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Global Expertise

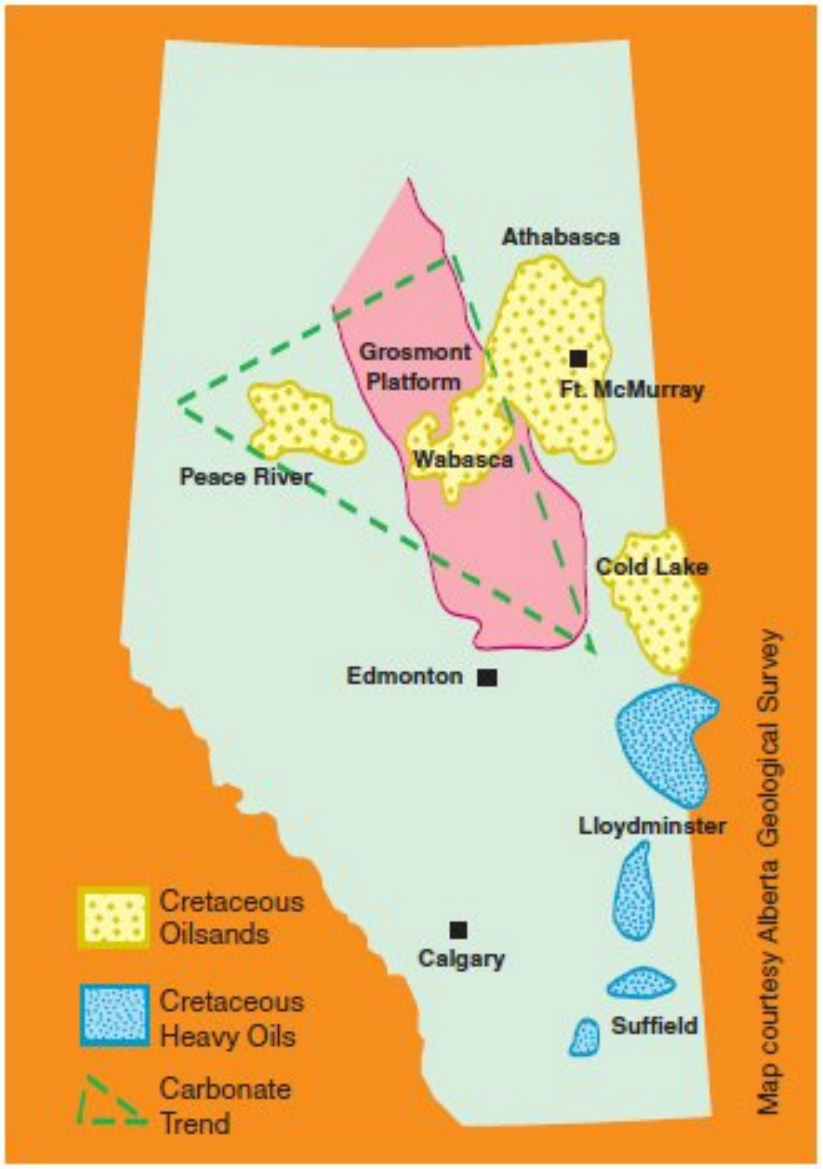
Carbonates vs Clastics

How the Differences Impact our SAGD Assessments

Caralyn Bennett, P. Eng.

July 6, 2011

Source:
Alberta Geological Survey


Athabasca
Grosmont Platform
Ft. McMurray
Wabasca
Peace River
Cold Lake
Edmonton
Lloydminster
Calgary
Suffield
Cretaceous Oilsands
Cretaceous Heavy Oils
Carbonate Trend
Map courtesy Alberta Geological Survey

Formations Prospective for Oil Sands

Carbonates	Clastics
Grosmont	
Leduc	McMurray-Wabiskaw
Cooking Lake	Clearwater
Nisku	Grand Rapids
Upper Ireton	

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Carbonates in Perspective

Alberta OBIP	1812 BBbls
Athabasca OBIP	1493 BBbls
Athabasca Insitu OBIP	1362 BBbls
Athabasca Insitu Clastics OBIP	890 BBbls
Athabasca Insitu Carbonates OBIP	472 BBbls

