Effects of initial crack distribution on inner-structures and flow properties of shear deformed rocks

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Flow properties along a fault strongly depend on the inner structure of the fault zone, such as distribution of damage zone, where crack density is high. 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 the factor. In this study we operated flow property measurements during uniaxial deformation under confining pressure with rock specimens with various initial crack densities.

We operated the experiment by using rock deformation-flow test apparatus in Toho University. The rock 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 40 mm in length. To investigate effects of initial crack densities on the results, we prepared cracked specimens (average porosity is 14%) by heating up to 900°C and cooling down to room temperature, and intact (not heated) rock specimens (average porosity is 14%). The confining pressure was 5 or 10 MPa, the upstream pore pressure was up to 1 MPa and the downstream one was atmospheric pressure. The rock deformation experiments were performed at a constant axial strain rate of 10^{-5} s^{-1}.

In all experiments, sudden brittle failure was observed, and evolutions of flow rate parallel to the axial direction of the specimen until the failure were qualitatively similar to each other: the flow rate was increased from the yielding point till the failure. An increment of flow rate per unit volumetric strain increase for the intact rock specimens were approximately one order larger than that for the heated specimens. This may be because the increment of the flow rate is larger for the specimen with lower initial crack density. The flow rate after the sudden failure was decreased rapidly in the case of the intact rock specimens. In the case of the heated specimens, on the other hand, the flow rate was increased after the failure. We could find the difference in inner-structures of the deformed specimens between the intact and heated rocks: in the case of the intact rock specimens, multi-failure structures were concentrated on the upstream side; in the case of the heated specimens, a single shear fracture connecting the upstream and downstream sides was observed. The flow rate change at the sudden failure may be mainly because of (1) aperture decreases of cracks parallel to the axial direction caused by decreases of differential stress and (2) creation of specimen-scale brittle failure structures. The difference on the flow rate change between the intact and heated rocks probably because the impact of (1) is relatively effective in the case of the intact rocks, and in the case of the heated rocks, the impact of (2) is more effective.

Keywords: Fault zone, Deformation flow test

