values were obtained.

(7) Retaining Bituminous Sand Permits Nos. 82 and 83, provided sulphur rights are related to the rights to the bituminous sand. The bedrock in these two permits consists of Cretaceous rocks stratigraphically higher than the oil sands and no high sulphur values were obtained from the samples.

S. R. L. Harding, P. Geol.

1009 Fourth Avenue S.W.,
Calgary, Alberta.
November 26, 1968.
SRLH/fc

APPENDIX I

Laboratory Report Number - Chemical & Geological Laboratories Ltd.

C68-4216-1	Sample Nos. 82-2, 82-3, 82-4
C68-4216-2	Sample Nos. 191-1, 191-2, 191-3-1, 191-3-2, 191-3A, 191-4, 191-4A, 191-5, 191-6, 191-7, 191-8, 191-9, 191-10, 191-11, 191-12, 191-13.
C68-4216-3	Sample Nos. 186-1, 186-2, 186-3, 186-4, 186-5, 186-6, 186-7, 186-8.
C68-4216-4	Sample Nos. 188-1-1, 188-1-2, 188-2, 188-3, 188-4, 188-5-1, 188-5-2, 188-5-3, 188-5-4, 188-6, 188-7, 188-8, 188-9, 188-10, 188-11, 188-12, 188-13, 188-14, 188-15.
C68-4216-5	Sample Nos. 190-1, 190-2, 190-3-1, 190-3-2, 190-4, 190-5, 190-6, 190-7, 190-8, 190-9-1, 190-9-2, 190-10, 190-11, 190-12, 190-12A, 190-13, 190-17, 190-18, 190-19, 190-20.
C68-4216-7	Sample Nos. 187-1-1, 187-2-1, 187-2-2, 187-3-1, 187-4-1, 187-5-1, 187-6, 187-7, 187-8, 187-9, 187-10, 187-11, 187-12, 187-13, 187-14-1, 187-14-2, 187-14-3, 187-14-4, 187-15, 187-16, 187-17, 187-18, 187-19, 187-20, 187-21, 187-22-1, 187-22-2, 187-22-3, 187-23.
C68-4216-8	Sample Nos. 93-1, 93-2, 93-3-1, 93-3-2, 93-4-1, 93-4-2, 93-5, 93-6.
C68-4216-9	Sample Nos. 184-1-2, 184-1-3, 184-1-4, 184-1-5, 184-2-1, 184-2-2, 184-3-1, 184-3-2, 184-4-1, 184-4-2, 184-4A-1, 184-4A-2, 184-5, 184-6, 184-7, 184-8, 184-9, 184-10A, 184-10-1, 184-10-2.
C68-4216-12	Sample Nos. 185-1, 185-2, 185-3, 185-4, 185-5, 185-6, 185-7, 185-8.
C68-4216-13	Sample Nos. 189-1-1, 189-2-1, 189-2-2, 189-3-1, 189-4-1, 189-4-2, 189-4-3, 189-5-1, 189-6-1, 189-7-1, 189-8-1, 189-8-2, 189-9-1, 189-9-2, 189-10-1, 189-11-1, 189-12-1, 189-13-1, 189-14-1, 189-15-1, 189-15-A, 189-16, 189-17, 189-18, 189-20, 189-21, 189-22.
C68-4216-14	Sample Nos. 192-1, 192-2, 192-3, 192-4, 192-5, 192-6, 192-7, 192-8, 192-9, 192-10, 192-11, 192-12, 192-13, 192-14, 192-15, 192-16

CHEMICAL & GEOLOGICAL LABORATORIES LTD.

14240 - 115th. Avenue, Edmonton, Alberta.

4605 - 12th. Street, N. E., Calgary 67, Alberta.

Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-1

Kind of Sample: Soil Date Reported: November 5th., 1968

J. C. SPROULE & ASSOCIATES LTD.

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
82-2	Trace	Organic sample - muskeg.
82-3	Trace	Organic sample - grassy swamp.
82-4	Trace	Organic sample - grassy swamp.

NOTE: Sample Location 82-1 was a fresh water spring with no evidence of sulphur. A sample was not obtained.

CHEMICAL & GEOLOGICAL LABORATORIES LTD.

14240 - 115 AVENUE, EDMONTON, ALBERTA

4605 - 12th. Street, N. E., Calgary 67, Alberta.

Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-2

Kind of Sample: Soil Date Reported: November 5th., 1968.

J. C. SPROULE & ASSOCIATES LTD.

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
191-1	Trace	S Soil sample.
191-2	0.54	O Organic material - muskeg.
191-3-1	Trace	O Marl deposit.
191-3-2	6.64	O Marl deposit.
191-3A	Trace	L.S. Botton sample - lake.
191-4	1.70	O Organic material - muskeg.
191-4A	Trace	O Organic material - muskeg.
191-5	Trace	O Organic material - muskeg.
191-6	Trace	O Organic material - muskeg.
191-7	Trace	O Organic material - muskeg.
191-8	Trace	O Organic material - muskeg.
191-9	Trace	O Organic material - muskeg.
191-10	Trace	S Silt on hill top.
191-11	0.95	O Sediment from spring.
191-12	0.80	S.S. Silt by stream.
191-13	6.74	S Silt from lowland above river.

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Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-3

Kind of Sample: Soil Date Reported: November 5th., 1968.

J. C. SPROULE & ASSOCIATES LTD.

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
186-1	Trace	Sandy soil.
186-2	2.24	Organic material.
186-3	0.79	Organic material.
186-4	0.86	Sandy soil.
186-5	1.03	Organic material - muskeg.
186-6	3.93	Organic material - muskeg.
186-7	Trace	Organic material - muskeg.
186-8	Trace	Soil sample.

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4605 - 12th. St. N. E., Calgary 67, Alberta

Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-4

J. C. SPROULE & ASSOCIATES LTD.

Kind of Sample: Soil Date Reported: November 5th., 1968.

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
188-1-1	Trace	S Sandy soil.
188-1-2	Trace	O Organic material - muskeg.
188-2	Trace	S Soil sample.
188-3	Trace	O Organic material - muskeg.
188-4	Trace	S Soil sample.
188-5-1	Trace	O Drift with oil sand.
188-5-2	Trace	O Sandy drift.
188-5-3	0.33	O Drift with oil sand.
188-5-4	1.16	O Drift with oil sand.
188-6	Trace	S Clay.
188-7	Trace	S Silt.
188-8	Trace	O Organic material - muskeg.
188-9	Trace	O Organic material - muskeg.
188-10	Trace	O Organic material - muskeg.
188-11	1.33	O Organic material - muskeg.
188-12	Trace	L.S. Organic material - lake bottom.
188-13	0.53	L.S. Organic material - edge of lake.
188-14	2.99	S Soil sample - head of muskeg area.
188-15	1.84	O Organic material - muskeg.

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Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-5

J. C. SPROULE & ASSOCIATES LTD.

Kind of Sample: Soil Date Reported: November 5th., 1968.

