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Replacement reactions and deformation by coupled dissolution and precipitation in amphibolites in the middle crust

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The thermo-mechanical properties of the middle-lower crust exert a fundamental control on the structure of orogenic belts, and on the amount and style of shortening during continental collision. In particular, how strain is distributed vertically and horizontally in orogenic belts is one of the more important questions in crustal dynamics, and one that can be addressed by investigating the deformation mechanisms associated with the accumulation of large (hundreds of km) tectonic transports along thrust faults during mountain building processes. In this study we analysed the development of a mylonitic microstructure and the associated deformation mechanisms in amphibolites from the COSC-1 drill core, central Sweden.

The amphibolites contain tschermakitic amphibole, plagioclase, chlorite, quartz, epidote, carbonate and ilmenite. The plagioclase displays two generations: (1) fractured millimetric porphyroclast cores with lobate edges (Plag1; Albite 99), which are wrapped by the foliation and are dark in the SEM-cathodoluminescence images, and (2) rims (Plag2; Albite 80-90), some tens of microns in size, which are bright in the cathodoluminescence images, heal the fractures and overgrow the cores of Plag1. Plag2 grows syn-deformationally, as it is commonly found in strain shadows around Plag1 porphyroclasts.

The tschermakite preserves corroded cores (Amp1) with higher Mg number compared to the rims (Amp2). The Amp2 rims are elongate parallel to the foliation and show intergrowths with Plag2 and chlorite in strain shadows. Amp-Pl thermobarometry constrains their growth at 600°C and 0.8-1GPa.

EBSD analyses indicate a homogeneous orientation of the porphyroclastic Plag1 without the development of low-angle boundaries, suggesting that Plag1 crystals are strain free. Furthermore, Plag2 displays the same crystallographic orientation as Plag1 both in the sealed fractures and in the rims, indicating fracturing and partial dissolution of Plag1 followed by epitactic growth of Plag2. Plag2 grains in the matrix have their [100] axes subparallel to the stretching lineation, but they are also internally strain free. Amphibole textures suggest a deformation history similar to plagioclase: amphibole has a strong crystallographic preferred orientation (CPO), with the (100) and [001] subparallel to the foliation and to the stretching lineation, respectively.

The combined use of X-ray chemical maps and EBSD maps suggests that the mylonitic amphibolites developed due to (micro)cracking that favoured fluid infiltration triggering mineral replacement by coupled dissolution and precipitation creep. Remarkably, crystal plasticity was not a dominant deformation mechanism, although deformation occurred at pressure and temperature conditions at which plagioclase is expected to deform by dislocation creep, which in turn considerably decreased the strength of this middle crustal shear zone. Finally, our study shows that CPOs in plagioclase and amphibole can be inherited from parental grains. Thus, care must be taken when considering CPOs in deformed rocks as an evidence of deformation by dislocation creep.