Experimental investigation on damage assessment of rocks under high strain rate

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1. Introduction

A mechanism of fault fracture zone has been thought to be gradually formed into the surroundings of the fault layer by the overlap of shear strain and the accumulation of wear (Scholz, 1987). However, it has been reported that pulverized rocks, characterized by no shear strain and remarkable shatter, are distributed along large strike slip fault. The fractal dimension on size distributions of particle in of pulverized rocks, especially those very close to faults, is higher than the theoretical upper limit of shear deformation (Muto et al., 2015). This suggests that they may have been formed by a fracture mechanism with even higher strain than shear deformation. In addition, recently, it is suggested that extremely high stain deformation may occur during fault rupture propagation in fault fracture zone (Reches and Dewers, 2005; Okubo et al., 2019). In particular, complex dynamic deformation due to off-fault damage occurring in the fault fracture zone reduces the rapture propagation rate of the main fault and also generate high frequency seismic waves (Okubo et al., 2019). Therefore, the process of off-fault damage is very important for understanding fault rupture, but we don’ t still precisely understand about the high strain deformation mechanism in fault fracture zone. So, we discuss damage assessment of rocks under high strain rates using an impact deformation tester.

2. Methods

We did rock deformation tests using the split Hopkinson pressure bar (SHPB), which can apply high strain rates (over 100 ⁄s) to rock samples. We used Inada granite, novaculite and macor as rock samples, which have been used in previous studies. We evaluated the damage of them by three methods: 1) measurement of the mechanical properties of the samples using stain gauges, 2) observation of cracks of samples using a high-speed camera, 3) measurement of the fractal dimension of crushed particles by sieving for the recovered samples.

3. Results and discussion

We measured the stress, strain and strain rate applied to the samples using strain gauges, and calculated the energy applied to the samples by integrating the stress-stain curve. It was found that only four of the eight samples achieved stress equilibrium.We could measure accurately the mechanical properties of samples that had achieved stress equilibrium and the strength of them increased with strain rate. Therefore, we calculated the strain rate dependence of the fracture strength of granite samples that might have achieved stress equilibrium, using the experimental data of Duan and d'Hour (2012).The results show that the strain rate dependence of the dynamic fracture strength at high strain is larger than that of the static strength at low strain rates.

By observing cracks using a high-speed camera, we have shown that the crack extension orientation may vary depending on the composition and grain size of the sample.

In all the recovered samples, the fractal dimension of coarse-grained particles (radius ›0.3 mm) tended to be larger than that of fine-grained particles (radius 0.1~0.3 mm). The fractal dimension of some coarse-grained particles was close to that of pulverized rocks, encountered in off-fault damage regions

(Muto et al., 2015), suggesting that our results may be analogues to actual high strain rate damage.

4. Summary

In order to understand the deformation mechanism under high stain rates in fault fracture zone, we evaluate damage at high strain rates in rocks as follows using impact deformation tester. We measured the mechanical properties of the samples and discussed the strain rate dependence of the fracture strength of granite, and we showed that the fracture extension orientation may change depending on the composition and grain shape of the sample, and we suggested that the samples in this research may reproduce the deformation at high strain rates in fault fracture zone. We need to improve the samples preparation process and the sample recovery rate to increase the accuracy of the experiment.

Keywords: fault, pulverized rock, fractal dimension

