Mineralogical and geochemical evolution of serpentines from the western Alps along a metamorphic gradient

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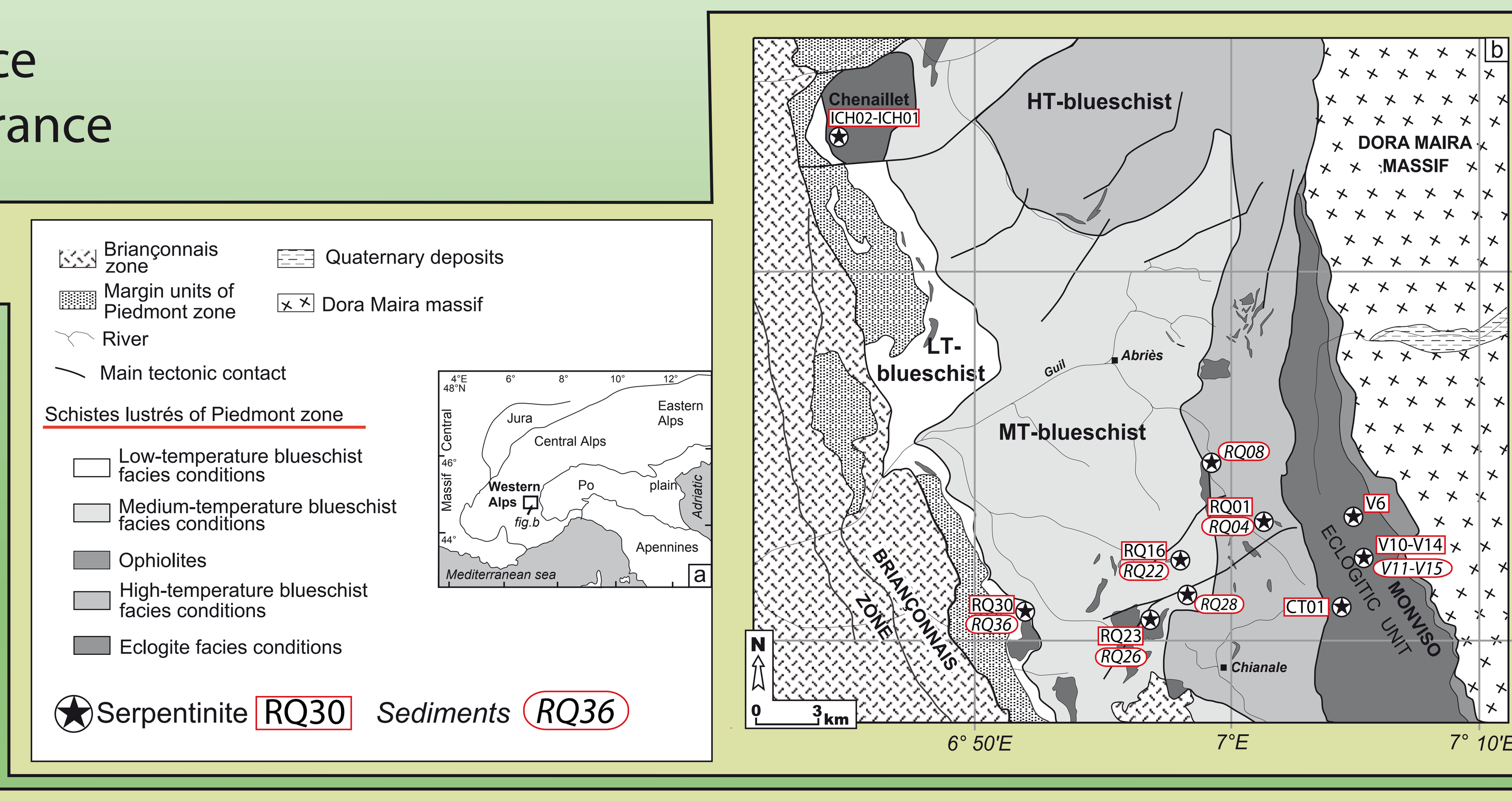
Introduction

