Oil Sands Discovery Centre

Facts about Alberta's oil sands and its industry

Alberta

CONTENTS

OIL SANDS DISCOVERY CENTRE FACTS

Official Name	Oil Sands Discovery Centre
Vision	Sharing the Oil Sands Experience
Architects	Wayne H. Wright Architects Ltd.
Owner	Government of Alberta
Minister	The Honourable Lindsay Blackett Minister of Culture and Community Spirit
Location	7 hectares, at the corner of MacKenzie Boulevard and Highway 63 in Fort McMurray, Alberta
Building Size	Approximately 27,000 square feet, or 2,300 square metres
Estimated Cost	9 million dollars
Construction	December 1983 – December 1984
Opening Date	September 6, 1985 Updated Exhibit Gallery opened in September 2002
Facilities	Dr. Karl A. Clark Exhibit Hall, administrative area, children's activity/education centre, Robert Fitzsimmons Theatre, mini theatre, gift shop, meeting rooms, reference room, public washrooms, outdoor J. Howard Pew Industrial Equipment Garden, and Cyrus Bucketwheel Exhibit.
Staffing	Supervisor, Head of Marketing and Programs, Senior Interpreter, two full-time Interpreters, administrative support, receptionists/cashiers, seasonal interpreters, and volunteers.
Associated Projects	Bitumount Historic Site
Programs	Oil Extraction demonstrations, *Quest for Energy* movie, *Paydirt* film, Historic Abasand Walking Tour (summer), special events, self-guided tours of the Exhibit Hall. Guided tours of the Bucketwheel and Industrial Gardens (summer), education programs, science camps, historic archives (fall/winter) and traveling exhibits.

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WEBSITE	**www.oilsandsdiscovery.com**
	www.experiencealbertahistory.com

OTHER RELATED WEBSITES

Fort McMurray Tourism
www.fortmcmurraytourism.com

Regional Municipality of Wood Buffalo
www.woodbuffalo.ab.ca

Fort McMurray Information
www.mymcmurray.com

Fort McMurray Labour Market News
www.woodbuffalo.net

Oil Sands Developers Group
www.oilsands.cc

Fort McMurray Today (newspaper)
www.fortmcmurraytoday.com

Fort McMurray Online
www.fortmcmurrayonline.com

Oil Sands Review
www.oilsandsreview.com

Alberta Canada Facts Sheets
www.oilsands.alberta.ca

OIL SANDS OVERVIEW

WHAT IS OIL SAND?

Oil sand is made up of grains of quartz sand, surrounded by a layer of water and clay, and then covered in a slick of heavy oil called bitumen. Alberta's oil sands are contained in three deposits (Athabasca, Cold Lake and Peace River) and cover an area the size of the province of New Brunswick. The entire area composes the largest single deposit of oil in the world, containing between 1.7 and 2.5 trillion barrels.

HOW IS OIL SAND FORMED?

It is believed that the oil sands were formed many millions of years ago when Alberta was covered by a warm tropical sea. The oil was formed in southern Alberta when tiny marine creatures died and fell to the bottom of the sea. Through pressure, heat and time, their tiny bodies were squished into an ooze which today, we call petroleum (rock oil). In northern Alberta, many rivers flowed away from the sea and deposited sand and sediment. When the Rocky Mountains formed, it put pressure on the land, and the oil, being a liquid, was squeezed northward and seeped into the sand, forming the Athabasca oil sands.

HOW IS OIL SAND REVOVERED?

Oil sand is recovered by two methods: surface-mining and in situ technology. Surface-mining techniques require the removal of forest and layers of overburden (muskeg and topsoil) to expose the oil sands. Huge hydraulic power shovels dig into the oil sand and dump it into 400-ton heavy hauler trucks. The trucks transport the oil sand to a crusher unit that breaks it up, and then moves it by conveyor to the extraction plant. Previous mining methods included using a bucketwheel, dragline, and conveyor system that was eventually phased out by 2006.

HOW IS THE OIL REMOVED FROM THE OIL SAND?

Once mined, bitumen is separated from the sand using a hot water extraction process that was patented in the 1920s by Dr. Karl A. Clark. Oil sand is mixed with hot water to form a slurry (a very thick liquid), which is pipelined to a separation vessel. This is called hydrotransport. In the vessel, the slurry separates into three distinct layers: sand settles on the bottom, middlings (sand, clay and water) sit in the middle, and a thin layer of bitumen froth floats on the surface. The bitumen froth is skimmed off and spun in centrifuges to remove the remaining sand and water, and then goes to the upgrading plant. The leftover sand, clay, and water are pumped to large storage areas called tailings ponds or settling basins, and the water is recycled back into the extraction plant for re-use.

HOW IS THE BITUMEN UPGRADED?

In the upgrading process, bitumen is chemically and physically changed into lighter products that can be easily refined. The two upgrading methods that are currently used are coking and hydrotreating. During coking, bitumen is heated to 500°C to break its complex hydrocarbon molecule into solid carbon called coke (which is very similar to coal) and various gas vapours. The gases are funnelled into a Fractionation Tower to be condensed and distilled into liquid gas oils that form synthetic crude oil. In the hydrotreating process, hydrogen is added to the bitumen to bond with the carbon in the molecule, creating more product while also removing impurities.

HOW IS THE DEEP OIL SAND RECOVERED?

Only 20 percent of Alberta's oil sands can be recovered through surface-mining techniques. If the oil sand layer is deeper than 75 metres from the surface, an in situ (in place) technology is used. Steam Assisted Gravity Drainage, or SAGD, is the most common in situ process presently used. This process involves drilling two L-shaped wells parallel to each other into the deposit and injecting steam down through the top well. This warms the oil sand, and causes the bitumen to separate and flow downwards (using gravity) into the bottom well. It is then pumped to the surface for processing. Other in situ methods include, Toe to Heal Air Injection (THAI), Vapour Extraction (VAPEX), and Cyclic Steam Stimulation.

HOW DOES THE PROCESS AFFECT THE NATURAL ENVIRONMENT?

The impact on the natural environment is a major concern for the mining companies. After mining, the land is reclaimed to its natural, productive state by using the left over sand (known as tailings sand) and soil, overburden and muskeg that were originally there. Process water is stored in tailings ponds or settling basins on the mine site and re-used in the extraction process. Air quality is monitored, and levels of emissions are recorded. Limits are set which the companies cannot exceed. Oil sands companies work with organizations such as the Wood Buffalo Environmental Association (WBEA) and Regional Aquatic Monitoring Program (RAMP,) to monitor aspects of environmental impact and ensure that land, air and water quality are at acceptable levels.

ALBERTA'S VAST RESOURCE
The biggest known oil reserve in the world!

THERE IS AN ESTIMATED 1.7 – 2.5 TRILLION BARRELS of bitumen in place in Alberta's oil sands. Canada's recoverable oil resource is second only to Saudi Arabia's. At current production rates, resources from Alberta's oil sands could supply Canada's energy needs for more than 500 years, or the total world needs for up to 15 years! 39% of Canada's total oil production is from oil sands. Currently, approximately 1.3 million barrels are produced per day and production is expected to grow to three million barrels per day by 2020.

Alberta has three major oil sands areas: Athabasca, Cold Lake, and Peace River. Each area is covered by a layer of overburden consisting of muskeg, glacial tills, sandstone and shale.

Different areas and deposits have distinct characteristics and require different techniques to extract the bitumen. In the Athabasca area around Fort McMurray, the oil sands are close enough to the surface to be mined. Everywhere else, the bitumen has to be recovered by underground, or in situ methods.

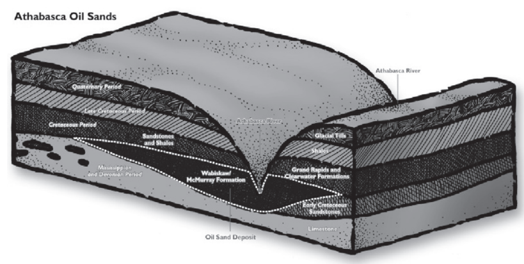
Over the next 10 years there is expected to be over $60 billion of direct capital expenditures into development of the oil sands. The Alberta Energy and Utilities Board speculates that Alberta's oil sand reserves will be the primary source for Canada's crude oil within a decade, offsetting rapidly declining conventional crude oil stocks.

Sources

www.capp.ca
www.centreforenergy.com

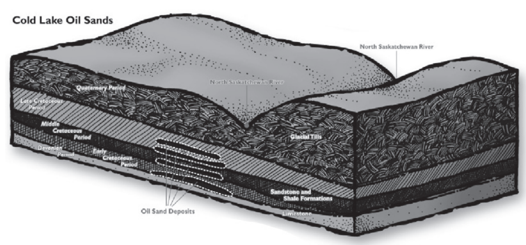
ATHABASCA AREA

At 40,000 square kilometres, this is the largest and most accessible reserve. It also contains the most bitumen. About 20% of the oil sands near Fort McMurray are close enough to the surface to be mined. In situ techniques are needed for other deeper deposits. This area also includes deposits in the Wabasca region.



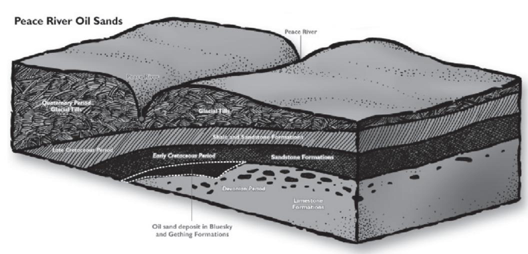
COLD LAKE AREA

At 22,000 square kilometres, this area has Alberta's second largest reserve of bitumen held in deep deposits ranging from 300 to 600 metres below the surface. Presently, some of these deposits are being recovered using in situ technology.



