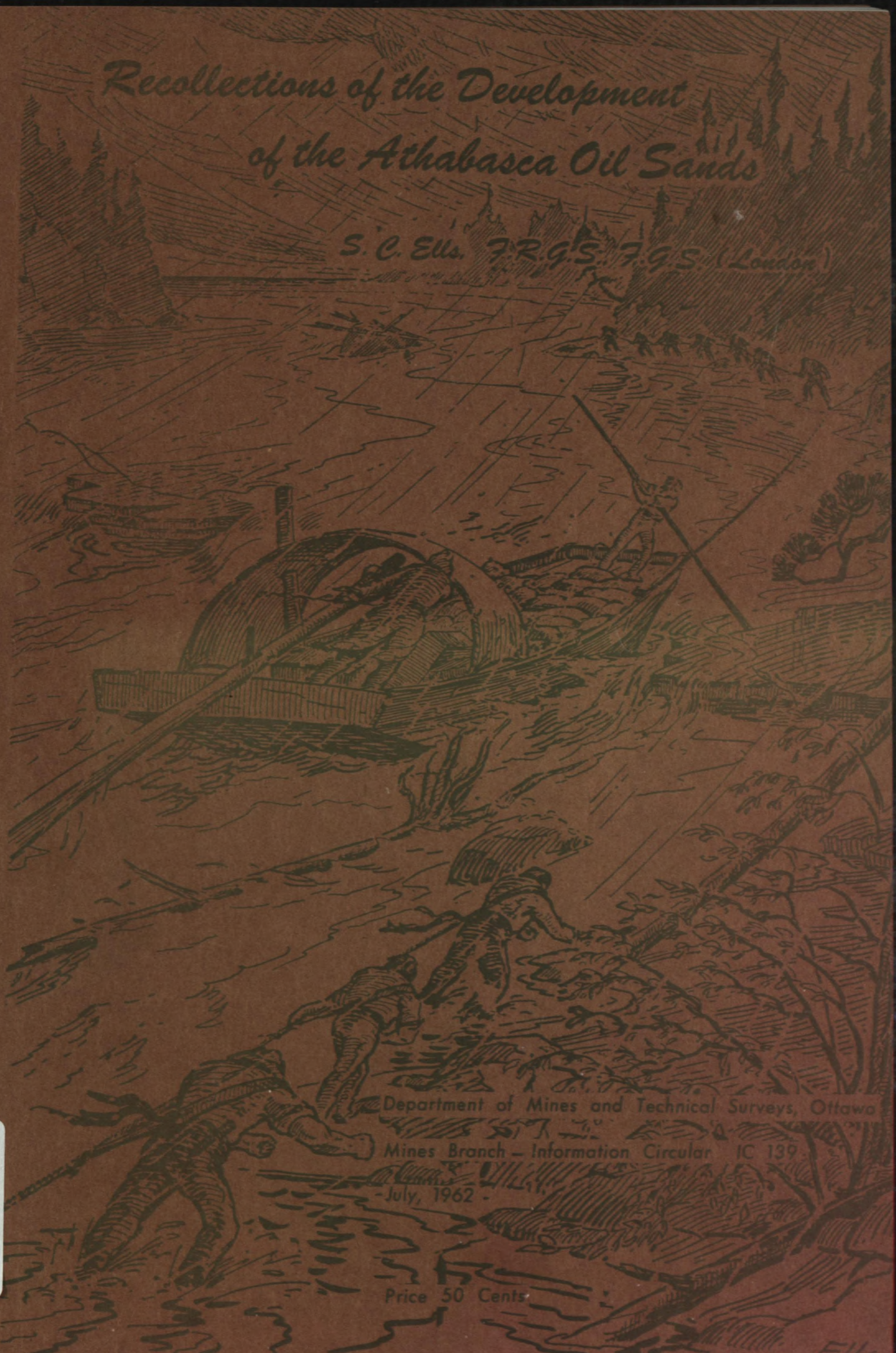
Recollections of the Development of the Athabasca Oil Sands

S. C. Ells, F.R.G.S., F.G.S. (London)



Department of Mines and Technical Surveys, Ottawa

Mines Branch – Information Circular IC 139

July, 1962

Price 50 Cents


Ft McKay
Ft McMurray
Athabaska River
Clearwater R.
Lac La Loche
La Loche Portage (Methye)
Bulls Ho.
Buffalo L. (Peter Pond L.)
Ile-à-la-Crosse
Ft Lac la Biche
Beaver River
Churchill R.
Frog Por.
Reindeer Lake
Churchill River
Pelican Narrows
Amisk Lake
Cumberland Ho.
Saskatchewan River
Burntwood R.
Nelson R.
Hayes R.
HUDSON BAY
Ft York
Oxford House
Cross L.
Norway Ho
Grand Rapids
Lake Winnipegosis
Lake Winnipeg
Lake Manitoba
Winnipeg R.
Ft Qu'Appelle
Qu'Appelle R.
Fort La Reine
Assiniboine R.
Brandon Ho.
Ft Garry
Lake of the Woods
Red R.
Legend
Canoe Routes
Portages
Clearwater R.
Elsmo
Est 1690
Rendezvous
La Loche Portage (Methye)
Ft Methye
Est 1460
H.B.Co.
Lac La Loche (Methye Lake)
Scale of Miles
0 10
Scale of Miles
50 0 50 100 150 200

CANADA

RECOLLECTIONS OF THE DEVELOPMENT OF THE ATHABASCA OIL SANDS

by

S.C. Ells, F.R.G.S., F.G.S. (London)

FUELS AND MINING PRACTICE DIVISION

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EPARTMENT OF MINES AND
ECHNICAL SURVEYS, OTTAWA

MINES BRANCH

INFORMATION CIRCULAR

IC-139 July, 1962

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The illustrations appearing on the inside and outside covers, the verse on the facing page and the poem "Epilogue" on page 105 have been reproduced from "Northland Trails" by S. C. Ells, 1956, with the permission of the publishers, Burns and MacEachern, Toronto.

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S. C. ELLS

The shepherd turns to uplands broad, the herdsman to the plain,
And lowlands beckon husbandman with lure of yellow grain;
The timbered lands call woodsman to vale and mountain side,
And restless sea draws sailorman as moon draws flooding tide;
But now the rock-ribbed northland——empire of vale and hill——
Echoes the thud of bursting charge, the clink of sledge on drill,
For college don and tenderfoot and seasoned pioneer
Have turned their faces northward——men of the new frontier!

First verse of "THE SEEKERS" from NORTHLAND TRAILS by S. C. Ells, Burns and MacEachern, Toronto, 1956.

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FOREWORD

The hydrocarbon resources in the McMurray district of Alberta have received - periodically - public attention during the past fifty years. These deposits are known by various names such as bituminous, tar or oil sands indicating the doubt that exists in the minds of people as to the true nature of the hydrocarbon occurrence. There has been unfounded speculation as to the magnitude of the reserves and estimates have suggested several hundred billion barrels. However, the potential importance of this resource has never been questioned since the initial years of surveys and exploration conducted by Mr. S. C. Ells. In this regard, the Mines Branch and the Department of Mines and Technical Surveys with their long term outlook with respect to the mineral resources of this country have maintained an uninterrupted interest in the oil sands and during a fifty-year period have engaged in surveys and exploration, research in separation by the cold-water method of the bitumen from the sand, and, more recently, in refining investigations. The final goal of achieving the most economical separation and establishing the best refining techniques for producing from this low-grade material the high-quality petroleum products now demanded by the public has not been reached, but much valuable work has been done by many investigators, some of whom are referred to by Mr. Ells. This affords me the opportunity of recognizing the work of Dr. Karl A. Clark and his associates of the Alberta Research

Council, which since its inception in 1921 has also demonstrated its interest through many significant activities including pilot separation plants on the Clearwater River and later at Bitumount, Alberta. Amongst other government research agencies the work of Dr. P. E. Gishler of the National Research Council in his thermal method of separation must not be overlooked.

In recent years much investigational and developmental work has been done by private enterprise. Today, in spite of the abundance of high-grade crude oils, an important group has undertaken a serious investigation to separate the bitumen and to convert it to flowable and usable products.

The march of events briefly recounted here recalls the initial evaluation of the resource by Mr. Ells from 1913 onward. At that time there were not the transportation nor exploration facilities that exist today and no one can deny that much of the progress in the Canadian mineral industry was made through the efforts of men like Mr. Ells. Fortunately for the country, there were not a few of Mr. Ells' contemporaries who showed their dedication to duty and worked unselfishly for the public good. One of Mr. Ells' contemporaries was Wilbert H. Norrish now with the Mines Branch, who was a land surveyor with the Department of the Interior. He completed fifty years of service with the government in May, 1962, and it was considered fitting for him to write a short biography of Mr. Ells as a preface

from notes and information supplied by the author.

Mr. Ells has published many technical reports in various Departmental and other publications, many of which are now out of print. For easy future reference, a fairly complete bibliography accompanies the present publication which provides, in narrative form and in reasonably chronological order, the various aspects of Mr. Ells' work on the bituminous sands from 1913 to 1945. Although the information contained in this review is believed to be reliable, the Mines Branch cannot take responsibility for its accuracy.

John Convey,
Director, Mines Branch.

OTTAWA, July 1962.

PREFACE

Historians remind us that in order to chart our course into the future to the best possible advantage we must first study the path we have already followed. When we review the history of the Canadian mineral industry, we often find that we also receive as a bonus some of the flavour and romance associated with the careers of those rugged individuals who laid the foundations of our present mining empire. One of these hardy pioneers is Mr. S. C. Ells, who was a senior engineer of the Mines Branch from 1912 to 1945. In the following colourful narrative Mr. Ells portrays for us in a picturesque manner certain problems and frustrations as well as the lighter side of the study and development of the Athabasca oil sands at a time when the area was still almost virgin territory.

Mr. Ells graduated from McGill University, Montreal, as a Bachelor of Arts in 1900 and as a Bachelor of Science in 1908. In addition to his university training he also acquired a great deal of varied practical experience during the period 1901 to 1912. His first connection with mining was in the Nova Scotia coal fields as a miner and later as a mine surveyor. This was followed by his surveys of two divisions of the Grand Trunk Pacific Railway line in Northern Ontario and Manitoba, as a maintenance engineer for the Grand Trunk Railway, and as a locating engineer and harbour engineer for the Temiskaming and Northern Ontario Railway. During this twelve year period Mr. Ells was also concerned with the evaluation of

mineral properties in Ontario, Quebec and British Columbia. He investigated and mapped oil shale areas in New Brunswick and Nova Scotia in 1908 and 1909. It seems probable that this first interest in petroleum deposits influenced his later decision to devote most of his working life to the development of the Athabasca oil sands.

This story is concerned mainly with the oil sands deposits - their outlining, the most suitable mining method, the separation of the bitumen from the sand and also the use of the sands as road-paving material. Although this appears to have been a very full programme for one individual to direct, Mr. Ells also found the time and energy necessary to undertake additional projects for the Mines Branch. These included an investigation of oil shales in the Pasquia Hills area in Saskatchewan, a geological reconnaissance in previously unmapped areas of Northern Saskatchewan,* and supervision of the improvement of mining roads and trails in many parts of British Columbia. During the early years of World War II he was loaned to the Department of Transport in which position he assisted in the inspection of some seventy airports necessitated by the British Commonwealth Training plan and was engaged in the construction of the Watson Lake airport which was a vital link in the strategic northwest staging route.

Mr. Ells has described his technical work in a series of Mines Branch reports issued during the period 1913 to 1935. He has

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* See Appendix, Exploration in Northern Saskatchewan.

also compiled many maps of the Athabasca area that are still considered by those interested to be the best available. In addition to formal reports Mr. Ells has written a number of articles for the technical press as well as for newspapers and popular periodicals. He has also compiled his memoirs in two volumes which have been deposited with the Public Archives* in Ottawa.

One cannot read Mr. Ells' story without being impressed by his unswerving determination to see that the oil sands project was pushed ahead in spite of formidable difficulties. Patience and persuasion were necessary to obtain approval and funds for the work. Tenacity, physical courage and a deep understanding of human nature were essential in seeing that his plans were actually carried out in the face of many obstacles, both human and natural. To men of such vision and perseverance must go much of the credit for Canada's development as a modern industrial nation.

OTTAWA, Canada.
May, 1962.

W.H. Norrish

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* Ells Papers, V.4, Memoirs, 1959.

RECOLLECTIONS OF THE DEVELOPMENT OF THE ATHABASCA OIL SANDS

by

S. C. Ells*

INTRODUCTION

In the spring of 1912 private considerations prompted my decision to resign my position as Locating Engineer with the Timiskaming and Northern Ontario Railway and to accept a position which had been offered to me by the Director of the Mines Branch, Department of Mines, Ottawa. In my position as Assistant to the Director, I handled much of the technical correspondence and edited for publication reports submitted by various members of the staff. The above occupation was not without a certain degree of interest.

Early in 1913 an inquiry with respect to the oil sands** of northern Alberta was received from the late Senator Coté of Edmonton, but my subsequent search through official publications revealed little information. In 1883 an official of the Geological Survey had secured fragments of "float" while ascending the Athabasca River, and a laboratory analysis indicated a bitumen content of some 12.5%. The assumption was made that the sands extended over an area of a thousand square miles, and that the average thickness was two hundred feet; as a result the estimated bitumen content reached astronomical proportions. This estimate had a peculiar appeal to unscrupulous promoters, but was not

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* Engineer, Fuels Division, retired 1945.

** The previously accepted term "tar sands" is, of course, a misnomer. The term "oil sands" is also open to criticism, but for the sake of brevity the term oil sands has here been adopted. (See Appendix 1, Mines Branch Report No. 632, 1926.)

confirmed by my own subsequent observations. Nevertheless, as early as 1905 illustrations in a prospectus issued by one of the promoters depicted McMurray* as a miniature metropolis with a network of railway sidings, tall plumed stacks, and steamers furrowing adjacent waters. Actually, a rail connection with Edmonton did not reach Waterways until many years later in 1926.

From time to time prior to 1913 vague but intriguing references to the oil sands had also appeared in the press; in order to clarify the situation I suggested the desirability of a reconnaissance of the reported deposit. I was well aware that in pre-Biblical times bitumen had been extensively used in the Middle East[1] and that, subsequent to 1835, bituminous sands and bituminous limestone had been extensively used in Europe and in the United States as paving material.[2, 3] Attempts which had been made to separate the associated bitumen had, however, met with little success.

Conditions in the McMurray area in 1913 were those common to many other northern fields. With the exception of a track survey of the Athabasca River made by the late William Ogilvie in 1884 and completion of the survey of the 23rd Base Line (which passes a few

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* Fort McMurray. Name changed to McMurray in July, 1910.

1 S. Hemsley, "Oil in the Middle East", Longman's (1954).

2 Ref. I-3. (References are to reports by S.C. Ells, which are listed at the end of this Information Circular.)

3 G.H. Eldridge, "The Asphalt and Bituminous Rock Deposits of the United States", U.S. Geol. Survey 22nd Annual Report (1901).

miles south of McMurray) by G.H. Blanchette in 1911, the country north of Athabasca Landing was virtually unsurveyed. Between 1778 and 1885 most northbound freight had moved over the famous La Loche (Methye) portage and thence down Clearwater River to its junction with the Athabasca River at "The Forks". But with the completion of a wagon road from Edmonton to the "Landing" in 1886, the old La Loche route was finally abandoned in favour of the Athabasca River.

I was so enthralled with the possibilities of the oil sands that I preferred resigning my position rather than being deprived of making an investigation. Finally, in view of the above considerations, I was authorized in April,1913 to proceed to the McMurray field, and thereafter until my retirement in 1945 I was in charge of all field work undertaken by the federal Department of Mines in that area. The first step had been taken on a long, long trail which over many years was to lead to almost every hardship that can be encountered in the north. It also led to offices of senior executives of the petroleum industry in England and in the United States, to thrilling research laboratories, and finally to the solution of not a few problems. Every line and phrase of Kiplings' "If" were to be lived; still another chapter was to be added to the age-old

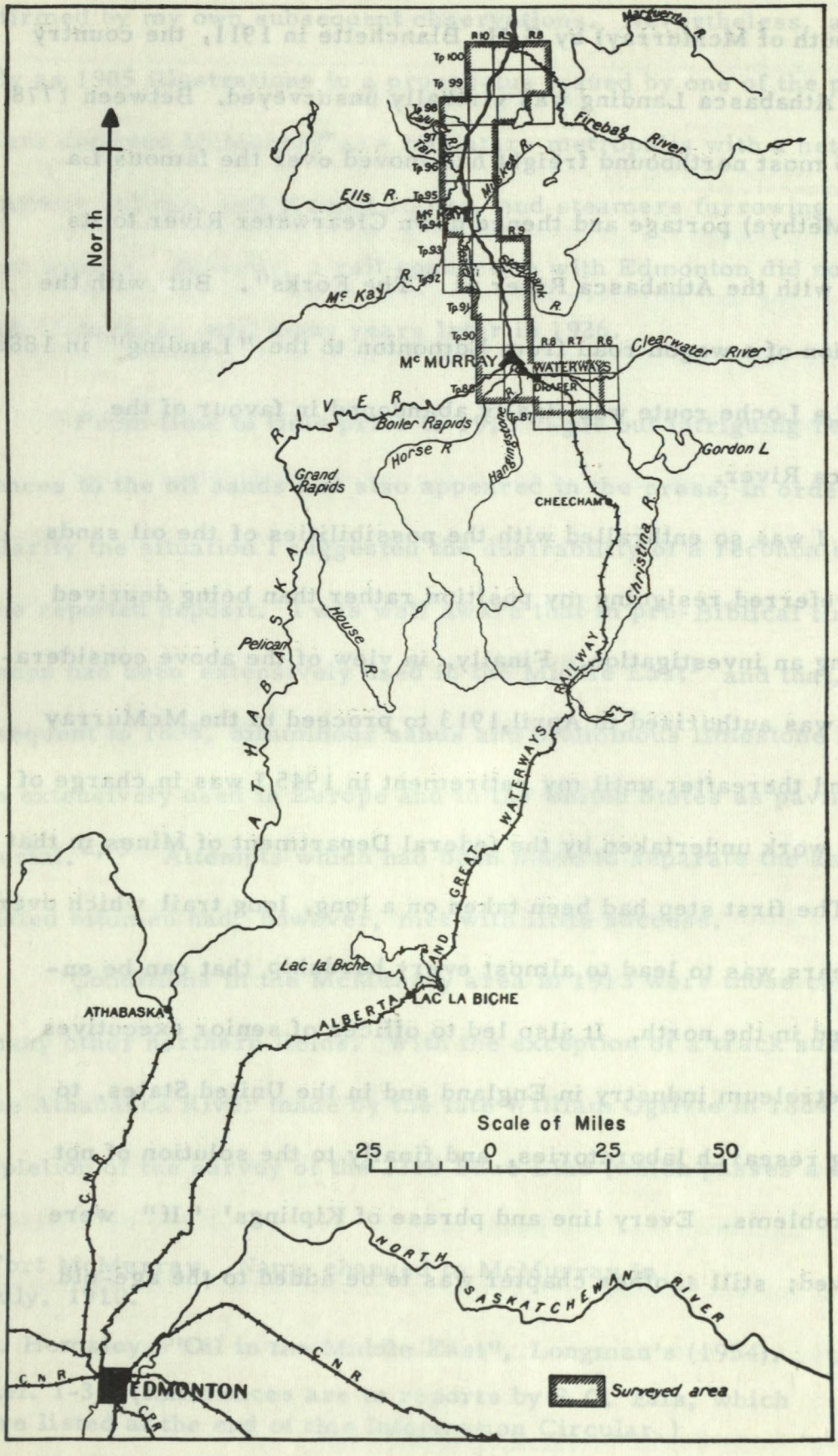

FIGURE 1. Map showing relation of the McMurray area to Edmonton, Alberta. (after Ref. I-3)

romance of mining.*

INITIAL EXPLORATION AND SURVEYS

The investigation of the bituminous sands presented many and varied problems of a practical nature. Among these were the handling of small and large field parties, conducting topographical and geological surveys, mining and the use of explosives, ensuring necessary supplies and equipment required for lengthy periods in relatively remote areas, and ensuring adequate transportation by land and by water. Fortunately I had had wide experience with such operations and moreover at that time was the only Canadian with first hand knowledge of many deposits of bituminous sand and bituminous limestone in the United States. In the winter of 1907-8 in company with my father, Dr. R.W. Ells, I had also visited deposits of asphalt and manjak in Trinidad and in Barbados. Subsequently in 1928 (and largely at my own expense) this knowledge was extended to include similar deposits in Spain, France, Alsace, Germany, Hungary, Romania, Italy, Sicily, and Albania.