OBIP = Original Bitumen In Place

Source: ERCB 2010

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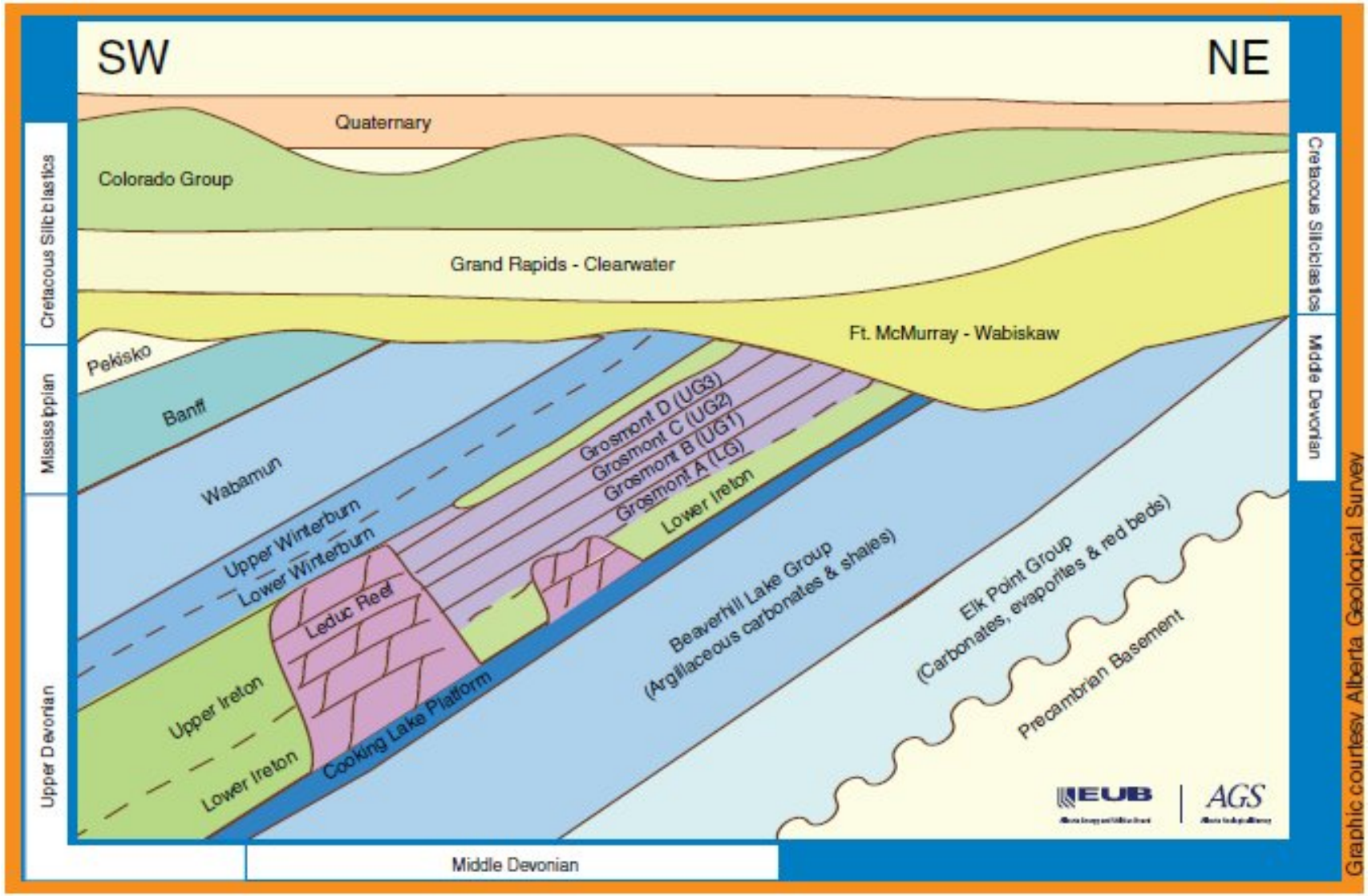
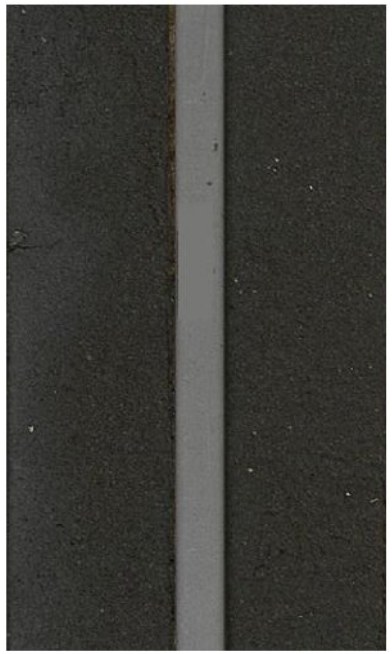
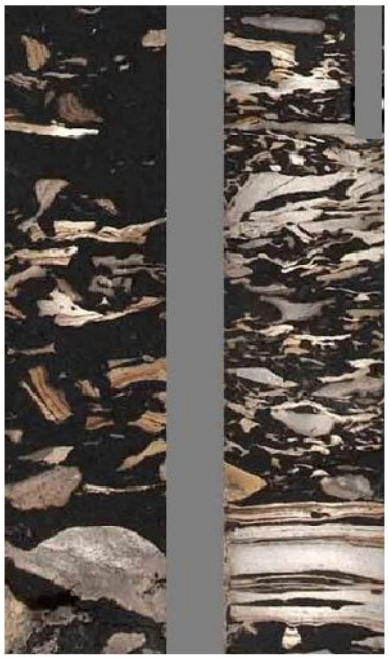