PEACE RIVER AREA

At 8,000 square kilometres, this is the smallest of Alberta's oil sands areas. These deep deposits (ranging from 300 to 770 meters below the surface) are being recovered with in situ methods.



OTHER HYDROCARBONS

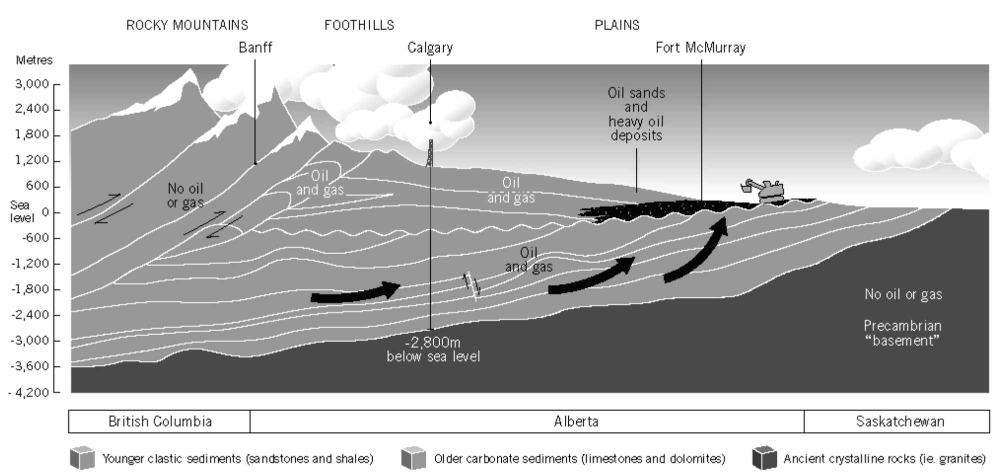
Several oil sands leases also produce significant quantities of coal, coal bed methane, and natural gas. These other hydrocarbon resources may become increasingly valuable energy sources in the future.

GEOLOGY
Why does Alberta have oil sands?

THE FORMATION OF BOTH CONVENTIONAL OIL AND THE HEAVY OIL in the oil sands required a certain set of conditions—the presence of organic material, bacteria, heat and pressure, a reservoir for the oil to accumulate and plenty of time (over 400 million years).

Like all crude oil, it is believed that bitumen and heavy oil resources started out as living material. Oil is typically derived from marine (water based) plants and animals, mainly algae that have been gently cooked for at least one million years at a temperature between 50 and 150°C.

It is speculated that the naturally occurring oil sands evolved millions of years ago when an ancient ocean covered Alberta. The remains of tiny creatures called marine plankton that lived in the ocean formed organic material in the depressions in the sea bed. Bacteria removed most of the oxygen and nitrogen, leaving primarily hydrogen and carbon molecules. Tremendous heat and pressure caused by the layering of rock, silt and sand accumulated over time, essentially pressure-cooked the organic material. The decomposition of the microscopic creatures led to a reorganization of their carbon and hydrogen bonds to form hydrocarbons or oil. This formation of oil is very similar to that of conventional oil deposits, except, the oil absorbed into the existing sand. Due to pressure from the formation of the Rocky Mountains, the oil was forced north into the existing sand deposits left behind by ancient river beds, thus forming the oil sands. Amongst the oil sands are fine particles of clay and other minerals such as various metals and sulphur.



Courtesy of the Petroleum Communication Foundation

Sources

Albian Sands – AlbianAdvantage

The Science Behind the Oil Sands

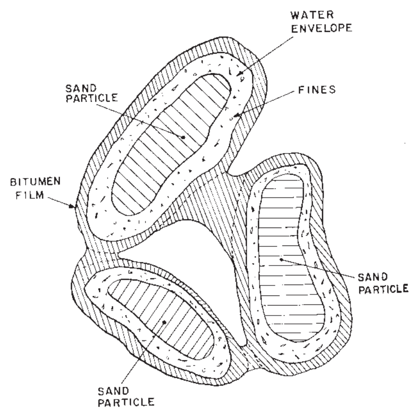
Bott, Robert. *Our Petroleum Challenge, Sixth Edition—Exploring Canada's Oil and Gas Industry.* Petroleum Communication Foundation, 1999.

Centre for Energy
www.centreforenergy.com

OIL SANDS

OIL SANDS ARE HYDROPHILIC OR WATER WET. Each grain of sand is covered by a film of water, which is then surrounded by a slick of heavy oil (bitumen). The sands are bonded firmly together by grain-to-grain contact. The sand is composed of 92% quartz with traces of mica, rutile, zircon, tourmaline, titanium, nickel, iron, vanadium and pyrite. The sand is triangular in shape, making it very abrasive. On the Moh's hardness scale, with diamond being 10, oil sand is 7.4.

COMPOSITION OF OIL SANDS



Graphic

pp. 194, *Athabasca Oil Sands – The Karl A. Clark Volume*

Oil sand is often incorrectly referred to as "tar sand", because the bitumen (or oil) resembles black, sticky tar. However, the term oil sand is the correct term. Tar is a man-made substance formed through the distillation of organic material. It is **bitumen** (a heavy thick oil), not tar, that is found in the oil sands. The bitumen content in deposits varies from 1% – 18%. More than 12% bitumen content is considered rich, and less than 6% is poor and not usually considered economically feasible to mine, although it may be mined with a blended stock of higher grade oil sand. On average, it takes 2 tonnes of mined oil sand to produce one barrel of synthetic crude oil (159 litres). In the winter the water layer in the oil sand will freeze making it as hard as cured concrete. In the summer, it's as soft as molasses making driving conditions treacherous.

SURFACE MINING

The Athabasca area is the only reserve shallow enough to be surface mined. Resources recoverable by mining are estimated to be 65 billion barrels. There are currently four companies doing surface mining operations in the Athabasca area, and several other mining projects under development.

IN SITU—TAPPING INTO THE POTENTIAL

Approximately 80% of Canada's oil sands lie deep below the surface and cannot be recovered by open pit (surface) mining techniques, so *in situ* processes are used to access these deposits. No single method of *in situ* recovery can be applied to all oil sand deposits, since the bitumen varies considerably from deposit to deposit as well as within each deposit.

Sources

Carrigy, M.A., ed. *Athabasca Oil Sands – The Karl A. Clark Volume*. Edmonton, Alberta, Canada: Research Council of Alberta, 1963.

McRory, Robert E. *Energy Heritage – Oil Sands and Heavy Oils of Alberta.* Edmonton, Alberta, Canada:

Alberta Energy and Natural Resources, 1982.

Canadian Association of Petroleum Producers: www.capp.ca

THE BASICS OF BITUMEN

BITUMEN IS THE OIL IN THE OIL SANDS. It is a naturally occurring viscous mixture of hydrocarbons with a consistency of molasses and an API of 8–14°. Bitumen molecules contain thousands of carbon atoms. This makes bitumen one of the most complex molecules found in nature. In its natural state, it is not recoverable through a well like conventional petroleum. Bitumen cannot be refined into common petroleum products like gasoline, kerosene, or gas oil without first being upgraded to crude oil.

On average, bitumen is composed of:

Carbon	83.2%
Hydrogen	10.4%
Oxygen	0.94%
Nitrogen	0.36%
Sulphur	4.8%

Bitumen can be rich in either the hydrocarbons of the naphthalene type (used in making gasoline and petrochemicals), or asphaltenes type (used to make asphalt), depending on the type of fraction.

Aboriginal peoples of the Athabasca and Clearwater River regions used bitumen to waterproof birch bark canoes. They also heated it in smudge pots to ward off mosquitoes in the summer time.

In 1719, a Cree named Wa-Pa-Su (meaning "the Swan") presented a sample of oil sand for trade at the Hudson's Bay Company to Henry Kelsey, who was the first recorded European to see it.

In 1787, Alexander MacKenzie provided the first recorded description of the Athabasca oil sands:

> *At about 24 miles from the fork (of the Athabasca and Clearwater Rivers) are some bituminous fountains into which a pole of 20 feet long may be inserted without the least resistance. Smelled of sea coal…*

In 1884, Robert Bell of the Geological Survey of Canada wrote:

> *…The banks of the Athabasca would furnish an in exhaustible supply of fuel…[they] have found it to contain from 12–15 per cent of bitumen. This proportion may appear small, yet the material occurs in such enormous quantities that a profitable means of extracting oil…may be found.*

In 1915, Sidney Ells experimented with hot water extraction both with and without the addition of reagents, but did not patent his findings. He also paved a stretch of road with oil sand.

In 1922 Robert Fitzsimmons:

> *went to Fort McMurray…to investigate the possibilities of obtaining oil from the Bituminous sand…[he] was struck with the richness of the deposit…and decided to purchase the adjoining property…*

In 1920, Dr. Karl A. Clark joined the Alberta Research Council and became interested in the methods of oil separation. He was given the approval to conduct research concerning the extraction of bitumen from the oil sands and to access the value of bitumen as a road-covering material.

In 1923, Dr. Clark, along with his associate Sidney M. Blair, built a small separation unit in the basement of the U of A power plant.

