CHAPTER 7

MICROSTRUCTURAL STUDY

Microstructural studies were carried out on mylonitic rocks which are exposed at the N-S trending ductile shear zone and E-W trending RSZ (Fig. 7.1). Additionally, the microstructural characters of the pseudotachylite veins associated with the mylonitic rocks of the RSZ were also examined. This collective approach helped to constrain the evolutionary history of the shear zones present at the study area.

7.1 Methodology

Before microstructural analyses, oriented samples of the migmatitic felsic gneiss (samples PH 10GM4 and PLB 21) from both the shear zones were collected and subsequently cut parallel to the stretching lineation and the mylonitic foliation to obtain the XZ sections of strain ellipsoid. Microstructural information was obtained in polarizing microscope using these XZ sections. Subsequently, quartz grains from the two samples of the migmatitic felsic gneiss from N-S trending ductile shear zone and one sample of the migmatitic felsic gneiss from the RSZ were analyzed for EBSD patterns using the Nordlys system attached to scanning electron microscope JEOL JSM6390A at Department of Earth and Planetary Systems Sciences, Hiroshima University, Japan with accelerating voltage of 15 KV and sample tilt of 70°. Data were processed using HKL Channel 5.0 software package. The crystallographic preferred orientation (CPO) data obtained from the EBSD analyses are represented as pole figures in equal area stereographic diagrams of the lower hemisphere with the trace of the mylonitic foliation (S) and stretching lineation (L) as reference directions.

7.2 Microstructural study from the N-S trending ductile shear zone

The mylonitic fabric (S_{4S}) of the N-S trending ductile shear zone which resulted from the $D_{4'}$ deformation is dominantly defined by recrystallized K-feldspar and retrograded biotite±sillimanite-bearing assemblage in the aluminous granulite, migmatitic felsic gneiss and the coarse-grained charnockite (Figs. 7.2a, b). K-feldspar grains of these rocks are stretched parallel to the mylonitic foliation (S_{4S}) and surrounded by fine recrystallized grains formed by grain boundary migration which produced core and mantle microstructure (Fig. 7.2c). It is important to mention that the plagioclase grains present along the S_{4S} mylonitic fabric are not plastically deformed and sometimes are fractured (Fig. 5.1q). S-C fabric is common in XZ sections of these mylonitic rocks and it gives sinistral shear sense if looked from south (Fig. 7.2d). The C fabric is found to be parallel to the mylonitic foliation (S_{4S}) and S fabric occurs obliquely with the former. While the C fabric is defined by the biotite-bearing assemblage, the S fabric is defined by elongated quartz grains which are dominantly deformed by subgrain rotation recrystallization but minor occurrences of quartz grains deformed by high-temperature grain boundary migration are also noteworthy. Quartz grains which have deformed by subgrain rotation recrystallization are notably equidimensional.

7.3 Microstructural study from Ranipathar shear zone (RSZ)

The mylonitic fabric (S_{5S}) which is present at RSZ is the result of D_5 deformation. This mylonitic fabric (S_{5S}) is defined by dynamically recrystallized quartz and feldspar grains in the migmatitic felsic gneiss, felsic augen gneiss, aluminous granulite and the coarse-grained charnockite (Fig. 7.3a). Mafic granulite having such mylonitic foliation is deformed by recrystallized clinopyroxene and plagioclase grains (Fig. 7.3b). In the migmatitic felsic gneiss, felsic augen gneiss, aluminous granulite and the coarse-grained charnockite, quartz grains dominantly form ribbons (Fig. 7.3c). Occurring parallel to the mylonitic foliation (S_{5S}), these ribbons are composed of polycrystalline quartz grains and frequently wrap around the garnet and K-feldspar porphyroclasts. In most cases, individual quartz grains of the ribbons shows straight grain contacts with the adjacent quartz grains and subgrain boundaries are notably absent within the grains (Fig. 7.3d). Locally, quartz grains of the ribbons are deformed by high-temperature grain boundary migration (Fig. 7.3e). Such ribbons are separated by feldspar-rich domains where quartz grains are completely absent. These feldspar-rich domains are characterized by recrystallized K-feldspar and plagioclase grains which are deformed by grain boundary migration (Fig. 7.3f). Garnet grains of the migmatitic felsic gneiss, felsic augen gneiss and the aluminous granulite are brecciated which produced angular clasts (Fig. 7.3g, h).

