The Athabasca oil sands in north-west Canada, a short geological overview

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Abstract.

The province of Alberta contains the natural resource oil sand. Demaison (1977) described the Alberte tar sands as “the world largest selfcontained accumulation of hydrocarbons”.

1.7 to 2.5 trillion barrels of oil are trapped in a complex mixture of sand, water and clay.

This oil sand deposit is primarily located in and around Fort McMurray. The McMurray Formation is a lower Cretaceous oil-bearing quartz sandstone. Much of this oil is wrapped as a coationg around individual, water wet sand grains, so the extraction problem is not of getting the oil out of the sand but of getting the sand out of the oil (North 1985).

Introduction:

Alberta is one of Canada's provinces in the western and its capital is the city of Edmonton. Alberta has an area of 661,190 km². Southwards, it borders the US state of Montana. Eastwards it borders the province of Saskatchewan and to the west, its border with British Columbia and the Rocky Mountains.

Unconventional petroleum is petroleum which is not sufficient either liquid or gaseous to be extracted, transported and used in this conventional manner. (F.K.North,1985)

Bituminous sands are those impregnated with oil too heavy and viscous to be extracted by conventional drilling techniques. Bitumen is the name of the oil which comes from the sands. Bituminous sands are popularly misnamed as “tar sands” and so the US Geological Survey has proposed a definition for tar sands. (F.K.North,1985)

“Tar sands are any unconsolidated or consolidated rock that contains a hydrocarbon material with gas-free viscosity, measured at reservoir temperature, greater than 10000mPa s, or that contains a hydrcocarbon material that is extractable from the mindes or quarried rock.” (USGS)

The largest and most prospective tar sand deposit are exposed at the surface or buried beneath no more than thin, little-consolidates sediments such as glacial drift are alluvium.(F.K.North,1985)

Gerard Demaison (1977) indicates that about 20 deposits contain more than $3*10^{11}$ m³ of oil in place. About 98% of this oil is contained in sands in Venezeuela, the former Soviet Union and of course the Canadian province of Alberta.

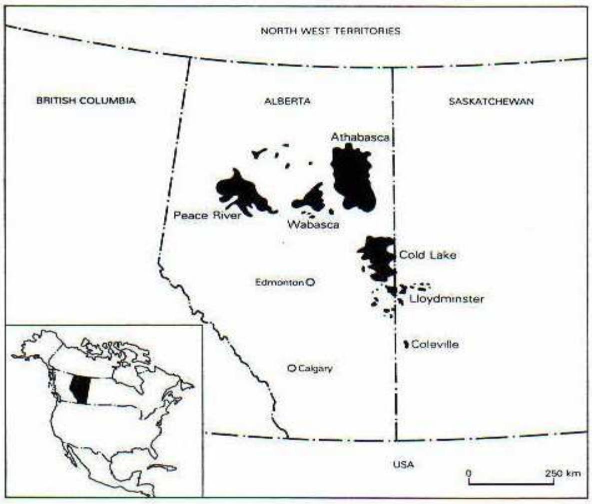

Fig.1: Heavy oil deposits in the Lower Cretaceous sandstones of Alberta, Canada. The Athabasca, Peace River and the Cold Lake deposits.

Alberta tar sand

Alberta's oil sands contain the biggest known accumulation of hydrocarbons in the world. An estimated 1.7 to 2.5 trillion barrels of oil are trapped in a complex mixture of sand, water and clay. The Oil sand is composed of approximately 70% sand and clay, 10% water, and anywhere from 0% to 18% oil.
The Athabasca Oil Sands are hydophillic. The grains of sand are surrounded by a film of water, which is then surrounded by oil. (http://collections.ic.gc.ca)

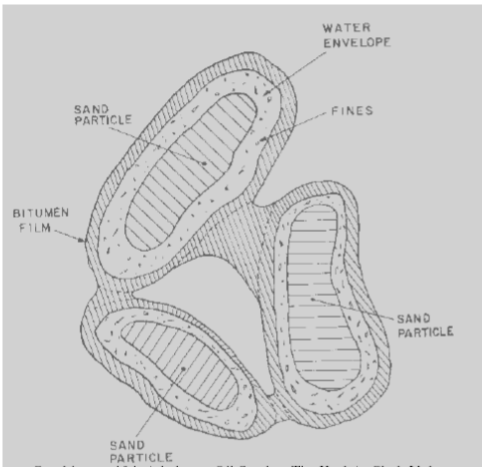

Fig.2: Composition of oil sands (idieal shape)
(Carrigy, M.A; pp. 194, Athabasca Oil Sands – The Karl A. Clark Volume)

