Oil sand

Ferian Anggara

Previous class

- Unconventional reservoir
- Low permeability

Oil sand

Oil sand

- Oil sands are a mixture of sand, water, clay and bitumen
- Bitumen is oil that is too heavy or thick to flow or be pumped without being diluted or heated
- High viscosity: 8 to 10 API degrees at room temperature
- At 10 °C, bitumen is hard as a hockey puck

Oil sand origin

- The heavy oils are conventional oils which have become altered by biodegradation and associated phenomena. They could have either a Devonian or a Lower Cretaceous source.
- The heavy oils are young immature unaltered oils.
- The heavy oils are derived from organic matter which was deposited in situ with the host sands.

Motgomery et al., 1974

Oil sand origin

- Oil escaped through fissures from Devonian reservoirs during or since Early Cretaceous (Link, 1951; Sproule, 1951).
- Derived in situ from organic material deposited with the sand (Hume, 1951; Corbett, 1955).
- Derived from shales of the Clearwater Formation, age equivalent to the McMurray Formation (McLean, 1917; Ball, 1935; Hitchon, 1963).
- Originally, light oil that migrated from the deep basin and was later altered to heavy crude (Gussow, 1956).
- Oil was derived from materials leached from soils into McMurray sandstones and subsequently converted to heavy hydrocarbons (Hodgson and Hitchon, 1965).
- Hydrocarbons which moved out of the deep basin in micellar or colloidal solution in compaction waters and were "precipitated" on anticlinal structures or sand pinchouts perhaps due to a salinity change (Vigrass, 1968).
- Sand and oil deposited together from a breached Paleozoic reservoir (Gallup, 1974).
- The heavy oils were emplaced by upward migration of inorganic petroleum via deep faults which extended into the mantle (Porfir'ev, 1974). It is noted that this inorganic theory has been tested by a well drilled into the Precambrian granite by C. Warren Hunt, with negative results.
- Oil was sourced from Lower Cretaceous, Jurassic and Triassic carbonaceous shales-non marine (Masters, 1984).
- Oil was likely sourced from basinal Jurassic and cratonic Devonian-Mississippian strata (Porter, 1992).

Oil sand origin

- coal is the source of oil-sands bitumen, released mainly during bituminization.
- Oils sourced from marine shales and carbonates are believed to be minor contributors
- Late Jurassic to Early Cretaceous age

Stanton, 2004

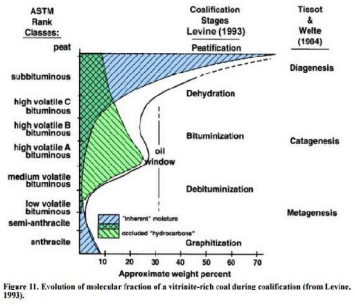


Figure 11. Evolution of molecular fraction of a vitrinite-rich coal during coalification (from Levine, 1993).

Oil sands production

From Oil Sands

- Bitumen (3-18%
- Water (2-10%)
- Sand (50-75%)
- Clay (10-30%)

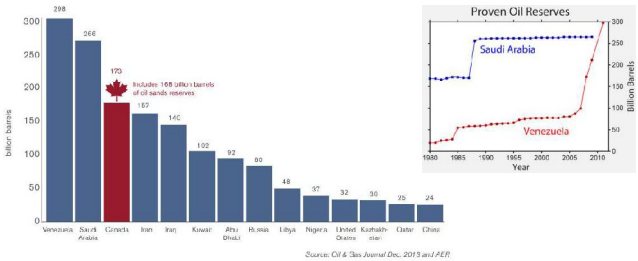
To Bitumen

- High viscosity
- 4.5% sulfur
- Contains Vanadium, Nickel, Nitrogen, Oxygen

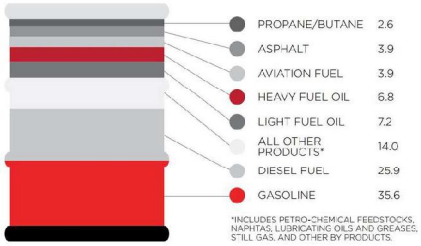
To Synthetic Crude Oil

- Low viscosity
- Low sulfur
- Low V, Ni, N, O

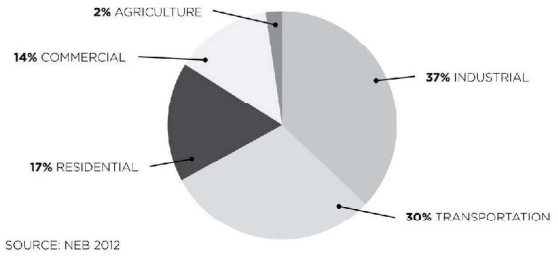
Global crude oil reserves by country



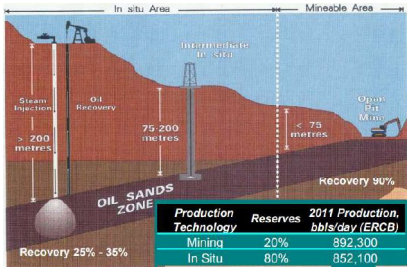
AVERAGE OUTPUT FROM A BARREL OF OIL (%), CANADA



