Mines Branch Technical Bulletin TB 62

ADDENDUM TO BUREAU OF MINES REPORT NO. 826* (VOLUMES 1-3, 1949), 'DRILLING AND SAMPLING OF BITUMINOUS SANDS OF NORTHERN ALBERTA'

by

K.W. Bowles** and R.G. Draper**

- - -

ABSTRACT

The report on the drilling and sampling of the bituminous sands of Northern Alberta was published in three volumes in 1949 and presents an appraisal of the bituminous sands from the results of drilling, sampling and analysis.

This addendum gives a brief description of the method of analysis and shows how these data were used to evaluate the average bitumen and clay contents of the drill-hole cores. An explanation of other relevant items is also included. This information was not covered by the 1949 report, but is considered necessary for the proper understanding of the procedures that were employed in carrying out the investigation.

---

* In 1949, the departmental designation was: Bureau of Mines, Mines, Forests and Scientific Services Branch, Department of Mines and Resources, Ottawa, Canada.

** Senior Scientific Officer, Fuels and Mining Practice Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

Direction des mines

Bulletin technique TB 62

SUPPLÉMENT AU RAPPORT DU BUREAU DES MINES N° 826* (VOLUMES 1-3, 1949), "FORAGE ET ÉCHANTILLONNAGE DES SABLES BITUMINEUX DU NORD DE L'ALBERTA"

par

K. W. Bowles** et R. G. Draper**

RÉSUMÉ

Le rapport sur le forage et l'échantillonnage des sables bitumineux du nord de l'Alberta a été publié en trois volumes en 1949 et il présente une évaluation des sables bitumineux d'après les résultats de forage, d'échantillonnage et d'analyse.

Le présent supplément donne une brève description de la méthode d'analyse et montre comment ces données ont été utilisées pour évaluer les teneurs moyennes des carottes de sondages en bitume et en argile. Il comporte aussi une explication d'autres points pertinents. Ces renseignements ne faisaient pas partie du rapport de 1949, mais on croit qu'ils sont nécessaires pour bien comprendre les procédés employés lors des recherches.

---

*En 1949, la désignation officielle se lisait comme suit: Bureau des mines, Direction des mines, forêts et services scientifiques, ministère des Mines et des Ressources, Ottawa, Canada.

**Chargé de recherches principal, Division des combustibles et du génie minier, Direction des mines, ministère des Mines et des Relevés techniques, Ottawa, Canada.

CONTENTS

INTRODUCTION

The Bureau of Mines Report No. 826, "Drilling and Sampling of Bituminous Sands of Northern Alberta", presented the results of the drilling program undertaken by the Dominion Government in the years 1942-47 to assess the value of the deposits of bituminous sands occurring along both banks of the Athabasca river in Northern Alberta. The report was published in 1949 in three volumes: Volume I, Results of investigations, 1942-1947; Volume II, Detailed drilling and sampling records; and Volume III, Cross-sections and plans of areas drilled.

From the inquiries received from various industrial firms concerned with the exploitation of the Athabasca bituminous sands, it became evident that certain items in Report No. 826 were insufficiently dealt with and further explanatory detail was required. This addendum is an attempt to overcome this deficiency.

Because Volume II, which presents in tabular form the results of the drilling, sampling and analysis of the bituminous sands, is entirely lacking in any explanatory text, a description of the sampling and analytical methods used is given in this addendum. This is followed by an explanation of other items associated with the analysis of the bituminous sands.

METHOD OF ANALYSIS OF CORE SAMPLES OF BITUMINOUS SANDS (1) (2)
(Volume II, Detailed Drilling and Sampling Records; Volume III, Cross-sections and Plans of AreasDrilled.)

Item 1

In order to facilitate the description of the procedure followed in the analysis of the bituminous sand, four terms have been introduced in this addendum which are as follows: major clay partings, minor clay partings, gross analytical sample, and net analytical sample. These terms will be explained below as they occur. In order to clarify the significance of these terms, a graphical description of them is given in Figure 1 which shows a portion of Hole No. B 48, Mildred-Ruth Lakes Area.

