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Lotsberg Halite Formation: lithological and geochemical constraints for a prime H2 cavern target in Alberta, Canada

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The Lotsberg Formation is the most favored target for solution-mined caverns in WCSB. Repurposing the cavern-making technology for hydrogen storage must consider higher reactivity of H_2, including its known dissolving effect on sulfate minerals and intense production of H_2S through bacterial sulfate reduction. This talk presents new core observations, geochemical and mineralogical data made on a continuous core through the Lotsberg Formation and overlying red beds in PMC 140 FT SASK 7-23-55-22 well. High content of anhydrite nodules and partings in these red beds should be considered in H_2 purposed cavern design. Reactivity of H_2 with carbonates above and within the Lotsberg halite succession should also be considered. This work also advances understanding of the depositional history. The "middle red beds" (1894.0-1899.45 m in test well) represents a solution-collapse breccia, thus indicating an intraformational unconformity and an episode of meteoric salt removal prior to deposition of the upper Lotsberg halite.

Summary

Due to its thick (up to ~170 m near Cold Lake, AB) intervals of clean homogeneous halite, the Lotsberg Formation is the most favored target for solution-mined caverns in Alberta used for LPG, LNG storage and industrial waste disposal since 1970s (Hauck, 2020). Repurposing the cavern-making technology for H_2 storage must consider higher reactivity of H_2, including its known dissolving effect on sulfate minerals and intense production of H_2S through bacterial sulfate reduction. Kabanov et al. (in review) present new core observations, geochemical and mineralogical data made on a continuous core through the Lotsberg Formation and overlying red beds of the Ernestina Lake Formation in PMC 140 FT SASK 7-23-55-22 well. Our results elucidate high content of anhydrite nodules and partings in these red beds (Figs. 1 and 2), whereas the thick (42.9 m in our test well), exceptionally clean and homogeneous upper Lotsberg halite contains anhydrite only in trace amounts as detected with whole-rock XRD (Fig. 2). If the cavern roof is made close to the overlying anhydritic dolostone, escape of H_2 into caprock may cause rapid dissolution of anhydrites leading to roof collapse, also accumulation of H_2S through bacterial sulfate reduction. This warrants further R&D for preservation of a sufficiently thick, undamaged salt roof during cavern making, which is a challenge (Piotr Kukiałka, pers. comm). Reactivity of H_2 with carbonates in the caprock should also be considered, although available experimental data suggest only minor corrosive effect on limestone and dolostone with by-production of methane. Anhydrite nodules also occur in the basal one-third of the Lotsberg Formation, the interval containing more non-halite impurities than the upper Lotsberg (Figs. 1 and 2). In this basal part of the section, anhydrites do not seem to represent the same concern as they will be exposed to cavern-floor sump and cushion gas, whereas H_2 reservoir can be operated within the limits of the upper Lotsberg halite. Results of this work shed light on the composition of non-halite interbeds within the Lotsberg Formation, as well as the basal red beds underneath. Non-halites within the Lotsberg Formation represent silty and argillaceous, microcrystalline (≤50μm) dolostones (dolomarls). A dolomarl-dominated interval at 1894.0-1899.45 m, traced as the middle red beds, represents a solution-collapse

breccia, thus indicating an intraformational unconformity and an episode of meteoric salt removal prior to deposition of the upper Lotsberg halite.

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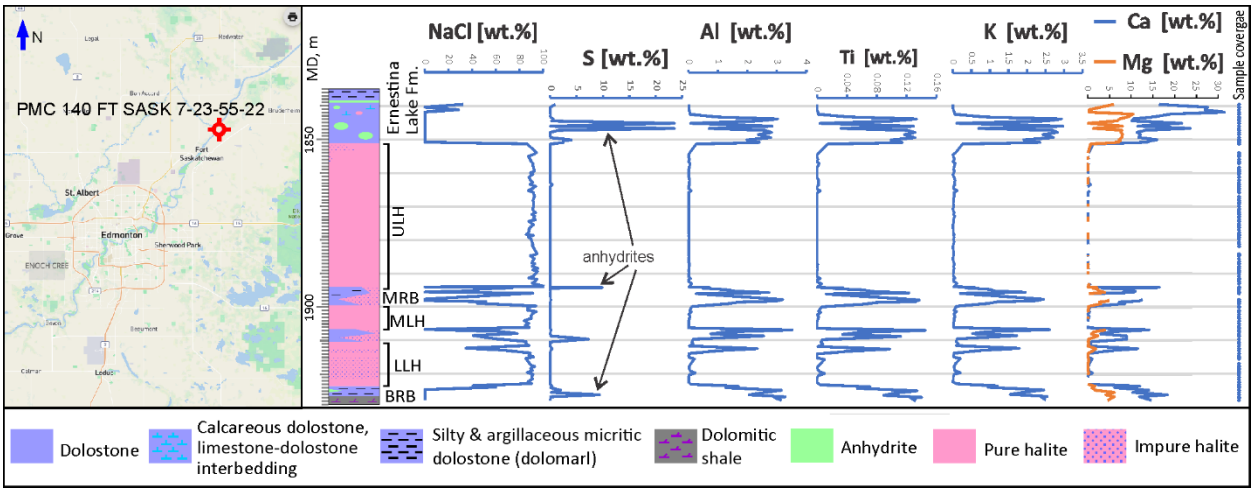

