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Geophysical monitoring of brine migration in rock salt: results from an in situ heater and tracer experiment at WIPP

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The thermohydrological processes related to the geological storage of heat generating nuclear waste play a critical role in disposal barrier integrity. In rock salt, the key thermohydrological processes induced by heat include strong deformations, brine migration as well as mechanical changes. While geophysical methods are routinely used for field-scale subsurface imaging and are suitable for monitoring such processes in nuclear waste disposal facilities, such methods have rarely been applied to characterize heat-induced processes in rock salt.
Here we present a pilot scale field test conducted at the Waste Isolation Pilot Plant (WIPP) facility in New Mexico (USA) to understand the suitability of an electrical geophysical method, i.e. Electrical Resistivity Tomography (ERT), for visualizing the thermohydrological processes near a heat generating source in a bedded salt formation. In addition to cross-well ERT imaging, a brine tracer was introduced during the experiment while heating was maintained at 120oC. In addition to the field experiments, laboratory tests were conducted to establish the petrophysical correlations between the geophysical signals and key rock salt parameters, such as moisture content. Laboratory results indicate significant sensitivity of geophysical signals to the moisture content of rock salt where electrical resistivity (or conductivity) variation over five orders of magnitude was observed. Field scale results revealed the spatial variability of the resistivity structure of the rock salt near the heat source, and its changes over time during the experiment due to temperature increase as well as brine migration into the formation with tracer addition. A much larger change of the resistivity is associated with brine migration when compared to the pure temperature effect. The petrophysical models derived from the laboratory experiments were used to quantify changes of moisture content in the brine during the field experiments.
The experimental results provide valuable insights into the thermohydrological processes occurring near a heat generating source in rock salt. The experimental data will be used to calibrate and improve model predictions of long-term barrier performance associated with nuclear waste disposal in bedded salt formations.