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Athabasca region shallow CO_2 gas hydrate storage potential: identifying the key uncertainties for storage capacity

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Abstract

CO_2 gas hydrate storage (GHS) provides potentially large, efficient, secure, and local CO_2 storage opportunity for Athabasca oil sands and in situ producers, in both shallow Athabasca gas pools and regional aquifers, sometimes in geographic association. The analysis of gas pool storage pore space volume indicates 18 are currently in the CO_2 gas hydrate stability zone (GHSZ). An additional 38 gas pools are potential GHS reservoirs at increased pressure. Gas pool storage capacity depends critically on achievable gas hydrate saturation (Sgh), which is poorly constrained to be 15%-90%. Average CO_2 storage capacity is three times the initial natural gas in-place (IGIP) volume at 15% Sgh, but the average efficiency increases to eleven-fold IGIP if Sgh is 54%. Depending on Sgh the total gas pool CO_2 GHS capacity in 56 candidate gas pools is 79-472 Mt CO_2 (284 Mt at 54% Sgh). The 10-15 largest gas pools contain 81% to 91% of the total storage capacity. There are 3-11 gas pools with individual GHS capacities >10 Mt CO_2 if Sgh is 15%-90%. Gas pool average net pay in the 56 candidate pools is 4.1 m, but the CO_2 GHSZ commonly extends up to 300 m deeper than the gas-water interface. This associated water-leg GHS potential may increase candidate gas pool storage volumes significantly, but it is uncharacterized so that Athabasca gas pool GHS capacity is described conservatively. Gas pool GHS estimates are also conservative because the discovered, largely Mannville Group gas pools are a subset of the total potential gas pool storage. An assessment of Athabasca Mannville natural gas resources inferred that 53% of the probably Mannville natural gas resource is discovered, making it likely that additional gas pool storage opportunities could be discovered. Despite their potentially large cumulative storage potential the undiscovered gas pools are inferred generally smaller than the largest pools discovered. Much additional CO_2 GHS potential, perhaps as much as ~61 Gt CO_2, occurs in regional aquifers. However, the aquifer storage volume is less well characterized because temperature data outside gas pools are less reliable, the methods employed to describe aquifer CO_2 GHSZ is approximate, and because the regional pore space volume is less well characterized, while the achievable Sgh is similarly uncertain. We infer that 10-11% or 6-7 Gt of aquifer GHS is a more realistic regional aquifer storage estimate. Even so discounted, the majority of Athabasca GHS occurs in regional aquifers rather than gas pools. The proximity of GHS to oil sands and bitumen operations reduces transportation costs, while the efficiency and security of solid sequestration increases GHS repository performance and safety. Together these considerations make GHS an important option for future oil sands and bitumen carbon management. The immediate focus of future work should be uncertainty reduction with emphasis on the 10-15 largest candidate gas pools and their environs. The greatest uncertainties to be resolved are, achievable Sgh and the potential augmentation of gas pool storage in associated water legs. Yet another potential uncertainty is improved temperature data from high precision temperature loggers, especially where temperatures are near the limits of the GHSZ.