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
190-1	4.49	Sediment from well flowing sulphur water.
190-2	75.45	Sediment from well flowing sulphur water.
190-3-1	3.33	Oil sand.
190-3-2	Trace	Soil sample.
190-4	Trace	Clay.
190-5	Trace	Silt.
190-6	5.68	Oil sand detritus.
190-7	Trace	Iron spring.
190-8	Trace	Silt
190-9-1	Trace	Silt
190-9-2	Trace	Limy soil.
190-10	1.15	Soil near oil sand.
190-11	Trace	Soil sample.
190-12	Trace	Soil sample.
190-12-A	Trace	Soil sample.
190-13	0.61	Soil sample near oil sand.
190-17	Trace	Deposit by spring.
190-18	Trace	Organic material - muskeg.
190-19	Trace	Soil sample.
190-20	Trace	Silt.

NOTE: Samples from Locations 190-11A, 190-14, 190-15, and 190-16 are limestone and were not analyzed.

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Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-7

J. C. STROULE & ASSOCIATES LTD.

Kind of Sample: Soil Date Reported: November 5th., 1968

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
187-1-1	Trace	S Soil sample.
187-2-1	1.58	S.S 6" Organic material - river bank.
187-2-2	2.23	S.S 10" Organic material - river bank.
187-3-1	0.63	S Silt sample.
187-4-1	0.40	O Black mud - swamp.
187-5-1	Trace	S.S Silt - stream bank.
187-6	Trace	S Soil sample.
187-7	Trace	S Soil sample - grass meadow 18".
187-8	Trace	O Organic material - muskeg.
187-9	Trace	S Soil sample - edge of muskeg.
187-10	Trace	S Soil sample - forest area.
187-11	Trace	S Soil sample - grassy meadow.
187-12	Trace	O Organic material - meadow.
187-13	Trace	S Soil sample - edge of muskeg.
187-14-1	9.17	O Mud in sulphur spring.
187-14-2	3.50	O Surface scum at sulphur spring.
187-14-3	2.42	S Sandy clay at 2'.
187-14-4	2.00	O Marl deposit in meadow.
187-15	nil	O Organic material - muskeg.
187-16	nil	O Organic material - muskeg.
187-17	nil	O Organic material - muskeg.
187-18	trace	O Sediment - iron spring.
187-19	nil	O Organic material - muskeg.
187-20	trace	O Organic material - muskeg.
187-21	trace	O Organic material - muskeg.
187-22-1	0.90	O Marl deposit.
187-22-2	1.05	O Marl deposit.
187-22-3	trace	O Marl deposit.
187-23	2.04	O Sediment - sulphur spring.

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14240 - 116 AVENUE, EDMONTON, ALBERTA

4605 - 12th. St. N. E., Calgary 67, Alberta

Date Received: October 24th., 1968 Laboratory Report Number: C69-4216-8

J. C. SPROULE & ASSOCIATES LTD.

Kind of Sample: Soil Date Reported: November 5th., 1968.

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
93-1	Trace	RX Clearwater shale, yellow bloom.
93-2	0.64	O Organic material - muskeg.
93-3-1	Trace	RX Clearwater shale, yellow bloom.
93-3-2	Trace	RX Clearwater shale, white bloom.
93-4-1	Trace	S Iron-stained mud.
93-4-2	Trace	RX Clearwater shale, white bloom.
93-5	0.41	O Organic material - spruce swamp.
93-6	Trace	O Organic material - muskeg.

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4605 - 12th. Street, N. E., Calgary 67, Alberta.

Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-2

Kind of Sample: Soil Date Reported: November 5th., 1968

J. C. SPROULE & ASSOCIATES LTD.

Sample Number	Elemental Sulphur (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
184-1-2	Trace	O Surface sample by sulphur spring.
184-1-3	10.73	RX Sulphur crust on dolomite.
184-1-4	Trace	S.W Sandy sediment in stream.
184-1-5	1.05	S.W Sediment in stream.
184-2-1	Trace	O Surface sample by weak sulphur spring.
184-2-2	Trace	O Sediment in weak sulphur spring.
184-3-1	Trace	O Organic material - dry muskeg 1'.
184-3-2	Trace	O Organic material - dry muskeg 2'.
184-4-1	1.05	L.S. Surface mud - pond bottom.
184-4-2	Trace	L.S. Sample at 2' - pond bottom.
184-4A-1	Trace	O Surface mud - marl deposit.
184-4A-2	1.04	O Sample at 4' - marl deposit.
184-5	1.40	O Organic material - dry muskeg.
184-6	Trace	O Organic material - muskeg.
184-7	0.90	O Sediment at sulphur spring.
184-8	Trace	O Organic material - muskeg.
184-9	Trace	O Organic material - muskeg.
184-10A	2.50	O Surface sample.
184-10-1	Trace	L.S. Surface sample - pond bottom.
184-10-2	Trace	O Organic material - muskeg 4'.

NOTE: Sample 184-1-1 is dolomite and was not analyzed.

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14240 - 116 AVENUE, EDMONTON, ALBERTA

4605 - 12th. St. N. E., Calgary 67, Alberta.

Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-12

Kind of Sample: Soil Date Reported: November 5th., 1968

J. C. SPROULE & ASSOCIATES LTD.

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
185-1	Trace	Organic material - muskeg.
185-2	Trace	Organic material -spruce muskeg.
185-3	Trace	Organic material - muskeg.
185-4	Trace	Organic material - at edge of lake.
185-5	Trace	Sandy soil.
185-6	Trace	Sandy soil - edge of muskeg.
185-7	Trace	Organic material - muskeg.
185-8	Trace	Organic material - muskeg.

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14240 - 115 AVENUE, EDMONTON, ALBERTA

4605 - 12th. St. N. E., Calgary 67, Alberta.

Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-13

Kind of Sample: Soil Date Reported: November 5th., 1968

J. C. SPROULE & ASSOCIATES LTD.

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (By S. R. L. Harding)
189-1-1	0.51	S,S Silt on river bank.
189-2-1	12.94	O Deposit by water off oil sand.
189-2-2	21.36	O Deposit by water off oil sand.
189-3-1	7.94	O Iron springs near oil sand.
189-4-1	2.79	S Organic clay - base McMurray Fm.
189-4-2	Trace	S Clay - Base McMurray Fm.
189-4-3	Trace	S Clay - Base McMurray Fm.
189-5-1	Trace	S Silt.
189-6-1	Trace	S Silt.
189-7-1	9.29	O Oil sand float.
189-8-1	Trace	S Sand on hilltop.
189-8-2	10.72	O Oil sand.
189-9-1	Trace	S Soil sample.
189-9-2	6.02	O Oil sand.
189-10-1	Trace	S Soil sample.
189-11-1	5.38	S Soil sample - low land.
189-12-1	Trace	S Soil sample - bush area.
189-13-1	5.60	S Soil sample - low land.
189-14-1	8.07	O Oil sand.
189-15-1	0.75	S Soil sample - above McMurray Fm.
189-15-A	Trace	S Soil sample - meadow.
189-16	Trace	O Organic material - muskeg.
189-17	3.12	S Soil sample - near muskeg.
189-18	5.09	O Organic material - muskeg.
189-20	1.50	O Organic material - grassy swamp.
189-21	3.79	O Organic material - muskeg.
189-22	3.28	S,S. Silt on river bank.

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14240 - 115 AVENUE, EDMONTON, ALBERTA

4605 - 12th. St. N. E., Calgary 67, Alberta.