In 1928, Dr. Clark and Sidney Blair were granted a Canadian patent for the hot water process on a commercial scale.

OIL SANDS PIONEERS

Bitumount Historic Site

IN 1922, ROBERT C. FITZSIMMONS, a former farmer and businessman, arrived in Fort McMurray to make his fortune from the "huge pools of oil" in the Athabasca deposit. In 1923, he took over the Alcan Oil Company and acquired its lease in Townships 96 and 97, Range 40, approximately 90 km (65 miles) north of Fort McMurray. He renamed the site **Bitumount**, and started drilling explorations there.

On August 12, 1927, Fitzsimmons formed the **International Bitumen Company Ltd.** (I.B.C.). He continued to drill on the lease looking for the ever-elusive pools of oil that never appeared. Discouraged by the results of conventional drilling, he turned to mining and extraction techniques. In 1930, he built a small hot-water separation plant on the site. It was a simple design based on Dr. Karl Clark's experimental plant located on the Clearwater River. The oil sand was shovelled into a tank, mixed with hot water, then fed into a second separation tank where the bitumen froth was skimmed off and the sand tailings were removed manually. It was a labour-intensive, primitive, small-scale operation. The seven-man crew at Bitumount produced about 300 barrels of bitumen during the summer months of 1930.

The bitumen produced at Bitumount was shipped to Waterways by barge, then to Edmonton by rail. The Marshall-Wells hardware store chain distributed the products. Most of it was used for waterproofing roofs, but the prospectus for the International Bitumen Company listed almost 50 other uses for bitumen. These included: fuels, lubrication oils, printers' ink, medicines, rust and acid-proof paints, fireproof roofing, street paving, patent leather, and fence post preservatives. According to the I.B.C.'s slogan, bitumen was "Nature's Supreme Gift to Industry."

Investment funds were a constant problem for Fitzsimmons. While his company had many shareholders, the capital he raised never met all his expenses. By 1932, he had spent over $200,000 at his Bitumount site. Eventually, his sources of capital funds ran dry and the plant did not operate between 1932 and 1937. In 1936, Fitzsimmons attempted to get the plant operating again. He hired Harry Everard, an experienced oil engineer, to build an oil refinery and reconstruct the separation plant. It took a year for the separation plant to become operational, so the refinery was only able to work at one-third of its capacity. In September 1937, Everard closed the plant, claiming that he and his co-workers had not received payment for their work. Fitzsimmons replaced Everard with Elmer Adkins, an engineering graduate from the University of Alberta, who had worked at Max Ball's Abasand Oils Ltd. company. Between January and June 1938, Adkins worked to rebuild the separation plant and the company started to produce again.

By the end of 1938, Fitzsimmons had exhausted all his sources of capital, and left the country to avoid his creditors. In 1941 he was forced to sell the company to Lloyd Champion, a Montreal entrepreneur and financier who renamed it **Oil Sands Limited**.

As President of Oil Sands Ltd., Champion retained Fitzsimmons in an advisory capacity at the plant site until 1944. For two years, Champion tried unsuccessfully to raise private capital and gain government contracts as a supplier of petroleum products. He submitted a proposal to the provincial government to join his company in a business partnership. The provincial Minister of Lands and Mines hired Dr. Karl Clark to evaluate Champion's proposal. Clark recommended a joint public-private venture for the construction of an experimental separation plant at Bitumount. The purpose of the project was to iron out the technical problems of the extraction process and to test the commercial feasibility of a large-scale venture. Despite the initial optimism of the provincial government, work proceeded slowly on the project. There were numerous problems and cost over-runs, and Champion found it increasingly difficult to finance the costly experiment. In November 1948, the new plant became the sole property of the provincial government.

In 1955, the provincial government sold the Bitumount plant complex to CanAmera Oil Sands Development Ltd. for $180,000. CanAmera installed new Coulson separators in the separation plant.

In 1957, CanAmera sold the Bitumount plant to Royalite Oil Company for $180,000 plus royalties. In 1958, Royalite closed down operations at Bitumount. In 1969, Royalite merged with Gulf Oil Company Limited.

In 1974, Bitumount was declared a Provincial Historic Site, and is currently managed by Alberta Culture and Community Spirit. Access is currently prohibited to ensure its long-term preservation.

The International Bitumen Company was the **first** commercial oil sands separation and refining operation to be established, despite many problems. Lack of capital, lack of markets, and lack of effective industrial machinery all plagued the I.B.C., as they did frontier resource developments everywhere. But the efforts of small private inventors like Mr. Fitzsimmons in the 1920's and '30's have resulted in the full-scale development of the oil sands by major oil companies today.

Source

O'Donnell, Cynthia. *Bitumount, A History of the Pioneers of the Oil Sands Industry*. Alberta Culture and Multiculturalism.

RELATED WEBSITES

Ghosts of Industry www.ghostsofindustry.com

http://www.history.alberta.ca/energyheritage/bitumount/Default.aspx

Historic Abasand

IN 1930, MAX BALL, an American, and his associates formed Canadian Northern Oil Sand Product Ltd., which later became Abasand Oils Ltd. Ball was granted a federal lease on the Horse River and began negotiations with the province to erect and operate a separation plant capable of handling a minimum of 250 tons of oil sand per day. Site clearing began in January 1936.

The plant officially opened September 1, 1936. It was operating on a regular basis by 1941, and produced 200 barrels per day of bitumen between May and November that year. In total, 19,000 tons of oil sand was mined in 1941. The mining method found to be most effective involved drilling holes in the oil sand where blasting powder was inserted and triggered. The loosened sand was then loaded directly onto dump trucks and hauled to the separation plant.

In November 1941, a fire broke out in the Abasand powerhouse. The plant was rebuilt in 1942 with an even greater capacity for operation. An enlarged pipeline and haul road to Waterways was completed.

In 1943, during World War II, the federal government grew concerned about potential fuel shortages in the west. They took control of the Abasand plant under the War Measures Act. George Webster was then appointed to redesign and reconstruct the operation.

In June 1945, a second disastrous fire was caused by a welder's torch, destroying most of the plant. Flames spread to the nearby forest and threatened the bunkhouses and an explosives area. The federal government abandoned the site in May 1946 since the need for fuel diminished after the end of World War II. Attempts by company shareholders to restart the plant operation were unsuccessful.

During the months of June, July and August, staff of the Oil Sands Discovery Centre lead guided walking tours of the Historic Abasand Site.

Sources

Comfort, Darlene J., *The Abasand Fiasco*. Edmonton: Friesen Printers, 1980

Sheppard, Mary Clark, ed. *Oil Sands Scientist – the Letters of Karl A. Clark 1920-1949*. Edmonton: University of Alberta Press, 1989.

MIGHTY MINING MACHINES

MINING OIL SANDS REQUIRES EXTREMELY LARGE MACHINES. The original mining process has evolved as new innovations in equipment and techniques allow the process to become more efficient and economical. In the early 1900s, oil sand was mined completely by hand. Technology has come a long way since then!

To prepare the area for surface mining, bulldozers, backhoes, loaders, water trucks, scrapers, side booms and graders are all used to remove the overburden (the muskeg and layers of soil over top of the oil sands deposit), which is saved for use in reclamation.

When Suncor started in 1967 as Great Canadian Oil Sands, they mined oil sand with huge bucketwheel excavators which dug directly into the side of the open mine pit. The oil sand was picked up by the buckets and deposited onto a conveyor belt system that transported it into the extraction plant. *(Also see Cyrus Fact Sheet)*.

When Syncrude opened their mine in 1978, they used draglines (the largest walking machines on earth) and bucketwheel reclaimers. The dragline scooped up the oil sand, and dumped it into a pile called a windrow. The bucketwheel reclaimer then scooped up the oil sand from the windrow and deposited it onto a conveyor belt system that moved it into the extraction plant. The use of draglines and bucketwheel reclaimers was phased out by 2006.

Today Suncor, Syncrude and Albian Sands are all using the same mining technology —truck and shovel. The shovels can move more easily to select the richest oil sand and ignore low-grade ore. Truck and shovel mining is more mobile, requires less maintenance and has much less effect on general production if there is an equipment break down.

The open pit mining method is done in benches or steps. Each bench is approximately 12–15 metres high. Giant shovels dig the oil sand and place it into heavy hauler trucks that range in size from 240 ton to the largest trucks, which have a 400-ton capacity. (The 150-ton truck on display at the Oil Sands Discovery Centre is a baby compared to the size of these newest heavy haulers). The trucks dump the oil sand into sizers or crushers, which break up the big chunks of oil sand to prepare it for transport into the plant. These sizers are the largest of their kind ever manufactured.

Oil sand companies have adapted some of the equipment to meet the unique needs of the industry. For example, a crawler tractor used to build up walls of the tailing ponds has its radiator and cooling fan on top of the cab. This prevents oil particles, water and sludge from getting into the radiator, causing the engine to overheat.

MINING FAST FACTS

- The replacement cost of a Dragline was approximately $110 million.
- The bucket size of the Dragline is 68 cubic metres (89 cubic yards), which is approximately the size of a two-car garage.
- The replacement cost of a Bucketwheel Reclaimer was $35 million.
- Conveyor belts cost $1,000 per foot to purchase and maintain.
- At the peak of conveyor belt use Syncrude had 30 km (19 miles) and Suncor had 8 km (5 miles) of conveyor belt in their mines.
- The conveyor belt in use at Albian Sands is one of the largest in width at 244 cm (96 inches).

