Opportunities and Challenges in Accessing Stranded Pay and Heterogenous Reservoirs in SAGD Bitumen Projects

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Summary

Currently uneconomic oil-sands deposits found near the edges of existing SAGD pads, stranded pay above or below producing intervals, and within heterogeneous oil-sands zones could provide future opportunities for operators to grow the reserve base for their projects. In many cases this would be dependent on the development of new technologies. Reservoir heterogeneity and variable reservoir quality associated with inclined heterolithic stratification (IHS) commonly limit production growth for SAGD operations in the McMurray Formation. The most challenging reservoirs are characterized by mud-dominated IHS, which has a strong negative impact on performance, especially where muds create laterally extensive vertical permeability barriers between the injector and producer. New technologies to pre-condition and enhance vertical permeability within IHS-dominated reservoirs may be the next breakthrough needed to enhance *in-situ* oil-sands production.

Recognizing that new technologies need time to test and implement other proven advances in SAGD operations can be considered for enhancing production for variable quality reservoirs. Non-condensable gas (NCG) or methane co-injection takes advantage of gas-push to assist in recovering conductively heated bitumen intervals not in direct contact with the steam chamber. Results indicate that bitumen production can be maintained while reducing steam injection rates and associated cumulative steam-oil ratio. This process takes advantage of both convective and conductive heating in oil-sands reservoirs with heterogeneity above the injector well but having a relatively high permeability interval at the base which enables efficient communication between injector and producer wells.

Challenges

The presence of IHS commonly creates heterogeneity that can result in large variations in steam-chamber height along the well pair, inconsistent sub-cool conditions, variable production performance, and in some instances, flashing steam to the producer resulting in liner damage.

A critical consideration is the presence (or absence) of a relatively high permeability reservoir interval providing communication between injector and producer wells at a similar elevation over the majority of the length of the well pair. High permeability intervals are characterized by cross-bedded sands and/or structureless beds, although sand-dominated IHS can also be considered for some oil-sands reservoirs. Where IHS-dominated intervals are encountered at the base of the reservoir, SAGD operations can result in failure, especially where mud-dominated IHS is encountered. The presence of mud-dominated IHS can create a laterally extensive permeability barrier between the injector and producer wells preventing communication and/or creating large pressure differentials.

Efficient production in SAGD follows a codependent cycle of displacement of bitumen to the underlying producer, allowing continued steam injection; and the development of a “steam in” and “bitumen out” process. An example, for discussion purposes, is the well pair EO305 from the Foster Creek Project, illustrating, comparing and contrasting poor communication to good communication over the first half and second half of the well pair, respectively (Figs. 1 to 3).

A conformable steam chamber and its associated production can be developed along the well pair with good communication. Poor vertical permeability and prominence of mud-dominated IHS beds illustrated by observation well C4-18, prevents communication and associated steam chamber growth, impacting production using SAGD from heel to mid-way point of this well pair (Fig. 4).

Opportunities

Opportunities to increase recovery and reduce steam-oil-ratio (SOR) for oil-sands reservoirs amenable to SAGD include non-condensable gas co-injection. Experiences from MEG Energy's Christina Lake operations provide optimism for enhancing production from reservoirs with significant heterogeneity above the injector level. SAGD production commenced in well pairs A1, A2 and A3 in March 2008 and modified to include NCG injection in December, 2011.

Bitumen production from the A1, A2, A3 and infill wells (Figs. 5, 6 and 7) increased by March 2012, co-incident with NCG injection and reduced steam injection rates. Cumulative SOR decreased, in part, due to production of conductively heated bitumen. MEG provides documentation in the 2012 ERCB report, showing an instantaneous SOR reduction from 2.7 to 1.3, while increasing production from 400 m^3 to 500 m^3 in the pilot area.

