Effect of initial crack distribution on inner structure and permeability of fault zone

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Evaluation of flow properties along a fault is important in various fields such as risk assessment of Carbon Dioxide Capture & Storage (CCS). Flow properties along a fault strongly depend on the inner structure of the fault zone, such as distribution of damage zone, which is highly fractured zone next to fault core (Caine et al, 1996). One of the possible factors that affects damage zone developments is crack distribution in the host rock. However, it is not necessarily clear how the damage zone development depends on this factor. In this study, to investigate how the initial crack density affects damage zone structure and permeability of a fault, we are operating axial deformation and flow experiments under confining pressure (Pc), with rock specimens having various initial crack densities, and investigated the inner structure of deformed specimens.

Experiments are performed using intra-vessel rock deformation and fluid flow apparatus at Toho University. The specimens selected for this study was a sandstone from Rajasthan, India, which is mainly composed of 68% quartz, 18% orthoclase and 10% plagioclase. The specimens are cylindrical, 20 mm in diameter and 50 mm in length.

To investigate how Pc affects localization of shear deformation for the sandstone used in this study, we operated axial deformation experiments under Pc ranging 5 to 50 MPa. The results show that, at Pc = 5 to 20 MPa, the shear deformation is mainly localized in a single fault, which condition is suitable for this study.

We are trying to prepare specimens with various initial crack densities by heating and cooling a specimen: a specimen heated up to 650 ˚C and cooled in a furnace (650 ˚C_slow; porosity is 11.7%); a specimen heated up to 650 ˚C and cooled by being dipped in ice water (650 ˚C_rapid; porosity is 13.2%); a specimen heated up to 900 ˚C and cooled in a furnace (900 ˚C_slow; porosity is 14.6%); intact (not heated) specimen (porosity is 11.5%). Various porosity values suggest that crack densities of specimens were increased by the heating-and-cool treatments. We operated deformation experiments using these specimens under Pc = 10 MPa. As a results, a single fault was induced in a deformed specimen for all experiments. However, in the case of 900 ˚C_slow, maximum differential stress was higher than that for intact specimen. This is possibly because the minerals in the specimen 900 ˚C_slow were metamorphosed by the heat treatment.

Based on the results of the above pilot experiments, we are planning to operate experiments under a condition of Pc = 5 to 20 MPa, using specimens of intact, 650 ˚C_slow and 650 ˚C_rapid.

Reference: Caine, J.S., Evans, J.P., & Forster, C.B., 1996, Fault zone architecture and permeability structure, Geology, 24(11), 1025 - 1028.

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