Evolution of F and Cl relative to lithophile trace elements in oceanic crust, from oceanic to subduction metamorphisms in Western Alps

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Fluorine and Chlorine are useful geochemical tracers of oceanic and suduction metamorphisms, because of their strong affinity for the hydroxyl sites in the minerals produced and destructed during these processes. Our earlier study showed that amphibole is a dominant host of fluorine, while pyroxene and lawsonite host significant chlorine in addition to amphibole (Debret et al., 2016, Lithos).

We report new data of previously described samples, including lithophile trace elements abundances in the same mineral phases. Our results show the element intake to and release from the host phases (amphibole, Ti phases). During oceanic hydrothermal metamorphism recorded in Chenaillet ophiolite (France), amphiboles are formed at different temperature, with various degrees of seawater interactions, resulting in a range of TiO_2 content. The concentration of Nb in the amphiboles correlates positivily with TiO_2. Because Cl shows a weak anticorrelation with TiO_2, Cl/Nb varies significantly, from 1.5 to 500. Here high Cl/Nb corresponds to low TiO_2 which also indicates the condition of low temperature hydrothermal amphibole formation. Our observation identifies such hydrothermal amphiboles as an ideal assimilant that can increase Cl/Nb values in oceanic basalts.

Abundances of F, Cl, and Nb in glaucophane are lower than amphiboles of lower metamorphic grade. However Cl/Nb shows limited variation at relatively high value (530±280). Mass balance model of Nb budget shows that bulk Nb abundances remain approximately constant during prograde metamorphism, in which a decrease of Nb in amphibole is accomodated by increasing proportions of Ti-phases (ilmenite-titanite-rutile). This suggests that significant halogen mobilization is not accompanied by a loss of Nb from an oceanic crust. Laboratory experiments report a significant increase of cation element mobility due to complexation with halogens. Our preliminary observation of a limited Nb mobility during prograde metamorphism suggests that the compositonal changes of ocean crusts in Western Alps must be driven by a fluid phase other than brine.