The most prominent theory of how this vast resource was formed says that light crude oil from southern Alberta migrated north and east with the same pressures that formed the Rocky Mountains. Over time, the actions of water and bacteria transformed the light crude into bitumen, which is much heavier, carbon rich and extremely viscous oil. The percentage of bitumen in oil sand can range from 1% - 20%. The oil saturated sand deposits left over from ancient rivers in Athabasca and other areas. (http://oilsandsdiscovery.com)
This heavy oil deposit is in a Lower Cretaceous sandstone. The Athabasca deposit being in the lowest sandstone resting unconformably on Devonian limestones and evaporites. The Athabasca sandstone is a Precambrian formation on Lake Athabsca. The hostrock is a cleanly washed, white quartz sand formation about 50—80m thick with a net thickness of about 20 m saturated with tar.

The lower part of the reservoir sandstone is an alluvial complex and the upper part consist of tidal flat and lower delta plain deposits. (F.K.North,1985)
So the overall reservoir sandstone is coastal and transgressive, principally nonmarine but with marine components at the top. The highest oil saturation were founded in the upper part with the fluvial and tidal channel sands.
The today structure of this tar sand region is a wide, flat dome, which is cause by drap reversal of the regional dip due to solution of underlying Devonian salt. (F.K.North,1985)
The oil is typically derived from marine plants and animals (mainly algae). The remains of 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 layer upon layer of rock, silt and sand accumulated over time. The decomposition of the microscopic creatures led to a reorganisation of their carbon and hydrogen bonds to form 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 and formed the oil sands. (R.Bott,1999; http://www.pcf.ab.ca)

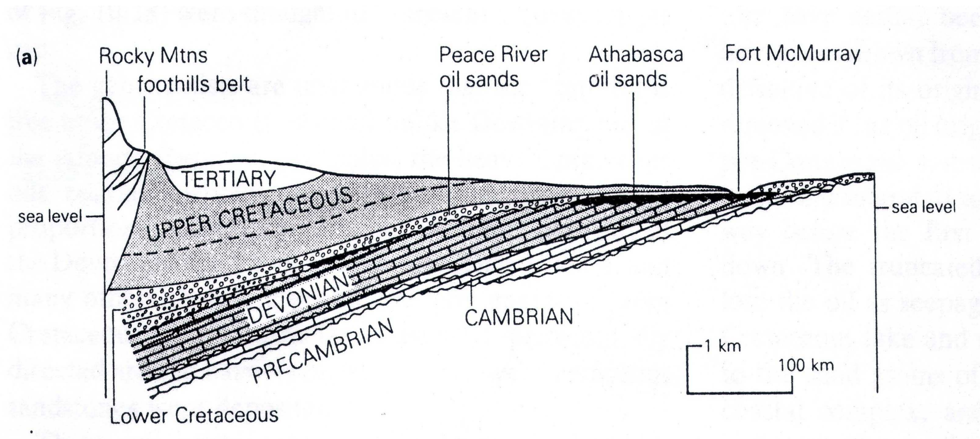

Fig.3a: Cross section of Alberta Basin (F.K. North 1985, pp 106)

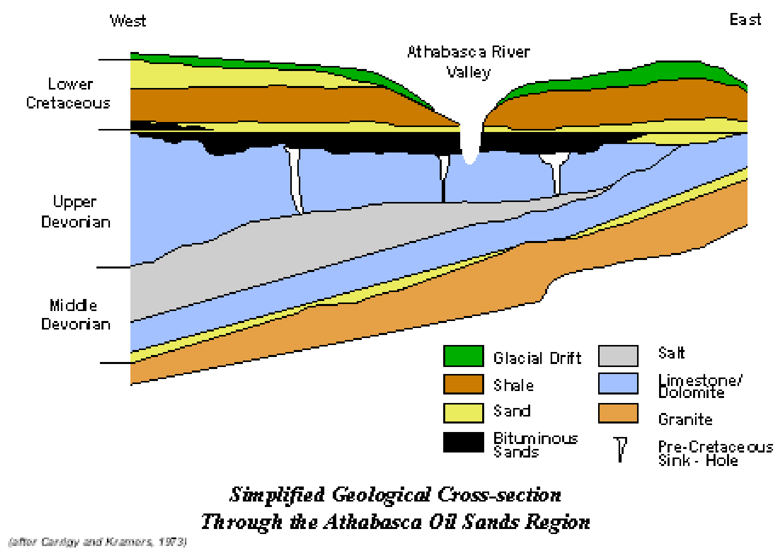

Fig.3b: Cross section of the Athabsaca oil sands region from west to east (http://collections.ic.gc.ca/oil/)