HEAVY HAULER TRUCKS

- Caterpillar 777 (100 ton), Caterpillar 793 (240 ton), Komat'su 830E (240 ton), Komat'su 930E (320 or 340 ton)
- Caterpillar 797 (360 & 380 ton) and Caterpillar 797B (400 ton), and Liebherr (400 ton) haul trucks currently in use

Caterpillar 797

- *Truck empty weight:* 557,820 kg (1,230,000 lbs.)
- *Drive:* 3524B EUI twin turbocharged and after cooled diesel engine
- *Max. speed:* 64 km/h or 40 mph
- *Horse power:* 3500
- *Suspension:* self-contained oil pneumatic suspension cylinder on each wheel
- *Height empty:* 7.1 metres (23 feet, 8 inches) *Length:* 14.3 metres (47 feet, 7 inches) *Body width:* 9.0 metres (30 feet)
- *Dumping height:* 14.8 metres (49 feet, 3 inches)
- *Tire size:* 3.8 metres (12.9 feet) in diameter
- *Estimated cost:* $5 to 6 million

Caterpillar 797B

- *Truck empty weight:* 623,690 kg (1,375,000 lbs)
- *Drive:* 3524B Series, 24 cylinder, four-stroke cycle, diesel engine
- *Max speed:* 67 km/h or 42 mph
- *Horse power:* 3550
- *Suspension:* independent, self-contained, oil-pneumatic suspension cylinder on each wheel
- *Height empty:* 7.6 metres (24 feet, 11 inches)
  Length: 14.5 metres (47 feet, 5 inches) *Body width:* 9.8 metres (32 feet)
- *Dumping height:* 15.3 metres (50 feet, 2 inches)
- *Fuel capacity:* 6,814 litres or 1,800 US gallons
- *Estimated cost:* $5 to 6 million

SHOVELS

O & K RH400 Hydraulic Shovel

- *Powered by:* 2 Cummins QSK60 Diesel Engines (2000 horse power each) or 2 Caterpillar 3516 Diesel Engines (2200 horse power each)
- *Fuel capacity:* 16,000 litres—allows 24 hr continuous operation without refueling
- *Bucket capacity:* 80 to 90 tonnes
- *Maximum dig height:* 17.1 metres (57 feet, 1inch)
- *Hydraulics:* 10,000 litres Hydraulic Fluid, 5000 PSI Operating Pressure, 8 main pumps move 8000 litres per minute, produces 2100 kg or 471,930 lbs of breakout-force
- *Under-carriage:* World's largest final drive transmission, 1.8 km/h, 2000mm wide track shoes
- *Estimated cost:* $12 to 13 million

P & H 4100TS Cable Shovel

- *Working weight:* 1,351,558 kg (2,977,000 lbs)
- *Suspended load capacity:* 154,360 kg (340,000 lbs)
- *Dipper capacity:* 47.4 cubic metres
- *Voltage:* 15,000 volts
- *Boom length:* 21.34 m (69.4 feet)
- *Travel speed:* 0.84 km/h (0.52 mph)
- *Crawl shoes:* 3.54 metres (138 inches)
- *Cost:* $17 million

Bucyrus' 495HF Electric Rope Shovel

- *Gross working weight:* 1,315,000 kg (2, 900,000 lbs)
- *Overall height:* 20.72 metres (68 feet)
- *Overall width:* 13.01 metres (42 feet, 8 inches)
- *Overall length:* 28.85 metres (94 feet, 8 inches)
- Single pass loading of 100 tons
- *Cost:* $15 million

TIRES

- One tire for a 400 ton 797 truck costs an estimated $55 000 to $60,000 CDN.
- *Dimensions:* 4 meters high and they weigh over 15,000 kilograms
- *Life span:* 1 year to 15 months
- *Reused for:* cattle feeders, play ground features, and other recycled rubber materials

RELATED WEBSITES

P & H Mining Equipment
www.phmining.com

Caterpillar
www.cat.com

Komatsu
www.komatsu.com

O & K – Orenstein and Koppel
www.orenstein-koppel.com

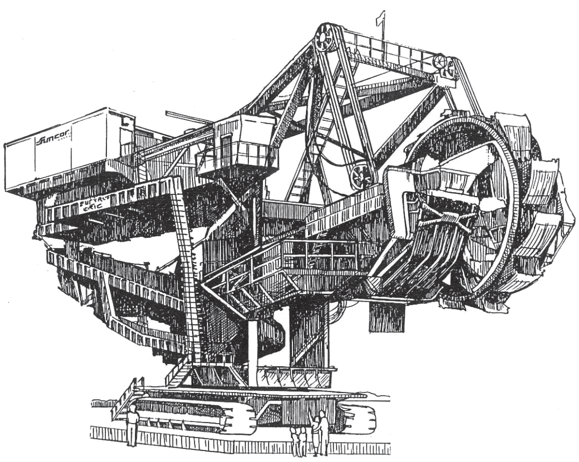
LeTourneau Inc.
www.letourneau-inc.com

Finning
www.finning.com

Transwest Mining Systems / SMS Equipment
www.smsequip.com

CYRUS
THE BUCKETWHEEL EXCAVATOR 1303

CYRUS, THE BUCKETWHEEL EXCAVATOR 1303 was donated to the Oil Sands Discovery Centre by Suncor Energy in 1988. The Friends of the Oil Sands Discovery Centre undertook a major fundraising project to bring the artifact from the Suncor mine site to its new home at the Centre. It took four years, $1 million, hundreds of volunteer hours, and many donations of services to complete the project. Officially unveiled on September 19, 1992, Cyrus represents an important piece of oil sands mining history.



Manufactured by Bucyrus-Erie Company of South Milwaukee, Wisconsin, in 1963, Cyrus was originally used in Los Banos, California to construct an earthen dam.

Cyrus was purchased by Great Canadian Oil Sands (GCOS), now Suncor Energy, in 1971. It was used until 1983 for overburden removal and mining operations, and was then retired in 1984 because of high maintenance requirements.

Disassembly of the machine began in January 1991. It took eleven weeks to break it into six massive pieces, which were transported on a 144-wheel, 45 metre-long trailer. Travel was done at night during the winter when the frozen roads could support the weight of the heavy loads.

The machine was reconstructed in 3 months by a crew of Suncor employees using three huge cranes.

The operating weight of Cyrus is 773,000 kilograms (850 tons)—the weight of over 500 mid-sized cars.

Cyrus was powered by electricity, requiring 1.8 megawatts—equivalent to the power required for 600 homes. The cable reel car (the vehicle located behind the bucketwheel) controlled the slack on the machine's electrical cable.

The operating crew consisted of three people: bucketwheel operator, oiler, and cable reel car operator.

Cyrus stands 6 storeys tall, and is one of Canada's largest land based artifacts.

Manufacturer	Bucyrus-Erie Company
Customer	Suncor Energy (formerly Great Canadian Oil Sands Ltd.)
Years of construction	1963–1964
Service weight	773,000 kilograms
Wheel diameter	9.15 metres
Number of buckets	10
Bucket capacity	1,913 litres
Maximum discharges per minute	80
Maximum cutting speed	230 metres/minute
Maximum capacity	5,371 cubic metres/hour
Maximum cutting height	12.2 metres
Maximum cutting depth	61 centimetres
Width of wheel boom conveyor	213 centimetres
Length of wheel boom	18.3 metres
Length of discharge boom	19.2 metres
Mean ground pressure	23,060 kg/square metre
Supply voltage	460 volts DC
Bucket wheel drive power	560 kilowatts
Total installed power	1809 kilowatts

SURFACE MINING
Extraction

HISTORY

G.C. Hoffman of the Geological Survey of Canada first attempted the separation of bitumen from oil sand with the use of water in 1883. In 1915, Sidney Ells of the Federal Mines Branch began to study oil sands separation techniques and used the oil sand to pave 600 feet of road in Edmonton, AB that lasted for 50 years. Dr. Karl Clark of the Alberta Research Council, after extensive experimentation, was granted a patent for the hot water extraction process in 1928. The present extraction process is based on this method invented decades ago.

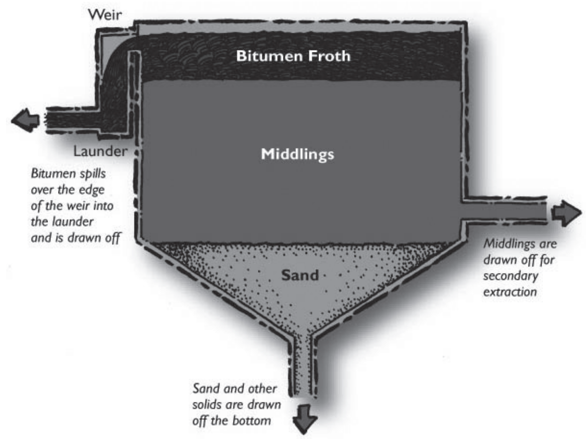
CONDITIONING

The first step in separating bitumen from oil sand is conditioning. Large lumps of oil sand are broken up, coarse material is removed, and the oil sand is mixed with water. An earlier method to condition oil sand was to mix it with hot water in huge tumblers or conditioning drums to create a thick mixture of water and oil sand called a **slurry**. The tumblers introduced air into the slurry and screened it to remove coarse material. Today **hydrotransport** pipelines replace tumblers and conveyor belts, by serving to mix or condition the slurry and move it from the mine to the extraction facilities. The water used for hydrotransport is cooler (35°C) than in the tumblers or conditioning drums (80°C), further reducing energy costs.