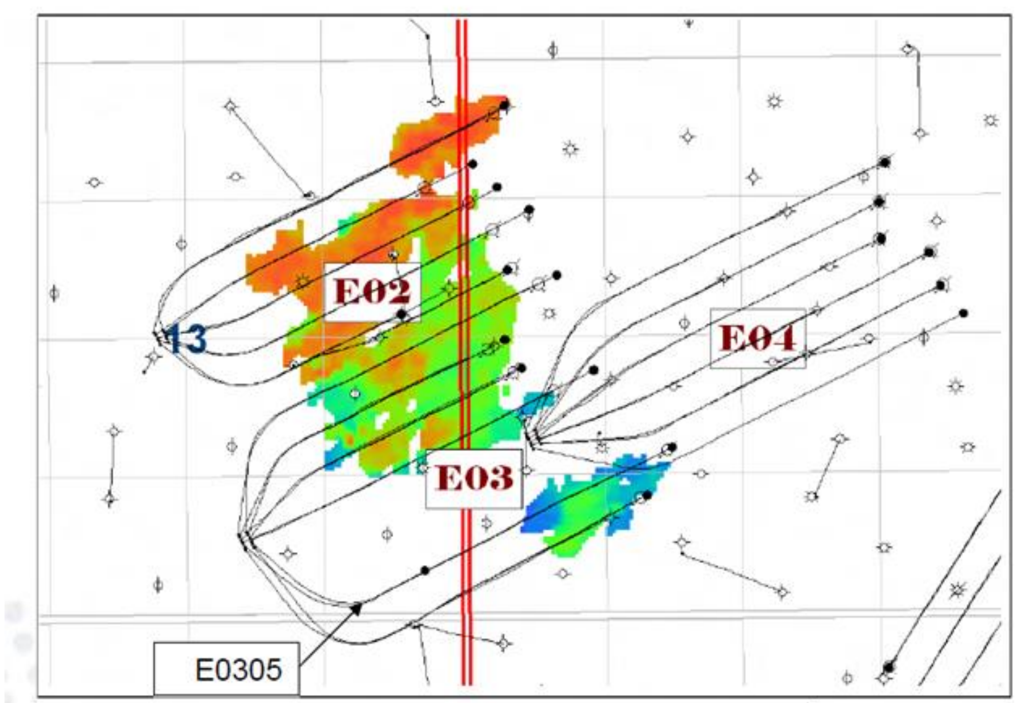

Figure 1: Cenovus Foster Creek well pair EO305, time-lapse seismic interpretation. No steam chamber development is achieved due to poor communication between injector and producer wells along the first half of the well pair. Source: Cenovus 2011 Report to the ERCB.