The Athabasca tar sands became the object of vigorous discussions until now.
Here I would mentioned two works on it.

In the paper “Coupled fluid flow, heat and mass transport, and erosion in the Alberta basin: implications for the origin of the Athabasca oil sands” written by J.J. Adams et al, are discussed many of theories of the origin of the oil sands in Athabasca. But I only focused on one of the theories.
In the Athabasca oil sands formation is an evidence of regional topographydriven fluid migration in the Alberta Basin since maximum burial. The erosion case discharges brines near the Peace River, where both saline soils and oil sands are found. “The ability of the simulations to mimic present groundwater flow features suggests that the Athabasca oil sands may have migrated due to buoyancy and capillary forces either before development of, or independent of, the regional-scale topography-driven flow system. Thus, the flow systems modelled here may have been responsible for in situ water-washing and biodegradation of the Athabasca oil sands.” (J.J. Adams et al,2004)
The Athabasca oil sand has been interpreted as result of regional-scale fluid flow associated with the Laramide orogeny.
Garven (1989) predicted long-lived and rapid transport of the required volume of fluids to form this deposit.
“Present temperature and salinity conditions can be reproduced; however, formation of the Athabasca oil sands cannot be predicted solely by dissolved-phase hydrocarbon transport. Constant erosion of an exponential land surface has a minimal effect on flow patterns. Initially, increased relief produces faster fluid fluxes than constant topography solutions, but the exponential shape of the landscape and a linearly decreasing topographic gradient dampen fluid fluxes over time. Higher erosion rates at later time generate underpressures large enough to stimulate a flow reversal (i.e., fluids move downdip into the basin); conductive heat transport dominates in all cases. In contrast, salinity transport in the basin is via advection, hence salinity distributions are most influenced by fluid fluxes. Late formation of local topographic features generates local-scale flow systems in the upper strata (<500 m depth)”. (J.J.Adam et al,2004)
“Erosional simulations do not increase discharge to the oil sands, but rather force the regional-scale topography-driven flow system to decay by thinning of the capping Cretaceous aquitard, generation of underpressures inthe western portion of the basin, and the development of local relief. To integrate the accumulation of the Athabasca oil sands and present conditions in the Alberta basin over many millions of years, a comprehensive simulation would have to consider the transience of driving forces (compaction, buoyancy, capillary forces, and hydrodynamic flow), including the development of surface topography and three-dimensional spatial distribution of permeability through time.” (J.J.Adam et al,2004)

F.K.North (1985) said “there is near-universal agreement that the oil has undergone long lateral migration”.
“The areal relation between the tar-sand deposit and the subcrop of the Devonian shales and carbonates is direct; in particular, a large, tabular, reef dolomite occupying much of the subcropping interval is in facies contact downship with the principal source sediment for the productive Devonian reefs, but is itself truncated at the unconformity directly beneath the tar sand. The dolomite there contains no oil or tar, but along the so-called “carbonate trend” to the northwest the Devonian carbonates are saturated with heavy oil comparable with that in the Lower Cretaceous reservoirs.” (F.K.North,1985)
F.K.North also said 1985, that the tar cannot have migrated over hundreds of kilometers in its present state. Therefor it must have been earlier in a quite different state and inferences drawn from its present chemical state are not definitive of its origin. It would be easier ton understand if the oil originated in any pre-Cretaceous source sediments in the basin to the west and migrated towards the foreland in normal way before the first Cretaceous sediments were laid down. The truncated Devonian reservoir might then lose the oil as seepage droplets into the newly formed Cretaceous lake and shallow sea. The droplets

adhered to the sand grains of the developing fluvial-deltaic-coastal complex and were deposited as part of the sediment. Thus viscous, no heavy oil has migrated in the conventional sense and entry into the present reservoir would precede the cohesion of the reservoir's components. So there is he concept, that the tar acquired both its present physicochemical condition and its relation to the host rock through being of sedimentary derivation. (F.K.North 1985)
But North (1985) mentioned that, "no-one has found a satisfactory explanation for the oil surviving below an erosion surface which was developed over some 150 Ma before it was finally buried by Cretaceous sediments; and it is experimentally impossible to get viscous asphaltic oil to adhere as a coating around sand grains in an aqueous environment. It is among the greatest ironies of the oilsman's science that such a large-scale and geologically simple phenomenon should continue to defy unanimity on so many vital points."

