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Alberta Oil Sands:
Fuel of the Future?

Maurice Carrigy

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Article abstract

The Alberta Oil Sands, which contain more than 890 billion barrels of crude bitumen in place, will require the expenditure of vast sums of money to overcome the major environmental problems associated with the surface mining and hot-water washing method, and to develop a viable in-situ method of squeezing the oil from the subsurface deposits if they are to offset the predicted decline in Canada's conventional oil production.

Conference Reports

Alberta Oil Sands: Fuel of the Future?

Maurice Carrigy
Geology Division, Alberta Research, 11315 – 87th Avenue, Edmonton, Alberta

Summary
The Alberta Oil Sands, which contain more than 890 billion barrels of crude bitumen in place, will require the expenditure of vast sums of money to overcome the major environmental problems associated with the surface mining and hot-water washing method, and to develop a viable *in-situ* method of squeezing the oil from the subsurface deposits if they are to offset the predicted decline in Canada's conventional oil production.

Background
Originally the editor of *Geoscience Canada* asked me to review the papers presented at an oil sands symposium sponsored by the Canadian Society of Petroleum Geologists and held in Calgary from September 5 to 9, 1973 for this issue. Speakers at this symposium, which attracted 550 delegates, surveyed the geography, geology, and geochemistry of bituminous sands and reviewed the state of the technology being developed for producing a crude oil substitute from the bitumen in these sands. Because the full text of the papers presented are being published shortly as a memoir by the Society and in view of the importance the Alberta Oil Sands have assumed in the national petroleum picture, I have taken the liberty of using the space allotted to present as succinctly as possible the factual data on the Alberta Oil Sands, i.e., the location, size, extent, bitumen quality and reserves of the major deposits, and to show their importance relative to Canada's and the world's conventional petroleum resources. My hope is that this article will enable the reader to keep the potential of the Alberta Oil Sands in proper perspective when they are being hailed as the answer to the current energy shortage.

Interest in the so-called alternative fossil fuels (oil sands, oil shales, and coal) has been stimulated by recent political events and a growing awareness that the world's fossil fuel resources are finite, and, in view of the exponential growth in demand, may not last as long as we had expected. Since crude oil began to be produced in commercial amounts about 100 years ago the apparent abundance and low cost of this fuel has given birth to a new culture in the western world which relies on the ready availability of portable liquid fuel. The inevitable decline of this liquid fuel culture can be slowed, but not reversed, by the use of higher-cost crude oil substitutes. The current hope is that by using these alternative fuels we can buy enough time to make a smooth change-over to nuclear or solar energy. The fact that vast reserves of light (convential) crude oil exist in the Middle East, which could meet the world demand, has discouraged until very recently the big investments required to develop these high-cost alternative fuel sources such as the Alberta Oil Sands and the Colorado Oil Shales.

Because Canada's reserves of light oil are limited (about 1 per cent of world reserves) and she has the largest reserves of heavy oil in the world, it is clear that if Canada is seeking self-sufficiency in fossil liquid fuel as a long-term national objective, then the only reasonable course of action open is to develop the high-cost technology required to extract and refine the heavy crude oil now locked in the Alberta Oil Sands as rapidly as possible. Even a cursory glance at Figure 1, which depicts the relative amounts of petroleum found in conventional oilfields and that found in the oil sands, will indicate why this course of action is inevitable. However, what is not obvious from this diagram are the many problems that have to be overcome before this heavy oil can be upgraded to a marketable product.

Descriptions of Deposits
The major oil sand deposits in Canada are located within the heavy oil belt of northern Alberta (Fig. 2). They are found in beds of Lower Cretaceous age at various stratigraphic levels (Fig. 3). The largest deposit and the only one which outcrops at the surface is the Athabasca deposit whose existence has been known for almost 200 years. This deposit is

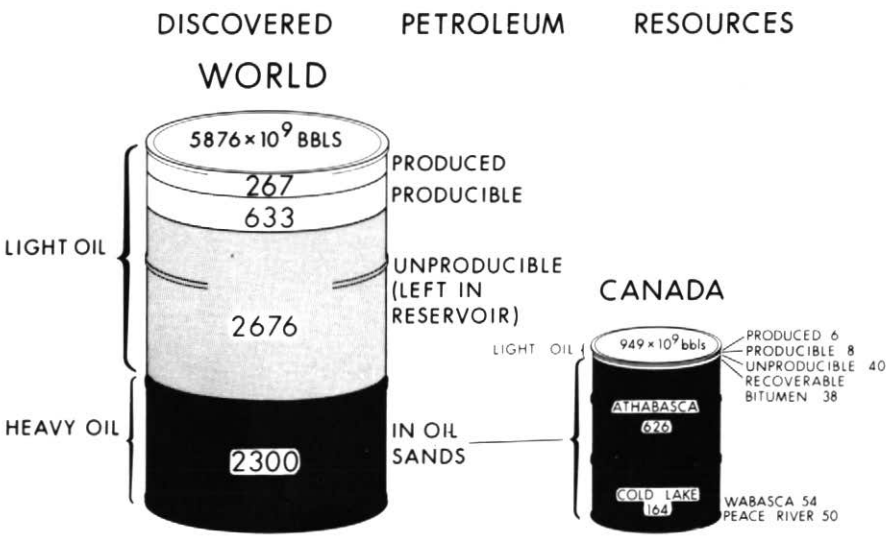

Figure 1
Comparison of petroleum resources discovered in Canada with the estimated world total. Note the preponderance of heavy oil (crude bitumen) in the Canadian barrel.

