CANADA

DEPARTMENT OF MINES

HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH

JOHN MCLEISH, DIRECTOR

INVESTIGATIONS OF MINERAL RESOURCES AND THE MINING INDUSTRY, 1932

No. 735

OTTAWA
J. O. PATENAUDE
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1934

CANADA

DEPARTMENT OF MINES

HON. W. A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER

MINES BRANCH

JOHN MCLEISH, DIRECTOR

INVESTIGATIONS OF MINERAL RESOURCES AND THE MINING INDUSTRY, 1932

No. 735

OTTAWA
J. O. PATENAUDE
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1934

Annual reports on Mines Branch investigations are now issued in four parts, as follows:—

Investigations of Mineral Resources and the Mining Industry.
Investigations in Ore Dressing and Metallurgy (Testing and Research Laboratories).

Investigations of Fuels and Fuel Testing (Testing and Research Laboratories).

Investigations in Ceramics and Road Materials (Testing and Research Laboratories).

Other reports on Special Investigations are issued as completed.

MINES BRANCH INVESTIGATIONS OF

MINERAL RESOURCES AND THE MINING INDUSTRY, 1932

I

SILICA DEPOSIT NEAR GATINEAU POINT, QUEBEC

L. H. Cole and R. K. Carnochan

Along the foot of the escarpment running along the north side of the Ottawa River between Buckingham and Gatineau Point, Quebec, are a number of outcrops of Potsdam sandstone that hold possibilities for commercial exploitation for the production of silica sand and for building stone. One of these outcrops is already under development by the Ottawa Silica and Sandstone, Limited, at Templeton, Quebec.

LAURIN PROPERTY

Location. Another prominent outcrop occurs on Lot 25, Range II, Templeton Township, Quebec, on the farm of X. Laurin. The locality is shown on the sketch plan, Figure 1.

Transportation. The deposit is situated $1\frac{7}{8}$ miles by dirt road from the nearest railway siding at Talon, a small flag station on the Canadian Pacific Railway, but the railway runs only one mile directly south of the deposit. The distance to Ottawa (post-office) is $6\frac{1}{2}$ miles by highway.

Power and Water Supply. One of the transmission lines of the Gatineau Power Company runs across the south end of the lot on which the sandstone occurs so that ample power is available if necessary. A small creek runs through the flat at the foot of the escarpment, but whether sufficient water for washing purposes could be obtained from this source by proper damming is questionable. A possible source of water would be from drilled wells.

Topography. The sandstone escarpment, which at its southern end rises 20 feet above the level of the clay flat of the district, increases in height towards the north, so that where it disappears under the heavy overburden of the rising ground to the north a face of nearly 50 feet of sandstone is exposed.

The top of the sandstone escarpment is comparatively flat and there are about 12 acres completely bare of overburden. (*See* Plate I.)

The Rock. The rock is a friable sandstone of medium to fine grain texture, the individual quartz grains being rounded to subangular in shape. The stone in places is very white, but in others it is heavily stained with iron to a bright yellow to brownish colour. No pyrite, however, was visible on the surfaces exposed.

The beds vary in thickness from a few inches to several feet, and blocks of sufficient size for building purposes could readily be obtained.

No development work, outside of a few shots put in for sampling purposes, has been done, so that the nature of the rock at depth is unknown.

Samples were taken from the surface for testing purposes but none of this material was from a depth greater than 2 feet below the surface.

PLATE I

General view on top of sandstone ridge, looking east, on Lot 25, Range II, Templeton Township, Quebec.

TESTS

Two lots were taken from this property for testing purposes, one called Lot No. 2 was taken from the discoloured stone, a light brownish yellow in colour, the other called Lot No. 1 was taken from the fairly clean white stone. Lot No. 1 weighed 63·5 pounds and Lot No. 2, 38 pounds net. A small hand-specimen was retained from each lot before crushing.

The lots were crushed separately in a small jaw crusher and rolls to pass 12 mesh. A sample was cut out of each lot and analyses made for iron both before and after washing. The two lots were washed separately four times in an Akins classifier, a Wilfley pump being used to feed the Akins. The overflow from the classifier was allowed to run into a tank and settle. After washing each lot the pump was opened and a certain amount of sand removed and kept separate. After washing of both lots was completed the tank was cleaned out and the sand obtained kept by itself. The washed sand and clean-up of pump from both lots were dried and sampled for analysis. The weights and analyses were as follows—

	Lot No. 1			Lot No. 2		
	Weight		Fe_2O_3	Weight		Fe_2O_3
	lb.	oz.	%	lb.	oz.	%
Received	63	8		38	0	
Specimen	1	8		1	8	
To crusher	62	0		36	8	
Sample of crushed	1	13	0·09	1	3	0·25
To washer	60	3		35	5	
Washed	39	2	0·051	24	2	0·11
Clean-up of pump	12	6	0·064	8	2	0·14

Combined washings from tank of Lots Nos. 1 and 2: 7 lb. 0 oz.

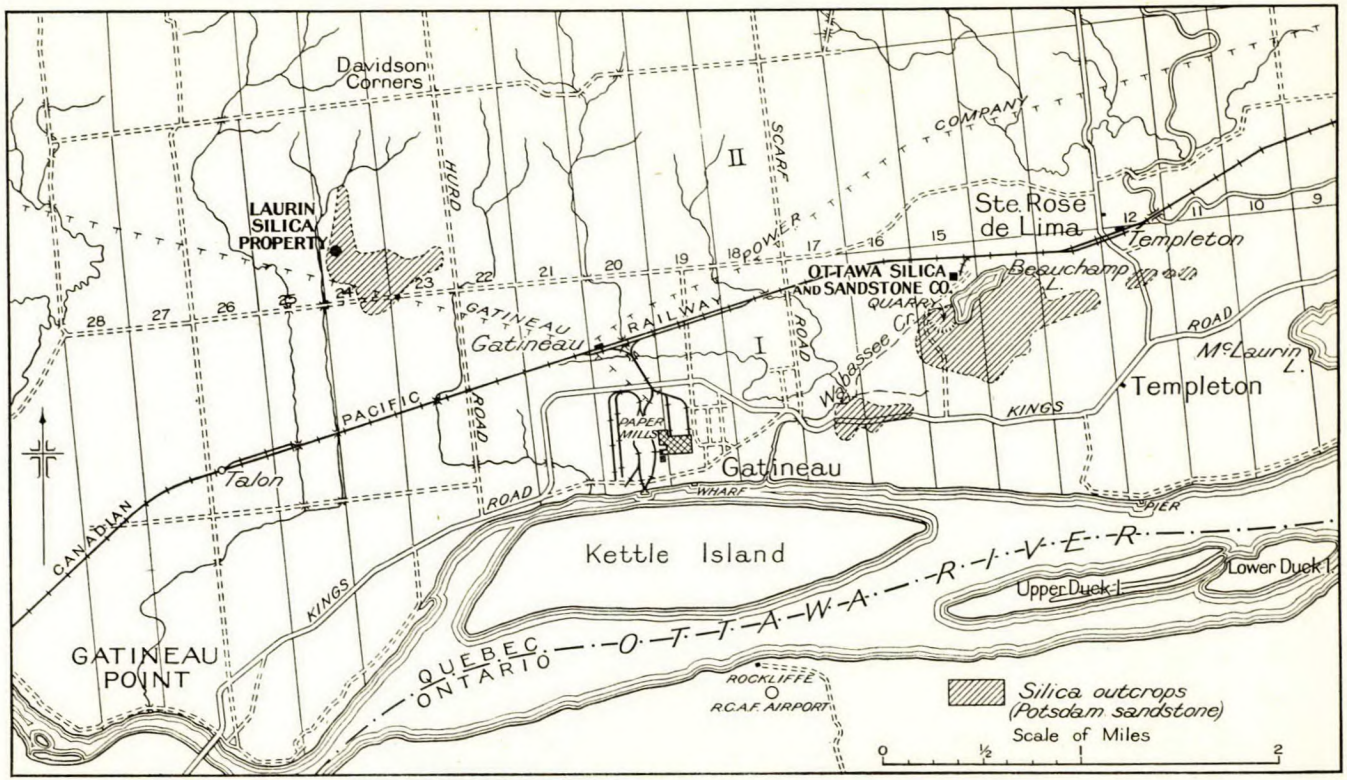

Figure 1. Silica outcrops between Gatineau Point and Templeton, Que.

CONCLUSIONS

Results indicate that it might be possible to produce from this deposit a silica sand sufficiently free from iron to be employed in the manufacture of glass, but it would be necessary, before any exploitation took place, to determine the nature of the rock accurately at depth over the whole area, as well as to determine whether sufficient water were available for washing purposes.

II

SANDSTONE AT HAWKESBURY, ONTARIO

L. H. Cole

Location. A band of sandstone of the Chazy formation outcrops just south of the Canadian National Railway station at Hawkesbury, Ontario. Stone for building purposes has been quarried from this locality from time to time during the past hundred years.

Transportation. The Canadian National Railway runs past the present quarry and a siding affords ready facilities for loading flat cars. The distance by rail to Montreal is 54·6 miles and to Ottawa 59·2 miles.

Historical. Probably the first stone quarried in this district from this formation was used in the construction of the locks of the Grenville canal on the north side of the Ottawa River opposite Hawkesbury. In the first lock of this canal below Grenville there is a block of sandstone on which is carved the date 1825, and the figures are still sharp and distinct although the block is just below the water line when the lock is filled, and would thus be exposed to soaking and drying alternately every time the lock was emptied and filled. The lockmaster's house at this lock is built of the same stone and the keystone over the doorway also bears the date 1825. Old quarry excavations are to be found about one-quarter mile to the south of the present quarry and this was probably the locality from which the material for the canal was excavated, and these are most likely the quarries referred to by Dawson[1] as follows:

> This sandstone from the vicinity of Hawkesbury was used in the construction of the locks of the Grenville canal.