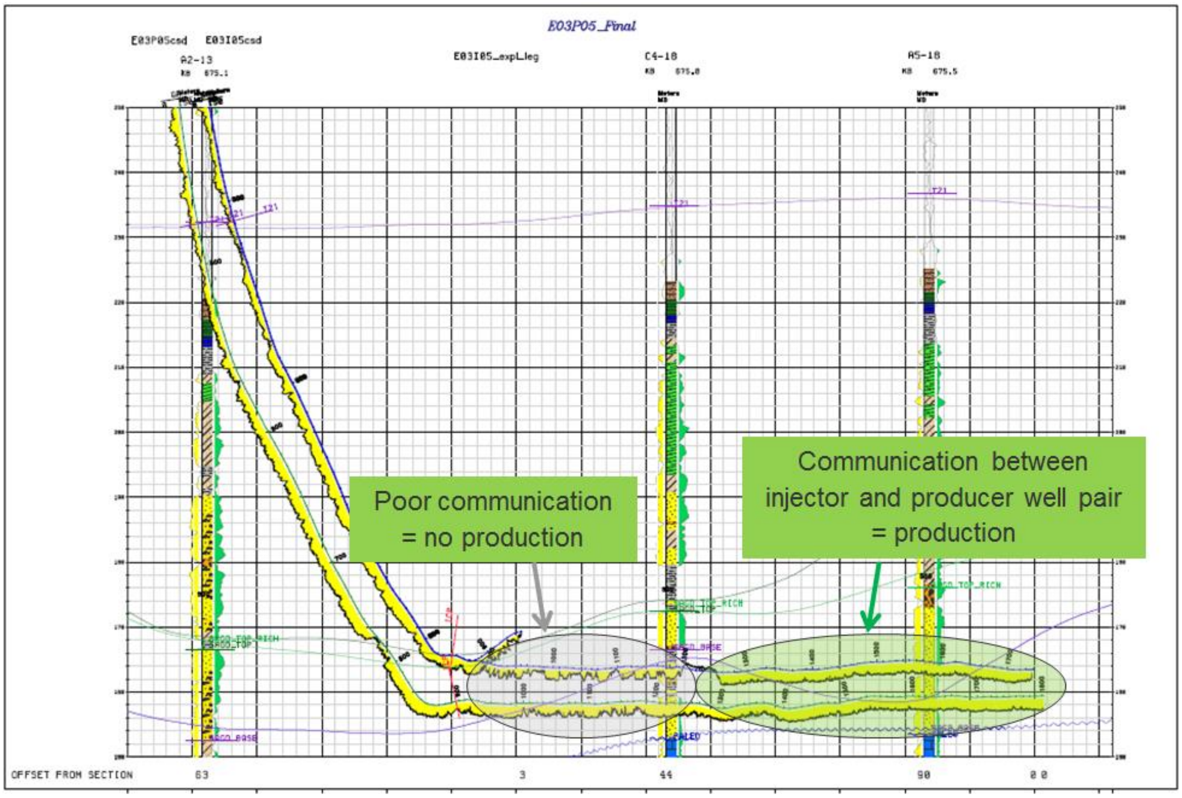

Figure 2**:** Cenovus Foster Creek well pair EO305, illustrating reservoir quality variation along the injector and producer horizontal wells, and associated vertical observation wells. Poor communication in the first half of this well is caused by IHS between the injector and producer wells. Modified after the Cenovus 2011 Report to the ERCB.

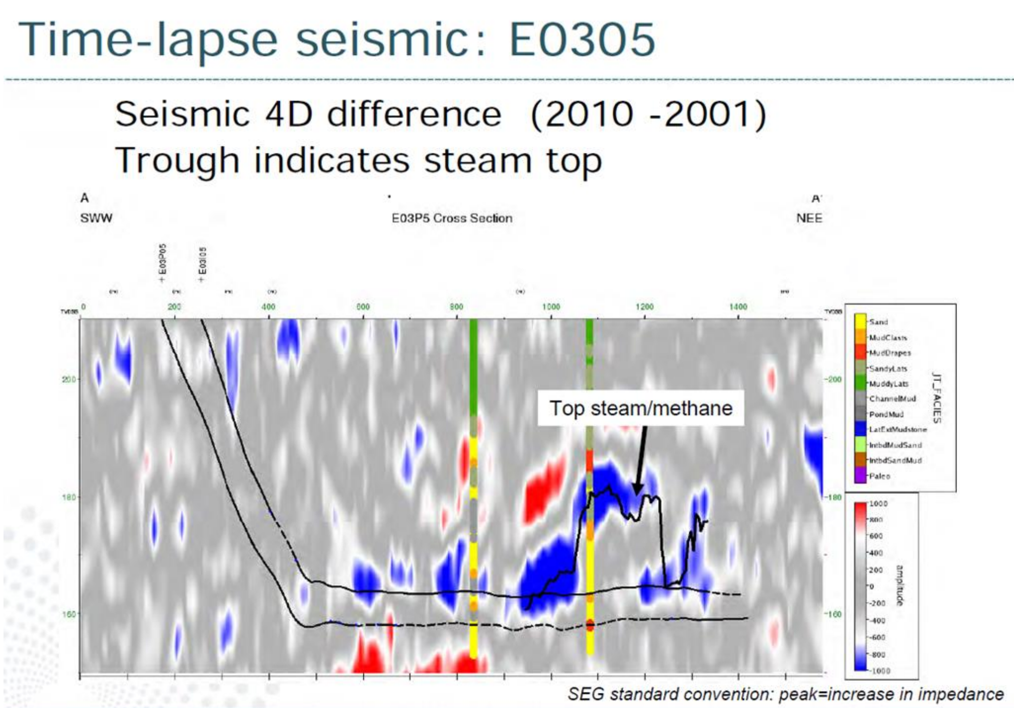

Figure 3: Cenovus Foster Creek well pair EO305, time-lapse seismic illustrating steam chamber development restricted to the toe of this well pair. Source: Cenovus 2011 Report to the ERCB.