nearly 200 miles in length and over 100 miles in width and contains 626 x 10^9 barrels of heavy oil (API gravity 6 to 10). The depth of burial varies from 0 to 1800 feet. The second largest accumulation of heavy oil is the Cold Lake deposit which is located 60 miles south of the Athabasca deposit just west of the Alberta-Saskatchewan border. This deposit is completely buried and has only been known since 1967 and is still being actively explored. The oil in this deposit has been trapped at several stratigraphic levels in the Mannville Group sediments (Fig. 3). The whole deposit underlies an area of at least 3,500 square miles, is over 80 miles long and 60 miles wide, and is overlain by 1500 feet of younger sediments. The gravity of the oil in this deposit is said to be lighter than that in the Athabasca deposit varying from 10 to 12° API. The most recent (1973) reserve figure for the Cold Lake deposit given by the Alberta Energy Resources Conservation Board is 164 x 10^9 barrels of heavy oil in place.

The other two major deposits (Fig. 2); the Peace River and Wabasca deposits, are known only from the subsurface and were first brought to public attention by the geological staff of the Alberta Energy Resources Conservation Board in 1963. The Wabasca deposit is located to the south and west of the Athabasca deposit and overlaps it to some extent. Most of the oil in the Wabasca deposit is trapped in higher beds of the Mannville Group than the Athabasca oil and the total extent of the oil impregnation is only imperfectly known at this time. The overburden on this deposit varies from 300 feet or less in the northeast to 2500 feet or more in the southwest. The in-place reserves of 10 to 13° API gravity oil in this deposit are estimated by the Alberta Energy Resources Conservation Board to be in excess of 54 x 10^9 barrels. The Peace River heavy oil is trapped in the Bluesky and Gething Formations which are equivalent in age to the Wabiskaw-McMurray units of the Athabasca deposit. This deposit is buried from 1500 to 2500 feet below the surface and has in-place reserves in excess of 50 x 10^9 barrels of 8 to 23° API

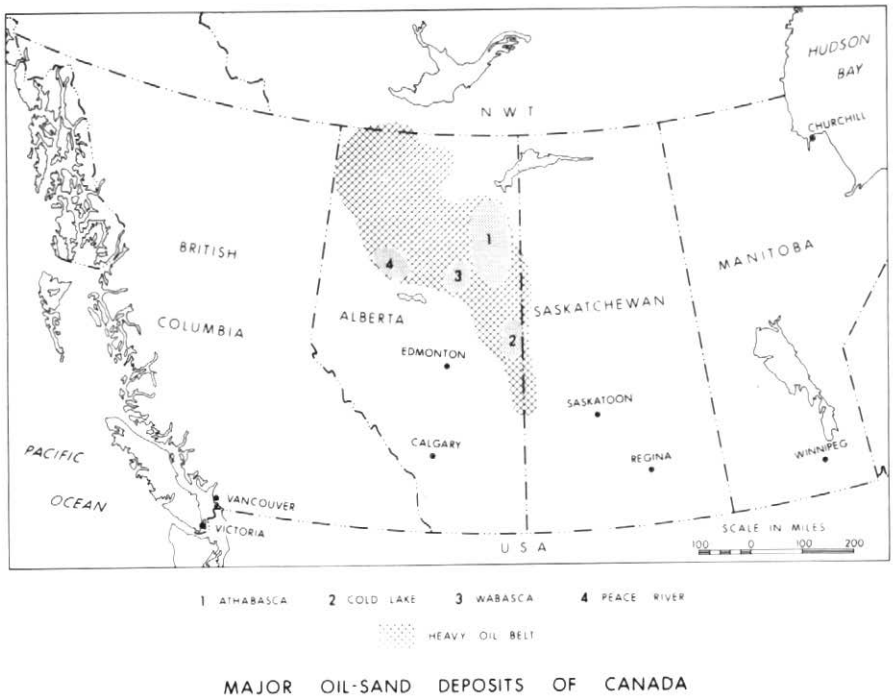

Figure 2
Location of the major oil sand deposits in the heavy oil belt of northern Alberta. Numerous minor deposits found in this belt are not shown on this map.