Figure 1. Stratigraphic distribution of major elements through the Lotsberg and Ernestina Lake formations in the test core. NaCl is calculated based on near-total residence of Na in halite. UHL = upper Lotsberg halite; MHL = middle Lotsberg halite; LLH = lower Lotsberg halite; MRB = middle red beds; BRB = basal red beds. Modified from Kabanov et al. (in review).

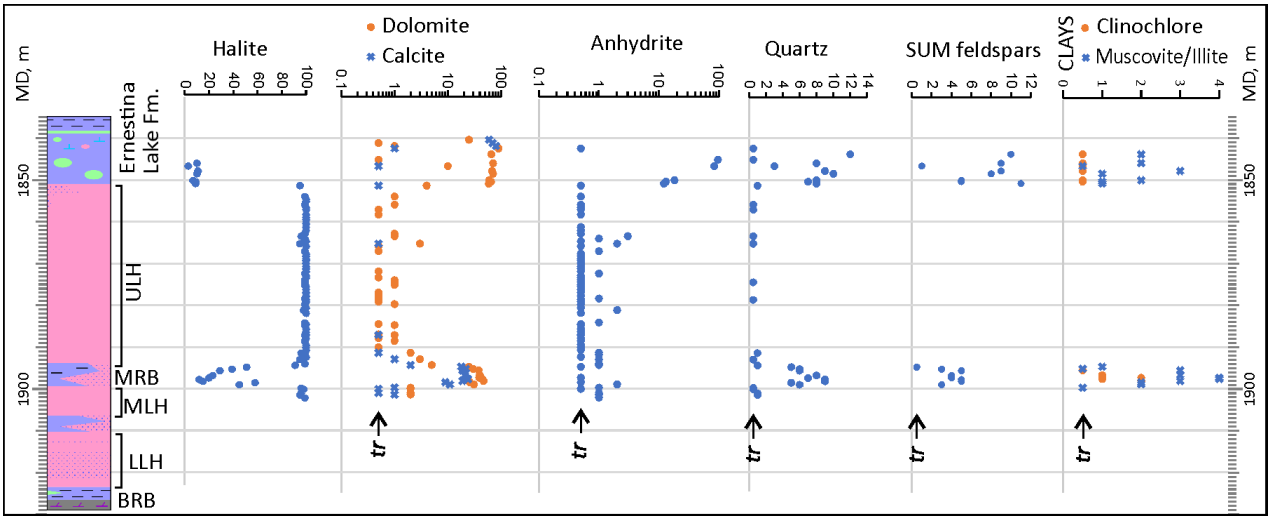

Figure 2. Stratigraphic variations of XRD mineral composition (wt.%) in the upper Lotsberg halite, its caprock and middle red beds. Arrows point at unquantified trace amounts (tr). SUM feldspars: K-feldspar + plagioclase. Carbonates and anhydrite on $\log_{10}$ scale. From Kabanov et al. (in review).

References

Hauck, T.E. 2020. The Elk Point Group of Alberta: insights into paleogeography, evaporite karstification, and salt cavern potential based on net-evaporite mapping; Alberta Energy Regulator / Alberta Geological Survey, AER/AGS Report 99, 60 p.

Kabanov, P.B. et al. (in review) Lotsberg Halite Formation: lithological and geochemical constraints for a prime H_2 cavern target in Alberta, Canada. *Bulletin of Canadian Energy Geoscience*