All the recovered core samples of bituminous sand were numbered at the site of the drilling operation. The depth interval, the footage, and the approximate estimate by visual inspection of the quality of the bituminous sand and the clay content were recorded. These data are shown in the tables of Volume II. Most of the bituminous sand core samples were recovered, but a few could not be obtained. The unrecovered core samples were designated as "Lost Cores" in the column entitled "Condensed Field Log" of the tables of Volume II. Some of the core samples consisted wholly of inorganic matter, and these were designated as clay, shale, etc., in the "Condensed Field Log". The lost cores and the cores devoid of bituminous sand, or almost so, were not given a sample number but their depth interval and footage were recorded. These cores were rejected at the drilling site. Because the core samples of inorganic matter were composed mostly of clay, these will be referred to as "major clay partings" in this addendum.

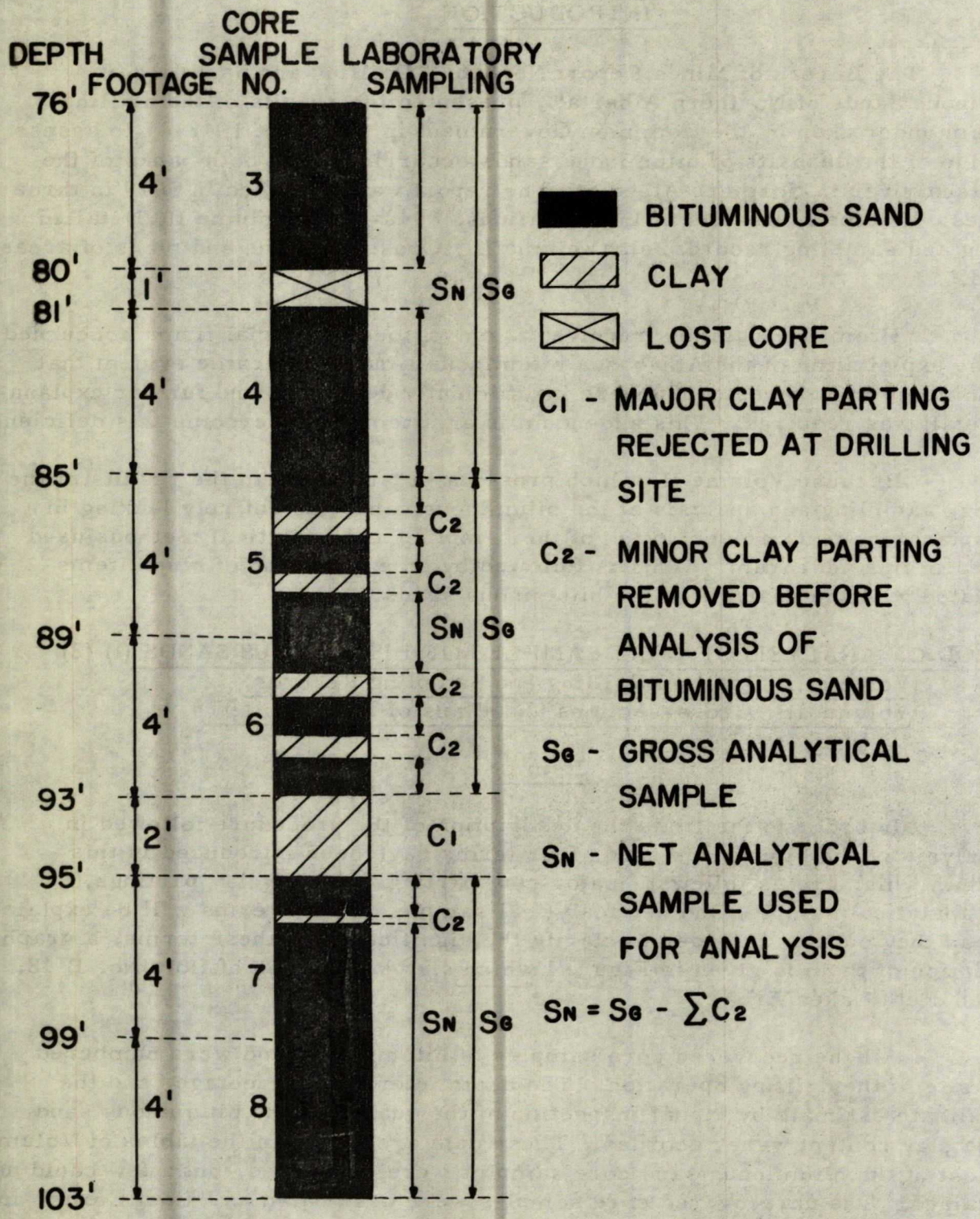

FIGURE 1 - PORTION OF CORE FROM HOLE NO. B48, MILDRED - RUTH LAKES AREA, VOLUME II, PAGE 585 AND VOLUME III, PAGE 72.

When the boxes of core samples were received at the Fuels Division, they were opened and the moisture in the cores was stabilized by air-drying. The loss of moisture on stabilization was not measured, as no account was taken of the loss in moisture during transportation from the drilling site to Ottawa*.

To facilitate the analytical work, the samples for analysis comprised one or more of the numbered core samples of bituminous sand, depending on the amount of bituminous sand present. A number of the analytical samples contained minor clay partings. These clay partings were noted by visual inspection; the length of each was measured in inches and recorded in the tables of Volume II as "Clay Bands". As these clay partings were smaller than the major clay partings, they will be referred to as minor clay partings in this addendum in order to differentiate them from the latter. These minor clay partings were cut out and removed from the remainder of the analytical sample. The remaining bituminous sand was ground by means of an ordinary household meat-grinder and thoroughly mixed. In order to avoid confusion, two terms referring to the analytical sample will be used in this addendum: gross analytical sample, and net analytical sample. The former will refer to the analytical sample containing both the bituminous sand and the clay partings which were removed, and the latter will refer to the analytical sample containing only the bituminous sand portions on which the actual analysis was made.

