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Metamorphic sole formation and early plate interface rheology: Insights from Griggs apparatus experiments

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Metamorphic soles correspond to m to ∼500 m thick highly strained metamorphic rock units found beneath mylonitic banded peridotites at the base of large-scale ophiolites, as exemplified in Oman. Metamorphic soles are mainly composed of metabasalts deriving from the downgoing oceanic lithosphere and metamorphosed up to granulite-facies conditions by heat transfer from the mantle wedge. Pressure–temperature peak conditions are usually estimated at 1.0±0.2 GPa and 800±100ºC. The absence of HP–LT metamorphism overprint implies that metamorphic soles have been formed and exhumed during subduction infancy. In this view, metamorphic soles were strongly deformed during their accretion to the mantle wedge (corresponding, now, to the base of the ophiolite). Therefore, metamorphic soles and banded peridotites are direct witnesses of the dynamics of early subduction zones, in terms of thermal structure, fluid migration and rheology evolution across the nascent slab interface.
Based on fieldwork and EBSD analyses, we present a detailed (micro–) structural study performed on samples coming from the Sumeini window, the better-preserved cross-section of the metamorphic sole of Oman. Large differences are found in the deformation (CPO, grain size, aspect ratio) of clinopyroxene, amphibole and plagioclase, related to mineralogical changes linked with the distance to the peridotite contact (e.g., hardening due to the appearance of garnet and clinopyroxene).
To model the incipient slab interface in laboratory, we carried out 5 hydrostatic annealing and simple-shear experiments on Griggs solid-medium apparatus. Deformation experiments were conducted at axial strain rates of 10-6 s-1. Fine-grained amphibolite was synthetized by adding 1 wt.% water to a (Mid-Ocean Ridge) basalt powder as a proxy for the metamorphic sole (amphibole + plagioclase + clinopyroxene ± garnet assemblage). To synthetize garnet, 2 experiments were carried out in hydrostatic conditions and with deformation at 800°C with confining pressure of 2 GPa. Another simple-shear experiment has been carried out at 800°C and 1 GPa with fined-grained natural garnet. With the aim of mimicking the early slab interface (between the metamorphic sole and banded peridotites at the base of the ophiolite), 2 simple-shear deformation experiments with 2 layers have been carried out at 800°C and confining pressure of 1 GPa. The bottom layer was made of hydrated basalt powder and the top layer was made of olivine.
Fined-grained garnet-free amphibolite is significantly weaker than dunite but the appearance of harder minerals in the amphibolite (garnet and clinopyroxene) has major implications on its rheological evolution. These results allow liking field observations of strain localization at the interface to the metamorphic sole formation.