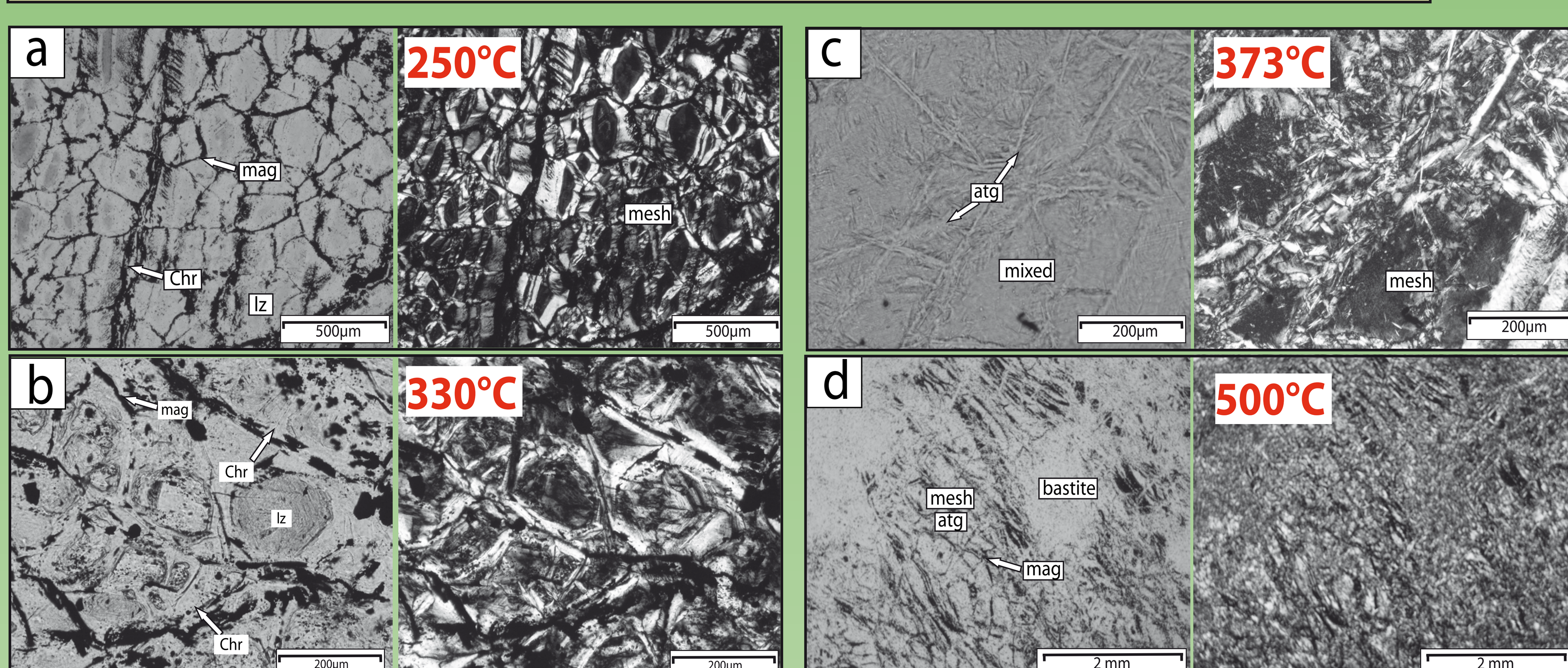
Serpentinites observed in Queyras accretionary wedge result from two serpentinization processes: (i) a first stage during fluid/rock interactions in oceanic context and (ii) a second during the first step of subductio. Serpentinisation affect physical, geochemical and rheological properties of the oceanic lithosphere. Exhumed serpentinite units are commonly characterized by different co-stability serpentine species (chrysotile, lizardite and antigorite).