A portion of the net analytical sample was analyzed for water and bitumen contents. The reported percentage of water has no meaning as far as the natural moisture content of the bituminous sand in place is concerned, due to the losses of moisture in transit and during the stabilization procedure. Nevertheless, the residual moisture content had to be determined, as the percentage of bitumen was calculated from the total loss in weight of the sample after extraction corrected for moisture and any fine mineral matter that passed through the extraction thimble.

The water content of the bituminous sand was determined by the ASTM method D 95 (3) (Dean and Stark method), using a 50-gram sample for the single determination. The results of this analysis are shown in the tables of Volume II under the heading, "Water". Water less than 0.1% was reported as a trace. The unusually high percentage of water in those analytical samples containing "Bitumen concentration"**(Hole No. B 17, for example) is probably due to some of the water in the gel mud*** used in the drilling operation forming an emulsion with the bitumen. The water dispersed in the bitumen would not be lost readily during the stabilization procedure and it seems somewhat unlikely that there would be emulsified water in natural bitumen.

---

* See Item 3, Page 8 of this addendum.

** See Item 2, Page 8 of this addendum.

*** See Item 5, Page 9 of this addendum.

The bitumen content was determined by using a Soxhlet extraction apparatus, a paper thimble of double thickness, and carbon tetrachloride as the solvent. Duplicate determinations were made, using 50 grams of bituminous sand for each. The amount of fine solid matter passing through the thimble and into the extraction flask was determined by evaporating an aliquot of the contents of the flask and ashing the residue. The calculated total weight of this fine inorganic matter was added to the weight of the solid matter in the thimble. The per cent bitumen in the net analytical sample used for extraction was calculated on the dry bituminous sand basis. A correction was then made to obtain the bitumen content as a percentage of the gross analytical sample which included the discarded clay portion. This was done by multiplying the per cent bitumen in the net analytical sample by the ratio of the length of the analytical sample without the clay portion divided by the length of the analytical sample with the clay portion. It was assumed that the clay portion which was removed contained no bitumen. The bitumen content of the gross analytical samples is shown in the tables of Volume II under the heading, "Bitumen, Dry Basis".

