Experimental study and numerical simulation of failure of feldspathic-mafic rocks by phase change of fluid

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BDT (Brittle-Ductile Transition) is the boundary transition of crustal rocks from brittle to ductile. We had thought that especially the BDT of granite is the limit of geothermal developments because granite is one of the most common rocks in the upper crust and the permeability of rocks reduces significantly in the area deeper than BDT of granite. However, recent studies have revealed that geothermal development could be expected even there in that situations. For example, Watanabe et al. (2017) reported that the potentially available resources may exists in the ductile area of granitic rocks at temperature from 375℃ to approximately 460℃. Therefore, we need to think the way to generate the fracture network at that area. For that, we focused on the rock fracturing by the phase change of fluid by rapid decompression of high temperature and high pressure fluid. In this method, we use thermal shock occurred by cooling that caused by fluid decompression. Previous our studies have revealed that quartz was the important factor to make rock more permeable by fracturing because quartz tended to make cracks at the grain boundaries between other minerals and itself due to low thermal expansion coefficient. However, it was unrevealed if cracks will be generated with no quartz.

In this study, we conducted rapid decompression experiments for three times to gabbro, which is common rock in the lower crust and has no quartz, and compared permeability and porosity with those of granite conducted same experiments in the same situation and equation of granite’s permeability and porosity from Watanabe et al. (2017). Moreover, we observed samples after experiments by X-ray CT and SEM. As a result, we found that cracks in gabbro was smaller and less permeable than those in granite. We also conducted numerical simulation using FEM (Finite Element Method) to reveal where stress concentrates during fracturing. We found that stress concentrates at the grain boundaries of ilmenite and other minerals in gabbro, similar to quartz of simulation result of granite.

References

Watanabe et al., 2017. Nature Geoscience 10, 140-144

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