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* It may be interesting to recall some of the men whom I met, or with whom I was associated, in the course of my work. To mention but a very few, these have included Herman Frasch and Hans Frasch, Herbert Abraham, Charles F. Kettering, A. Beeby-Thompson, Sir E.W. Beatty, Baron Bing of Vimy, T.A. Rickard, Max W. Ball, Glen Ruby, J.M. Blair, Col. C.R. McCollum, J.G.G. Kerry, Presidents of Standard of New Jersey, of Shell Union, of Marland Oil, of Anglo Persian and many others. Detailed references to some of these will be found in my "memoirs", deposited with the Public Archives.

"The surface of the area underlain by bituminous sand may be described as a peneplain, much of which is covered by swamp and muskeg. Through this plain the more important streams, excepting only the Clearwater and the Athabasca, have cut narrow, notch-like valleys. On emerging above the rim of these valleys, for the most part one reaches the level country almost at once. With such a topography outcrops of bituminous sand are thus confined to the slopes of older valleys, and to cutbanks along younger water-courses.

"The Athabasca and Clearwater valleys constitute the chief topographical features of this area. From a study of topographical maps, which are referred to in the bibliography, it is seen that the lower portion, at least, of the Clearwater valley constitutes the true easterly continuation of the original Athabasca valley and that the present Athabasca River, south of the latitude of McMurray, flows through a much younger and, probably in part post-glacial valley. It is also evident from the size and character of the Clearwater-Athabasca valley that the volume of water was at one time very much greater than at present although as yet no adequate drainage connection or connections toward the south or southeast has been definitely identified". The above is an extract from my Report No. 632.*

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* Ref. I-3.

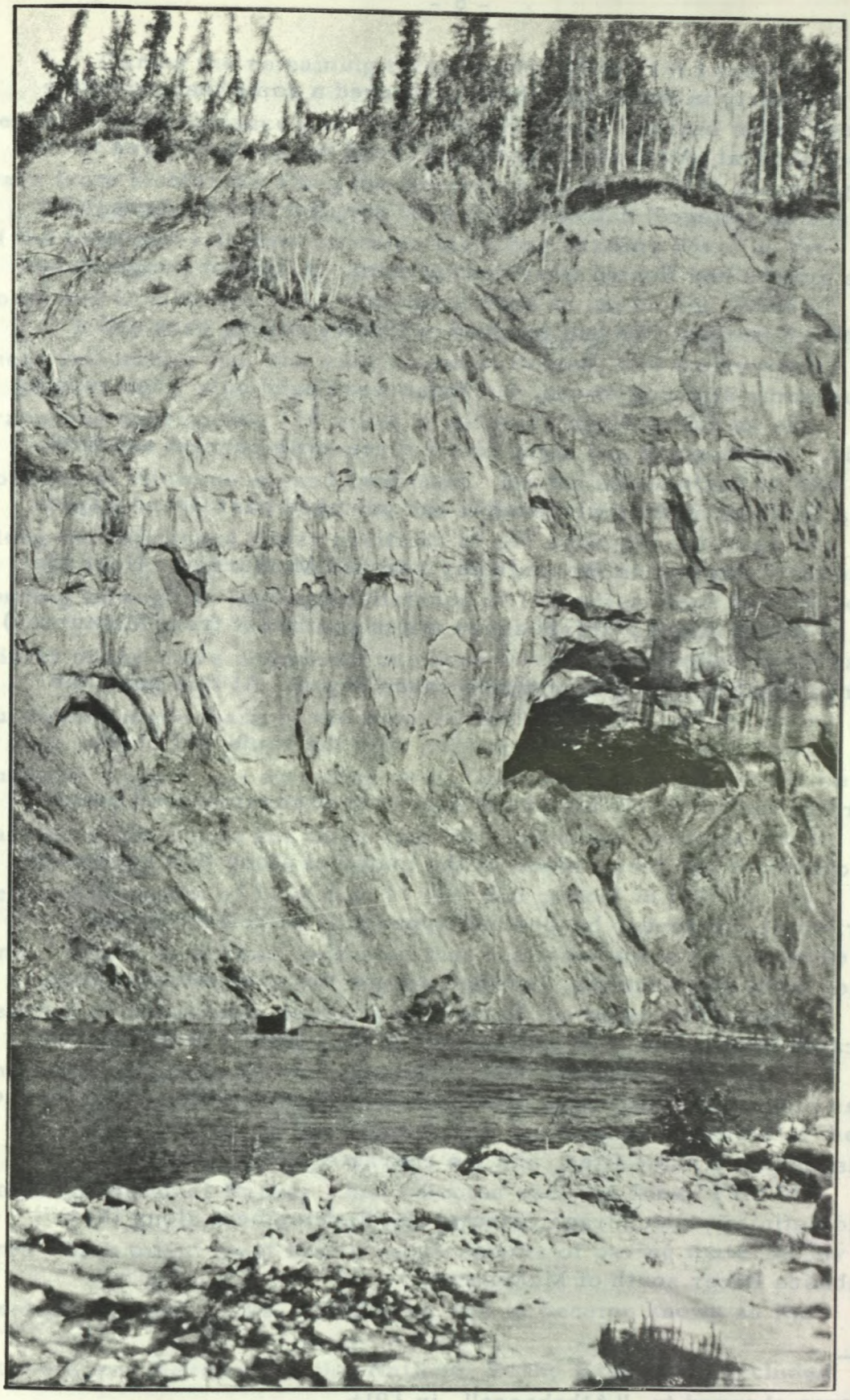

FIGURE 2. Exposure of bituminous sand on the east side of the Steepbank River, illustrating the massive structure and cleavage typical of the richer grades of bituminous sand.

Early in June, 1913 having secured a somewhat primitive 30-foot scow at Athabasca Landing,* I and my crew of three white men and an (alleged) native pilot loaded supplies and equipment for three months and floated away downstream. A 22-foot freight canoe was towed behind. We had roughed out heavy rowing oars and a cumbersome steering sweep, but these were used only when running rapids. Drifting day and night with a three-mile current and with only a look-out on duty we reached and portaged past Grand Rapids on the third day and on the ninth day reached McMurray. Near the head of Boiler Rapids (thirty-seven miles southwest from McMurray) the investigation of the bituminous sands began. At this point the first exposure emerges above water; with the rapid fall of the river and the southerly dip of the sands the exposures soon reach a thickness of 155 feet. Much of the material along this section of the river is, however, banded and apparently of relatively low grade, while two sections, levelled across the precipitous valley, indicated the thickness of overburden to vary from 150 to 300 feet. It was clear that difficulties presented by transportation, the absence of disposal and plant sites, and the character of the sand itself, would definitely discourage commercial development along the Athabasca River south of McMurray.

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* Name changed to "Athabasca" in 1916.

During the remaining three months of the 1913 season a general reconnaissance was made extending one hundred miles northward from McMurray along the Athabasca itself and also along eight of the principal tributary streams including Firebag River in the north and Clearwater and Christina Rivers in the south. None of these tributaries had previously been surveyed, and instrumental traverses aggregating 110 miles in all were made as far as exposures of bituminous sand continued. On the above streams and along the Athabasca River positions of 247 separate outcrops extending through an aggregate distance of 185 miles were established. Eighty of the more prominent outcrops were photographed and measurements were made of the exposed thickness of sand and overburden. Augers and extension rods, hand tools and explosives were carried in the canoe and more than 200 individual samples were secured at depths of from 5 to 17 feet and packed in friction top tins. Where conditions indicated that unaltered material might be reached at reasonable depth, a number of the holes were loaded and fired and sacks of representative bulk samples secured.

Meanwhile, at the request of a far-sighted Director of the Canadian National Parks, I had selected early in June, 1913 an area which might meet future requirements of paving material for western national parks. This area was to become known as the Horse River Reserve of the National Parks Branch; it included some 580 acres along the Horse River and was approximately 1 1/2

miles from McMurray*. The estimated tonnage available within the reserve was apparently large, while mining conditions were favourable and quality of material good. This area subsequently proved to contain the only large workable deposit of sand within a reasonable distance of rail transportation. Consequently, during the period 1920-45, it became the scene of important activities and the principal focal point of attempts to develop a method for the recovery of bitumen on a commercial scale.

It is not my intention to emphasize the difficulties encountered over a period of many years in a fly-infested country, on many streams, in timbered or burned over areas, and on almost limitless muskeg. Nevertheless, it may be in order to recall one of many examples.

On completion of the 1913 season's field work toward the end of September the return trip to Athabasca Landing was begun. Poling, tracking, and portaging had been routine for many weeks, but on arrival at McMurray 240 miles of tracking still lay ahead. A 40-foot scow was secured, my crew augmented by a dozen natives (only one of whom spoke or understood English) and nine tons of equipment and samples were stored on board. Incidentally, the above were the first true samples of bituminous sand to be brought from the McMurray field. But when the 500-foot, 7/8-inch manilla tracking

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* Transferred to the Alberta government by P.C. 1957 - 1043 dated August 7, 1957.

line was laid out along the shore the tracking crew refused to move. At this critical juncture (for practically the entire population of McMurray was looking on) Constable (afterwards Assistant Commissioner) La Nauze, RCMP, rushed down the river bank, seized the leading harness on the tracking line, and shouted to the trackers in their own tongue. Thereupon each man donned his harness; slowly the scow gathered headway.

Scow tracking south of McMurray was anything but child's play. Harnessed to the heavy tracking line, men fought their way grimly along the rough boulder-strewn beaches or through a tangle of overhanging brush often ankle deep in mud or waist deep in water. The ceaseless torture of myriads of flies from daylight until dark and the heavy work which only the strongest could long endure made tracking one of the most brutal forms of labour. Between McMurray and Grand Rapids, a distance of 82 miles, there is a strong and steady current that at the many rapids aggregating upwards of twenty miles in length increases at times to ten or twelve miles per hour. Breakfast was eaten by firelight; we pulled on the line until dark and then, lacking tents, slept under the dripping trees. Nevertheless it required seven long days to reach Grand Rapids and during this period three men were incapacitated either by hernia, appendicitis, or pneumonia and placed in the "sick bay" on the bottom of the leaky scow. Thereafter I took a place on the tracking line.

On three occasions during the journey my dusky "colleagues" dropped their tracking harnesses, threw their blankets ashore and disappeared into the bush. Eventually diplomacy and a strong "line" enticed them back to the river shore and to the tracking line. Fortunately on the third occasion we were in a stretch of quiet water and with but three of us on the tracking line (and no doubt to the discomfiture of the "deserters" who were watching from the shelter of the brush) the scow moved along smartly. Half a mile further on I told the men of the skeleton crew to build a big fire and make tea on the shore. At the time a cold wind accompanied by snow was sweeping the grey waters of the river and the apparent ease with which we had departed with the scow together with the appeal of a real fire and hot tea was too much for the missing trackers. In a few minutes they appeared running along the rough shore. Fortunately they had not called my bluff!

Twenty-three days after leaving McMurray* and two hours after dark we saw the faint glimmer of lights at Athabasca Landing and soon after we beached our battered and leaking scow. It had snowed or rained throughout seventeen of the twenty-three days. For purposes of comparison with present-day labour conditions it may be noted that, as late as 1913, established custom required that trackers be paid $45 for the trip regardless of the time occupied

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* See my Christmas Card of 1926. (Filed with the Public Archives.) See also "Northland Trails".

and that they find their way back to McMurray as best they could and without further remuneration. It was also an immutable custom that they be provided with moccasins and tobacco and I had therefore laid in a gunny sack full of each at a cost of $38.00. (It may be noted that the tobacco consisted of plugs which were rather badly mildewed). However, on reaching Ottawa (and having completed a trip which was long discussed around northern campfires) an indulgent and grateful Department of the Government declined to remunerate me for the cost of the moccasins and tobacco. My salary at the time was $1800.

Among conclusions based on the 1913 field program were the following (written in November, 1913):

(1) "Owing to displacement and subsequent re-consolidation of the unstable outcrops of bituminous sand, superficial inspection of such exposures may be entirely misleading. Consequently, only after detailed exploration by the use of suitable core-drilling equipment, can the true value of any sub-area of the extensive field be determined. Nevertheless, considerations presented by heavy overburden and by apparent variation in the quality of the sand itself - often within comparatively short distances - will probably eliminate quite 80% of the exposures from further consideration. Difficulties presented by transportation will still further reduce the remaining number. Nevertheless certain areas should lend themselves to large scale commercial development."

(2) "The present commercial use of bituminous sand is apparently limited to construction of paved surfaces, and its value as such can only be established by actual demonstration construction."

(3) "A process that can be adapted to efficient separation of bitumen from the sand aggregate will ultimately prove of decisive value, but no such process is at present available either in America or elsewhere. (Incidentally, it was this statement which first focussed attention on the separation problem. As will be seen in the following pages, the considerations outlined in 1913 have charted the programme of all subsequent investigations.) In 1913 I also wrote in part as follows: 'Discovery of petroleum fields in Western Canada will have a direct bearing on the development of Alberta bituminous sands'."

(4) "Finally, it was obvious that transportation costs would be of vital importance."

During the years subsequent to 1913 the above conclusions based on a hurried preliminary reconnaissance have been fully verified.

In due course a problem was presented by the laboratory examination of the many core and bulk samples secured during the progress of initial field work in 1913. It was found, however, that suitable apparatus required for making necessary analyses and various physical tests was not available in Ottawa, nor were laboratory personnel familiar with the examination of the new type of material. Accordingly, at my suggestion, authority was given me to spend a short time at the Municipal Testing Laboratory, New York, N.Y., and as a result, during a period of two months and under expert guidance, I became familiar with the various types of equipment and with approved laboratory techniques. On the con-

clusion of the above training I purchased and shipped to Ottawa essential laboratory apparatus and carried out all analyses and physical and distillation tests on the many scores of samples from the McMurray field. This work constituted the first laboratory study of Alberta bituminous sands. Incidentally, the more important pieces of the laboratory equipment purchased in 1914 were still in use at the Division of Fuels, Ottawa, in 1948.

It may be noted that in 1913, McMurray consisted of a dozen primitive log cabins, a bug-infested hovel proudly referred to as the "hotel" and during the summer months many Indian tepees and tents. Everywhere starving train dogs roamed at will and the greatest care for the protection of food and other supplies was essential. The community depended solely on the fur trade and this was conducted by the Hudson's Bay Company and two "free-traders" in small log cabins. There was no telegraphic communication, but theoretically a mail service operated from Athabasca four times a year, by water in summer and by dog train in winter. Damage to and loss of goods in transit down river dictated commodity prices and salt, sugar and similar perishable goods sold at three pounds for a dollar. Consequently McMurray was known as one of the "three for a dollar" settlements.

Construction of the Great Waterways Branch of the Northern Alberta Railways was completed to Cache 23 (near the junction of Christina and Clearwater Rivers) in March, 1916. In 1926 the railway was completed to its present terminus at Waterways.

Following the inauguration of a definitely casual train service to Cache 23, it was customary for southbound travellers to man-pack their belongings from McMurray, a distance of about 17 miles; alternatively, during the period of open water transportation by motorboat up the Clearwater River was at times available. The railway charter had specified a line "from Edmonton to McMurray". Unfortunately, owing to a dispute with respect to a right-of-way into McMurray settlement, construction was halted at a point about one-half mile east of the settlement. Taking advantage of a technicality, "construction" freight rates were maintained for many years after the line was completed. In 1941-42 in order to meet requirements of the Canol project the line was extended across Hanging Stone Creek by the United States Army and extensive railway siding facilities were installed on the Prairie section of McMurray settlement.

Prior to the completion of the line to Waterways a number of empty box cars were usually to be found at Cache 23. By cutting up empty gasoline tins travellers established a fireplace on the wooden floor of the car selected, at the same time a supply of spruce boughs and firewood was obtained and housekeeping organized. Not infrequently several days might elapse before a locomotive

picked up the southbound "empties" and even then progress was subject to interruptions as one or more cars left the uneven rails. It is said that the longest recorded trip from Cache 23 to Edmonton (280 miles) by box car was eleven days.

Results of field exploration and laboratory work during 1913 had been definitely encouraging. Construction of a rail line from Edmonton to Lac La Biche had been undertaken, an extension to McMurray had been proposed, and plans were underway to establish telegraphic communication between Athabasca Landing and McMurray. All in all conditions appeared to warrant further study of the McMurray deposit. Eventually authority to lay a demonstration pavement was granted, but, owing to the necessity of mining and sacking a shipment of oil sand for paving purposes in 1914, no further exploration was undertaken in that year.

In addition to supervising paving operations (which will be referred to in the section on "Paving"), detailed topographical surveying of a number of strategic areas aggregating 84 square miles was also carried out in 1915, and six map sheets were subsequently published (on a scale of one inch equals one thousand feet) showing contour intervals of twenty feet.* These maps were subsequently superseded, as a result of more extensive surveys carried out by myself in 1922-24.**

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* Ref. III - 2, 3, 4, 5, 6, and 7.

** Ref. III - 8, 9, 10, 11, 12, 12, 14, 15.

PAVING WITH OIL SANDS

Selection and Mining of Oil Sand (1914)

Pools of bitumen and deposits of a variety of bituminous sand, bituminous limestones, and bituminous sandstones occur in many parts of the world and, in a lengthy paper written in 1930, I referred to similar occurrences in some thirty foreign countries. By comparison it was clear that the Alberta deposit is much larger than any other known occurrence of similar material and from present knowledge may possibly represent a larger tonnage than that of all other similar deposits combined. In certain Middle Eastern countries during and subsequent to pre-Biblical times bitumen was extensively used in embalming, paving, waterproofing, and for various other purposes. Indeed at one time its transportation by camel from the Euphrates valley to Egypt constituted one of the more important items of caravan freight. The bitumen was derived chiefly from pools adjacent to seepages and was partially purified when necessary by the use of heated water.* Following the disintegration of the Roman Empire subsequent to the fourth century, the use of bituminous substances became almost a forgotten art, only to be revived again in France about 1838.**

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* S. Hemsley, "Oil in the Middle East", Longman's (1954).

** L. Malo, "Note sur l'Asphalte", Paris (1863).

Subsequent to 1838 there have been important developments of bituminous deposits as a source of surfacing materials for streets and highways and to a very minor extent as a source of impure separated bitumen. When adapted as a surfacing material bituminous limestones have been and are still being successfully used to a considerable extent in England and on the continent of Europe. Similarly, in various localities in the United States, bituminous sand and bituminous limestones have also been extensively used as surfacing materials; when properly used they have given satisfactory results.* In the United States important production of refinery asphalt together with increasing mining costs have tended to affect adversely the use of rock asphalts; nevertheless in 1958 one and one third million tons of this material were used, the average price per ton f. o. b. at the mines being $3.74. During the same year more than eleven million tons of refinery asphalt were produced. Competition by rock asphalts with the refinery product has only been possible as a result of the granting of a sand-gravel classification to the former by the railways.

