OIL SANDS

Frances J. Hein [1] and Debra K. Higley [2]

Extra-heavy (bitumen) and heavy oil deposits have been reported from over 70 countries on a world-wide basis, with the largest deposits located in Canada and Venezuela (Dusseault et al., 2008; Hein and Marsh, 2008; Hernandez et al., 2008; Marsh and Hein, 2008; Meyer et al., 2007; Villarroel, 2008). The only active commercial oil sands areas are in the Western Canada Sedimentary Basin (WCSB), in northeastern Alberta, Canada (Hein et al., 2008). Other areas most likely for future oil sands growth include the northwestern portion of Saskatchewan in the WCSB; the Colorado Plateau, Uinta and Paradox basins of Utah; the North Slope of Alaska; the Black Warrior Basin, Alabama; the Maverick Basin, southwest Texas; the Borderland Basins of California; the Eastern Interior and Appalachian basins of Kentucky and Illinois; and the Tri-State, Mid-Continent region of Kansas, Missouri and Oklahoma, U.S.A.

2. How much is currently being produced and what is forecast for future production?

In North America all of the bitumen currently being produced is from Alberta, Canada. In 2007 Alberta's crude bitumen production totaled 482.5 million barrels (76.7 million cubic-meters). This total production is equivalent to 1.32 million barrels per day (210 thousand cubic-meters per day). Of this total bitumen production, 59% (284.7 million barrels) came from surface mining and 41% (197.8 million barrels) came from *in-situ* production. The bitumen that was produced by surface mining was upgraded to synthetic crude oil (SCO). In situ bitumen production was marketed as nonupgraded crude bitumen (Alberta Energy Resources Conservation Board, 2008). In 2008, total bitumen production decreased by 1% compared to 2007, with 2008 bitumen production from the surface mineable area down by 8%, and bitumen production from the in-situ area increasing by 9%. Because the overall volume of bitumen production is greater in the surface mineable area compared to the in-situ thermal area, there was an overall decrease by 1% for total bitumen production in the province (Alberta Energy Resources Conservation Board, 2009, in press).

Alberta bitumen production has more than doubled in about the last decade, and is expected to increase to greater than 3 million barrels per day (> 0.48 $10^6 m^3$) within the next decade. In 2006 the production of raw bitumen and SCO accounted for 62% of Alberta's total crude oil and raw bitumen production (Figure 1). Over the last 10 years, the contribution of bitumen to Alberta's total crude oil and raw bitumen production has increased steadily, with an expected increase to 86% by 2016 (Alberta Resources Conservation Board, 2008).

[1] Energy Resources Conservation Board, Calgary, Alberta, Canada T2P 3G4
[2] U.S. Department of the Interior, U.S. Geological Survey, Denver, Colorado, USA

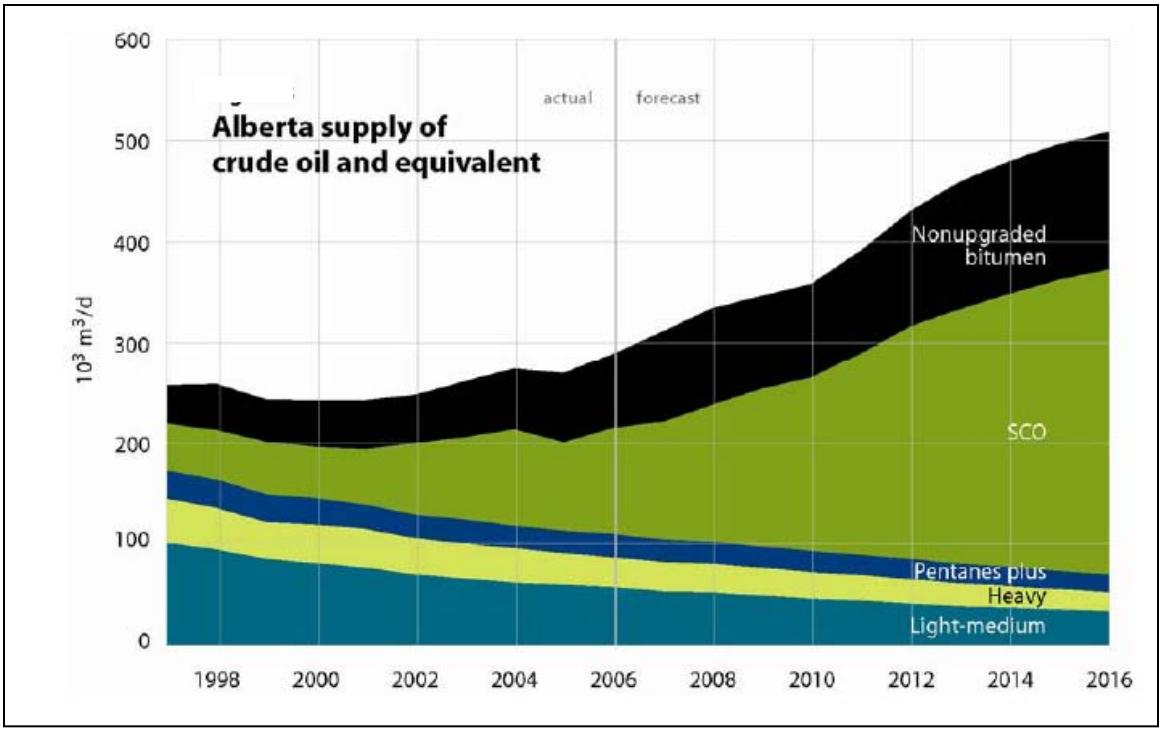

Figure 1. Alberta supply of crude oil and equivalent (from Alberta Energy and Utilities Board, 2007). SCO refers to synthetic crude oil produced from bitumen.

3. What are the sources of funding for current and planned activity (private industry, government, consortia)?

It is difficult to find all the sources of funding for oil sands research. Canadian federal funding the following website: www.InnovationCanada.ca. U.S.A. federal sources include the U.S. Department of the Interior, Bureau of Land Management (www.blm.gov), and the National Science Foundation (www.nsf.gov; info@nsf.gov). A comprehensive listing of funding for oil sands research in Canada, the U.S.A., and other countries (with location, granting agency, purpose, and website/email addresses) is given in the EMD oil (tar) sand committee chair report for the 2007 Annual Meeting in Long Beach (see EMD site postings).

