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Trace element behaviour during serpentinisation/deserpentinisation of an eclogitised oceanic lithosphere: a LA-ICPMS study of the Lanzo ultramafic massif (Western Alps)

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Serpentinites are a major component of the oceanic lithosphere. During oceanic mantle hydration and alteration, they trap fluid mobile elements and then play a major role in the fluid and elemental transfer occurring between the dehydrating slab and the mantle wedge in subduction context. The Lanzo massif is an eclogitised oceanic lithosphere that records different serpentinisation and de-serpentinisation steps, from oceanic mantle denudation, to subduction prograde metamorphism, up to serpentine dehydration, and finally retrograde metamorphism during exhumation. Thus, it constitutes a suitable place to study the chemical mass transfer associated with serpentinites during cycling of the oceanic lithosphere.

Oceanic serpentinisation is preserved in slightly serpentinised peridotites where the lizardite crystallises as veins crossing orthopyroxene and olivine or, when the hydration is more important, as mesh and bastite textures in serpentinised channels of 1-2mm of width. The trace element composition of lizardite veins is similar to that of the host mineral. It suggests that their composition is inherited from the primary mantle phases. Mesh and bastite trace element compositions and patterns are homogenous at the scale of the thin section and are intermediate between orthopyroxene and olivine. Lizardites have a higher B content (2-75 ppm) and display a positive Eu anomaly (EuN/Eu*=1.74-7.54) relative to primary phases.

In the slightly serpentinised peridotites, prograde antigorites crystallised during subduction as veins crossing all primary minerals and lizardites. Their trace element patterns are homogenous in one thin section. They are marked by flat HREE patterns (GdN/YbNPM=0.45-1.18) close to clinopyroxene (GdN/YbNPM=1.08-1.45). This suggests that clinopyroxene destabilisation is contemporaneous with antigorite crystallisation. The composition of antigorite veins is close to that of the host mineral.

In the massive serpentinites, where previous phases are mostly destabilised, the trace element composition and pattern of prograde antigorite are homogenous at outcrop scale: they are intermediate (GdN/YbNPM= 0.17-0.33) between orthopyroxene (GdN/YbNPM=0.12-0.20) and olivine (GdN/YbNPM= below limit detection) in serpentinised harzburgite and are intermediate (GdN/YbNPM= 0.85-0.97) between clinopyroxene, orthopyroxene and olivine in serpentinised lherzolite. Antigorite display a variable Eu anomaly (EuN/Eu*=0.55-1.18) and lower B (0.6-7 ppm) and Li (0.06-0.39 ppm) content compared to lizardite. At the peak of metamorphism, the antigorite is destabilised into secondary olivine that display a similar XMg (0.84-0.90) and are enriched in HFSE and HREE (Lu=0.5-0.7xC1) relative to primary olivine (XMg=0.83-0.91, Lu=0.02-0.2xC1).

During the massif exhumation, the crystallisation of a retrograde antigorite obliterated all previous phases in the massive and foliated serpentinites. Antigorite trace element composition and pattern are homogenous (Lu=0.4-2.2xC1, GdN/YbNPM=0.2-0.9) at massif scale and are close to serpentinite (Lu=0.2-0.9xC1, GdN/YbNPM=0.3-1.1) and lherzolite (Lu=1.8-2.8xC1, GdN/YbNPM=0.2-0.9) whole rock analyses.

The geochemical analyses of serpentine and associated minerals show that the serpentinisation of Lanzo massif took place in a relatively closed system. The successive episodes of serpentinisation remobilise trace element of mineral phases preserved in intra-oceanic context. Those recrystallisations conduce to the homogenisation of serpentine composition from outcrop scale, during prograde serpentinisation, to massif scale during retrograde serpentinisation.