Date Received: October 24th., 1968 Laboratory Report Number: C68-4216-14

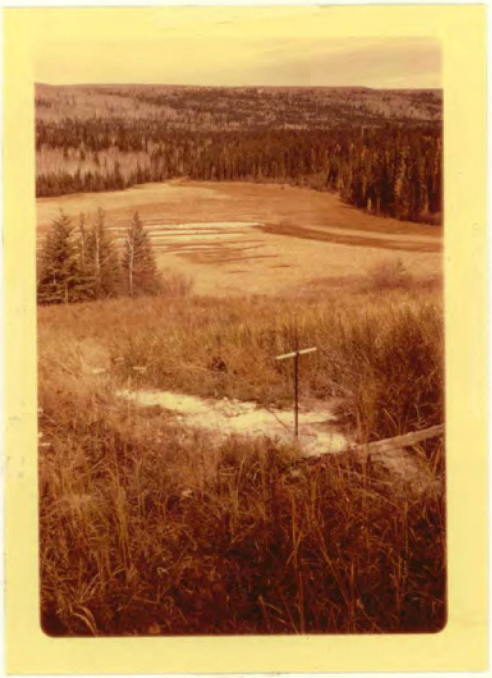
Kind of Sample: Soil Date Reported: November 5th., 1968.

J. C. SPROULE & ASSOCIATES LTD.

SAMPLE NUMBER	ELEMENTAL SULPHUR (% by Weight on Dry Sample)	FIELD NOTES (by S.R.L. Harding)
192-1	Trace	Glacial drift.
192-2	Trace	Soil sample - treed area.
192-3	Trace	Soil sample - treed area.
192-4	Trace	Sediment from springs.
192-5	Trace	Sediment from iron springs.
192-6	6.95	Soil sample - in area of fir trees.
192-7	Trace	Sample from creek bottom.
192-8	8.99	Organic material - grass meadow.
192-9	2.55	Organic material - muskeg.
192-10	4.26	Organic material - grassy muskeg.
192-11	Trace	Soil sample.
192-12	Trace	Soil sample.
192-13	Trace	Soil sample.
192-14	Trace	Organic material - muskeg.
192-15	Trace	Soil sample.
192-16	Trace	Soil sample

PLATES

PLATE I



A. One of several sulphur springs on the south bank of the Athabasca River valley, Sample Location 187-14, with marl deposits in meadow below. Twp. 88, Rge. 6, W. 4 M.

October 3, 1968

B. Sulphur springs emerging from porous dolomite at Sample Location 184-1 on north bank of Clearwater River. Twp. 89, Rge. 3, W. 4 M.

October 2, 1968

Photos by S. R. L. Harding

A. Aerial view of marl deposit at Sample Location 191-3, with Athabasca River in background. The deposit covers an area of approximately 5 1/4 acres and is four feet or more in thickness. Lsd. 5, Sec. 2, Twp. 99, Rge. 10, W. 4 M.