In the paleo-accretionary wedge of the western Alps, different oceanic units have been metamorphosed from low temperature blueschist facies conditions (T<350; P<1GPa) to eclogitic facies conditions (T>500°C, P> 2GPa). We investigate stability domains of differents serpentine species by microtextural and RAMAN spectroscopy study along a metamorphic gradient.

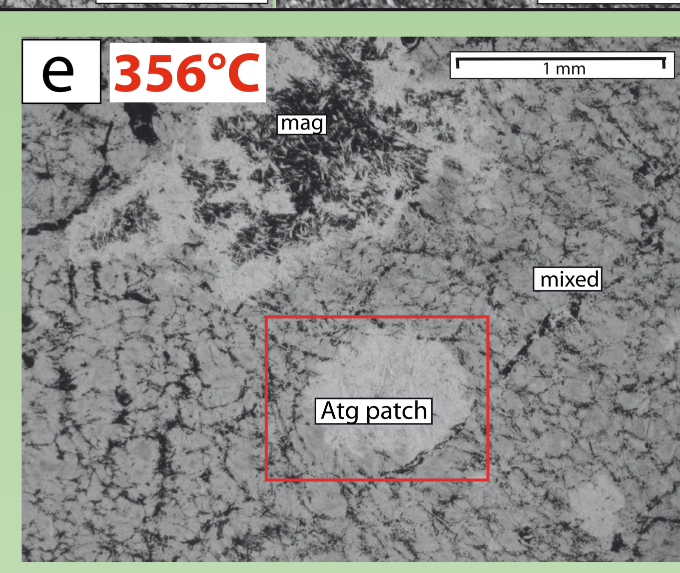
During transition from chrysotile/Lizardite to antigorite geochemistry of serpentinite seems to be strongly affected. Indeed we studying the major and trace elements evolution along this gradient with bulk rock, ICP-MS and LA-HR-ICP-MS analysis.