At some later date a quarry was opened in this formation by J. C. Higginson (known as the Higginson quarry), and Dr. Parks[2] refers to this quarry as follows:—

> The quarry is situated near the C.N.R. station and presents a face of 6 feet; the upper 3 feet is thin and shaly but the lower bed is in places fully 3 feet thick. All the product seems to have a tendency to break up owing to the lenticular parting planes. A well in the vicinity shows that the deposit is fully 50 feet thick.
>
> Whether the shattered condition of the material lying in the quarry is the result of the method of quarrying or whether it is due to the peculiarity of the beds, I am unable to say. The lower bed looks quite free from such flaws where it has not been disturbed. With a thickness of 50 feet it is reasonable to suppose that some good beds would be exposed by a careful examination. The present output is used locally as a road metal only.

In 1917 the writer collected a sample from the lower bed in this quarry to test its suitability for the manufacture of pulpstones. The tests showed that the stone was too fine-grained and soft for this purpose.

The Quarry

A few years ago the present quarry, situated some 100 yards to the southwest of the station, was opened up by the Ottawa Valley Stone Quarry

[1] Geol. Surv., Canada, Report 1863, p. 814.
[2] Parks, W. A.: Building and Ornamental Stones of Canada. Mines Branch Report No. 100, p. 162 (1912).

Ltd., Robt. A. Reid, President, for the purpose of testing the lower beds for use as building stone. Unfortunately the excessive use of dynamite in the earlier operations caused incipient cracks in many of the large blocks then taken out and also shattered the beds so that even some of the beds in place were rendered useless. However, by the adoption of channelling and the greater use of plugs and feathers, with only occasional use of powder, some sound excellent building stone of large dimension has been obtained.

Quarrying is being carried on in the thicker beds below the top 3 feet of shattered thin beds referred to by Dr. Parks and the quarry has reached a depth of 12 feet, beds of 3 to 5 feet in thickness in places being encountered.

During the past year a contract to supply stone for a large school erected by the Christian Brothers at Alfred, Ontario, was obtained by the company, and the cutting and dressing of the dimensioned blocks was done by the Ottawa Cut Stone Company, a stone-dressing shed being erected at the quarry for this purpose.

Equipment. The quarry is well equipped with a 30-ton steel boom-derrick and an Ingersoll-Rand portable compressor of sufficient size to operate six drills. The quarry is kept free from surface water by means of pumps.

At the dressing plant of the Ottawa Cut Stone Company there is a gang-saw capable of sawing large blocks into any desired size. A 10-ton electric stiff-leg derrick handles the stone at this shed.

The Stone

The stone is a fine-grained, grey sandstone with angular grains composed principally of quartz and occasional granules of feldspar cemented by an argillaceous matrix. A screen analysis made on the material, broken down to its original grain by hand in a small porcelain mortar, gave the following results:—

			Cumulative
Retained on	65 mesh	6·57	6·57
"	100 "	10·85	17·42
"	150 "	24·58	42·00
"	200 "	24·49	66·49
Through	200 "	33·25	
Average fineness			138·19

The following analysis* kindly furnished by Mr. Blackwell shows the composition of the stone from this quarry:

Royal Queont Pearl Grey Building Stone Quarried at Hawkesbury, Ont.

	Per cent
Silica	72·48
Iron oxide	2·29
Alumina	13·88
Lime	3·52
Magnesia	0·81
Soda, Potash } Alkalis by difference	4·20
Loss on ignition	2·82

*J. T. Donald & Co., Ltd., Analysts.

Absorption tests made by J. T. Donald & Co. gave the following results:—

Mark	Dry weight	Weight after immersion	Difference in weight	Absorption
	grms.	grms.	grms.	%
A	334·5	342·5	8·00	2·39
B	329·75	338·0	8·75	2·65
Average				2·52

Crushing Strength. A large block of the stone was obtained from the quarry and from it a number of 2-inch cubes were cut by a carborundum saw. These cubes were used for crushing and freezing tests.

Six of the cubes were crushed on an Olsen compression machine, three on the bed and three across the bed. An average was then taken of the crushing strength of each three.

Six more of the cubes were then subjected to alternate freezing and thawing for 40 separate times and then crushed as above.

The following results were obtained from these tests:—

— —	Crushing strength, lb./sq. in.			Change in weight on freezing, %
	Fresh sample, average 3 cubes	Frozen sample, average 3 cubes	Gain[1]	Loss
On bed	11,470	16,040	4,570	0·0322
Cross bed	10,675	15,997	5,332	0·0454

The cubes after freezing showed no signs of spalling or cracking.

Working Qualities. The stone when first quarried is comparatively soft and works well under the dressing tools. Blocks can readily be obtained of sufficient size to make cutting by gang-saws economical. It lends itself readily to carving, and the stone is sufficiently resistant to weather to keep the sharp edges of carving over long periods of time.

CONCLUSIONS

The strength of the stone as shown in the above tests makes it suitable for building purposes and since it works easily it should find a ready market in both the Provinces of Quebec and Ontario.

[1] These results may at first glance appear to be inconsistent, since one would naturally expect that the freezing would decrease the strength of the stone. It is a well known fact, however, that certain stones do increase in strength after being seasoned, and it is probable that this factor may have some bearing on the results obtained. The crushing tests on the fresh samples were made shortly after the stone had been freshly quarried before it had time to season and the tests on the frozen cubes were made after a considerable lapse of time, the cubes having had time in the interval to season. Tests on this stone on seasoned samples without freezing have not been made so that it cannot be stated how much of the above increase can be credited to seasoning. This point is being further investigated.

III

SOME ECONOMIC ASPECTS OF THE BITUMINOUS SANDS OF NORTHERN ALBERTA

S. C. Ells

The bituminous sands of Alberta should be regarded as a source of petroleum products to supply present and future markets and so will have to meet and overcome the competition of similar products derived from established sources of supply.

Prior to 1913 little definite information was available regarding these extensive deposits situated in the northern part of the Province of Alberta. As a result, however, of field and laboratory investigations conducted during recent years[1] it is now possible to consider with some degree of confidence the problem of their successful commercial development.

This report deals with the subject under the following five headings:—

(*a*) Estimated potential production from McMurray area.
(*b*) Estimated production costs.
(*c*) Estimated markets available.
(*d*) Competition from present sources of supply.
(*e*) Conclusion.

---

[1] Ells, S. C.: Sum. Rept. 1913, Mines Branch, Dept. of Mines, Canada.
Bituminous Sands of Northern Alberta, Rept. No. 281, Mines Branch, Dept. of Mines, Canada (1914).
Sum. Rept. 1914, Mines Branch, Dept. of Mines, Canada.
" 1915, " " "
" 1916, " " "
" 1920, " " "
" 1922, " " "
" 1923, " " "
" 1924, " " "
Bituminous Sands of Northern Alberta, Rept. No. 625, Mines Branch, Dept. of Mines, Canada (1924).
Maps Nos. 536, 537, 538, 539, 540, 541, Mines Branch, Dept. of Mines, Canada (1915).
Maps Nos. 633, 634, 635, 636, 637, 638, 639, 640; Sections Nos. 1, 2, 3, 4, Mines Branch, Dept. of Mines, Canada (1925).
Use of Alberta Bituminous Sands for Surfacing of Highways, Rept. No. 684, Mines Branch, Dept. of Mines, Canada.
Bituminous Sands of Northern Alberta—Experimental Drilling and Paving Operations, Rept. No. 694, Mines Branch, Dept. of Mines, Canada.
Core Drilling Bituminous Sands of Northern Alberta, Rept. No. 710-1, Mines Branch, Dept. of Mines, Canada.
Bituminous Sands of Northern Alberta—Operations during 1929, Rept. No. 719, Mines Branch, Dept. of Mines, Canada.
Bituminous Sands of Northern Alberta—Operations during 1930, Rept. No. 723-1, Mines Branch, Dept. of Mines, Canada.
Exploration of Bituminous Sand Areas in Northern Alberta. Recent Progress in the Commercial Separation of Bitumen from Bituminous Sand; Estimated Cost of Producing Solid and Liquid Hydrocarbons from Bituminous Sand, Rept. No. 727, Mines Branch, Dept. of Mines, Canada.

Clark, K. A. and Pasternack, D. S.: Eleventh Annual Report of Research Council of Alberta, Road Materials Section, 1930.
Hot Water Separation of Bitumen from Alberta Bituminous Sand, Ind. and Engr. Chem., vol. 24, No. 12 (Dec., 1932).

Warren, T. E.: Experiments on Hydrogenation of Alberta Bitumen and on the Effect of Pressure on the Pyrolysis of Methane, Rept. No. 725-1, Mines Branch, Dept. of Mines, Canada (1932).
Report of Experimental Work on the Hydrogenation of Canadian Coal, Coal Tar, and Bitumen for the Production of Motor Fuel. Rept. No. 737-3, Mines Branch, Dept. of Mines, Canada (1933).

ESTIMATED POTENTIAL PRODUCTION FROM McMURRAY AREA

It is quite impossible to estimate accurately the potential production of petroleum products that may ultimately become available from Alberta bituminous sand. It is definitely known that the area underlain by bituminous sand is not less than 1,500 square miles and the total areal extent of the deposit is probably very much greater. The extent to which commercial development may be practicable will depend on degree of enrichment, extent to which open-cut mining methods can be employed, the possibility of recovering bitumen associated with bituminous sand by *in situ* methods, and accessibility to adequate transport facilities.

