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Impact of coupled gas migration and thermo-hydro-mechanical processes on the performance of repositories for high level nuclear waste

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ABSTRACT:

The main goal of this project is to gain a better understanding on the possible effect of gas migration (particularly through discontinuities) on the performance and long term behavior of engineered barrier systems (EBS) envisaged for the isolation of high-level radioactive waste (HLW). Fundamental, experimental, and numerical investigations will be conducted to accomplish this objective. The behavior of clayed materials is of central interest in the design of HLW repositories because of their potential involvement as: a) a raw material to construct the man-made engineered barrier envisaged around the waste canister; b) a component of the backfill mixture planned to stabilize the disposal galleries and prevent water entering through the tunnel; c) a raw material to manufacture seals for mined and very deep borehole isolation concepts; and d) a geological barrier in mined repositories in claystone formations.

In recent years significant advances have been made on the Thermo-Hydro-Chemo-Mechanical (THCM) behavior of engineered barriers and surrounding rocks, however there are yet important features associated with this problem that need further research; such as the understanding and modeling of preferential pathways for the flow of fluids in EBS. The presence of preferential paths is inherent to the design of HLW repositories and they can appear in different forms in the EBS. For example, the interface at the contact between engineered barriers and host rock are unavoidable in the design of HLW disposal, as well as, the contact between gallery-backfill and rock. These interfaces are generally difficult to seal. Furthermore, discontinuities (in the form of cracks and/or fine fissures) may develop in the natural and engineered barriers during repository lifetime triggered by different factors, amongst others: heat-induced dry-out in the canister vicinity; gallery ventilation during repository construction; build-up of the gas pressure in the barrier. These preferential paths for the flow and transport of water and radioactive pollutants can severely compromise the safety functions of the HLW repository.

To achieve the main objective stated above, fundamental, experimental and numerical investigations are contemplated in this project. The fundamental studies will be aimed at gaining a better understanding of the phenomena behaving gas migration. The formation of discontinuities in barrier materials will be another important component of this research. The experimental activities will focus on replicating in the lab under controlled conditions plausible scenarios that may lead to the development of preferential pathways in EBS. Flow of fluids and transport properties through discontinuities will be investigated in the laboratory. The numerical investigation will be advocated to extend a current modeling framework to deal with pre-existing (e.g. interfaces) and evolving (e.g. cracks) discontinuities in EBS materials. The specific outcomes of this study will be an improved understanding of the role of gas migration and discontinuities in the performance of HLW disposals. The underlying aim is to improve the design of the EBS to assure a safe isolation of nuclear waste.

This proposal is based on a research collaboration between Texas A&M University (TAMU) and international collaborators. TAMU Professor will direct the research and will supervise the two graduate students contemplated in this project.