SW
NE
Quaternary
Colorado Group
Grand Rapids - Clearwater
Ft. McMurray - Wabiskaw
Cretacous Siliciclastics
Mississippian
Upper Devonian
Middle Devonian
Pekisko
Banff
Wabamun
Upper Winterburn
Lower Winterburn
Grosmont D (UG3)
Grosmont C (UG2)
Grosmont B (UG1)
Grosmont A (LG)
Lower Ireton
Leduc Reef
Upper Ireton
Lower Ireton
Cooking Lake Platform
Beaverhill Lake Group
(Argillaceous carbonates & shales)
Elk Point Group
(Carbonates, evaporites & red beds)
Precambrian Basement
EUB
AGS
Graphic courtesy Alberta Geological Survey

Clastics - Core Photos



clean sand

IHS



breccia

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Carbonates - Core Photos

vuggy & fracture

intercrystalline
dolo-fudge

laminated

Distinguishing Characteristics

Complex geological model and phi – k relationships : chemically formed via a series of processes

Deposits tend to be laterally continuous

Multiple porosity types : intercrystalline matrix, moldic-vuggy, fractures, solution breccia, interparticle

Fractures – bed-bound or larger scale regional stress induced fractures : rock is generally consolidated, competent and brittle

Distinguishing Characteristics

Heterogeneous on multiple scales : rock properties harder to determine and extrapolate, more uncertainty – less predictability

Higher permeability in certain regions or beds : barriers less likely

Lower porosity : range 14-24%, typically 18%

Higher average residual oil saturation (S_{or}) + greater uncertainty in estimates : range 25-35% best estimate, 15-20% high estimate

Distinguishing Characteristics

Deeper deposits, 5-9 degrees API and higher viscosity

Higher development costs – drilling and completions more challenging, deeper, steering through caverns, issues with lost circulation, cementing, coring and borehole instability

Maximum net pays >100 m in reefal build-ups - thicker

Impact of Lower Porosity

Porosity	14%	18%	22%	24%	30%	34%
OBIP (MSTB/wp)	1900	2443	2986	3257	4072	4614
RF	58%	58%	58%	58%	58%	58%
Recoverable (MSTB/wp)	1108	1425	1742	1900	2375	2692
Peak Rate (BOPD)	650	725	800	850	950	1000
CSOR	4.3	3.6	2.9	2.7	2.3	2.0

Carbonate porosity 14-24% vs sandstone porosity 30-34%
Carbonate has 30-55% less OBIP
Carbonate CSORs are 35-85% higher – more rock to heat

SAGD development with all else equal as follows :
pay 30m – well length 800m – spacing 100m – S_o 80% – k 4D – operating P 2000 kPa

Impact of Higher S_{or}

S_{or}	10%	15%	20%	25%	30%	35%
OBIP (MSTB/wp)	4343	4343	4343	4343	4343	4343
RF	58%	54%	50%	46%	42%	38%
Recoverable (MSTB/wp)	2533	2352	2171	1991	1810	1629
Peak Rate (BOPD)	975	950	900	875	825	775
CSOR	2.2	2.3	2.5	2.6	2.9	3.2

Carbonate S_{or} 15-35% vs sandstone S_{or} 10%
Carbonate has 20-35% less recoverable BE & 5-15% less recoverable HE
Carbonate CSORs are 20-45% BE & 5-15% higher HE – more heated bitumen left insitu

SAGD development with all else equal as follows :
pay 30m – well length 800m – spacing 100m – phi 32% – S_o 80% – k 4D – operating P 2000 kPa

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Impact of Higher k

k (D)	2	3	4	5	8	10
OBIP (MSTB/wp)	4343	4343	4343	4343	4343	4343
RF	58%	58%	58%	58%	58%	58%
Recoverable (MSTB/wp)	2533	2533	2533	2533	2533	2533
Peak Rate (BOPD)	700	850	975	1100	1375	1550
CSOR	2.3	2.2	2.1	2.1	2.1	2.0

Fractured carbonate k 5-10 D vs sandstone k 2-5 D
Higher perms increase peak rates 40-55%
CSORs are reduced due to faster extraction

SAGD development with all else equal as follows :
pay 30m – well length 800m – spacing 100m – phi 32% – S_o 80% – S_{or} 10% – k 4D – operating P 2000 kPa