Meanwhile results of field investigations by the Mines Branch indicate that at least 750 million tons of bituminous sand can be mined by open-cut methods. On a basis of 12 per cent bitumen content this is equivalent to 90 million tons of bitumen or 500 million barrels. In addition, assuming the commercial application of a satisfactory method of developing bituminous sand areas not available by open-cut mining methods, and assuming for such areas an average bitumen content of 10 per cent, and that petroleum products to be derived from separated bitumen would be equivalent to 75 per cent by volume of the original bitumen, then potential production of petroleum products—on the basis of consumption in 1930—would be sufficient to supply the requirements of Canada and the United States for more than 100 years. It is of interest to note that during the period 1873–1919, the total production of petroleum from the Scotch oil-shale fields was equivalent to approximately 78 million barrels. Core drilling in the McMurray field indicates an average bitumen content, in three small but representative areas, in excess of 70,000 barrels of bitumen per acre. Quantity of distillation products recoverable from this bitumen would be materially less. Although well production from drilled oil sands represents only a comparatively small part of their total petroleum content, it may be noted that records from 43 principal producing fields in the United States to December, 1931, indicate production equivalent to less than 13,000 barrels of petroleum per acre.[1]

ESTIMATED PRODUCTION COSTS

Distillation[2] and refining of separated bitumen have been conducted by the use of small-scale laboratory apparatus and stills of one-barrel capacity, but, especially as regards refining and possible value of lubricating fractions, further study is desirable. As yet distillation and refining have not been attempted on a commercial scale.

On the other hand, processing of many types of crude petroleum has become standardized and commercial costs have been determined. Making necessary assumptions, and basing calculations on data at present available, an estimate of production costs has been prepared.[3] This estimate is subject to revision as results of further research become available from time to time. Estimates are based on the operation of a plant having a throughput capacity of 1,500 tons of bituminous sand per 24 hours and an operating year of 300 days. Bitumen content of sand is assumed to be $12\frac{1}{2}$ per cent.

[1] Oil and Gas Journal, March 24, 1932, page 11. "No Dominant Field in United States" by James McIntyre.
[2] Mines Branch, Dept. of Mines, Canada, Rept. No. 632.
[3] Mines Branch, Dept. of Mines, Canada, Rept. No. 727

70427—2½

Calculations have been divided into five parts under the following subheadings: mining, separation, distillation, cracking and refining, and investment charges. Some difference of opinion exists with regard to separation costs. Dr. K. A. Clark[1] suggests a cost of approximately 75 cents per barrel, whereas the writer considers 50 cents per barrel will prove to be a conservative estimate. It is also impossible at the present time to indicate the finished products that might be produced most advantageously from separated bitumen. Present market requirements in western Canada indicate, however, that maximum production of the lower boiling fractions is desirable. The extent to which such production may be possible will depend on the process to which the separated bitumen is subjected, and hydrogenation, if practicable, has obvious advantages over other distillation methods. With reference to this aspect of the problem, Dr. T. E. Warren comments in part as follows:—

In 1926, samples of bitumen were sent to the Universal Oil Products Laboratory for a test according to conditions of the Dubbs process. The bitumen was charged to the cracking apparatus without preliminary treatment and heated at 750° F. under a pressure of 90 pounds per square inch. The yield of gasoline was 27 per cent by weight of the charge and there was a coke residue of 28 per cent. The gasoline was found to have a good knock rating (benzol equivalent 33·2).

During the past year (1932-33), a small-scale continuous liquid-phase hydrogenation apparatus has been in use at the Fuel Research Laboratories. Tar, coal paste, and bitumen were treated in it, more for the purpose of testing the apparatus and method than to find the optimum conditions for each material. Only one experiment was run with Alberta bitumen.

The experiment was a short one, operation being continued only eight hours after bringing the equipment to the reaction temperature. The average temperature during the eight-hour period was 439° C., the average pressure 184 atmospheres, and the rate of recirculation of hydrogen 112 cubic feet per hour, measured at atmospheric pressure and room temperature. The catalyst was molybdic oxide supported on coke, in quantity about 10 per cent of the charge in the reaction chamber.

A summary of the material balance for the whole experiment is as follows:—

	Weight, per cent of charge
Distillate product, including water	60·5
Liquid removed from levelling standpipe	6·4
Liquid left in reaction chamber at end of run	21·6
Sulphur recovered in scrubber	2·9
Methane and ethane in gas	2·8
Vapour loss, handling loss, and unrecovered impurities	5·8
	100·0

No coke was formed, and the consumption of hydrogen was 5·7 per cent of the weight of the charge.

Simple distillation of the distillate product yielded the following reactions:—

Fraction	Volume, per cent
Up to 410° F.	47·3
410° to 572° F.	42·6
Liquid residue	9·5
Distillate loss	0·6

The fraction up to 410° F. from the distillation was submitted without further treatment to examination as a gasoline. The gum formation was high, and the colour and odour poor. The Octane number determined in a Series 30B Ethyl Gasoline Corporation engine at 345° F. and 900 r.p.m. was 53. It is apparent, therefore, that some refining would be necessary to produce a good grade of gasoline from the distillate product.

[1] Eleventh Annual Rept., Research Council of Alberta, 1930.

The results of the chemical analysis of the distillate product are tabulated as follows:—

—	Volume, per cent			
	First half of run		Second half of run	
	Fraction up to 410° F.	Fraction 410° to 572° F.	Fraction up to 410° F.	Fraction 410° to 572° F.
Acids	0	0	0	0
Bases	1	1	1	1
Olefines	12	11	10	10
Aromatics	18	35	18	36
Paraffins and naphthenes	69	53	71	53
	100	100	100	100

It is to be noticed that there are no acids in the product, and that in spite of the hydrogenating conditions 10 to 12 per cent of olefines is present.

The yield of light oil is 73 per cent by volume of the dry charge, if the material left in the reaction chamber at the end of the run is considered as loss. However, considering the residue as charging-stock, the yield is 102 per cent of the dry charge by volume. The higher figure is probably closer than the lower to the result which would be obtained in a run of long duration. The volume of product obtained per hour is roughly 30 per cent of the volume of the liquid phase.

As yet definite costs of hydrogenation of separated bitumen are not available. Consequently, the adoption of some established method of distillation and cracking has been assumed with production of gasoline, fuel oil, road oil, and residual asphalt suitable for paving purposes. Wholesale selling prices of the above commodities at centres in western Canada during recent years may be summarized as follows[1]:—

—	Winnipeg	Regina	Calgary	Vancouver
Asphalt for paving (type used in street paving) per net ton, tank car—	$	$	$	$
1930	27 00	27 00	27 00	18 00
1931	27 00	27 00	27 00	18 00
1932	23 47	25 00	25 00	17 00
Fuel oil, light, per Imperial gallon—				
1930	0·107	0·124	0·101	0·055
1931	0·099	0·116	0·093	0·055
1932	0·099	0·116	0·093	0·055
Motor gasoline, per gallon (tank wagon)—				
1930	0·210	0·258	0·233	0·230
1931	0·188	0·229	0·204	0·195
1932	0·202	0·242	0·217	0·200

[1] Data furnished by Internal Trade Branch, Dominion Bureau of Statistics.

On the above assumption and accepting also separation costs at 50 cents per barrel[1], total expenses based on one day's operations would be as follows[2]:—

Mining 1,500 tons of bituminous sand (equivalent to 1,050 barrels of bitumen) at 22·2 cents per ton	$ 333
Separating 1,050 barrels at 50 cents per barrel	525
Pipe-still distillation of 1,050 barrels of bitumen at 10 cents per barrel	105
Cracking and refining of 462 barrels of oil at $1 per barrel	462
Investment charges	333
	$1,758

Products from the above operation would be as follows:—

Paving asphalt	535 bbl.
Fuel oil*	139 "
Gasoline	222 "

*It is assumed that approximately one-half of the fuel oil would be required in connexion with operation of plant.

Assuming that gasoline produced is sold at the refinery at 10 cents per gallon[3] and that no valuation is placed on fuel oil produced, then paving asphalt could be sold at the refinery at $10.50 per ton. A higher

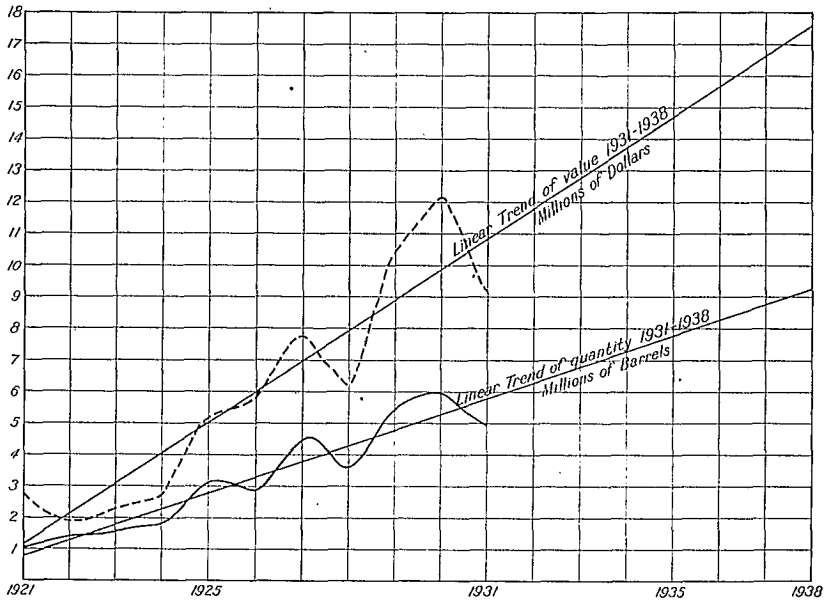

Figure 2. Curves showing value and quantity of crude petroleum imported into Manitoba, Saskatchewan, and Alberta, plus Alberta production.

selling price for asphalt would permit of a correspondingly lower selling price for gasoline. The above selling prices provide for depreciation and include a return on the investment of 10 per cent.

[1] In Mines Branch Rept. No. 727, an estimated cost of producing solid and liquid hydrocarbons from bituminous sand appeared. In the present estimate certain modifications have been made. The cost of separation, exclusive of investment charges, has been reduced from 63·8 cents to 50 cents. Cracking and refining costs have been increased from 83·6 cents to $1.00, exclusive of investment charges. A more liberal allowance for working capital has been made which increases this item from $708,000 to $1,000,000.

