Large-Scale Permeability of Volcanic Rocks

N M Coleman (US Nuclear Regulatory Commission, Office of NMSS, Washington, DC, 20555; 301-415-6615; nmc@nrc.gov)

Recent data from terrestrial flood basalts, sub-sea basalts, and welded tuffs enhance our understanding of permeability (k) in brittle volcanic rocks. Bulk k in these rocks is mostly controlled by fracture network properties, with a large fraction of groundwater flux being carried by higher-k zones. In flood basalts, features like lava tubes can greatly enhance local k values. For Columbia Plateau basalts at Hanford, WA, bulk k estimated from single-well transmissivities (T) ranges from 6E-17 to 1E-9 m^2, with a trend of decreasing k with depth. At Creston, WA, a multi-well test in the Roza Basalt yielded horizontal bulk k values around 3E-12 m^2. Estimates from single-well tests for Snake River Plain basalts range from 3E-14 to 2E-9 m^2. Oceanic basalts have been studied at many sites to better understand heat flows and fluid migration. Core data yield a low k range, from 1E-22 to 1E-17 m^2. Larger- scale in situ data (pressure slug tests and constant-rate injection tests) range from 1E-18 to 1E-13 m^2. Indirect methods based on borehole temperature and flowmeter logs, and models of coupled heat and fluid flow yield the largest values (1E-16 to 1E-9 m^2). Very young oceanic crust appears to have higher k values than older crust. At Yucca Mt., NV, tuff cores have a k range of about 1E-18 to 1E-12 m^2. Values of k for a large tuff block with a volume of over 5000 m^3 range over five orders of magnitude (1E-15 to 8E-11 m^2). A km-scale, 320-day aquifer test with multiple observation wells yielded T values of 650-2700 m^2/d. The estimated horizontal k range from this test is 2.8E-12 to 2.2E-11 m^2. These relatively high values may be due to the extensional tectonics of the Great Basin. Observation wells for this test yielded T values 1-2 orders of magnitude higher than were obtained from single-well tests. This shows the importance of large-scale, long-term, multi-well tests to estimate aquifer-scale T and k. Patterns of increasing k with scale of measurement, noted previously by others, are evident in the Yucca Mt. data. In summary, the upper k range for brittle volcanics, based on large-scale tests and analyses, covers about 3 orders of magnitude (1E-12 to 1E-9 m^2). This helps define large-scale properties of flood basalts and tuffs, where we are interested in site-scale flow modeling to evaluate potential waste disposal sites.