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Deformation mechanisms of amphibolites at lower crustal conditions during subduction initiation: a metamorphic sole's viewpoint

Soret Mathieu (1), Agard Philippe (1), Ildefonse Benoît (2), Dubacq Benoît (1), Prigent Cécile (3), and Rosenberg Claudio (1)

(1) ISeP, UPMC-Sorbonne Universités, Paris, France, (2) Geosciences, Univ. Montpellier, Montpellier, France, (3) ISTerre, Univ. Joseph Fourier, Grenoble, France

This study sheds light on the deformation mechanisms of subducted mafic rocks metamorphosed at amphibolite and granulite facies conditions, and on their importance for strain accommodation and localization at the plate interface during subduction initiation.
These rocks, called metamorphic soles, are oceanic slivers stripped from the down-going slab and plastered below the upper plate mantle wedge during the first million years of intra-oceanic subduction, when the subduction interface is still warm. Their formation and intense deformation (i.e. tectonic restorations have inferred large shear strain > 4-5) attest to a systematic and transient coupling between the plates over a restricted time span of $\sim$ 1 My and specific rheological conditions.
Combining micro-structural analyses with mineral chemistry has allowed us to constrain, the grain-scale mechanisms active along the plate interface during early subduction dynamics. This study outlines how rock strength varies due to the progressive (dis)appearance of the index phases (amphibole, plagioclase, clinopyroxene and garnet) at the top of the slab undergoing significant changes in pressure–temperature–water activity conditions:
Dehydration during increasing P-T conditions (from amphibolite to granulite facies replaces low-grade amphibole and plagioclase ($\pm$ epidote) with garnet, clinopyroxene and high-grade amphibole, hence increasing the strength of the rock. In spite of a strong CPO and SPO of amphibole, brittle deformation of amphibole and garnet are observed. We propose that this brittle deformation corresponds to the onset of strain localization in the rock and potentially to the detachment from the slab and accretion to the peridotites at peak conditions ($\sim$850°C–1 GPa).
Intense shearing during early exhumation and cooling (from $\sim$850 down to $\sim$700°C–0.5 GPa), in the garnet-clinopyroxene-bearing amphibolite was accommodated by pressure-solution and grain boundary sliding promoting phase mixing and oriented grain growth. This second stage is intimately associated with the onset of retrogression triggered by fluids derived from continuous slab dehydration (as supported by the crystallization of plagioclase and hydrous phases), which has for consequence to progressively weaken the amphibole-rich rock.
An important strain weakening is also expected across the interface in the upper plate mantle, which becomes metasomatized. This progressive and coeval weakening on both sides of the plate interface likely explains the continuous deformation recorded in the amphibolite of the metamorphic sole and the banded peridotites, which is thought to solve, at least in part, two major conundrums: 1) the ubiquitous distribution of metamorphic soles below the ophiolite, and 2) the thinning of the future obducted ophiolite.