It should be noted that the clay portions of the gross analytical samples were not included in the samples for analysis for two reasons: (1) It was difficult to uniformly mix the clay and the bituminous sand to obtain a homogeneous sample. (2) The presence of even a small quantity of clay in the sample plugged the extraction thimble and rendered the extraction difficult and sometimes impossible.

The analytical tests were concluded by making a screen analysis of the extracted sand from the two Soxhlet extractions. The results of these tests are also shown in the tables of Volume II.

At the foot of each table of the detailed analytical data, a summary of the analysis for the complete core is given. This includes the depth interval and footage of the overburden, bituminous sand and any major partings of clay or other inorganic material occurring between the overburden and the bottom of the hole. The average percentage of bitumen and of clay for the total length of the core below the overburden is given in the summary. In some of the summaries the core is divided into sections and, in this case, the bitumen and clay percentages of the bituminous sand sections are also given. In the summaries the term "clay bands" refers to total clay and includes the major clay partings as well as the minor clay partings removed from the gross analytical samples.

The average per cent bitumen in the length of core specified in the summary was calculated by dividing the sum of the products of the length of the core representing the gross analytical sample and the corrected percentage bitumen of the sample, by the total length of the core. The average per cent "clay bands" (total clay) was calculated by dividing the sum of the lengths of the major and minor clay partings by the total length of the core and multiplying by one hundred.

These calculations are illustrated by the following equations:

Average % bitumen

$$= \frac{\text{Sum of } \left\{ \left(\begin{array}{c}\text{Core length of gross} \\ \text{analytical sample}\end{array} \right) \left(\text{Corrected \% bitumen} \right) \right\}}{\text{Total length of core}} . \qquad .. (1)$$

Average % clay bands (total clay)

$$= \frac{\text{Sum of lengths of major and minor clay partings}}{\text{Total length of core}} \times 100. \qquad .. (2)$$

Strictly speaking, the weight of the core should be used in Equation (1) instead of the length. The justification for employing the abbreviated form of the required equation is due to the fact that the specific gravity of the bituminous sand may be considered constant for all practical purposes and is approximately 2.0 *. Letting W equal the weight in pounds of a one-foot length of core, this weight is as follows:

$$W, \text{ lb} = \left(\frac{3.14}{4} \right) \left(\text{Diameter of core in feet} \right)^2 \left(62.5 \right) \left(2 \right) .$$

Thus, the average percentage bitumen is the following:

Average % bitumen

$$= \frac{\text{Sum of } \left\{ \left(\text{Length of core} \right) \left(W \right) \left(\frac{\text{\% bitumen}}{100} \right) \right\}}{(\text{Total length of core})\ (W)} \times 100.$$

Cancellation of the common factors results in Equation 1 using the core lengths. The same explanation applies to Equation 2.

In order to clarify the method used for calculating the percentages of bitumen and clay in the summaries, an example is given below of the calculations for Hole No. B 48, Mildred-Ruth Lakes Area, Volume II, Pages 585 and 586 and Volume III, Page 72.

---

* See Item 4, page 9 of this addendum.

Summary, as it appears in Volume II, Page 586:

0' - 76' = 76' Overburden.
76' - 156' = 80' @ 13.77% bitumen & 9.7% clay bands.
156' - 186' = 30' Clay.
186' - 220' = 34' @ 17.03% bitumen &.03% clay bands.
76' - 220' = 144' @ 11.67% bitumen & 27.3% clay bands.

Average Bitumen and Clay Percentages in the Core Interval 76 to 156 feet.