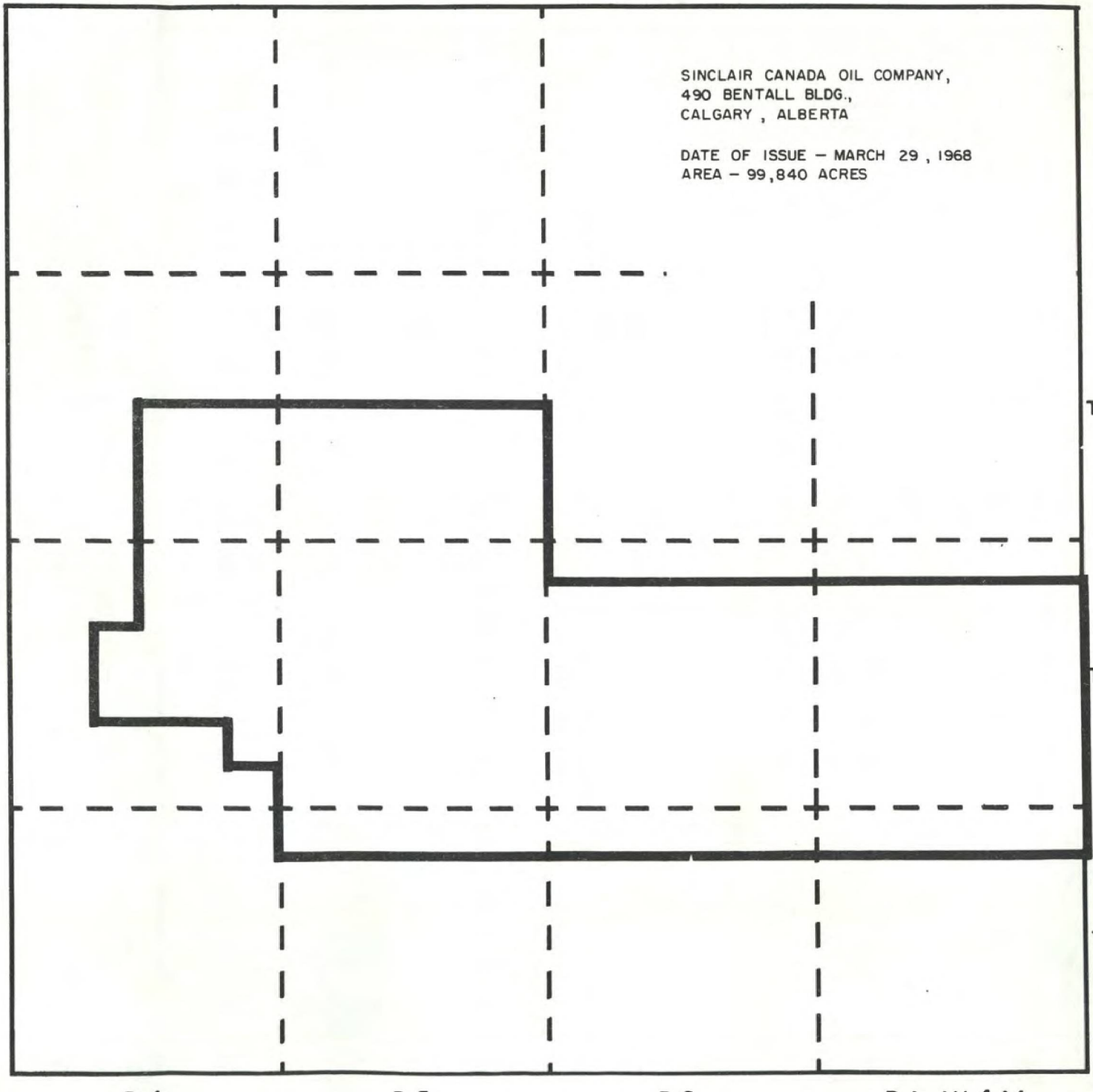
September 30, 1968

B. Outcrop of Precambrian gneiss at Sample Location R-1. Twp. 100, Rge. 5, W. 4 M.

September 29, 1968

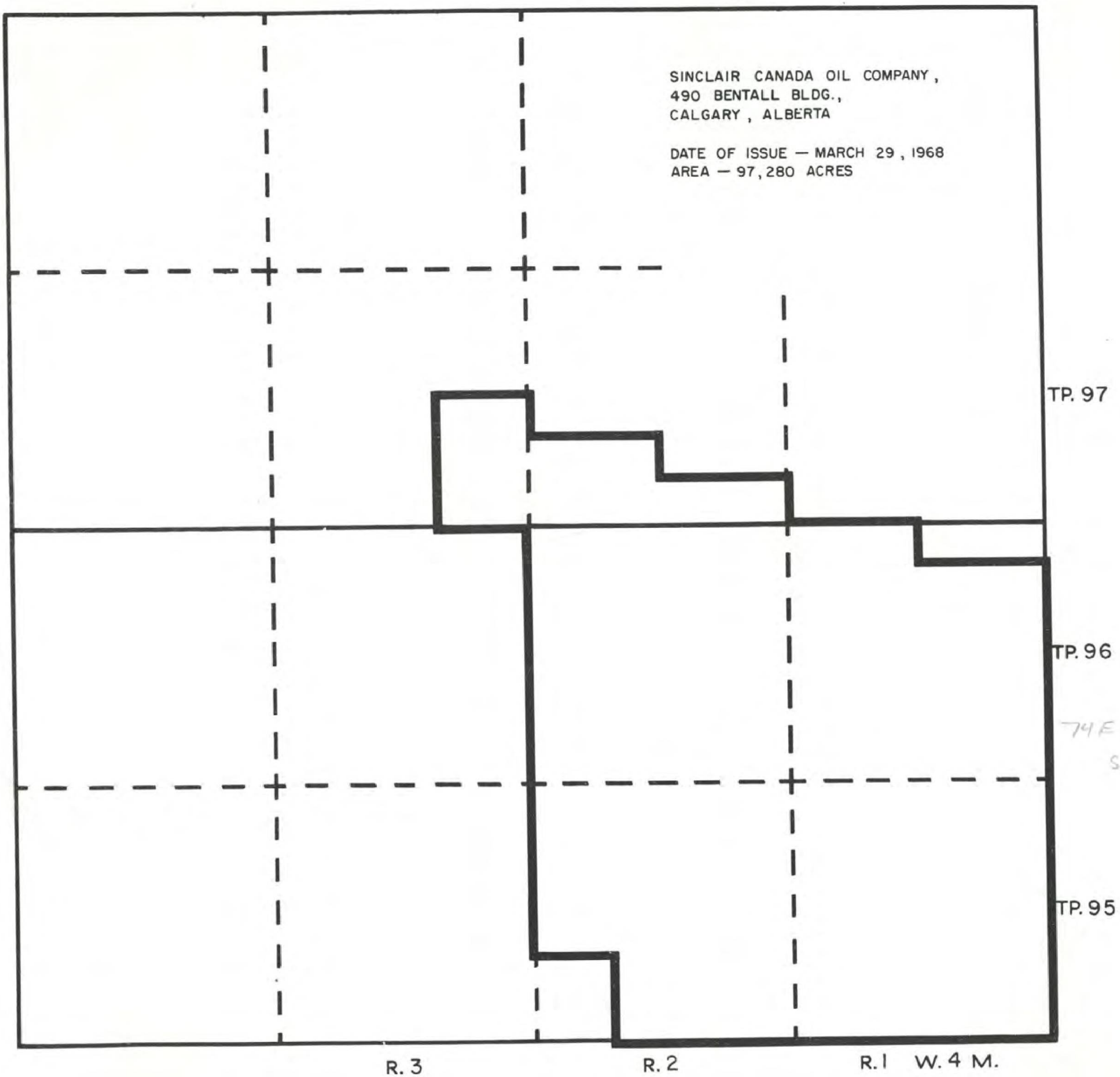