The Alberta Energy Research Institute (AERI) in Alberta (AERI@gov.ab.ca) promotes joint industry-government-university energy research, technology evaluation and technology transfer in areas including heavy oil and oil sands. AERI promotes consortia by building knowledge networks and integration of knowledge, skills and investment potential of industry players, federal and provincial governments, other research providers and universities. A goal of AERI applied research is towards technology implementation designed to secure the future sustainability of Alberta's energy industry. AERI also advises the Minister of Advanced Education and Technology and the government of Alberta on energy research policy. Recent AERI-funded projects in heavy oil and oil sands include: thickened tailings field trials (paste technology) for tailings management improvement; further research into in-situ steam-assisted gravity drainage (SAGD) with gas push and addition of solvents; on-site viscosity measurements of drill cuttings and newly extracted core with forensic fingerprinting

of fluid migration in the subsurface (University of Calgary and Gushor; Larter et al., 2006, Huang et al., 2008); the AOSTRA-Taciuk process (ATP) that uses a dry-retorting process for extracting bitumen in surface mining operations, by moving oil sand through a rotating drum, cracking the bitumen with heat to get lighter hydrocarbons; the OSLO Cold Water Extraction (OCWE) that separates bitumen from oil sands in the surface mineable area. This technology avoids the use of caustic to improve the bitumen extraction, and operates at ambient temperatures; and, for carbonate-bitumen deposits laboratory experimental trials for in-situ thermal coil heating of the bitumen for extraction (Laricina Energy Ltd.).

4. What kinds of research are taking place and who is doing it?

Only about 22% of the established oil sands reserves in Alberta can be recovered through surface mining, with the remaining 78% recoverable using in-situ, mainly thermal technologies. The most common in-situ technologies are Cyclic Steam Stimulation (CSS, used mainly at Cold Lake and Peace River oil sands areas) and Steam Assisted Gravity Drainage (SAGD, used mainly in the Athabasca oil sands area).

In Alberta, SAGD was originally developed between 1986 and 1998, -- largely due to collaboration between the Government of Alberta, through AOSTRA (Alberta Oil Sands Technology Research Authority) and industry partners. Pilot tests were done at the Underground Test Facility (UTF) Dover-site near Fort McMurray, Alberta.

In 1999-2000, a number of the original development partners were licensed to use SAGD technology and announced commercial ventures worth a total of over $3.4 billion (AERI@gov.ab.ca). These include:

- Suncor - $750 million investment
- Gulf - $1.3 billion investment in Surmont
- PanCanadian - $370 million investment in Christina Lake
- Alberta Energy Company - $240 million investment in Foster Creek
- Amoco - $500 million at Primrose
- Japex - $200 million expansion at Hangingstone
- Projects are also proceeding with Northstar Energy at Dover and Petro-Canada at McKay River (AERI@gov.ab.ca).

Much of the extent of the vast WCSB oil sands has been well documented, and improved methods for identification of the developable oil sands deposits are the result of increased capabilities in reserves estimates and mapping of reservoir heterogeneities using multidisciplinary approaches that include geology, engineering, high-resolution shallow geophysics (Bauman, 2009; Bellman et al., 2009). Recent research interests relate to SAGD-development in areas of thin overburden and elsewhere in the province, in which factors such as cap-rock integrity, influence of karsting, glaciotectonics and the presence of Quaternary channel-fills as potable aquifers have to be assessed for development strategies in the Alberta oil sands areas (Collins, 2005; Hein et al., 2009; Marsh et al., 2009).

Much of the current technological research is on the following:

- enhanced development of SAGD technology for in-situ thermal recovery of the clastic-hosted bitumen;
- prediction of flow distribution and steam migration in SAGD schemes using permanently installed fiber-optic monitoring (Krawchuck et al., 2006);
- experimental in-situ thermal coil heating of carbonate-hosted bitumen (www.laricinaenergy.com); use of developing technologies to cut SAGD fuel (and water) costs while reducing greenhouse gas emissions (Budd, 2006);
- improvements concerning tailings disposal (Keyser, 2009); and,
- remediation of the landscape to return the sites to a biodiversity at least equal to the biodiversity index prior to mining or in-situ extraction in the area.

In early February 2009, the Energy Resources Conservation Board (ERCB) issued Directive 074 that outlines new cleanup rules and harsh penalties for non-compliance regarding tailings ponds regulations for the oil sands areas. This directive came about when the ERCB acknowledged that although operators invested heavily in improved tailings reduction strategies, targets set out in the original development applications have not been met. Firm performance criteria were set for reclaiming the tailings ponds, with performance inspections, and subsequent penalties due to neglect, omission or commission.

List of Specialists in Western Canada

- Dr. Clayton Deutsch, The University of Alberta, Edmonton: Numerical modeling, geostatistics and simulation of oil sands reservoir engineering and in-situ technologies;
- Dr. Martin Fowler, Geological Survey of Canada – Calgary, Natural Resources Canada (NR-Can): Geochemistry and fingerprinting of oil sources, biodegradation;
- Dr. Murray Gingras and Dr. S. George Pemberton, The University of Alberta, Edmonton: Ichnology (trace fossils) and depositional models for the oil sands;
- Dr. Murray Gray, The University of Alberta, Edmonton: Oil sands production technologies and development of clean transportation fuels;
- Dr. Jacob Masliyah, Dr. Zhenghe Xu, and Dr. Jan Czarnecki, The University of Alberta, Edmonton: Engineering theory and practice of bitumen recovery from Alberta oil sands;
- Dr. Frances J. Hein, Rick Marsh, and Dr. Farhood Rahnama, Alberta Energy Resources Conservation Board, Calgary: Regional geologic framework, depositional models of the Alberta oil sands and reserves estimates; with Corey Froese and Kristine Haug, Alberta Geological Survey, Alberta Energy Resources Conservation Board, Edmonton: cap-rock integrity in areas with shallow overburden, karsting, glaciotectonics and bedrock channels that host Quaternary potable aquifers;
- Dr. Steven Larter, The University of Calgary: Biodegradation of oils, recovery processes of heavy oil and bitumen, alternative underground in-situ recovery and refining methods; heavy oils and tar sands (HOTS) fluid research;
- Dr. Jennifer Adams, The University of Calgary and Gushor: Measurement, documentation and interpretation of vertical and lateral viscosity variation in heavy oil and oil sands deposits;
- Dr. Alex Turta, Alberta Research Council, Calgary: Toe to Heel Injection Process (THAI) in situ process, comparisons with Steam Assisted Gravity Drainage (SAGD);
- The University of Calgary, Institute for Sustainable Energy, Environment and Economy (ISEEE) and the Alberta Ingenuity Centre for In Situ Energy: Cleaner and more efficient ways to producing bitumen and heavy oil, underground refining.

- Dr. Kent Barrett and Mauro Cimolai, Laricina Energy Ltd., Calgary: Mega-porosity/mega-permeability laboratory testing and core experiments on in-situ thermal coil heating and geologic analysis of carbonate-bitumen deposits, www.laricinaenergy.com;
- Dr. Derald G. Smith, University of Calgary (Emeritus and Consultant), Geomorphological reconstruction of Cretaceous fluvial paleo-meander belts with application to oil sands deposits;
- Dr. Stefan Bachu, Alberta Research Council, Edmonton: CO2 sequestration and co-generation in oil sands and heavy oil development areas;
- Government of Saskatchewan, www.ir.gov.sk.ca\

List of Specialists in U.S.A.

