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Phase distribution and deformation processes in an amphibolite facies ultramylonite

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Rocks deforming by diffusion creep are usually characterized by a small grain size, an anti-correlated phase distribution and the lack of a crystallographic preferred orientation.
Grain boundary sliding contributes either as a strain accommodating or strain producing process, the latter required an accommodation process to maintain strain compatibility. The present study suggest the importance of bulk material transfer during homogeneous flow of an amphibolite facies ultramylonite.

The analyzed samples are from the Nordmannvik Nappe, Upper Allochton of the Norwegian Caledonides. The shear zone separates a marble unit from a garnet amphibolite with enclosed relict mafic granulite lenses. Contacts with the wallrock are very sharp and no transitional, intermediate strain zone is present.

The ultramylonite has a very homogeneous matrix composed of quartz, biotite, white mica, oligoclase and ilmenite with grain sizes below 10 μm (eq. diameter). Grains have slightly lobate, interlocking boundaries. Aligned grain and phase boundaries are absent and shear bands are very rare.

Garnet, white mica, and plagioclase-quartz aggregates form porphyroclasts. Towards the center of the shear zone, porphyroclasts disappear subsequently while garnet porphyroclasts are the last being present. The increase in matrix percentage from 80 to 98% is interpreted to result from increasing strain.

White mica and plagioclase-quartz porphyroclasts attain aspect ratios of 2-3. White mica porphyroclasts have monoclinic shapes and a stable orientation of the clast long axis at 5° with respect to the lineation, which is independent on strain and clast size. Plagioclase porphyroclasts have orthorhombic shapes and reach a stable orientation less frequently. Garnet remains at low aspect ratios.

The matrix shows a strong anti-correlation of quartz and biotite parallel to the foliation where biotite stacks separate quartz grains and clusters. Those quartz clusters have a long axis at 50 -70° to the foliation, inclined against the sense of shear. Occasionally thin ilmenite seams decorate quartz grain boundaries which are oriented at a low angle to the foliation.

In the sector of instantaneous shortening around porphyroclasts, matrix biotite is depleted and garnet shows indications of solution. In the sectors of instantaneous stretching, biotite grows and occasionally garnet porphyroclasts show newly grown seams.

The matrix microstructure suggests that dissolution, nucleation and precipitation of primarily biotite occurs synkinematically and simultaneously. It is suggested that flow in the matrix is achieved by phase redistribution through a dissolution-precipitation mechanism. The phase distribution and grain shapes in the matrix do not permit grain boundary sliding as the dominant strain producing mechanism. In addition, differences in the anisotropy and affinity to dissolve and precipitate or newly nucleate and grow can explain the differences in porphyroclast behavior.