Photos by S. R. L. Harding

SULPHUR PROSPECTING PERMIT No. 184



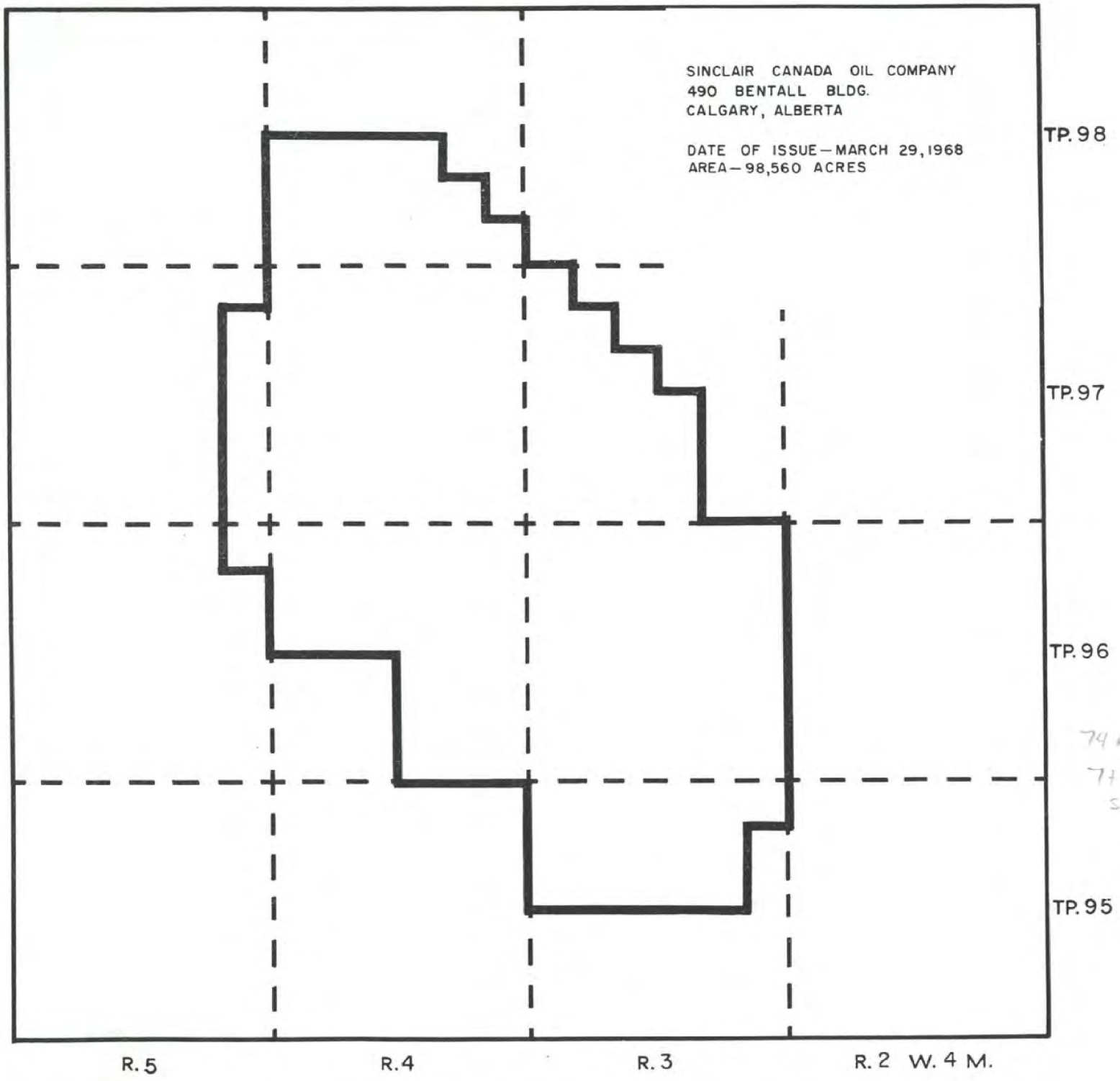
74D/
9,10,15+16
NE

SULPHUR PROSPECTING PERMIT No. 185



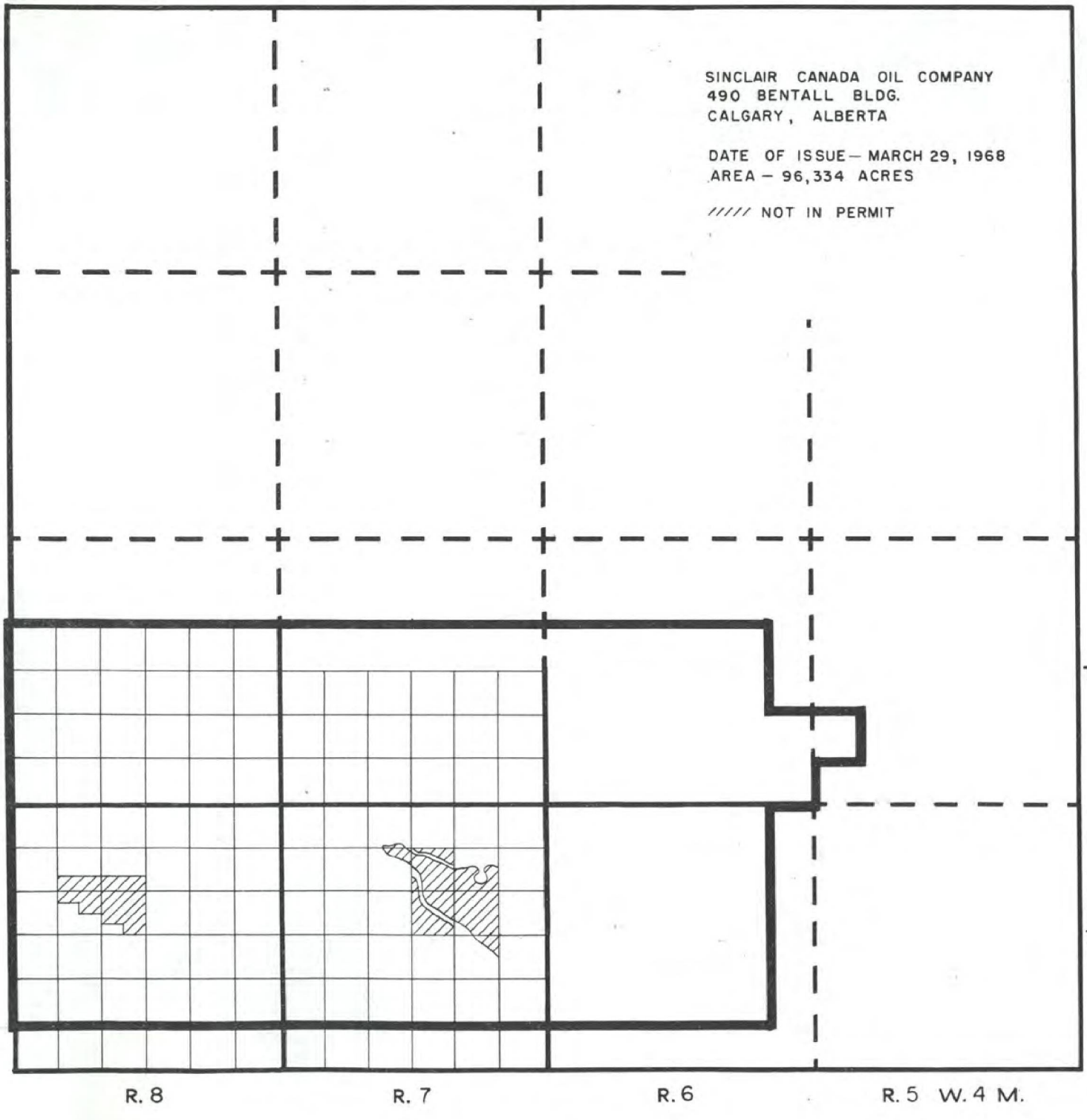