Mining

Since the 1920's, open pit mining has been central to oil sands development.
Only 7% of the Athabasca Oil Sands deposit can be mined using the surface mining technique.
"Surface mining is the mining method which is currently being used by Suncor Energy and Syncrude Canada Limited to recover oil sand from the ground." (http://collections.ic.gc.ca)
"Syncrude's original mining method, using draglines and bucket-wheel reclaimers, has largely been replaced by shovel-and-truck mining, which gives greater flexibility. Surface mining can be used in mineable oil sand areas which lie under 75 metres or less of overburden material." (htpp://www.mining-technology.com)
"The first large scale commercial operation, Great Canadian Oil Sands (Suncor Energy), introduced German manufacturer O&K bucketwheels from the coal mining industry when they opened in 1967. Syncrude Canada Limited opened in 1978 and introduced gigantic draglines 60 times as large as the bucket on display from Bitumount, the first commercial oil sands plant." (http://oilsandsdiscovery.com)
The first step in surface mining is the removal of overburden and the muskeg, a water-soaked area of decaying plant material that is one to three metres thick and lies on top of the overburden. First the muskeg must be drained of its water content than it can be removed. Overburden which is used to build dams and dykes around the mine, is a layer of clay, sand, and silt which lies directly above the oil sands deposit. After all of the overburden is removed, the oil sand is exposed and can be mined. (http://collections.ic.gc.ca/oil)
Suncore Energy and Syncrude are the main miners so there are used two mining methods in the Athabasca Oil Sands. Suncor Energy uses of the truck and shovel and Syncrude uses the truck and shovel method of mining, as well as draglines and bucketwheel reclaimers. The draglines and bucketwheels (Fig.4) will be replaced soon with large trucks and shovels. The shovel scoops up the oil sand and dumps it into a heavy hauler truck. "The heavy hauler truck takes the oil sand to a conveyor belt which transports the oil sand from the mine to the extraction plant. Presently, there are extensive conveyor belt systems that transport the mined oil sand from the recovery site to the extraction plant". With the development of new technologies the conveyors will be also replaced with hydrotransport technology, which is a combination of ore transport and preliminary extraction".(http://collections.ic.gc.ca/oil)
The equipment must be durable and strong enough to withstand extreme climate and abrasive oil sand. Mining never stops, the trucks and other equipment work day and night, every day of the year. Planning is an essential and continuous part of the process.(http://oilsandsdiscovery.com/)
"After the bitumous sands have been recovered using the truck and shovel method, it is mixed with water and caustic soda to form a slurry and is pumped along a pipeline to the extraction plant". (http://collections.ic.gc.ca/oil/)

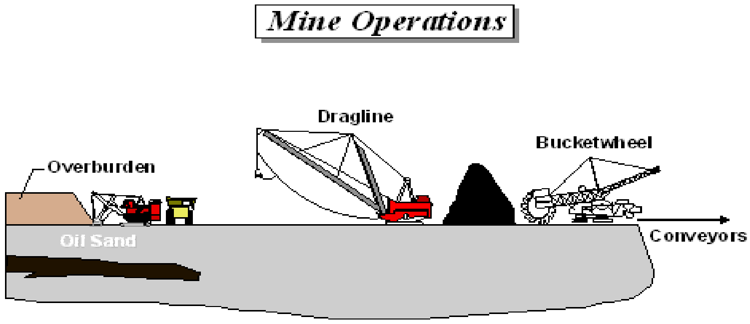

Fig.4: Mine Operations with Overburden, Dragline and Bucketwheel (http://collections.ic.gc.ca/oil)

