

Crude Bitumen Pay Thickness and Geological Structure Contour Maps

Regional Map

Sub-Cretaceous Unconformity

The sub-Cretaceous unconformity is the stratigraphic surface that forms the base on which the bitumen-bearing Cretaceous sediments were deposited. **Figure R3.3** is a structure contour map of that surface as it would have appeared at the end of Bluesky/Wabiskaw time. The parts of the Nisku and Grosmont formations that are bitumen bearing are outlined on this map. These Devonian carbonate formations subcrop along the sub-Cretaceous surface and contain bitumen in an updip location along the subcrop edge. Of particular note are the areas on this map identified as having a relative subsea elevation of greater than zero. These areas were still emergent at the end of Bluesky/Wabiskaw time and would have existed as islands within the transgressing northern Boreal Sea.

Peace River Oil Sands Area

Peace River Bluesky-Gething Deposit

The Bluesky-Gething deposit was reassessed for year-end 2006. **Figure R3.4** is the bitumen pay thickness map for the Bluesky-Gething deposit based on cutoffs of 6 mass per cent and 1.5 metres (m) thickness. The Bluesky-Gething is mapped as a single bitumen zone so that the full extent of the deposit at 6 mass per cent can be shown. Also shown on **Figure R3.4** are the paleotopographic highlands as they would have existed at the time of the end of the deposition of the Bluesky Formation. These highlands, composed of carbonate rocks of Devonian and Mississippian age, controlled the deposition of the Bluesky and correspondingly the extent of the reservoir. Oil migrated updip became trapped beneath the overlying Wilrich shales and against the highlands, where it was eventually biodegraded into bitumen.

Athabasca Oil Sands Area

Athabasca Grosmont Deposit

In 2009, the AER updated the previous (1990) resource assessment of the Athabasca Grosmont deposit. Over 1330 wells were used within the study area, which extended from Townships 62 to 103 and Range 13, West of the 4th Meridian, to Range 6, West of the 5th Meridian. In its resource assessment, the AER included the bitumen from the Upper Ireton Formation. The Grosmont and the Ireton formations are considered to be in hydraulic communication.

The Grosmont Formation is a late-Devonian shallow-marine to peritidal platform carbonate consisting of four recognizable units within the deposit: the Grosmont A, B, C, and D. All of the hydrocarbons are

located in an updip position, structurally trapped along the erosional edge and contained by the overlying Clearwater Formation. **Figure R3.5** is the cumulative bitumen net pay isopachs for the entire Grosmont deposit.

Athabasca Wabiskaw-McMurray Deposit

In 2003, the AER completed a reassessment of the Wabiskaw-McMurray deposit using geological information from over 13 000 wells and bitumen content evaluations from over 9000 wells to augment the over 7000 boreholes already assessed within the surface mineable area (SMA; see below for details). In 2005 and 2007, nearly 700 and 2700 new wells respectively, mostly outside the SMA, were added to the reassessment, and the volumes and maps were revised. In 2008, about 2500 additional wells outside the SMA and about 18 000 wells inside the SMA were added. In 2009, about 1700 wells, including about 350 from within the SMA, were added.

Figure R3.6 is a bitumen pay thickness map of the Wabiskaw-McMurray deposit revised for year-end 2009 based on cutoffs of 6 mass per cent and 1.5 m thickness. In this map, the deposit is treated as a single bitumen zone and the pay is accumulated over the entire geological interval. Also shown is the extent of the SMA, an AER-defined area of 51½ townships north of Fort McMurray covering that part of the Wabiskaw-McMurray deposit where the total overburden thickness generally does not exceed 65 m. This designation is for resource administration purposes and carries no regulatory authority. That is to say that while mining activities are likely to be confined to the SMA, they may occur outside the area's boundaries, while in situ activities may occur within the SMA. Because the extent of the SMA is defined using township boundaries, it incorporates a few areas containing deeper bitumen resources that are more amenable to in situ recovery. The AER has generated a line that generally separates the mineable portion of the deposit from the in situ portion, and that line is shown in **Figure R3.6**.

Athabasca Upper, Middle, and Lower Grand Rapids Deposits

The 2011 year-end review for the three Athabasca Grand Rapids deposits (Upper, Middle, and Lower), **Figure R3.7**, **Figure R3.8**, and **Figure R3.9**, included an evaluation of 3575 wells for stratigraphic tops and 1887 for reservoir parameters. The study area covered Townships 73 to 87 within Range 17, West of the 4th Meridian, to Range 1, West of the 5th Meridian. The reassessment resulted in in-place bitumen resources being increased from $8678 \times 10^6 \text{ m}^3$ to $9274 \times 10^6 \text{ m}^3$ for the Grand Rapids deposits. This represents a 7 per cent increase, which is attributed to an increased number of wells drilled in the area.

