Aquifer Characterization in the Blue Ridge Physiographic Province

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(ABSTRACT)

Existing models of the hydrogeology in the Blue Ridge Province in the eastern United States generally assume a simplified two-layered system consisting of shallow unconsolidated and relatively homogeneous and porous regolith with a water-table aquifer that slowly supplies water downward to the underlying variably fractured crystalline bedrock. In these models, interconnected fractures in the crystalline bedrock act as conduits for predominantly downward vertical and limited horizontal flow. Fracture density is depth–limited and correlated with proximity to topographic lineaments. Current models consider the porous regolith as the primary water storage reservoir for the entire aquifer system.

In this research, detailed hydrogeologic studies in the Blue Ridge Province in Floyd County, Virginia reveal a substantially different framework for groundwater flow. Recent acquisition of two-dimensional surface resistivity profiles collected using a variety of array techniques combined with borehole geophysical logs revealed new insights into this geologically complex province. Dipole-dipole arrays were particularly important in gathering high resolution resistivity profiles that document horizontal and vertical resistivity variation reflecting changes in subsurface geology and anomalous low resistivity areas in crystalline bedrock associated with fault zones.

The shallow regolith contains unsaturated areas and also localized sand and clay prone facies with water table and confined aquifer conditions residing locally. Hydraulic heads between the shallow aquifer and the deeper fractured bedrock aquifer can vary by 20 m vertically. Within the crystalline bedrock are anomalous lower resistivity intervals associated with ancient fault shear zones. Brecciated rock adjacent to the shear zones, and the shear zones themselves, can be hydraulically conductive and serve as pathways for groundwater movement. Aquifer testing of the regolith-bedrock fracture system occurred over a 6-day period and produced rapid and relatively uniform drawdowns in surrounding wells completed in the fractured bedrock aquifers. The shallow aquifers experienced minimal drawdowns from the aquifer test indicating low vertical hydraulic conductivity and limited communication between the shallow and deeper bedrock aquifers. Water chemistry and chlorofluorocarbon (CFC) age dating analyses indicated significant differences between water samples from the shallow and deep aquifers. A new conceptual model for Blue Ridge aquifers is proposed based on these research findings.