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Measurement of Helium Diffusion in Lotsberg Salt Cores: As a Proxy to Evaluate Hydrogen Diffusion

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Abstract

Hydrogen is a critical part of the energy transition and salt caverns are ideal for underground hydrogen storage due to their inert properties. While hydrogen has been stored successfully in salt for many years, caution must be exercised when selecting caverns for storage to ensure safe operation. This study evaluated the relationship between mineral impurities and crystal size on helium diffusion into core samples from the Lotsberg Formation.

Salt-rock cores with varying mineralogy and crystal size from the Lotsberg Formation, Alberta, Canada, were tested to investigate the effects of rock heterogeneity on helium diffusion. First, diffusion tests were conducted using a custom-designed HPHT visualization cell at in-situ pressure conditions. The decline rate of pressure was measured and compared for core samples with different composition and crystal size. Second, we used a CT scan machine to visualize and characterize the salt-crystal shape and size of the tested cores, and to evaluate crystal boundaries and existence of possible fractures. The results of helium diffusion tests showed that the visual cell pressure decreases slowly with time for most of the samples, suggesting helium diffusion in the salt cores. For the salt core sample composed of pure halite without any visible crystal boundaries, the pressure decline is negligible, indicating negligible helium diffusion into pure halite crystals. For salt-rock cores with crystal boundaries, it is observed that the pressure declines faster for the plugs with smaller crystal size. This can be explained by preferential diffusion of helium through the crystal boundaries. Similarly, helium diffuses faster through marlstone cores with fractures. In summary, samples with higher amounts of mineral impurities and samples with more crystal boundaries experienced higher helium diffusion compared with samples with less impurities or crystal boundaries.

Key words: Hydrogen storage in salt caverns, Helium diffusion, Mineral composition, Salt crystal size.