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Grain-size-reduction process of K-feldspar and change in its deformation mechanism under mid-crustal condition

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The deformation mechanism of individual minerals and mineral aggregates, which constitute the crust, is the most important factor in determining crustal strength. Feldspar is a major constituent of crustal rocks, and in combination with quartz, commonly forms the load-bearing framework of such rocks. Grain-size reduction of feldspar, an important process that controls the rheology of the crust, is governed by fragmentation, dynamic recrystallization, the myrmekite-forming reaction, and dissolution-precipitation. Such processes produce fine-grained feldspar with grain sizes in the order of micrometers. The deformation mechanism of such fine grains can be determined by EBSD analysis. In an analysis of granitoid mylonites deformed under greenschist-facies conditions, Ishii et al. (2007) concluded that fine-grained K-feldspar aggregates were deformed by dislocation creep, whereas Menegon et al. (2008), reported that dissolution-precipitation creep was dominant. There are few reports on this topic, and the rheological behavior of K-feldspar aggregates under conditions of the middle-upper crust remains unclear.
In this study, we used electron-backscattered diffraction (EBSD) to measure the crystal preferred orientations (CPOs) of K-feldspar grains in granitoid mylonites from a ductile shear zone within the Ryoke metamorphic belt, SW Japan, which was deformed under greenschist-facies conditions. The mylonite consists mainly of quartz, plagioclase, fine-grained K-feldspar (around 30 um in size), and K-feldspar porphyroclasts (up to 2 mm in size). Fine-grained K-feldspar in the matrix is rounded or subrounded. Fine-grained K-feldspar (up to 50 um in size) also occurs between the separated fragments of individual K-feldspar porphyroclasts (pull-apart areas), where it is commonly elongate and oriented parallel to the displacement direction of the porphyroclast fragments, oblique to the mylonitic foliation in the matrix. This fine-grained K-feldspar within pull-apart areas shows distinct CPOs patterns that indicate deformation by dislocation creep. Grain-size reduction of large K-feldspar porphyroclasts was accompanied by subgrain rotation recrystallization. In contrast, fine-grained K-feldspar in the matrix shows no CPO. These observations, coupled with microstructural observations, indicate that the deformation mechanism in the matrix was grain-size-sensitive flow (diffusion creep). In conclusion, large K-feldspar porphyroclasts were initially deformed by dislocation creep with subgrain rotation until the grain size of recrystallized aggregates became sufficiently small that it favored diffusion creep.

Keywords: granite, K-feldspar, grain size reduction, dislocation creep, diffusion creep, mid-crustal condition