[2] Other cost estimates from independent sources, believed to be reliable, are materially lower than the above. Thus, for example, Mr. Max W. Ball of Denver estimates that separated bitumen can be produced at a cost of approximately 56 cents per barrel, and that finished products can be produced, refined, and marketed at a cost of $1.43 per barrel.

[3] This price does not include Provincial and Municipal taxes, sales taxes, general marketing expenses, packages, and a small contingency reserve, equivalent in all (in 1930) to approximately 5·5 cents per gallon.

ESTIMATED MARKETS AVAILABLE

It is assumed that markets available to various solid and liquid hydrocarbons derived from Alberta bituminous sand will be limited to Manitoba, Saskatchewan, and Alberta. Figure 2[1] and Table IX indicate imports and production of such products in these provinces during recent years. Tables I[2] and II[2] and Figure 3 illustrate consumption of crude petroleum in, and production of petroleum products from petroleum refineries in Manitoba, Saskatchewan, and Alberta. Table III[3] comprises cost summary of operations by Imperial Oil, Ltd., during 1930. Tables IV[3] and V summarize operating and marketing costs distributed over principal products at Sarnia refinery.

The following summary indicates present capacity[4] in barrels per day of petroleum refineries in Manitoba, Saskatchewan, and Alberta:—

	Bbl.
Manitoba—	
North Star Oils, Ltd., St. Boniface	700
Radio Oil Refineries, Ltd., East Kildonan	1,200
Saskatchewan—	
Imperial Oil Refineries, Ltd., Regina	7,000
Hi-Way Refineries, Ltd., Regina	150
Saskatoon Hi-Way Refineries, Ltd., Saskatoon	240
Sterling Oil Refineries, Ltd., Moose Jaw	750
Karels Oil Refinery, Regina	150
Tower Refineries, Ltd., Moose Jaw	200
Alberta—	
Imperial Oil Refineries, Ltd., Calgary	6,000
Bell Refining Co., Ltd., Calgary	750
Maple Leaf Petroleum, Ltd., Coutts	4,000
Regal Oil and Refining Co., Ltd., Calgary	3,000
Northwest Stellarene Co., Inc., Coutts	2,500
J. W. Fraser Refining Co., Wainwright	300
Total	26,940

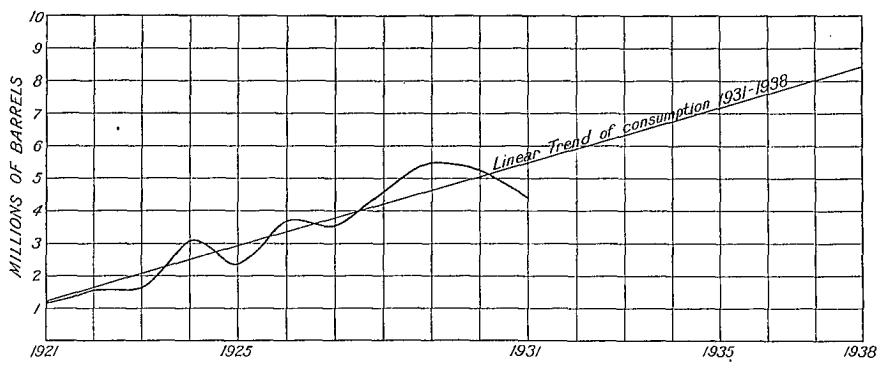

Figure 3. Crude oil received at petroleum refineries in Manitoba, Saskatchewan, and Alberta, 1921-1931.

[1] All curves indicated on graphs are controlled not only by the factor of population, but also to an important degree by the factor of employment. This is seen in the departures from trend during seasons of prosperity and depression. To illustrate this a second curve on Figure 3 shows the trend of population for motor vehicle since 1921. Departures of actual population per vehicle from this curve follow faithfully the conditions of employment. Thus, any projection of registration of motor vehicles must take such departures into consideration as well as the trend of population.

[2] Tables I and II embody information compiled by Mining, Metallurgical and Chemical Branch, Dominion Bureau of Statistics.

[3] Statement submitted to Select Standing Committee of House of Commons, on Price of Gasoline, 1932.

[4] Of the capacity indicated, it appears that approximately 10,050 barrels may be attributed to skimming operations as opposed to cracking. Permanency of operation of skimming plants—that is, plants which process crude oil to three primary products, namely, gasoline, kerosene, and fuel oil—depends on the possibility of securing supplies of relatively low-priced crudes.

TABLE I

Consumption of Crude Petroleum in Canadian Refineries, 1921-32

(Barrels)

Year	Eastern Provinces (Nova Scotia, New Brunswick, Quebec)		Ontario		Western Provinces (Manitoba, Saskatchewan, Alberta, British Columbia)		Canada	
	Domestic production	Imported	Domestic production	Imported	Domestic production	Imported	Domestic production	Imported
1921	.....	4,029,704	168,003	4,305,489	5,976	2,163,107	173,978	10,489,300
1922	.....	4,444,866	160,362	4,368,252	6,766	2,783,270	167,127	11,596,387
1923	.....	4,450,976	166,795	2,957,942	1,949	3,074,070	168,744	11,511,560
1924	.....	4,087,759	144,963	4,325,186	1,406	4,786,248	147,796	13,199,192
1925	.....	3,998,722	138,833	4,625,580	213,659	3,740,798	352,491	12,365,100
1926	.....	5,721,477	141,958	5,238,507	205,280	5,418,959	348,665	16,378,944
1927	16,912	7,449,798	148,717	6,234,314	281,007	6,336,963	446,636	20,021,077
1928	.....	8,473,892	128,139	7,369,415	452,570	7,859,807	580,709	23,703,113
1929	.....	10,761,454	126,482	9,191,077	940,330	9,632,901	1,066,811	29,585,431
1930	.....	10,001,432	112,714	9,810,632	1,359,368	9,128,282	1,472,082	28,940,346
1931	9,855	11,112,392	125,223	10,424,893	1,284,023	7,741,844	1,419,101	29,289,129
1932	7,058	9,147,988	134,418	9,357,849	925,391	7,001,985	1,066,866	25,507,821

NOTE.—Consumption of Canadian crude in western Provinces includes Royalite naphtha shipped to refineries for blending.

During the past four years gross sales of gasoline in Manitoba, Saskatchewan, and Alberta have been as follows:—

—	1929	1930	1931	1932
	(Imp. gals.)	(Imp. gals.)	(Imp. gals.)	(Imp. gals.)
Manitoba	34,765,203	36,353,462	30,307,724	25,569,881
Saskatchewan	78,456,744	76,630,024	49,449,699	33,635,929
Alberta	50,208,495	51,676,343	43,478,465	41,300,236
	163,430,442	164,659,829	123,235,888	100,506,046

Assuming bituminous sand to contain 12½ per cent bitumen and assuming a yield of 40 per cent gasoline, consumption in 1929 would involve the processing of 1,300,000 tons of bituminous sand or approximately 35,000 tons per day throughout the year.

Consumption of liquid asphalt (road oils, etc.), kerosene, and fuel oil during recent years has been as follows:—

(M, Manitoba; S, Saskatchewan; A, Alberta).

—	1929	1930	1931
	(Imp. gals.)	(Imp. gals.)	(Imp. gals.)
Liquid asphalt	304,319 (A) 904,425 (S) ?	1,634,585 (A) 659,038 (S) 894,576 (M)	1,281,662 (A) 507,176 (S) 2,953,786 (M)
Total	.....	3,188,199	4,742,624
Kerosene (41-47 A.P.I.)	12,200,000 (A) 9,300,000 (S) 6,100,000 (M)	7,000,000 (A) 7,770,000 (S) 5,400,000 (M)	11,400,000 (A) 10,600,000 (S) 6,100,000 (M)
Total	27,600,000	20,170,000	28,100,000
Fuel oil (5-40 A.P.I.)	13,500,000 (A) 4,100,000 (S) 6,500,000 (M)	15,500,000 (A) 6,500,000 (S) 6,100,000 (M)	10,000,000 (A) 6,000,000 (S) 5,000,000 (M)
Total	24,100,000	28,100,000	21,000,000

Registration of motor cars and motor vehicles in Manitoba, Saskatchewan, and Alberta during the period 1921-32 is indicated in Table VI[1] and Figure 4.

[1] Based on data compiled by Transportation Branch, Dominion Bureau of Statistics. Population has been estimated on the basis of natural increase and present trend of immigration. This may rise faster than predicted, in which case motor vehicle registration will be affected accordingly.

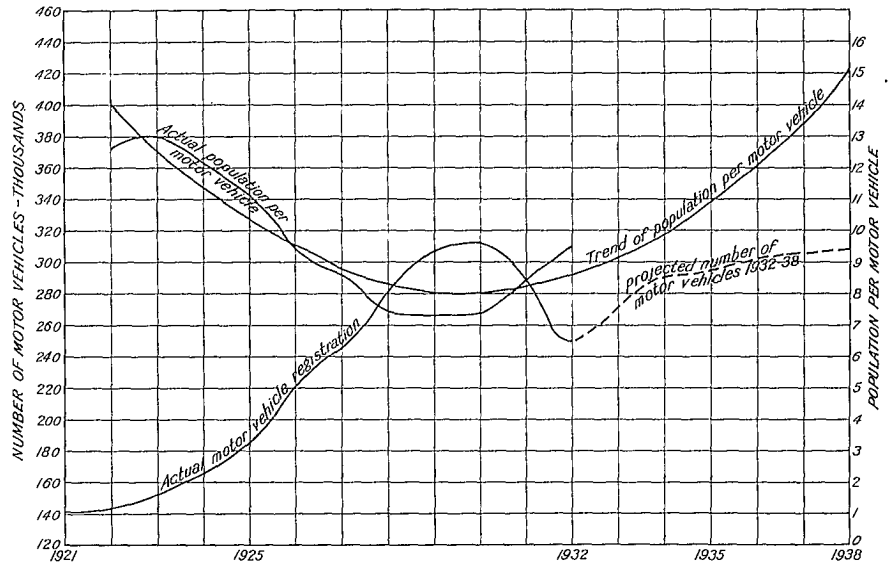

Figure 4. Motor vehicles registered in Alberta, Saskatchewan, and Manitoba, 1921-1932.

