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Joint inversion of ground-penetrating radar and thermal-hydrological data collected during a large-scale heater test

M.B. Kowalsky, J. Peterson, J. Birkholzer, S. Finsterle, S. Mukhopadhyay, and Y. Tsang

Earth Sciences Division, Lawrence Berkeley Laboratory, Berkeley, CA

A large-scale *in situ* heater test was conducted at Yucca Mountain, Nevada, in order to better understand the coupled thermal, hydrological, mechanical, and chemical processes that may occur in the fractured rock mass around a geologic repository for high-level radioactive waste. During and after the four-year heating phase of the test, time-lapse geophysical measurements (e.g., cross-borehole ground-penetrating radar) and thermal-hydrological data (e.g., temperature and neutron-probe-derived water content) were collected, making possible a novel application of hydrogeophysics. Here we describe a joint inversion methodology that combines geophysical and thermal-hydrological data to estimate (1) the thermal-hydrological parameters (such as permeability, porosity, thermal conductivity, and parameters describing the capillary pressure and relative permeability functions) that are necessary for modeling the flow of fluids and heat in the subsurface, and (2) the parameters of the petrophysical function that relates water saturation, porosity and temperature to the dielectric constant. The joint inversion methodology relies on the coupling of the model that simulates ground-penetrating radar travel times with the model that simulates fluid and heat flow in fractured rock. First, we test the methodology using a synthetic example that is based on the heater test, and examine parameter sensitivity (for the thermal-hydrological and petrophysical parameters) and issues related to the ground-penetrating radar measurements. Finally, we apply the methodology to the field data collected at Yucca Mountain. This work was supported in part by the U.S. Dept. of Energy under Contract No. DE-AC03-76SF00098.