74E/1+8
SE

SULPHUR PROSPECTING PERMIT No.186



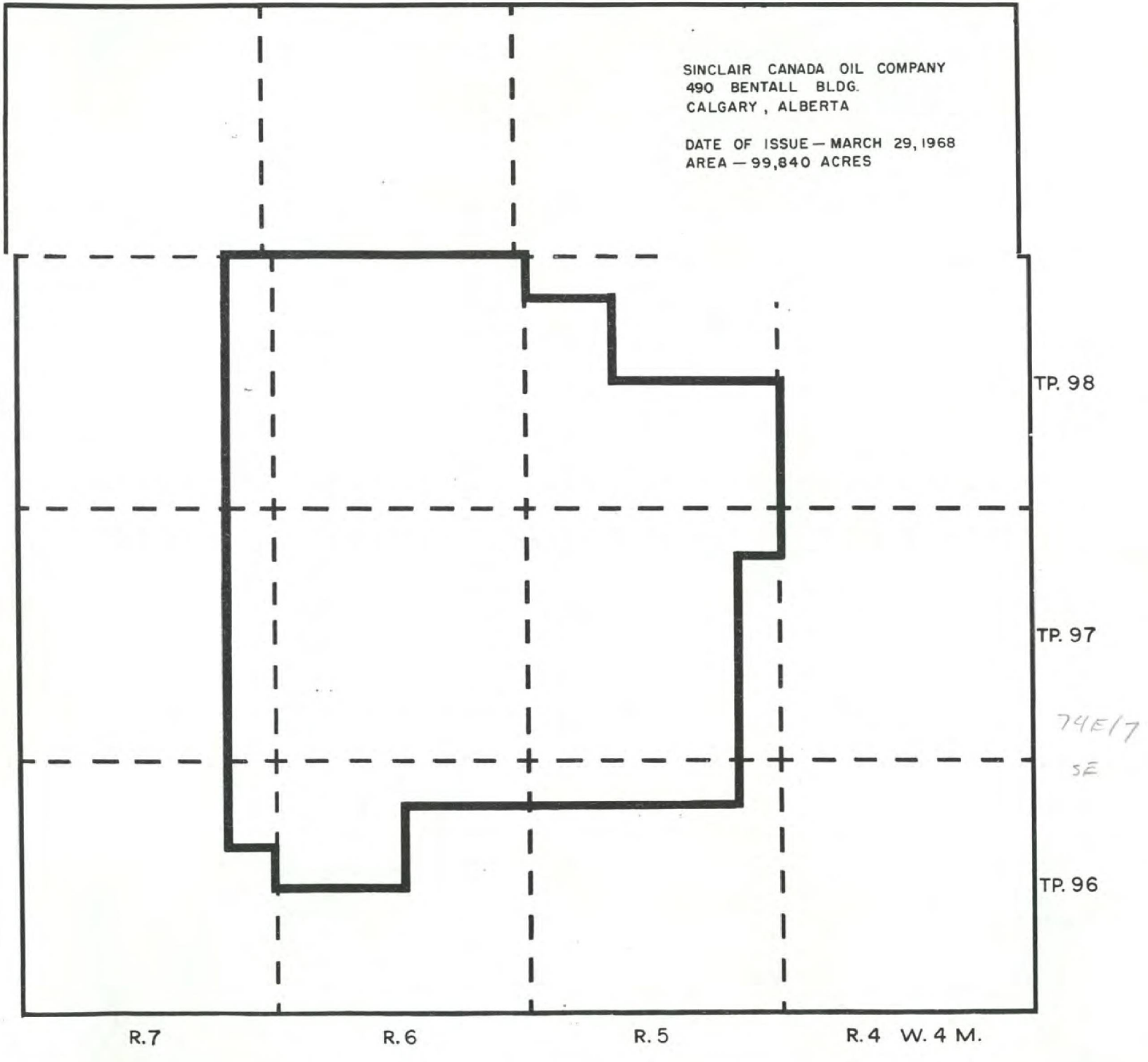
74 E/
7 1 8
SE

SULPHUR PROSPECTING PERMIT No. 187



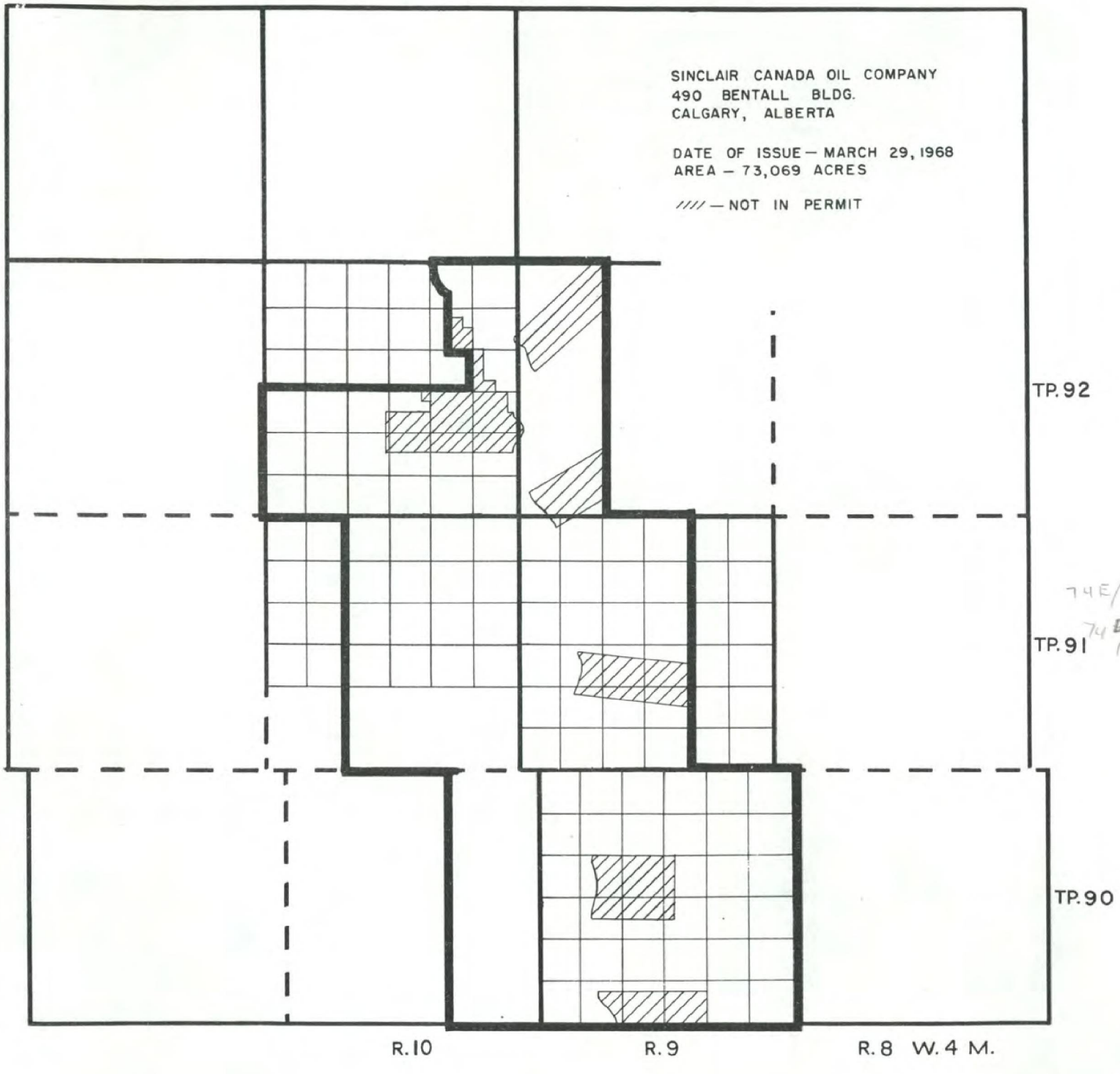
74D/
10+11
NE+NW.

