Consideration of water pressure change at a hydraulic test in a sparsely fractured rock

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1. Introduction

In KURT, whose host rock is massive granite, there is a 500 m long borehole, and the hydraulic tests such as constant head withdrawal and recovery tests were conducted at several packed-off intervals of the borehole. Figure 1 shows the fracture numbers and estimated interval transmissivities from the hydraulic tests. In the intervals with many fractures, the estimated transmissivity from the constant head withdrawal test is similar to that from the recovery test. However, at the intervals with few fractures, those from the constant head withdrawal test are ~ 1 order smaller than those from the recovery test. Several phenomena can be suspected as the cause of this observation, but the nonlinear groundwater flow in a fracture due to a highly imposed hydraulic gradient [*Ji et al.*, 2008] and trapping zone effect from the directional anisotropy of flow [*Boutt et al.*, 2006] cannot be the reason, because the imposed hydraulic gradient and groundwater flow direction are equal between the constant head withdrawal and recovery tests.

Considering that the water pressure decreases during the constant head withdrawal test while it increases during the recovery test, the change of water pressure may lead to a small change in aperture, and it may make the difference between the hydraulic test results. The difference between them then increases as the number of fractures in the packed-off interval decreases (Figure 1), which indicates the possibility that the influence of the water pressure change on the aperture decreases in the intervals with many fractures because it diffuses into many fractures. To verify this idea, a change in an aperture is directly observed in this study when the water pressure is changed.

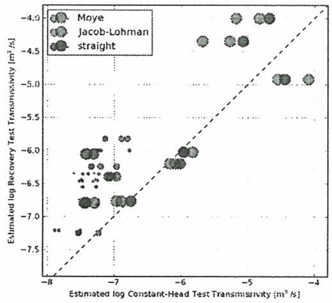

Fig. 1. Estimated transmissivity from hydraulic tests at DB-1 in KURT. The size of circle represent the number of fractures in the test interval.

2. Approach

For direct observation of the fracture aperture during a test, a special double packer system is designed. It is composed of three parts: outer pipe, inner pipe and acrylic pipe. Eight rubber packers to mechanically isolate a specific zone in a borehole are attached to the outer pipe, and an observation window is located between the upper and lower packers in the outer pipe. The inner pipe is a passage for a borehole camera and cables, and a barrier to shut out the influence of the assigned water pressure to the test zone on the camera. It is coupled with the acrylic pipe for direct observation of a fracture using a borehole camera, and placed inside the outer pipe. Note that the outer and inner pipes are made of the stainless steel and can be extended to the target zone using pipes with same diameters.

In the test interval, preliminary hydraulic tests such as a constant head withdrawal and recovery tests are conducted. The constant head withdrawal test results are analyzed with the Moye, Jacob-Lohman and straight line model while the recovery test results Horner models.

3. Results

From the constant head withdrawal test, the transmissivity of the test zone is estimated to 3.6×10^{-9}, 4.8×10^{-9} and 5.2×10^{-9} m^2/s with the Moye, Jacob-Lohman and straight line models, respectively. It is about 0.2 times smaller than the estimated one from the recovery test, which is 2.7×10^{-8} m^2/s. Note that the initial and assigned heads are 22.7 and 11.2 m, respectively, in our constant head withdrawal test.

To reveal the relation between the water pressure and aperture, the aperture and steady state injection rate of water are measured while various water pressures are imposed. The hydraulic head is initially 1.4 m. When the experiment begins, it abruptly increases to 50.5 m, and is kept in a constant although it oscillates slightly due to the injection pump. The injection rate is the maximum at the beginning of the experiment, and stabilized to 1.06×10^{-3} m^3/d. The target fracture was recorded using a borehole camcorder. Immediately after the water pressure of 5 bars is imposed, the aperture is increased by 1.25 times in average. Then, as the time is elapsed from the pressurizing it gradually gets large, and is stabilized when the elapsed time is about 20 minutes. The stabilized aperture is about 1.43 times larger in average than the initial one.

When the water pressures of 2, 3 and 4 bars are applied, the changes of aperture are also observed. They are similar to the case where the water pressure of 5 bars is imposed: the apertures increase exceedingly at the beginning of the experiments, and are stabilized after gradual increase. When the water pressures of 2, 3 and 4 bars are applied, the hydraulic heads are converged to 21.4, 29.2 and 37.5 m, respectively, and the apertures are finally increased by 1.22, 1.27 and 1.29 times in average, respectively, from the initial one.

4. Acknowledgement

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5. References

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