Microstructures and misorientation analysis of quartz in the Sanbagawa metamorphic belt, Shikoku, Japan

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It was previously revealed that quartz grains in the Sanbagawa metamorphic belt show microstructures of subgrain rotation and strain-driven grain migration irrespective of metamorphic grades along Asemi river route (Ueda and Shimizu, 2018 JpGU). This study scrutinized intracrystalline misorientation of quartz to investigate the subgrain rotation process in the schists, using electron back-scattered diffraction (EBSD) maps obtained by the previous study.

To extract boundaries in single grains from the total data set, the misorientation analysis was conducted by making data sets of grains that are larger than about 9 times the mapping step sizes and are not in contact with each other. The grain detection before this procedure was conducted with 12° threshold excluding dauphine-twin boundaries. Such extraction of grains was conducted for a few times for each thin section so that the sum of the data sets covers most (>~80% in area) of indexed quartz grains and no quartz grain is duplicated in the data sets. To eliminate boundaries arising from dauphine-twin-type misindexed grains, the grains smaller than 5 times the mapping step sizes that occur in grain detection without excluding dauphine-twin boundaries were excluded from the data set.

Samples showed the following features irrespective of metamorphic grades. Misorientation angle distributions show two peaks; one is at low angles (<10°) and the other is at 60°. Boundaries with 30-40° misorientation are nearly absent and those with >65° misorientation are absent. The frequency of misorientation gradually decreases from low angle to ~30°, gradually increases from ~45° to 60°, and rapidly decreases above 60°. In the crystal coordinate system, misorientation axis distributions of <~12° misorientation show weak concentration about c-axis and do not show concentration about the pole to the m planes, even though most samples show c-axis concentration subnormal to the foliation. Compared to the concentration of low-angle misorientation axis about c-axis, misorientation axis distributions of ~15-40° generally show concentration off the c-axis direction. Misorientation axis distributions of 45-65° show strong concentration at the direction of c-axis. Grains with c-axis nearly normal to the foliation show weaker concentration of misorientation axis of low-angle boundaries about c-axis than grains with c-axis parallel to the foliation and perpendicular to the lineation, but general characteristics of misorientation in crystal coordinate system are similar. In the sample coordinate system, misorientation axis distribution of <~12° show weak concentration about the direction parallel to the foliation and perpendicular to the lineation for samples in which flattened planes of quartz grains are subparallel to the foliation. For samples in which flattened planes of quartz are at high angle (>~45°) to the foliation, misorientation axes of <~12° are weakly concentrated about the direction subparallel to the quartz flattening plane and perpendicular to the lineation.

The misorientation angle distributions and misorientation axis distributions indicate that the misorientation of boundaries formed solely by subgrain rotation is less than ~40° and high angle boundaries of ~45-60° are formed by the combination of dauphine twinning and subgrain rotation. The weak concentration of misorientation axes about c-axis for low angle boundaries, which implies prism-a slip, is enigmatic, considering most samples show c-axis concentration nearly perpendicular to the foliation, which is generally interpreted as basal-a slip. However, the coexistence of the misorientation feature and c-axis fabric may be justified, considering that subgrain boundaries are annealed dislocation structures and that most dislocations in crystals suffering steady-state deformation are generally supposed to be forest dislocations. Misorientation axis of subgrain boundaries may indicate rather subsidiary slip systems than main ones.

Keywords: Quartz, Dislocation creep, EBSD, Subgrain rotation, Sanbagawa metamorphic belt, Misorientation analysis