TABLE II

Production from Petroleum Refineries in Manitoba, Saskatchewan, and Alberta (1930-32)

—	1930				1931				1932			
	Made for own use		Made for sale		Made for own use		Made for sale		Made for own use		Made for sale	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
		$		$		$		$		$		$
1. Gasoline— (*a*) Straight run....bbl.	302	1,915	1,672,972	10,358,133	494	2,296	1,980,647	9,621,527	353	1,497	1,210,480	5,695,714
2. Gasoline— (*b*) By cracking....bbl.	.....	.....	910,640	5,728,886	.....	.....	505,346	2,619,930	.....	.....	489,805	2,222,723
(*c*) Royalite naphtha..bbl.	.....	.....	666,636	2,693,143	.....	.....	.....	.....	.....	.....	.....	.....
3. Fuel and gas oils.....	145,405	237,036	902,615	1,432,546	116,281	171,116	832,040	1,389,643	154,658	219,786	639,587	793,653
4. Solvent naphtha (distillates, etc.).....	.....	.....	145	1,083	.....	.....	2,758	12,642	.....	.....	225,479	1,028,783
5. Kerosene.....bbl.	1,465	8,338	323,158	1,840,545	386	2,062	327,333	1,607,812	288	1,081	375,914	1,582,401
6. Lubricating oils.....bbl.	.....	.....	14	250	.....	.....	11	100	.....	.....	11	100
7. Grease.....lb.	.....	.....	.....	.....	.....	.....	579,049	16,212	.....	.....	881,203	39,632
8. Tar.....lb.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
9. Asphalt.....bbl.	.....	.....	130,984	278,492	.....	.....	122,451	192 450	.....	.....	37,695	133,825
10. Petroleum coke.....ton	13,463	75,794	12,779	65,708	10,853	59,506	5,236	21,101	4,892	33,268	4,243	30,707
11. Still gas.....M cu. ft.	722,489	203,762	.....	.....	529,493	97,618	.....	.....	331,134	63,393	.....	.....
12. Wax.....lb.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
13. Candles.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14. Other products.....	.....	.....	.....	5,621	.....	.....	.....	.....	.....	.....	.....	.....
15. Tractor distillate.....bbl.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	7,398	29,322
Total.....	.....	526,845	.....	22,404,407	.....	332,598	.....	15,482,417	.....	319,025	.....	11,556,860

NOTE.—Values as stated are those realized at refineries.

TABLE III

Summary of Costs of Operations—In Cents per Imperial Gallon of Gasoline, Fiscal Year 1930

—	Retail gasoline			Wholesale gasoline			Total gasoline		
	Sarnia	Halifax	All refineries	Sarnia	Halifax	All refineries	Sarnia	Halifax	All refineries
Refinery costs—									
Crude and other materials	8·52	11·41	11·10	8·33	11·41	10·96	8·44	11·41	11·06
Manufacturing expenses	1·85	1·59	1·71	1·84	1·59	1·71	1·85	1·59	1·71
Depreciation and general administration	0·70	0·75	0·73	.....	.....	.....	0·40	0·60	0·45
Provincial and municipal taxes	0·03	0·04	0·06	.....	.....	.....	0·02	0·04	0·04
Dominion income tax	0·17	0·15	0·15	0·01	0·02	.....	0·10	0·12	0·08
Total refinery costs	11·27	13·94	13·75	10·18	13·02	12·67	10·81	13·76	13·34
Marketing costs—									
Freight from refinery to marketing stations	2·55	1·86	2·45	2·77	1·20	2·29	2·64	1·73	2·39
Provincial and municipal taxes	0·22	0·20	0·22	.....	.....	.....	0·13	0·16	0·13
Sales taxes	0·11	0·13	0·13	0·11	0·12	0·12	0·11	0·12	0·13
Marketing expenses	4·05	3·63	3·96	0·01	0·01	0·01	2·34	2·90	2·45
Packages	0·02	0·02	0·02	.....	.....	.....	0·01	0·02	0·01
Contingency reserve	0·07	.....	0·37	.....	.....	.....	0·04	.....	0·23
Total marketing costs	7·02	5·84	7·15	2·89	1·33	2·42	5·27	4·93	5·34
Total costs	18·29	19·78	20·90	13·07	14·35	15·09	16·08	18·69	18·68
Average selling price	20·22	21·47	22·56	13·12	14·60	15·05	17·22	20·09	19·69
Average net profit	1·93	1·69	1·66	0·05	0·25	*0·04**	1·14	1·40	1·01

*Loss.

TABLE IV

Sarnia Refinery—Year 1930

Product	Imperial Gallons Sold	Per Cent	Gross Value of Sales Receipts		Deduct Sales Charges											
					Freight Refinery to Marketing Stations		Taxes: Provincial Income, Provincial Corporate, Municipal and School, etc. Exclusive of Provincial Gasoline Tax		Sales Tax		Marketing Expense		Total Cost of Packages		Contingency Reserve	
			Total	Per I.G.	Total	Per I.G.	Total	Per I.G.	Total	Per I.G.	Total	Per I.G.	Total	Per I.G.	Total	Per I.G.
			$ cts.	cts.	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.
Gasoline	75,667,057	30·69	15,301,879 08	20·22	1,927,592 47	2·55	169,323 71	0·22	82,765 04	0·11	3,060,193 60	4·05	16,573 30	0·02	52,913 21	0·07
" Jobbers	55,298,154	22·43	7,255,145 09	13·12	1,533,028 44	2·77	.....	.....	57,262 86	0·11	5,639 94	0·01	.....	.....	.....	.....
	130,965,211	53·12	22,557,024 17	17·22	3,460,620 91	2·64	169,323 71	0·13	140,027 90	0·11	3,065,833 54	2·34	16,573 30	0·01	52,913 21	0·04
Ref'd Oil and Dist.	11,289,293	4·58	2,376,186 26	21·05	342,906 82	3·03	23,774 30	0·21	11,076 37	0·10	430,843 54	3·82	10,877 89	0·10	10,601 02	0·09
" " Jobbers	2,930,026	1·19	412,697 56	14·08	122,826 07	4·19	.....	.....	3,565 93	0·12	308 21	0·01	.....	.....	.....	.....
	14,219,319	5·77	2,788,883 82	19·61	465,732 89	3·28	23,774 30	0·17	14,642 30	0·10	431,151 75	3·03	10,877 89	0·08	10,601 02	0·07
Lubricating Oils	11,048,215	4·48	5,985,143 55	54·17	752,625 87	6·81	24,642 62	0·22	44,811 11	0·41	446,663 64	4·04	303,306 05	2·75	78,375 92	0·71
" Jobbers	4,184,091	1·70	1,008,035 19	24·09	126,778 90	3·03	.....	.....	12,616 57	0·30	536 11	0·01	26,897 09	0·64	.....	.....
	15,232,306	6·18	6,993,178 74	45·91	879,404 77	5·77	24,642 62	0·16	57,427 68	0·38	447,199 75	2·94	330,203 14	2·17	78,375 92	0·51
Fuel Oils and Still Gas	66,132,399	26·83	4,169,682 95	6·31	628,301 61	0·95	20,711 72	0·03	241 01	.....	377,029 06	0·57	216 30	.....	362 57	0·01
Asphalt	6,042,363	2·45	504,297 16	8·35	103,375 38	1·71	1,135 96	0·02	3,957 09	0·07	20,624 21	0·34	22,710 45	0·38	6 94	.....
Coke	10,888,671	4·42	374,322 67	3·44	367 23	.....	432 32	0·01	1,001 61	0·01	7,923 00	0·07	.....	.....	.....	.....
Grease	1,909,816	0·77	1,578,229 22	82·64	142,256 33	7·45	4,012 09	0·21	10,129 17	0·53	72,927 87	3·82	200,365 20	10·49	23,036 71	1·21
Wax	1,002,242	0·41	472,289 94	47·12	36,992 07	3·69	1,044 04	0·10	2,301 73	0·23	18,973 72	1·89	17,262 70	1·72	1,064 62	0·11
Candles	131,646	0·05	189,409 79	143·88	12,211 42	9·28	350 50	0·27	1,635 09	1·24	6,309 22	4·79	14,413 06	10·95	1,375 83	1·04
Total	246,523,973	100·00	39,627,318 46	16·07	5,729,262 61	2·32	245,427 26	0·10	231,363 58	0·09	4,447,972 12	1·80	612,622 04	0·25	167,736 82	0·07