- R.E. Blackett, Utah Geological Survey, Utah Department of Natural Resources: Tar-sand resources of the Uinta Basin, Utah;
- James W. Bunger, Bunger and Associates with Anton R. Dammer, on contract to U.S. Department of Energy, Washington, D.C.: Production Planning for U.S. Tar Sands;
- Thomas E. Ewing, Frontera Exploration Consultants, San Antonio, TX: Tar sands and heavy oil in the southwest Texas heavy oil province;
- P.A. Freeman, U.S. Geological Survey (USGS): Heavy oil and natural bitumen resource estimates (World and USA);
- Patrick J. Gooding, Kentucky Geological Survey, University of Kentucky, Lexington, KY: Tar sand exploration in the Appalachian and Illinois basins of Kentucky;
- Dr. William H. Green, Massachusetts Institute of Technology: Using unconventional hydrocarbons in oil sands and oil shales;
- L.C. Marchant, J.J. Stosur, and C.Q. Cupps, U.S. Department of Energy, Laramie Energy Technology Center, Laramie, Wyoming: Recent activities in U.S.A. tar sands;
- R.F. Meyer, U.S. Geological Survey (USGS): Heavy oil and natural bitumen resource estimates (World and USA);
- M.C. Noger, Kentucky Geological Survey, University of Kentucky, Lexington, KY: Tar sands occurrences of Western Kentucky;
- Dr. Sarah Pietraszek-Matter, Indiana University, Bloomington, Indiana: Biodegradation of crude oils in the Illinois Basin;
- Dr. G.V. Wilson, Alabama Geological Survey: Physical and chemical characteristics of Alabama tar sands.

5. Which companies are considered the leaders in development of oil sands?

Unless otherwise indicated, the following main oil sands offices are in Calgary, Alberta, with field offices in Fort McMurray, Cold Lake, or Peace River, Alberta. Included in the following list are the bitumen (extra-heavy) and heavy oil leaders.

1. CNRL (Canadian Natural Resources Ltd.);
2. Chevron Texaco Energy Research and Technology Co.;
3. China National Offshore Oil Corp.;
4. Conoco Phillips;
5. Eco-Petrol (Columbia);
6. EnCana Corp.;
7. Husky Energy Inc.;
8. Imperial Oil Resources Ltd.;
9. JACOS (Japan Canada Oil Sands Ltd.);
10. KNOC (Korean National Oil Corp.);
11. Laricina Energy Ltd.,
12. Lukoil-Overseas Venezuela Ltd. (Caracas, Venezuela);
13. Nexen Inc.;
14. Oil Sands Quest (Saskatchewan, Canada);
15. Ossum; PDVSA (Caracas and Maracaibo, Venezuela);
16. Petro-Canada; Petro-China Co.;
17. Petrozuata; Shell International Ltd. & Shell Canada; STATOIL (Norway);
18. Suncor Energy Inc.;
19. Syncrude Canada Ltd.;
20. Temple Mountain Energy Inc. (Utah);
21. Total E & P Canada Ltd.;
22. UTS Energy Corp.;
23. Western Oil Sands.

6. What is the focus of recent activity?

As of December 2008, the Alberta bitumen reserves under active development (mainly by surface mining) accounted for only 15% of the remaining established reserves at 21 billion barrels ($3.3\ 10^9\ m^3$). To unlock the huge potential of the remaining bitumen resources, other in-situ technologies will have to be improved. The most commonly used in-situ technologies are Steam Assisted Gravity Drainage (SAGD) and Cyclic Steam Stimulation (CSS). Both SAGD and CSS have high demands for both energy and water to produce steam, the need for good permeability (both vertical and horizontal), relatively thick pay zones (> 10 m), and an absence of barriers (cemented zones, thick, laterally-continuous shales) and the lack of significant top/gas or bottom water thief zones.

Some of the focus of and advances in recent *in-situ* technology includes:

- Integration of future oil sands with emerging oil shale co-production in the western U.S.A.;

- New developments concerning *in-situ* recovery and underground refining technologies for oil sands in western Canada, including underground combustion and refining;
- Use of Cold Heavy Oil Production with Sand (CHOPS) as a specialized primary type of production where progressive cavity pumps assist is lifting bitumen and sand to surface, and utilizing production of sand to produce wormholes in the reservoir to increase permeability;
- Search for alternative sources of energy for steam production, including the development of nuclear industries in conjunction with oil sands *in-situ* production plants (Peace River, Alberta).
- Further development and use of technologies, including Vapour Extraction (VAPEX), Toe-to-Heel-Air-Injection (THAI), Supercritical Partial Oxidation (SUPOX), and various hybrid developments, including CO_2 flooding.

The U.S. Geological Survey released a report (Meyer et al., 2007) concerning the world-wide distribution of heavy oil and natural bitumen resources, including classification of occurrence in different geological basins. A regional geologic overview of the Canadian oil sands is given in Hein, among others (Hein, 2006; Hein and Marsh, 2008; Hein et al., 2007; Marsh and Hein, 2008). On a world wide basis, extra-heavy oil in Venezuela and oil sands of the Western U.S., China, Russia are of interest, in addition to the vast oil sands of Canada,.

A comprehensive, two-volume edition book (~ 1200 pages), entitled: "Handbook on Theory and Practise of Bitumen Recovery from Athabasca Oil Sands" is currently in final stages of production, which is planned for 2009: www.ualberta.ca/cmeng/os-handbook (Masliyah et al., in press). The main focus of the handbook is the extraction of bitumen from oil sands primarily using surface mining methods, although there is a chapter on in-situ processes as well. Volume I will cover the basic scientific principles of bitumen recovery, froth treatment, diluent recovery and tailings disposal; while Volume II is devoted to industrial practices (editor, Jan Czarnecki, at jc7@ualberta.ca).

Current economics and transportation research is conducted on transportation alternatives for heavy crude and bitumen using new and existing infrastructure of pipelines and railways. Such integration has be called a virtual "pipeline on rails" to get the raw and upgraded bitumen to U.S. markets (Perry and Meyer, 2009).

