Stress states in the deep part of subduction megathrust estimated from dynamically recrystallized grain size and dislocation creep flow laws of quartz

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Strength of the continental lithosphere has been extensively studied, but little is known about stress states in subduction zone megathrusts. In this paper, we estimate paleo-stress in a Cretaceous subduction zone of the Sanbagawa belt in southwest Japan, using grain size piezometers and dislocation creep flow laws of quartz.

Laboratory studies showed that recrystallized grain size in dislocation creep is primarily controlled by the applied stress but physical basis of the piezometric relations is still in debate. Theoretical models predict that the steady-state grain size in dynamic recrystallization (DRX) is not only dependent on stress, but also on temperature. The common idea among existing theories is that competition between grain-boundary formation, and grain growth determines the steady-state grain size. For grain growth, grain boundary migration driven by strain-energy (ρGBM), or that driven by surface-energy (γGBM), have been considered. Both processes result in overall coarsening, but in the case of ρGBM, strain-free small grains grow with the expense of larger deformed grains, while in γGBM, small grains shrink and larger grains grow. A simple nucleation-and-growth model with ρGBM produces a left-skewed distribution on a section that is approximated by a log-normal distribution with a single scaling parameter, *dc* (Shimizu, 1999). In addition to subgrain rotation (SGR) nucleation and grain growth by ρGBM, surface-energy drags were also taken into account in the revised theoretical piezometer (Shimizu, 2012).

We analyzed microstructures of quartz schists (meta-chert) taken from the Asemi-gawa root, central Shikoku. The grain size of quartz was measured by tracing grain boundaries on microphotographs and by mapping crystallographic orientations using the electron back-scattered diffraction (EBSD) method (Ueda & Shimizu, 2016, JpGU). Observed grain size distributions (GSDs), which were characterized by increasing numbers with decreasing grain size, were far different from bell-shaped distributions known for static grain growth driven by surface energy, and more like the theoretical distribution derived for the nucleation-and-ρGBM model.

To estimate differential stress, we applied the revised theoretical piezometer (Shimizu, 2012) assuming that the grain size at the largest volume fraction corresponds to *dc*. The paleo-stress estimates were also done by extrapolating dislocation flow law of wet quartz to the peak metamorphic temperatures. Preliminary results obtained for the sample in the garnet zone (ca. 500 ^{o}C) were within reasonable agreement with the dislocation creep model, whereas direct application of the experimental piezometer proposed by Stipp and Tullis (2003), re-calibrated by Holyoke & Kronenberg (2010), gives considerably smaller estimates.

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Keywords: differential stress, dynamic recrystallization, dislocation creep , grain size distribution, quartz, Sanbagawa metamorphic belt

