geoconvention
Calgary • Canada • May 11-13 2026

Laboratory Investigation of Solution Mining in Rock Salt: A Case Study at Robinson River, Newfoundland

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Summary

Salt caverns are widely regarded as one of the most promising options for large-scale underground hydrogen storage [1,2]. Such caverns are typically created by solution mining in salt domes or bedded salt formations [3,4], making quantitative knowledge of rock salt dissolution critical for controlling leaching efficiency and achieving the designed cavern volume and geometry. To better reflect realistic solution mining conditions, laboratory scale static dissolution experiments were conducted on field-recovered, intact salt core samples from the Robinson River area, Newfoundland, characterized by relatively high contents of insoluble materials and impurities.

The measured mass loss rate exhibited a pronounced early-stage maximum followed by a gradual decrease with time as saturation was approached. Dissolution released insoluble residues with an approximately unimodal particle size distribution, which provides insight into the nature of sump material likely to remain after solution mining. The insoluble particles are fine with a median particle size of 14.45 μm. Evaporation of the filtered solution indicated a dissolved salt concentration of approximately 0.103 g/mL, which is the potential by-product after solution mining operation.

Theory / Method / Workflow

Salt core samples were prepared from the Robinson River salt dome in Newfoundland from a depth of 597.82m to quantify salt rock dissolution behavior using static dissolution. The specimen was selected from the original cores, where they were dry-cut into approximately regular geometries, and their dimensions and initial dry mass were recorded prior to testing. This section is based on prior measurements of insoluble content, where the samples with relatively low insoluble fractions (~5 wt.%) were selected.

Dissolution experiments were performed in a glass beaker containing 200 mL of deionized water, placed on a temperature-controlled hotplate stirrer operated at 25 °C and 50 rpm. A hollow spacer and fine-mesh metal screen were used to support the specimen. This ensures full immersion while preventing contact with the beaker bottom and stir bar. During dissolution, specimen mass was measured periodically by removing, blotting, and weighing the sample. Measurements were taken at 1-minute intervals during the initial dissolution stage and at 2-minute intervals as the mass loss rate decreased. The experiment was terminated when no measurable change in specimen mass was observed over successive measurements.

Following dissolution, the solution was filtered to separate insoluble residues. The insoluble residues retained on the filter were dried and examined under an optical microscope to determine

particle size distributions. The density of the filtered clear solution was measured, and a 50 mL aliquot was evaporated to dryness to determine the mass of dissolved salt.

Results, Observations, Conclusions

During the initial stage of dissolution, the specimen exhibited rapid mass loss. As dissolution progressed, the rate gradually decreased (Figure 1A). The rapid early-stage dissolution suggests high initial reactive surface availability, while the subsequent rate attenuation reflects reduced concentration gradients at the solid-fluid interface.

Following dissolution, insoluble residues were recovered and analyzed. Particle size distributions derived from image analysis (Fig. 1C) show a unimodal distribution with a mean particle size of 21.54 µm and a median particle size of 14.45 µm. The cumulative distribution (Fig. 1D) indicates characteristic percentile diameters of D10 = 5.64 µm, D50 = 14.4 µm, and D90 = 47.82 µm, reflecting a fine dominated residue with a minor coarse fraction. Evaporation of a 50 mL aliquot of the filtered clear solution resulted in the crystallization of 5.167 g of salt (Fig. 1B), confirming substantial halite dissolution under static conditions.

Novel/Additive Information

This study is novel in that it represents one of the first static dissolution experiments conducted on field recovered, intact salt core samples. By using native cores from the Robinson River formation, the experiments directly assess the feasibility of solution mining, including the role of naturally occurring insoluble phases. The results provide quantitative insight into the nature and grain size distribution of insoluble residues that would remain as sump material following dissolution, as well as the amount of dissolved salt recoverable from the brine as a potential by-product.

Acknowledgements

The authors would like to thank Vortex Energy Corp., Alberta Innovates Hydrogen Centre of Excellence, Future Energy Systems, Mitacs and Natural Sciences and Engineering Research Council of Canada (NSERC) for providing funding of this project.