In 1913 the possible potential importance of mineral deposits in areas north of McMurray was still based on incomplete evidence, and the inconsiderable tonnage of freight involved in connection with the fur trade was practically the only immediately available source of freight for the proposed railway. Actually, pending development

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* Ref. I - 4 and 6, II - 8.

of a separation process, it was clear that any important increase in freight lay in shipments of oil sand for paving purposes.* Moreover at least two years would elapse before a demonstration pavement could be laid and given an adequate test. It was also clear that such a test would indicate the merits of the sand as a paving material and that the results might have far reaching effects. Eventually my suggestion to mine and ship sufficient material and to subsequently lay a city pavement was officially approved.

It is rarely that grading of aggregate of bituminous sand in any single locality, whether in Canada or elsewhere, conforms to accepted specifications. At the extensive quarries of the City Street Improvement Company near Godola, California, the difficulty had been overcome by combining coarse-grained and fine-grained material from two adjacent strata. Consequently, the initial test shipment from the McMurray field included rather coarse-grained sand mined at a point on the Athabasca River some forty-five miles north of McMurray and rather fine-grained sand mined on the Horse River. Subsequently it was found unnecessary to combine two grades of bituminous sand since a balanced aggregate in the final paving mixture could be secured through the addition of the necessary percentage of suitable clean aggregate. This is especially true in the case of bituminous concrete and stone-filled sheet asphalt mixtures.

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* Ref. I - 1 and 2.

Initially, however, in selecting (in 1914) bituminous sand for the proposed demonstration pavement, the grading of aggregate and the percentage of associated bitumen were regarded as the controlling factors; therefore laboratory equipment and material for making the necessary determinations in the field were assembled. Essentially this included solvent and apparatus for determining the percentage of bitumen, standard screens for determining grading of aggregate, and necessary weighing apparatus. A large tent served as a laboratory. All equipment (which also included explosives, augurs and other necessary tools) was carried in a large freight canoe that was tracked or poled along the Athabasca River and up its tributary streams. During 1913 a large number of separate outcrops had been examined and classified and as a result it was possible to eliminate many outcrops from further consideration. Nevertheless care and judgement were required in making a final selection of a point or points from which material might be taken. It was also desirable that the outcrops selected should be such as would subsequently lend themselves to commercial development. Eventually some 1200 sacks each containing one hundred pounds were filled with oil sand, hauled in scows to McMurray, and there stored in a roughly constructed log storehouse. Incidentally, as loading of the sacks in ten-ton scows proceeded, leaks developed. I therefore took a blanket and an alarm clock down to the shore and during a period of 48 hours got up at intervals of one hour and pumped out the boats. It was a longish

shift. Finally, in December, 1914 I completed arrangements for the transportation of the above material. In January and February, 1915, in temperatures ranging from 20 to 50 below zero and without tents for men or horses, twenty-three teams from Athabasca Landing broke a trail for 160 miles down the Athabasca River to a point near Grand Rapids and thence made their way overland as best they could through 85 miles of bush to McMurray. Ultimately these teams delivered the sixty tons of sand at the Landing without the loss of a single sack. Under really difficult transportation conditions the cost had been only 6.3 cents per ton mile. Yet even in 1950 the equivalent cost per mile to Edmonton by rail was 1.6 cents and has since then increased to the point where it has become prohibitive.

On September 30, 1914 with one man I started south by way of La Loche Portage and Big River in order to examine a reported occurrence of oil sand at the narrows of Buffalo (Peter Pond) Lake.* While I was tracking along a section of the shore on Clearwater River below La Loche Portage and through heavy overhanging brush, my companion, who was in the canoe, allowed the bow to swing out into the strong current and a moment later our food, equipment and the capsized canoe were floating downstream. When we subsequently reached the primitive Hudson's Bay Company post on La Loche Lake a day later, we found that owing to low water conditions the annual shipment of supplies had not reached the company trader who was subsisting on fish and a little flour. However the waters teemed with

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* In addition to examining the oil sand near Buffalo Narrows, I ascended the Buffalo River for some 30 miles, but saw no outcrop or oil sand. Apparently the oil sand in the area represented glacial float of no economic significance.

with whitefish and trout and on this rather tiresome and saltless boiled diet we reached Big River some ten days later.

Meanwhile the remainder of my party had returned south by tracking up the Athabasca River from McMurray. On the way by the use of excavating equipment they carried out an examination of coal exposures that outcrop for several miles along the valley slopes below Grand Rapids. The results of analyses of representative samples indicated that the seams contained such a high percentage of impurities as to be worthless as a source of fuel. Other samples collected in the McMurray area in 1915 included clay, ironstone, and mineral waters from a number of localities. Clay samples taken in the same year by the use of augers on a number of tributary streams were subsequently tested by myself in the ceramic laboratories of the University of Toronto under the supervision of the late Joseph Keele.*

Laying Demonstration Pavement at Edmonton (1915)

Although the principal field activity in 1915 consisted in the laying of a demonstration pavement in Edmonton, detailed topographical surveys were also initiated. Toward the end of May I took instrument men and a crew of axemen together with four months' supplies to McMurray by scow. However, early in June word reached me that certain members of the Edmonton City Council wished to have small areas of the proposed pavement laid in their respective wards.

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* S. C. Ells, "Notes on Clay Deposits near McMurray, Alberta", Mines Branch Report No. 336, Dept. of Mines, Ottawa, p. 15 (1915).

In view of the limited supply of bituminous sand available such action would have nullified the value of the proposed demonstration. It may be noted that prior to leaving Edmonton en route to McMurray (and after consultation with the City Engineer) I had selected a site for the proposed pavement. But now Edmonton was calling; the time had come to assume a new and serious responsibility - the responsibility of determining the possible merits of Alberta oil sand as a paving material. In view of the road problem which faced the province of Alberta fifty years ago the outcome might well have far-reaching results.

In due course one morning the cook jammed into my packsack a quantity of pork sandwiches sufficient for seven days and suspended a small tea-pail from one of the straps. In addition to the sandwiches, which became a solid conglomerate, I also carried spare boots and necessary books and papers, all of which brought the weight of the pack to about seventy pounds. The distance overland from McMurray to Athabasca Landing was approximately 250 miles, but thanks to long hours of daylight I was able to travel from three a. m. to eleven p. m. My only companion was a cocker spaniel and I carried no tent or blanket. Apart from the cabin of a trapper-trader at House River (Mile 85) and another at Calling River (Mile 189) the country was completely uninhabited. As far as House River much of a partially overgrown trail led through swamps, hay meadows and muskeg. Between House River and Calling River (104 miles) there was no trail.

During the first twenty-four hours a number of serious blisters developed on both of my feet due to ill fitting boots. When I discarded the boots for moccasins, bruising of my feet added to my discomfort. A cold north wind accompanied by driving rain had prevailed throughout my second day on the trail. On the unstable waterlogged terrain there was no camping place available and late in the evening, to make matters worse, I reached the edge of an extensive "hay meadow" where only the tips of tall grass showed above the water. However, half a mile ahead I discerned a low bushy "island", and with the spaniel swimming and splashing behind I finally reached a few square yards of firm ground. I could see that beyond the island the partially submerged hay meadow re-commenced. Growth on the "island" consisted chiefly of dripping alder bushes, but there were also the trunks of two fallen trees.

A cold and continuous north wind accompanied by driving rain can chill one in the summer almost as completely as low winter temperatures and in spite of the exertion of travel my teeth were chattering and my fingers numb. In my saturated clothes there was no means of lighting a match. When the situation appeared almost hopeless - for time was running out - I remembered that early in the day and for the first and only time in my experience I had tucked a piece of birch bark into my waterproof packsack. Then groping on my hands and knees by good luck I found a dry spot on the underside of one of the fallen tree trunks. With chattering teeth

and numb fingers I managed to shred the precious birch bark, to strike a match, and to add a few dry twigs. Almost holding my breath I watched a tiny flicker become a small flame and by carefully adding small bits of alder the flame grew. Finally, heaping on alder bushes torn out by the roots, for it is amazing how even wet and green alder will burn, I was soon warmed through, but the problem of passing the night still remained. Fortunately I had in my packsack about a square yard of rabbitskin blanket and this with the little spaniel solved the problem. Putting him next to my own skin I wrapped the bit of blanket about us both, cemented the "entente" by a couple of loops of the tump line, and by piling green alders on the fire at intervals we survived the night. At daylight we navigated the remainder of the half submerged "hay meadow" and on reaching firm ground our worries were over. I knew only too well that it had been a near thing.

As was to be expected, constant immersion of blistered and bleeding feet in swamp water did not decrease normal difficulties. When at daylight of the seventh day (having travelled throughout the night) I saw the first farm house of a new settlement some four miles north of Athabasca Landing, serious infection and swelling in my groin had developed. Owing to inability to control my shaking hands I was unable even to tie my moccasin strings. With these trailing behind, I knocked on the door of the farmhouse about 3 a.m. When the man who opened the door saw his dishevelled

visitor he tried to slam the door in my face. However I managed to get inside where my first words were: "I'll give you a dollar for a drink of whiskey". A large cupful of the "medicine" taken neat had no effect. When the farmer advised me an hour later that he was driving a load of pigs into Athabasca, I climbed into the back of the springless farm wagon with my porcine companions.

An hour later we reached Athabasca and late the same day I reached Edmonton. Four days later as a result of skilled medical attention I was able to begin preparations for the proposed demonstration pavement. However, owing to the condition of my feet, it was a further two weeks before I could exchange heavy socks and buckskin moccasins for more conventional city footwear. Meanwhile I had appeared before the City Council and had cleared up a contention that had developed with respect to the location of the proposed pavement.

When proceeding from Ottawa to Edmonton in 1915 I had detoured by way of San Francisco* in order to confer with Mr. J.R. Price of the City Street Improvement Company. Mr. Price, who had laid many miles of bituminous sand pavement in California, was the recognized authority on the use of such material. Therefore, in view of the obvious importance that would attach to the success or failure of the initial use of the Alberta sands, I had arranged with

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* Cost of railway travel direct from Ottawa to Edmonton was about $10 less than by way of San Francisco.

him to come to Edmonton for a few days in a consulting capacity. While in San Francisco I had also observed a small portable mixing plant in operation on one of the city streets and had had a lengthy discussion with the foreman in charge. The plant, which had been built by the Rapid City Mixer Company, Grand Rapids, Michigan, appeared to meet the requirements of the proposed paving work in Edmonton. The same day, although such matters are customarily handled by time consuming memoranda to Ottawa, I took the responsibility of wiring the company at Grand Rapids to ship a similar unit to Edmonton. Subsequent results justified this action. Incidentally, on completion of the paving work, the mixer was used by the city over a period of years in connection with patching work on Edmonton streets.

The mixing plant had a charged capacity of 1400 pounds. However, as a preliminary to actual paving, a number of small trial batches were put through in order to determine heating temperatures and other specifications. In tuning up the plant and in ensuring its efficient operation during actual paving operations pay sheets for personnel employed indicated an average working day of sixteen hours. It is of interest to note that the men employed took a keen interest in their job and that no suggestion was made with respect to increased overtime pay beyond the customary ten-hour day.

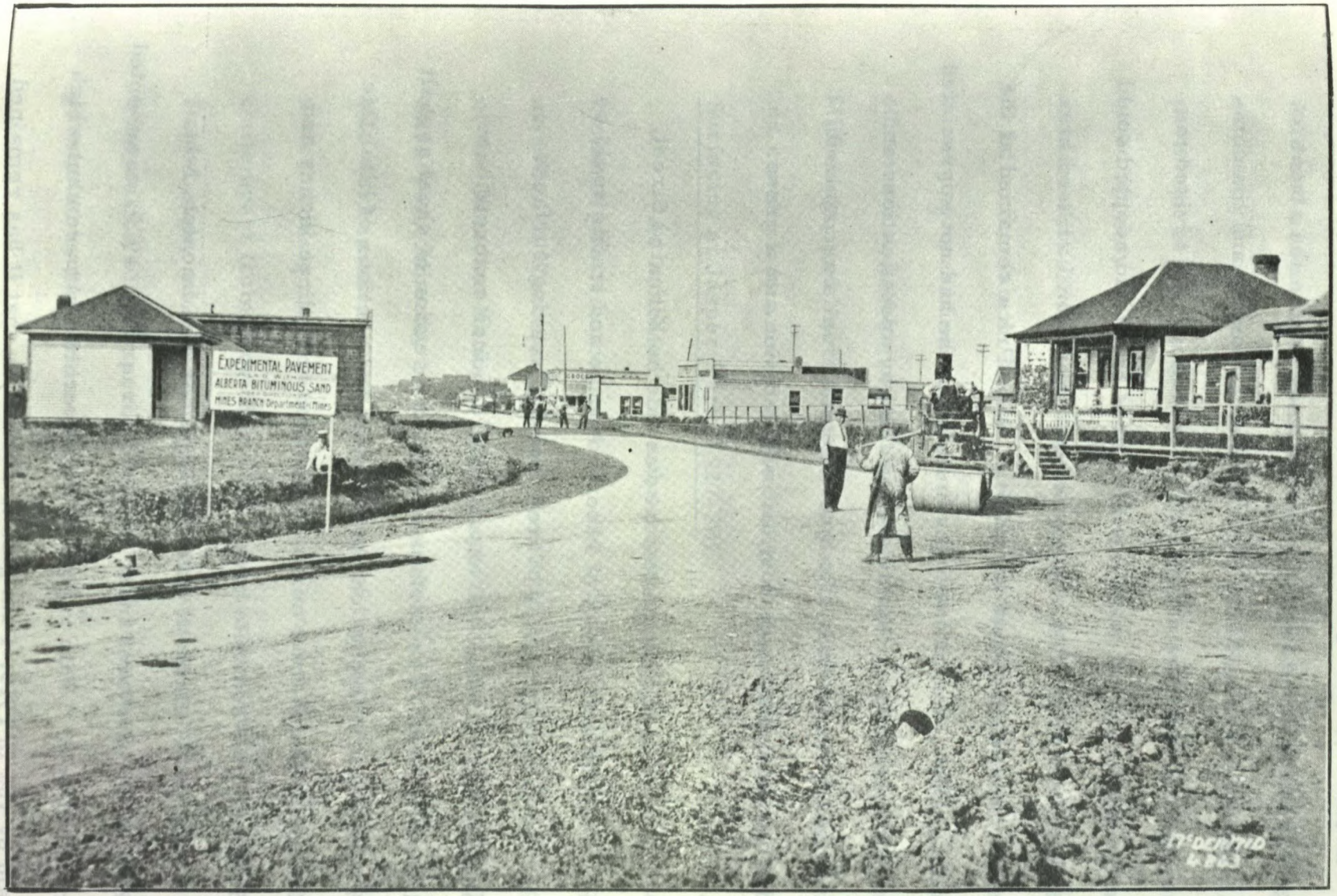

FIGURE 3. Demonstration pavement laid in Edmonton, Alberta, under the supervision of S. C. Ells, Mines Branch, August, 1915.

Eventually, having worked out specifications of mixtures and heating temperatures the first truck loads were sent to the street on July 2. Three days later Mr. Price reached Edmonton and his comment on my procedure was definitely disconcerting. He advised me that the temperatures and other specifications that I had adopted could not give satisfactory results. After due consideration I advised him that I would have to disregard his advice. Mr. Price remained at the plant for nine days, and on leaving admitted that he had not appreciated our climatic conditions. He also agreed that my specifications and procedure had been correct. To ignore advice from a recognized authority had involved a decidedly difficult decision and a grave responsibility.

The demonstration pavement was laid on Kinnaird Street, Edmonton, immediately south of Alberta Avenue and traffic could be described as decidedly heavy. Three types of wearing surfaces were adopted and all were laid on a standard 6-inch concrete base provided by the city. The surfaces included a section of sheet asphalt (compacted to 2 1/2 inches on open binder) and sections of bitulithic and of bituminous concrete mixtures compacted to three inches and laid directly on the concrete base.

Mr. A.W. Haddow, the City Engineer of Edmonton, when referring to the pavement under date of February 10, 1925, commented in part as follows: "With regard to the experimental pavement which was laid by you in 1915, I am glad to advise you that it has remained in excellent condition, shows no sign of defect or deterioration to

date and seems to be good for many years of satisfactory service." Subsequently under date of May 8, 1950, Mr. Haddow referred to the above pavement in part as follows: "The work you laid in Edmonton in 1915 has stood up very well and is in good condition, having only had the usual minor repairs that all flesh and pavements are heir to." On completion of paving in Edmonton late in August, I made my way to McMurray, closed down surveying operations and then devoted some three weeks to a study of low-cost surfacing of highways by mixed-in-place methods in Wisconsin, Minnesota, and North Dakota. A manuscript report on observations made and conclusions arrived at, is on file at the Mines Branch, Ottawa.

Surfacing at Jasper Park (1927-28)

As indicated above the pavement laid in Edmonton had given eminently satisfactory results, and moreover had attracted considerable attention in Western Canada. Consequently, in 1926 the Director of the Canadian National Parks suggested that a section of highway at Jasper, Alberta, be similarly surfaced. The carrying out of this work involved further extension of the quarry at McMurray and also the designing and construction of a new and larger mixing plant. Quite apart from providing a dustless surface leading to Jasper Park Lodge, an opportunity was presented to secure further useful information with respect to mining, and to unexpected problems presented by rail shipments of oil sand.*

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* Ref. I - 3.

Having organized all details with respect to expanded quarrying operations at McMurray, I returned to Edmonton in July, 1927, and in the drafting office at the City Hall prepared working drawings for a new mixing plant. I then engaged three helpers and with their assistance constructed the plant itself. Through the courtesy of Mr. A.W. Haddow we were allowed space in the municipal machine shop and use of its facilities. The Mayor and other officials accompanied by photographers witnessed a trial run before the plant was taken down and shipped to Jasper. It worked beautifully.

The design of the above plant was based on that of somewhat similar mixers used in Texas, Oklahoma and Alabama.* The essential features included two revolving steel mixing drums fitted with an effective arrangement of heavy mixing baffles, two oil-fired combustion chambers, and loading and discharging chutes. The hot blast from the combustion chambers was injected into each drum. The combined capacity of the two drums was approximately three tons and power was provided by a 50 hp motor. The cost of labour in building and assembling the plant was approximately $2,000. The critical features in construction and operation included correct design of the combustion chambers, choice of the type of oil burners, diameter and length of the flues from combustion chambers, rotating

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* Ref. I - 4, II - 8.

speed of the drums, temperature of the blast, and periods of heating. During the first few days' operation various adjustments were necessary, but by the end of a week the plant was functioning smoothly. In order to ensure efficient and continuous operation, however, minor adjustments and repairs were necessary from time to time, and these, together with the operation of the plant, usually involved for key personnel and myself a working day from 5 a.m. to 10 p.m.

It may be added that it was necessary to move all shipments of bituminous sand upstream on scows to Waterways where we erected (in three long working days) a 120-foot steeply-inclined trestle leading from the river shore to a point above a railway siding. With a home-made drum (operated by our old faithful $300 tractor previously purchased in 1926), small mine cars were hauled to a platform fourteen feet above the railway track and dumped directly on the decks of flat cars the sides of which had been boarded up to a height of three feet. The whole set-up aided by not a little sweat and profanity worked smoothly and efficiently and it was never necessary to pay demurrage on railway cars which had been "spotted" nearby.