7. What are the estimated U.S. and international resources/reserves and what is the strategic impact of these resources?

World resources of bitumen and heavy oil are estimated to be 5.6 trillion barrels, of which over 80% are located in Venezuela, Canada and the U.S.A. (Figure 2, Table 1) (Hein, 2006). The largest accumulation of oil sands in the world is located in Alberta, Canada, with current estimates of 270 10^9 10^3 m ("billion cubic meters, BCM") of in-place bitumen resource being currently identified (Marsh and Hein, 2008). Of this huge resource, it is estimated that 27.5 BCM (or about 173 billion barrels (BB)) is considered to be recoverable from the currently mined and drilled areas using current commercial technologies (Alberta Energy Resources Conservation Board, 2008).

Bitumen accumulations are not currently commercially produced in the U.S.A., although these occurrences are estimated to have 6.1 billion barrels of recoverable bitumen (Meyer and Attanasi, 2003). At present, Canada is considered to be an important strategic source of bitumen and synthetic crude oil (obtained by upgrading bitumen). Commercial development of United States oil sand deposits (Table 1) would aid in energy independence, either by surface mining or *in-situ* extraction, and should be included as part of its commercial daily oil production.

8. What are the critical technology needs and how are these being addressed?

Critical technology needs mainly concern the development of more environmentally-friendly methods of extraction, production and upgrading of oil sands. For surface mining operations, this involves emphasis on reclamation of tailings and consolidated tailings and re-vegetation of open pit mine sites. Most of the bitumen resources are extracted by in situ technologies (mainly thermal, such as Steam Assisted Gravity Drainage and Cyclic Steam Stimulation). Because there is significant production of GHGs (greenhouse gases) with bitumen production and upgrading, critical technology needs involve research into: 1) alternative sources of heat for generation of steam (i.e. geothermal, nuclear, burning of slag); 2) use of other methods to reduce the viscosity of the bitumen so it will flow to the well bore or through pipelines more easily (i.e. diluents, catalysts, microbial and nanotechnology); 3) underground in-situ extraction, refining and upgrading; and 4) co-sequestration of greenhouse gases by injection into abandoned reservoirs or other geologic media. At present, due to excess supply in sulfur much of the produced sulfur associated with bitumen production and upgrading is presently being stockpiled.

View the main researchers' contact information and website postings (under point 4. above) to see the advances in these regards.

9. What are the critical environmental or geohazard issues and how are these being addressed?

The critical environmental issues relate to the balance between greenhouse gas emissions and water/energy usage and the recovery, production and upgrading of bitumen. Specifically, the critical environmental issues are how to extract, produce and upgrade the

bitumen in an environmentally friendly way such that: 1) the use of energy to heat the water to steam is reduced; 2) the greenhouse gas emissions are reduced or compensated for by carbon trading or CO_2 sequestration; 3) that the extraction, production and upgrading of the bitumen is done by efficient and economic means. Some of the areas of focus include: land reclamation in surface mining; tailings and consolidated tailings disposal and reclamation; co-production of other products from tailings and bitumen upgrading (such as vanadium, nickel, sulphur, etc.); in-situ recovery, and underground refining. In Canada oil sand developers are working to reduce CO_2 emissions by 45% per barrel by 2010, compared to 1990. Also in Canada, developers are legislated to restore oil sand mining sites to at least the equivalent of their previous biological productivity. For example, at the Syncrude mine site near Fort McMurray, Alberta, the Fort MacKay Indian band has reclaimed much of the previous tailings pond areas into grasslands that are now supporting a modest bison herd (~ 500 – 700 head).

10. What EMD technical sessions, publications, workshops, etc. exist or are planned that are relevant to this commodity?

In October 2007 an AAPG Hedberg Research Conference on "Heavy Oil and Bitumen in Foreland Basins – From Processes to Products" was held in Banff and Calgary, Alberta (Suter et al., 2007; Hein et al., 2007). At the 2009 AAPG Annual Meeting in Denver an EMD poster session on oil (tar) sands is part of the unconventional sessions; a similar EMD session is planned for the 2010 AAPG Annual Meeting in New Orleans.

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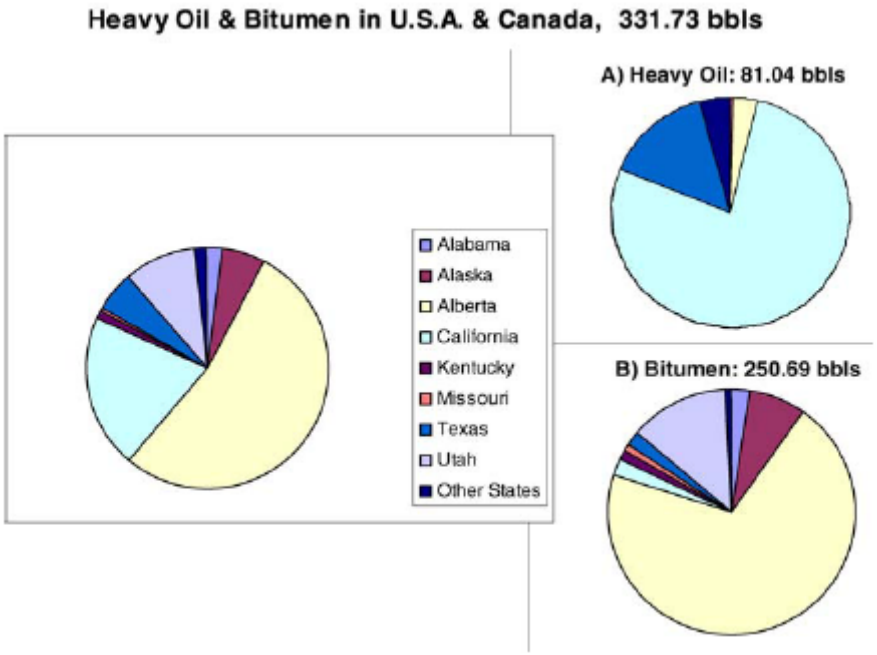

Figure 2. Pie charts showing the distribution of combined heavy-oil/bitumen resources for the U.S.A. and Canada, with breakdown insets: A) heavy oil; and B) bitumen resources (see Table 1, from Hein (2006).

Location	Bitumen billion barrels (bbls)	Bitumen Per Cent (%)
Alberta	174.5	69.61
Utah	32.33	12.90
Alaska	19.00	7.58
Alabama	6.36	2.53
Texas	5.44	2.17
California	5.34	2.31
Kentucky	3.42	1.26
Missouri	2.07	0.83
Other States	2.23	0.89
Totals	250.69	100.00

Table 1. Bitumen Resources of North America (from Hein, 2006).

