Fluid-rock Interactions recorded in Serpentinites subducted to 60-80 km Depth

D. PETERS1, T. JOHN2, M. SCAMBELLURI1 AND T. PETTKE1

1University of Bern, Institute of Geological Sciences, Bern, Switzerland; 2Freie Universität Berlin, Institute of Geological Sciences, Berlin, Germany; 3University of Genova, DIPERT, Genova, Italy - (correspondence: daniel.peters@geo.unibe.ch, pettte@geo.unibe.ch)

Introduction
The Erro Tobbio high-pressure metaserpentinites (HPS) exhibit the metamorphic assemblage of antigorite + olivine + magnesite + diopside + Ti-clinohumite formed at 500-600 °C and 2-2.5 GPa, and were one of the first ultrabasic rocks interpreted to represent subducted hydrated lithospheric mantle [1]. HP-LT metamorphism beyond the brucite-out reaction led to the formation of dehydration veins with the same HP assemblage. The origin of the peridotites and location of serpentinitisation, i.e., along faults in the bending slab with pore fluid contribution (2.3) or along the slab-mantle interface by slab fluids [4] remains controversial. Here we present constraints on fluid origins and element fractionation during dehydration based on an extensive bulk rock data set and compiled published serpentinite data in order to decipher the serpentinitisation environment and characterise fluid cycling in subduction zones.

Methods
Bulk rock data were obtained by applying the PIP-LA-ICP-MS protocol described in [5]. The serpentinite compilation comprised data from six mid-ocean ridge (MOR) and three forearc (FA) settings. The term forearc is thereby allocated by the location of sampling (Figs. 2.1 and 3).

Selected Conclusions
✓ Combining the results with halogen [2] and noble gas data [3] suggests that serpentinisation of oceanic lithospheric mantle occurred along bend faults or as detached slices in the shallow forearc by fluids equilibrated within the accretionary prism.
✓ Initial heterogeneities will govern the spatial extent of serpentinitation and FME enrichment, ultimately amplifying heterogeneities
✓ FME enrichments from serpentinitation are largely retained and reincorporated into the convecting mantle, providing potential fractionation mechanisms for U-Th systematics (HIMU) and enriched mantle (EM) sources
✓ FMEs such as As, Sb, W and Bi, which are rarely quantified, can provide essential information to further discriminate between serpentinitisation environments
✓ No data have been published on the commonly used FMEs such as As, Sb, W and Bi, which are rarely quantified, and can provide essential information to further discriminate between serpentinitisation environments.

1 Magmatic Stage

2 Hydration Stage

During serpentisation, fluid pathways are again highly governed by the distribution of porosity and permeability within the rocks; diffusion is expected to be of subordinate importance. Hydration and enrichment in fluid-mobile elements (FMEs) of the peridotites is expected to imprint a characteristic geochemical signature.

- Despite higher water contents in the mylonites, concentration ranges are similar in mylonitic and granular HPS
- Larger scatter towards higher concentrations in granular rocks
- No evidence for additional serpentinitisation stage in mylonites from FMEs as proposed by [4]
- Indication that hydration and element enrichment are not necessarily coupled - FME enrichment is accumulative
- Post-serpentinitisation homogenisation of most hydrated, i.e., mechanically weakest, parts by mylonitisation?

2.1 Serpentinisation Environment

- FME patterns in MOR and FA serpentinites from serpentinite compilation allow for discrimination of serpentinitisation environments; patterns are retained during progressive metamorphism (Figs. 2; Peters et al., in prep)
- Erro Tobbio metaperidotites clearly exhibit a FA-like serpentinite signature, indicating hydration distance to MORs and under sediment influence (cf. PaMa serpentinites), i.e., along bend faults in the subducting slab, or serpentinitisation of oceanic lithospheric mantle or mantle wedge along the shallow plate interface
- Distinction between accretionary wedge and plate interface not possible with current FME data set
- Relic mantle clinopyroxenes and olivine cores are preferably preserved in the granular rocks, hence could account for apparent geochemical differences between the mylonitic and granular rocks [4]

1. Magmatic Stage

Erro Tobbio peridotites are subject to partial melting and reactive porous flow during decompression [6]:
- Local onset of partial melting is driven by minor differences in bulk chemistry
- Melt percolation is guided by local porosity and permeability
- Mylonitic metaperidotites are slightly more depletiated
- Imprint of first order physicochemical heterogeneity on the peridotites

2. Hydration Stage

- Veins have similar PM-normalised trace element patterns as wall rocks but slightly enriched; only Li, P, and Ti are highly enriched
- Li enrichment by dehydration fractionation and Ti is linked to higher modal abundance of Ti-clinohumite; source for P unknown
- No evidence for external fluids; veins are internal dehydration pathways
- Dehydrated rocks retain FME enrichment signature beyond brucite-out (Erro Tobbio) and even antigorite-out (Almirez) indicating deep-independent Alkalai-U fractionation
- FME fractionation during dehydration produces higher UAAlk ratios in the residual rocks, i.e., U depletion is less severe
- Imprinted residual signatures are recycled into the mantle inducing, e.g., high U/Ti and UA/Alk ratios

3. Dehydration Stage

Partial dehydration upon brucite breakdown induces vein formation. Fluid-mobile elements are expected to be released into the fluids during dehydration reactions and metasomatising the overlying subduction channel and mantle wedge.

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References

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