Physical and Chemical Characteristics of Salts Recovered from an Active CO2 Injection Well

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Summary

Downhole images from the injection well at the SaskPower's Boundary Dam Integrated Carbon Capture and Storage (CCS) Demonstration project reveal that scales of simple salts have formed on the inside of a CO2 injection well (Movahedzadeh et al. 2021; Talman et al. 2020). These deposits are typically localized at and directly below many perforations and have been interpreted as having been formed by highly saline water leaking back into the dry-CO2 filled injector. As such, their appearance will be associated with zones of high water saturation, and hence relatively low injectivity.

Theory / Method / Workflow

Samples of formation water were recovered during drilling of the injection well. Its salinity is close to 330,000 ppm, with Cl contributing over 99% of the anionic charge. The cations were present with Na>Ca>>K>Mg. Precipitation to near dryness of a litre of formation water will lead to the formation of some 220 g of halite, 120 g of sinjarite ($CaCl_2 \cdot 2H_2O$), 15 g of bischofite ($MgCl_2 \cdot 6H_2O$) and 10 g of sylvite. Mineral stability calculations undertaken using the THEREDA Pitzer-type thermodynamic data base to define ionic activities indicate that the formation water is at, or nearly in, equilibrium with halite and anhydrite at bottom-hole conditions. Sylvite and other chlorides are significantly under-saturated. Consequently, only minor evaporation of water leaking back into the injection well will induce halite precipitation (as well as very minor volumes of anhydrite and likely calcite). Continued evaporation will eventually lead to sylvite, sinjarite and bischofite formation, although not before most of the water has been lost. In the event of a further introduction of formation water back into these precipitates, the under-saturated minerals (sylvite, sinjarite and bischofite) will re-dissolve liberating Cl-, inducing halite precipitation, as well as mobilizing K, Mg, and Ca ions which will eventually precipitate further from the source.

Aside from the borehole images, some few samples of the precipitates were recovered during subsequent work on the well. These were imaged with SEM and EDAX.

Results, Observations, Conclusions

Four zones of the injection well were perforated. Perforations in the upper two zones were generally free, or only moderately impacted by the salts (Figure 1a), but massive bodies (Figure 1b) developed in the third zone (Talman et al., 2020). These deposits continued through much of the fourth perforated zone.

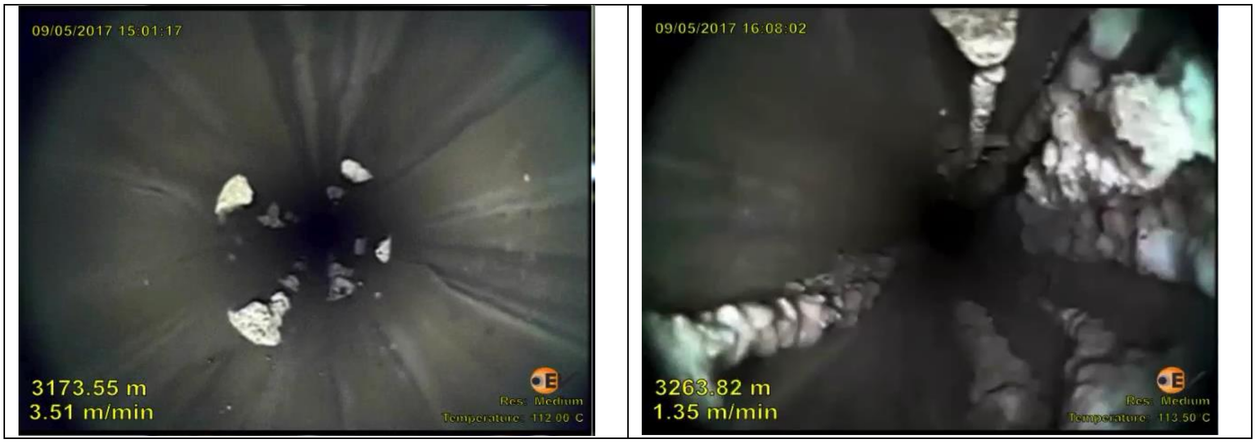

Figure 1. Images of the interior of the injection well in the (a) upper, less affected zones (right) and (b) a deeper section which is heavily impacted zone by the precipitates.

The recovered samples consisted of one hollow, tube-like piece, one cm sized more regularly shaped piece, and several smaller blocky grains. The samples tended to be very porous, and with well defined, planar, outer surfaces (Figure 2a). The pores tended to be irregularly shaped, although typically the surfaces were smooth. Halite was by far the most dominant phase present, although sylvite, calcite and minor amounts of a CaCl2 rich phase were also detected. Figure 2b shows a small grain of sylvite within a halite matrix.

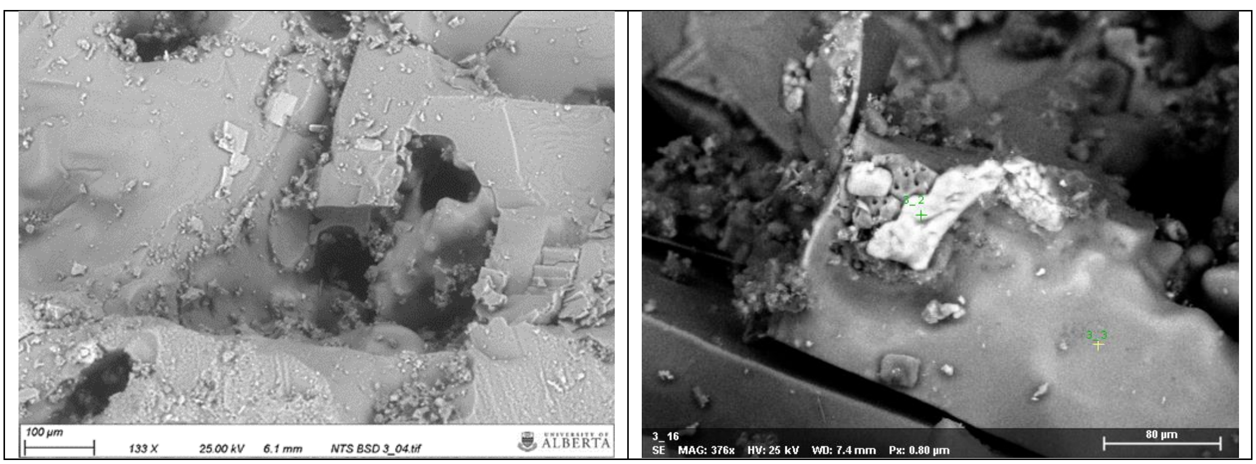

Figure 2. SEM images of (a) a NaCl dominated grain (left) showing a relatively flat outer boundary and extensive smooth pores, and (b) a composite sample (right) which is primarily NaCl but with an imbedded lighter KCl grain in the center of the image.

Novel/Additive Information

Borehole images and other descriptions of the deposited salts will be presented. Salt precipitation within the target reservoir has previously been identified as having the potential to cause formation damage in CO2 injection operations. The observations presented here also suggest that salt build-up inside the well, which is associated with perforations into low-permeability zones, may also interfere with CO2 inflow into perforations located below these zones and affect CO2 injectivity (Rangriz Shokri et al. 2019, 2021).

Acknowledgements

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References

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