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Characterization of preferential flow paths from single and cross-borehole flowmeter tests in a fractured aquifer

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The structure of the permeability field and in particular the connectivity of preferential flow paths controls the fluxes at large scale as well as the transport properties. However, this information is rarely available in the field unless intensive and time-consuming packer testing is achieved. In this study, we present a characterization of flow paths connectivity at the Plœmeur fractured crystalline aquifer from cross-borehole flowmeter tests. We also compare hydraulic properties estimates obtained from single borehole flowmeter experiments, cross borehole flowmeter experiments and long term pumping tests.

Cross borehole flowmeter tests have been recently proposed as an efficient technique to characterize the connectivity of fractures between boreholes. Cross borehole flowmeter tests consist of measuring transient vertical flow in an observation borehole when the pumping rate is changed in a nearby pumping well. The rate of change in borehole flow between flow zones intersected by the borehole depends on the connectivity and hydraulic properties of the flow zones between the two boreholes. Flow measurements were achieved with a calibrated heat-pulse flowmeter whose principle is to measure the time for a heat pulse to travel from a heat grid to a thermistor located a few cm above or below the heat source. We combined this method with single borehole flowmeter tests and long-term pumping tests to characterize the connectivity, geometry and hydraulic properties of large scale flow paths at the Plœmeur aquifer where long-screened observation boreholes does not allow the use of packers. The aquifer is located on the south coast of Brittany in crystalline bedrock terrain charac-

terized by igneous and metamorphic rocks. We restrict our analysis to the boreholes that are the closest to a pumping station within an area of approximately 600 meters in diameter. These boreholes react relatively rapidly to the pumping variations even for large borehole separations. Most boreholes are about 100 meters deep and intersect a series of producing zones with variable inflows.

We show that cross borehole flowmeter tests are an efficient method to image the geometry of preferential permeable flow paths at the Plœmeur site. We found that the high transmissivity zones are well connected over distances of at least 150 meters all over the site. In parallel, the synthesis of all hydraulic tests on the Plœmeur fractured crystalline aquifer show that a large range of hydraulic properties characterizes the site. However, we observe that borehole scale variability of transmissivity estimates vanishes at larger scale and that the transmissivity converges towards the high values of the transmissivity distribution. This effect may be explained by the organization of the flow field in the subsurface, and particularly the good connectivity of the permeable zones all over the site. On the other hand, storage coefficient estimates remain relatively variable even when obtained from long term pumping tests.