Development of shear zones in the lower crust: Eidsfjord shear zone, northern Norway

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Mode of occurrence and deformation mechanism of shear zones developed in the lower crust are crucial to understand the rheological properties and generation mechanisms of inland earthquakes of the continental crust. We studied the mode of occurrence of shear zones and collected many rock samples, including cataclasite, mylonites and pseudotachylytes in Langøya, Lofoten Islands, northern Norway. According to the previous studies (e.g. Markl 1998, Plattner et al. 2003; Steltenpohl et al. 2011), this area includes a crustal-scale detachment fault (Eidsfjord shear zone) and a zone of many pseudotachylytes (Heier's zone of pseudotachylytes), and then one of the best places for clarifying the deformation process in the lower crust.
In the studied area, coarse-grained anorthosites (Eidsfjord anorthosite) and monzonites are widely exposed (Markl 1998). In these rocks, several centimeters to meters wide coarse- or fine-grained mylonites develop locally as ductile shear zones. The coarse-grained mylonites consist mainly of plagioclase (mean diameter of ~85 μm, up to 350 μm), Cl-rich amphibole, epidote, biotite, muscovite and quartz, with minor kyanite. The fine-grained mylonites are comprised of plagioclase (mean diameter of 42 μm), Cl-rich amphibole, biotite, muscovite, scapolite, garnet and quartz, with minor kyanite and apatite. Plagioclase grains in the coarse-grained mylonites slightly elongated with the aspect ratio of ~2, whereas those in the fine-grained mylonites are polygonal. In the coarse-grained mylonites, fragmented plagioclase porphyroclasts are found. Within the porphyroclasts, there are fracture zones filled with fine-grained plagioclase, suggesting that fracturing and fragmentation is a dominant process for grain-size reduction in these rocks. Anorthite contents of porphyroclastic plagioclase differ from those of matrix grains; the former has higher values than the latter. The fine-grains in the intracrystalline shear zones have the same values in An content with the host porphyroclast. Utilizing the results of the conventional thermobarometers of Kohn and Spear (1990) and Holland and Blundy (1994), pressure-temperature conditions for the formation of the metamorphic minerals during deformation are estimated to be ~700 °C and ~800 MPa. Based on the EBSD analysis, plagioclase aggregates in the matrix of the fine-grained mylonite and in the coarse-grained mylonite do not show any distinct lattice-preferred orientation (LPO), suggesting their deformation mechanism of grain-size-sensitive creep (i.e. diffusion creep or grain-boundary sliding). The results of the study imply that the deformation process to form the mylonites includes (1) fracturing and fragmentation, (2) Influx of Cl-rich fluid, (3) hydration metamorphism, and (4) grain-size-sensitive creep. Furthermore, it suggests that grain-size-sensitive creep may dominate even in relatively coarse-grained plagioclase aggregates with mean grain size of ~80 μm.
References: Holland and Blundy (1994) Contrib Mineral Petrol116:433-447; Kohn and Spear (1990) Am Mineral 75:89-96; Markl (1998) NGU Bull 434:53-75; Plattner et al. (2003) Contrib Mineral Petrol 145:316-338; Steltenpohl et al. (2011) J Struct Geol 33: 1023-1043

Keywords: Rheology of the Lower crust, Gabbroic mylonite, Deformation mechanism