EMD Oil (TAR) SAND COMMITTEE SUBMISSION
Part 2 of 3

"Technical Areas" write-up for the public portion of the website
(http://emd.aapg.org/technical_areas/oil_sands.cfm)

by Frances J. Hein, Alberta Energy and Resources Conservation Board, Oil Sands Chair for EMD; and Debra Higley, U. S. Geological Survey, Denver, Vice-Chair for Government, EMD Oil Sands Committee

Oil sands (also called tar sands) consist of bitumen and host sediment with associated minerals, excluding any related natural gas. Bitumen is soluble organic matter. The bitumen in oil sands is derived from degradation of oil either as seeps that come to surface or within shallow subsurface reservoirs. Other bitumen may be pre-oil bitumen (intermediate between kerogen and oil) (i.e. Curiale, 1986; Lewan 1985; Lewan et al., 1986)[1] and may be found in other sediments such as oil shales, as fracture-fills, or as karst-fill within carbonate bitumen deposits. In the present usage, the bitumen in the oil sands would be classified as Curiale's (1986) 'post-oil type.'

The largest single oil sand deposit in the World is the Athabasca oil sands located in northeastern Alberta, Canada. Here the shallow oil sands are recovered in open-pit mines by truck-and-shovel operations in which the World's largest Caterpillar 797 and 797B trucks have payloads of 380 tons. The oil sand is transported to processing plants, where hot or warm water separates the bitumen from the sand, followed by dilution with lighter hydrocarbons and upgrading to synthetic crude oil (SCO).

About 22 percent of the oil sands reserves in Alberta are recoverable by surface mining, where the overburden is less than 75 m. The remaining 78 per cent of the oil sands are buried at a depth of greater than 75 m and require *in-situ* technologies (largely thermal techniques such as Steam Assisted Gravity Drainage, or SAGD; Cyclic Steam Stimulation, or CSS; or, Hybrid Steam Assisted Gravity Drainage, or HSAGD) to extract the bitumen.

The most commonly used *in-situ* process is Steam Assisted Gravity Drainage (SAGD), in which pairs of horizontal wells are drilled near the base of the bitumen deposit. Steam is injected into a well located about 5 metres above the producer well. The steam rises and heats the bitumen which loses its viscosity, and then flows down under gravity to the underlying producer well, from which it is pumped to the surface. The bitumen is then either upgraded on site, at a regional upgrader, or mixed with diluent and shipped to a refinery. In 2005, 200 million barrels (31.7 million m3) of synthetic crude oil was

[1] References Cited: Curiale, J.A., 1986, Origin of solid bitumens, with emphasis on biological marker results: Organic Geochemistry, v. 10, p. 559-580; Lewan, M.D., 1985, Evaluation of petroleum generation by hydrous pyrolysis experimentation: Philosophical Transactions of the Royal Society of London, series A, v. 315, p. 123-134; Lewan, M.D., Bjoroy, M., and Dolcater, D.L., 1986, Effects of thermal maturation on steroid hydrocarbons as determined by hydrous pyrolysis of Phosphoria retort shale: Geochimica et Cosmochimica Acta, v. 50, p. 1977-1987.

produced from the mined raw bitumen (upgraded onsite or in a regional refinery). Most of the in-situ bitumen production was marketed as non-upgraded crude bitumen.

Oil sands are found in about 70 other countries around the world, including the U.S.A., Venezuela, Russia, Cuba, Indonesia, Brazil, Trinidad and Tobago, Jordan, Madagascar, Colombia, Albania, Romania, Spain, Portugal, Nigeria and Argentina. Within the United States, oil sand deposits occur mainly in Utah, Alaska, Alabama, S.W. Texas, California, Kentucky, Oklahoma, and Missouri, with scattered deposits in other states. A map showing occurrences in North America is below.

World Heavy Oil &
Bitumen Deposits (CLICK TO ENLARGE)

In most cases, the oil-sand deposits occur at the surface or at relatively shallow depths of burial (< 200 m), where hydrocarbon reservoirs are in contact with the atmosphere, groundwater aquifers or shallow formation waters. Ages of host rocks in North America range from Ordovician to Quaternary. Geologically, oil sand deposits can be broadly classed into two end-member categories – (1) very large and large deposits at the shallow up-dip edge of foreland basins; and (2) medium to small scale deposits that are related to loss of caprock integrity. Oil sands are commonly associated with faults and unconformities, and may also be found in association with oil seeps, springs, tufa deposits and/or mud volcanoes. A world-wide compilation of heavy oil and natural bitumen deposits in relation to the different types of geologic basins was completed by the U.S. Geological Survey in 2007 (website posting: http://pubs.usgs.gov/of/2007/1084/OF2007-1084v1.pdf).

All of the North American bitumen production is from Alberta. Alberta's crude bitumen production in 2007 totaled 482.5 million barrels (76.7 million m3), with 59% (284.7 million barrels) coming from extraction by surface mining and with 41% (197.8 million barrels) coming from *in-situ* underground thermal operations. This production of crude bitumen is equivalent to 1.32 million barrels per day (210,000 m3/day). By 2016 it is expected that this production from Alberta will at least be double that recorded in 2005. It is expected that the contribution of bitumen to Alberta's total crude production will increase to 86% by 2016.

Because of the expected growth in oil sands production, a large number of specialists will be needed including subsurface and mine geologists (depending upon *in-situ* or surface mining methodology), geophysicists, reservoir engineers, computer modelers, environmental and reclamation specialists, policy specialists, and economists.

If you're interested in learning more about oil sands, there's additional information in the member's only area of the EMD website including a compilation of references; a field guide to Alberta oil sands; a table of reserves estimates; references to pertinent and recent articles; website links; a reference to a video of oil sand extraction, production and geology; articles from the AAPG Explorer, Search and Discovery pages, and AAPG Bulletin; and abstracts from section/region and annual meetings.

EXPLORER NOVEMBER 2004

Note Need Someone to Provide Link Here to January 2010 Explorer on Oil Sands By Fran Hein Article I do not know how to do this.

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For more information contact:

Frances J. "Fran" Hein, Chair
Phone: (403) 297-6929
Email : fran.hein@ercb.ca

3. Updates to the Members-Only Webpage. This can be viewed at http://emd.aapg.org/members_only/oil_sands/index.cfm

Web Links

Alberta Energy Resources Conservation Board: www.ercb.ca

Alberta Chamber of Resources: www.abchamber.ca

Alberta Department of Energy: www.energy.gov.ab.ca

Alberta Department of Sustainable Resource Development: www.gov.ab.ca/srd

Alberta Energy Research Institute: www.aeri.ab.ca

Alberta Environment Information Centre: www.environment.gov.ab.ca

Alberta Geological Survey: www.ags.gov.ab.ca;

