Serpentine days, Porquerolles, 2012.

µXANES study of iron oxidation state in serpentines from ridge to subduction zone.

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Serpentinites may be present in more than 40% of the oceanic lithosphere that formed at slow to ultra-slow spreading centers. Serpentine could thus be one of the most abundant hydrated minerals recycled into the mantle in subduction zones. Prograde metamorphism of serpentinites being subducted is accompanied by the dehydration of lizardite into antigorite, and then into secondary olivine. The released fluids partly control the oxidation state of the mantle wedge that then affects arc magmatism. In order to investigate the possible redox state of these metasomatizing fluids, we have studied the iron speciation and oxidation state of a series of serpentinite samples representative of various metamorphic grades, from the ridge to dehydration conditions in subduction.

At mid-ocean ridge, during the alteration of peridotite into serpentinite, the iron is mostly redistributed between magnetite and oceanic serpentine (usually lizardite). The oxidation state of iron in lizardite is controlled by the degree of serpentinisation of the peridotite: Fe^{3+}/Fe^{tot} of the lizardite ranges from 0.2 in slightly serpentinized peridotites to 1 in fully serpentinized peridotites. Furthermore, the evolution Fe^{3+}/Fe^{tot} in lizardite is non-linearly related to the local degree of serpentinisation.

During subduction, in fully serpentinized peridotites and under the greenschist facies, antigorite crystallizes as veins with a low Fe^{3+}/Fe^{tot} contents (i.e., 0.3-0.5). At their contact, the magnetite is dissolved and the meshes are partly recrystallized into antigorite. These mixed assemblages have a lower Fe^{3+}/Fe^{tot} (i.e., 0.6-0.7) than preserved oceanic mesh ($Fe^{3+}/Fe^{tot} \approx 0.95$). Under blueschist conditions, a network of antigorite is developed at mesh rims and bastite centers, and mantle clinopyroxene and spinel are partly destabilized into antigorite and magnetite. The meshes are zoned: their Fe^{3+}/Fe^{tot} contents increase from core (≈ 0.5) to rim (≈ 0.6-0.7) while antigorite has a high Fe^{3+}/Fe^{tot} (≈ 0.6-0.7). Under eclogite conditions mantle clinopyroxene and oceanic phases are totally destabilized into antigorites with a low Fe^{3+}/Fe^{tot} (= 0.25-0.40) while magnetite is partly transformed into hematite.

We used whole rock analyses, magnetic measurements, SEM observation and XANES to establish the evolution of Fe^{tot} in serpentinite, the amount of magnetite and the speciation of iron in serpentine phases during subduction. Our results show that, from the ridge to dehydration conditions in subduction, the Fe^{tot} of serpentinite remains constant (=7-10 wt.%, depending on the primary mode of the peridotite) while the magnetite mode decreases under the blueschist facies, down to less than 2% under the eclogite facies. The evolution of Fe^{3+}/Fe^{tot} in serpentine is not linear during subduction. At high metamorphic grade, the antigorite is reduced and its dehydration should not provide highly oxidized fluids.