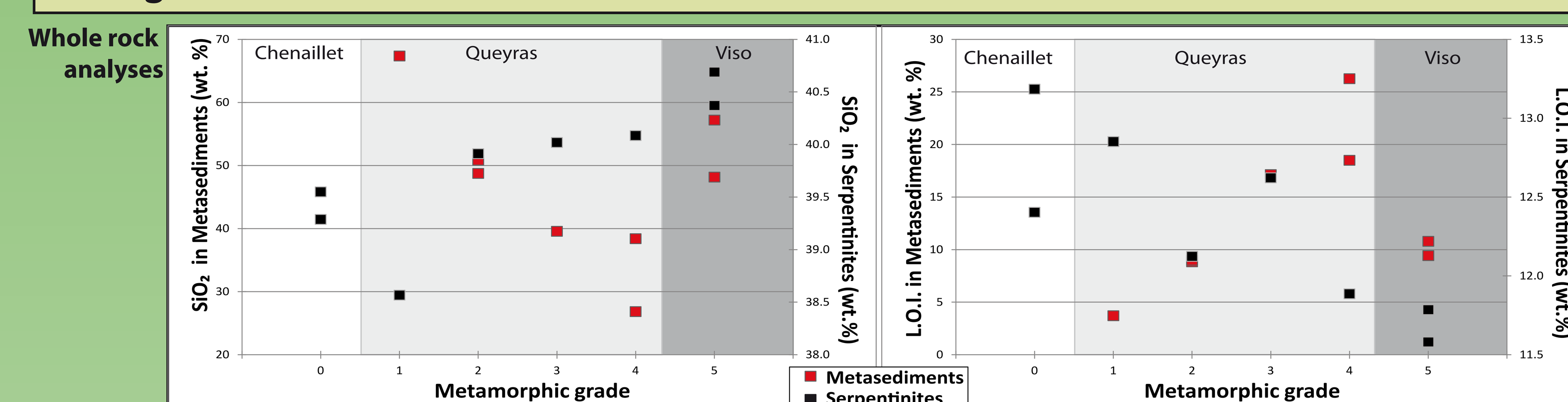
Mineralogical evolution



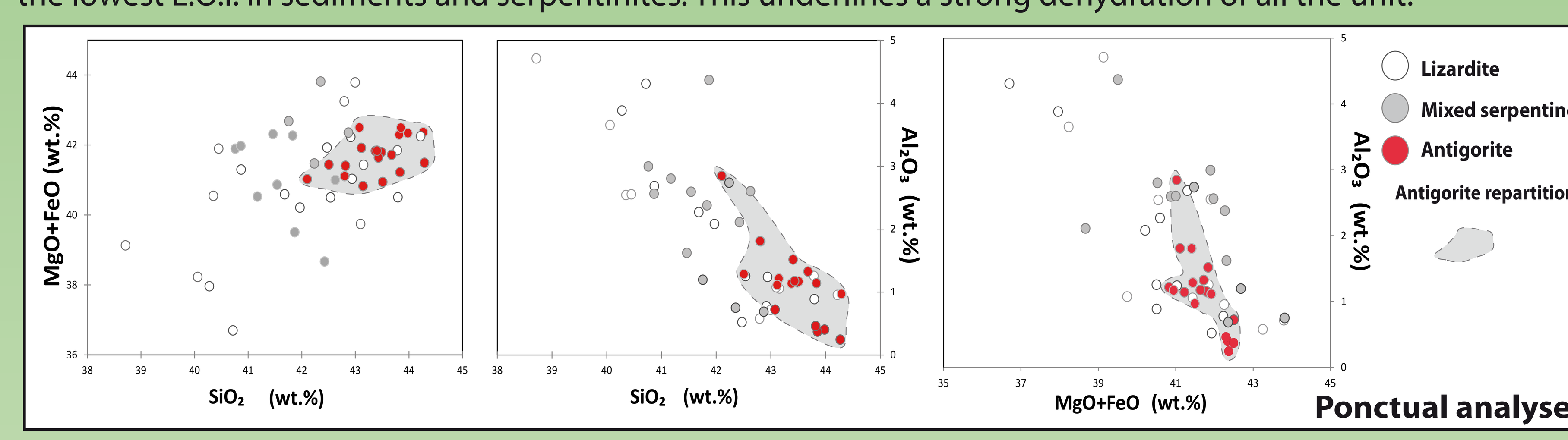
We show a progressive destabilization of lizardite/chrysotile **(a,b)** in favor of antigorite **(c,d,e)** along the increasing subduction gradient. In Viso some metamorphic olivine are observed. Lizardite seems to completly disappeared around 380°C. Serpentinites are mainly dominated by pseudomorphic lizardite **(a)** showing hourglass texture replacing primary olivine surrounded by magnetite underlying the mesh texture. Relictual pyroxenes are still preserved in the core of some bastites. Raman spectroscopy reveal a particular kind of spectra interpreted as the results of a mix between lizardite and antigorite compositions. Particular antigorite patch texture is observed in RQ23 **(e)**.



