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Oman metamorphic sole formation reveals early subduction dynamics

Mathieu Soret (1), Philippe Agard (1,2), Benoît Dubacq (1), Alexis Plunder (1,3), Benoît Ildefonse (4), Philippe Yamato (5), and Cécile Prigent (6)

(1) Institut des Sciences de la Terre de Paris, Sorbonne Universités, UPMC Univ Paris 06, CNRS, 4 place Jussieu 75005 Paris, France, (2) Insitut Universitaire de France, F-75005, Paris, France, (3) Utrecht University, Department of Earth Sciences, Utrecht, Netherlands, (4) Géosciences Montpellier, Univ Montpellier, CNRS, F-34095 Montpellier, France, (5) Géosciences Rennes, Univ Rennes 1, CNRS, F-35042 Rennes, France, (6) ISTerre, Université de Grenoble Alpes, CNRS, F-38041 Grenoble, France

Metamorphic soles correspond to m to ∼500m thick tectonic slices welded beneath most of the large-scale ophiolites. They typically show a steep inverted metamorphic structure where the pressure and temperature conditions of crystallization increase upward (from 500±100ºC at 0.5±0.2 GPa to 800±100ºC at 1.0±0.2 GPa), with isograds subparallel to the contact with the overlying ophiolitic peridotite. The proportion of mafic rocks in metamorphic soles also increases from the bottom (meta-sediments rich) to the top (approaching the ophiolite peridotites). These soles are interpreted as the result of heat transfer from the incipient mantle wedge toward the nascent slab (associated with large-scale fluid transfer and possible shear heating) during the first My of intra-oceanic subduction (as indicated by radiometric ages). Metamorphic soles provide therefore major constraints on early subduction dynamics (i.e. thermal structure, fluid migration and rheology along the nascent slab interface).

We present a detailed structural and petrological study of the metamorphic sole from 4 major cross-sections along the Oman ophiolite. We show precise pressure–temperature estimates obtained by pseudosection modelling and EBSD measurements performed on both the garnet-bearing and garnet-free high-grade sole. Results allow quantification of the micro-scale deformation and highlight differences in pressure–temperature–deformation conditions between the 4 different locations, showing that the inverted metamorphic gradient through the sole is not continuous in all locations.

Based on these new constraints, we suggest a new tectonic–petrological model for the formation of metamorphic soles below ophiolites. This model involves the stacking of several homogeneous slivers of oceanic crust leading to the present-day structure of the sole. In this view, these thrusts are the result of rheological contrasts between the sole and the peridotite as the plate interface progressively cools down. These slivers later underwent several stages of retrogression (partly mediated by ascending fluids from the slab) from amphibolite- to prehnite/pumpellite-facies conditions.