SIMULATING AIR-ENTRAPMENT IN LOW PERMEABILITY MUDROCKS USING A MACROSCOPIC INVASION PERCOLATION MODEL

Abhishek Singh, INTERA Incorporated, 512-996-8892, asingh8@gmail.com

1. Abhishek Singh, INTERA Incorporated
2. Robert M. Holt, University of Mississippi
3. Banda Ramarao, INTERA Incorporated
4. Tom Clemo, INTERA Incorporated

Three radioactive waste disposal landfills at the Waste Control Specialists (WCS) facility in Andrews County, Texas are constructed below grade, within the low-permeability Dockum Group mudrocks (Cooper Canyon Formation) of Triassic age. Recent site investigations at the WCS disposal facilities indicate the presence of a trapped and compressed gas phase in the mudrocks. The Dockum is a low-permeability medium with vertical and horizontal effective hydraulic conductivities of 1.2E-9 cm/s and 2.9E-7 cm/s. The upper 300+ feet of the Dockum is in the unsaturated zone, with an average saturation of 0.87 and average capillary pressure of 2.8 MPa determined from core samples. Air entry pressures on c ore samples range from from 0.016 to 9.8 M Pa, with a mean of 1.0 M Pa. Heat dissipation sensors, thermocouple psychrometers, and advanced tensiometers installed in Dockum borehole arrays generally show capillary pressures one order of magnitude less than those measured on core samples. These differences with core data are attributed to the presence of a trapped and compressed gas phase within Dockum materials. In the vicinity of an instrumented borehole, the gas phase pressure equilibrates with atmospheric pressure, lowering the capillary pressure.

We have developed a new macroscopic invasion percolation (MIP) model to illustrate the origin of the trapped gas phase in the Dockum rocks. An MIP model differs from invasion percolation (IP) through the definition of macro-scale capillarity. Individual pore throats and necks are not considered. Instead, a near pore-scale block is defined and characterized by a local threshold spanning pressure (a local block-scale breakthrough pressure) that represents the behavior of the subscale network. The model domain is discretized into an array of grid blocks with assigned spanning pressures. An invasion pressure for each block is then determined by the sum of spanning pressure, buoyance forces, and viscous forces. An IP algorithm sorts the invadable blocks, selects the block connected to the growing cluster with the lowest invasion pressure, and invades it. Our new MIP model incorporates several new features, including an efficient three-dimensional clustering algorithm; simultaneous invasion/reinvasion of water and air phases; hysteresis in water and air drainage curves; capability for distributed porosities and drainage parameters; and gas-phase compression and trapping. We apply this model in simulations representing the WCS site and illustrate the origin of the trapped and compressed gas phase in Dockum mudrocks.