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Characterization of flowpaths geometry in a complex crystalline aquifer from detailed core analysis and numerical inversion of cross-boreholes flowmeter tests.

S. Ruelleu, O. Bour, T. Le Borgne

Géosciences Rennes, UMR 6118 CNRS, Université de Rennes 1, Campus de Beaulieu, 35042 Rennes Cedex, France (sebastien.ruelleu@univ-rennes1.fr)

Crystalline rocks aquifers are very difficult to characterize since flow is mainly localized in few fractures or faults. The large scale hydraulic properties of such media strongly depend on the connectivity of permeable fractures. In case of long range connectivity, crystalline rocks can represent important aquifers. The influence of the structural properties on the fracture connectivity is still not well understood. New methods based on precise flow measurement in borehole now allow obtaining information on preferential flow path connectivity. Using such method and a detailed geological description from cored boreholes, we investigate the relationship between geological and flow structures for a fractured crystalline aquifer.

This study is focused on the Ploemeur aquifer (Britanny France), which is located in a fractured crystalline bedrock terrain characterized by igneous and metamorphic rocks. The unusually high production rate of the site (10^6 m^3/year) is though to be related to the large connectivity of permeable fracture zones. The site is located at the roof of the Ploemeur granite, just at the contact between the hercynian granite and some micashists. The zone of contact is quite complex with enclaves of micachists within the granite and dyke of pegmatites or aplites within the micaschists. The structural contact dips about 30˚ but is locally affected by steeply dipping sub-meridian faults. Some great deformation zones such as mylonites and faults are locally observed. These structures are supposed to be major pathways for fluid flow although no clear relationship was established between geological structures and hydraulic prop-

erties.

A new cored borehole 108 meter deep was drilled recently. Detailed core analysis and geophysical logging (optical, electric, gamma ray and acoustic imagery) permit to improve the geological description of the different fracture sets and of the main deformation zones. Micaschists and leucogranite bodies as well as pegmatites are encountered all along the borehole with variable fracture intensity. A two-meter thick breccias zone and a highly fractured zone are observed.

The hydrologic characterization was made by borehole flowmeter tests including single borehole tests and cross-borehole tests. Single borehole flowmeter tests are used to identify the main flow paths in fractured aquifers. This method was extended recently to a cross borehole setting that allows characterizing cross borehole connectivity properties. We used a heat-pulse flowmeter that allows a high resolution measurement of vertical flow (minimum velocity 10^{-3} m/s). The cross-borehole flowmeter tests were made with few other highly producing boreholes at distances varying from 10 meters to 100 meters. The hydraulic parameters were obtained through a model that permits to inverts flow data taking into account the geometry of the main flow zones.

The comparison of the geological information and the flowmeter characterization show that there are three main types of flow paths: single fractures, a pegmatitic zone and a breccias zone. From the cross borehole flowmeter tests, we investigate which of these structures provides connectivity at the site scale.

Flowmeter tests associated with detailed core analysis thus provides simple and efficient tool for imaging connectivity and hydraulic properties of main flow paths.