Alberta Government: www.alberta.ca

Alberta's Industrial Heartland Association: www.industrialheartland.com

Alberta Ingenuity Centre for In Situ Energy: www.aicise.ca

Alberta Innovation & Science: www.innovation.gov.ab.ca

Alberta Research Council: www.arc.ab.ca

Alberta Sulphur Research Ltd.: www.chem.ucalgary.ca/asr

Athabasca Regional Issues Working Group: www.oilsands.cc

Canadian Association of Petroleum Producers: www.capp.ca

Canadian Energy Research Institute: www.ceri.ca

Canadian Geoscience Council: www.geoscience.ca

Canadian Heavy Oil Association: www.choa.ab.ca

Canadian Institute of Mining, Metallurgy & Petroleum: www.cim.org

Canadian Petroleum Institute; www.cipid.com

Canadian Society of Petroleum Geologists: www.cspg.org

Canadian Well Logging Society: www.cwls.org

CanMet Mining and Mineral Sciences Laboratories: www.nrcan.gc.ca

Careers: The Next Generation: www.nextgen.org

Climate Change Central: www.climatechangecentral.com

EnergyInet: www.energyinet.com

Environment Canada: www.ec.gc.ca

Fort McMurray Chamber of Commerce: www.fortmcmurraychamber.ca

Freehold Owners Association: www.fhoa.ca

Geological Survey of Canada: www.gsc.nrcan.ca

Institute for Sustainable Energy, Environment and Economy: www.iseee.ca

International Energy Foundation: www.ief-energy.org

National Energy Board: www.neb-one.gc.ca

National Research Council's Industrial Research Assistance Program: www.irap-pari.nrc-cnrc.gc.ca

Natural Resources Canada: www.nrcan-rncan.gc.ca

North American Oil Sands Corporation: www.naosc.com

Oil Sands Discovery Centre: www.oilsandsdiscovery.com

Oil Sands Environmental Research Network: www.osern.rr.ualberta.ca

Petroleum Society of CIM: www.petsoc.org

Petroleum Technology Alliance Canada: www.ptac.org

Petroleum Technology Research Centre: www.ptrc.ca
Saskatchewan Industry and Resources: www.ir.gov.sk.ca

Saskatchewan Government: www.ir.gov.sk.ca

Saskatchewan Research Council: www.src.sk.ca

Seeds Foundation: www.seedsfoundation.ca

Small Explorers and Producers Association of Canada: www.sepac.ca

Society of Petroleum Engineers: www.speca.ca

The Canadian Society of Exploration Geophysicists: www.cseg.ca

The Environmental Association of Alberta: www.esaa.org

U.S. Geological Survey: http://pubs.usgs.gov/of/2007/1084/OF2007-1084v1.pdf

U.S. Bureau of Land Management: www.blm.gov

Utah Heavy Oil: http://www.heavyoil.utah.edu/outreach.html;
http:/map.heavyoil.utah.edu/

Events Calendar

October 5 –7, 2009

Engineering Sustainable Development of the Oil Sands, Banff, Alberta; CSPG Gussow Research Conference.

November 2009

3rd World Heavy Oil Congress, Maracaibo, Venezuela

February 2 – 3, 2010

InSight (An ALM Event), Oil Sands & Heavy Oil Technologies Conference and Exhibition, Calgary, Alberta, Canada

April 19, 2010

The Canadian Heavy Oil Association (CHOA), Slugging It Out, XVIII, Calgary, Alberta, Canada.

April 27 –28, 2010

The Canadian Institute, Oil Techniques and Technologies for Improved Production, Recovery and Economic Performance, Calgary, Alberta, Canada.

May 3, 2010

Heavy Oil Conference, New York City, New York, USA (Raymond James)

May 10 – 12, 2010

GeoCanada 2010, Calgary, Alberta, Canada.

One dedicated oral session as follows:

Modern Analogs for the McMurray Formation

May 31 – June 2, 2010

Heavy Oil World (MENA), Manama, Bahrain.

July, 2010

Oil Sands Conference Calgary, Alberta, Canada (TD Newcrest)

July 20 – 22, 2010

Oil Sands and Heavy Oil Technologies Conference and Exhibition, Calgary, Alberta, Canada.

September 14 – 15, 2010

Oil Sands Trade Show & Conference, Fort McMurray, Alberta, Canada.

September 12 – 15, 2010

AAPG 2010 ICE Calgary, Alberta, Canada.

Selected Oil Sands/Heavy Oil/Bitumen Sessions Include:

Special Session & Forum on Unconventionals A-Z

EMD - Heavy Oils/Bitumen North American Regional I oral session

EMD - Heavy Oils/Bitumen Alberta Field Studies II oral session

EMD – Heavy Oils/ Bitumen Carbonates/ Oil Sands poster session

EMD – 2-day pre-conference core course on Oil Sands: Reservoirs and Cap Rock Integrity and Regulatory Concerns.

AAPG Field trip to the Oil Sands in the Fort McMurray Area, NE Alberta.

Recent References on Oil Sands

Alberta Energy and Utilities Board, 2007, Alberta's Energy Reserves 2006 and Supply/Demand Outlook 2007-2016, Alberta Energy and Utilities Board, Statistical Series, ST98-2007, p. 1-1 to 9-14, 4 Appendices.

Alberta Energy Resources Conservation Board, 2008, Alberta's Energy Reserves 2007 and Supply/Demand Outlook 2008-2017, Alberta Energy and Utilities Board, Statistical Series, ST98-2008. [in press, to be released June, 2008].

Dusseault, M.B., Zambrano, A., Barrios, J.R., and Guerra, C., 2008, Estimating technically recoverable reserves in the Faja Petrolifera del Orinoco – FPO, Proceedings World Heavy Oil Congress, Edmonton 10-12 March, 2008, paper 2008-437, 6 p.

Hein, F.J., 2006, Heavy oil and oil (tar) sands in North American: An overview and summary of contributions: Natural Resources Research, 18 p.

Hein, F.J. and Marsh, R.A., 2008, Regional geologic framework, depositional models and resource estimates of the oil sands of Alberta, Canada, Proceedings World Heavy Oil Congress, Edmonton 10-12 March, 2008, paper 2008-320, 9 p.

Hein, F.J., Marsh, R.A., and Boddy, M.J., 2007, Overview of the oil sands and carbonate bitumen of Alberta: Regional geologic framework and influence of salt-dissolution effects: Proceedings and Abstracts, AAPG Hedberg Conference, "Heavy Oil and Bitumen in Foreland Basins – From Processes to Products," September 30 – October 3, 2007, Banff and Calgary, AB, Canada, extended digital abstract, modified and posted March 24, 2008, Search and Discovery Article #10145, 3 p. with 2 figures and one table. http://www.searchanddiscovery.net/documents/2008/08017hein/index.htm

Hein, F.J., Leckie, D., Suter, J., and Larter, S., 2007, Heavy oil and bitumen in foreland basins – From processes to products: Core Conference, Program with Abstracts, AAPG Hedberg Research Conference, Calgary, Alberta, 37 p.