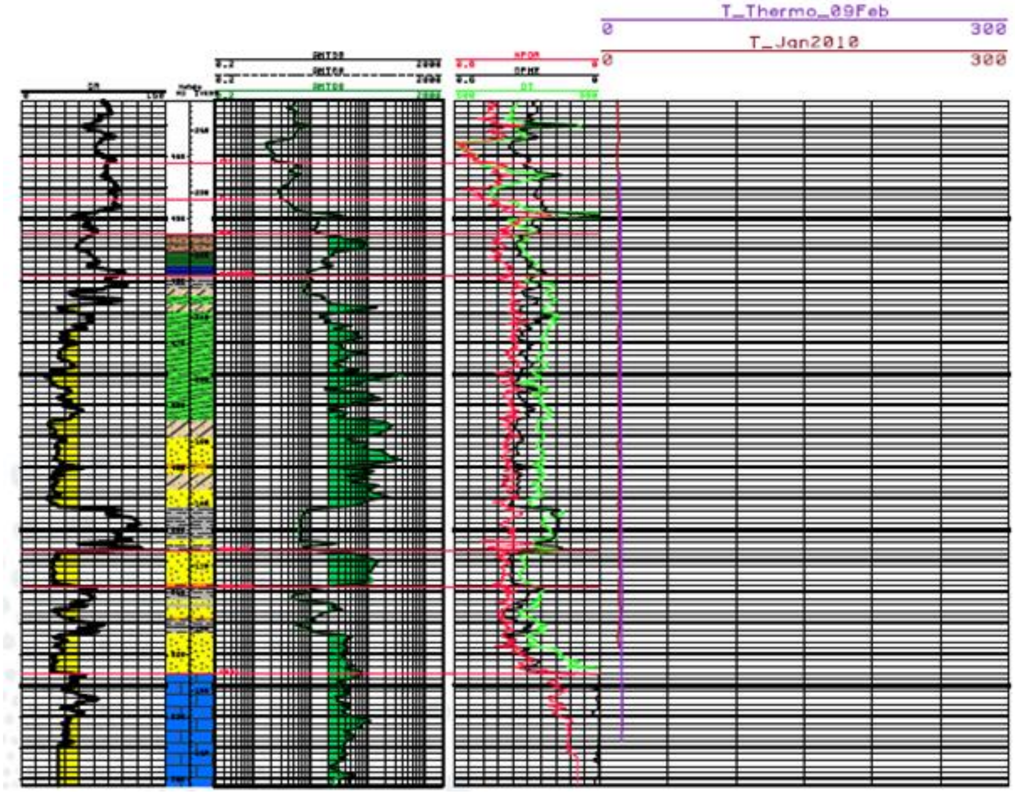

Figure 4: Cenovus Foster Creek observation well C4-18 along the heal portion of well pair EO305. Vertical permeability barriers between injector and producer wells prevent steam chamber development and associated production. Source: Cenovus 2011 Report to the ERCB.

