Microstructures and quartz c-axis fabrics in granitic protomylonite from the Median Tectonic Line fault zone, Mie Prefecture, south-west Japan

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During major orogenic events, the conditions and mechanisms of deformation play an important role in their development. Deformation conditions and histories can be obtained from various microstructures in constituting mineral phases of deformed rocks. Among them, quartz c-axis fabrics in quartz-rich tectonites are the very useful indicators. In this study, we will report microstructures and quartz c-axis fabrics from granitic protomylonite to mylonite, which occur along the Median Tectonic Line (MTL), Mie Prefecture, south-west Japan, and infer deformation conditions and histories during the development of the MTL.
The MTL is a major strike slip fault system with the largest structural break in southwestern Japan that has been defined as the boundary fault between Sambagawa metamorphic rocks and Ryoke granitic and metamorphic rocks. Protomylonite in the MTL was derived from granitoids in the Ryoke belt in the latest Cretaceous called the Kashio phase, before the MTL was formed as the boundary fault during the exhumation of the Sambagawa metamorphic rocks at 63-58Ma (Kubota and Takeshita, 2008).
Protomylonite from the MTL, which suffered cataclasis to a certain degree, consists of quartz ribbons and feldspar porphyroclasts in a matrix consisting of finely-crushed quartz and feldspar porphyroclasts, chloritized mafic minerals, muscovite altered from plagioclase, and calcite veins. The feldspar porphyroclasts show many extension fractures with $\sigma 1$ being perpendicular to the foliation. Some of the feldspar porphyroclasts are decorated by recrystallized feldspar grains along grain boundaries. The quartz ribbons are large and strongly flattened relic grains showing undulatory extinction, deformation lamellae, and fluid inclusion arrays, surrounded by very-fine recrystallized quartz grains indicating buldging recrystallization (Stipp et al., 2002). Type III and type IV deformation twin of calcite (Burkhard, 1990) dominate in the calcite veins.
The c-axis orientation distribution of large quartz grains was measured by a scanning electron microscope (SEM; JEOL JSM6390A) equipped with an electron backscatter diffraction (EBSD) detector, which mostly shows a Y maximum with type II crossed girdles indicating dominant operation of prism {10-10} slip system and a type I crossed girdle pattern with r-maxima for a small number of samples indicating the dominant operation of rhomb {1011} slip (Tullis, 1977; Lister and Hobbs, 1980; Schmid and Casey, 1986; Law, 1990; Heilbronner and Tullis, 2002; Takeshita et al. 1999; Okudaira et al. 1995).
The crystallographic orientation map of recrystallized quartz grain, which was measured by the EBSD mapping with step size of 1 micrometer, illustrated many subgrain boundaries and small recrystallized grains surrounded by larger recrystallized grains, suggesting a strong overprinting recrystallization at higher differential stresses. Two groups of recrystallized quartz grain occur in the protomylonite samples: the larger and the smaller recrystallized quartz grains with the size of approximately 70 micrometer and 10 micrometer, respectively. Further, several sizes of dynamically recrystallized fine-grained quartz are observed at the peaks of approximately 20 micrometer and 45 micrometer.
The Y-max quartz c-axis fabric associated with the coarse-grained recrystallized quartz (70 micrometer) could indicatite the deformation temperatures in protomylonite samples around intermediate temperatures (400-500 ^{o}C), whereas the fined-grained recrystallized quartz (10 micrometer) could have formed at temperatures of 300-400 ^{o}C based on the paleostress estimation from recrystallized quartz grain size (e.g. Stipp and Tullis, 2003) and constitutive equations of flow in quartz aggregates (e.g.

Gleason and Tullis, 1995). Thus, overprinting deformation could have occurred in these protomylonites along the MTL, represented by the reduction of recrystallized quartz grain size from c. 70 micrometer to c. 10 micrometer with several peak sizes of dynamically recrystallized fine-grained quartz. This overprinting deformation could have occurred heterogeneously in both spatial and temporal development during the exhumation of protomylonite along the MTL.

Keywords: Microstructures, Quartz c-axis fabrics , Protomylonite, The MTL