Hernandez, E., Bauza, L., and Cadena, A., 2008, Integrated reservoir characterization and oil in place estimation for Ayacucho area, Orinoco oil belt Venezuela, Proceedings World Heavy Oil Congress, Edmonton 10-12 March, 2008, paper 2008-426, 14 p.

Higley, Debra K., Lewan, Michael D., Roberts, Laura N.R., and Henry, Mitchell, 2009, Timing and Petroleum Sources for the Lower Cretaceous Mannville Group Oil Sands of Northern Alberta Based on 4-D Modeling: American Association of Petroleum Geologists Bulletin, v 93 no. 2, 28 p

Marsh, R.A. and Hein, F.J., 2008, Canada's extra-heavy (bitumen) and heavy oil resources, reserves and development, Journal of Canadian Petroleum Technology, 9 p. [in press].

Meyer, R.F., E.D. Attanasi, and P.A. Freeman, 2007, Heavy oil and natural bitumen resources in geological basins of the world: U.S. Geological Survey Open-File Report 2007-1084, 36 p. http://pubs.usgs.gov/of/2007/1084/OF2007-1084v1.pdf

Suter, J., Leckie, D., and Larter, S., 2007, Heavy oil and bitumen in foreland basins – From processes to products: Program with Abstracts, AAPG Hedberg Research Conference, Banff, Alberta. 120 p.

Villarroel, T., 2008, New developments in Orinoco oil belt projects reflect a positive effect on the areas reserves, Proceedings World Heavy Oil Congress, Edmonton 10-12 March, 2008, paper 2008-412, 8 p.

Proposed Functions, Activities, and Contributions of the Oil Sands Committee*

1. Annual meetings

(Special sessions related to Heavy Oil/Oil Sands and Bitumen have been scheduled at prior annual meetings, e.g. 2004 Dallas; 2005 Calgary; 2007 Long Beach, 2009 Denver, sessions co-chaired by F. Hein, ERCB, along with others at different meetings.

Assist AAPG and EMD identify, develop and execute sessions related to heavy oil/oil sands and bitumen geology, engineering and technology in forthcoming annual meetings. This process will be facilitated with greater awareness of and participation in these thematic issues.

2. Cooperation with Other Divisions

Our "to do" list includes contacting members/officers of DEG to identify activities/sessions of mutual interest, ideally through cross-membership.

3. GTW's, Webinars, and Speakers Bureau

Material is available now (Mid-Year/Preliminary Annual Mtg report "Comments on Oil Sands Commodity Reports") that could support a webinar.

4. Publications

Short pieces have been published for *AAPG Explorer*, most recently in November 2009, Lots of Potential, Lots of Hurdles: Needed: Resourceful Technology (Hein, 2009, 2009), and a longer article for *Natural Resources*.

AAPG Memoir on Oil Sands approved by the AAPG Publications Committee and the EMD (January 25, 2009).

- Tentative Title: **Heavy Oil/Bitumen Petroleum Systems in Alberta & Beyond**
- Format multi-authored papers
- Medium – electronic DVD (preferred for high resolution seismic images)
- Names Frances J. Hein; John Suter; Dale Leckie; and Steve Larter (order TBD)
- **Table of contents**
- **Overview**
    1. Oil Sands and Heavy Oil Overview: The Future is Non-Conventional by F. Hein, J. Suter, D. Leckie and S. Larter.
    2. Petroleum Systems of Two Supergiant Bitumen-Heavy Oil Accumulations: The Faja Petrolifera del Orinoco, Venezuela, and the Athabasca Oil Sands, Alberta, Canada by J. Suter, D. Leckie, S. Larter and F. Hein.
    3. Heavy Oil and Oil Sands Resources/Reserves by Rick Marsh and Farhood Rahnama
- **Geological Models and Reservoir Characterization**

    4. Dynamic Interplay of Oil Mixing, Charge, Timing and Biodegradation in the Formation of the Athabasca Oil Sands: Insights from Modeling, Geochemistry and Microbiology by J. Adams, S. Larter, B. Bennett, H. Huang and J. Westrick.

* Submitted by F. Hein, 26 March, 2010

5. Comparison of Oil-Generation Kinetics Derived from Hydrous Pyrolysis and Rock Eval in 4-D Models of the Western Canada Sedimentary Basin and Its Northern Alberta Oil Sands by D. Higley and M. Lewan.
6. Impact of Oil-Water Contacts, Reservoir Continuity, and Reservoir Properties on Variability of Bitumen Properties and Composition in the Athabasca Oil Sands Deposits, Alberta, Canada by M. Fustic, B. Bennett, H. Huang, T. Oldenburg, S. Larter and S. Hubbard.
7. Stratigraphic Architecture of a Large-Scale Point Bar Complex in the McMurray Formation, LIDAR and Subsurface Data Integration at Syncrude's Mildred Lake Mine by T. Nardin, H.R. Feldman and B.J. Carter
8. Braided River and Avulsive Depositional Systems in the McMurray Formation – LIDAR and Subsurface Data Integration at Syncrude's Aurora North Mine by T. Nardin, B. J. Carter, and Nina E. Bassey
9. Paleoenvironmental Interpretations of Palynofloral Assemblages from the Surmont and Surrounding Areas, Athabasca Oil Sands by G. Dolby, T.D. Demchuk, and J.R. Suter.
10. Depositional Setting and Characterization of Wave-Dominated Giant Longitudinal Sand Bar Reservoirs, Ells River Oil Sands Deposit, Athabasca Basin, Alberta, Canada by P. Broughton.
11. Geology and Development History of the Foster Creek and Christina Lake SAGD Project Areas, Alberta, Canada by B. Mattison and S. Gittens.
12. The Depositional Significance of Various Modes of Inclined Heterolithic Stratification in the McMurray Formation, Alberta, Canada by M. Gingras, C. Lettley and M. Ranger.
13. Geology of a Giant Carbonate Bitumen Deposit, Grosmont Formation, Saleski, Alberta, Canada by K. Barrett and J. Hopkins.
14. Oil-Saturated Mississippian-Pennsylvanian Sandstones of South-Central Kentucky, USA by M. May.
15. Unconventional Reservoired Oil Resources of the Uinta Basin, Utah by Steven Schamel.
16. New Developments in Orinoco Oil Belt Projects Reflect a Positive Effect on Reserves by T. Villarroel.
17. Sedimentology, Stratigraphy and Reservoir Characterization of the Oficina Formation in Petrocedeno (Early Miocene), Orinoco Heavy Oil Belt, Venezuela by A. Martinius, J. Casas, J. Hegner, X. Mathiew, R. Mjos, and J. Peralta.
18. Natural Bitumen Fields in the Olenek Uplilft of the Siberian Platform by Vladimir A. Kashirtsev and F. J. Hein