Energy use by sector



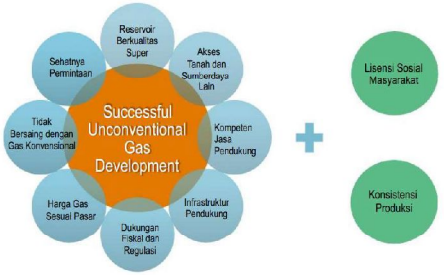
The nature of the oil sands resource



Recovering the oil

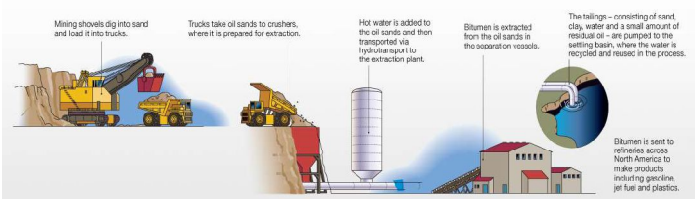
- Open-pit mining
- In-situ drilling
  - ✓Primary production,
  - ✓Cold heavy oil production with sand (CHOPS),
  - ✓Cyclic Steam Stimulation (CSS),
  - ✓Steam Assisted Gravity Drainage (SAGD),
  - ✓Vapor Extraction (VAPEX),
  - ✓Toe to Heel Air Injection (THAI),
  - ✓Combustion Overhead Gravity Drainage (COGD).

Successful unconventional gas development



SLB Analysis, 2014

Open pit mining



Open pit mining

- Approximately 20% of the oil sands lie close enough to the earth's surface to be mined, which impacts 3% of the surface area of the oil sands region.
- Open-pit mining is similar to many coal-mining operations. Large shovels scoop the oil sands into trucks, which take it to crushers, where the large clumps of clay are broken down. The oil sands is then mixed with water and transported by pipeline to a plant, where the bitumen is separated from the other components. Tailings ponds are an operating facility common to all types of surface mining. In the oil sands, tailings consisting of water, sand, clay and residual oil are pumped to these basins – or ponds – where settling occurs and water is recycled for reuse in the process. When the ponds are no longer required, the land will be reclaimed.

A picture is worth a thousand words

Group 3

Latar Belakang

- Penambangan *oil sand* di Kanada terdiri dari 3 *pit* (Athabasca, Cold Lake dan Peace River), yang semua berada di Provinsi Alberta.
- Dengan estimasi minyak sebesar 1,7 hingga 2,5 triliun *barrel* yang belum dieksplorasi, *oil sand* di Kanada ini merupakan deposit tunggal terbesar di dunia.
- *Oil sand* terdiri dari pasir, lempung, air, dan *heavy oil* yang proses ekstraksi dan penyulingan menghasilkan limbah polutan yang sangat banyak.

Group 2

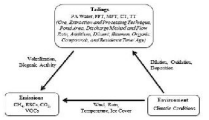
Mining study

In mining activities, particularly oil sands mining in Canada, affected aspects besides the environmental and social impact of geography as well, namely the local geomorphology landform changes. Supposedly natural landscape of tectonic processes as well as other things, result in changes in the landscape.

OIL SANDS MINING IMPACT

- ✓**Landform Changes**
- ✓**Carbon Intensity**
- ✓**Water Use**
- ✓**Tailings**
- ✓**Cumulative impacts**

Sources : http://www.resilience.org/stories/2009-09-22/environmental-impacts-oil-sands-development-alberta



Summary of the factors and processes that increase emissions in the oil sands tailings (Christina, et al, 2014)

In-situ drilling

- ✓Primary production,
- ✓Cold heavy oil production with sand (CHOPS),
- ✓Cyclic Steam Stimulation (CSS),
- ✓Steam Assisted Gravity Drainage (SAGD),
- ✓Vapor Extraction (VAPEX),
- ✓Toe to Heel Air Injection (THAI),
- ✓Combustion Overhead Gravity Drainage (COGD).

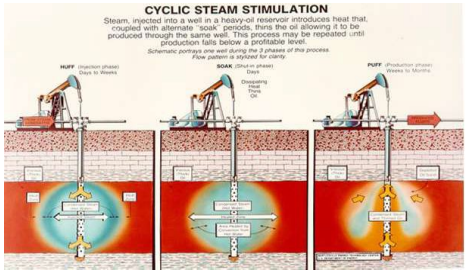
Method of extraction:

- Primary production, surface mining, oil sand tailing pond, Cold heavy oil production with sand (CHOPS), Cyclic Steam Stimulation (CSS), Steam Assisted Gravity Drainage (SAGD), Vapor Extraction (VAPEX), Toe to Heel Air Injection (THAI), Combustion Overhead Gravity Drainage (COGD).