Extraction

Extraction is the process whereby the bitumen is separated from the sand, water and other impurities.
"It is estimated that around 80% of the Alberta tar sands are too far below the surface for the current open-pit mining technique. Techniques are being developed to extract the oil below the surface. These techniques require a massive injection of steam into a deposit, thus liberating the bitumen underground, and channelling it to extraction points where it would be liquified before reaching the surface." (http://en.wikipedia.org./wiki)
The extraction process thus begins with the mixing of the water and agitation needed to initiate bitumen separation from the sand and clay. Dr. Karl Clark, a scientist working for the Alberta Research Council, developed and patented the hot water extraction technique. (http://collections.ic.gc.ca/oil/)
"The oil sand is processed through apron feeders or feeder bins then into tumblers or conditioning drums. In the drums the oil sand is rotated while hot water, about 80 degrees Celsius, and caustic soda are added to form slurry. Heat is used in the hot water treatment to reduce the viscosity or thickness of the bitumen. Caustic soda helps the attachment of bitumen to the air in the froth formation while releasing it from the sand particles. It essentially helps "clean" the bitumen off the sand. The bitumen then forms small globules that are important in the formation of froth. Agitation also aids in the break up of the oil sand. The slurry passes through a series of vibrating screens that separate and reject any rocks or clumps of clay still in the slurry. It is then pumped into separation tanks." (http://collections.ic.gc.ca/oil/)
"The primary separation vessel is a twenty minute process that allows the oil sand slurry to settle out into its various layers. The most important of these layers is the layer of bitumen froth which rises to the top. The sand (or tailings sand) sinks to the bottom. The primary separation vessel is equipped with a rake at the bottom of the vessel. This rake slowly rakes the sand in a downward motion which aids in the separation process. The tailings sand and excess water is pumped into a pipe which carries it to special holding tanks called tailings pond. The tailings sand is used to build dams and dykes around the tailings ponds. The water is treated and is reused and recycled within the plant site. The middle layer (middlings) consists of bitumen, clay and water. The middlings remain suspended between the sand and the bitumen froth until it is drawn off and put through the secondary separation vessel. The secondary separation vessel extracts the remaining bitumen from the middlings (usually 2% to 4% more bitumen can be extracted). The bitumen froth once again rises to the top of the vessel.
The final two steps in the extraction process are the scroll centrifuge and the disc centrifuge. This is an efficient way to extract large volumes of bitumen. By adding a gasoline-like product called naphtha, the bitumen froth is thinned, or made less

dense than the water in the froth. This decreases viscosity and aids in the speed of separation. The disc centrifuge rotates much like a cream separator. The bitumen froth remains in the middle, while the clay, water and sand are thrown to the sides of the centrifuge. The water, sand and clay mixture are pumped out as tailings into the tailings pond. Meanwhile, the bitumen is run through a diluent recovery vessel to remove the naphtha and sent on to upgrading. The recovered naphtha is returned to the extraction process." (http://collections.ic.gc.ca/oil/) The resulting bitumen froth then forms the feed for upgrading to synthetic crude oil.
"The Canadian Athabasca oil sands deposit has an estimated reserve production capacity of 750,000 barrels (150,000 m³) of crude oil per day using the current hot water processes. As traditional or conventional sources of oil suffer from depletion, new sources of oil such as oil sands will increasingly be relied upon to make up the difference in future global oil production. This synthetic crude oil process takes two tons of tar sand to fill one barrel of upgraded synthetic crude oil." (http://en.wikipedia.org./wiki)

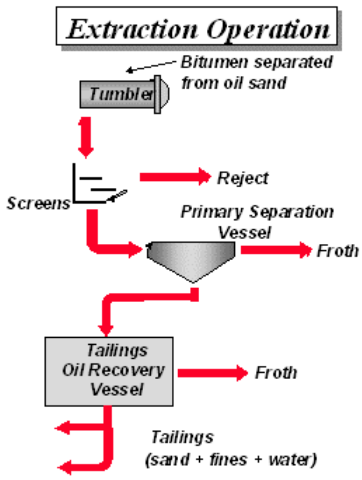

Fig.5: Extraction Operation; from Tumbler to Tailngs Oil Recovery Vessel (http://collections.ic.gc.ca/oil/)

