Influence of hydration products on brittle deformation of olivine gabbro

*Yuya Akamatsu[1], Ikuo Katayama[1]

1. Hiroshima University

Hydration of mantle and oceanic crustal rocks plays a key role on several aspects of geodynamical process of the oceanic lithosphere, because hydration products such as serpentine have characteristic physical and mechanical properties. For instance, deformation experiments demonstrate that the small amount of serpentine reduces the strength of peridotite to that of pure serpentinite and hence can weaken the oceanic lithosphere (Escartín et al. 2001). Meanwhile, the influence of hydration on these properties of gabbroic crustal rocks is poorly understood. In this study, we carried out triaxial deformation experiments of gabbroic rocks containing partially serpentinized and/or altered olivine to understand the influence of hydration on the mechanical and physical properties of oceanic crustal rocks.

For deformation experiments, we used gabbro collected from the Oman Ophiolite. These gabbros contain small amount of olivine, where hydration products such as serpentine and chlorite are formed along grain boundaries and intragranular cracks. The experiments were conducted using the intra-vessel deformation and fluid flow apparatus at room temperature, a constant confining pressure of 20 MPa, and a constant strain rate of ~10^{-6} s^{-1}. Compressional and shear waves traveling in a direction normal to the loading axis were measured during deformation. For comparison, additional experiments were conducted using unaltered gabbroic rocks and lizardite serpentinite.

Hydrated olivine gabbros showed maximum differential stress of 200–350 MPa, which was comparable to that of lizardite serpentinite, while unaltered gabbroic rocks showed much higher maximum stress of ~600 MPa. This indicates that small amounts of serpentine and/or chlorite reduce the fracture strength of gabbro. Elastic wave velocity of hydrated olivine gabbros was nearly constant even prior to failure, suggesting that the mode of brittle deformation of these samples were not associated with development of extensile cracks that are commonly recognized in most crystalline rocks and which are responsible for dilatancy (e.g. David et al. 2018). Microstructural observation of these samples recovered after deformation demonstrated that crack damage was limited to the immediate vicinity of the fracture zones, while the regions apart from the shear zones remained nominally undeformed and hence indistinguishable from the starting materials. By combining these data, the fracture strength of gabbro can be weakened by the small amounts of hydration products such as serpentine and chlorite, because the deformation is accommodated primarily by these mechanically weak phyllosilicate minerals (Escartín et al. 1997, Moore & Lockner 2004). Since these hydration minerals are commonly recognized in gabbroic crustal rocks at the various tectonic settings, including mid-ocean ridges and subducting oceanic plates, hydration of gabbro can weaken the oceanic crust and promote further deformation in such regions.

Keywords: Gabbro, Hydrothermal alteration, Brittle deformation, Elastic wave velocity, Serpentine, Chlorite