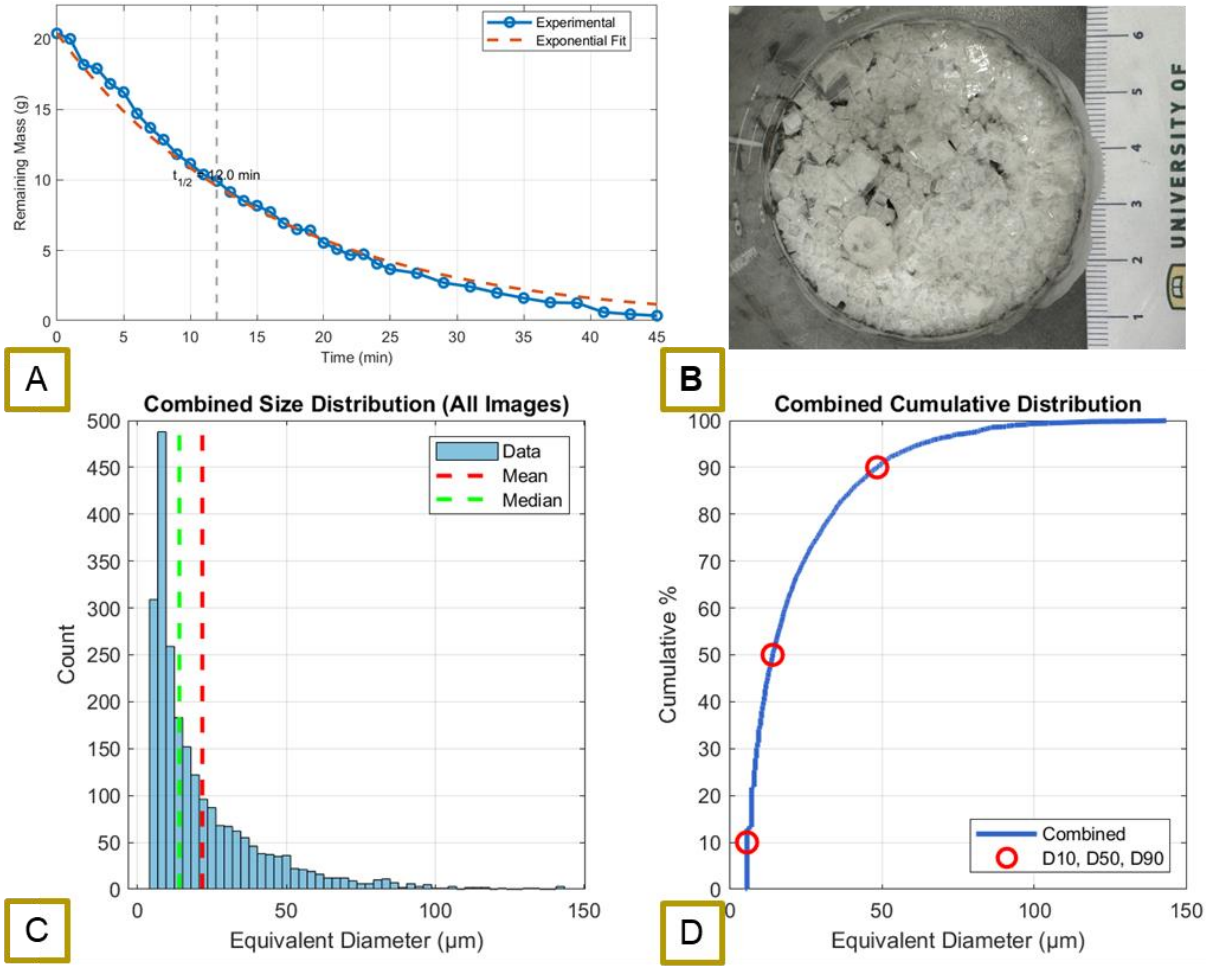


Figure 1 Static dissolution behavior of salt rock and characteristics of dissolution products

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