In situ

In situ is Latin for "in place". It is a new mining process for recovering bitumen from deep oil sand deposits. One method is steam assisted gravity drainage.
"About 80% of the oil sands in Alberta are buried too deep below the surface for open pit mining. This oil must be recovered by in situ techniques. Using drilling technology, steam is injected into the deposit to heat the oil sand lowering the viscosity of the bitumen. The hot bitumen migrates towards producing wells, bringing it to the surface, while the sand is left in place Steam Assisted Gravity Drainage (SAGD) is a type of in situ technology that uses innovation in horizontal drilling to produce bitumen. In situ technology is expensive and requires certain conditions like a nearby water source. Production from in situ already rivals open pit mining and in the future may well replace mining as the main source of bitumen production from the oil sands." (http://oilsandsdiscovery.com)
"Cyclic Steam Stimulation (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) is the most popular enhanced oil recovery technology currently being adopted by Canadian heavy oilproducers.

An estimated one trillion barrels of oil in the Athabasca deposit are potentially recoverable with the present technology. Surface mining is only feasible for recovering up to 20% of the oil sands deposits, making SAGD the best known alternative for recovering the potential 80% of the remaining oil sands deposits.
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. This second well 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. Water is injected into the bitumen-drained area to maintain the stability of the deposit.
Toe to Heal Air Injection (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) 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." (B.G. Ferguson et al, 1978)

Upgrading

The bitumen, a complex hydrocarbon made up of a long chain of molecules. In order for bitumen to be processed in refineries, the chain must be broken up and reorganised. Bitumen is carbon rich and hydrogen poor. Upgrading means removing some carbon while adding additional hydrogen to make more valuable hydrocarbon products and it is the most complex area of operation in an oil sands recovery plant.
The purpose of upgrading is to purify the bitumen into synthetic crude oil which is then suitable for pipeline transport to a refinery. Bitumen from the centrifuges is not suitable for transmission until it is broken down into lighter components and impurities have been removed. The impurities are mainly nitrogen, sulphur and/or carbon.(http://collections.ic.gc.ca/oil/)
Upgrading is using three main processes: coking removes carbon and breaks large bitumen molecules into smaller parts, distillation sorts mixtures of hydrocarbon molecules into their components, catalytic conversions help transform hydrocarbons into more valuable forms and hydrotreating is used to help remove sulphur and nitrogen and add hydrogen to molecules. (http://oilsandsdiscovery.com)
The first step takes place in the coker. The naphtha that was added as a diluent in the separation process is removed. Raw bitumen is then fed into huge cokers. The long heavy bitumen molecules are heated and cracked into lighter molecules. The by-product of this cracking process is coke. Coke is a coal-like substance but has a higher sulphur content. The remaining lighter molecules of kerosene, naphtha, and gas oil are removed from the coker in the form of vapour.
The second step is fractionation. A fractionator separates the cracked bitumen into various components. This happens at different temperatures and levels of the fractionator. The hottest temperature is at the bottom, while the temperature gets cooler as it nears the top. "Bitumen components that boil at the hottest temperature condense first and are removed low in the tower; bitumen components that boil at cooler temperatures rise and are extracted further up the tower. "Therefore, the

order in which the various components condense from the bottom of the fractionator to the top are: gas-oil, kerosene, naphtha, sour gas. Eventually all the vapours leave the fractionator and are processed in the final stage of upgrading – hydrodesulpurization.
In the final stage of upgrading, hydrogen is added to the vapours and sulphur is removed as a means to purify the petroleum liquids from the fractionator. Some of the sulphur is tracked to sulphur refineries for commercial use, while the remainder is stockpiled on site. The clean liquid products are removed from the hydrodesulphurization unit and stored in tanks until they are recombined for shipment as synthetic crude oil. This product is called synthetic crude oil; synthetic because its original molecular structure was changed in the upgrading process."(http://collections.ic.gc.ca/oil/)
The synthetic crude oil, is shipped by underground pipelines to refineries across North America/ Edmonton to be refined further into jet fuels, gasoline and other petroleum products.

