EMD Oil (TAR) SAND COMMITTEE CHAIR SUBMISSION
Report for 2007 Mid-Year Meeting

by Frances J. Hein, Alberta Energy and Utilities Board, Oil Sands Chair for EMD

1. Where are the active basins and which ones are most likely to see future growth?

The only active commercial oil sands areas are in the Western Canada Sedimentary Basin, in northeastern Alberta, Canada. Other areas most likely for future oil sands growth include the northwestern portion of Saskatchewan in the Western Canada Sedimentary Basin; the Colorado Plateau, Uinta Basin and Paradox Basin 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 Basin and Appalachian Basin areas 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 2006 Alberta's crude bitumen production totaled 44.1 million cubic-meters (278 million barrels) from the surface mineable area and 28.7 million cubic-metres (180 million barrels) from the in situ area, totaling 72.8 million cubic-meters (458 million barrels). This total production is equivalent to 199 thousand cubic-meters per day (1.25 million barrels per day). The bitumen that was produced by surface mining was upgraded, and yielded 38.1 million cubic-meters (240 million barrels) of synthetic crude oil (SCO). In situ bitumen production was marketed as nonupgraded crude bitumen (Alberta Energy and Utilities Board, 2007).

In 2006 the production of raw bitumen and SCO accounted for 62 per cent 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 per cent by 2016 (Alberta Energy and Utilities Board, 2007).

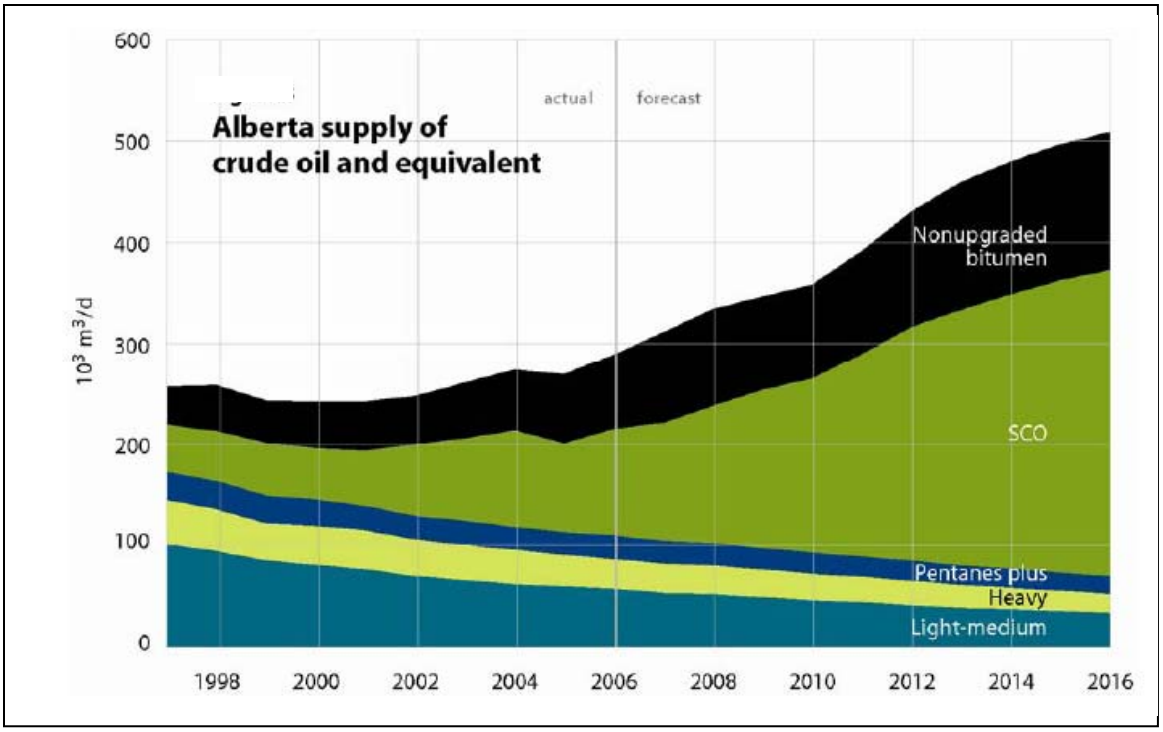

Figure 1. Alberta supply of crude oil and equivalent (from Alberta Energy and Utilities Board, 2007). SCO refers to synthetic crude oil produced from bitumen.

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. For Canadian federal funding refer to the following website: www.InnovationCanada.ca. In the 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).

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

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 fingerprint 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. Frances J. Hein, Rick Marsh, and Farhood Rahnama, Alberta Energy and Utilities Board, Calgary: Regional geologic framework, depositional models of the Alberta oil sands and reserves estimates;
- 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. 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.
- Government of Saskatchewan, www.ir.gov.sk.ca\

U.S.A.

