NEUP | Nuclear Energy University Programs
U.S. Department of Energy

Reduced diffusion and enhanced retention of multiple radionuclides from pore structure characterization of barrier materials for enhanced repository performance

PI: Qinhong Hu, the University of Texas at Arlington
Collaborators: N/A
Program: FC-4.1 Used Nuclear Fuel Disposition: Disposal

ABSTRACT:

Diffusion, retention, and transport are important processes of evaluating the long-term performance of a geological repository. Diffusion process can be significantly affected by the pore structure (geometry and topology) of porous media, and pore connectivity, a largely overlooked topological characteristic of pore structure, is oftentimes more important than the geometrical aspects. The enhanced isolation and retention of radionuclides from low connectivity and clay intercalation in low-permeability barrier materials are under-appreciated for a performance assessment of geological repository. Utilizing complementary and multi-scale experimental approaches, this project will achieve the following research objectives:

1. Multi-scale and complementary approaches to characterizing and quantifying pore structure (especially connected pore space as a function of sample sizes) for enhanced isolation of radionuclides from low pore connectivity for a range of generic low-permeability barrier materials (clay/shale, salt, crystalline rock, and tuff).
2. Mechanistic understanding of the intercalation process, and magnitude, of radionuclides in clay minerals for their enhanced retention in barrier materials.
3. Realistic assessment of diffusion and retention of radionuclides in cm-sized intact-/whole-rock barrier materials, using "unsaturated transport-sorption approach", to address the uncertainty of diffusion and the batch-sorption K_d (distribution coefficient) values in the performance assessment with the context of their enhanced performance of geological repository to store high-level radioactive wastes.
4. Multiple (mercury intrusion capillary pressure, gas and liquid diffusion) approaches to achieving uncertainty assessment of radionuclide diffusion in barrier materials.

Key deliverables will be about 10 peer-reviewed journal articles, and six presentations at scientific conferences (Goldschmidt, Migration, International High-Level Radioactive Waste Management, American Geophysical Union, and Geological Society of America). The outcomes of this proposed research will directly benefit the Used Fuel Disposition program by bridging fundamental knowledge gaps of pore structure characterization of barrier materials, accurately measured diffusion and retention rates and models of multiple radionuclides, reduced uncertainty and improved confidence of the performance predictions of disposal concepts, as well as the education and training of PhD and undergraduate students in a minority-serving university.