Major Element Evolution

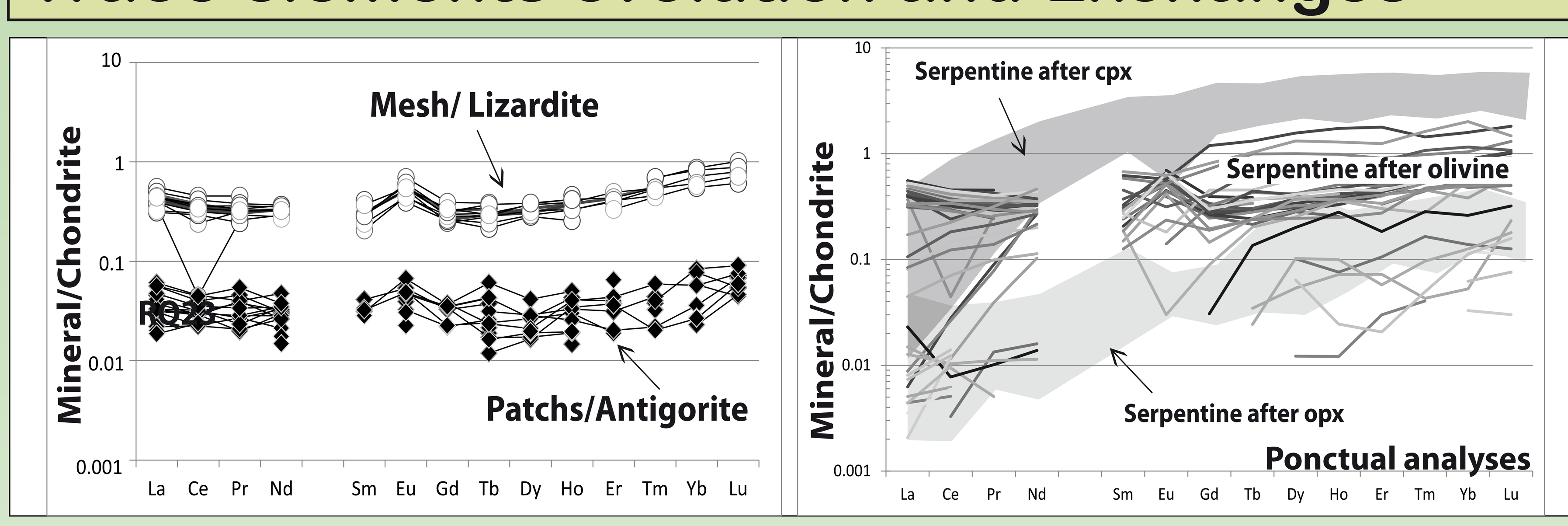


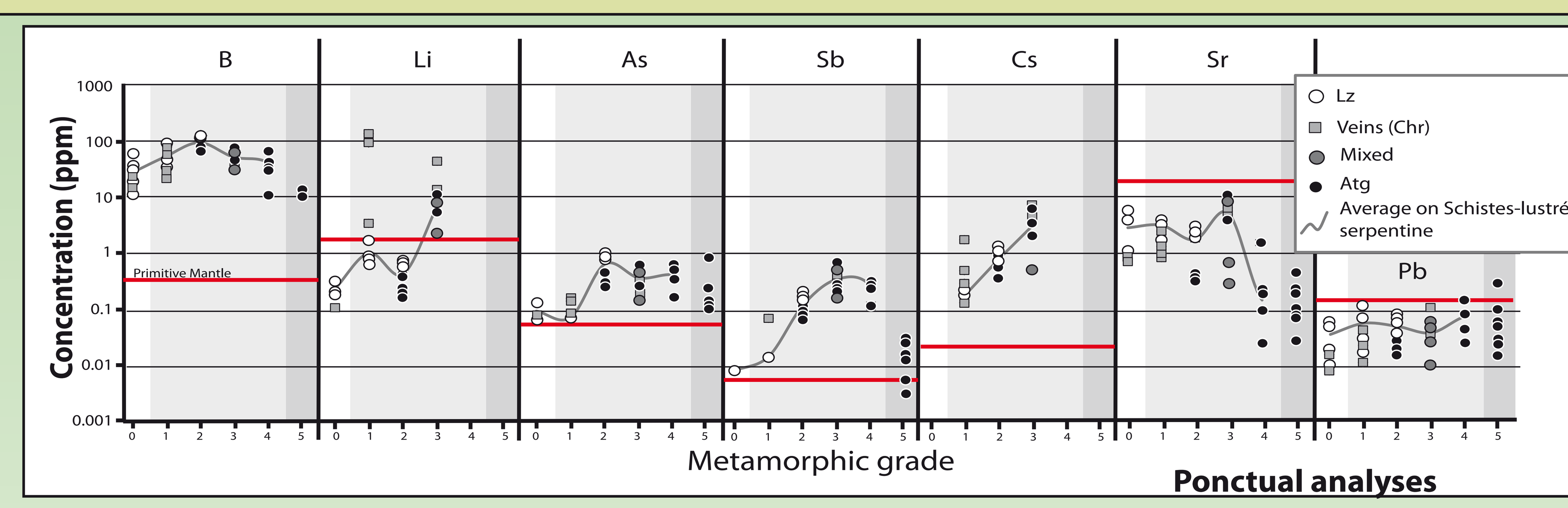
Serpentinites are relatively homogeneous in term of major elements. We assume that they derive from a protolith having depleted lherzolite composition. SiO_2 content is slightly increasing with metamorphic grade, whereas L.O.I. tends to decrease. This is the opposite for metasediments. Viso present the highest level in SiO_2 and the lowest L.O.I. in sediments and serpentinites. This underlines a strong dehydration of all the unit.



