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Mantle Wedge formation during Subduction Initiation: evidence from the refertilized base of the Oman ophiolitic mantle

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Although the Oman ophiolite is classically regarded as being the direct analog of oceanic lithosphere created at fast spreading ridges, the geodynamic context of its formation is still highly debated. The other alternative end-member model suggests that this ophiolite entirely formed in a supra-subduction zone setting. The latter one is supported by studies on volcanic sequences, whereas all studies dealing on the mantle section have recognized a first stage of oceanic accretion before subduction initiation.

We herein focus on basal peridotites from all along the ophiolite strike in order to decipher and characterize potential fluid/melt transfers due to subduction processes. Samples were taken along hm- to km-long sections across the basal banded unit directly overlying the amphibolitic/granulitic metamorphic sole. We carried out a petrological, structural and geochemical (major, trace elements and boron isotopes) study on these rocks and their constitutive minerals. Results were then interpreted using thermal modelling of the ophiolitic mantle evolution during subduction initiation.

Our results show that basal peridotites range from lherzolites to highly depleted harzburgites in composition. The clinopyroxenes (cpx) display melt impregnation textures and co-crystallized with HT/HP amphiboles (amph). The major and trace elements of the constitutive minerals indicate that the different basal lithologies only result from varying degrees of melt extraction. Combined with isotopic data, we demonstrate that the initial melt reacting with these peridotites derives from the mixing of asthenospheric melt and metamorphic sole-derived fluids, and was later extracted in variable proportions.

From these observations and thermal modelling of the Fizh ophiolitic mantle evolution after subduction initiation, we interpret the occurrence of these basal lherzolites as representing a freezing front developed by thermal re-equilibration (cooling) of the subduction: the asthenospheric melt mixed with subduction-related fluids was extracted at different degrees until getting ultimately trapped, and crystallized cpx, amph and other associated minerals.

The young and still very hot mantle section of today's northern Fizh massif thus contrasted, during subduction initiation, with the colder southernmost massifs of the ophiolite. These different thermal structures reflect different maturity of the oceanic lithosphere at the onset of subduction, which is hardly reconcilable with the ophiolite being formed in an entire supra-subduction zone system. We therefore favor a model in which a preexisting marginal basin acquired its arc-signature during subsequent subduction processes. If our interpretation is correct, the base of the Oman ophiolite could provide the best proxy for the composition of a frozen-in, incipiently forming mantle wedge.