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Authors

Zhang, Yingqi
Birkholzer, Jens

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Modeling a Thermal Seepage Laboratory Experiment

Yingqi Zhang and Jens Birkholzer

Lawrence Berkeley National Laboratory
Earth Sciences Division

A thermal seepage model has been developed to evaluate the potential for seepage into the waste emplacement drifts at the proposed high-level radioactive materials repository at Yucca Mountain when the rock is at elevated temperature. The coupled-process-model results show that no seepage occurs as long as the temperature at the drift wall is above boiling. This important result has been incorporated into the Total System Performance Assessment of Yucca Mountain. We have applied the same conceptual model to a laboratory heater experiment conducted by the Center for Nuclear Waste Regulatory Analyses. This experiment involves a fractured-porous rock system, composed of concrete slabs, heated by an electric heater placed in a 0.15 m diameter “drift”. A substantial volume of water was released above the boiling zone over a time period of 135 days, giving rise to vaporization around the heat source. In this study, two basic conceptual models, similar to the thermal seepage models used in the Yucca Mountain Project, a dual-permeability model and an active-fracture model, are set up to predict evolution of temperature and saturation at the “drift” crown, and thereby to estimate potential for thermal seepage. Preliminary results from the model show good agreement with temperature profiles as well as with the potential seepage indicated in the lab experiments. These results build confidence in the thermal seepage models used in the Yucca Mountain Project. Different approaches are considered in our conceptual model to implement fracture-matrix interaction. Sensitivity analyses of fracture properties are conducted to help evaluation of uncertainty.