Conditioning by either method starts the separation of the bitumen from the oil sand by breaking the bonds that hold the bitumen, water and sand together.

SEPARATION

Additional hot water and the slurry is fed into a Primary Separation Vessel (PSV) where it settles into three layers. Impure bitumen froth floats on top, sand sinks to the bottom and a combination of bitumen, sand, clay and water sits in the middle (known as middlings). The settling and separation takes approximately 20 minutes. The PSV has a rake at the bottom that pulls the sand down and speeds up the separation. The sand and water mixture is pumped into storage areas or settling basins called **tailings ponds**.



SECONDARY SEPARATION

In secondary separation, air is injected into the middlings (a suspended mixture of clay, sand, water and some bitumen) in flotation tanks. This encourages the creation of additional bitumen froth. The intent is to recover a further 2–4% of bitumen. Bitumen from the secondary recovery system is recycled back to the primary system. The froth is heated to approximately 80°C, and excess air bubbles are removed in a vessel called a de-aerator. Air must be removed to allow pumps to operate efficiently (aerated froth causes cavitation which could destroy the pump).

FROTH TREATMENT

Bitumen froth contains, on average, about 30% water and 10 % solids (mainly clays) by weight. De-aerated bitumen froth from the extraction area is cleaned of solids and water in the froth treatment plant or **counter-current decantation vessels** (Albian Sands).

At the froth treatment plant, the bitumen is diluted with naphtha, to make it flow easily and is then sent through a combination of **Inclined Plate Settlers** (IPS), and **Centrifuges**. Inclined plate settlers allow for particles to settle efficiently under gravity, in a relatively small vessel by increasing settling area with inclined plates. A centrifuge uses centrifugal force to spin heavier materials outward. Two types of centrifuges are used in froth treatment:

- The scroll centrifuge spins out coarser particles, and relies on an auger-like action to convey solids out of the machine
- The disc centrifuge removes the finer material, including very small water droplets. The disc centrifuge works like a spin cycle on a washing machine and spins the remaining solids and water outward. This stream is collected as tailings.

The clean diluted bitumen product is now dry (less than 5% water) and with only small amount of solids (0.5% mineral). This completes the extraction process. This hot water extraction process recovers up to 98% of the bitumen contained in the oil sand feed. The bitumen is now ready to be upgraded into synthetic crude oil.

Froth treatment tailings have trace amounts of solvent (mainly naphtha), which is recovered in a stream-stripping column called a **NRU** (naphtha recovery unit), before the tailings are discharged to the tailings ponds.

The counter-current decantation vessels at Albian Sands mix solvent with the bitumen feed. Water, solids and some asphaltenes (heaviest component of bitumen) are removed. The end result is a clean, diluted bitumen product called **Dilbit**. The Dilbit is sent down the Corridor pipeline to the Scotford Upgrader where the bitumen is processed further.

UPGRADING

UPGRADING IS THE PROCESS THAT CHANGES BITUMEN into lighter products , such as synthetic crude oil, that can be refined. This is done by either removing carbon or adding hydrogen. Upgrading also involves sorting bitumen into its component parts and then using them to produce a range of additional products and byproducts. Some of these products can be used "as is", while others become raw materials for further processing. The main product of upgrading is synthetic crude oil that can be refined like conventional oil into a range of consumer products. It is called "synthetic" because it is altered from its naturally occurring state (bitumen) by a chemical process.

There are four various methods to the upgrading process: Thermal Conversion, Catalytic Conversion, Distillation, and Hydrotreating. The purpose of upgrading is to separate the light and convert the heavy components of bitumen into a refined product. Oil sand companies use these processes in different ways and at different stages in the transformation of bitumen into synthetic crude oil, but the principles behind this transformation remain the same. Syncrude and Suncor upgrade their bitumen on their own lease sites. Albian Sands sends diluted bitumen down their pipeline to the Scotford Upgrader (in Fort Saskatchewan) where it is upgraded into synthetic crude oil.

The initial step in upgrading is to remove naphtha in a simple distillation process (diluent recovery unit). This naphtha can then be re-used in the froth treatment process.

THERMAL CONVERSION (COKING)

Thermal Conversion or Coking involves breaking apart the long heavy hydrocarbon molecules using heat. Hydrocarbons have an interesting and very useful property. If they are subjected to high temperatures they will react and change their molecular structures. The higher the temperature, the faster these reactions will happen. This is sometimes called "cracking" because large hydrocarbon molecules crack, or break down into smaller molecules. Coking is an intense thermal cracking process. It is particularly useful in upgrading bitumen into lighter, refined hydrocarbons (naphtha, kerosene distillates, and gas oils) and concentrates extra carbon into a fuel called coke, which is a byproduct of the coking process. Coke can be used as fuel for coke furnaces, heat for hydrotreating; it is used in the steel making industry and can also be stockpiled for further energy use. Currently oil sands companies use two types of coking to upgrade bitumen: delayed coking and fluid coking.

Delayed coking is a process where bitumen is heated to 500°C (925°F), then pumped into one side of a double-sided coker (furnace). The bitumen cracks into two products: solid coke and gas vapour. It takes approximately 12 hours to fill one side with coke. When one coke drum is full the heated bitumen is diverted into the second coker in the pair to continue the cracking process. A high-pressure water drill is used to cut out the solid coke from the first coking drum. The **fluid coking** process is similar except it is a continuous process. There is just one coking drum for fluid coking. The bitumen is heated to 500°C (925°F) but instead of pumping the bitumen it is sprayed in a fine mist around the entire height and circumference of the coker. The bitumen cracks into gas vapour and coke. The coke is in a much finer powder-like form, which is then drained from the bottom.

CATALYTIC CONVERSION

Catalytic Conversion is another way to crack oil molecules into smaller, refined hydrocarbons. Because it too requires high temperatures, catalytic conversion is really an enhanced form of thermal conversion. Catalysts have a very interesting effect on chemical reactions. They help those reactions to take place, but the catalyst itself is not chemically altered by the reaction. There can be different types of catalysts used (shaped like beads or pellets); the most common being Ni/Mo (Nickel/Molybdenum) or Co/Mo (Cobalt/Molybdenum). The surface area of the catalyst is quite important; the cracking occurs when heated bitumen contacts active sites on the catalyst. Catalysts encourage "cracking" of hydrocarbons in two ways. When large hydrocarbons contact active sites on a catalyst, they react by breaking down into smaller molecules. Catalysts also act as sieves letting some molecules with specific sizes and shapes through while holding others back to continue reacting. Sometimes high-pressure hydrogen is added in the process of catalytic cracking. This is called hydroprocessing. Adding hydrogen helps to produce lighter, hydrogen rich molecules. This is necessary in upgrading bitumen, which is rich in carbon but has proportionally less hydrogen than conventional oils.

Catalytic conversion is more expensive than thermal conversion but it does produce more upgraded product for refining.

DISTILLATION

Distillation is a very common industrial process that can be used to sort liquids and gases into their component parts. A distillation, or fractionating tower works because different substances boil at different temperatures. The temperature inside the tower varies, with the hottest temperatures at the bottom and the coolest at the top. The lightest hydrocarbons with the lowest boiling points travel as a vapour to the top of the tower, while heavier and denser hydrocarbons with higher boiling points collect as liquids lower in the tower. The gas vapour condenses into a variety of heavy and light gas oils; kerosene and naphtha.

HYDROTREATING

Hydrotreating is used on gas oils, kerosene, and naphtha produced from the original bitumen feedstock. In this process, heated hydrocarbon feedstock is mixed with hydrogen at high pressure and temperature ranging from 300 to 400°C depending on the liquid. The various petroleum liquids pass through separate towers and flow around special catalytic pellets. Hydrotreating stabilizes the crude oil synthesized from the original bitumen by adding hydrogen to some unsaturated molecules. If this were not done, the crude oil produced would continue to react and change its chemical composition on its way to final refining.

Hydrotreating also reduces or removes chemical impurities, such as nitrogen, sulphur and trace metals. This is very important because impurities can cause environmental concerns and they may cause set backs at the refineries.

The petroleum liquids are kept in separate storage tanks on site until they are ready to be blended and shipped via pipeline for refining.

Source

Canadian Association of Petroleum Producers. www.capp.ca

ON THE MARKET

Canada uses oil at the highest per capita rate in the world, with a consumption rate of 2.048 million barrels per day. A family of four consumes an average of 92 barrels of oil per year. Why? Because Canada is a large country with a cold climate, requiring large quantities of energy for transportation and heating.

The synthetic crude oil produced in Fort McMurray is transported by underground pipeline to refineries. The oil travels at 5 km/h (the rate of a brisk walk). At the refinery, the oil is made into different fuels , including gasoline, jet fuel, and home heating fuels. There are, however, more than 3,500 other products derived from petroleum. Do any of these surprise you?

ballpoint pens	**toothpaste**	**straws**
plastic dishes	**lipstick**	**helmets**
sneakers	**computers**	**t-shirts**
Velcro	**synthetic fabrics**	**elastic bands**
lip balm	**Lego**	**video games**
Frisbees	**bubble gum**	**hockey pucks**
perfume	**candy wrappers**	**rubber gloves**
erasers	**cleaning products**	

PIPELINES

CANADA'S PIPELINES FORM A MAJOR TRANSPORTATION NETWORK. Almost 700,000 kilometres of underground pipeline transport virtually all of the country's daily crude oil and natural gas production to consumers in Canada and the United States. If laid end to end, there are enough pipelines in Canada to circle the Earth about 17 times around the equator. Alberta has 332,464 kilometers of pipeline that connects to a network across North America.