SULPHUR PROSPECTING PERMIT No. 188



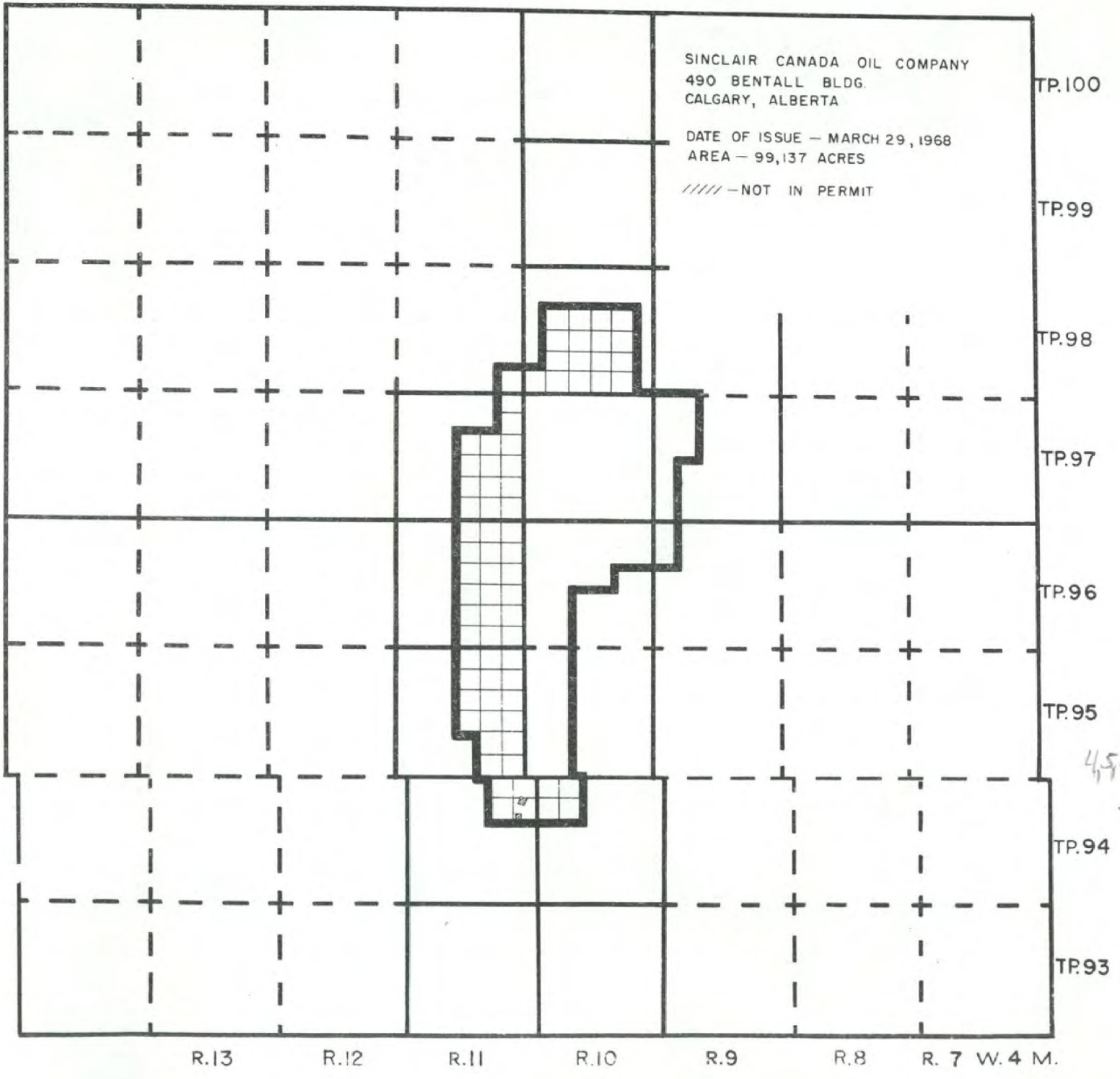
74E/7
SE

SULPHUR PROSPECTING PERMIT No.189



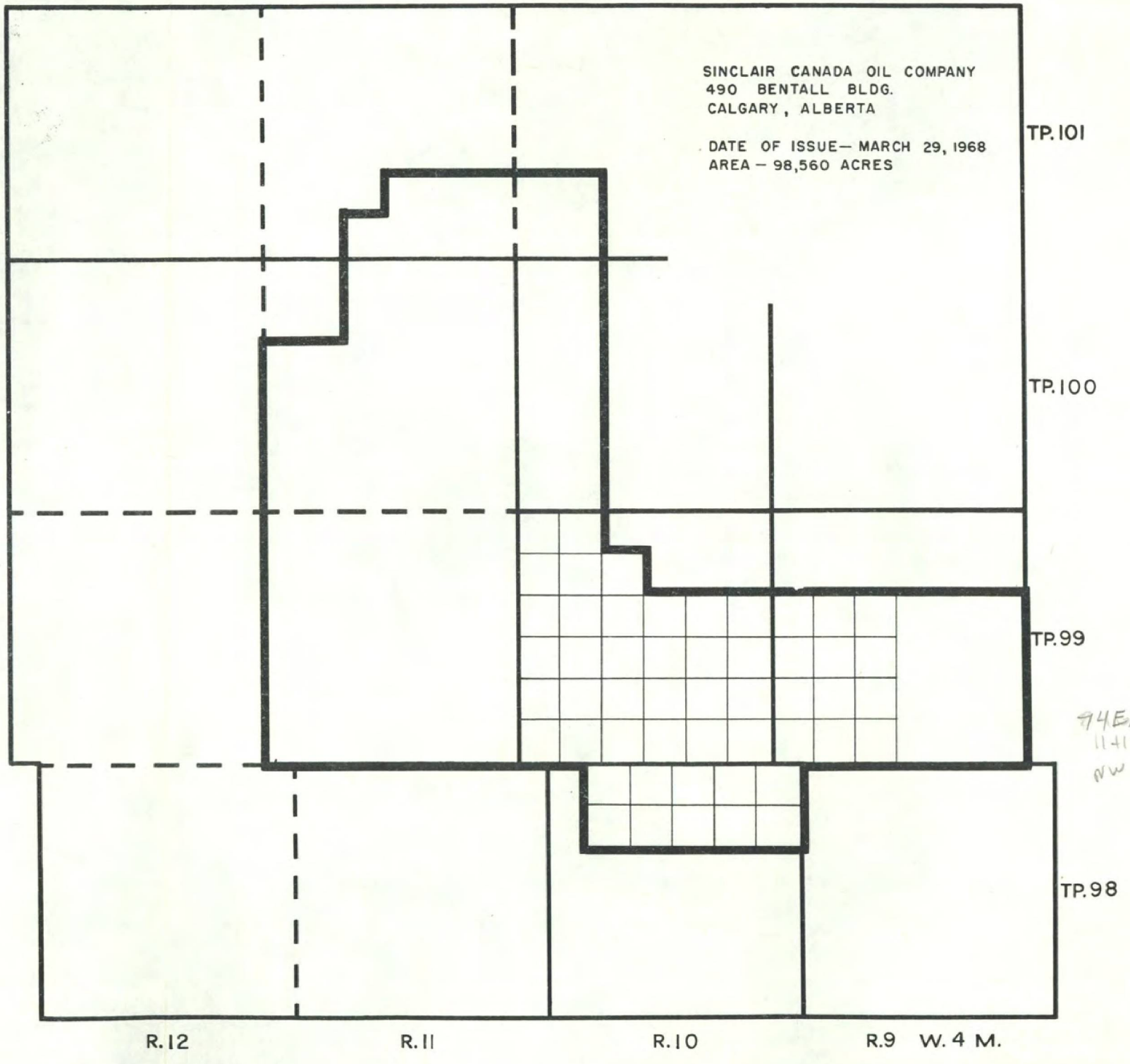
74E/3+4 SW
74 D/ 13+14 NW

SULPHUR PROSPECTING PERMIT No. 190



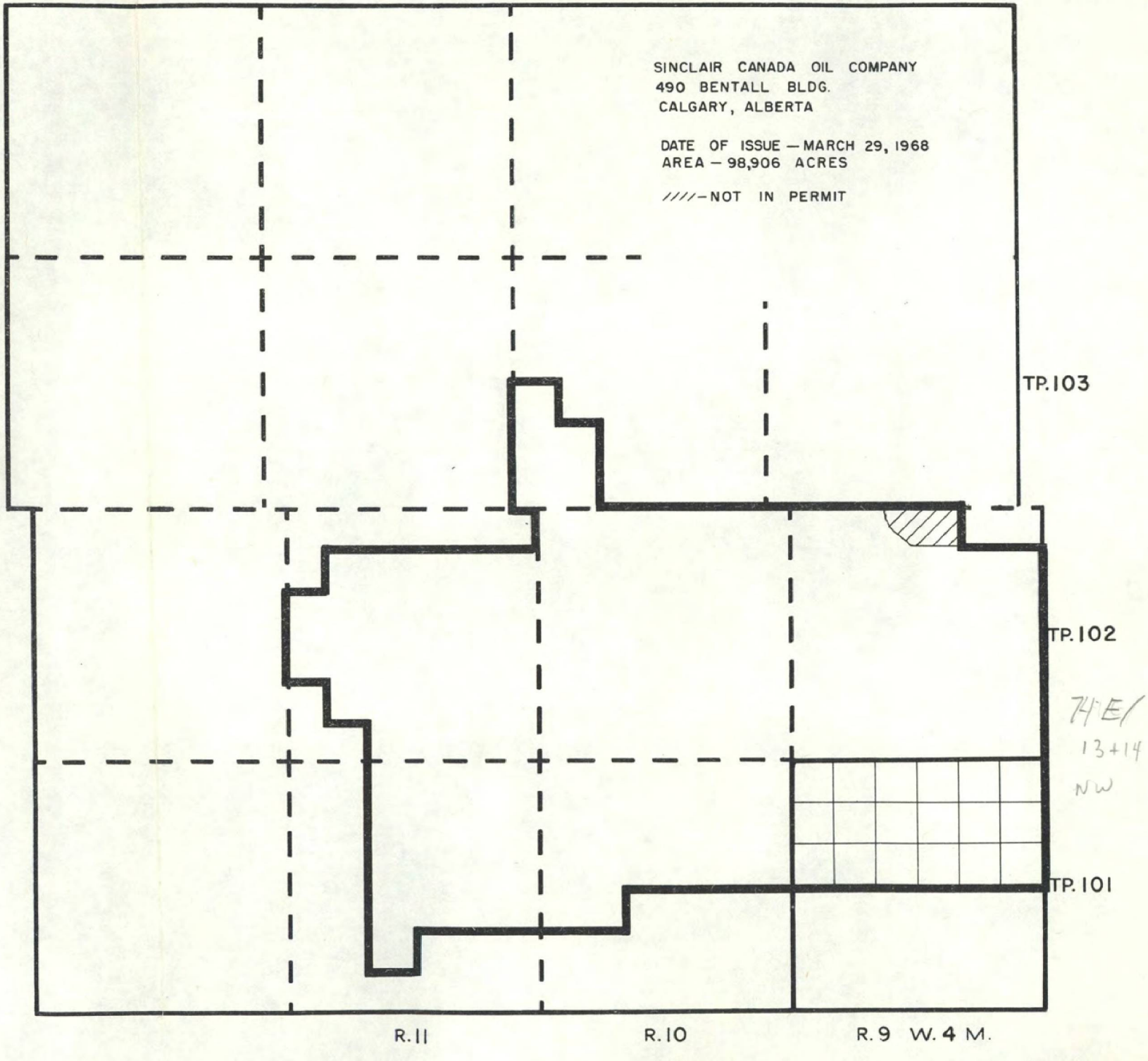
74E/4,5,6,12 SW¼NW

SULPHUR PROSPECTING PERMIT No. 191



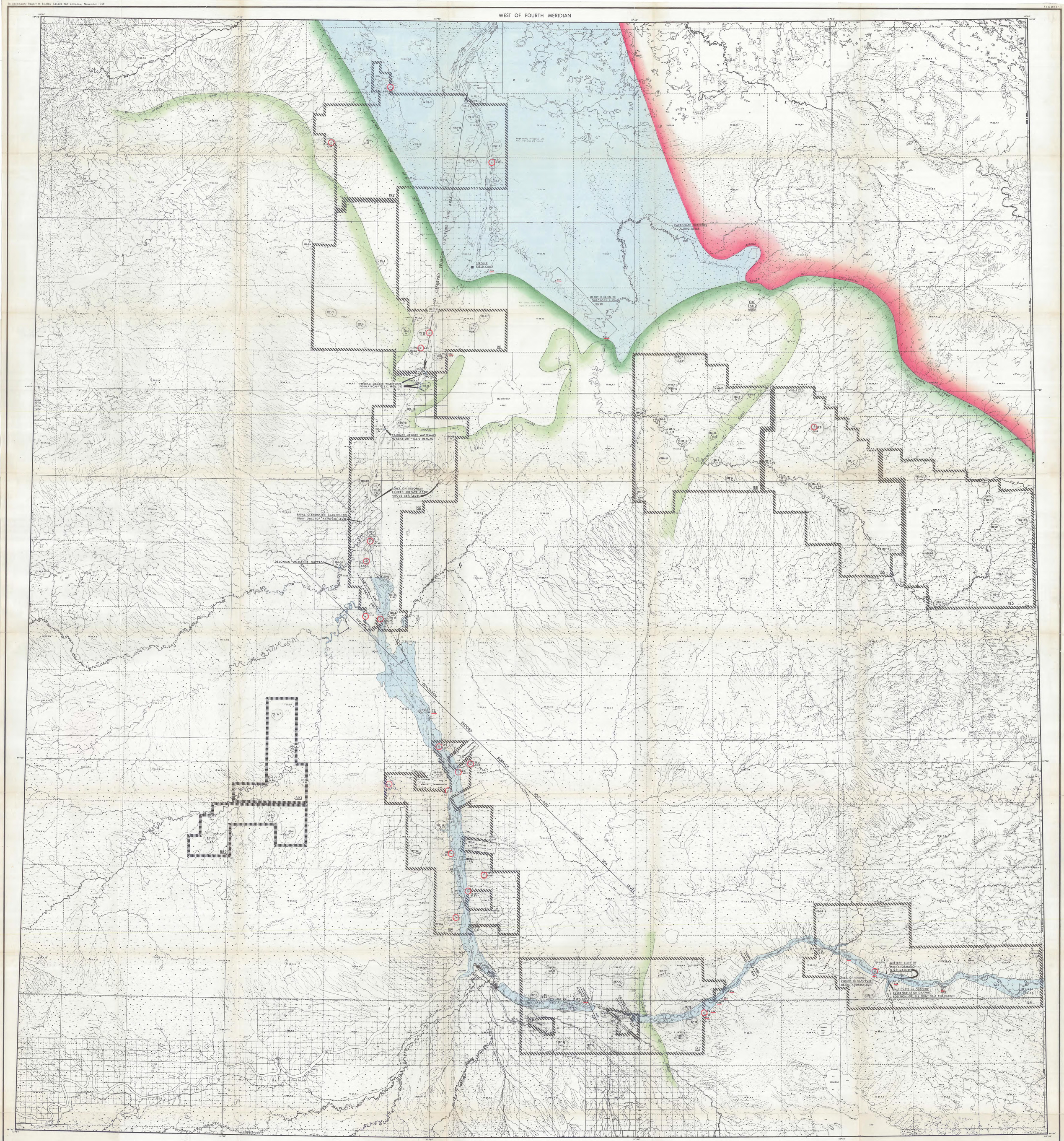
94E/
11+12
NW

SULPHUR PROSPECTING PERMIT No. 192



74 E/
13+14
NW

WEST OF FOURTH MERIDIAN



SULPHUR PROSPECTING PERMIT

BITUMINOUS SANDS LEASE

DEVONIAN { WATERWAYS FM. { MOBERLY MBR. / CHRISTINA MBR. } / ELK POINT SALT FM. { CALUMET MBR. / FIREBAG MBR. } / METHY FM. }

FW ABANDONED FLOWING WELL

SSx SULPHUR SPRING

FSp FRESH SPRING

× 184-2 SAMPLE LOCATION

0.90 % SULPHUR DRY WEIGHT

Tr TRACE OF SULPHUR

SULPHUR >3% DRY WEIGHT

FAULT

NOTE: Area of Devonian Formation after G.S.C. MEM. 313.

Planimetric map taken from maps prepared by Technical Division, Dept. of Lands & Forests, Province of Alberta.

PLANIMETRIC MAP
FORT McMURRAY AREA
ALBERTA
WEST OF FOURTH MERIDIAN

SHOWING

SINCLAIR SULPHUR PERMITS AND SAMPLE LOCATIONS IN RELATION TO REGIONAL GEOLOGY

SCALE 1" = 2 MILES

Interpretation by: S.R.L. Harding, November 1968

Prepared for

SINCLAIR CANADA OIL COMPANY

November 1968

19680149

J.C. SPROULE AND ASSOCIATES LTD., CALGARY

FIGURE-1