It appears some differences in term of major elements between each species of serpentine. Lizardite have the most heterogeneous compositions in SiO_2, and MgO+FeO, whereas antigorite is most homogeneous and has the higher contents in SiO_2 and MgO+FeO. This observation is particulary clear in sample RQ23 at the thin section scale where antigorite patches are systematically SiO_2-rich compare to the surrounding lizardite mesh.

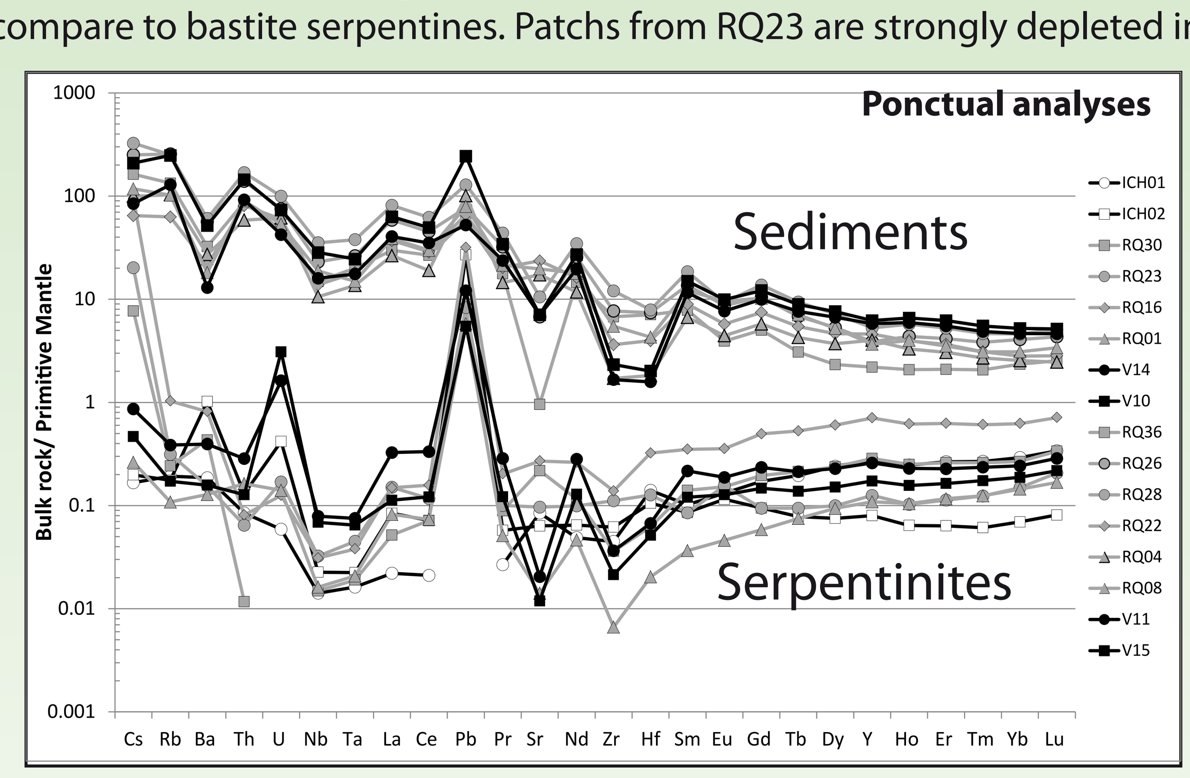
Trace elements evolution and Exchanges

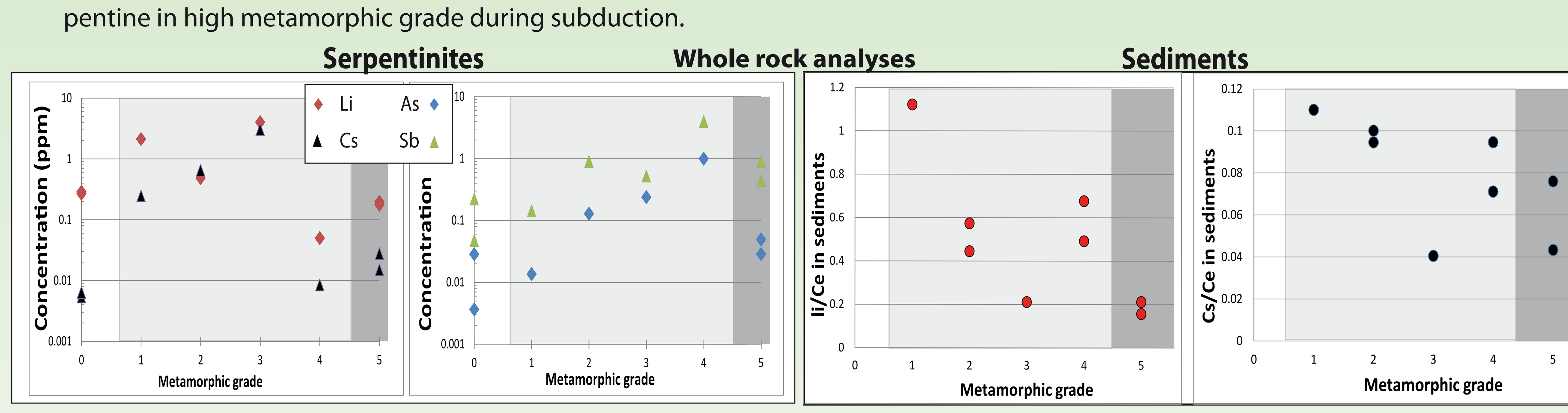




Concerning REE, whole rock analysis reveal an heterogeneous origine depending from sample location. LA-HR-ICP-MS permit to identifiate trace element composition in-situ for serpentine in mesh, bastite or veins. All samples are depleted compare to the primitive mantle. REE diagram realised in mesh derived from olivine are more complex compare to bastite serpentines. Patchs from RQ23 are strongly depleted in REE.

Concerning Fluid-Mobile-Elements, we observed a strong enrichment along the metamorphic gradient. This enrichment seems to be independant of serpentine variety. In grade 3 (RQ23), patchs are systematicaly less enriched. For several elements we see a stronger depletion in highest metamorphic grade (Li, Cs, Sr). Sediments associated to serpentine are relatively homogeneous and seems to be depleted in FME along the metamorphic gradient. Whereas the high quantity of sediments compare to ultramafic rocks and the concentration observed, they represent the source for FME. Viso is systematically depleted in trace elements probably lost during the dehydration of serpentine in high metamorphic grade during subduction.





Conclusions

We indicate a progressive transition from lizardite/chrysotile assemblage to antigorite. An enrichment in fluid-mobile elements (FME: As, B, Li, Sb...) is observed during increasing of metamorphic conditions in low metatmorphic grade units of the accretionary wedge. Homogeneisation and/or metasomatism is involved during antigorite propagation.

Viso represents the highest grade unit and is interpreted as a paleo-subduction channel. Serpentinites are systematicaly depleted in trace elements and associated sediments are partly dehydrated.

This highlights cations exchange and fuid circulations from the metasediments to the serpentinites into the accretionary wedge from 30 to 70 km depth and temperature comprises between 350 and 500 °C. Thus, serpentinites are the vector of transfer for fluid mobile elements (FME) at great depth. In this studied case, serpentinites abruptly released FME above 500°C.