Quartz and K-Feldspar Microboudins in Felsic Granulites: Evidence of Rheological Turnover and Implications to Weak Lower Continental Crust

*Bhathiya Madhura Bandara Athurupana[1], Jun Muto[1], Jun-ichi Fukuda[2], Hiroyuki Nagahama[1], Toshiro Nagase[1]

1. Department of Earth Science, Tohoku University, 2. Department of Earth and Planetary Science, Tokyo University

Quartz and feldspar are the major mineral constituents in quartzofeldspathic rocks abundant in the lower continental crust. Rheology of the lower continental crust is a vital aspect in Earth's dynamics. Deformation experiments and microstructural observations on naturally deformed rocks are the major ways to study the rheology of those mineral constituents to illuminate the rheology of the lower crust. We carried out microstructural observations of quartz and K-feldspar in quartzofeldspathic gneiss (QFG) samples from the Highland Complex of Sri Lanka. The Sri Lankan terrain is a lower crustal exposure of East Gondwana and it has undergone granulite facies metamorphism with multiphase ductile deformation. The QFG samples contain two sets of deformation microstructures (Athurupana et al., 2014). The first set is quartz ribbons, K-feldspar boudins in quartz ribbons, and dynamically recrystallized K-feldspar in the matrix. The second set is quartz boudins in K-feldspar matrix and exsolution microstructures of K-feldspar. The observed microstructures represent two high temperature (>450˚C) deformation events occurred at different times in the metamorphic history. The first set of microstructures belongs to a deformation event occurred on the prograde path before peak metamorphism. The second set of microstructures belongs to a deformation event occurred during the retrograde decompression cooling path.
Both quartz and K-feldspar domains show the formation of microboudins in QFG samples. Microboudins shapes represent viscosity contrast, large viscosity contrast causes rigid separation by fracture while low contrast cause for the formation of pinch and swell structures. Regarding crystal plasticity, quartz is weaker than feldspar in a wide range of crustal conditions (>400˚C). The K-feldspar microboudins in quartz manifest such general rheological behavior, which is visible in experimental studies and naturally deformed samples. Conversely, the formation of quartz microboudins in K-feldspar matrix indicates rheological turnover during the second deformation event. Both K-feldspar and quartz microboudins show necking related separation and it indicates moderate to low viscosity contrast. Especially, the K-feldspar boudins show much lower viscosity contrast to quartz ribbons. It would be a result of the weakening of K-feldspar by thermally activated creep processes related with the K-feldspar phase mixing on the prograde path. The rheological turnover during the second deformation is a result of the significant weakening of matrix K-feldspar. Exsolution microstructures indicate a ductility enhancement of K-feldspar due to the cryptoperthite formation (coherent spinodal decomposition) on the retrograde cooling path (Athurupana et al., 2016). The coherent spinodal decomposition enhances the rate of dislocation climb in K-feldspar. In addition, primarily coarsened (coarsening during spinodal decomposition) cryptoperthite lamellae form subgrain walls within K-feldspar grains. Such dynamic processes can cause a significant weakening in K-feldspar during fast syntectonic cooling. This microscopic weakening of K-feldspar allows QFG to maintain low bulk strength and accommodate large strains in ductile manner. Finally, the rheological turnover in QFG samples provides some implications to the weak lower continental crust where QFG are the dominant suits of rocks.

Reference

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