Core interval, in feet	Core length, in feet	Corrected % bitumen *	Product of columns 2 and 3	Length of clay bands, in inches **	Remarks
76-85	9	14.8	133.2	0	Contains one lost core.
85-93	8	10.6	84.8	25	
93-95	2	---	---	---	Sandy clay ***.
95-103	8	14.6	116.8	1.5	
103-111	8	15.6	124.8	0	
111-121	10	14.7	147.0	6.5	Contains one lost core.
121-129	8	12.9	103.2	22.5	
129-137	8	16.2	129.6	0	
137-145	8	12.0	96.0	13.25	
145-154	9	14.9	134.1	1	Contains one lost core.
154-156	2	16.0	32.0	2	
Total	80		1101.5	71.75	

Average percentage bitumen $= \frac{1101.5}{80} = 13.769 = 13.77\%$

Average percentage clay bands (minor clay partings) $= \frac{71.75}{(80)(12)} (100) = 7.47 = 7.5\%$

Average percentage sandy clay (major clay partings) $= \frac{2}{80} (100) = 2.50 = 2.5\%$

Average percentage clay bands (total clay) $= 7.47 + 2.50 = 9.97 = 10.0\%$

---

* % bitumen on dry basis of gross analytical sample corrected for minor clay partings removed before analysis.
** Minor clay partings removed from gross analytical samples.
*** Major clay parting.

Average Bitumen and Clay Percentages in the Core Interval 156 to 186 feet.

Core interval, in feet	Core length, in feet	Corrected % bitumen*	Product of columns 2 and 3	Length of clay bands, in inches**	Remarks
156-186	30	---	---	---	Sandy clay***

Average Bitumen and Clay Percentages in Core Interval 186-220 feet.

Core interval, in feet	Core length, in feet	Corrected % bitumen*	Product of columns 2 and 3	Length of clay bands, in inches**	Remarks
186-190	4	15.3	61.2	0	
190-198	8	16.8	134.4	0	
198-206	8	18.1	144.8	1.5	
206-214	8	16.5	132.0	0	
214-220	6	17.8	106.8	0	
Total	34		579.2	1.5	

Average percentage bitumen $= \frac{579.2}{34} = 17.035 = 17.04\%$

Average percentage clay bands (minor clay partings) $= \frac{1.5}{(34)(12)} (100) = 0.37 = 0.4\%$

Average Bitumen and Clay Percentages in the Core Interval 76 to 220

Total length of core $= 80 + 30 + 34 = 144$ feet.

Average percentage bitumen $= \frac{1101.5 + 579.2}{144} = 11.672 = 11.67\%$

Average percentage clay bands (minor clay partings) $= \frac{71.75 + 1.5}{(144)(12)} (100) = 4.24 = 4.2\%$

Average percentage sandy clay (major clay partings) $= \frac{(2 + 30)}{144} (100) = 22.22 = 22.2\%$

Average percentage clay bands (total clay) $= 4.24 + 22.22 = 26.46 = 26.5\%$

* % bitumen on dry basis of gross analytical sample corrected for minor clay partings removed before analysis.

** Minor clay partings removed from gross analytical samples.

*** Major clay parting.

It will be noted that in the "Summary" (Volume II, Page 586), the percentage of bitumen is reported to two decimal places. As the results of the analysis were accurate to and reported to only one decimal place, this should also have been done in the "Summary". Regarding the accuracy of the calculations, the recalculations of the summary of this hole and others indicated that no error of any consequence occurred in the percentage of bitumen; however, some significant errors were found in the values of the percentage of clay.

BITUMINOUS SAND OF UNUSUALLY HIGH BITUMEN CONTENT (1)
(Volume II, Detailed Drilling and Sampling Records; Volume III, Cross-sections and Plans of Areas Drilled.)

Item 2

Some of the core samples of bituminous sand contained an unusually high bitumen content. All samples in which the bitumen content exceeded 18% were included in this category. This material of high bitumen content is referred to by several designations: (1) as "bitumen concentration" in the Condensed Field Logs in the tables of Volume II; (2) as "liquid bitumen" in the notes on the Method of Calculating Tonnage on the summary sheet of Bituminous Sand Drilling, Mildred-Ruth Lakes Area, inserted before page 72 of Volume III; and, finally, (3) as "bitumen aggregate" in the column heading "Bitumen Aggregate Thickness", in the table of Estimates of Grade and Tonnage on the summary sheet of Bituminous Sand Drilling, Mildred-Ruth Lakes Area, inserted before page 72 of Volume III. "Bitumen Aggregate Thickness" refers to the total length of the high-bitumen-content material in the total core.

