**Project Summary – Erosion, Transport, and Dispersion in Granular**

**and Porous Media**

**Overview:** The objective of this proposal is to analyze a set of complex, dynamical problems that arise in geophysical porous-media applications by using a host of newly developed computational tools. The problems of interest include: (1) The erosion of microscopic constituents of porous media leading to anisotropic macroscopic properties; (2) The modified transport of tracers through the medium, including anomalous dispersion; (3) The occurrence of catastrophic events, such as sink hole collapse, resulting from interaction between groundwater seepage, erosion, and buoyancy forces. These problems will be analyzed using a synergetic combination of cutting-edge computational techniques and reduced mathematical models, with a complementary set of laboratory experiments for comparison.

**Intellectual Merit:**

The problems listed above present a host of new computational challenges and opportunities. First the range of scales is vast: spatial scales range from microscopic granular constituents to large geological aquifers; timescales range from that of a sudden sinkhole collapse to years required mechanical and chemical erosion. The systems are inherently multicomponent, with coupling between the fluid and solid phases. Although the governing PDEs are linear, the presence of moving boundaries introduces nonlinear feedback between geometry and flow. To tackle these challenges, the PIs will combine cutting-edge computational tools with reduced-order modeling. Mixed-scale, deep neural networks will be used to learn from the data generated by high-fidelity numerical simulations to parameterize coarse-grained models based on the multiphase framework. Additionally, controlled laboratory experiments will be used to guide and verify theory developed herein.

**Broader impacts:**

By gaining a deeper understanding of the underlying physical processes, this investigation offers the societal benefit of better management of water resources in the face external factors, such as contamination of sinkhole formation. For example, the understanding developed herein may enable identification of specific regions most susceptible to contamination or to collapse. Promoting teaching, training, and learning while advancing discovery is an essential part of the project. The funded graduate students will be exposed to fundamentally cross-disciplinary research, with state-of-the art mathematical computations that will lead to advances in geophysical and environmental sciences. At least two graduates will be trained if the project is funded.