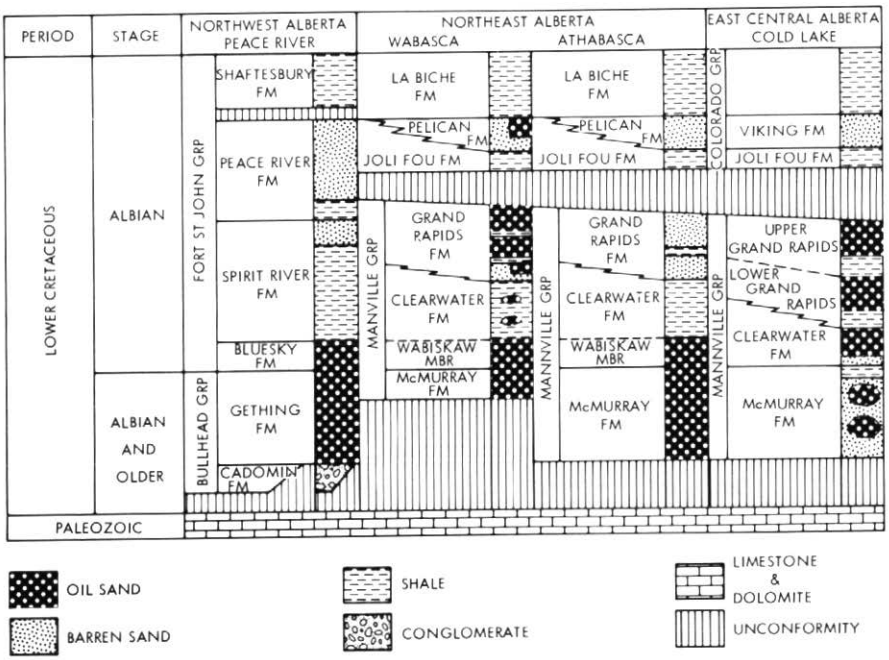

Figure 3
Location of crude bitumen impregnation in the stratigraphic columns of the northern Alberta Oil Sand Deposits.

gravity oil. The significant statistics on these major deposits are summarized in Table 1. Several other minor oil sand deposits are located within the heavy oil belt outlined in Figure 2, and as exploration proceeds some of these will undoubtedly prove to be major heavy oil reservoirs.

Table 1: Characteristics of Alberta Oil Sands.

	Athabasca	Cold Lake	Wabasca	Peace River
Depth (ft.)	0-1800	1000-2000	250-2500	1000-2500
Area (sq. miles)	10,000+	5,000	3,000	2,000
Total Bitumen in place (bbls x 10^9)	626	164+	54+	50+
Gravity (°API)	6-10	10-12	10-13	8-23
Sulphur (%)	3.8-5.0	3.8-4.5	4.4-5.5	5.8-6.5
Pay Thickness (ft)	100	40	30	40

Quantity and Quality

Although the magnitude of the in-place reserves in the Alberta Oil Sands is impressive, the quality of the oil is very poor. It commonly contains a high proportion of sulphur, nitrogen, oxygen and trace metals such as vanadium, nickel, iron and other heavy metals which make refining difficult. Another feature preventing rapid development is the fact that apart from that portion of the Athabasca deposit accessible to open pit mining and hot-water washing, the greater part of the oil is locked in the reservoirs at depth and is not economically available with any current technology. To produce oil from the subsurface deposits, many methods of *in-situ* extraction have been proposed. All of these involve production from a well after some form of stimulation. Among the many novel methods tried or proposed are: injection of gases, steam, and solvents; underground combustion; and nuclear explosions. However, it is estimated by people most familiar with these developments that it will take at least 10 years of experimental work in the field before any of these methods will result in commercial production. Currently, four experimental *in-situ* sites are in operation in the Alberta Oil Sands. Two of these are in the Athabasca deposit and one each in the Peace River and Cold Lake deposits. This is obviously a field of research and development where much more effort could be expended with a view to reducing the lead time to large-scale commercial production from the oil sands.

Technology and Timing

In 1973 the Alberta Energy Resources Conservation Board added 38 x 10^9 barrels of crude bitumen from the Athabasca deposit to the recoverable oil reserves of the province, from which it is estimated that 26.5 x 10^9 barrels of synthetic crude oil will ultimately be produced. This synthetic oil will come only from surface mining and hot-water washing and the rate at which this synthetic crude oil will arrive on the market depends on a number of factors, other than the availability of a satisfactory extraction technology.

In broad terms these are:

1. the price of competitive oil;
2. the availability of capital;
3. the availability of technical manpower;
4. the satisfactory solution to a large number of environmental problems such as reduction of SO_2 emissions from the burning of high-sulphur fuels in power and steam generators, the reclamation of the vast areas of sterile sand remaining after the oil has been extracted, the efficient use of recycled water to reduce the volume of water in tailings ponds;
5. guarantees of an assured market for the oil for a period of 30 years or more from the commencement of production.

At the recent Oil Sands Symposium in Calgary Dr. G. W. Govier, Chairman of the Alberta Energy Resources Conservation Board forecast a gradual build up of synthetic oil production from the current rate of about 60,000 barrels per day to 200,000 b/d by 1980 and to 800,000 b/d in 1985. This rate of development, if realized, should, however, be sufficient to offset the anticipated decline in conventional oil production and must be reached if Canada is to remain self-sufficient in petroleum liquids until the end of this century.

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