Continuous borehole self-potential measurement - a new approach to characterize hydrological properties of fractured rock

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To evaluate fluid, heat or chemical species transport in fractured rocks, it is very important to characterize hydrological properties of the medium, in which the fracture region plays an important role for fluid flow, whereas the matrix region works as a major storage of fluid and/or heat. Conventional well testing methods such as pressure transient/interference and tracer tests are applied to characterize fractured rocks. However, it is usually difficult to characterize both of the fracture and matrix regions separately by using these methods. Ishido and Pritchett (2003) carried out numerical simulation of electrokinetic phenomena in fractured rocks and showed that features of fractured rocks appears much more clearly in the 'self-potential transients' than in the pressure transients. Combining continuous pressure and self-potential measurements is thought to therefore provide a mean for better characterizing fractured rocks.

In order to study this prediction experimentally, Nishi et al.(2006) carried out short term borehole continuous SP monitoring using well KF-1 at the Kamaishi Mine, Japan. Based on this test experiment, we have carried out continuous SP monitoring using multi Ag-AgCl electrodes installed within well KF-1 and KF-3 at the Kamaishi Mine, Japan. The observed streaming potential divided by the pressure change due to wellhead valve opening shows different behaviors between intact host rock and fractured rock regions. A double-porosity behavior is observed in the fractured region, which suggests that the time required for pressure equilibrium between the fracture and matrix regions is 1000 to 2000 seconds. Fracture spacing is estimated to be 1 to 4 meters corresponding to 1 to 10 micro-darcies of assumed permeability of the matrix region.

To develop a practical system for borehole SP measurement, we have also started preliminary experiments to study proper electrode installation procedures and the effects of iron casing on the measurement.