The heated mixture delivered from the drums of the mixing plant may be described as a stone-filled sheet asphalt. On the arrival of flat cars from Waterways, a distance of 540 miles, core samples were analysed in a field laboratory, and the necessary percentages of clean aggregate and of filler determined. The heated mixture was discharged into five-ton trucks, and a two-inch compacted

surface laid directly on the gravel road which had previously been in use. As neither plant nor road crews had had previous experience with the handling of asphaltic materials, close supervision of all phases of the work by myself was essential. Owing to unusually wet weather and to the fact that actual paving did not commence until October 6 only 500 tons of mixture were sent to the road in 1926, but surfacing of 12,000 linear feet of highway and of extensive walks at the Lodge was completed during the summer of 1927. The quantity of bituminous sand used amounted to 2,373 tons. Plant and road costs amounted to $9.90 per ton of mixture used, but by the introduction of the most elementary labour-saving devices the cost could have been materially reduced. Commenting on the above pavement under date of July, 1928 Mr. J.B. Snape, Resident Engineer at Jasper Park, wrote in part as follows: "The road from Jasper to the Lodge, which was paved with McMurray bituminous sand last year, has come through the winter in excellent shape, and in fact the general appearance is better than last Fall. It is quite dustless, gives excellent trackage normally and also during wet weather, and there is no danger of skidding and side-slipping. In fact it seems to be the ideal road surfacing material." Subsequently, in 1938, I had occasion to drive over the above pavement and it appeared to be in excellent condition. Inquiries from operators of motor vehicles, including trucks, cars and motorcycles, confirmed complete endorsation of Mr. Snape's reference to the non-skid

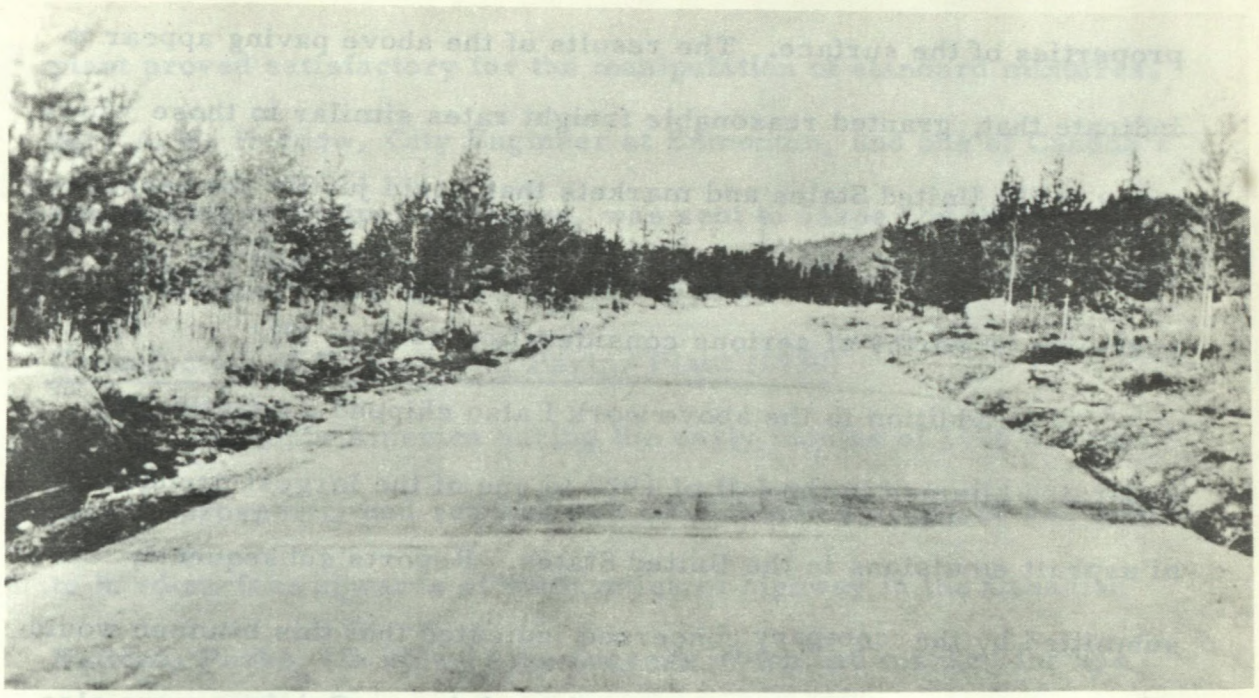

FIGURE 4. First commercial use of Alberta bituminous sand for road surfacing, Jasper Park, Alberta.

FIGURE 5. First trainload of bituminous sand for road surfacing at Jasper Park, Alberta.

properties of the surface. The results of the above paving appear to indicate that, granted reasonable freight rates similar to those which apply in the United States and markets that would justify the necessary capital expenditure, the commercial use of Alberta sands for road surfacing is worthy of serious consideration (see p. 19).

In addition to the above work I also shipped a quantity of separated bitumen in the fall of 1927 to one of the largest producers of asphalt emulsions in the United States. Reports subsequently submitted by the company concerned indicated that this bitumen would be found suitable for various types of emulsions. Opinions were also secured from a number of recognized authorities in Canada and in the United States on the use of asphalt emulsions in general.

As indicated above only bituminous sand mixtures had been used during the paving operations in 1926-27. Subsequently, during the period June 30 - July 9, 1929, a number of trial batches consisting of "D" grade refinery asphalt combined with clean aggregate were also run through the Jasper mixing plant. It was found that the discharge of the heated mixture from the drums required an inclination of the discharge chutes somewhat steeper than in the case of the bituminous sand mixtures, but that in all other respects the

plant proved satisfactory for the manipulation of standard mixtures. Mr. A.W. Haddow, City Engineer at Edmonton, and one of Canada's outstanding municipal engineers, was sent to Jasper by the city in order to observe the operation of the plant.

Construction of Commercial Paving Plant (1930)

In North America during the early months of 1929 a form of pseudo-prosperity had reached new heights and a proposal was made to hard-surface upwards of sixty miles of highway in the Canadian National Parks. In view of the success which had marked the use of oil sand in previous years it was also proposed that as far as possible this material should be used. Consequently, in the fall of 1929, I was authorized to design and construct a portable or semi-portable mixing plant which would meet the requirements imposed by relatively large-scale operations.

In previous years I had had an opportunity for observing in the United States the operation of a number of plants designed for the treatment of bituminous sand and bituminous limestone when used for road surfacing.* The majority of these plants, of which more than thirty were in operation at one time in the United States, embodied general principles similar to those which had been incorporated in the unit used at Jasper. I therefore drafted detailed working plans for a new plant along somewhat similar lines, and

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* Ref. I - 4.

these were submitted for comment to the Superintendent of the Uvalde Rock Asphalt Company, San Antonio, Texas. With minor modifications my designs were approved, and in December, 1929 I proceeded to Edmonton.

Large steel drums of the type required were very costly. However, I was fortunate in discovering two such drums in a salvage yard at Lethbridge, and following the customary "negotiations" I obtained the pair together with gears and shafting for the almost nominal sum of $800. These drums were eight feet in diameter and six feet wide. Early in January, 1930, with the assistance of three helpers, I erected a building of light construction forty feet long and twenty feet wide on a wind-swept field adjacent to the machine shop of the Standard Iron Works, Edmonton. Two converted gasoline drums served as heating stoves and usually, but by no means always, these kept the temperature in which we worked above the freezing point. The two mixing drums together with necessary shafting and gears were then assembled on a heavy frame of structural steel twenty-eight feet in length, and pieces of additional equipment required were either purchased or fabricated. Power was provided by a 75 hp motor. In spite of the severe cold and other handicaps construction was completed in May, a short railway spur was built and the new plant was placed on a steel flat-car rented from Canadian National Railways. Meanwhile at the Clearwater quarry, a field assistant, Mr. Paul Schmidt, mined

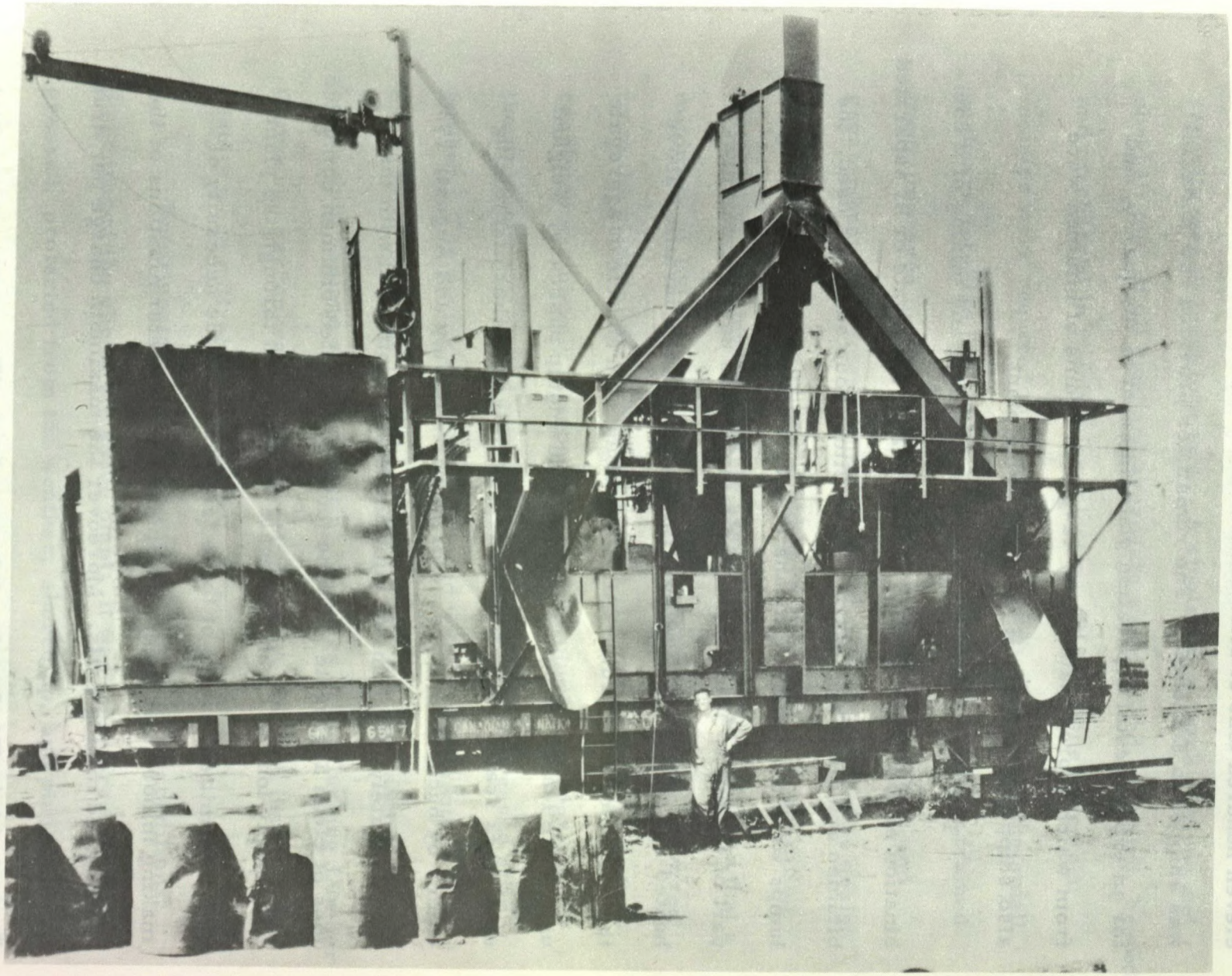

FIGURE 6. Front view of commercial, mobile, internally-heated, drum-type mixing plant, showing loading and discharge chutes. Built by S. C. Ells at Edmonton, Alberta, 1930.

eleven hundred tons of bituminous sand of which an adequate amount was shipped to Edmonton. The remainder provided raw material for an experimental separation plant adjacent to my quarry, and from which approximately fifty 42-gallon drums of bitumen were also shipped to the site of the new paving plant.

This plant* was adapted to the heating and mixing of a combination either of bituminous sand and clean aggregate or of separated bitumen and clean aggregate. When bituminous sand was used, the lumps were broken up by means of a crusher which was an integral part of the plant; when separated bitumen was used, it was preheated and then pumped to metal measuring boxes installed above the hopper of each drum. All bituminous sand and clean aggregate used were loaded by hand into small side-dump pushcars, weighed on a track scale, and then transferred to the crusher and mixing drums by bucket elevators. During parts of July and August, 1930, approximately forty tons of bituminous sand combined with thirty tons of clean aggregate and nine tons of separated bitumen combined with ninety tons of clean aggregate were passed through the plant. The intermittent nature of these trial runs and the necessity of making minor adjustments precluded definite determinations of the heating and mixing costs. Moreover the maximum charge per drum

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* Ref. I - 6, II - 8.

did not exceed three and one-half tons, whereas the individual drum capacity was at least four tons. A single drum batch of three and one-half tons of oil sand and aggregate was crushed, elevated, heated and discharged in twenty-nine minutes. Of this time seventeen minutes were required to load, tram, weigh, and empty the small pushcars into the boot of the ground elevators. Properly trained men, improved loading facilities such as storage pockets, and greater heating efficiency through minor modification in the design of the combustion chambers would have speeded up the operation materially. Making reasonable assumptions, it seems clear that a minimum of 700 tons of heated mixture could have been delivered from the plant in two eight-hour shifts. If the total charge had consisted exclusively of separated bitumen plus clean aggregate, the production of heated mixture would have been increased still further. The paving mixtures produced were experimentally used for various purposes including a heavy-duty machine shop floor, a heavy-duty haulage strip connecting buildings of the Cushing Lumber Company, garden walks, and street patching. In each instance the results were entirely satisfactory.

Unfortunately, subsequent to 1930, financial conditions discouraged the use of the above plant; it was therefore thoroughly greased, protected from the weather, shored up, and placed in temporary storage. The total cost of the plant had been $15,000, but its actual value was much more. However, in due course and without my knowledge it was disposed of at almost scrap value.

QUARRYING

Prior to 1930, I had quarried upwards of 5,000 tons of bituminous sand. Groups of holes up to fourteen feet in depth had been drilled in the sand by hand augers and various types of explosives had been used. Comparisons had also been made between results when holes had been "sprung" before loading and when holes had not been sprung, but in general the advantages of "springing" were almost negligible, and indeed at times such action was a disadvantage.

By 1930 the quarry which I had opened up in 1926 had been exhausted. However, the marked success which had attended the construction of pavements at Edmonton and at Jasper, and the probability that further paving would be undertaken indicated the necessity of developing a new quarry adjacent to the ground previously worked out. This site was on the east shore of the Clearwater River in Sec. 14, Tp. 89, R. 9, and about a mile below Waterways Station.

As a preliminary step the underlying sand was sampled by the use of hand augers. Following the removal of forest growth, towers were erected and the stripping of overburden effected by a scraper operated by tractor-powered head and tail lines. In the construction of the loading dock, 140 feet in length, a cribwork of heavy logs was placed in position along the river front. This was filled with material deposited by the scraper at the top of the bank. The material was sluiced into the cribbing by a tractor-operated

hydraulic unit installed on the deck of a nearby scow. A total of more than 3,000 cubic yards of overburden were removed and disposed of. In spite of the small scale of the operation and the definitely crude improvised methods, the cost was less than 60 cents per cubic yard, and at least 7,000 tons of good quality sand were made available. Subsequently, the necessary towers were erected, a rather primitive but efficient tractor-operated aerial tramway extemporized, and upwards of 1,200 tons of sand were delivered to the small separation unit which had been established nearby by the Alberta Research Council.

In previous years (1915-27) well preserved fragments of Cretaceous wood had been found in the bituminous sands and, in the course of quarrying operations in 1929, logs of similar wood up to 40 feet in length and up to 12 inches in diameter were encountered. Due to impregnation by bitumen much of the wood was in an excellent state of preservation, and subsequently I submitted samples to Dr. I.W. Bailey of the Bussey Institute for Research and Applied Biology, Boston. Following a lengthy study Dr. Bailey submitted to me a detailed report which concluded with the following comment: "It is evident that the material you are finding deserves very careful and systematic investigation". However, no such investigation has as yet been made.

With respect to quarrying operations it was of course obvious that my previous costs could be greatly reduced by large-scale operations and by the use of standard equipment. Accordingly I arranged

that representatives of the Bucyrus-Erie Company, South Milwaukee, The Eagle Iron Works, Des Moines, Iowa, and the Canadian Explosives Company, should visit the newly opened quarry. On the arrival of these representatives on July 17, 1929 a number of previously prepared holes were fired using varying charges of different explosives. The Bucyrus-Erie Company was represented by Mr. D.S. Watters who was accompanied by Mr. H.G. Malcomson of Mussens Ltd., the Eagle Iron Works by Mr. Theo Aulman (President of the Company), and the Canadian Explosives Company by Mr. R.A. Gorman. Reports were subsequently submitted to me by the above engineers and copies are available at the Mines Branch, Booth Street, Ottawa. These reports indicate that in the case of somewhat soft and unaltered sands power operated shovels will prove satisfactory. In the case of weathered and harder sands heavy duty shovels might dig the material without blasting; but, as the effort required would impose a severe strain on the equipment, the preliminary use of explosives would be desirable. Shale planers will excavate bituminous sand and deliver finely divided material which would be a blend of the full thickness of the sand strata. With respect to the type of explosives used and the blasting procedure to be followed, Mr. Gorman confirmed the methods of procedure and the explosives that I had already adopted.

Subsequently, during the period 1936-42, more than 30,000 tons of sand were quarried by Abasand Oils Ltd. In drilling holes steam jets ultimately superseded augers and this resulted in greatly increased efficiency and a corresponding reduction in costs. In practice the area from which overburden had been removed was drilled in a checkerboard pattern, the spacing and depth of the holes being varied as appeared necessary. The number of holes in individual groups varied from fifteen to forty, and costs per ton of sand were segregated under various headings including labour, steam, powder, caps, and fuse. To begin with, the spacing of holes and the charges of explosives used required experimentation on a somewhat small scale. Although a maximum of only 475 tons was broken per blast, the average total cost per ton amounted to only 14.5 cents. Subsequently, when larger-scale blasting was adopted and upwards of 6,000 tons were broken down by a single blast, the total cost per ton was reduced to 6.17 cents. The cost of powder was 20.1 cents per pound and the cost of caps was 15 cents each; if purchased in quantity, the cost of these items would have been much less.

Oil Shales of Northern Saskatchewan

It so happened that in 1921, a full fledged oil shale boom was in progress along the upper Carrot River valley in Central Saskatchewan. Having in previous years reported on the oil shales of the Maritime Provinces, I was appointed to investigate the alleged deposit in the western field. Thereafter, during a period of four

months, burdened with drills, explosives, excavating tools, and a portable field laboratory, we hewed out miles of trail through dense undergrowth. In due course our three pack horses fell victims of bears or wolves; thereafter we man-packed cumbersome loads along the northern escarpment of the Pasquia Hills. Oil shales exposed on the steep slopes of creek valleys were accurately sampled by trenching the shales to depths of four to six feet, and the oil content of each sample was determined. Incidentally, the results of these analyses made with my field retort agreed almost exactly with the analyses of check samples subsequently tested in Ottawa.

The results of this investigation indicated that the shales could not possibly be considered of economic value. It may be noted that during the progress of the investigation what appeared to be the bones of a dinosaur were discovered in one of the shale banks on the Man (Nabi) River. Some representative fragments were sent to the Geological Survey at Ottawa for study and the results confirmed this conclusion. The discovery was given front-page publicity in newspapers from New York to San Francisco.

TOPOGRAPHICAL SURVEYS

In 1913 it had become obvious that mining of the bituminous sand would involve the removal of overburden and the adoption of open-cut mining. The ratio of overburden to underlying sand would be one of the determining factors in the selection of areas that might be regarded as of economic value, and the necessity of contouring the ground surface and also the surface of underlying sand was therefore evident. Consequently, topographical surveying and the running out of surface profiles constituted the principal field work during the summers of 1922 and 1923 and the winter of 1922-23.* Subsequently, during the period 1943-47, results of extensive core drilling indicated with adequate accuracy the contours of the surface of the sand within two distinctly promising areas. (Further details will be found under "Drilling".)