TABLE V

Sarnia Refinery—Year 1930

Product	Net Realization Netted back to Refinery		Total Cost Crude Oil and Other Material		Deduct Manufacturing Charges						Dominion Income Tax		Total Expenses		Net Earnings	
					Manufacturing Expenses		Depreciation and General Administration		Taxes: Provincial Income, Provincial Corporate, Municipal and School Tax, etc.		Total	Per I.G.	Total	Per I.G.	Total	Per I.G.
	Total	Per I.G.	Total	Per I.G.	Total	Per I.G.	Total	Per I.G.	Total	Per I.G.						
	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.	$ cts.	cts.
Gasoline	9,992,517 75	13·20	6,448,639 96	8·52	1,397,281 30	1·85	527,550 29	0·70	24,360 74	0·03	132,286 91	0·17	13,839,480 53	18·29	1,462,398 55	1·93
" Jobbers	5,659,213 85	10·23	4,606,456 27	8·33	1,021,143 66	1·84	.....	.....	.....	.....	5,189 70	0·01	7,228,720 87	13·07	26,424 22	0·05
	15,651,731 60	11·95	11,055,096 23	8·44	2,418,424 96	1·85	527,550 29	0·40	24,360 74	0·02	137,476 61	0·10	21,068,201 40	16·08	1,488,822 77	1·14
Ref'd Oil and Dist.	1,546,106 32	13·70	1,004,800 41	8·90	232,550 75	2·06	63,894 18	0·57	2,950 45	0·03	17,478 51	0·15	2,151,754 24	19·06	224,432 02	1·99
" " Jobbers	285,997 35	9·76	260,786 92	8·90	60,356 46	2·06	.....	.....	.....	.....	.....	.....	447,843 59	15·28	*35,146 03*	*1·20*
	1,832,103 67	12·88	1,265,587 33	8·90	292,907 21	2·06	63,894 18	0·45	2,950 45	0·02	17,478 51	0·12	2,599,597 83	18·28	189,285 99	1·33
Lubricating Oils	4,334,718 34	39·23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
" Jobbers	841,206 52	20·11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	5,175,924 86	33·98	3,745,263 33	24·59	754,532 25	4·95	164,592 13	1·08	7,600 39	0·05	42,599 49	0·28	6,531,841 47	42·88	461,337 27	3·03
Fuel Oils and Still Gas	3,142,820 68	4·75	2,182,448 23	3·30	506,153 47	0·76	110,411 29	0·17	5,098 48	0·01	28,632 24	0·04	3,359,605 98	5·84	310,076 97	0·47
Asphalt	352,487 13	5·83	250,849 41	4·15	54,332 86	0·90	11,852 06	0·19	547 29	0·01	2,950 68	0·05	472,342 33	7·82	31,954 83	0·53
Coke	364,598 51	3·35	253,607 58	2·33	58,826 55	0·54	12,832 30	0·12	592 56	.....	3,274 78	0·03	338,857 93	3·11	35,464 74	0·33
Grease	1,125,501 85	58·93	888,419 32	46·52	124,720 79	6·53	33,041 21	1·73	2,557 47	0·13	6,489 04	0·34	1,507,955 20	78·97	70,274 02	3·67
Wax	394,651 06	39·38	292,437 54	29·18	52,683 78	5·25	13,957 06	1·40	1,080 31	0·11	2,915 76	0·29	440,713 33	43·97	31,576 61	3·15
Candles	153,114 67	116·31	119,169 81	90·53	18,278 05	13·88	4,842 25	3·68	374 80	0·28	883 35	0·67	179,843 38	136·61	9,566 41	7·27
Total	28,192,934 03	11·44	20,052,878 78	8·14	4,280,859 92	1·74	942,972 77	0·38	45,162 49	0·02	242,700 46	0·10	36,998,958 85	15·01	2,628,359 61	1·06

TABLE VI

Population and Registration of Motor Cars and Motor Vehicles in Manitoba, Saskatchewan, and Alberta

—	Manitoba		Saskatchewan		Alberta		Totals	
Estimated population 1932	705,000		971,000		740,000		2,416,000	
Passenger Cars		Per cent increase		Per cent increase		Per cent increase		Per cent increase
1921								
1922	38,913		60,352		38,214		137,479	
1923	39,192	0·7	63,017	4·4	39,742	3·9	141,951	3·2
1924	40,843	4·2	64,666	2·6	47,871	20·5	153,380	8·0
1925	46,736	14·4	71,205	10·1	50,496	5·5	168,437	9·8
1926	52,201	11·7	86,105	20·9	59,767	18·4	198,073	17·6
1927	57,718	10·5	92,640	7·6	67,665	13·2	218,023	10·1
1928	63,384	9·8	102,839	11·0	78,302	15·7	244,525	12·1
1929	68,441	7·9	108,630	5·6	85,087	8·7	262,158	7·2
1930	68,550	0·2	108,161	* 0·4	85,067	0·02	261,778	* 0·1
1931	64,940	* 5·3	91,846	*15·1	79,225	6·9	236,011	* 9·8
1932	61,420	* 5·4	75,685	*17·6	72,079	9·0	209,184	*11·4
Total Motor Vehicles								
1921	40,215		61,184		40,235		141,634	
1922	42,200	4·9	61,367	0·3	40,642	1·0	144,209	1·8
1923	42,428	0·5	67,337	9·7	43,044	5·9	152,809	5·9
1924	44,322	4·5	70,754	5·7	51,148	18·8	166,224	8·7
1925	51,241	15·6	79,078	11·7	54,357	6·3	184,676	11·1
1926	57,857	12·9	97,267	23·0	65,590	20·7	220,714	19·5
1927	63,905	10·5	106,599	9·6	73,830	12·6	244,334	10·7
1928	71,163	11·4	121,615	14·1	89,249	20·9	282,027	15·4
1929	77,840	9·4	130,229	7·1	99,650	11·6	307,719	9·1
1930	79,308	1·9	129,851	* 0·3	102,652	3·0	311,821	1·3
1931	75,564	* 4·7	108,563	*16·4	95,686	6·8	279,813	*10·3
1932	71,570	* 5·3	91,275	*15·9	86,878	9·2	249,723	*10·8

*Decrease.

In addition to the above, internal combustion engines operating on farms in 1931 were distributed as follows: Manitoba, 17,552; Saskatchewan, 38,534; Alberta, 26,930.

COMPETITION FROM PRESENT SOURCES OF SUPPLY

As indicated by Tables VII, VIII, and IX, present production of crude petroleum in Canada is relatively small. In 1930 such production—equivalent to approximately 3½ per cent of the quantity received at Canadian refineries—would represent somewhat less than 12 days' supply. In 1932 crude received at principal refineries in Manitoba, Saskatchewan, and Alberta, was derived from the following sources: Montana, 40·4 per cent; Turner Valley, 38·9 per cent; Texas, 8·9 per cent; Oklahoma, 5·9 per cent; Wyoming, 2·2 per cent; Red Coulee, 2·0 per cent; Kansas, 1·3 per cent; Wainwright, 0·3 per cent; Arkansas, 0·1 per cent. Approximate distances by rail from the more important producing centres to

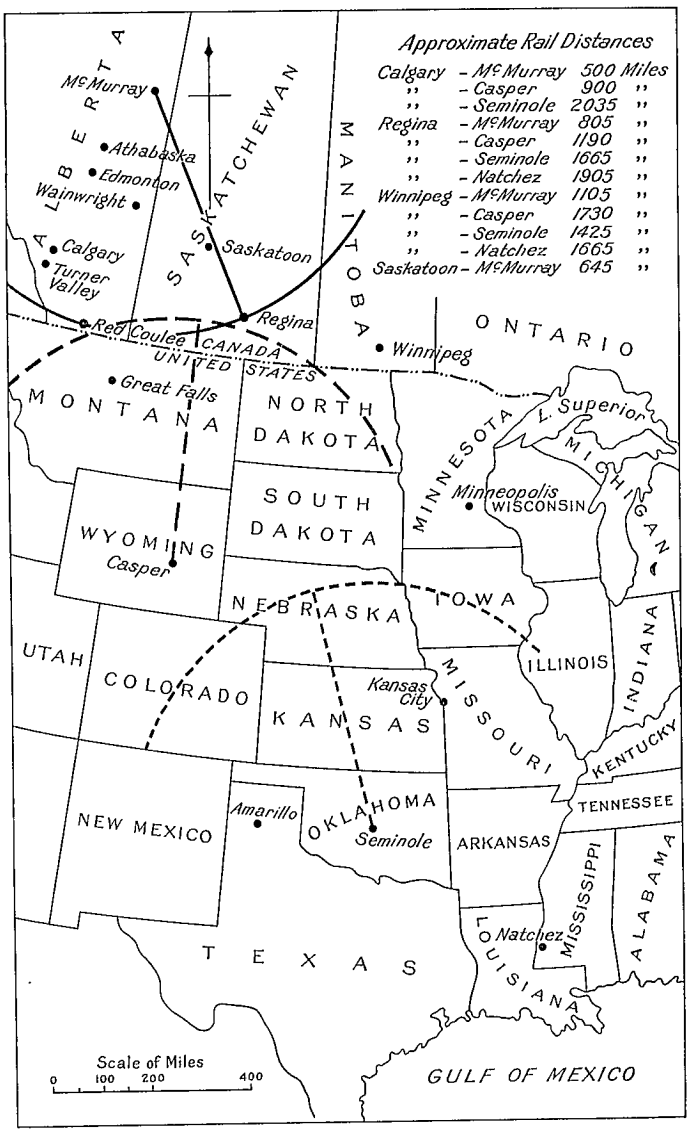

Figure 5. Map indicating position of McMurray, Alberta, in relation to certain sources of supply of crude petroleum.

principal refining centres in Saskatchewan and Alberta are indicated below. For purposes of comparison distances from McMurray to the same refining centres are also indicated. (Figure 5.)

