Disruption of folded porphyroclasts and grain-size reduction during mylonitization

Hugues Raimbourg[1]; Tsuyoshi Toyoshima[2]; Yuta Harima[3]; Gaku Kimura[4]

[1] Dpt. Earth Planet. Sci., Univ. Tokyo; [2] Grad. Sch. Sci. & Tech., Niigata Univ.; [3] Grad.Sch.Sci.&Tec.,Niigata Univ.; [4] Earth and Planetary Science . Inst., Univ. of Tokyo (Jamstec, IFREE)

Grain size reduction is one the principal mechanisms of rheological weakening occurring in mylonite zones and responsible for the strong localization of plastic deformation in the lower levels of the crust. We present here observations of the plastic folding affecting inherited orthopyroxene porphyroclasts in a mylonite shear zone of the Hidaka Metamorphic Belt, Hokkaido, Japan. As only one single dislocation system was active, folding resulted in lattice rotations within crystals, which we analyzed using EBSD. The symmetric geometry of folds can be reconciled with the asymmetry of the macroscopic shear stress field if the folds developed under the action of gradients in the shear applied to their long rims, which is equivalent to a compression on their tips. Orthopyroxene folds wavelength is inversely correlated with their width, in agreement with classical models of compressional folding of heterogeneous media, yielding a relatively low viscosity contrast between the plagioclase matrix and the stronger orthopyroxene porphyroclasts.

Furthermore, the observation of etched thin sections, where the thin clinopyroxene exsolutions unraveled the internal structure of the orthopyroxene porphyroclasts, showed that the plastic deformation is not homogeneous, but rather concentrated in two kinds of thin zones, whose structure varies according to their orientation with respect to host porphyroclast: (i) tilt walls perpendicular to [001] crystal direction and (ii) subgrain boundaries differently orientated. The connection of these two kinds of deformed zones led to the division of a single porphyroclast into several subgrains rotated with each other with respect to [010] direction. In addition, type (ii) subgrains boundaries proved to be exsolutions-free, in contrast with the rest of the orthopyroxene porphyroclasts, which contains abundant clinopyroxene exsolutions. Therefore, it seems that the subgrains boundary, much similarly to normal grain boundaries, enabled accelerated element transport and the diffusion of the exsolutions out of the porphyroclasts. Finally, as exsolutions can be regarded as a structural component strengthening the grain (for example by preventing dislocation climb), the interplay between formation of subgrains boundaries and the dissolution of exsolutions can be interpreted as self-enhancing processes leading to the localization of the internal plastic deformation of orthopyroxene grains within limited zones and eventually to the disruption of a single porphyroclasts into several smaller grains.