Influence of Si-metasomatism on slab-mantle interface rheology

Ken-ichi Hirauchi1,*, Sabine den Hartog2, Christopher Spiers2

1 Graduate School of Human and Environmental Studies, Kyoto University, 2Faculty of Geosciences, Utrecht University

Aqueous fluids liberated during dehydration of the subducting slab cause hydration of the overlying forearc mantle wedge, changing the mechanical properties of the slab-mantle interface. Antigorite, a high-temperature serpentine mineral, is expected to be the main hydrous mineral present in the forearc wedge, while slab-derived fluids are likely to contain significant amounts of dissolved silica, leading to Si-metasomatism and replacement of antigorite by talc. However, it remains unclear how the strength and internal structure of antigorite-rich rocks evolve in the presence of reacting silica-rich fluids.

To determine the effect of Si-metasomatism on the rheological properties of antigorite, we performed a series of frictional sliding experiments on 100% antigorite, 100% talc and antigorite (70%) plus quartz (30%) gouges under hydrothermal conditions, using a ring shear machine. The pure antigorite and talc gouges showed steady-state shearing at a friction coefficient of 0.63 and 0.21, respectively. In contrast, the antigorite/quartz (atg/qtz) gouges exhibited a peak friction coefficient of 0.40-0.62 followed by strain weakening towards a quasi-steady-state strength with the friction coefficient of 0.25-0.47. The degree of weakening of atg/qtz relative to pure antigorite increased with increasing temperature and decreasing sliding velocity. The weakening was mainly due to the development of through-going, talc-bearing boundary shears, which widened until the steady-state sliding was attained.

Our experiments indicate that in the lowermost part of the forearc wedge, where silica-saturated fluids infiltrate from the dehydrating slab, metasomatically produced talc slip surfaces or shear bands will form in the intensely sheared plate interface, causing a much larger weakening effect than expected for antigorite, even if the total amount of talc formed is minor (<10 vol%).

Keywords: antigorite, fluids, mantle wedge, metasomatism, subduction zone, talc