	Miles
Calgary—McMurray	500
" Casper (Wyoming)	900
" Seminole (Oklahoma)	2,035
" Turner Valley	30
Regina—McMurray	805
" Turner Valley	505
" Casper (Wyoming)	1,190
" Seminole (Oklahoma)	1,665
" Natchez (Mississippi)	1,905
Winnipeg—McMurray	1,105
" Casper (Wyoming)	1,730
" Seminole (Oklahoma)	1,425
" Natchez (Mississippi)	1,645
Saskatoon—McMurray	645

Well prices of crude oil from Mid-Continent,[1] Illinois, and Canadian fields at Sarnia in 1930-1933 were as follows[2]:—

Crude Oil Prices: 1930-1933

—	Mid-Continent (36 Gravity)				Illinois				Canadian (Sarnia)			
	1930	1931	1932	1933	1930	1931	1932	1933	1930	1931	1932	1933
January	$1 45	$0 95	$0 77	$0 44	$1 75	$1 30	$0 95	$0 62	$2 20	$1 95	$1 90	$ 1 60
February	1 33	0 95	0 77	0 44	1 68	1 30	0 95	0 62	2 13	1 95	1 90	1 75
March	1 22	0 70	0 77	0 44	1 60	0 91	0 95	0 62	2 05	1 78	1 90	1 75
April	1 26	0 59	0 92	0 44	1 63	0 80	0 95	0 62	2 08	1 75	1 90	1 75
May	1 29	0 59	0 92	0 25	1 65	0 80	1 10	0 47	2 10	1 75	1 90	1 75
June	1 29	0 35	0 92	0 25	1 65	0 56	1 10	0 47	2 08	1 75	1 90	1 75
July	1 29	0 23	0 92	0 44	1 65	0 45	1 10	0 67	1 95	1 65	1 90	1 75
August	1 29	0 46	0 92	0 64	1 65	0 62	1 10	0 87	1 95	1 76	1 90	1 85
September	1 29	0 62	0 92	0 89	1 65	0 80	1 10	0 97	1 95	1 80	1 90	1 85
October	1 24	0 62	0 92	.....	1 61	0 80	1 10	.....	1 89	1 80	1 90	.....
November	0 95	0 76	1 04	.....	1 30	0 94	1 10	.....	1 88	1 89	1 90	.....
December	0 95	0 77	1 04	.....	1 30	0 95	1 10	.....	1 95	1 90	1 90	.....

[1] According to information furnished by the Missouri Pacific Railway, freight rates per barrel on crude petroleum from Tulsa, Oklahoma, to refining centres in western Canada were (Oct. 1933) as follows: to Winnipeg, $1.40; to Regina, $1.40; to Calgary, $1.70; to Edmonton, $5.06, and to Saskatoon, $4.00.

[2] Filed by Imperial Oil, Ltd. with Select Standing Committee, House of Commons, on the Price of Gasoline 1932.

Range of prices of crude[1] delivered at Calgary during 1931 and 1932 from Kevin-Sunburst Field,[2] Montana, was as follows:—

	Per Bbl. High (Jan. 1, 1931)	Per Bbl. Low (July 10, 1931)
Cost at Sunburst	1·55	0·70
Pipeage to Kevin	0·1250	0·1250
Excise tax at 1 per cent	0·0155	0·0155
Freight to Calgary at 20c. per cwt	0·6200	0·6200
Estimated tank car rental	0·0500	0·0500
	2·3605	1·5105

	High (Dec. 30, 1932)	Low (Jan. 9, 1932)
Cost at Sunburst	1·05	0·90
Exchange at 13 per cent	0·1365	0·1365
	1·1865	1·0365
Excise tax at 3 per cent	0·0356	0·0356
Pipeage to Kevin	0·1250	0·1250
Exchange on pipeage at 13 per cent	0·0162	0·0162
Freight to Calgary at 20c. per cwt	0·6200	0·6200
Surcharge on freight, 9 per cent	0·0558	0·0558
Estimated tank car rental	0·0500	0·0500
	2·0891	1·9391

Gravity 30·2

TABLE VII

World Crude Oil Production, 1930-1932*

(Figures in thousands of barrels)

	1932		1931		1930	
	Quantity	Per cent of total	Quantity	Per cent of total	Quantity	Per cent of total
United States	781,845	59·9	851,081	62·0	898,011	63·6
Russia (U.S.S.R.)	155,250	11·9	162,842	11·9	125,555	8·9
Venezuela	116,300	8·9	116,613	8·5	136,669	9·7
Roumania	54,160	4·1	49,127	3·6	42,759	3·0
Persia	49,470	3·8	44,376	3·2	45,833	3·3
Netherland East Indies	39,000	3·0	35,539	2·6	41,729	3·0
Mexico	32,805	2·5	33,039	2·4	39,530	2·8
Colombia	16,417	1·3	18,237	1·3	20,346	1·4
Argentina	13,000	1·0	11,709	0·9	9,002	0·6
Trinidad	10,100	0·8	9,744	0·7	9,419	0·7
Peru	9,900	0·8	10,089	0·7	12,449	0·9
India, British	8,430	0·7	8,200	0·6	8,887	0·6
Poland	4,115	0·3	4,662	0·3	4,904	0·3
Sakhalin, Russian	2,800	0·2	2,734	0·2	1,805	0·1
British Borneo (Sarawak)	2,400	0·2	3,854	0·3	4,907	0·4
Egypt	1,790	0·1	2,038	0·1	1,996	0·1
Japan (including Taiwan)	1,630	0·1	2,050	0·2	2,047	0·2
Germany	1,617	0·1	1,606	0·1	1,222	0·1
Ecuador	1,595	0·1	1,762	0·1	1,553	0·1
Canada	1,057		1,543		1,522	
Iraq	910		830		909	
France	528		520		523	
Italy	210	0·2	124	0·3	59	0·2
Czechoslovakia	190		134		157	
Bolivia	44		25		56	
Other Countries	60		54		56	
	1,305,563	100·0	1,372,532	100·0	1,411,905	100·0

* Petroleum in 1932. U.S. Bureau of Mines.

[1] Personal communication.

[2] Cost of crude from Pondera Field is 10 cents less than from Kevin-Sunburst and delivered price Calgary should be computed in the same manner, except that there is no pipeage. Freight rate is the same. Gravity 30·5.

TABLE VIII

Imports of Petroleum and Petroleum Products into Manitoba, Saskatchewan, Alberta, and British Columbia, 1930-1932*

—	Asphalt[1]		Road Oil	Crude Petroleum		Fuel Oil		Total Value
	Tons	Value	Value	Bbls.	Value	Bbls.	Value	
		$	$		$		$	$
1930								
From U.S.A. into:								
Manitoba	2,303	29,702	5,270	46,025	55,033	67,693	100,517	
Saskatchewan	75	1,832	.....	2,409,384	3,314,192	1,540	2,498	
Alberta	328	14,289	.....	2,083,440	3,848,959	18,417	66,292	
British Columbia	2,758	67,139	1,645	5,760,335	5,841,835	343,016	722,650	
From Peru into British Columbia	.....	.....	.....	247,904	320,643			
Total	5,464	112,962	6,915	10,547,088	13,380,662	430,666	891,957	14,392,496
1931								
From U.S.A. into:								
Manitoba	1,831	22,578	11,388	100,638	86,564	22,222	31,446	
Saskatchewan	183	3,118	.....	1,858,145	2,236,934	2,990	5,300	
Alberta	210	11,732	.....	1,668,275	2,845,156	4,239	13,204	
British Columbia	1,917	42,061	14,577	4,971,022	5,326,426	785,492	706,130	
From Peru into British Columbia	.....	.....	.....	164,842	209,818			
Total	4,141	79,489	25,965	8,762,922	10,714,898	814,943	756,080	11,576,432
1932								
From U.S.A. into:								
Manitoba	335	5,542	23,508	129,637	105,748	9,007	13,278	
Saskatchewan	.....	.....	.....	1,588,910	1,078,460	8,335	26,557	
Alberta	47	1,082	.....	1,240,687	1,326,755	11,363	32,498	
British Columbia	2,079	37,871	649	4,523,046	3,350,322	1,479,487	578,833	
From Peru into British Columbia	.....	.....	.....	271,711	355,757			
Total	2,461	44,495	24,157	7,753,991	6,217,042	1,508,192	651,166	6,936,860

*Based on data compiled by Dept. of National Revenue.
[1] Asphalt was also produced from imported crude at refineries in Alberta and Saskatchewan.

TABLE IX

Imports of Crude Petroleum into Manitoba, Saskatchewan, and Alberta, together with Production from Turner Valley*

—	Imports of Crude into Manitoba, Saskatchewan and Alberta		Production (Turner Valley)		Total	
	Bbls.	Value $	Bbls.	Value $	Bbls.	Value $
1921	1,016,671	2,822,802	7,203	33,133	1,023,874	2,855,935
1922	1,358,192	1,910,270	6,559	30,171	1,364,751	1,931,441
1923	1,527,319	2,255,792	1,943	8,937	1,529,262	2,254,729
1924	1,830,023	2,699,167	844	3,882	1,830,867	2,703,049
1925	3,010,878	4,275,165	183,241	845,269	3,194,119	5,120,434
1926	2,569,954	4,784,031	209,993	898,617	2,779,947	5,682,648
1927	4,068,551	6,680,978	315,698	1,183,036	4,384,249	7,864,041
1928	3,053,109	4,384,265	474,376	1,758,710	3,527,485	6,142,975
1929	4,462,455	6,862,206	971,821	3,444,821	5,434,276	10,307,027
1930	4,656,455	7,489,305	1,340,428	4,695,762	5,996,883	12,185,067
1931	3,656,506	5,218,604	1,334,039	3,899,504	4,990,545	9,118,108
1932	2,991,366	2,583,296	854,116	2,600,000	3,845,482	5,183,296

*Based on statistics compiled by Dept. of National Revenue, and the Mining, Metallurgical and Chemical Branch, Dominion Bureau of Statistics.

