SAND2008-3186C

Characterization of a High Lithophysal Welded Tuff Unit Using a Multi-Scale Approach

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Abstract

Yucca Mountain, Nevada is the proposed site for the nation's first high-level nuclear waste repository. The site is composed of a layered sequence of volcanic tuffs, both welded and non-welded, that are situated in the vadose zone well above the regional water table. Based on repository design considerations, a significant portion of the repository will be constructed in a rock unit composed of welded tuff with a significant volume fraction of lithophysae ranging in scale from centimeters to meters. Characterizing this unit and determining the thermal and mechanical response of the rock to conditions expected during repository operations and closure for the purpose of developing engineering models for design and performance assessment proved to be challenging.

The strategy for characterizing the thermal and mechanical behavior of the rock mass, involved three principal components. First, the rock mass was examined to determine lithophysal characteristics, size distributions, and spatial distribution of porosity. Next, a multi-scale testing program of laboratory-to-field experiments was designed and implemented to gather sufficient data to develop models and validate extrapolations to repository scale. Sampling and testing plans included gathering data from multiple locations to document potential spatial variability. Finally, site-specific models that explicitly treated the effect of the lithophysal porosity distribution were developed and validated against field data.

This paper will focus on the design, execution, and results of the multi-scale testing effort to determine the thermal and mechanical behavior of the lithophysal rock unit. For laboratory-scale testing, large cores (300 mm) were excavated from regions of the unit where the size distribution of lithophysae (25-75 mm) was compatible with core size. Cores with varying amounts of lithophysal porosity were tests in uniaxial compression to determine deformation modulus and strength, which were essential for basic model construction. Similarly, thermal expansion of the rock was determined up to the design limit of 200^{o}C. Some smaller core samples were also tested in compression with extensive acoustic emission diagnostics. The data from these tests were used to verify that the principle mechanism for deformation and failure was fracturing of the matrix web material between lithophysae cavities. Three in situ tests were conducted at separate

locations within the Yucca Mountain Exploratory Studies Facility. These tests, employing flat jacks in parallel slots, allowed the loading to failure of approximately one cubic meter of rock. Results of the tests at different scales are compared and conclusions on the effects of scaling are discussed.

Welded tuff core recovered from YMP

Compression test of lithophysae tuff

In situ slot test (slots on left and right).
Central hole provided stress concentration
so that failure could be achieved and allowed
for key deformation measurements to be made.

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.