Project Title: Pelletized Clay Mixtures with Enhanced Thermal Conductivity for Engineered Barriers in a Geologic Repository for High-Level Nuclear Waste and Spent Nuclear Fuel

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ABSTRACT:

The design of Engineered Barrier System (EBS) for high-level nuclear waste (HLW) and spent nuclear fuel (SNF) has been mainly based on placing blocks of compacted bentonite in the space between the canister (containing the HLW/SNF) and the gallery rock. However, the construction of such a barrier is challenging, and leads to the presence of physical gaps, which jeopardize EBS safety functions. Clay mixtures based on high-density bentonite-pellets are becoming the preferred candidate to construct engineered barriers for HLW/SNF because they present several advantages with respect to other sealing materials, particularly reduction of gaps in the EBS and ease of emplacement because the pellets are directly projected into the openings. The interest for this kind of material has significantly increased in the last few years, with several EBS hydration and heating experiments based on clay-pellets. Even though these previous studies have contributed to improving the understanding of these multiscale materials, there are still several aspects that require further research. For example, studies examining clay-pellets behavior at high temperature are scarce. A potential problem associated with the effect of high temperatures in pellet mixtures is that the combination of strong drying and large inter-pellets pores may negatively impact the buffer's thermal conductivity, preventing a proper dissipation of the heat emitted by the HLW/SNF. To prevent this type of issue, we will investigate the enhancement of the material's thermal conductivity by adding highly heat conductive materials (e.g., graphite) to the mixture.

The overarching goal of this project is to advance the current understanding of the behavior of pelletized clay mixtures intended for the isolation of HLW/SNF. The following are the four main objectives of this project: (1) Gain a better understanding of the key features associated with the behavior of pelletized clay mixtures, including material degradation when subjected to thermo-hydro-mechanical (THM)processes. Particular attention will be paid to: i) the effect of high temperatures (up to 190°C) on the response of pellet mixtures, and ii) engineering of pellet mixtures to enhance their thermal conductivity; (2) Produce high-quality experimental data related to clay-pellet mixtures involving tests at different scales from microfabric/microstructural studies up to medium-scale laboratory tests, which will contribute to expanding the current database in this area. The experimental campaign includes a variety of stress levels, temperatures, stress history, and clay degradation scenarios; (3) Upgrade the THM constitutive and numerical models to be used to gain a better understanding of this type of materials under different conditions, and for designing geological repositories for HLW/SNF; (4) Develop training opportunities for graduate and undergraduate students on this topic.

This project will improve the current understanding of high-level nuclear waste disposal in a generic mined geologic repository, with particular focus on the design of innovative clay-pellet mixtures intended for effective and safe isolation.