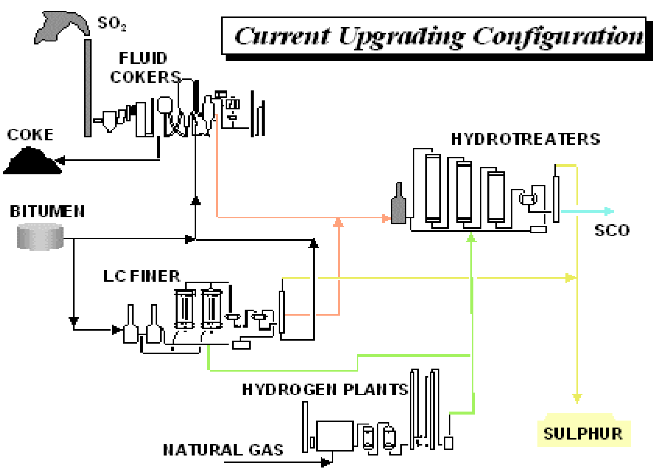

Fig.6: Upgrading Configuration; Cokers, Hydrotreaters, Finer Hydrogen plants, Bitumen (http://collections.ic.gc.ca/oil/)

Environment/Future / Syncrude Canada Ltd

The final product is shipped by pipeline to refineries, an environmental footprint remains. This can include open pit mine holes, process water dykes and emissions. Minimising the impact to the environment begins by understanding the complexity of eco-systems. In Alberta, this form of oil extraction completely destroys the boreal forest, the bogs, the rivers as well as the natural landscape. Between 3 and 5 barrels of waste water are dumped into tailing ponds. The mining industry believes that the boreal forest will eventually colonize the reclaimed lands, yet 30 years after the opening of the first open pit mine near Fort McMurray, Alberta, no land is considered by the Alberta Government as having been "restored." This information is used to help develop reclamation plans that determine how to return productive areas, to a self- sustaining, productive state, as required by all lease agreements. An important part of this process is state of the art environmental monitoring programs and communication with stakeholders including environmental groups and aboriginal people. This is an area of ongoing research activity, and while improvements in environmental stewardship have been made, huge challenges remain. Protecting the environment is a shared responsibility involving industry, government and consumers of hydrocarbon products. These products include gasoline, fuel for our homes, and petroleum chemical products like plastics, fleece and even toothpaste. The forecasted growth in synthetic oil production in Alberta also threatens Canada's international commitments. (http://oilsandsdiscovery.com / http://en.wikipedia.org)
In ratifying the Kyoto Protocol, Canada agreed to reduce, by 2012, its greenhouse gas emissions by 6 percent with respect to the reference year 1990.

In 2002, Canada's total greenhouse gas emissions had increased by 24 percent since 1990.

“The future of the oil sands industry looks overwhelmingly positive. Using current surface mining techniques only 7% of the oil sand in the Athabasca Oil Sands is recoverable. This 7% could sustain an enormous amount of mining activity well into the future. The other 93% will have to be removed using in-situ methods.” (http://collections.ic.gc.ca/oil/) “One method of in-situ recovery is steam injection. Large vertical shafts are drilled into the oil sand through which high pressure steam is injected. The heat from the steam reduces the viscosity of the bitumen allowing it to flow. The water from the condensed steam forms an emulsion with the flowing bitumen and is pumped from the wells. This method is the most productive of all the in-situ methods and so is the main one employed.

Two other in-situ methods are fireflooding and electrovolatization. Fireflooding is similar to the steam injection method in that it involves the transfer of heat into horizontal and vertical wells dug into the bitumous sands to reduce the viscosity of the bitumen. However, instead of using steam as a medium for the energy, the bitumen itself is ignited, supplying heat to the surrounding deposits.

Because this combustion requires oxygen gas, air is pumped into the wells with a small amount of water to emulsify the bitumen that flows into the wells. Electrovolatization involves the application of electric energy across the bitumous sands to extract the bitumen. The oil itself becomes a passive element and the electric current that flows through it heats up the bitumen and the bitumen flows into the wells.

