Stress in the Sanbagawa metamorphic belt estimated from flow laws of quartz: influence of water fugacity

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Strength of the continental lithosphere has been extensively studied, but little is known about stress states in subduction zones. At deep parts of subduction zones, shear deformation on the plate interface would be localized within the oceanic crust layer, especially within the siliceous sedimentary layer, which is undergoing high pressure metamorphism. Thus plastic deformation of quartz is a key to understand stress states on the subducting plate interface. Herein we extrapolate laboratory-based dislocation creep flow laws of quartz to high pressure and temperature (PT) conditions of the Sanbagawa metamorphic belt and constrain stress fields in the Cretaceous subduction zone in southwest Japan.

Flow law parameters of quartz determined in laboratories varies with water content, confining pressures, and the initial grain size. The influence of confining pressures on dislocation creep of quartz has been understood in terms of water fugacity; high water fugacity leads to large concentrations of water defects, which are the cause of water weakening effects. However, whether or not the equilibrium concentration of water defects was attained during high PT metamorphism remains unsolved. Previous infrared (IR) spectroscopic studies of water in quartz schists taken from the Asemi-gawa root in the Sanbagawa metamorphic belt demonstrated that the amounts of non-structured water decrease with increasing metamorphic grades (Nakashima et al., 1995). They suggested that fine-grained siliceous sedimentary rocks, such as chert, gradually released water during prograde metamorphism. We also made IR analysis of water in quartz schists taken from the same area but with more detailed mapping analysis. The amounts of water in mica-poor parts of quartz aggregates in the chlorite and garnet zones were far smaller than previously reported values, and showed no systematic changes with metamorphic grades. To evaluate flow stress at the time of peak metamorphism, we postulated that equilibrium concentrations of water defects were attained even in the lowest metamorphic grade zone, and applied dislocation creep flow laws of wet quartz (Luan and Paterson, 1992) with water fugacity correction.

Paleostress in the Sanbagawa belt was also estimated using grain size piezometers of quartz. The grain size of quartz was measured by the electron back-scattered diffraction (EBSD) mapping method (Ueda & Shimizu, 2017, *JpGU*). The differential stresses derived from theoretically calibrated grain size piezometers (Shimizu, 2012; Shimizu and Ueda, in prep.) were within reasonable agreement with the dislocation creep model, whereas direct application of the experimental piezometers gives considerably smaller estimates.

References

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