The Grand Rapids Formation is interpreted as a series of prograding sequences of shoreface sands and shales. Informally the formation has been divided into Upper, Middle, and Lower sequences, with the boundaries defined by laterally extensive marine shales (maximum flooding surfaces). The Athabasca Upper Grand Rapids accounts for the majority (approximately 60 per cent) of the bitumen-bearing sand within this formation (**Table R3.3**). The Grand Rapids Formation is bounded above and below by the marine shales of the Joli Fou and Clearwater formations, respectively.

Athabasca Nisku Deposit

The 2011 year-end review of the Athabasca Nisku Formation, **Figure R3.10**, included an evaluation of 560 wells for stratigraphic tops and 130 wells for reservoir parameters. The AER, in its evaluation of the Nisku Formation, included bitumen from the Blueridge Formation. The Calmar Formation is a shale within this deposit. Information to date indicates that the Calmar Formation is a potential baffle. The study area covered Townships 75 to 96 within Range 18, West of the 4th Meridian, to Range 4, West of the 5th Meridian. The reassessment resulted in in-place bitumen resources being increased from $10\,330\,10^6\text{ m}^3$ to $16\,232\,10^6\text{ m}^3$. This represents a 57 per cent increase, which is attributed to an increase in well data and the expansion of the delineated resource area.

The Nisku Formation is a late-Devonian shelf carbonate. Early dolomitization and subsequent leaching of meteoric waters led to karsting and the creation of vugs and caves. The Nisku is a naturally fractured reservoir. Similar to the Grosmont Formation, the bitumen in the Nisku is contained in a triple porosity system within the vugs, the fractures, and the rock matrix. Hydrocarbons were probably trapped structurally along the updip erosional edge before degradation to bitumen.

Cold Lake Oil Sands Area

Sub-Cretaceous Unconformity

Figure R3.11 is a map of the reconstructed structure contours for the sub-Cretaceous unconformity in the northern part of the Cold Lake Oil Sands Area as they would have been at the beginning of deposition of the Mannville Clearwater Formation.

Cold Lake Wabiskaw-McMurray Deposit

For year-end 2005, the AER reassessed the northern portion of the Cold Lake Wabiskaw-McMurray deposit. Stratigraphic information and detailed petrophysical evaluations from almost 400 wells were used in this reassessment. **Figure R3.12** is the bitumen pay thickness map for the Cold Lake Wabiskaw-McMurray deposit based on cutoffs of 6 mass per cent and 1.5 m thickness. Although the Wabiskaw-McMurray contains some regionally mappable internal seals, and therefore several bitumen zones, this map was produced as a single bitumen zone to provide a regional overview of the distribution of the bitumen-saturated sands. A cutoff of 6 mass per cent bitumen was used.

Cold Lake Clearwater Deposit

For year-end 2005, the AER completed a reassessment of the Clearwater deposit. **Figure R3.13** is a bitumen pay thickness map for the Clearwater deposit based on cutoffs of 6 mass per cent and 1.5 m thickness. As the Clearwater does not contain regionally mappable internal shales or mudstones that can act as seals, the deposit is mapped as a single bitumen zone.

Cold Lake Upper and Lower Grand Rapids Deposits

A reassessment for year-end 2009 of the Upper and Lower Grand Rapids deposits included a review of some 12 000 wells for stratigraphic tops and net pay. The study area from Townships 52 to 66 replaced the area used in the previous assessment. Stratigraphy and net pay determination were completed for

each Grand Rapids zone: Colony, McLaren, Waseca, Sparky, General Petroleum (GP), Rex, and Lloydminster.

Although crude bitumen within both Grand Rapids deposits is pervasive throughout much of the Cold Lake Oil Sands Area, the developable resource (primary bitumen for the most part) is generally associated with Paleozoic highs. **Figure R3.14** and **Figure R3.15** are maps of the cumulative net pay isopachs for the Upper Grand Rapids deposit and the Lower Grand Rapids deposit respectively. The net pay interpretations and volumetric calculations were completed for each zone and were then summed for the relevant deposit. The Colony, Waseca, and McLaren are included in the Upper Grand Rapids, and the Sparky, GP, Rex, and Lloydminster are included in the Lower Grand Rapids.