- **Geostatistics, 3-D Modeling and Technology**

19. Characterization of Oil Sands Lithofacies by Electro-Facies Modeling by David Garner and Paul Broughton
20. Multiple Scale Geological Models for Heavy Oil Reservoir Characterization by Clayton Deutsch
21. 3D Object Based Modeling – A Novel Approach for Modeling the Athabasca Oil Sands Reservoirs -- Case Study from Long Lake, Alberta, Canada by M. Fustic, D. Thurston, A. Al-Dilwe, D. Leckie, and D. Candou.
22. Modeling of Tide-Influenced Point-Bar Heterogeneity Distributions and Impact on SAGD Production: Example from Steepbank River Outcrops, McMurray Formation, Canada by R. Labourdette, G. Musial and J-Y Reynaud.
23. Quantification of Reservoir Heterogeneity in a Large-Scale Point Bar Complex in the McMurray Formation at Syncrude's Mildred Lake Mine by H.R. Feldman and T. R. Nardin
24. Three-Dimensional Seismic Definition of Channels in a Lower Cretaceous (Mannville Group) Heavy Oil Reservoir in West-Central Saskatchewan by S. Sarzalejo and B. Hart.
25. Characterization of Heavy Oil Reservoirs Using Vp/Vs Ratios and Spectral Decomposition by Carmen Dimistrescu and Larry Lines
26. Fundamentals of Heat, Steam, Solvent and Oil Transport at the Edge of Steam Chambers by I. Gates, D. Gotawala and J. Sharma

27. SAGD, CSS and Steam-Solvent Hybrid Processes for Bitumen Recovery: Impact of Geological and Fluid Compositional Heterogeneity by I. Gates, S. Larter and B. Bennett
28. Integration of SAGD Fundamentals with Reservoir Characterization to Optimize Production by R. Strobl
29. Screening Criteria and Technology Sequencing for In Situ Production from Viscous Oil Sands by Maurice Dusseault

- **Sustainable Development of the Oil Sands**

30. Sustainable Oil Sands: Long Term Potential for Reduction of Greenhouse Gas Emissions Through Carbon Capture and Storage by S. Singh, E. Isaacs and D. Nguyen
31. Geologic Risk Assessment of the Athabasca Oil Sands and Development Strategies by F. Hein, K. Haug, P. Greene.
32. Quaternary Bedrock Channels and Glacial Fold-and-Thrust Triangle Zone Complexes, Fort Hills Area: Challenges to Oil Sands Mining in Northeast Alberta by Laurence Andriashek and Fran Hein
33. Trading Water for Oil: Tailings Management and Water Use in Surface Mined Oil Sands by R. Mikula.
34. A subsurface well delivery system to commercially develop the Grosmont Formation, by J. Russel-Houston, A. Abrams and P. Putnam
35. Technological Challenges in the Integral Development of the Faja Petrolifera del Orinoco, Venezuela by T. Villarroel.

For Consideration: AAPG GIS Product on North American Oil (Tar Sands) (Sam Limerick).

5. Section and Region Meetings

To date the committee has been involved regional events and international events, both within and outside the AAPG, including:

AAPG Hedberg Conference, "Heavy Oil and Bitumen in Foreland Basins – From Processes to Products" Organizers and Co-Conveners for Poster and Oral Presentations in Banff, Alberta; and a Core Conference in Calgary, Alberta (September and October, 2007).

Canadian Society of Petroleum Geologists (CSPG) Gussow Geoscience Conference, "Engineering Sustainable Oil Sands Development," October 5 – 7, 2009.

AAPG 2010 ICE Calgary, EMD Co-Chair for Local Organizing Committee, Special Heavy Oil/Bitumen Sessions: 2 full oral sessions (1 day) and 1 poster session (1 day). Joint EMD-SEPM Field Trip (pre-Conference); and a 2-Day Core Course on Oil Sands (pre-Conference) Dealing with the Alberta Oil Sands: Regional Geology and Regulatory Concerns.

6. Technical Interest Groups

Establish and moderate a web-based Technical Interest Group that will serve as an online forum for the discussion of technical issues related to heavy oil/ bitumen-carbonate/ oil sand exploration and development.

7. Interaction with Non-Geological Organizations

The Canadian Heavy Oil Association ('CHOA,' based in Calgary, includes geologists, geophysicists, engineers, transportation and marketing specialists, as well as policy makers) and is a group which could be particularly helpful to AAPG members interested in various aspects of heavy oil/ carbonate bitumen and oil sands.

8. Webpages

This is an area that could use development/improvement. It is currently updated twice a year using the Oil Sands Committee reports. To date, these have largely reflected the views of the Chair along with one or two committee members. As the Commodity Committee grows the expansion and updating of the webpages will be facilitated, including posting of interesting powerpoint presentations, as submitted by committee members.

Oil Sands Committee

Position	Name	Appointment	Position	Employment	City, Province of State, Country	Email
Chair	Frances J. Hein	ongoing to 2012	Senior Geologist, Oil Sands Advisor	Energy Resources Conservation Board	Calgary, Alberta, Canada	Fran.hein@ercb.ca
Vice-Chair for Industry	Mark Holz	2009-12	Director, International Business Development, EOR	Praxair	Austin, Texas, USA	Mark.Holz@Praxair.com
Vice-Chair for Government	Debra Higley	2009-12	Research Geologist, Oil Sands	U.S. Geological Survey	Denver, Colorado, USA	higley@usgs.gov
Vice-Chair for University	Burns Cheadle	2009-12	Professor Bill Bell Chair in Petroleum Geology	University of Western Ontario	London, Ontario, Canada	bcheadle@uwo.ca
Active Committee Members						
	Steven Schamel	2009-12	Consultant Working on Oil Sands in USA	GeoX Consulting, Inc	Salt Lake City, USA	Geox-slc@comcast.net
	Thomas Richard Nardin	2009-12	Consultant Working on Oil Sands in Canada	Consulting Geologist to Imperial Oil Ltd.	Calgary, Alberta Canada	Com.nardin@esso.ca
	Thomas Edward Ewing	2009-12	Consultant Working on Oil Sands and Hydrogeology	Independent Consulting Geologist	San Antonio, TX, USA	tewing@fronteraexploration.com
	Jennifer Adams	2009-12	Research Geologist, Oil Sands	Conoco Phillips Ltd.	Houston, TX, USA	Jennifer.J.Adams@conocophillips.com
	Steve Larter	2009-12	Canada Research Chair in Petroleum Geology, AIF Scholar, Codirector Alberta Ingenuity Centre for In Situ Energy	University of Calgary	Calgary, Alberta Canada	slarer@ucalgary.ca
	Jean-Pierre Fossy	2009-12	Research Geophysicist	Total Oil and Gas Company	Cedex, France	Jean-Pierre.FOSSEY@total.com