- E.D. Attanasi, U.S. Geological Survey (USGS): Heavy oil and natural bitumen resource estimates (World and USA);
- 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;
- 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?

Unless otherwise indicated the 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 extra-heavy and heavy oil leaders.

CNRL (Canadian Natural Resources Ltd.); Chevron Texaco Energy Research and Technology Co.; China National Offshore Oil Corp.; Conoco Phillips; Eco-Petrol (Columbia); EnCana Corp.; Husky Energy Inc.; Imperial Oil Resources Ltd.; JACOS (Japan Canada Oil Sands Ltd.); KNOC (Korean National Oil Corp.); Lukoil-Overseas Venezuela Ltd. (Caracas, Venezuela); Nexen Inc.; Oil Sands Quest (Saskatchewan, Canada); PDVSA (Caracas and Maracaibo, Venezuela); Petro-Canada; Petro-China Co.; Petrozuata; Shell International Ltd. & Shell Canada; STATOIL (Norway); Suncor Energy

Inc.; Syncrude Canada Ltd.; Temple Mountain Energy Inc. (Utah); Total E & P Canada Ltd.; UTS Energy Corp.; Western Oil Sands.

6. What is the focus of recent activity?

Integration of oil sands and oil shale co-production in the western U.S.A.; new and development in situ recovery and underground refining technologies for oil sands in western Canada; nuclear industries in conjunction with oil sands in-situ production plants (Peace River, Alberta). On a world wide basis, oil sands in China, Russia, and extra-heavy oil in Venezuela are of interest.

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). At present no bitumen accumulations are currently being 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). If the U.S.A. wants to become more energy independent, its existing oil sand deposits (Table 1) should be included as part of its commercial daily oil production.

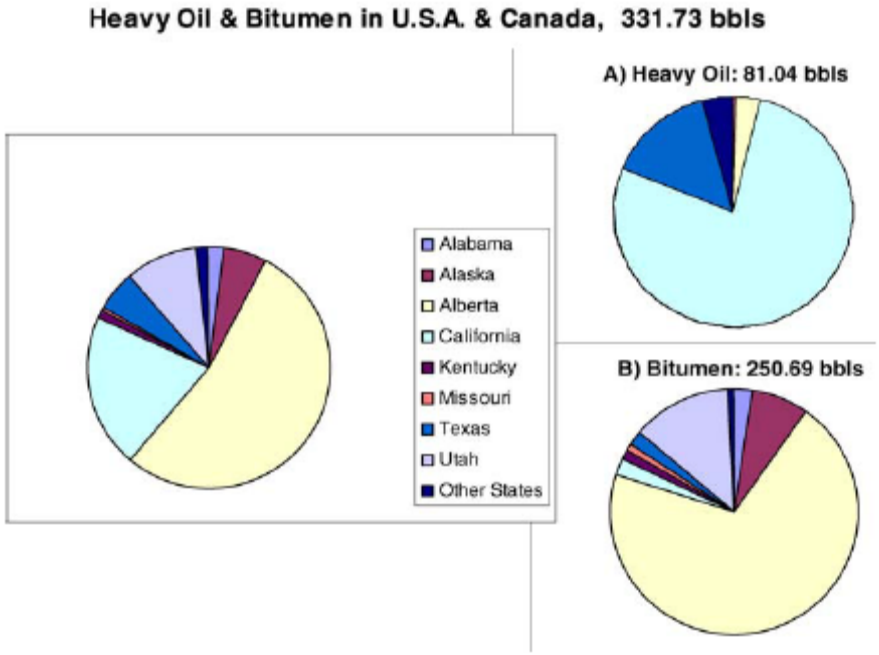

Figure 2. Pie charts showing the distribution of combined heavy-oiol/bitumen resources for the U.S.A. and Canada, with breakdown insets: A) heavy oil; and B) bitumen resources (see Table 1). From Hein (2006).

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).

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 tailings and consolidated tailings reclamation and revegetation 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. View the main researchers' contact information and website postings 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 CO2 sequestration; 3) that the extraction, production and upgrading of the bitumen is done by efficient and economic means. Some of the things that are being worked on 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 CO2 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?

At the Annual Meeting in San Antonio a poster session is planned on oil sands that is part of the unconventional sessions. A recent AAPG Hedberg Conference was held in Banff, Alberta (October 2007) (Suter et al., 2007; Hein et al., 2007), the results of which are planned to be published as an AAPG Memoir. For other publications see the AAPG EMD-2007 Annual Meeting Long Beach Report.

References Cited

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.

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., 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.

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.