The area topographically surveyed in 1922-23 aggregated approximately 1,250 square miles. Surveys were based largely on stadia measurements and involved the running of upwards of 2,800 miles of transit line, the establishing of elevations at some 27,000 points, and the running of east-west profiles aggregating 700 miles in length. Subsequent to 1914 surveys of the 24th, 25th, and 26th base lines and much subdivision work had been completed

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* Ref. III - 8 to 15 inclusive.

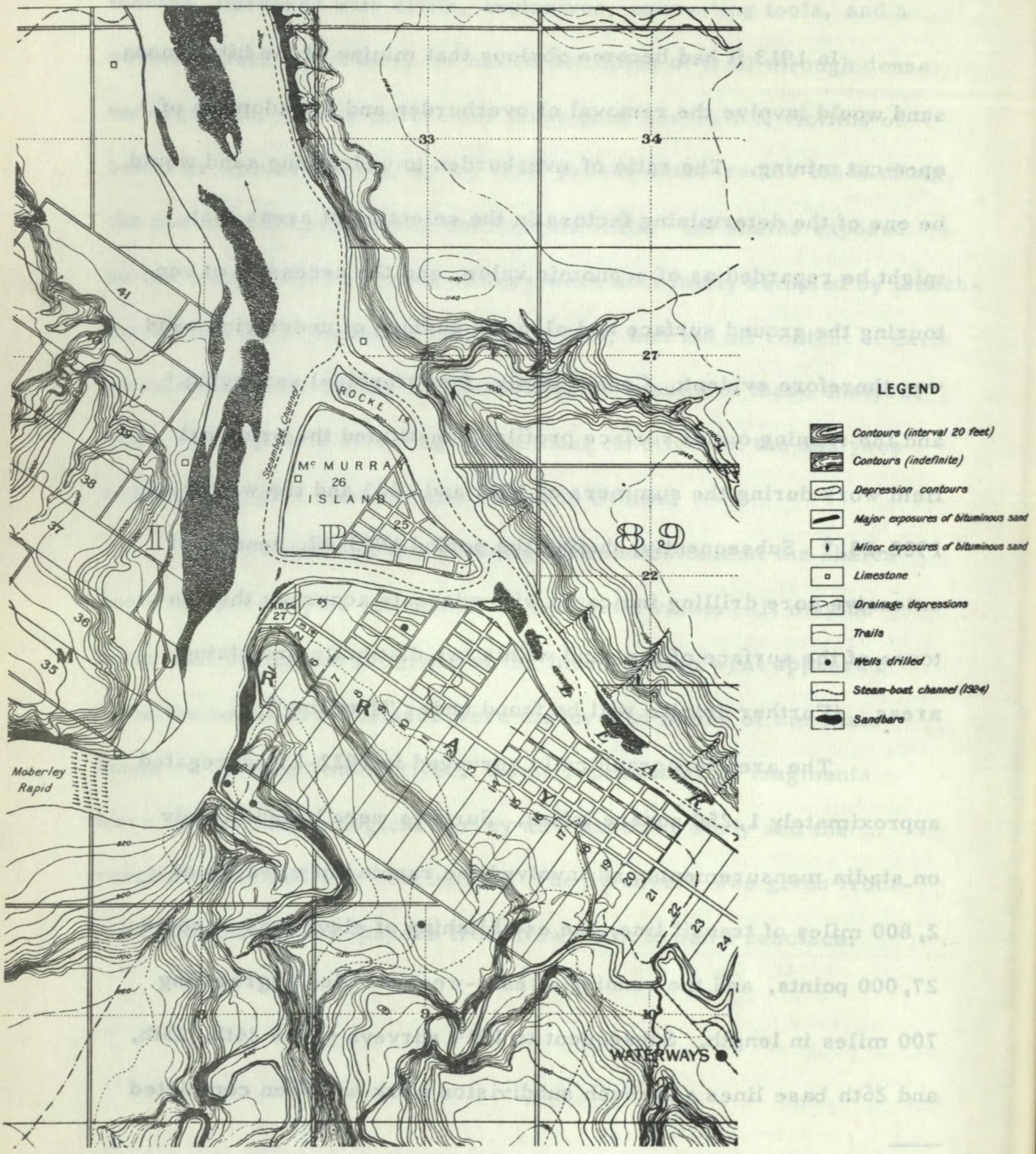

FIGURE 7. Typical example of topographical mapping which comprised a total area of 1250 square miles.

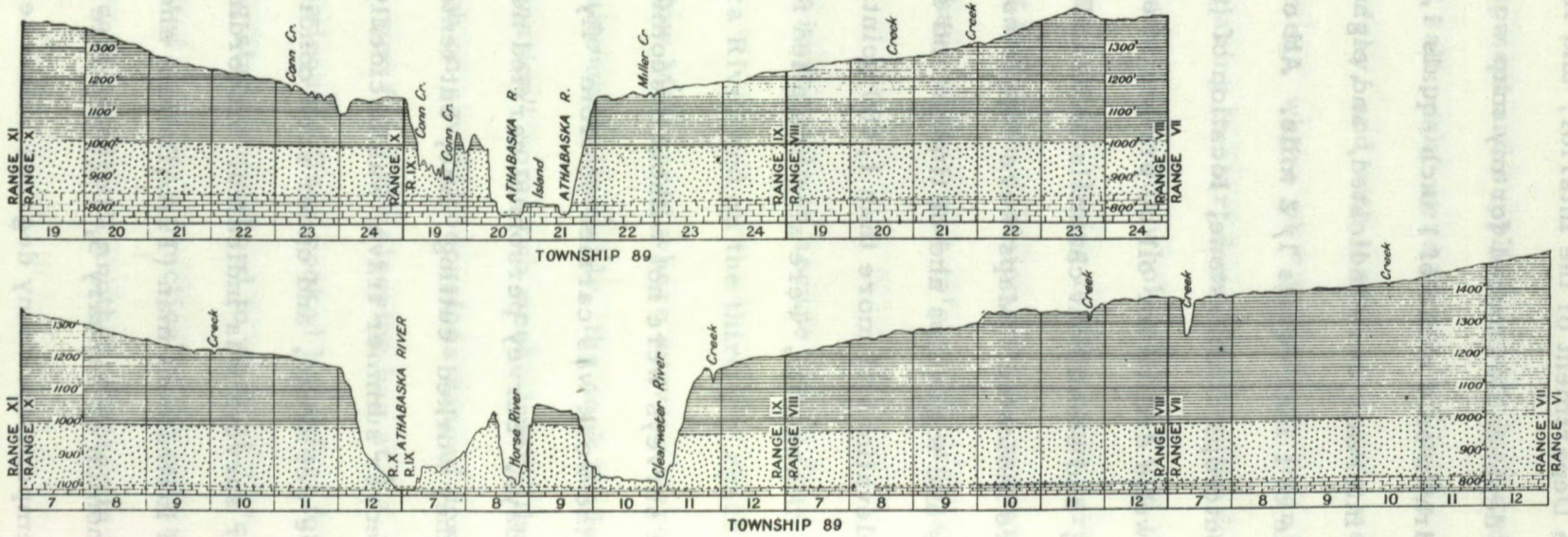

FIGURE 8. Examples of provisional profiles. Total length of all profiles is 750 miles.

by surveyors of the Department of the Interior, and iron posts and mounds provided a dependable control for my map work. Manuscript maps were drawn on a scale of 1 inch equals 1,000 feet, contours of 20-foot intervals were indicated, and eight map sheets published on a scale of 1 inch equals 1/2 mile. All exposures of bituminous sand, outcrops of limestone, location of (then) usable trails, location of wells drilled for oil by private interests during the period 1907-23, and steamboat channels and sandbars (as of October, 1923) were indicated. Maps were supplemented by a summary of ranges and townships and of timber and soil conditions. Tables indicating elevations of more than 1,400 points, which are referred to survey monuments, were also compiled for possible future use.

The above surveys were not without discomfort for of necessity much of the work was carried on from "fly" camps of from seven to ten days. Survey personnel carried necessary food and equipment as they worked cutting line, but tents were dispensed with. Moreover summer travel was decidedly difficult in certain extensive wet areas, and under such conditions the advantage of winter surveys was indicated. Accordingly, in due course and with an instrument man (T. A. Dalkin) and ten "other ranks", I left Edmonton on January 3, 1923 and late on the following evening with the temperature many degrees below zero we climbed down from the caboose of a work train at the end of steel. In the

darkness our equipment and supplies, which included several hundred pounds of very fat salt pork, were thrown off in the snow some six miles from McMurray, and with loaded toboggans we followed a bush trail to the settlement, where we "denned up" in an empty warehouse. When preparing to start down river on the following day, as it was not possible to carry our whole outfit, I told the boys to leave the tents and stoves behind. Being for the most part "green" hands the significance of the above decision was not properly appreciated. However, we did have canvas lean-to's which at least ensured ample ventilation.

As it was impossible to secure sleigh dogs, we broke trail down the Athabasca River and on the third day reached a point some 55 miles below McMurray where surveys were to begin. Unfortunately, but quite understandably, the cook tendered his unconditional "resignation" some two weeks later; thereafter, in temperatures which on several occasions ranged down to 50 degrees below zero, I emerged from my sleeping bag at 5 a.m. in darkness and cold, built an adequate fire, cooked breakfast for the crew, and under the glittering stars snowshoed to work at 7 o'clock. Throughout the winter melted snow was practically the only source of water. Thus was completed still another chapter in the "birth of a new industry".

Quite understandably members of our happy little family were not wholly enamoured with sleeping accommodations provided by the management, and as a result the grounds for occasional, but abortive, requests by certain individuals that they be permitted to resign were at times ingenious. Among these a typical instance may be noted. One of my "recruits" was a young and rather delicate chap named Gilbert Clark, who prior to his enlistment had been a ladies' tailor in Edmonton and who was quite unacquainted with conditions of work in that much publicized "great out-of-doors". One night, as we sat about our open fire, Gilbert made his way to where I was sitting and passed me a slip of paper. On this was written the cryptic words "Mother has passed away; come at once". This correspondence having been filed for future reference in the adjacent snow-bank another message handed to me some nights later read "Unless you return at once, you will be disinherited". However, in view of the fact that we were completely out-of-touch with the mail service, the above notes did not impress me too deeply, but I assured Gilbert that he could start any time he cared to. However local conditions rendered resignations somewhat difficult. McMurray was many miles distant, the trip would have involved breaking trail all the way, and at the low temperatures which prevailed it was extremely doubtful whether a green man would have survived even the first night. Apart from the above the men had signed up for six months with the understanding

that payment of wages would be contingent on keeping their signed agreement. Moreover we were already short-handed, and to replace one or more men would have been difficult if not impossible. It may be added that although the conditions under which the surveys were carried out may appear somewhat primitive, we did have one amenity as represented by a snow-shovel, and each night with this we dug a circular pit in the snow. With a fire in the centre of this cosy "lounge", we formed a sort of "family circle", dried our footwear, mended our snowshoes, and indulged in such social amenities as circumstances permitted. Actually, when the surveys were completed in May, 1923, every member of the party was in excellent health and expressly desired to remain on the job as long as required.

Field exploration and further surveys were resumed in May, 1931,* and these included a geological reconnaissance (the first and only one to be made prior to 1945) of a previously unsurveyed area some four thousand square miles in extent in that part of northeastern Alberta lying south of Lake Athabasca. Mr. J.C. Sproule and Mr. Paul Schmidt acted as field assistants. Ground surveys by Dominion land surveyors within the above area had been restricted to the running of the largely obliterated 4th

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* Ref. II - 12.

Meridian, to various base lines, and to my own topographical surveys of areas adjacent to the Athabasca and Clearwater Rivers. In and subsequent to 1931, and at my insistence, extensive aerial photographic surveys of certain other areas to the east and west of the Athabasca valley were also made by the RCAF.

Marginal boundaries of the McMurray formation and of the bituminous sand itself had previously been established (by myself) on all tributary streams with the exception of Marguerite and High Hills Rivers and Reid Creek. In 1931 the boundaries were established on these remaining streams and, on a map subsequently prepared, boundaries of Precambrian, Palaeozoic and Cretaceous areas were indicated. Pleistocene deposits cover not less than 90% of the whole area.

As a whole the area may be described as an alluvial plain, much of which is covered by sand derived from Precambrian sandstone lying to the east of the 4th Meridian. However, it is well watered; except in the immediate vicinity of water courses inadequate drainage is reflected in extensive sloughs, muskeg and swamp. Rock outcrops are infrequent, but a wide variety of interesting glacial forms, frequently modified by wind action, were observed throughout the areas adjacent to the headwaters of the Richardson, Marguerite, and Firebag Rivers.

Apart from the oil sands economic resources of the area include water-fowl and grouse, fur bearers and big game. Of the latter, fur bearers constitute the most promising potential asset, and (notably along the upper reaches of Reid Creek and Marguerite River) I do not know of any area which is better adapted to the establishment of reserves for the propagation of beaver, muskrat and mink.* Certain of the larger lakes, such as Patterson Lake and Forrest Lake, which I named after two of my canoe men, may ultimately provide a basis for commercial fishing.**

Samples of oil sand were secured from outcrops on Reid Creek, Marguerite River, and between Mile 29 and Mile 56 on Firebag River. Between Mile 43 and Mile 47 on the latter river exposures appeared to indicate the presence of a large tonnage of high-grade sand, but on Reid Creek and Marguerite River, deposits appeared to be of doubtful importance. Saline and sulphur springs appeared at many points, but analyses of my samples of water indicated that the percentage of potash was relatively low. During the progress of field exploration and mining many fossils were collected and reports on these clearly indicate the age of the oil sand deposits.

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* Ref. II - 12.

** In 1937 this assumption was proved to be correct as at my suggestion commercial fishing was initiated by the McGinnis Fish Company.

Among the many other interesting features noted were extensive sand-dune areas between the Richardson and Athabasca Rivers.* Under the action of the prevailing winds Pleistocene sands originally derived from Precambrian sandstones in Saskatchewan are gradually encroaching on and obliterating forest growth. Subsequently I outlined the above situation to the proper authorities in Regina in the event that it might be possible to check the sand drifting, but no definite decision was reached. Another interesting feature was revealed by a study of aerial photographs taken by the RCAF. Certain of these photographs show clearly the presence of two series of parallel trenches extending for many miles which are apparently due to glacial action.** This phenomenon has not as yet been examined on the ground, but would provide the basis for an interesting study.

From time to time prior to 1916 I had secured fossils - notably on Hangingstone River and along the lower slopes of the Birch Mountains - which appeared to indicate that the bituminous sands were of Lower Cretaceous age. This opinion was subsequently confirmed by Dr. F.H. McLearn of the Geological Survey, Ottawa.***

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* Ref. II - 12

** Ref. II - 12.

*** Geological Survey Museum Bulletin No. 29.

As opposed to Dr. Hume and others who had expressed the view that the bitumen had derived from crude petroleum that had originated from some southerly area, I had always considered that the bitumen had originated in situ. Following a visit to the McMurray field in 1927, Mr. A. Beeby-Thompson, Chief Geologist of the Anglo Persian Oil Company, confirmed my contention.

TEST PITS

An important feature of my work during the field season of 1920 was a somewhat detailed examination of and a report on the National Parks Branch Horse River Reserve made at the request of the Director of the National Parks Branch. This report was based on shafting through overburden at twenty-one points followed by core drilling from the bottom of each shaft through the underlying oil sand. In sinking pits light pole derricks equipped with double blocks, a primitive handmade winding drum and cumbersome metal buckets were used. Seepage water was removed by a hand pump and caving was prevented by the use of light dimension timber, light poles, and rough boards. Timber and lumber were brought to the mouth of the Horse River by scow, nails were driven into the ends of each piece, and the pieces were connected to each other by bits of hay wire. With a tump line connected to the leading piece strings of lumber three to four hundred feet in length were then hauled to the required locations by men wading up the shallow river.

This method proved entirely satisfactory. At the same time a survey was made of river bottom areas and precipitous valley slopes, and a map was drawn on a scale of one inch equals two hundred feet with contour lines at ten-foot intervals.

The results of this exploration and mapping of the Horse River Reserve and of the field analyses indicated that some five million tons of commercial grade sand were available and that mining would involve the removal of some three million tons of overburden.* Furthermore it had become clear that the Horse River Reserve was the only area within reasonable distance of McMurray where bituminous sand could be mined at moderate cost. Consequently for many years it was here that much of the semi-commercial separation was later attempted. These attempts will be referred to under "Separation".

Meanwhile, requests for varying quantities of sand had been received from a number of private investigators. However, at that time no road to the Horse River Reserve was available. It was therefore necessary to obtain the required material from locations immediately adjacent to water transportation on the Athabasca River, and as a result small pits were opened on terraces adjacent to the river in Townships 89 and 93. In view of the possible deterioration

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* Subsequent estimates based on core drilling by Boyles Brothers in 1944 deviated by less than 3% from my 1920 estimate.

of the sand during lengthy delays imposed by rather sketchy transportation facilities, it appeared necessary to seal all of the containers used. For small shipments 4-gallon gasoline tins were filled and the lids soldered; for larger shipments, stout wooden casks, each of which contained about 800 pounds of sand, were used. The handling of these casks down steep declivities and the subsequent loading on small barges presented interesting problems.

A third feature of the 1920 program was a general classification of the bituminous sand areas as represented by outcrops along various streams. These areas were grouped under outcrops of possible commercial value, outcrops of doubtful commercial value, and outcrops of no commercial value. The classification was based on three factors; the thickness and character of overburden, the conditions governing disposal of overburden, and the apparent quality and estimated quantity of sand available. The classification also involved a great number of instrumental measurements and much arduous work in scaling the many precipitous cliffs and steep slopes. It is of interest to note that years of subsequent exploration have not materially altered the conclusions reached in 1920. (Owing to the absence of adequate exposures it was not until 1926 that, as a result of my drilling and close study of surface indications, I recognized the true potential importance of the Mildred Lake - Ruth Lake area).

In addition to other activities in 1924 it was possible to undertake a very limited amount of shafting. Two shallow shafts, thirty and forty-two feet in depth respectively, were sunk in Sec. 14, Tp. 89, R. 9 at a distance of 150 feet inland from the nearest river-bank exposure. In each instance heavy timbering was used, but, owing to disturbance of equilibrium within the body of sand, the greatest care was required. Heavy blocks and tackle and a hand-operated winding drum consisting of a section of a log were the principal items of equipment. Previous knowledge of the character of the bituminous sand had necessarily been based on augered samples obtained at points adjacent to outcrops. Work in the shaft was arduous and dangerous, but the results brought to light much new knowledge that could not have been obtained in any other way. In order if possible to prevent accidents and also to observe any new features that might be of interest, I usually remained at the bottom of the shaft whenever men were working.

Specific data based on the above work included information relating to:

(1) Movement due to pressure and consequent difficulty of maintaining shafts by timbering

(2) Origin of sulphur

(3) Interstratified partings and their significance

(4) Filaments of bitumen and their significance

(5) Local enrichment and depth of alteration from outcrops

(6) Instability of fresh bituminous sand

(7) Weathering of and alteration in fresh sand immediately after mining

(8) Gas sands.

As blasting in the shafts was followed by an accumulation of gas, it was necessary to ignite the gas (which at times continued to burn for several minutes) before work could be resumed. Bituminous sand had been accepted as the source of gas at Pelican Rapids and the same conclusion apparently applied to certain other areas north of Edmonton. It also appeared that partings of unimpregnated or partially impregnated material act as gas channels (Subsequently, comparative analyses were made of samples of unaltered bitumen obtained in the above shafts, of bitumen from weathered exposures, and of bitumen from Pechelbronn in Alsace-Lorraine.) At one point in one of the shafts a small seepage of bright green oil was observed, which was possibly derived from some ancient organic body.