IN SITU WATER

Item 3

It has been found that the voids in the extracted sand of 150 mesh and coarser amount to 23.8% by volume when packed as in the natural state in the bituminous sands deposit (4). In the deposit these voids are filled with bitumen, water, fine sand and clay in varying amounts. If the total of the water and fine solid contents is high the bitumen content is low, and if the former is low the bitumen content generally is high.

No attempt was made to determine the original water content of the core samples. As the core boxes were not hermetically sealed, the water content would change from the time the sample was taken to the time the sample was analyzed.

BASIS OF ASSUMPTIONS THAT ONE TON OF BITUMINOUS SAND EQUALS 16.0 CU FT AND ONE TON OF OVERBURDEN EQUALS 15.5 CU FT (5) (Volume III, Cross-sections and Plans of Areas Drilled.)

Item 4

Laboratory tests on core samples of varying bitumen content have indicated that bituminous sand in place has a specific gravity of 2.0, equal to 125 pounds per cu ft or 16.0 cu ft per ton. This is due to two factors: (1) The bitumen, water and clay, which fill the voids in the sand, have approximately the same specific gravity, that is, a specific gravity of one; (2) the total void volume is approximately constant and is completely filled. Thus the combination of the heavier sand and the lighter, void-filling substances results in a fairly constant specific gravity, regardless of the variation in the individual percentages of bitumen, water and clay, as the total weight fraction of these materials is constant. The overburden is composed of about one-third sand and two-thirds clay, and on a dry basis it would have a specific gravity of slightly less than 2.0. However, some allowance must be made for natural moisture and it is considered that 15.5 cu ft per ton gives a reasonably close estimate of the overburden tonnage.

PREVENTION OF CONTAMINATION OF THE BITUMINOUS SAND CORE BY THE GEL MUD USED IN THE DIAMOND DRILLING (6)

Item 5

In diamond drilling the bituminous sands to obtain samples, the core was collected in a core barrel located inside the drill housing above the drilling bits. At the beginning of the drilling program it was found that the ground water leached out the oil in the sample. This problem was successfully overcome by the use of gel mud. This drilling mud consisted of a paste of powdered bentonite clay and water. The gel mud was pumped down the hole between the core barrel and the drill housing and flowed up the hole outside the drill housing. The gel mud did not penetrate inside the cores. The small amount that adhered to the surface was easily wiped off before the cores were placed in the core boxes.

REFERENCES

1. Private communication (1964) from A.A. Swinnerton, Engineer, Fuels Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, retired 1959. (Mr. Swinnerton was responsible for the sampling and analysis of the core samples.)

2. R.G. Draper, A. Yates and H. McD. Chantler, "A Comparison of Three Laboratory Methods for Determining the Bitumen Content of Bituminous Sands", Fuels Division Report FRL-211, Mines Branch, Department of Mines and Technical Surveys, Ottawa, 1955.

3. Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials, D 95-46, ASTM Standards on Petroleum Products and Lubricants, American Society for Testing Materials, Philadelphia, 1947.

4. Private communication (1964) from D. S. Montgomery, Senior Scientist, Fuels and Mining Practice Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa.

5. "Drilling and Sampling of Bituminous Sands of Northern Alberta", Bureau of Mines Report 826, Mines, Forests and Scientific Services Branch, Department of Mines and Resources, Ottawa, 1949. Volume I, Results of Investigations 1942-1947, page 21.

6. Private communication (1964) from S.C. Ells, Engineer, Fuels Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, retired 1947.

ACKNOWLEDGEMENT

The authors wish to express their appreciation to Mr. M.P. Pleet, of the Fuels and Mining Practice Division, for the drawing of Figure 1.

- - - - - -

KWB:RGD:ec