TABLE VIII

Imports of Petroleum and Petroleum Products into Manitoba, Saskatchewan, Alberta, and British Columbia, 1930-1932*

—	Asphalt[1]		Road Oil	Crude Petroleum		Fuel Oil		Total Value
	Tons	Value	Value	Bbls.	Value	Bbls.	Value	
1930		$	$		$		$	$
From U.S.A. into:								
Manitoba	2,303	29,702	5,270	46,025	55,033	67,693	100,517	
Saskatchewan	75	1,832	.....	2,409,384	3,314,192	1,540	2,498	
Alberta	328	14,289	.....	2,083,440	3,848,959	18,417	66,292	
British Columbia	2,758	67,139	1,645	5,760,335	5,841,835	343,016	722,650	
From Peru into British Columbia	.....	.....	.....	247,904	320,643			

ERRATA SLIP

Mines Branch Report No. 735, page 26, Table VIII. The fiscal year ending March 31st is used throughout. Errata occur in Table VIII, col. 6, p. 26, as follows:

Line 4,	343,016	should	read	843,016
" 5,	430,666	"	"	930,666
" 14,	1,479,487	"	"	622,345
" 15,	1,508,192	"	"	651,050

TABLE IX

Imports of Crude Petroleum into Manitoba, Saskatchewan, and Alberta, together with Production from Turner Valley*

—	Imports of Crude into Manitoba, Saskatchewan and Alberta		Production (Turner Valley)		Total	
	Bbls.	Value $	Bbls.	Value $	Bbls.	Value $
1921	1,016,671	2,822,802	7,203	33,133	1,023,874	2,855,935
1922	1,358,192	1,910,270	6,559	30,171	1,364,751	1,931,441
1923	1,527,319	2,255,792	1,943	8,937	1,529,262	2,254,729
1924	1,830,023	2,699,167	844	3,882	1,830,867	2,703,049
1925	3,010,878	4,275,165	183,241	845,269	3,194,119	5,120,434
1926	2,569,954	4,784,031	209,993	898,617	2,779,947	5,682,648
1927	4,068,551	6,680,978	315,698	1,183,036	4,384,249	7,864,041
1928	3,053,109	4,384,265	474,376	1,758,710	3,527,485	6,142,975
1929	4,462,455	6,862,206	971,821	3,444,821	5,434,276	10,307,027
1930	4,656,455	7,489,305	1,340,428	4,695,762	5,996,883	12,185,067
1931	3,656,506	5,218,604	1,334,039	3,899,504	4,990,545	9,118,108
1932	2,991,366	2,583,296	854,116	2,600,000	3,845,482	5,183,296

*Based on statistics compiled by Dept. of National Revenue, and the Mining, Metallurgical and Chemical Branch, Dominion Bureau of Statistics.

A large part of the exports from Montana consists of crude that originates in Wyoming[1] and in both states production has decreased during recent years. It appears (see Table X) that by 1938, production—more especially as regards high gravity oils—in both states will have decreased to such a point that exports will be negligible.[2] Production from the Turner Valley field decreased from 1,334,039 barrels in 1931 to 854,116 in 1932[3], and during recent years a number of carefully located test wells have been abandoned. Recognized and exceptional difficulties in discovering production in the Foot-hills render difficult any forecast as to the probable future of this field. Present production from the Red Coulee and Wainwright areas is small. Although opinions differ as to the probable future importance of the latter field, it may be significant that Imperial Oils, Ltd. has abandoned its acreage in that area.[4] On the other hand, Mr. Wm. Calder,[5] Director, Petroleum and Natural Gas Division, Department of Lands and Mines, Alberta, states that "in the Wainwright area, every well drilled to date has proved the presence of oil, and, as these wells are widely separated, there is ample evidence available to justify the statement that by concentrating the drilling of new wells and thereby reducing production costs, the returns from small production will be much larger than is now appreciated."

TABLE X

Petroleum Produced in Montana and Wyoming (1921-31)*

(In thousands of barrels)

Year	Montana	Wyoming	Total
1921	1,509	19,333	20,842
1922	2,449	26,715	29,164
1923	2,782	44,785	47,567
1924	2,815	39,498	42,313
1925	4,091	29,173	33,264
1926	7,727	25,776	33,503
1927	5,058	21,307	26,365
1928	4,015	21,461	25,476
1929	3,980	19,314	23,294
1930	3,349	17,868	21,217
1931	2,830	14,834	17,664

*Petroleum in 1931. U.S. Department of Commerce, Bureau of Mines.

It is impossible to forecast the period during which adequate supplies of crude may be available from present sources in Texas and Oklahoma. Referring to oil reserves in the United States as a whole, L. C. Snider,[6] Consulting Geologist, Henry L. Doherty and Company, comments in part as follows:—

Statements have been made to the effect that the United States certainly has reserves of petroleum sufficient to meet the demand for decades, and even for centuries. This is certainly not the consensus of opinion of the students of the industry, but it is probably

[1] It appears that, with improved demand, large production of heavy—14 to 22 gravity—high sulphur oils may be expected from the Big Horn and Wind River basins, Wyoming, but it is anticipated that a comparatively small amount of this will be available for export.

[2] It is assumed that a period of four years would be required to establish large commercial production of petroleum products from Alberta bituminous sand.

[3] Partly due to cessation of drilling.

[4] Select Standing Committee, House of Commons, Ottawa. Minutes of Proceedings and Evidence on Price of Gasoline, p. 336, 1932.

[5] Can. Min. and Met. Bull., Nov., 1932.

[6] Trans. A.I.M.E. Petroleum Development and Technology, 1932.

safe to say that the present demand rate could be met for some such period as two to three years by drilling up the known fields at a reasonable rate. Also, it may reasonably be expected that new fields will be discovered fast enough to prolong the interval in which demand will probably not greatly exceed the available supply to some such period as 10 years. . . . Under any conditions which may be reasonably imagined, however, it appears that the industry as a whole has every assurance of an ample supply for at least five years.

In the course of an address delivered in Vienna on May 12, 1933, before the Lower Austrian Trade Society, Dr. Carl Bosch[1] referred to the broader aspects of petroleum production as follows:—

For some years past there has been an overproduction of petroleum which has given the impression of great potential supplies. This condition resulted in decreased prices equivalent to about one-third of those that prevailed in 1929. . . . The immediate oversupply might be misinterpreted as indicating that very large supplies of petroleum are available in the world. In reality, however, such supplies are quite limited when considered from the long range view. It is true that, at the right moment, new fields have always been found, and, especially in more recent years, the discovery of petroleum has been facilitated by the adoption of geophysical methods. It must, however, be recognized that the world, and especially North America, has already been very closely prospected for oil. According to Garfias, a well known American oil statistician, the reserves of fields discovered and already producing amount to about 3·5 milliards of tons.[2] This would be sufficient for but 19 years with a production of 183 million tons such as was produced in 1932. Such calculations have only a limited practical value, nevertheless they show clearly that in the future very considerable oil occurrences will have to be discovered continuously, in order to supply the demand for motor fuel which is bound to increase after the passing of the world crisis. The American outcry for "Oil Conservation" is therefore only too well justified. In order to limit waste of crude and to provide sufficient new capital for the search for and opening up of new fields, it is necessary for every oil-producing country to turn as soon as possible from the scale of ruinous prices to a healthy prosperity for its oil industry.

As a result of abnormal conditions during recent years prices of crude have been marked by wide fluctuations and in many instances have fallen to unprofitable levels. It may be assumed that within a period of much less than 5 years present prices will show a marked increase.

CONCLUSIONS

Since 1914, the writer has maintained that the McMurray deposit of bituminous sand should be regarded as a potential source of liquid hydrocarbons. Technically and economically, such production constitutes a many-sided problem, which can merely be touched upon in a general statement, and in certain respects is analogous to that presented by the proposed development of petroliferous shales. It is true that the average content of crude petroleum per ton of bituminous sand is less than that of many of the shales of New Brunswick, Nova Scotia, and certain foreign fields, and that the amount of nitrogen that might be recovered in the form of ammonium sulphate would be negligible. On the other hand, the cost of mining bituminous sand would certainly be much lower than in the case of most of the oil-shales.

Production of petroleum from Alberta bituminous sand constitutes a problem that is, in many respects, similar to the mining and treatment of low-grade ores.[3] Satisfactory financial returns will depend on large throughput capacity together with able technical, business, and administrative con-

[1] Director, I. G. Farbenindustrie, A.G., Nobel Prize Winner.
[2] Equivalent to somewhat less than 25 billion barrels.
[3] Mines Branch, Department of Mines, Canada, Rept. 632, p. 162.

trol. Production will be directly affected by the future trend of the petroleum situation in the United States and to a lesser extent by development of other foreign fields, the potential importance of which is, in many instances, as yet unknown. Other factors to be considered include possible competition with certain suggested substitutes for petroleum, labour supply, transportation, and the development and holding of stable and assured markets.

On the other hand, production of petroleum products from Alberta bituminous sand would be relatively free from certain well recognized hazards that attach to the production of well petroleum. Among these may be mentioned the uncertainty of locating oil pools, the incomplete recovery from producing sands, the uncertainty respecting amortization of capital, the fluctuating price due largely to inability to maintain uniform production, and the pernicious effect of the law of capture.

In the past, aggregate cost of petroleum production in the United States has materially exceeded aggregate returns to the producer. This has been due in no small measure to competitive drilling—an inevitable result of the operation of the law of capture, which makes ownership of oil depend on its reduction to possession on surface—and of physical conditions that govern the flow of oil. The unfortunate results of what has been regarded as unavoidable haste have been frequently discussed.[1] It is questionable whether the mining of fluids such as gas and oil can ever be carried out with such close approximation of supply to demand as can undoubtedly be done with the easily worked deposits of bituminous sand.

Ownership of the oil in place is assured to the lessee of bituminous sand deposits; the mode of occurrence further provides for controlled production of the crude bitumen and consequent maximum economy in storage of both this and its distillation products. The favourable situation of the deposits in regard to the large and growing markets of the Prairie Provinces and the possibility of meeting competition from existing oilfields alone confer on the bituminous sand of Alberta a claim for serious consideration as a source of oil. This is enhanced by the promising results of investigations already carried out on the conversion of the separated bitumen into merchantable products.

It would thus appear that ownership of oil (including bitumen) in place, controlled production and consequent economies as regards storage, are factors which should ultimately prove favourable to commercial development of the Alberta bituminous sands.

[1] *See* L. C. Snider, loc cit.