As an indication of the attitude of men who were really interested in their work, the following comments may be added. Needless to say the clothing of the men working in the shaft was completely covered with sticky bitumen. Consequently, on reaching the surface on completion of a shift, each man simply stepped out of his overalls, left them lying on the ground nearby quite regardless of the weather, and walked to the camp a few hundred feet away. One night after the evening meal one of the boys remarked that he felt uneasy about the stability of a square set and in

company with another chap he returned to the shaft. The work, which he thought appeared to be necessary, was not completed until after eleven o'clock, but there was no suggestion of pay for overtime nor was it expected. I would also like to pay tribute to another of my men, namely, Leonard Patterson. Leonard and his two brothers had come out from England, had homesteaded near Red Deer, Alberta, and were the support of their widowed mother. On the outbreak of World War I all three brothers enlisted and served with the First Division, one being killed and Leonard being twice wounded. Incidentally, when advised to apply for a separation allowance for their mother, they declined rather than "put the Government to additional expense"! Subsequently, when hiring men in Edmonton in 1920, I called at the Veterans' Club and through the Secretary attempted to secure the required recruits. Of the many men sitting about the club only Patterson volunteered and subsequently worked with me during several field seasons. Years later (in 1935) Patterson, who always wore a heavy horsehide body support necessitated by one of his several wounds, accompanied me on a strenuous season's exploration. When we returned to McMurray in the Fall he complained of being unwell, and the local doctor at once sent him to hospital. He then told me that for some weeks he had only been able to carry on with great difficulty, but he had been determined "not to let me down". His military pension was $18.00 per month and he died some months later. Would that we had in Canada more men like Leonard Patterson!

DRILLING

In an initial report on field work undertaken in 1913, I had stated that "only after detailed exploration by means of adequate equipment, can the true commercial value of any area underlaid by bituminous sand be determined". The advisability of this procedure, which is of course common practice with respect to practically all mineral deposits, was based not only on observations in the McMurray field, but also on my observations of the variable character of similar deposits in Europe and in the United States. Between 1913 and 1925 I had repeatedly urged the Director to authorize core drilling, but it was not until 1925 that permission was granted to attempt such work. For this project the allocation for drilling equipment and for subsequent drilling costs was limited to $5,000.

As a preliminary step (when returning to Ottawa in 1926) the headquarters of the Oil Well Supply Company, Pittsburgh, Pa., and of the Longyear Drilling Company, Minneapolis, Minn., were visited. It was found, however, that there was no precedent for core drilling material having the characteristics of oil sand, and engineers of the above companies were unable to suggest equipment that would meet the unusual requirements. Nevertheless, on my own initiative, I purchased at Petrolia and shipped to the end of steel a few miles east of McMurray two strings of percussion tools (together with necessary under-reamers), drilling cable, etcetera, and also a supply of 3-inch and 4 5/8 - inch casing. This

equipment was subsequently unloaded from a work train at end of steel several miles from McMurray and discovered by us in the brush some days later. A light rotary table was also secured in order to avoid the necessity of turning by hand a variety of augers previously given to me in San Francisco. Bull-wheels and draw-works were secured from an abandoned standard Canadian drilling rig, while a portable forge and necessary hand tools together with an ancient second-hand wheeled tractor purchased for $300 completed the outfit. Three heavy tamarack poles 18 inches in diameter at the butt were cut and hauled from the nearby swamp, and a substantial and well braced 3-pole derrick 60 feet high was erected.

The above equipment was used in drilling through 111 feet of overburden. When traces of bitumen appeared on the well water, the use of a variety of augers and other extemporized cutting tools was resorted to. However, even in the richest beds of bituminous sand, partings of fine gravel, clay and other materials occurred and acted as water carriers. Since even under the action of cold water bitumen separates from unaltered sand almost immediately, it was necessary to resort to various, and at times ingenious, expedients in order to keep the well dry. The well was completed at a depth of 237 feet with a core recovery of 96.4 per cent. All cores were logged, placed in friction top tins, and later analysed. This work marked the first successful attempt ever made to core drill bituminous sand.

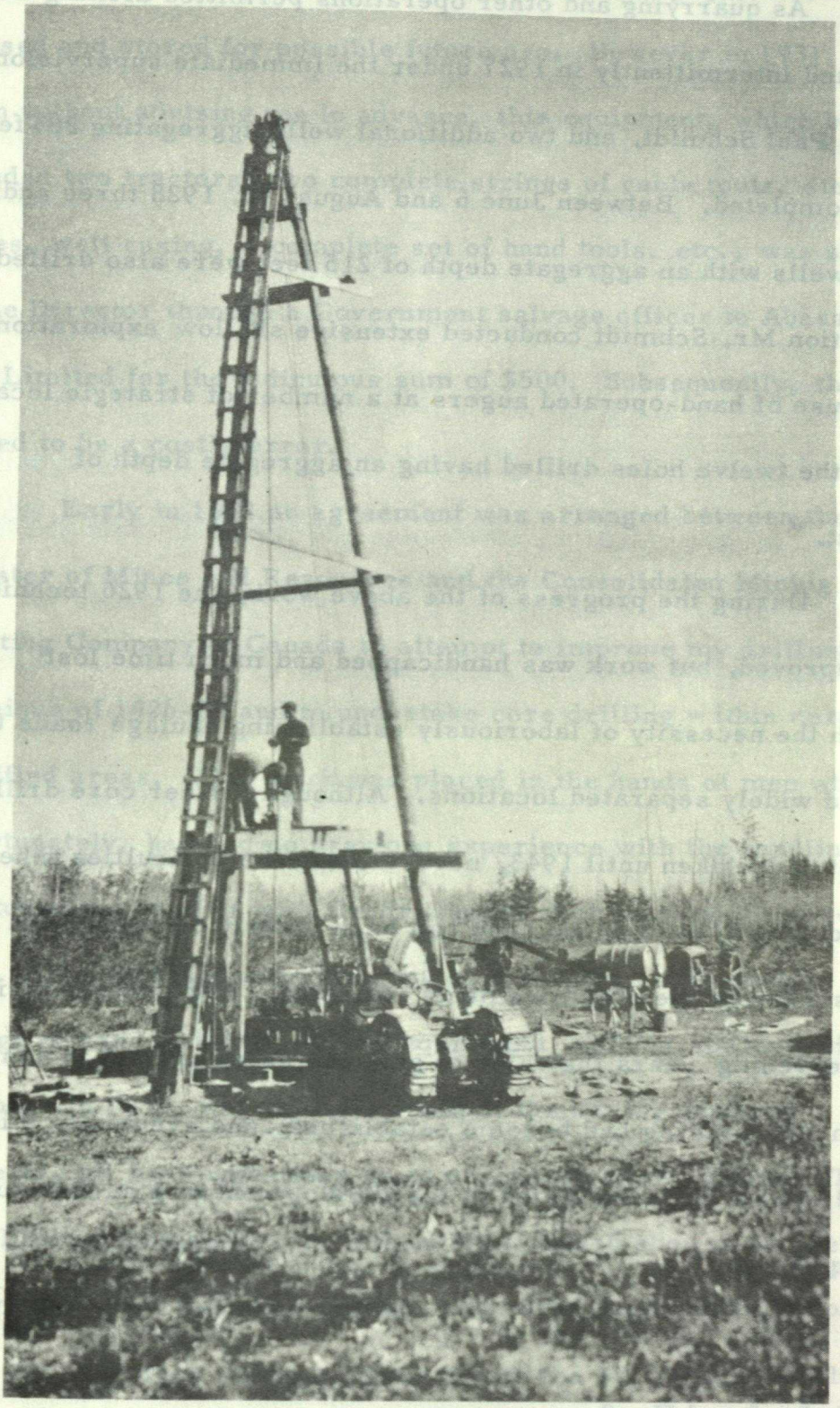

FIGURE 9. Core drilling rig used in 1926.

As quarrying and other operations permitted drilling was continued intermittently in 1927 under the immediate supervision of Mr. Paul Schmidt, and two additional wells aggregating 284 feet were completed. Between June 6 and August 11, 1928 three additional wells with an aggregate depth of 215 feet were also drilled. In addition Mr. Schmidt conducted extensive shallow explorations by the use of hand-operated augers at a number of strategic locations, the twelve holes drilled having an aggregate depth of 259 feet. *

During the progress of the above work, the 1926 technique was improved, but work was handicapped and much time lost through the necessity of laboriously establishing haulage roads to new and widely separated locations. Although further core drilling was not undertaken until 1943, nevertheless the difficulties inherent in the coring of bituminous sand had been clearly demonstrated and the basis for further improvements indicated. Fortunately during the intervening years the value of gel-mud as an adjunct in connection with drilling had become established, and eventually this proved to be a decisive factor in the development of a successful technique.

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* Ref. I - 5 and II - 8.

On the conclusion of drilling in 1928 all equipment was greased and stored for possible future use. However in 1931, and again without advising me in advance, this equipment, which by then included two tractors, two complete strings of cable tools, steel cables, well casing, a complete set of hand tools, etc., was sold by the Director through a Government salvage officer to Abasand Oils Limited for the ridiculous sum of $500. Subsequently, this proved to be a costly error.

Early in 1942 an agreement was arranged between the Minister of Mines and Resources and the Consolidated Mining and Smelting Company of Canada to attempt to improve my drilling technique of 1926-28 and to undertake core drilling within certain specified areas. This work was placed in the hands of men who, unfortunately, had had no previous experience with the handling of bituminous sand or with the drilling of such material. Moreover, although I had previously cored through a considerable footage of sand and although my equipment, sold to Abasand Oil Company in 1931, was still available at the nearby Abasand property, all my suggestions as to procedure were ignored. The very limited footage of core ultimately obtained showed an average recovery of less than 60 per cent. Following the expenditure of $135,000, a rather striking contrast with the $5,000 previously allotted for my own drilling program, the company reported as follows: "Our methods for drilling and sampling were essentially those

developed by Mr. S.C. Ells. Other drilling devices were tried out at various times but none was found to be better". Early in 1943 the agreement with the Consolidated Mining and Smelting Company was terminated and shortly thereafter a drilling contract was negotiated with Boyles Brothers Drilling Company of Vancouver. The initial contract price per foot in 1943 was approximately $8.00, but subsequently in certain areas this was reduced to $5.50. The apparent high cost was due in part to the fact that contracts initially granted were for relatively short seasonal periods. This condition involved undue expense in shutting down and re-opening camps and in moving drilling crews by air back and forth between McMurray and Vancouver.

On my recommendation initial drilling by Boyles Brothers was undertaken in the Steepbank area which occupies a triangle formed by the junction of the Athabasca and Steepbank Rivers some 22 miles north of McMurray. During the period June 17-18, 1943, with a crew of five men I established a set of commodious floored tents adjacent to the area to be drilled and on June 20, provided transportation to the campsite for the drilling crews. Meanwhile I had selected and staked locations for a number of initial holes. Actual drilling began on June 26 under the capable supervision of Mr. Lewis Swiggum. Initially, augers that I had used during previous years were employed, and the procedure adopted was very similar to that which I had evolved in 1926-28.

At that time I had attempted to use a rotating core barrel, but removal of cores from the barrels had presented difficulties.

As was the case during my own previous drilling operations, difficulty was experienced in preventing the leaching action of water on the cores. In an attempt to remedy this condition I therefore excavated a quantity of highly plastic clay from a nearby exposure which I had sampled in 1915. (See Mines Branch Bulletin No. 10, * 1915). When this material was dried and pulverized, I fed it into the drill holes. Although of necessity this was done in a somewhat haphazard manner, it served to a considerable extent to prevent leaching by protecting the core. About July 15 Mr. A.R. Campbell, General Manager of Boyles Brothers, visited our camp and discussed with me the possible use of non-rotating core barrels. When I advised him of the encouraging results which followed my use of finely divided clay, he at once decided that the use of gel-mud was indicated. The following morning Mr. Campbell flew to Vancouver and ten days later returned with a number of non-rotating core barrels and a supply of gel-mud. The use of these marked the turning point in the development of an efficient technique for the core drilling of bituminous sand and the final perfection of a method for coring this type of material. Apparently my use of

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* S.C. Ells, "Notes on Clay Deposits near McMurray, Alberta", Mines Branch Report No. 336 (Bulletin No. 10), Dept. of Mines, Ottawa (1915).

powdered clay had provided an important clue.

Originally it had been planned to restrict drilling to the Athabasca-Steepbank triangle. I had, however, become convinced during my previous exploration and limited drilling that the area lying immediately east of the Steepbank River* and also the so-called Mildred Lake - Ruth Lake area immediately west of the Athabasca River presented attractive possibilities. The maximum distance to either of these areas from the Athabasca-Steepbank triangle was not more than 1 1/2 miles, and eventually I was permitted to establish sites for initial wells in these two areas. As will be seen in the following summary the results increased the previously demonstrated tonnage of sand from approximately 3,000,000 tons to upwards of 2,000,000,000 tons and definitely confirmed my forecast. Moreover, and for the first time, it definitely proved the presence of a tonnage that would justify large-scale development on a long-term basis. Of almost equal importance, however, was the fact that responsible organizations were encouraged to acquire acreage in other areas and to undertake extensive core drilling operations.

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* See Figure 2.

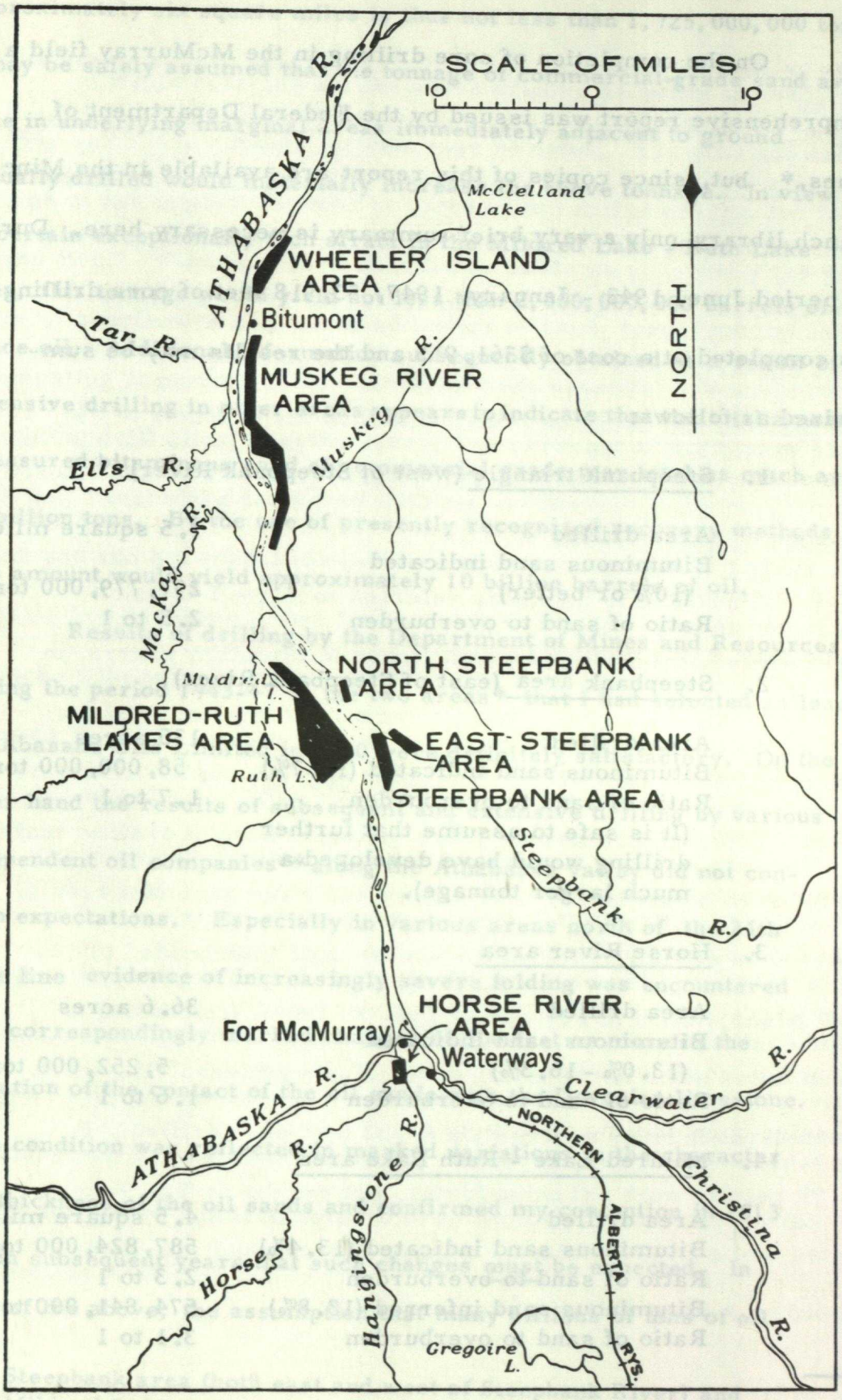

FIGURE 10. Map showing areas explored by drilling in 1943-1947 by the Mines Branch.

On the completion of core drilling in the McMurray field a comprehensive report was issued by the Federal Department of Mines,* but, since copies of this report are available in the Mines Branch library, only a very brief summary is necessary here. During the period June, 1943 - January, 1947, 53,918 feet of core drilling was completed at a cost of $361,913 and the results may be summarized as follows:

1. Steepbank triangle (west of Steepbank River)

Area drilled	1.5 square miles
Bituminous sand indicated (10% or better)	297,779,000 tons
Ratio of sand to overburden	2.5 to 1

2. Steepbank area (east of Steepbank River)

Area drilled	135 acres
Bituminous sand indicated (12.7%)	58,000,000 tons
Ratio of sand to overburden (It is safe to assume that further drilling would have developed a much larger tonnage).	1.7 to 1

3. Horse River area

Area drilled	36.6 acres
Bituminous sand indicated (13.0% - 16.3%)	5,252,000 tons
Ratio of sand to overburden	1.6 to 1

4. Mildred Lake - Ruth Lake area

Area drilled	4.5 square miles
Bituminous sand indicated (13.4%)	587,824,000 tons
Ratio of sand to overburden	2.3 to 1
Bituminous sand inferred (13.8%)	574,841,000 tons
Ratio of sand to overburden	3.1 to 1

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* "Drilling and Sampling Bituminous Sands of Northern Alberta", Results of Investigations 1942-1947 (three volumes), Mines Branch Report No. 826, Dept. of Mines and Tech. Surveys, Ottawa (1949).

The total bituminous sand indicated within areas aggregating approximately six square miles is thus not less than 1,725,000,000 tons. I may be safely assumed that the tonnage of commercial-grade sand available in underlying marginal areas immediately adjacent to ground actually drilled would materially increase the above tonnage. In view of certain exceptionally rich strata in the Mildred Lake - Ruth Lake area, this tonnage would yield not less than 2,000,000,000 barrels of crude oil. Additional information subsequently obtained as a result of extensive drilling in other areas appears to indicate that the total amount of assured bituminous sand of commercial grade may total as much as 10 billion tons. By the use of presently recognized recovery methods this amount would yield approximately 10 billion barrels of oil.

Results of drilling by the Department of Mines and Resources during the period 1943-47 in the two areas* that I had selected as leases for Abasand Oils Limited in 1930 were definitely satisfactory. On the other hand the results of subsequent and extensive drilling by various independent oil companies** along the Athabasca valley did not confirm expectations. Especially in various areas north of the 24th base line evidence of increasingly severe folding was encountered with correspondingly marked changes of 400 feet or more in the elevation of the contact of the oil sands with the Devonian limestone. This condition was reflected in marked variations in the character and thickness of the oil sands and confirmed my contention in 1913 and in subsequent years that such changes must be expected. In view of the above, the assumption that many billions of tons of oil

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* Steepbank area (both east and west of Steepbank River) and Mildred Lake-Ruth Lake area.