As the oil sands industry continues to expand, and other conventional sources of oil and gas begin to run out, it is inevitable that oil sands will play a greater role in meeting Canada's petroleum needs. The oil sands companies are involved with ongoing research to make the oil sands plants run more efficiently. As well, new companies from Canada and around the world are showing a keen interest in the oil sands deposits of Northern Alberta.” (http://collections.ic.gc.ca/oil/) With its operations just north of Fort McMurray (northern Alberta), Syncrude Canada Ltd is the world's largest producer of synthetic crude oil derived from oil sands. The company operates two separate mining complexes, at its original Mildred Lake location and at the Aurora mine, some 40km further north, with a bitumen upgrader unit that takes oil sand feed from both sources. Syncrude Canada Ltd. currently supply 13 percent of the nation's petroleum requirements. Syncrude produced its first synthetic crude oil in 1978, since when its operations have been expanded on several occasions. As of the end of 2003, the operation was producing at near-capacity of around 253,000 barrels per day. Syncrude is now currently in the midst of a multi-staged expansion called Syncrude 21. By 2006, total daily production from the Syncrude Project is expected to reach around 350,000 barrels of Syncrude Sweet Premium, a lower sulphur and nitrogen product with a higher smoke point and cetane number. The operations provide jobs for 14,000 people directly and indirectly across Canada. So Syncrude is the largest industrial employer of Aboriginal people in Canada. Aboriginals make up 12.5% of our employee/contractor workforce. In 2004, approximately $107 million in business was conducted with Aboriginal businesses in our region. (http://www.syncrude.ca and http://www.mining-technology.com)

Syncrude Canada Ltd.'s long term plans call for returning the land to a stable, biologically self-sustaining state. This means creating a landscape that has a productive capability at least equal to its condition before operations began. They envision a mosaic landscape dominated by productive forests, wetland areas alive with waterfowl and grasslands supporting grazing animals. Syncrude has already taken steps in this direction. For example, in February 1993, a herd of wood bison were moved to reclaimed land in a grazing research project in cooperation with the Fort McKay First Nation. Today, the herd numbers approximately 300 head. (http://www.syncrude.ca / http://www.mining-technology.com)

Conclusions

In the Athabasca oil sand are trapped nearly $1*10^{12}$ barrels of bitumen, which is more than the conventional oil reserve in the middle East, western Europe and USA together. Nearly 7% of the oil sands are near the surface and can be economically mined by open pit mining. The Cretaceous sands filled with bitumen, 12% of the Athabasca oils sand is bitumen, from Devonian shale as a source rock.
Extraction by hot water and steam separate the sand from the bitumen. The synthetic crude oil is transported to Edmonton by pipelines for refining.
With 53% of Canada’s mineral production Alberta has with the Athabasca oils sands the most important deposit in Canada.

Glossary

Bitumen: A naturally occuring viscous mixture of hydrocarbons that in its naturally occuring state is not recoverable at a commercial rate through a well. The molasses like substance which comprises up to 18% of oil sand.
Dragline: A mining machine which drops a heavy toothed bucket on a cable from the end of a boom into the oil sand, then drags the bucket through the deposit, scooping up the sand. Once full, the bucket is raised and emptied into a windrow.
Extraction: The process by which the bitumen is separated from the sand, water and other impurities.
*Froth***:** A mixture of air, water and bitumen which rises to the surface of the primary separation vessel.
In Situ: Means in-place. It is the new mining process for recovering bitumen from deep oil sand deposits. One method is steam assisted gravity drainage.
Mineable Oil Sand: Oil sand which can be recovered by surface mining.
Muskeg: A water soaked form of peat, sphagnum moss, one to three meters thick, found on top of the overburden.
Oil Sand: Sand and rock material which contain crude bitumen.
Overburden: The layer of sand, gravel and shale which overlies the oil sands.
Syncrude Canada Ltd : Company operating an oil sands operation in the Athabasca Oil Sands.
Tailings: Waste products from the mining, extraction, and upgrading process.
Tailings Pond: An enclosure to contain tailings.
Upgrading: The conversion of bitumen into synthetic crude oil.
Alberta: is one of Canada's provinces. It celebrated 100 years as a province in 2005 on September 1st. As part of the Centennial celebration, Queen Elizabeth II and Prince Philip visited the province from May 23 to May 25, 2005. Alberta's capital is the city of Edmonton.
Its most populous city and metropolitan area, Calgary, is Alberta's economic hub and is located in the southern region of the province. Other major cities and towns include Banff, Camrose, Wetaskiwin, Fort McMurray, Grande Prairie, Jasper, Lethbridge, Lloydminster, Medicine Hat, and Red Deer. See also: List of communities in Alberta. Alberta is in western Canada, with an area of 661,190 km² .Southwards, it borders the US state of Montana. Eastwards it borders the province of Saskatchewan. It is separated from the Northwest Territories. To the west, its border with British Columbia follows the line of peaks of the Rocky Mountains range along the Continental Divide.
(http://collections.ic.gc.ca/oil / http://en.wikipedia.org)
1 barrel = 0,1588 m³ = 158,8 l

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