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Orthopyroxene porphyroclasts folding and disruption during mylonitization

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We present in this study evidences of plastic folding of elongated orthopyroxene porphyroclasts in a granulite-facies mylonite zone of the Hidaka Metamorphic Belt, Hokkaido, Japan. As only one single dislocation system was active, folding affected not only the external shape of the grains but also 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, using etching of previously polished thin sections, we analyzed how the folding is accommodated within the porphyroclasts. Far from being homogeneous, plastic deformation is 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 exsolutionsfree, in contrast with the rest of the orthopyroxene porphyroclast, 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 process 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.