Impact of Heterogeneity

Conformance Factor	60%	70%	80%	90%
OBIP (MSTB/wp)	4343	4343	4343	4343
RF	44%	51%	58%	66%
Recoverable (MSTB/wp)	1900	2217	2533	2850
Peak Rate (BOPD)	975	975	975	975
CSOR	2.0	2.1	2.1	2.2

Carbonate BE conformance factor 70% vs sandstone 80%
Recoverable reduced by 12% BE

SAGD development with all else equal as follows :
pay 30m – well length 800m – spacing 100m – phi 32% – S_o 80% – S_{or} 10% – operating P 2000 kPa

Other Economic Impacts

Core hole costs higher by 25% to >100%

500-1000M$ for carbonates vs < 500M$ for sandstones

Well-pair drilling and completion costs higher by 15-25%

4000-5500M$ for carbonates vs 3500-4500M$ for sandstones

Wellhead pricing 1-2% lower

Carbonates : blend 0.46 BBL condensate for 1 BBL bitumen

Sandstones : blend 0.43 BBL condensate for 1 BBL bitumen

Aggregate Impact

Thicker pay needed for economic viability

Carbonates	Clastics
14 to 21 m	9 to 12 m

Compensate for
lower porosity, higher S_{or}, greater heterogeneity, higher costs and lower wellhead price

What About Categorization?

No commercial carbonate projects operating in Canada

Recoverable volumes are presently assessed by GLJ as
Contingent Resources – *Technology Under Development*

"Contingent Resources are those quantities of petroleum estimated, as of a given date, to be potentially recoverable from known accumulations using established technology or technology under development, but which are not currently considered to be commercially recoverable due to one or more contingencies."

"Reserves are estimated remaining quantities of oil and natural gas and related substances anticipated to be economically recoverable from discovered resources, from a given date forward, based on analysis of drilling, geological, geophysical, and engineering data; the use of established technology; and specified economic conditions, which are generally accepted as being reasonable"

Established Technology

Methods proven successful in commercial applications

which means

repeated success
technically
economically

or

A successful pilot in the subject reservoir

Technology Under Development

Technology developed and verified by testing as feasible for future commercial applications to the subject reservoir

which GLJ interprets as

Technology developed in other reservoirs
Testing = field & lab work plus simulation &/or pilot
Expectations adjusted for reservoir differences

ASC staff notice 51-327 differs from this interpretation
COGEH and PRMS are issuing clarifying documents

Current Operational Pilots

Laricina/OSUM Saleski SAGD 1800 BOPD Pilot

The 1st operational SAGD carbonate project

Designed to assess start-up strategy, conformance, thermal response, liner design and pump performance in Grosmont C & D

Injection begin December 23 2010

First trucking of sales oil occurred May 2011

Part 2 : assess a solvent cyclic-SAGD process

Current Operational Pilots

Sunshine Harper Vertical Steam Injection Pilot Q1 2011

Designed to assess bitumen mobility and reservoir response to steam in the Grosmont C

Two weeks steam injection at approximately 1500 BSPD, 2-3 MPa wellhead pressure in Jan – Feb 2011

Following a 2 day soak, the well produced approximately 440-535 BFPD with 1-3% oil cut

Maximum oil rate of approximately 65 BOPD was briefly achieved

Current Experimental Tests

AOSC Dover West Devonian Deviated Steam Injection Test Q1 2011

Designed to assess injectivity including conformance in the presence of fractures in the Leduc and Cooking Lake

Encouraging results with the demonstration of

- High steam injection rates
- Uniform injection along the length of the well, and
- Pressure buildup providing an indication of steam containment

Current Experimental Tests

AOSC Dover West Devonian TAGD Test Q2 2011 began 10 weeks ago in April 2011

Designed to acquire field data for calibrating in-house modeling of the TAGD process to better assess heat balance, drainage rates and recovery factors in the Leduc & Cooking Lake reservoirs

TAGD or thermal assisted gravity drainage uses conduction heating to warm the reservoir

200m electrical heaters have been run into two horizontal wells : 1 heater well is located 10m above a second heater-producer

Following 6-12 months of heating, the lower well will be produced

Carbonates : Closer to Commerciality?

Given the lack of commercial carbonate projects, successful pilots (SAGD, CSS, solvent-cyclic SAGD, electric heating) are required for specific project reserves bookings.

How long does it take to determine if a pilot is successful? Demonstration of production is required. Reserves bookings will be risked early on pending ongoing response and verification of performance.

What is the timing of generic carbonate commerciality? The Laricina/OSUM Saleski project is the only current application for a commercial project (12,500 BOPD) with first production expected in 2014. Given the unique attributes of carbonates, numerous technologies are being considered and tested. Repeated commercial success of any one specific technology looks years away.

Caralyn P. Bennett, P.Eng.

Insitu Bitumen Recovery Projects

cbennett@gljpc.com

403 266 9552