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Mechanical behaviour of the Oman metamorphic sole: rheology of amphibolites at lower crustal conditions during subduction initiation

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Amphibolites are commonly found in the middle to lower continental crust and along oceanic transform faults and detachments. Amphibolites are also the main component of metamorphic soles beneath highly strained peridotites at the base of large-scale ophiolites as exemplified in Oman. Metamorphic soles are crustal slivers stripped from the slab during early subduction and underplated below the upper plate (future ophiolite) mantle when the subduction interface is still young and warm (i.e. during the first million years -My- of intra-oceanic subduction). Understanding the rheological behaviour of amphibolitic rocks is therefore of major interest to model and quantify deformation and strain localisation in varied geodynamical environments.

This contribution focuses on the deformation mechanisms of amphibole through a microstructural and petrological study of garnet–bearing and garnet–free clinopyroxene-bearing amphibolites, using EBSD analysis. The first aim is to test the influence of progres- sive changes in PT conditions during deformation and of the appearance/disappearance of anhydrous minerals (plagioclase, clinopyroxene and garnet) on the mechanical behaviour of mafic amphibolites. The second aim is to track deformation mechanisms during early subduction, through the study of these metamorphosed oceanic rocks, commonly 10-100 m thick, which range from high- to low-grade away from the contact with the peridotites (i.e. from 800 $\pm$ 100˚C - 0.9 $\pm$ 0.2 GPa to 500 $\pm$ 100˚C - 0.5 $\pm$ 0.1 GPa) and are essentially mafic at the top).

Our study points out the existence of two major steps of deformation in the high-temperature amphibolite slices of the metamorphic soles during the early subdduction dynamics. These two steps witness important mechanical coupling and progressive strain localization at plate interface under cooling and hydrated conditions after subduction initiation.

During the accretion of the first slice of metamorphic sole at 850 $\pm$ 50˚C (the garnet–clinopyroxene amphibolite), strain was essentially accommodated by the orientation of amphibole grains in the foliation plane, promoted by cataclastic deformation. Clinopyroxene grains were deformed at peak conditions by dislocation creep, resulting in formation and rotation of subgrains and minor rigid grain rotation, where embedded in amphibole-rich matrix.

During the accretion of the second slice of the downgoing plate, at lower P–T conditions, strain was accommodated by amphibole and plagioclase (present in equal modal proportions). Plagioclase grains were deformed by dislocation creep and formed a less viscous matrix promoting rigid body rotation of amphibole grains in the foliation plane. This step of deformation was assisted by an increase of fluid infiltration leading to the partial dissolution–precipitation of amphibole and plagioclase.