** Organizations included Ponder Oils, Sun Oil, Calvan Oil and Gas, Shell Oil, Bear, Socany, Hub City Drilling Company (Simpson Brothers) and also by L.R. Champion in the area adjacent to Bitumount.

sands of commercial grade are available appears to be entirely unfounded. It is of interest to note that in 1915 I had stated that not more than 5% of an area of some 1,200 square miles represented by outcrops could be considered of potential economic importance. Thereupon one of the active promoters wrote to the Minister of Mines and Resources to the effect that I was incompetent to discuss such matters and demanded that I withdraw my estimate of 5%. I promptly advised the Minister that I would gladly do so and altered the above estimate to 3%.

In addition to the areas referred to above I had also recommended that drilling be undertaken in two other areas. In one of these that occupies a triangle north of the junction of the Muskeg and Athabasca Rivers four holes aggregating 547 feet were drilled. Although in previous years my excavation of shallow test pits followed by the use of hand augers had given excellent results, deeper core drilling revealed the presence of interbedded clays. Other areas drilled in 1946 lie in Tps. 95 and 96 from three to fifteen miles north of the mouth of the Muskeg River; fifty three reconnaissance holes aggregating 8,452 feet were drilled. In Tp. 95 results were not encouraging, but results in Tp. 96 indicated that an undetermined tonnage of good sand may be developed by further drilling.

While carrying out the above drilling program in 1943, 1944, and 1945, another incident may be noted. The possible economic value of any deposit depends in part on the ratio of overburden to the sand itself. Consequently, in order to estimate accurately the yardage of overburden above drilled bodies of sand, topographical surveys indicating accurate surface contours were essential. In addition to locating drill sites, logging cores, and carrying on necessary supervision, I therefore attempted with the assistance of one man to cut line and run out accurate contours. Later I was able to engage three Indian boys ranging in age from twelve to fourteen years. Moreover much of the terrain to be contoured had been burned over, and as a result it was necessary to climb over or through a great deal of tangled blowdown. This, in addition to precipitous ravines, made the carrying of a 25-pound transit instrument a rather onerous matter for one sixty-seven years of age, and I finally requested Ottawa to send me a surveyor. In due course the "surveyor" arrived (having travelled first class from Ottawa), but when I outlined his work to my amazement he advised me that he had never run a transit. I therefore put my new "surveyor" on the line as an axe-man along with the native children noted above, and continued to do the instrument work myself.

Finally, when completing certain detailed topographical surveys at the close of the season in October, 1945, it became necessary to traverse the margin of an extensive hay meadow and lake which would obviously be the disposal site for overburden should commercial development be undertaken in the Steepbank area. This involved standing in cold water, for the most part ankle to knee deep, for a period of three days (during which time my young surveyor loafed about the camp), and as unfortunately there is a limit to what a human being can stand, this brought on a severe attack of sciatica. As a result I had to be carried down to our power boat and thence to McMurray. At McMurray, while waiting for a train to take me to Edmonton, I went to the hotel and, as I was unable to dress or undress myself or to go downstairs, a friendly bartender brought up my meals and looked after me. Later, after five sleepless nights of pain (maximum doses of morphine having had no effect) I moved to the small local hospital and two days later left for Edmonton. Meanwhile my retirement on pension had been approved, and in November, 1945 I ended my service with the Department of Mines and Technical Surveys.

SEPARATION AND REFINING

Work by Other Investigators

Previous to 1915 my attention had been directed to exploration and to the mining of a shipment of oil sand for a demonstration pavement.

In 1913, however, I had indicated the obvious desirability of attempting to develop a process for the recovery of bitumen from Alberta bituminous sand, and prior to 1920 had secured a considerable amount of information with respect to previous efforts which had been made in certain foreign countries to develop such a process. In Hungary, Spain, Italy, Southern France, and Nigeria the methods used had proved to be commercially impracticable. On the other hand, during the latter part of the 19th century appreciable quantities of impure bitumen had been derived from bituminous sand deposits in the Volga valley and at other points in Russia by the use of heated water and repeated decantations. In the United States I had visited in 1913 sites of ten plants, large and small, at which separation had been attempted between 1890 and 1910. In every instance only scattered pieces of equipment remained, but with the assistance of former local employees it had been possible to reconstruct on paper the plants as they had originally stood. With three exceptions the methods adopted and the equipment used had nullified any possible chance of commercial success, these exceptions being at Carpinteria and at Sisquoe in California and at Cline in Texas.

At Carpinteria the bituminous sand mined resembled very closely that found in the McMurray field, and separation by the use of heated water had met with some success. Plant construction prior to 1896 had involved a reported expenditure of some $300,000, but operations ceased about 1899. At Sisquoe, where the material treated was a rather hard bitumenized sandstone, a petroleum distillate had been used as a solvent, and I was informed that expenditures on plant and equipment had amounted to approximately $1,000,000. Operations were abandoned prior to 1901. At each of the above plants only at the outset were costs on a competitive basis with increasing productions of refinery asphalt. At Cline, Texas, during the period 1890-93 the Litho-carbon Company undertook to develop a process for the treatment of bituminous limestone containing from 12 to 15% of bitumen. Extraction was effected by the use of petroleum distillate, and operations were under the direction of the late Mr. H. A. Frasch. Throughput of the plant was 100 tons of limestone per 24 hours, and operating costs including mining were $1.36 per ton of ore treated. In 1913 Mr. Frasch prepared for me a lengthy statement regarding the above operation, and from this it appeared that the closing of the plant was due to causes quite apart from plant operation. It is of practical interest to note that, with an eye to the future, the Union Oil Company of California became interested in the ultimate importance which might be attached to oil sands as a possible source of crude petroleum. As a result between

1940 and 1943 the company core drilled an area some three hundred acres in extent in the Sisquoe district and also undertook a laboratory investigation to develop a separation process.

Late in the evening of September 24, 1914, a native returning from Athabasca Landing was attracted to our camp fire on Horse River. His rather garbled story was the first intimation that a war had been declared on August 4 and that many Canadians had volunteered for active service. Some two weeks later carrying a minimum of equipment my party set out for Lac la Biche. Early snow had fallen and for much of the distance (170 miles) there was only a sketchy trail. The trip occupied six days. On reaching Ottawa on October 17, I enlisted with the 23rd Battery, Royal Canadian Field Artillery, and was gazetted a lieutenant in February, 1915. I then proceeded to Toronto and under the supervision of the late Joseph Keele carried out complete tests of a number of clay samples from the McMurray area*. I also opened a recruiting office adjacent to the ceramic laboratory and recruited 130 men for our battery.

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* S. C. Ells, "Notes on Clay Deposits near McMurray, Alberta", Mines Branch Report No. 336, Department of Mines, Ottawa (1915).

Investigations at Mellon Institute

In 1914 my investigation of the oil sands had come to the attention of the authorities of the Mellon Institute of Industrial Research, Pittsburgh, Pa., and in January, 1915 the (then) director of that famous organization, Dr. Raymond F. Bacon, had written to the Ottawa authorities suggesting that I be given an opportunity to study the separation problem at the laboratories of the Institute. Laboratory facilities were to be provided without charge and also such assistance as the Institute's technical staff might be able to give. In due course, having notified the commanding officer of my battery that I would be available for overseas service on twenty four hours notice, I proceeded to Pittsburgh.

At that time some fifty or more research fellows, each assisted by from one to a dozen assistants, were engaged on a wide variety of investigations, and I was deeply impressed by their earnest and at times almost fanatical enthusiasm. It was not unusual for some to carry on their work through seven days each week, and in some instances from 8:30 in the morning until well into the night. Another notable feature was their almost unfailing willingness to lend any assistance possible to those engaged in other fellowships in adjacent laboratories.

At the Mellon Institute as a preliminary step* in dealing with the separation problem, I determined the relative efficiency of a

* Ref. I - 3.

variety of petroleum distillates and also of such chemical solvents as were commercially available at reasonable cost. As a result of my interviews with technicians at the Fletcher Works in Philadelphia, the possible use of various types of centrifuges was also studied but with discouraging results. This was followed by the use of heated water in both open and closed apparatus, the latter under pressures ranging up to 96 pounds per square inch, which gave a corresponding range in water temperatures of up to 325°F. By the use of pressure apparatus ebullition at temperatures above 212°F was avoided, and conditions were favourable for the settling out of clean sand. Eventually three types of flotation cells were secured or constructed, and separation attempted by the use of heated water both with and without the addition of varying percentages of acidic or alkaline reagents. Officials of the Mellon Institute advised me to apply for patents but no action was taken.

Investigation of Various Uses for the Separated Bitumen

At the outset it was necessary to assume certain possible commercial uses for the partially or wholly purified bitumen. Among these were included the following uses: as an asphalt cement binder in connection with paving construction in the preparation of asphalt mastic, as a binder for briquetting of certain fuels, and as an ingredient in the manufacture of paints, varnishes, roofing materials and certain other commercial products. Subsequent to 1932, tests of separated McMurray bitumen were

carried out for me by various commercial organizations. In order to determine the value of separated bitumen for a variety of uses, and following my representations to the Director of the Mines Branch in 1931, I was permitted to send samples of the material to a number of Canadian manufacturers. Shipments varied from 50 pounds to 2 tons, and were blown to various specifications in order to meet requirements in each individual case. Among the consignees to whom the bitumen was sent were the following: the Dunlop Tire Company, Toronto; the Canadian General Electric Company, Peterborough; the Imperial Paint and Varnish Company, Toronto; the Brantford Roofing Company, Brantford; and the Vulcan Asphalt and Supply Company, Toronto. In each case the outcome of tests made by the above organizations was so satisfactory that certain companies were prepared to pay a premium of as much as ten dollars per ton, above the current price for refinery asphalt. The Chief Chemist of the Dunlop Tire Company remarked to me: "Why don't you make the bitumen available to us commercially?" The above confirmed my earlier assumption in 1915. It may be noted that in 1931 the Vulcan Asphalt and Supply Company developed an asphalt mastic in which separated bitumen was incorporated, and demonstration surfaces were successfully laid in one of the departmental buildings in Ottawa.

Refining by Hydrogenation

As early as the period 1920-30 attention was already focusing on the refining of the separated bitumen. There was some testing in the United States, England, and Germany at the instigation of the Department. I was involved in many of the arrangements and I recall the discussions and correspondence with Dr. Bergius, the originator of the hydrogenation process in Germany, on the merits of this process for the production of petroleum products of quality.

In 1930 the investigation of the use of the hydrogenation process for the production of liquid fuels from the bitumen was initiated by Mr. B.F. Haanel, Chief of the Fuels Division. The work was carried out under the supervision of Dr. T.E. Warren and the results have been published in various reports.

In Situ Recovery

Apart from inconclusive results obtained by the Bituminous Sand Extraction Company, plans to recover bitumen by in situ methods exist only on paper. Obviously such recovery would greatly increase the potential production in the McMurray field by eliminating the necessity of removing heavy overburden. However, the low heat conductivity of the sand would constitute an adverse factor.

Visits which I had made (at my own expense) to properties of the Texas Gulf Sulphur Company and of the Freeport Sulphur Company prior to 1925 had suggested the possible use of the Frasch Sulphur Process. Mr. Frasch had previously told me of the long

and costly experimental work which had finally been crowned by success, and it was obvious that attempts to adopt such a process in the McMurray field would require strong financial backing. The superintendent of one of the major sulphur companies in the Texas Gulf field was, however, sufficiently impressed by the possibilities of such an attempt to volunteer to visit the McMurray field. So interested was he in the problem that the only stipulation made was that his expenses be paid. However, no action was taken.

One of the obvious difficulties presented by the adaptation of the Frasch sulphur process to the Alberta sands would be the maintenance of the concentric pipes in such unstable material. Therefore, in 1936 I drafted on paper a possible alternative plan. This plan was based on tunnelling into the underlying limestone, establishing a series of raises through the roofs of tunnels and crosscuts, and attacking the bituminous sand by the use of powerful jets of water. Dislodged and disintegrated material would then be sluiced to tunnel adits by the use of specially designed launders which would possibly be provided with double or triple bottoms. Appreciable separation would take place during this stage of treatment, and further treatment would be in the nature of a "clean-up" in a surface plant operation. The cost of a preliminary test of this method was conservatively estimated at $10,000, but the results of subsequent core drilling in 1945-48 appear to definitely discount the practical value of the method.

Separation of Bitumen from the Bituminous Sands

Between 1915 and 1924, attempts were made in the McMurray field to recover bitumen from the sands. On various occasions I had been asked by operators to inspect the methods being used and to comment on their possibilities. With three possible exceptions the procedure adopted had no possible chance of success.

In 1920, and on my recommendation, General W. B. Lindsay and his associate Mr. Spence-Thomas of Swansea, Wales had been granted a lease on the Horse River Reserve and they attempted to develop a separation process. Unfortunately, experimental work was undertaken near Swansea, and under instructions from Ottawa I mined and shipped overseas some forty tons of sand in sacks. As this quantity proved to be inadequate for experimental separation, their attention was chiefly directed to the refining of a heavy crude somewhat similar to McMurray bitumen and which had been obtained from the Middle East. It was stated that the expenditures on experimental work amounted to approximately $800,000, but following the death of General Lindsay the investigation was abandoned. Other investigations being carried on at that time in the McMurray field were those of the Bituminous Sand Extraction Company and the Georgeson Extraction Company.

In 1927 I had interested Mr. R.D. Canfield, President of the Altapave Manufacturing Company of Oakland, California, in the McMurray field, and on my recommendation he was given a provisional lease on the Horse River Reserve. Although no actual development of the sands was undertaken by Canfield, nevertheless he was the first to initiate the clearing of forest growth from the reserve. On my recommendation his lease was cancelled in 1929.

Subsequent to 1924 other organizations and one individual attempted the development of a separation process. These have included Abasand Oils Limited, the Alcan Oil Company, the International Bitumen Company, Oil Sands Limited, the Research Council of Alberta, the National Research Council, Ottawa, and Mr. Charles Gower of Regina. Brief references will be made to the operations by each of the above.

Separation by Mr. Charles Gower

During the period 1931-41 Mr. Charles Gower of Regina conducted an investigation of the possibility of recovering bitumen from bituminous sand by the use of a petroleum distillate. Following a study of the procedures adopted by other investigators Mr. Gower designed, installed, and operated small scale separating and refining units at Regina. In spite of the fact that the samples of the bituminous sand had been mined many months previously and had therefore become weathered and less amenable to treatment, Mr. Gower stated that the results of the plant operation were satisfactory.

Whereas other investigators had first subjected the sand to the action of heated water with or without the subsequent use of a solvent, Mr. Gower reversed this procedure by first subjecting the sand to the action of the solvent. Treatment of the tailings from this operation was effected by a simple form of water flotation. The quantity of solvent used was large, but it was claimed that recovery of the solvent was almost complete and was relatively inexpensive.

National Research Council at Ottawa

Subsequent to 1947 Dr. P.E. Gishler of the National Research Council conducted important studies in connection with the fluidized processing of the bituminous sand or the separated bitumen to produce a distillate free of water and solid matter. Information with respect to the methods adopted and the results obtained may be secured from the National Research Council, Ottawa*.

Abasand Oils Limited

At the request of Mr. Max W. Ball I visited Denver, Colorado in 1929, and during a stay of three days discussed with him and his associates the possible development of Alberta bituminous sands. As will be seen, this visit was to have far-reaching

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* P.E. Gishler, "The Fluidization Technique applied to Direct Distillation of Oil from Bituminous Sand", Canadian Journal of Research, F.27, 104-111 (March 1949), and W.S. Peterson and P.E. Gishler, "A Small Fluidized Solids Pilot Plant for the Direct Distillation of Oil from Alberta Bituminous Sand", N.R.C. No. 1987, National Research Council, Ottawa, Canada, 1949.

results, and it marked an important turning point in the history of the Alberta deposit.

Mr. Ball came to Ottawa early in 1930, and as a result of conferences with the Minister of Mines and the Director of National Parks was granted on my recommendation a lease on the Horse River Reserve. In addition he was given authority to select six square miles of potential bituminous sand acreage under binding conditions with respect to development. At that time Mr. Ball had not visited the McMurray field, and I was the only person sufficiently conversant with the area to make selections for him of what might prove to be promising ground. Yet in spite of the obvious fact that the making of such selections would be a decisive factor which might determine either success or failure, the Minister declined Mr. Ball's request for my assistance as a consultant. Such was the situation when I departed for the Athabasca country in the spring of 1932.

The sequel of the Minister's refusal is interesting. About 4 a.m. one day some weeks later the Hudson's Bay Company's steamer crept close in to the shore through dense morning mist. Repeated blasts of the whistle brought me hurrying down to the shore just as a heavily weighted package thrown from the steamer's bridge splashed in the mud nearby. The package contained a wire from the Minister instructing me to return immediately to Ottawa and select the Ball acreage.

At that time only a very limited amount of core drilling had been done, and it was only after sixteen days of intensive study and many revisions that final selection of the required acreage was completed. Incidentally, these selections included what appeared to be desirable acreage in the Steepbank and the Mildred Lake - Ruth Lake areas.

In 1930 a company known as Canadian Northern Oil Sands Products Limited had been organized by Mr. Ball, but this name was later changed to Abasand Oils Limited. Prior to 1939 expenditures by the Company had exceeded $500,000, and by 1942 had reached a total of not less than $1,000,000. During the period 1931-35 the Company's efforts had been directed to laboratory studies of a separation process, first at Denver and later at Toronto, under the able direction of the late J.M. McClave, and to his untiring efforts must be attributed much of the success which was subsequently achieved. At the same time research in connection with the recovery of petroleum fractions from the separated bitumen was carried on by qualified technicians of Mr. Ball's staff. Finally in December, 1935 plans were completed for the construction of a 250-ton separation and refining unit on Horse River, and a year later this pilot plant was completed. Subsequent operations indicated the necessity for important modifications, and in 1937 construction of a second separation unit with a capacity of 400 tons of sand per day was commenced. Following a series

of unavoidable delays this plant was completed in the Fall of 1940, and a haulage road and a pipe line connection were established between the plant and the railway terminus at Waterways. The above operations had been courageously carried out in the face of prejudice and skepticism, and during a period of the depression when financing had presented exceptional difficulties.

Meanwhile the problem of mining had been considered and a shale planer had been installed. Although the planer was well adapted to excavating shale, sand abrasion of moving parts and breakages due to the presence of pyritic nodules proved to be excessive, and consequently the use of the planer was discontinued. Thereafter light blasting and the use of a power shovel were adopted with satisfactory results. Nevertheless, although repairs to the planer had reduced efficiency at the quarry by an estimated 50%, nineteen thousand tons of sand were mined and seventeen thousand barrels of bitumen produced during the period May 19 to September 30, 1941, and this was subsequently processed to yield gasoline, diesel oil, fuel oil, and coke. Although corrosive sulphur had been removed from the gasoline, arbitrary specifications prohibited its sale locally. It was, however, used with entirely satisfactory results in motor cars and motor boats belonging to company employees. The diesel oil produced was of good quality, and the entire production was purchased by the Consolidated Mining and Smelting Company. The fuel oil and coke were burned under the boilers of

the power house. In November, 1941 the Abasand plant was destroyed by fire, was rebuilt in 1942, and in spite of many delays necessitated by adjustments it treated more than 11,000 tons of sand during a period of less than three months between August and October. In the operation of the plant the recovery of the bitumen exceeded 99%.

The operation of the power plant had involved the importation of an appreciable quantity of coal at a laid down cost of about $35 per ton. Even at the plant of the Alberta Salt Company immediately adjacent to the railway at Waterways, the use of natural gas at 60 cents per thousand cubic feet would have proved more economical than coal. Meanwhile over a period of many years I had maintained that adequate supplies of natural gas could be secured within a reasonably short distance of McMurray, and on my representations in 1944 I was permitted to blaze a trail and to locate three well sites for initial drilling at points approximately twelve miles to the south of the Abasand plant. I also made surveys for pipe line connections to other points of potential consumption. Although the depth of the gas-bearing strata would not have exceeded four hundred feet of inexpensive drilling and although the Alberta Salt Company had agreed to bear a proportional share of the cost, no further action was taken. It was considered by competent authorities that the cost of delivering gas to the Abasand plant would not have exceeded ten cents per thousand cubic feet.