A pipeline is a buried steel pipe that can be up to 48 inches (120 cm) in diameter. Pipelines use powerful pumps and compressors to push the crude oil to its destination. Traveling at 5 km/h it takes approximately 3 days for the synthetic crude oil to travel from Fort McMurray to Edmonton by pipeline, and another 21 days to travel from Edmonton to Toronto.

SUNCOR—OILSANDS PIPELINE (OSPL)

Suncor Energy Inc. owns and operates the Oilsands Pipeline system. The Oilsands Pipeline connects Suncor Energy Inc. with the Fort Saskatchewan and Edmonton markets. The line was constructed in 1966 and carries synthetic crude oil and high vapour pressure products.

Length	550 km
Diameter	16 inch (40 cm)
Potential Capacity	150,000 barrels per day

For more information visit: **www.suncor.com**

SUNCOR—ENBRIDGE PIPELINES (ATHABASCA) INC.

Enbridge Pipelines built and owns the Athabasca Pipeline that starts at Suncor and ends in Hardisty Terminal in Hardisty, Alberta. The Athabasca pipeline is the largest crude oil pipeline operating exclusively in the Province of Alberta and is the only pipeline that directly links the Athabasca and Cold Lake deposits.

Length	550 km
Diameter	30 inch (75 cm) mainline
Potential Capacity	570,000 barrels per day

For more information visit: **www.enbridge.com**

SYNCRUDE—ALBERTA OIL SANDS PIPELINE (AOSPL)

AEC Pipelines, L.P. built the Alberta Oil Sands Pipeline that extends from Syncrude to Edmonton, AB. In 2001, Pembina Pipeline Corporation purchased the AOSPL. The pipeline will be expanded along with the extensive multi-year expansion of the Syncrude 21 Project.

Length	430 km
Diameter	22 inch (55 cm)
Potential Capacity	389,000 barrels per day

For more information visit: **www.pembina.com**

ALBIAN SANDS—CORRIDOR PIPELINE

Kinder Morgan Canada, formerly Terasen Pipeline, Inc., the petroleum transportation division of Terasen Inc., built the Corridor Pipeline, which transports diluted bitumen from the Muskeg River Mine to the Scotford Upgrader. The Corridor Pipeline also connects the Upgrader to the Refinery and the pipeline terminal in the Edmonton area. This system was completed in 2002, and is part of the Athabasca Oil Sands Project.

Length	493 km
Diameter	24 inch (60 cm) (12.75 inch (32 cm) diluent return line)
Potential Capacity	155,000 barrels per day

For more information visit: **www.kindermorgan.com**

CANADIAN NATURAL RESOURCES LIMITED—HORIZON PIPELINE

Pembina Pipelines completed the Horizon Pipeline on July 1, 2008. This pipeline transports synthetic crude oil from CNRL's Horizon Project, located 70 kilometers north of Fort McMurray, to Edmonton, Alberta. The pipeline will transport a proposed 250 thousand barrels per day.

Potential Capacity	250,000 barrels per day

For more information visit: http: **www.pembina.com**

ENBRIDGE PROPOSED PIPELINE—WAUPISOO PIPELINE

The proposed Waupisoo pipeline will connect producers to their upgraders and refineries in the Edmonton area while also providing them with links to the Canadian inter-provincial oil pipeline systems. This project is currently slated to be put into commission by mid 2008.

For more information visit: **www.enbridge.com**

Sources

CERI—Canadian Energy Research Institute—*Introduction to the Canadian Oil Sands and Heavy Oil Industries, 2001.*

Centre for Energy www.centreforenergy.com

ENVIRONMENTAL PROTECTION

OIL SAND COMPANIES ARE REQUIRED BY LAW to take measures to minimize the impact on the environment. These measures fall into three categories:

- Land Reclamation
- Water Monitoring
- Air Monitoring

LAND RECLAMATION

Returning mined areas to a natural, self-sustaining state

- The aim of **land reclamation** is to restore disturbed land to be as productive or more productive than it was before it was mined.
- **Tailings sand** (leftover sand after the oil has been removed) is used to fill in the mined out areas and then is covered with **overburden** (the layers of sand, gravel and shale which covered the oil sands before mining began).
- Muskeg and topsoil are replaced, so that the area can be reforested. Native species of trees, grasses and shrubs, such as white spruce, aspen, dogwood, and blueberry, are then planted.
- Land can be reclaimed as forests, wetlands and meadows. Suncor reclaimed the **Crane Lake** area as a wetland habitat that attracts more than 170 species of birds, including the impressive Sand Hill Crane. Syncrude reclaimed the **Wood Bison** trail area as a forest, grasslands and wetlands. A herd of approximately 300 Wood Bison, as well as many species of small mammals and birds now live in this area.
- The Alberta Research Council's reclamation program assists companies in their land reclamation project.
- In 1997, Suncor first began monitoring the existance of Canadian Toads (a species listed as "may be at risk") in its reclaimed ponds. Toads were recorded thriving in the sandy soils of the ponds in 2001 and their populations have steadily increased over the years.
- In spring of 2008, Syncrude's Gateway Hill became the first reclaimed area to receive a Certificate of Reclaimation from the Alberta Government. The 104 hectare area consists of rolling forest, hiking trails and lookout points and is located 35 km north of Fort McMurray.

Sources

Canada NewsWire Group
www.newswire.ca

Government of Alberta
www.gov.ab.ca

WATER MONITORING

Ensuring that rivers and lakes are not contaminated

- All of the water required for extraction and upgrading comes from the **Athabasca River** and **Mildred Lake**. Once removed, water is not discharged back into the ecosystem, but is recycled and re-used in the same processes.
- Water testing is constantly conducted around the plant sites and residential areas to ensure that natural water supplies are not contaminated.
- Some rivers and creeks are re-directed if they flow through an area that will be mined.

TAILINGS MANAGEMENT

Draining, capping, and reclaiming

- **Tails** (the water used in the extraction process) are discharged into ponds called tailings ponds (or settling basins). The water contains a mixture of **sands**, **clays** and **fine silts** that can take many years to settle out of the water. Adhesives (such as gypsum) are often added to speed up the rate of settling.
- Syncrude and Suncor both have a long-term **consolidated fine tails** program which mixes **gypsum** or **acid/lime** (waste product from the extraction operation) with tailings to form an **inert** landfill material. "Inert" means that the material is chemically inactive. The ponds will then be filled with sand and covered with topsoil, trees, shrubs and grass, and reclaimed the same way the mined areas are.
- Albian Sands uses mechanical thickeners to mix tails with polymer to recover water and heat prior to settling – this speeds up the settling process.
- The Regional Aquatics Monitoring Program (RAMP) is a joint environmental monitoring program that assesses the health of rivers and lakes in the oil sands region.

AIR MONITORING

Checking for toxic gases and chemicals in the atmosphere

- Plant site odour is emitted from a variety of sources, the most significant being the extraction vents, the tailings ponds and tank farms. Although most sources have been identified, the industry continuously monitors and investigates all new odour complaints in order to identify and eliminate sources of odour. The Wood Buffalo Environmental Association (WBEA) is responsible for the air monitoring in the region. Fourteen monitoring stations are in place in Fort McMurray, at the plant sites and as far north as Fort Chipewyan. On one minute intervals the analyzers examine many factors such as: H_2S (hydrogen sulphide), SO_2 (sulphur dioxide), NOx (nitric oxide), CO (carbon monoxide), O_3 (ozone), THC (total hydrocarbon), PM2.5, PM10 (particulate matter), wind speed and direction, temperature and relative humidity, volatile organic compounds, polycyclic aromatics and metals. Every ten minutes these findings are averaged and posted on their website and are also available by phoning (780) 799 3200 in Fort McMurray and (780) 697 3200 in Fort Chipewyan. The data is examined and forwarded to Alberta Environment.
- Many efforts are being made to reduce emissions from the plants. For instance, **flue gas desulpherization** (FGD) works like a scrubber using limestone to remove sulfur dioxide (SO_2) from emissions. Consequently, SO_2 emissions per barrel of bitumen currently being produced, have decreased over the years (and are expected to do so in the future). However, with new projects under development, that would triple oil sands production. Between 2005 and 2015 it is estimated there will be a related increase in overall SO_2 emissions from the oil sands of over 50%.
- These reductions of emissions are in accordance with the Kyoto protocol. The Kyoto protocol is an agreement made under the United Nations Framework Convention on Climate Change. Countries that ratify this protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases. The mining companies are using new technology to reduce the CO_2 emissions, resulting in a 14% reduction in per barrel Green House Gas (GHG) emissions between 1990 and 2004.

