CO_2 Sequestration Options in the SAGD Operational Areas

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Summary

The enormous size of the potential in-situ development area in the Athabasca and Cold Lake regions brings with it concerns over significant emissions of CO_2. There are a number of proposals to transport the CO_2 to other areas of traditional oil and gas production for enhanced recovery, and these may initially be the most attractive sequestration schemes due to economic payback from incremental hydrocarbon recovery. However, production of CO_2 from oil sands development will no doubt far exceed the demand needed for EOR.

There are significant sites within the oil sands SAGD project areas which should be given consideration as sequestration targets for large volumes of CO_2. Sequestration potential has been proposed for conventional structural and stratigraphic traps, coal beds, and hydrodynamic trapping in deep saline carbonate aquifers. We suggest that shallow, lower salinity, low temperature, sand aquifers may also be suitable because of their immense volumes and well-known distribution and hydrodynamic properties provided by abundant well penetration and DST information. Furthermore, porosity and permeability of the shallow sand aquifers are reasonably well-known and predictable, due to minimal diagenetic cementation and a relative abundance of physical measurements from core. Deeper Paleozoic targets have much fewer drill penetrations. For example: of over 58,000 wells drilled in the study area, only 184 have penetrated the Middle Devonian Elk Point Group. Suitable sequestration targets in the deep saline Paleozoic strata will therefore require an extensive exploration program compared to the shallower Lower Cretaceous sands.

The Upper Mannville aquifers (Grand Rapids and Clearwater sands) have significant and widespread intervals of thick 100% water-saturated sands as well as a large number of depleted and partially depleted gas pools. The Lower Mannville aquifers (primarily McMurray) have a large number of depleted and shut-in gas pools overlying the oil sands. The Lower Mannville shut–in gas zones are subject to the Gas-over-Bitumen restrictions. We have mapped the area of TWP 60-104 and RNG 1-20W4, specifically investigating the reservoir characteristics and sequestration potential of the Upper Mannville (and possibly deeper Palaeozoic) zones. Using commercially available data from drill stem tests, we have mapped the regional trends in salinity, bottom-hole temperature and shut-in pressures, as well as cumulative gas production from Upper Mannville pools. CO_2 sequestration in Mannville sands would be restricted to dissolution in formation fluids (solubility

trapping). In-situ formation pressures and temperatures in these reservoirs preclude liquid miscible phase hydrodynamic trapping or buoyant supercritical trapping.

Sequestration of Mannville CO_2-charged formation waters would not necessarily require a structural or stratigraphic trap, provided the gas in solution remains below saturation point. Residence time in shallower aquifers therefore becomes the main concern for shallow, topography-driven, formation fluid flow. Published formation fluid flow rates range within centimetres per year, implying that movement of formation waters would take at least 10^4 to 10^6 years to reach the outcrop/subcrop discharge areas to the north and northeast.