Brittle-ductile transition of serpentinites

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Geophysical observations, numerical simulation of thermal structures in subduction zones, and phase analysis of hydrous minerals suggest that and subducting slabs and the wedge mantle are partly serpentinized. In this paper, we briefly review the rheological properties of serpentine and discuss future strategies of laboratory works. Based on friction tests of serpentine gouge, serpentinite has been suggested as a cause of aseismic creep of weak fault zones and a lubricant of thrust faults at plate boundaries. The frictional coefficient of crysotile, a low-temperature phase of serpentine stable up to 250 ^{o}C, was found to be 0.2 at room temperature, which is significantly weaker than ordinary rock types such as granite and dunite. However, frictional strength of other polymorphs (i.e., lizardite and antigorite) are not substantially smaller than that of granite. The strength of crysotile also increases at greater depths (e.g., Moore et a., 1996, *Geology*). It is not evident if aseismic plate boundaries just below the high Vp/Vs anomaly zones can be simply explained by the existence of serpentinized wedge mantle. Verification of the strength of serpentine minerals at pressure around 1 GPa, corresponding to the depth of the Moho, is essential to answer this question. However, the confining pressure (Pc) generated in triaxial testing machines using gas or liquid confining medium is generally restricted within 0.5 GPa. Griggs-type deformation apparatus can be used at higher pressure conditions up to 3 GPa, but mechanical data are not accurately acquired because of internal friction between pistons and solid confining medium.

Recently, a multianvil device named Deformation DIA (D-DIA) was introduced to the study of rheology of minerals at ultra high-pressures. Using D-DIA, Hilairet et al. (2007, *Science*) determined stress-strain curves of antigorite at 1 GPa and 4 GPa pressure. Based on temperature dependence of differential stress and stress exponents, they discussed that the deformation mechanism of antigorite change with increasing pressure, from frictional behaviors to glide-controlled dislocation creep (the Peierls mechanism) at 1 GPa, and to recovery-controlled dislocation creep at 4 GPa. They also suggested that antigorite is considerably weaker than olivine at these PT conditions. However, their creep laws should be carefully evaluated because differential stress is indirectly determined from anisotropy in spacing of the crystallographic planes.

Alternatively, we use solid-medium deformation apparatus of the Kumazawa-type to explore the brittle-ductile transition behavior of serpentinite. For accurate determine differential stress, the Kumazawa-type apparatus is designed to monitor and correct internal friction in the solid cell during deformation. The original Kumazawa apparatus (MK65S), developed at Nagoya University in 1965, enables us to deform samples at the PT conditions close to Moho (Kumazawa and Shimizu, 2006, *Japan J. Struct. Geol.*, No. 49, 5-14; Shimizu et al., 2006, *Japan J. Struct. Geol.*, No. 49, 15-26). A modified Kumazawa-type apparatus is developed at the University of Tokyo. The new apparatus generates Pc up to 2GPa (corresponding to 60 km depth) and axial stress up to 4GPa. Preliminary results at 0.8 GPa confining pressure suggests that the strength of antigorite is much larger than that proposed by Hilairet et al. (2007). Our data are consistent with those of Raleigh and Paterson (1965, *JGR*) obtained by gas apparatus at lower Pc (up to 0.5 GPa).