Grain size distribution of quartz in the Sanbagawa metamorphic belt analyzed by the electron back-scattered diffraction (EBSD) method

*Tadamasa Ueda[1], Ichiko Shimizu[1]

1.Department ofEarth and Planetary Science, Graduate School of Science, The University of Tokyo

The size of dynamically recrystallized grains in naturally deformed rocks has been used for paleostress estimates. However, the meanings of the “average” grain size in previous piezometeric studies (e.g. Stipp and Tullis, 2003) often have two large problems. One is derived from difficulty in distinguishing grains and subgrains under an optical microscope, and the other is unclarity about what is the appropriate definition of the “average” grain size (e.g., the arithmetic mean, the root mean square). Different definitions could yield different stress estimates.
We measured grain size of quartz by optical microscopy and electron back-scattered diffraction (EBSD) mapping. In the optical method, grain boundaries were manually traced on photomicrographs according to the difference in extinction angles and analyzed by an image processing software. In the EBSD analyses, the grain boundaries with the misorientation angles exceeding 12° were automatically detected based on the Euler angles of the crystal lattice orientation. EBSD mapping was conducted with changing step size, 0.5, 1, 2, and 8 microns. The size of each grain was defined as the diameter of the equivalent circle.
We analyzed microstructures of a quartz schist in the garnet zone of the Sanbagawa metamorphic belt, which was taken from the Asemi-gawa area, Shikoku Island, Japan. Under an optical microscope, large quartz grains show oblique shape fabric and intracrystalline deformation features, and small quartz grains are formed at the margins of large quartz grains.
The grain size distributions quantified by the optical analysis and EBSD showed severely right skewed shapes. Hence, different definitions of representative grain size yielded quite different values. The distributions are far different from the bell-shape distribution known for static grain growth. Right skewed distributions can be produced by a simple nucleation-and-growth model (Shimizu, 1999, Phil. Mag.). The modes of the distributions vary with methods and step sizes, ranging from ~10 to ~50 μm. Because the mode was not well defined, we used, as the representative value, the class of grain size occupying the largest area in each mapped area, which can be related to the length scale in the nucleation-and-growth model of Shimizu (1999) and is robust because it reflects measurements of large grains. In the result, this value ranges from 110 to 120 microns. Using a revised theoretical grain size piezometer (Shimizu and Ueda, 2016, JpGU), which takes temperature dependence into account, and the temperature estimate of the sampling locality (516.4°C; Bayssac et al., 2002), the differential stress is 29 and 62 MPa, assuming intracrystalline recrystallization and marginal recrystallization, respectively. These stresses are higher than that given by the empirical piezometer of Holyoke and Kronenberg (2010) (17 MPa), which uses the root mean square as the representative grain size and does not take the temperature effect into account. We will show results from quartz schists of other zones of the Sanbagawa metamorphic belt.

References:

Holyoke C. W., Kronenberg A. K., 2010, Tectonophysics, v494, p17
Shimizu, I., 1999. A stochastic model of grain size distribution during dynamic recrystallization., Philosophical Magazine A79, 1217–1231.
Stipp M., Tullis J., 2003, GRL, v30, no.21, 2088

Keywords: quartz, recrystallized grain size piezometer, Sanbagawa metamorphic belt