RELATED WEBSITES

Wood Buffalo Environmental Association (WBEA)
www.wbea.org

Alberta Energy
www.energy.gov.ab.ca

National Energy Board
www.neb.gc.ca

University of Alberta
www.rr.ualberta.ca/oilsands

Alberta Environment
www3.gov.ab.ca/env/

Alken-Murray Corporation
www.alken-murray.com

Alberta Research Council
www.arc.ab.ca

Canadian Broadcasting Channel
www.cbc.ca

National Pollutant Release Inventory (NPRI) database
http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm

Regional Aquatics Monitoring
www.ramp-alberta.org

Alberta Utilities Commission
www.auc.ab.ca

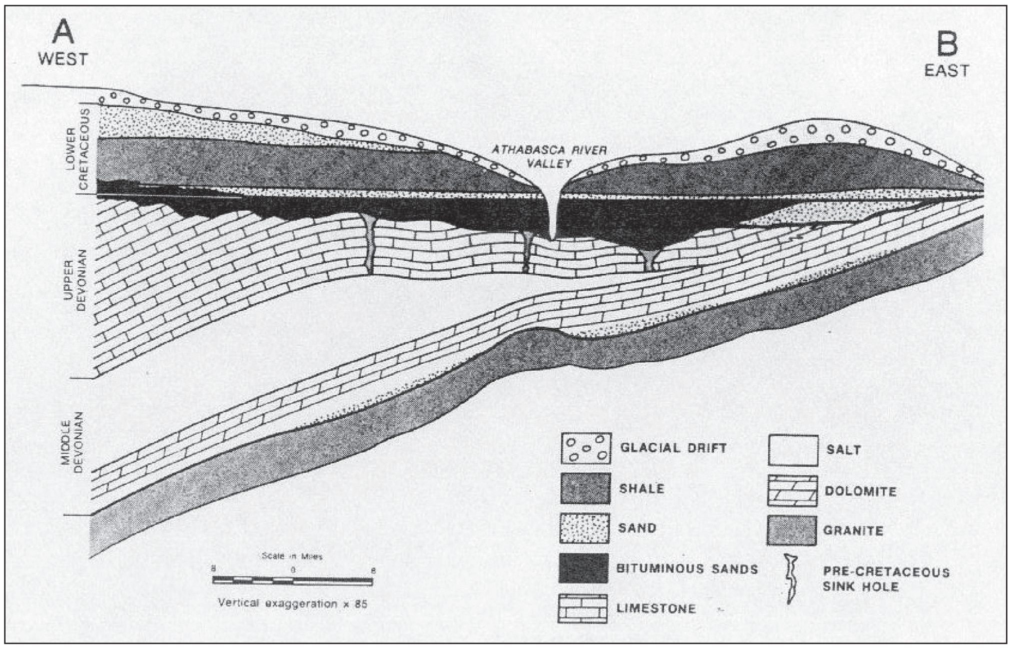
Energy Resources Conservation Board
www.ercb.ca

Regional Municipality of Wood Buffalo
www.woodbuffalo.ab.ca

Canadian Association of Petroleum Producers
www.capp.ca

IN SITU TECHNOLOGY

CANADA'S LONG-TERM ENERGY FUTURE depends to a large extent on the development of economical in situ recovery processes to tap Alberta's vast oil sands reserves. A variety of in situ methods are currently used to recover bitumen from deposits that are too deep to surface mine.



Graphic

pp. 183, *Athabasca Oil Sands: Northern Resource Exploration 1875–1951.*

All in situ approaches face two major challenges. How can the viscosity of the bitumen be reduced so it will flow? And how can the bitumen be recovered? Different deposits may favour different production methods. Today, two major in situ techniques, Cyclic Steam Stimulation (CSS) and Steam Assisted Gravity Drainage (SAGD), are used commercially in Alberta's oil sands.

Production figures show the growing importance of in situ methods. Today, total in situ production rivals production from mining oil sands. In the near future, as technologies advance, many believe that in situ operations may eventually produce more bitumen than mining.

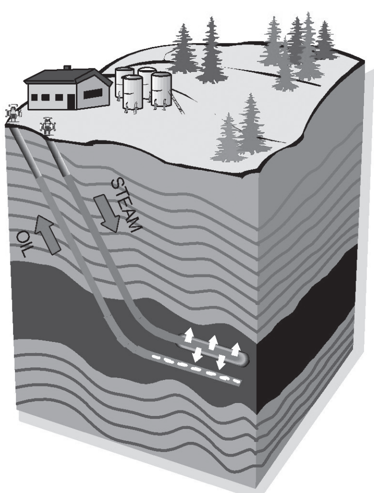
CYCLIC STEAM STIMULATION (CSS)

CSS injects high-pressure, high temperature (about 350°C) steam into oil sand deposits. The pressure of the steam fractures the oil sand, while the heat of the steam melts the bitumen. As the steam soaks into the deposit, the heated bitumen flows to a producing well and is pumped to the surface. This process can be repeated several times in a formation, and it can take between 120 days and two years to complete a steam stimulation cycle.

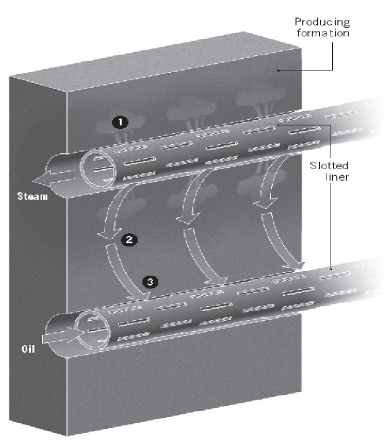
STEAM ASSISTED GRAVITY DRAINAGE (SAGD)

SAGD is the most popular enhanced oil recovery technology currently being adopted by Canadian heavy oil producers. An estimated one trillion barrels of oil in the Athabasca deposit are potentially recoverable with the present technology. Surface mining can recover up to 20% of the oil sands deposits, making SAGD the best known alternative for accessing the potential 80% of the remaining oil sands.

SAGD technology requires the drilling of two parallel horizontal wells through the oil-bearing formation. Into the upper well, steam is injected creating a high-temperature steam chamber. The increased heat loosens the thick crude oil causing it to flow downward in the reservoir to the second horizontal well that is located parallel to and below the steam injection well. This heated, thinner oil is then pumped to the surface via the second horizontal, or production well. Between 25 and 75% of the bitumen is recovered , and about 90% of the water can be recycled. Water is injected into the bitumen-drained area to maintain the stability of the deposit.



Courtesy of Petro-Canada



Courtesy of the Petroleum Communication Foundation

1. Steam is injected into oil-producing resevoir.
2. As the steam permeates the sand, the oil is heated and becomes less viscous.
3. The oil flows more freely through the wellbore's slotted liner and is pumped to the surface.

Sources

Ferguson, Barry Glen. *Athabasca Oil Sands: Northern Resource Exploration 1875–1951.* Canada: Gray's publishing Ltd., 1978. (currently out of print)

University of Alberta. *An Introduction to Development in Alberta's Oilsand.* Canada: Rob Engelhardt, Marius Todirescu, Feb. 2005

World energy Council. *Cost Analysis of Advanced Technology for the Production of Heavy Oil and Bitumen in Western Canada, 2005.* www.worldenergy.org

Oil Sands Review, October 2007; p. 46–49.

TOE-TO-HEEL AIR INJECTION (THAI)

THAI is a process by which hot air or oxygen is injected into a vertical well with hot fluid produced from a horizontal well. THAI technology offers many potential advantages over SAGD, including higher resource recovery of the original oil in place, lower production and capital costs, minimal usage of natural gas and fresh water, a partially upgraded crude oil product, reduced diluent requirements for transportation and significantly lower greenhouse gas emissions. The THAI process also has potential to operate in reservoirs that are lower in pressure, containing more shale, lower in quality, thinner and deeper than SAGD. This type of technology could be utilized in deep heavy oil resources both onshore and offshore.

VAPOR EXTRACTION PROCESS (VAPEX)

The VAPEX process is a technology similar to SAGD but instead of steam, solvent is injected into the oil sands resulting in significant viscosity reduction. The injection of vaporized solvents such as ethane or propane, help create a vapor-chamber through which the oil flows due to gravity drainage. The process can be applied in paired horizontal wells, single horizontal wells or a combination of vertical and horizontal wells. The key benefits are significantly lower energy costs, potential for *in situ* upgrading and application to thin reservoirs. The outstanding technical challenges are that it has yet to be field-tested and field injection and production strategies have yet to be developed.

ELECTRO–THERMAL DYNAMIC STRIPPING PROCESS (ETDSP)

This process is an alternative to recover buried bitumen that is too deep to surface mine yet too shallow for regular in situ techniques. It is the "electrical" heating of bitumen in place underground to lower the viscosity. Electricity passes from powered equipment at the surface to hollow steel electrodes suspended within the deposit. This process has the potential to produce no greenhouse gas emissions and engage in minimal water use. A company known as ET Energy has a pilot plant north of Fort McMurray, Alberta.

RELATED WEBSITES

Suncor Firebag Project
www.suncor.com

Japan Canada Oil Sands Inc.
www.jacos.com

Petro-Canada Inc.
www.petro-canada.ca/oilsands

Encana Corporation
www.encana.com

Opti/Nexen Long Lake Project
www.longlake.ca

Devon Canada Corporation
www.devonenergy.com

GLOSSARY

API
An American Petroleum Institute measure of specific gravity (API of bitumen is 8–14° and synthetic crude oil is 32–35).

Banked Cubic Metres (BCM)
A measurement of the volume of in situ material moved during mining operations.

Barrel
A common unit of measurement in crude oil industries. It equals 159 litres, 35 imperial gallons, or 42 US gallons.

Bitumen
Petroleum that exists in a semisolid or solid phase in natural deposits. It is the molasses-like substance which can occupy from 1% to 18% of the oil sand.

