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Simulation and Uncertainty Quantification of Gas Transport in Unsaturated Fractured Rocks as Viewed from the Roselend Natural Laboratory

The Roselend Natural Laboratory is a unique facility for studying gas transport in the subsurface. By combining experimental and numerical approaches, computer models are developed, calibrated, and validated for future predictive simulations. In addition to long-term monitoring of naturally produced 222Rn and CO2 gas-tracer experiments have been conducted recently with SF6, freon and 3He. The NUFT code, developed at the Lawrence Livermore National Laboratory, is used to model multi-phase multi-component transport and to interpret experimental data. Gas migration towards the ground surface is controlled by barometric pressure fluctuation through major conductive fractures. Infiltration that contributes to liquid-phase movement and saturation distribution can greatly affect gas transport. Using NUFT coupled to the LLNL PSUADE code, global-sensitivity analysis is conducted for identifying main parameters influencing gas transport and breakthrough at the surface. Surrogate-based optimization is then used to estimate rock parameters from experimental data, with the associated parametric uncertainties. By employing the calibrated model, simulations can be done to design future gas tracer experiments and to predict radionuclide migration from an underground nuclear cavity in a variety of geological and hydrological contexts.

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