The pseudotachylite veins are dominantly associated with the mylonitic rocks of RSZ and have typical features that confirm about the melt origin of the same. Of these, the presence of chilled margins at the contacts between the pseudotachylite veins and the pre-existing S_{5S} mylonitic fabric (Fig. 7.3i) conclusively proves the presence of a melt phase and rapid crystallization of the same. Within such veins, the grain size of the matrix gradually becomes larger towards the center (Fig. 7.3i). Elliptical fragments of the mylonite clasts within the pseudotachylite matrix are also common (Fig. 7.3j). The pseudotachylite matrix is dark colored and dominantly composed of fine-grained quartz and feldspar but tiny microlites of other phases like garnet and ilmenite are also common (Fig. 7.3k). These microlites are notably fern shaped implying rapid crystallization from a melt phase immediately after their formation. Quartz and feldspar grains within the pseudotachylite matrix are fine (approximately up to 20 μm) and have diffused grain boundaries (Fig. 7.3l). It is important to note that, in most instances, the pseudotachylite matrix appears to be deformed and characterized by stretched mylonitic clasts and stretched garnet and ilmenite microlites (Fig. 7.3m). Clasts of older pseudotachylite are also present within later generated pseudotachylite veins (Fig. 7.3n). Individual minerals (e.g. quartz, K-feldspar and sillimanite) present within these older pseudotachylite clasts are sub-rounded implying corrosion by a melt phase subsequent to their formation (Lin, 2008).

7.4 Crystallographic preferred orientation (CPO) development

Photomicrograph, band contrast image and related CPO data of the quartz grains which are parallel to the S fabric of the migmatitic felsic gneiss of N-S trending ductile shear zone are shown in figures 7.4a, b, c and d. In the band contrast image (Fig. 7.4b), the boundaries of the equidimensional quartz grains are very prominent and individual grains have large misorientations (greater than 10º) relative to the adjacent grains which suggest that subgrain rotation recrystallization of the quartz grains leading to the development of equidimensional new grains. The c-axis pole figures of the quartz grains of the migmatitic felsic gneiss samples consistently have maxima near the center (Fig. 7.4c) which indicate dominant deformation by dislocation creep on prism<a> slip. However, maxima located more towards the periphery of the c-axis pole figure (Fig. 7.4d) is also present which is indicative of the presence of rhomb<a> slip on a local scale. This is indicative of deformation temperature around 550ºC (Stipp et al., 2002).

Photomicrograph, band contrast image and related CPO data of the quartz grains which belong to the ribbons present within the migmatitic felsic gneiss of the RSZ are shown in figures 7.4 e, f, g and h. In the band contrast image (Fig. 7.4f), subgrain boundaries are notably low within the quartz grains which have straight grain boundaries. The c-axis pole figure of such quartz grains dominantly shows maxima near the center (Fig. 7.4g) which indicates deformation by dislocation creep on prism<a> slip. This implies the deformation by crystal-plastic processes occurred at high temperature condition (approximately 700ºC; Hippertt et al., 2001). The c-axis of the quartz grains which are deformed by grain boundary migration are clustered in the center but have a more diffused pattern (Fig. 7.4h) indicating presence of rhomb<a> slip.

7.5 Summary

1. Microstructural investigation of the quartz grains of the migmatitic felsic gneiss from the N-S trending ductile shear zone suggest dominant deformation by prism<a> and rhomb<a> slips.
2. Quartz ribbons which are present parallel to the mylonitic foliation (S_{5S}) of RSZ indicate its development by crystal-plastic processes at high temperature condition. Dominance of prism<a> slip in the quartz grains which belong to the ribbons also corroborates the above possibility.
3. Deformation thermometry reveals that the shear zones present at the study area possibly developed at amphibolite facies condition.
4. Microstructures preserved in pseudotachylite veins indicate its origin by melt crystallization following development of mylonititic rocks at RSZ. Deformed pseudotachylite matrix suggests at least one stage of deformation after pseudotachylite formation during reactivation of RSZ.