Catalyst
A chemical substance that increases the rate of a reaction without being consumed; after the reaction it can potentially be recovered from the reaction mixture chemically unchanged. The catalyst lowers the activation energy required, allowing the reaction to proceed more quickly or at a lower temperature. The catalyst used in upgrading is Ni (Nickle)/ Mo (Molybdenum) or Co (Cobalt)/ Mo (Molybdenum).

Coke
A high-carbon material similar to coal; it is a fuel produced in the coking process.

Coking
A process used to break down heavy oil molecules into lighter ones by removing the carbon that remains as a coke residue.

Conventional Crude Oil
Petroleum found in liquid form, flowing naturally or capable of being pumped without further processing or dilution.

Cyclofeeder
Receives oil sand feed and prepares it in slurry form for transport to extraction.

Dragline
A large machine which digs oil sand from the mine pit and piles it into windrows. (used at Syncrude until 2006)

Density
The heaviness of crude oil, indicating the proportion of large, carbon-rich molecules, generally measured in kilograms per cubic metre (kg/m3) or degrees on the American Petroleum Institute (API) gravity scale; in Western Canada oil up to 900kg/m3 is considered light to medium crude—oil above this density is deemed as heavy oil or bitumen.

Desulphurization
The process of removing sulphur and sulphur compounds from gases or liquid hydrocarbon mixes.

Extraction
The process of separating the bitumen from the oil sands.

Fine Tailings
Essentially muddy water—about 85% water and 15% fine clay particles by volume produced as a result of extraction.

Fluid Coking
A process by which bitumen is continuously cracked to produce lighter hydrocarbons and coke.

Gas Oil
The higher boiling point component of crude oil.

Gypsum
A mineral (from limestone) used as a soil amendment in consolidated tails technology.

Heavy Oil
Dense, viscous oil, with a high proportion of bitumen, which is difficult to extract with conventional techniques and is more costly to refine. This crude oil has a density of 900 kilograms or more per cubic metre and API of 10 to 22°.

Hydrocarbons
A large class of liquid, solid or gaseous organic compounds, containing only carbon and hydrogen, which are the basis of almost all petroleum products.

Hydrotransport
A pipeline system used to transport a slurry mixture of oil sand, hot water and caustic from the mine to the Primary Separation Vessel in the extraction plant.

Hydrotreater
A unit which removes sulphur and nitrogen from the components of crude oil by the catalytic addition of hydrogen.

In situ
In its original place; in position; in situ recovery refers to various methods (including steam injection, solvent injection and firefloods) that recover bitumen from deep oil sand deposits.

LC-Fining
Expanded ebulating bed hydroprocessing technology used to continuously crack bitumen into lighter products through the catalytic addition of hydrogen.

Light Oil
Generally crude oil with a density of less than 900 kilograms per cubic metre and an API of 22 to 35°, with low proportion of bitumen.

Mature Fine Tailings
When tailings are deposited at the disposal site, they separate and settle further to create a layer of clarified water on top that is used in extraction and a dense mixture of clay, silt and water on the bottom.

Muskeg
A water soaked layer of decaying plant material, one to three metres thick, found on top of the overburden; a Cree word meaning swamp.

Naphtha
Any of various volatile, often flammable, liquid hydrocarbon mixtures used chiefly as solvents and diluents. It is the lightest component in synthetic crude oil.

Oil Sand
Sand containing bitumen.

Oil Sand Lease
A long-term agreement with the provincial government which permits the leaseholder to extract bitumen, other metals and minerals contained in the oil sands existing within the specific lease area.

Overburden
Layer of rocky, clay-like material that lies under muskeg.

Petroleum
Derived from the Latin word for "rock oil", petroleum was the original term for crude oil. Petroleum is a naturally occurring mixture composed predominantly of hydrocarbons in the gaseous, liquid, or solid phase. It includes natural gas, crude oil, and bitumen.

Polymer
Large organic molecule formed by combining smaller molecules (monomers) in a regular pattern.

Residuum
A residual product from the processor distillation of hydrocarbons.

Sour Oil
Crude oil containing free sulphur, hydrogen sulphide or other sulphur compounds.

Steam Assisted Gravity Drainage
An in situ recovery technique for extraction of heavy oil or bitumen that involves drilling a pair of horizontal wells one above the other; one well is used for steam injection (SAGD) and the other for recovery/production.

"Sweet" Crude Oil
Oil that has sulphur and nitrogen removed.

Synthetic Crude Oil
A mixture of hydrocarbons, similar to crude oil, derived by upgrading bitumen from oil sands.

Tailings
A combination of water, sand, silt and fine clay particles that are a byproduct of removing the bitumen from the oil sand.

Upgrading
The process of converting heavy oil or bitumen into synthetic crude oil.

Viscosity
The resistance to flow or "stickiness" of a fluid.

Wet tailings
The water, sand, clays, and fine silts left over after the extraction process. Tails are discharged into tailing ponds (i.e. settling basins).

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OIL SANDS PROJECTS IN THE ATHABASCA OIL SANDS

Abbreviations and definitions

bpd	barrels per day
bbpd	barrels of bitumen per day
In situ	*In its original place* (Latin). In the oil sands industry, in situ refers to processes which remove the oil from the oil sand without removing the sand from the ground.
SAGD	Steam Assisted Gravity Drainage
Mbbl/d	thousands of barrels per day

While efforts have been made to obtain the most recent information, it should be noted that projects are constantly being re-evaluated by industry.

COMPANY	PROJECT NAME	EXTRACTION METHOD	AVERAGE DAILY PRODUCTION
Suncor Energy Inc. CONTACT www.suncor.com	Steepbank Mine Millennium Mine Voyageur	Surface-mining Surface-mining Surface-mining by 2012	Currently producing 277,000 bpd
	Firebag Project	In situ	140,000 bpd
Syncrude Canada Ltd. CONTACT www.syncrude.com	Base Mine North Mine (Mildred Lake) Aurora Mine	Surface-mining Surface-mining Surface-mining	Currently producing 301,000 bpd
	Syncrude 21 expansion	Surface-mining	350,000 bpd
Shell Canada Limited (formerly Albian Sands Energy Inc.) CONTACT www.shell.ca/oilsands	Muskeg River Mine	Surface-mining	Currently producing 155,000 bbpd
Canadian Natural Resources Ltd. CONTACT www.cnrl.com	Horizon Oil Sands Project	Surface-mining	110,000 bpd by 2008
	Kirby Project	In situ	232,000 bpd by 2012

COMPANY	PROJECT NAME	EXTRACTION METHOD	AVERAGE DAILY PRODUCTION
L.P/UTS Energy Corporation in association with Petro-Canada and Teck Cominco Ltd. CONTACT www.uts.ca www.petro-canada.ca	Fort Hills	Surface-mining	Ultimate capacity of 190,000 bpd by 2010
Petro-Canada CONTACT www.petro-canada.ca/oilsands	MacKay River	In situ	Production of 27,000 bpd
	Meadow Creek Lewis	In situ In situ	Potential to produce 40,000 bpd, with expansion 73,000 bpd
Japan Canada Oil Sands Inc. CONTACT www.jacos.com	Hangingstone Project		Currently producing 8,000 bpd Long term commercial plan of 35,000 – 45,000 bbpd
Devon Canada Corp. CONTACT www.devonenergy.com	Jackfish	In situ	35,000 bpd by 2009
OPTI Canada/Nexen Inc. CONTACT www.opticanada.com www.nexeninc.com	Long Lake Project	In situ	58,500 bpd mid-2010
Total E&P Canada / Sinopec Corporation CONTACT www.total-ep-canada.com	Northern Lights	Surface-mining	100,000 bpd by 2012

COMPANY	PROJECT NAME	EXTRACTION METHOD	AVERAGE DAILY PRODUCTION
EnCana Corporation CONTACT www.encana.com	Christina Lake	In situ	70,000 bbpd
	Foster Creek	In situ	Potential for 250,000 bpd
	Borealis	In situ	Potential for 100,000 bpd
ConocoPhillips Canada CONTACT www.conocophillips.com/canada	Surmont Plant	In situ	25,000 bbpd 100,000 bbpd by 2012
Shell Canada Limited CONTACT www.shell.ca	Jackpine Mine	Surface-mining	200,000 bbpd by 2010
Deer Creek Energy Limited/ Total E & P CONTACT www.deercreekenergy.com	Joslyn Creek	In situ	2,936 bbpd
		Surface-mining	Awaiting approval for expansion expected to increase production 100,000 bpd by 2013
Husky Energy CONTACT www.huskyenergy.ca	Sunrise Thermal Project	In situ	60,000 bbpd by 2012; with final capacity for 200,000 bpd
Imperial Oil Ltd. In association with Exxon Mobil Canada Ltd. CONTACT www.imperialoil.com	Kearl Lake Project	Surface-mining	100,000 bpd by 2012; capacity for 300,000 bpd

COMPANY	PROJECT NAME	EXTRACTION METHOD	AVERAGE DAILY PRODUCTION
Connacher Oil & Gas CONTACT www.connacheroil.com	Great Divide Oil Sands Project	In situ	10,000 bpd
MEG Energy in association with China National Offshore Oil Corporation CONTACT http://www.megenergy.com/	Christina Lake Regional Project	In situ pilot facility	Expected production of 25,000 bpd
Petrobank CONTACT www.petrobank.com	Whitesands Experimental Project	1st field-scale application of THAI	Designed to produce 1,800 bpd of partially upgraded bitumen

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