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Rheology of lower crustal fault rocks: an example of the Pankenushi gabbro mylonite

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The Pankenushi gabbro in the Hidaka metamorphic belt of central Hokkaido is mylonitized along its western margin (Toyoshima, 1994, 1998). The gabbro mylonite contains porphyroclasts (0.3-1.5 mm) of orthopyroxene, clinopyroxene and plagioclase in matrix of monomineralic plagioclase aggregate (0.05-0.15 mm) and fine-grained polymineralic aggregate (smaller than 0.03 mm) of orthopyroxene, clinopyroxene, hornblende, quartz and ilmenite. Alternating ribbons of plagioclase aggregate and elongate lenses of fine-grained polymineralic aggregate characterize NNW-trending, subvertical mylonitic foliation, while elongate pyroxene porphyroclasts and chains of fine-grained polymineralic aggregates derived from their mantles characterize subhorizontal mylonitic lineation. Both asymmetric pyroxene-porphyroclast mantles with respect to mylonitic foliation and shape-preferred orientation of plagioclase grains oblique to ribbons indicate a dextral sense of shear. The gabbro ultramylonite contains a few pyroxene porphyroclasts (0.1-0.5 mm) in fine-grained polymineralic matrix (smaller than 0.02 mm) of plagioclase, orthopyroxene, clinopyroxene, biotite, hornblende, quartz and ilmenite. Orthopyroxene porphyroclasts are elongate with aspect ratios up to 16. In fine-grained polymineralic matrix, grains other than plagioclase are rather homogeneously dispersed in plagioclase aggregate.

Plagioclase grains in ribbons are dynamically recrystallized mainly by subgrain rotation as indicated by well developed subgrains and core-and-mantle structure of porphyroclasts. In contrast, fine-grained pyroxenes in pyroxene-porphyroclast mantles with chemical compositions different from those of porphyroclast pyroxenes as well as their presence with hornblende and quartz suggest that the porphyroclast mantles and fine-grained polymineralic aggregates derived from them are composed of the products of a decomposition reaction of pyroxene porphyroclasts, i.e. a retrograde reaction from granulite facies to amphibolite facies. Application of two-pyroxene thermometry of Lindsley (1983) to the porphyroclast-mantle pyroxenes assuming a pressure of 500 MPa estimated for the adjacent gneisses yields ca. 600 degrees Celsius. Thus the Pankenushi gabbro mylonite has been likely developed through dynamic recrystallization of plagioclase and a decomposition reaction of two pyroxenes at a pressure of ca. 500 MPa and a temperature of ca. 600 degrees Celsius.

EBSD analyses of plagioclase crystallographic orientations reveal (001) alignment subparallel to mylonitic foliation and [110] concentration subparallel to lineation in both mylonite and ultramylonite, suggesting dominant [110](001) slip in plagioclase. The maxima of (001) pole and [110] anticlockwise oblique to the foliation pole and lineation, respectively, also indicate a dextral sense of shear. Such plagioclase crystallographic preferred orientations together with microstructural evidence for dynamic recrystallization indicate that plagioclase in both mylonite and ultramylonite is deformed by dislocation creep. In contrast, EBSD analyses reveal that crystallographic orientations of orthopyroxene and clinopyroxene in fine-grained polymineralic aggregate in the mylonite and those in fine-grained polymineralic ultramylonite matrix are almost random. This together with lack of microstructural evidence for crystal plastic deformation suggests that these two pyroxenes originated from reaction products are deformed by grain boundary sliding. Lenses of fine-grained polymineralic aggregate in the mylonite and grains other than plagioclase in the ultramylonite matrix are isolated in plagioclase aggregate. Thus plagioclase forms a stress-supporting network in both mylonite and ultramylonite, and their rheology is likely controlled by plagioclase deforming by dislocation creep, not by reaction products including fine-grained pyroxenes deforming by grain boundary sliding.