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Contact: Teklu Hadgu, Sandia National Laboratories, USA
505-844-7945 (ph), 505-284-4002 (fax), thadgu@sandia.gov

SENSITIVITY ANALYSIS OF SEALS PERMEABILITY AND PERFORMANCE ASSESSMENT OF DEEP BOREHOLE DISPOSAL OF RADIOACTIVE WASTE

Teklu Hadgu, Sandia National Laboratories
Bill Arnold, Sandia National Laboratories
Joon Lee, Sandia National Laboratories
Geoff Freeze, Sandia National Laboratories
Palmer Vaughn, Sandia National Laboratories

The disposal of used nuclear fuel and high-level radioactive waste in deep boreholes is a feasible concept for long-term waste isolation. The concept consists of drilling boreholes into crystalline rocks to a depth of 5 km, emplacing waste canisters in the lower 2 km, and sealing the upper 3 km. The viability of this disposal concept is supported by the presence of crystalline basement at many stable continental locations and drilling technology to construct boreholes at an acceptable cost. The safety of deep borehole disposal is supported by low permeability and high-salinity in deep crystalline rocks, limited interaction of deep fluids with shallower groundwater, and geochemically reducing conditions at depth, which limit the solubility and enhance the sorption of many radionuclides.

A potential pathway for the release of radionuclides to the biosphere is through the borehole seals or in the disturbed rock zone near the borehole. Thermally driven flow may transport radionuclides upward via this pathway. A sensitivity analysis of the effectiveness of seals using a 3D model of thermal hydrologic flow and a performance assessment model was utilized to evaluate the potential impacts.

For the analysis 400 disposal canisters were emplaced in the bottom 2 km of the borehole, followed by a series of robust sealing materials over 1 km length. The parameters of interest were seal, disturbed rock zone and host rock permeabilities. Thermal hydrology simulations were first conducted using the numerical code FEHM for a selected range of host rock and disturbed zone permeabilities. The output of the simulations was thermally driven vertical fluxes at different depths and times.

A series of probabilistic performance assessment simulations were then conducted using the vertical fluxes as input, to evaluate the possible migration of radionuclides to a "hypothetical" accessible environment. Radionuclide inventories, heat output, and waste-form degradation rates representative of different waste types were included. Simulations were also made to evaluate the impact of sorption and retardation on dose risk from the dominant dose contributor, ^{129}I. For likely host rock and seal zone permeabilies calculated mean doses were extremely small. For a bounding high-permeability case the simulated mean doses were very low and acceptable.

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