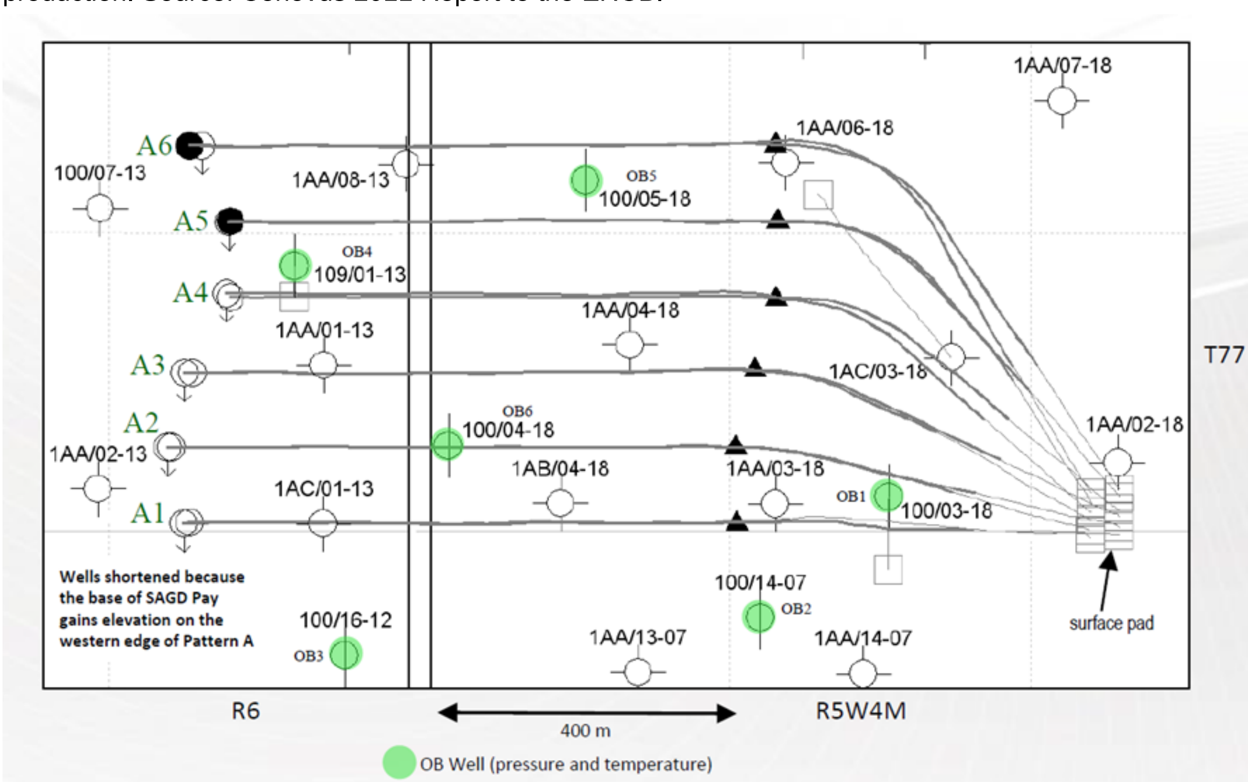

Figure 5: MEG SAGD wells A1, A2 and A3 used to pilot NCG. Source: MEG 2011 ERCB Report.