At this point reference may be made to the development of salt deposits at Waterways. About 1930 a promoter had attempted to interest me in a certain mining proposition in Eastern Canada, but I had advised him that development of the property that he had in mind had no possible chance of success. The promoter had already secured a considerable sum of money for development of the above property, and I suggested that he switch his available funds to the McMurray field. I indicated by townships and sections a potential salt area for which he could file applications and I marked on the map the position for an initial exploratory well. Subsequently, on the strength of representations which I made personally to the late Mr. Charles Ross, Minister of Mines for the Province of Alberta, the leases were granted and the initial well subsequently drilled intersected a two-hundred-foot bed of excellent rock salt at a relatively shallow depth. The subsequent successful history of commercial production by the Alberta Salt Company requires no comment. Operations which had been handicapped by excessive freight rates were however discontinued some three years later following the discovery of other salt deposits nearer to centres of population.

Meanwhile the desirability of changes in the flow-sheet of the Abasand plant had become apparent, but a serious problem was presented by the necessity for further financing. As a result, and especially in view of increasing demands for petroleum products imposed by the war, the Dominion Government through the Department

of Mines and Resources took over the Abasand property in April, 1943. The existing separation and refining units were to be retained as a test plant by the Dominion Government, but Abasand Oils retained the right to again take over the property should the Government decide to abandon the project.

As previously indicated, an agreement had been made by the Rt. Hon. C.D. Howe, Minister of Trade and Commerce, in 1942 with the Consolidated Mining and Smelting Company to undertake core drilling and to conduct certain test runs at the Abasand plant. No results having been achieved, the above agreement was terminated some twelve months later. It was then decided to redesign and reconstruct the Abasand separating and refining units and on October 1, 1943 this work was officially taken over by the General Engineering Company (Canada). In June, 1944 the first unit of the revised separation plant was completed. It had a nominal capacity of 100 to 115 tons of sand per twenty-four hours, and still retained what was essentially the McClave process. Early in 1945 a second separation unit was completed and this included certain modifications, notably with respect to temperatures in the pulpers and the use of Geco flotation equipment. These two units were regarded as experimental and the results of the operations were embodied in the design of a larger experimental-production plant with an estimated throughput capacity of 500 tons per day. It was claimed that the new plant embodied definite advances

in separation practice, but the validity of this claim is open to question. However, on June 15, 1945, the separation plant and other essential buildings were destroyed by a fire, and further operations ceased. Although a company fire brigade had been organized, a dam and storage pond installed, and water outlets provided throughout the plant, the pumps had not been kept in repair and as a result no water was available with which to fight the fire.

During the period of the General Engineering Company operation approximately 19,500 tons of sand were treated between September, 1944 and June, 1945, and it is believed that production of bitumen amounted to 16,700 barrels. Total expenditures as of June 15, 1945 have been placed at approximately $2,000,000*.

Research Council of Alberta

In 1930 Dr. K.A. Clark installed and operated an experimental separation unit on the Clearwater River**. This plant had a throughput capacity of two and one half tons of sand per hour; eight hundred tons were treated, and 15,000 gallons of bitumen produced. A considerable quantity of this product (containing 0.5% of water and 4% of mineral matter) was subsequently combined with aggregate

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* My own total allocations for work carried out during the period 1913-41 did not exceed $140,000.

** K.A. Clark, "Athabasca Oil Sands; Historical Review and Summary of Technical Data", 1959, and K.A. Clark and D.S. Pasterneck, Eleventh Annual Report, Research Council of Alberta, Edmonton, pp. 41-62 (1931).

in my paving plant at Edmonton* and used in the laying of various types of pavement.

Alcan Oil Company

Seepages of bitumen along the eastern shore of the Athabasca River in townships 96 and 97, Range 10, and analyses of my samples secured in 1914 had indicated the possibility of an important deposit of oil sands and prior to 1922 extensive acreage in this area had been acquired by a group of New York City police under the name of Alcan Oil Company. This company had opened up several miles of haulage roads and had drilled two wells that encountered rich oil sands. On one occasion, when returning from Richardson River and at the request of the company, I visited the well sites and scraped eight gallons of almost pure (98.4%) bitumen from a single lift of 4-inch drilling bit. I suggested that heated water be pumped into the well in order to stimulate separation, but a heavy inflow of cold water prevented the achievement of the desired results.

International Bitumen Company

In 1923 the Alcan leases were acquired by R. C. Fitzsimmons, and thereafter during each summer prior to 1929 he continued exploration supplemented by drilling. In 1929 he opened up a small pit, installed a make-shift hot water separation unit (at a reported cost of less than fifty dollars for materials), and subsequently recovered 8,400

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* Ref. I - 6.

gallons of bitumen containing 0.2% water and 3.9% mineral matter. Meanwhile in 1930 as a result of his efforts a post office under the name "Bitumount" had been established nearby in township 96.

During several subsequent years Fitzsimmons constructed a new and enlarged plant* together with a pipe-still and flash chamber, introduced improved mining procedure, and recovered a substantial quantity of bitumen**. Much of the bitumen was shipped to Edmonton and used in the waterproofing of roofs. An additional quantity in suitable containers was also disposed of through the Marshall-Wells organization. As a result of these operations credit must be given to Fitzsimmons for the pioneering of commercial production from the oil sands.

Oil Sands Limited

Subsequent to 1941 I had no contacts directly with operations at Bitumount, and the following brief comment is based on information made available by Dr. K.A. Clark.

Prior to 1941 expenditures by the International Bitumen Company had been not less than $300,000. In 1942, however, due to the lack of further financial support the company's separation

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* Ref. II - 13, p. 135-9.

** Rated capacity of the plant was twenty barrels of bitumen per ten hours. The bitumen had a water content of 0.4% and a mineral matter content of 4%.

plant together with the saw mill, sending and receiving radio equipment and various auxiliary buildings were purchased by L. R. Champion, and the name of the organization was changed to Oil Sands Limited.

In 1944 the Alberta government* authorized the expenditure of $250,000 and entered into an agreement with Oil Sands Limited for the construction of a separation plant on the lease of this company at Bitumount. This amount was later increased to $500,000. The company agreed to pay all amounts by which the cost exceeded $500,000 and further to administer the construction and operation of the above project. Rising costs of material and labour forced construction costs above the original estimates and the company was unable to raise the money to meet their obligations under the contract. In 1948 legal action by the government resulted in cancellation of the contract and the obtainment by the government of the sole ownership of the plant.

The design of the plant was the responsibility of Oil Sands. The flow-sheet of the hot water separation unit was based on the method devised by the Research Council of Alberta. During the design of the plant the Research Council worked on special problems connected with the separation especially on the cleaning and drying of the separated oil.

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* Annual Reports of the Research Council of Alberta, 25th, 1944 to 33rd, 1952 inclusive, Research Council of Alberta, Edmonton.

The construction and subsequent operation of the plant was under the supervision of Mr. W.E. Adkins, an engineer employed by Oil Sands Limited. The plant was completed early in 1949 and was operated during the summer of that year. The Research Council of Alberta equipped and operated the laboratory.

In processing the bituminous sand* the bitumen was separated by means of hot water and, after settling, an oil diluent was added to the product. After further settling, the product was dehydrated and fractionated, the diluent being recovered. The dry, diluted, separated crude oil contained about 2.5 per cent of mineral matter.

The results of the operation of the plant demonstrated that the process was technically feasible. In 1950 Mr. S.M. Blair was retained by the Board of Trustees of the Alberta Government Oil Sands Project to undertake a survey to determine the best sequence of operations and the economic feasibility of producing saleable oil products from the bituminous sands. In his report** published in December 1950, Blair showed that the total cost of producing a barrel of hydrogenated coker distillate similar to No. 2 grade fuel oil and delivering it to the Great Lakes market was $3.10. The market value of the oil at that time was $3.50 per barrel. In September, 1951 the Board of Trustees of the Oil

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* "Report to the Board of Trustees on the Oil Sand Project from Inception to December 31, 1948", prepared by the staff of Oil Sands Project.

** S.M. Blair, "Report on the Alberta Bituminous Sands", Government of the Province of Alberta, Edmonton, December, 1950.

Sands Project sponsored the Athabasca Oil Sands Conference which was held in Edmonton. As a result of the conference a number of commercial companies became interested in the development of the bituminous sands.

In 1953 the Alberta Government attempted to sell the plant, and ultimately it was purchased by Can-Amera Oil Sand Development Company and between 1955 and 1959, that Company in co-operation with various other organizations initiated sporadic operations. At the present time (January, 1961) subsequent to the development of important oil production in Western Canada, I expressed the view that commercial development of the oil sands should be deferred. The following summary of crude oil production and of indicated reserves in 1960* appears to substantiate the above view.

	Production	Estimated Reserves
Manitoba	4,750,000 bbls.	20,750,000 bbls.
Saskatchewan	52,107,000 "	502,078,000 "
Alberta	131,887,000 "	3,051,192,000 "
British Columbia	869,000 "	44,956,000 "
	189,613,000 bbls.	3,618,976,000 bbls.

It appears reasonable to assume that future increases in presently estimated reserves will ensure adequate production for at least 30 years.

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* Statistical Year Book, Canadian Petroleum Association, 1960.

IN RETROSPECT

On entering large industrial centres we accept as part of the natural order of things the great factories with their stacks and sky signs which we see on every hand. Although these factories supply conveniences and luxuries which are regarded as essential to every day life, how many of us pause to realize what each of them represents. Most of them represent years and sometimes scores of years of efforts by men, many of whose names have never been heard. They represent the successful solution of problems by the mechanical engineer and by the chemical engineer, problems of marketing and problems of financing through the working out of which ultimate success has been achieved.

In 1913 a great and potentially valuable natural resource in the northern part of the province of Alberta lay dormant and unknown while even the surface of the country was unsurveyed. Yet as a result of investigations in the field and in the laboratory, the outcome may ultimately be reflected in important commercial development. Where now the almost unbroken wilderness holds sway, industrial plants may arise and tall stacks dominate the landscape. Few will then pause to consider what these developments represent, but success will be the reward of those who had a part in the undertaking. It has been claimed that Canada's awakening north represents the greatest frontier remaining in the free world, and that the effect of its development on the future of

industry and on the North American economy challenges the imagination. In due course and when necessity arises, commercial development of the Alberta bituminous sand will play its part in answering the challenge.

At this point it is appropriate to give credit to those individuals and organizations who pioneered in the past towards the development of the bituminous sand. These include R. C. Fitzsimmons of the International Bitumen Company in the twenties, the late Max W. Ball of Abasand Oils Limited during the period 1935 to 1942, and Mr. W. E. Adkins of the Alberta Government Oil Sands Project in 1949. These men and their organizations made a substantial contribution in the mining, separation and refining operations on a semi-commercial scale. As an indication of mutual esteem between contemporaries in the same field, the late Max Ball, who I consider to have been one of the leading U.S. authorities on petroleum and natural gas, made the following statement in New York in 1950: "S. C. Ells may well be called the father of the Alberta bituminous sand research and development. He made the first systematic study of the deposits and the first - and as yet the only - comprehensive maps of the area in which they lie. He made the first systematic study of methods for separating the bitumen from the sands. He first developed and demonstrated the principal of hot water separation through pulping the bituminous sands and recovering the separated bitumen in a flotation cell. For thirty-five years in the face of indifference and skepticism, he has been the courageous and unremitting advocate of the value and importance of the bituminous sand deposits."

During the progress of work in the McMurray field many interesting features have come to light. Among these as a single instance, my excavation of ancient fossil wood during the period 1915-27 may be mentioned. While the bituminous sands were being deposited, trees and other water-borne driftwood, even as they do today, collected in eddies and on bars. Buried in the accumulating sands and insulated by the associated bitumen or oil, after many millions of years this wood is still well preserved and in some instances may be readily sliced with a knife. One interesting sample consisted of a log among the roots of which there still remained imbedded a mass of clay approximately two hundred pounds in weight. It requires little imagination to envisage this 100-million year old episode; a tree overhanging some northern stream, the current undercutting a clay bank, the tree with soil still adhering to its roots finally falling and being carried by the current to its present resting place. And now after thousands of centuries the curtain is lifted again. The log once more emerges from its long oblivion, and in the hands of experts becomes one more tangible link with an epoch long before the dawn of recorded history. From an examination of specimens, which I submitted to Dr. I. W. Bailey of Harvard University, it appears that one of the trees, a gymnosperm, is entirely unlike any genus found in North America at the present time. On the other hand it most closely resembles Sciadopitys, which grows in Japan, a coincidence which may eventually establish one more link in the chain of evidence connecting the early history of America with that

of Asia. We regard with something akin to awe the mummified bodies of early Egyptians protected through forty centuries of time by asphalt-coated shrouds. Yet trees of the ancient northern forest have been well preserved for probably more than a thousand centuries. The above discovery of fossil wood has been recognized in the scientific world as being of outstanding importance.*

It may be recalled that in 1912 Canada imported more than ninety-three per cent of its petroleum requirements at a cost of not less than $89,000,000. But for the fortunate discovery of important petroleum pools in Western Canada subsequent to 1946 the value of present day annual requirements per year (1960) would have involved the importation of petroleum and petroleum products valued at not less than $500,000,000. The impact of such a situation on our balance of trade requires no comment.

Petroleum pools are notable examples of wasting assets, but meanwhile the McMurray sands should ultimately prove to be a reserve of major importance. Such a situation appears to justify fully my insistence in 1913 that an investigation of the McMurray sands should be undertaken by the Mines Branch.

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* "Research Touches the North", Canadian Geographical Journal, June, 1942.

Over a lengthy period of years, in biting cold of northern winters and sultry heat of summer days, to have had a part however small in the stirring saga of the awakening north has been adequate reward. From the foothills of snow-capped mountains, forested rolling lands, muskeg, and barrens fading out in distant horizons, and on lake and foaming stream, and almost endless miles of trail, I acquired some knowledge of the great northland and of the ways of the "woodfolk"*, furred and feathered. A few short years ago it was a land where a blazed tree or even a broken twig might mean quite as much as the sign-boards and flashing lights along southern highways. It was a land where men pitted their wits against the woodfolk, where in mud-chinked hovel or smoke-stained teepee, women drew glossy pelts from fearsome dripping carcasses, where hungry dogs dragged heavily-laden toboggans over rough and drifted winter trails. And at far-flung lonely posts shrewd fur traders played a part in the northern drama.

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* Frank Conibear and J.K. Blondel, "The Wise One". Also S.C. Ells, "Northland Trails".

EPILOGUE*

S. C. Ells

I ask not stately man-made shaft of stone,
Within some crowded city of the dead,
One of a mighty host, — and yet alone,
While restless feet hurry above my head.

Out on a wind swept ridge then let me lie,
A rugged twisted pine my marker rude,
Where owls' deep call and loons' sad wavering cry,
Alone will break my peaceful solitude.

Yet not alone beneath my tree I'll lie,
For all about me furry things will play,
While stately antlered monarchs wander by,
Friends of the long, long trails of yesterday.

In tugging boughs that toss against wild sky,
The roaring gale will shout an anthem deep,
While whispering winds will croon a lullaby,
And gently lull me fast asleep! asleep!

Faint grow the trails my buckskinned feet have trod,
Faint the old landmarks, faint the headlands bold,
Fades afterglow, lengthen the shadows broad,
While flickering camp-fire fades to ashes cold.

But through the gathering mists I see afar,
Other fair woodlands under cloudless skies,
And in the 'happy hunting grounds' once more,
I'll take the trail, — to greet a new sunrise!

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* "Northland Trails", Burns and MacEachern, Toronto, 1956.

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APPENDIX

EXPLORATION IN NORTHERN SASKATCHEWAN

In 1935 my attention was again diverted from the McMurray field, and I was instructed to make a geological reconnaisance of an extensive area lying to the east of the Fourth Meridian and southward from McFarlane Lake. This area was shown as a complete blank on the map, and, although it was known to a few Indian trappers, I was apparently the first white man to enter that part of the province. On a previous occasion I had attempted to work my way eastward from the valley of the Firebag River to the Fourth Meridian by way of the Marguerite River, and it was only after seven weeks of arduous labour that a track survey was completed to our objective. Obviously, therefore, the use of air transport was indicated, and a crew of seven men with three canoes and supplies for three and a half months was flown in by a noted bush pilot - the late "Wop" May. The only instructions I could give were to fly down the Athabasca River to the 24th Base Line, to follow the faint traces of that line eastward to its intersection with the Fourth Meridian, and then to head in a north-easterly direction. After flying for approximately an hour, I noted a large lake,*

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* Subsequently named Lloyd Lake.

which my subsequent survey showed to have a shore line of more than 140 miles, and instructed the pilot to land near one of the many sandy beaches. Three plane trips were required to transport men and materials, and, considering the time saved, the cost was nominal.

It was of course obvious that wandering about in a large and unmapped area could only lead to vague generalities with respect to geological boundaries and other data. Consequently, at my suggestion, the Director had sent a formal note to the RCAF asking that an aerial survey be made of the area to be explored. As surveys by the RCAF were some two years behind schedule at that time, the Director's request was, as anticipated, promptly refused. I therefore (unofficially) visited A.N. Narroway, Director of Aerial Surveys, warned him that I would "sit on his doorstep" until he agreed to make the survey suggested, and eventually wore him down. As a result two planes made the desired survey in the late fall of 1935, and rendered possible an intelligible report on the newly explored area.*

During the progress of the work, track surveys or sketch maps were made of a number of peculiarly shaped lakes and, when copies of the aerial map were subsequently received, it was possible to fit in geological boundaries and other data with reasonable accuracy.

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* Map sheets 74F and 74G. National Topographic Series, 1938, and Mines Branch Report No. 727.

The pilot who had flown us in suggested that I fix a date on which he would pick us up in the fall. However, I said that somehow we would find a way out, and this we eventually did by following uncharted and unnamed streams. Inevitably there were the usual "incidents" when moose meat or fish saved the day, and also occasional incidents of a somewhat more serious nature. On one such occasion, while making a reconnaisance by canoe with one man, the creek which we had been following joined a river several hundred feet in width. My companion had had but little experience as a canoeman and, while running a long and heavy rapid, the canoe capsized. While our food and equipment rapidly disappeared downstream on the tossing white water, we managed to get the canoe ashore in a strong eddy, and at seven o'clock in the evening without any supper, in driving rain and a cold north wind, we stood dripping on the rocky shore. Our fishing tackle had been washed out of the canoe, there were no berries, and during the following three days from daylight until dark, without a mouthful of food and in almost continuous rain, we portaged, ran rapids and paddled approximately 160 miles. It subsequently developed that the stream which we had followed was the Upper Clearwater River. On the evening of the third day we reached Waterways, and a day later, having replaced our lost equipment, we rejoined the main party (by air) on Lloyd Lake.

The sequel to the above season's rather strenuous operations was of interest. In view of the fact that I was classified as an engineer rather than as a professional geologist, and although my identification of a rather large collection of somewhat complex rock samples had been confirmed by Dr. Joliffe, a senior member of the Geological Survey, my report was not published. On my own responsibility, therefore, it was sent, together with an extensive series of photographs, which were of course the first ever taken within the area explored, to the Industrial Development Branch of the Saskatchewan Government by whom it was adequately appreciated and put to practical use. It may be added that, remote from established air routes for a period of more than three months, in the event of sickness or accidents we had all risked our lives by being completely cut off from the "outside" world. By way of contrast with the above decision I may note that shortly afterwards I received the following cable from the Chief Geologist of the Anglo-Persian Oil Company in London. "Can you undertake a six months geological survey to elucidate structure of an oil property in Cuba, and advise earliest date you can leave Ottawa?"


Ellis.