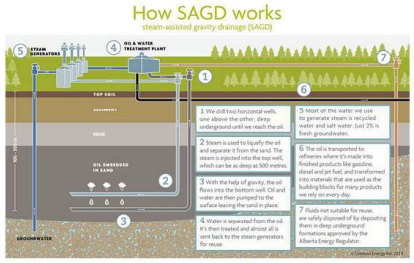
	Primary Production	CHOPS	CSS	SAGD	VAPEX	THAI	COGD
Oil recovery (%)	5-6	10	10-40	60-70	Experimental method	Experimental method	Experimental method

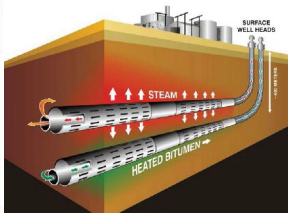
- Which one is the most efficient for producing oil? Why?
- Which one is the most environmentally friendly? Why?

Cyclic Steam Stimulation (CSS)

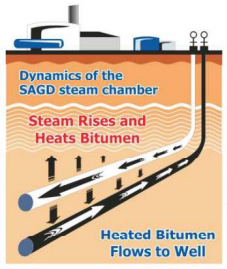


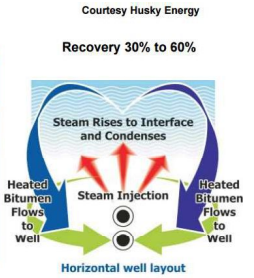
Steam Assisted Gravity Drainage (SAGD)





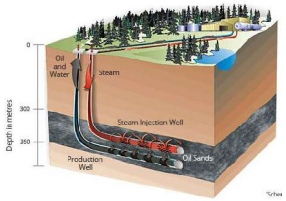
SAGD





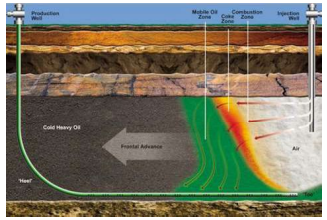
SAGD: Advantage and Disadvantage

- Recovery rates of 60-70%
- More economic
- The surface impact associated with SAGD operations is similar to that of conventional oil and gas operations
- A well pad surface disturbance is less than 10 per cent of the total resource area being accessed underground
- Consumes large quantities of water
- Use of water and natural gas for steam generation



Toe to Heel Air Injection (THAI)

- The THAI process combines controlled combustion with vertical and horizontal wells
- The oil is first heated to about 100 degrees C using steam injection. So far this sounds like conventional steam injection technology. But once this critical temperature is reached, the oil is ignited and only air is injected to keep the oil burning. The burning oil creates additional heat which makes the heavy oil flow more easily, and the combustion gases drive the flowing oil toward and up a set of production wells without any pumping.
- This isn't a bonfire, but rather more like a charcoal fire, very hot (400 to 600 degrees C) without flames.
- Recovery 70-80%



Advantages and Disadvantages

- a small land footprint,
- a relatively small need for external water and fuel at startup,
- the upgrading of the heavy oil into lighter oil *while it is in the ground* which lowers refining costs,
- the generation of electricity for site power using combustion gases from the wells for fuel which also means those gases aren't simply vented into the surrounding area, and
- A very high EROI (energy return on energy investment) of about 56
- has yet to be proven on a large scale
- there may be many unforeseen problems that could limit its usefulness

Recovery processes

- In general, recovery processes can be categorized into three types:
  - mechanical displacement (or immiscible):
    - injection of water and nonmiscible gases into heavy oil and bitumen reservoirs to displace and drive out the reserves.
    - the effectiveness of displacement processes is severely limited due to the high viscosity of heavy oil and bitumen reserves
  - thermal:
    - raises the temperature of a reservoir to reduce the viscosity of its reserves
    - 80% recovery
    - the thermal processes are often not economical. They cause large heat losses, require huge amounts of water and vast surface facilities, and are inefficient with the frequently encountered thin reservoirs
  - chemical (or miscible)
    - uses chemicals such as pure or mixed solvent gases to reduce the viscosity of heavy oil and bitumen upon gas absorption.
    - low capital costs: does not require extensive surface facilities such as those for hot water or steam generation (for hot water or steam drive) and the subsequent treatment of wastewater produced with live oil
    - uses approximately 3% of energy consumed by SAGD

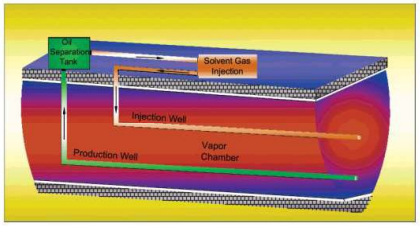
Upreti et al., 2007

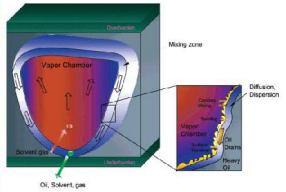
Vapor Extraction (VAPEX)

- Vapex or vapor extraction is the process of recovery of heavy oil and bitumen from a reservoir using vaporized solvents typically injected into its horizontal well configuration.
- The solvents diffuse and absorb into the highly viscous natural reserves and reduce their viscosity so that they can be easily drained and pumped out
- The experimental results showed that oil recovery was higher than that with hot water alone

Upreti et al., 2007

The concept of vapex





Upreti et al., 2007

End