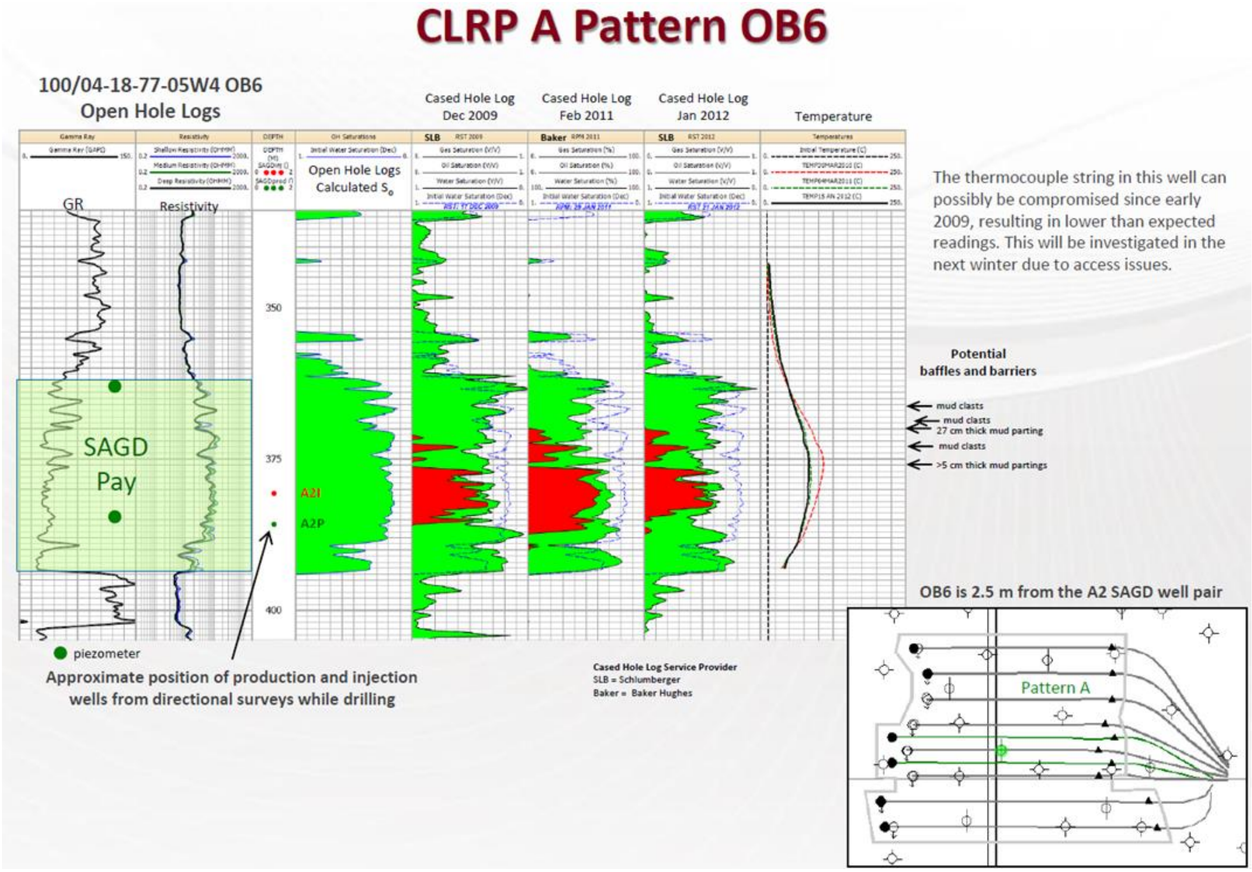

Figure 6: Observation well 100/04-18 illustrating RST logging results and associated production using NCG to optimize oil production and reduce cumulative SOR. Source: MEG 2012 ERCB Report.

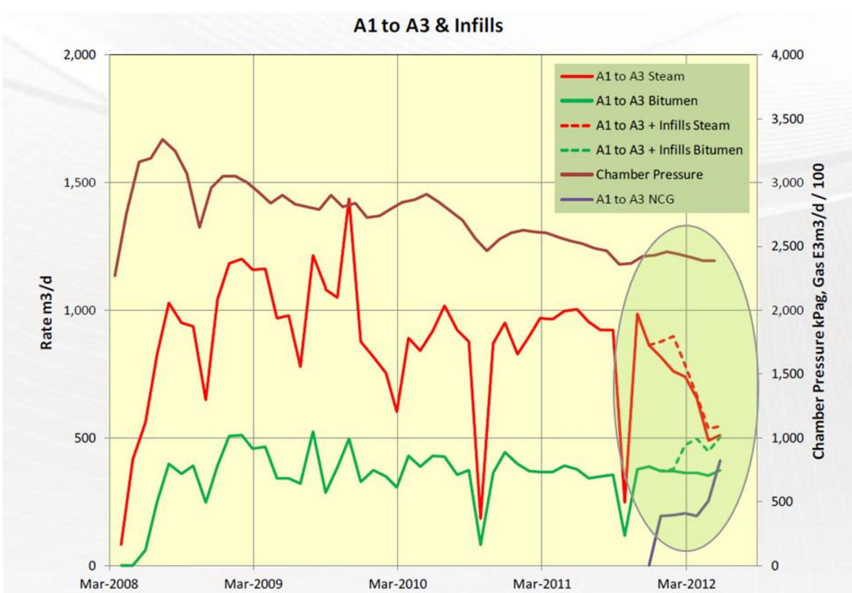

Figure 7: Production profiles of the A1 to A3 well pairs, and infill wells. Green highlighted circle illustrates how production is increased due to NCG injection while steam injection rates are reduced. Modified from MEG 2012 ERCB Report.

Conclusions

Opportunities for adding significant production by all operators include recovery in IHS-dominated oil-sands resources. Mud-dominated IHS is particularly problematic due to the impact of creating vertical permeability barriers between the injector and producer wells. In reservoirs amenable to current technology for SAGD, production can be further enhanced utilizing co-injection of gas to combine convective and conductive heating, reducing cumulative SOR.

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References

Cenovus 2011 Report to the ERCB, MEG 2011 ERCB Report, MEG 2012 ERCB Report

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