

Petrophysical Evaluation of Lotsberg Salt Formation for Evaluating Cavern Containment for Hydrogen Storage

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Abstract

Salt caverns have been used to store natural gas and hydrocarbon materials for several decades. However, there is a need for systematic laboratory experiments to assess and optimize hydrogen storage in salt caverns. Unlike methane and CO₂, small and reactive hydrogen molecules may diffuse into the salt-rock matrix and react with rock minerals and brine. The purpose of this study is to characterize salt-rock heterogeneity in terms of mineralogy, crystal size, and pore morphology for future hydrogen leakage and reaction experiments.

We tested salt and marlstone cores from three different wells in the Lotsberg Formation, representing different depth intervals of existing and future caverns. We conducted a pore-scale investigation by interpreting x-ray diffraction (XRD) data, and thin-section and scanning electron microscopy/energy dispersive X-ray spectrometry (SEM/EDS) images. The objectives were to 1) determine the mineralogy, 2) characterize the crystal shape and size, and 3) investigate the crystal boundaries. Samples from the Lotsberg salt are primarily composed of halite, with variable amounts of red-brown impurities dispersed through the halite crystals, which are identified as carbonates (dolomite/calcite/nahcolite) and clays. Samples from the Lotsberg marlstone are identified by a distinct red color and are mainly composed of carbonates and dispersed halite crystals. Iron-bearing dolomite can explain the red color of marlstone samples. Generally, the total crystal interface area is inversely proportional to the average crystal size. For intact and pure halite samples without visible crystal interfaces, micro-scale halite crystal boundaries can be observed at high magnification, which may provide possible pathways for fluid percolation. Compared to samples from the salt units, the marlstone samples with dispersed halite crystals have higher intercrystalline porosity, and thus a more connected pore network for fluid percolation.

Key words: Hydrogen Storage in Salt Caverns; Hydrogen Leakage; Salt-Rock Heterogeneity; Mineralogy.