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Brown, S., Boitnott, G., Bussod, G., and Hagan, P. (2004) "A Laboratory Study of Heterogeneity and Scaling in Geologic Media" Trans. Amer. Geophys. Union Fall Meeting 2004, NS41A-04.

Abstract

In rocks and soils, the bulk geophysical and transport properties of the matrix and of fracture systems are determined by the juxtaposition of geometric features at many length scales. For sedimentary materials the length scales are: the pore scale (irregularities in grain surface roughness and cementation), the scale of grain packing faults (and the resulting correlated porosity structures), the scale dominated by sorting or winnowing due to depositional processes, and the scale of geomorphology at the time of deposition. We are studying the heterogeneity and anisotropy in geometry, permeability, and geophysical response from the pore (microscopic), laboratory (mesoscopic), and backyard field (macroscopic) scales. In turn these data are being described and synthesized for development of mathematical models. Eventually, we will perform parameter studies to explore these models in the context of transport in the vadose and saturated zones.

We have developed a multi-probe physical properties scanner which allows for the mapping of geophysical properties on a slabbed sample or core. This device allows for detailed study of heterogeneity at those length scales most difficult to quantify using standard field and laboratory practices. The measurement head consists of a variety of probes designed to make local measurements of various properties, including: gas permeability, acoustic velocities (compressional and shear), complex electrical impedance (4 electrode, wide frequency coverage), and ultrasonic reflection (ultrasonic impedance and permeability). We can thus routinely generate detailed geophysical maps of a particular sample. We are testing and modifying these probes as necessary for use on soil samples.

As a baseline study we have been characterizing the heterogeneity of a bench-size Berea sandstone block. Berea Sandstone has long been regarded as a laboratory standard in rock properties studies, owing to its uniformity and ``typical'' physical properties. We find that both permeability and velocity exhibit complex heterogeneity at the centimeter scale. While some correlation with the outcropping of the bedding is apparent, much of the heterogeneity is not clearly associated with visual features. For the study of soil heterogeneity at a wide range of scales, we are focusing on a local glacial deposit. This deposit is a glacial kame terrace of fluvial origin with multi-scale sedimentary structures comprised of unconsolidated sands, clays, and gravels. There are also many joints and faults in the unconsolidated sediments, allowing study of these as potential fluid flow conduits or barriers. We have obtained undisturbed soil samples from this site, allowing detailed laboratory study using similar methods to those described for the sandstone block.

Contact NER for more information.