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Formation and evolution of inversely-zoned “complex feldspar” in the lower crust

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Within and near lower crustal shear zones, plagioclase grains frequently exhibit a peculiar compositional zonation: Albite-rich single crystals contain anorthite-rich lamellae and smaller, polygonal grains show an increase in anorthite-content from core to rim. This is the opposite of the zonation that develops during fractional crystallization in magmatic systems. Both the changes in plagioclase compositions and associated grain size reductions may affect rock rheology. Therefore, these microstructures may potentially provide valuable information about shear zone development and the behaviour of plagioclase-rich lower crustal rocks during an orogeny.

Next to shear zones in gabbronorites of the Ramberg section (Lofoten, Northern Norway), we observe both endmember microstructures (anorthite-rich inclusions in larger single crystals and zoned polygonal grains) as well as transitions between them. These were investigate in detail with scanning electron microscopy, including electron backscatter diffraction, and transmission electron microscopy.

The microstructures range from isolated, anorthite-rich lamellae in the host albite-richer plagioclase, via connected networks of anorthite-rich plagioclase within plagioclase single-crystals, to polygonal plagioclase grains with anorthite-rich rims close to the shear zones. These grains occur in clusters of similar orientation (presumably representing pre-existing larger grains). Preliminary work suggests that the plagioclase experienced an overall enrichment in Ca, which implies that fluid introduction played an important role during the reaction. The orientations of the anorthite-rich lamellae do not appear to be influenced by the crystallography of the host grain. Additionally, the density of the lamellae is highest in areas between grains of other phases than plagioclase, suggesting a stress-control on the reaction.

Ongoing transmission-electron microscopy work will help to understand whether the transition between the different microstructures is only spatial, or also temporal: Did the polygonal microstructure develop from the lamella-type microstructure, or are they expressions of the same event at different stress levels and/or fluid contents?