The behavior of chlorine and $\delta^{37}$Cl during the oceanic crust alteration

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The oceanic crust (OC) is a vector of chemical exchanges between the surface and the Earth’s interior. Hydrothermal circulation in the ocean’s floor is the major control of chemical compositions of both seawater (SW) derived fluids and crust (before subduction). In order to bring new constraints on the OC alteration, chlorine stable isotope composition ($\delta^{37}$Cl) was determined in both high (HTF) and low (LTF) temperature fluids, at ridge axis and off-axis, respectively, and in fresh and altered basalts.

Worldwide HTF (T ≥230°C) have a large range of chlorinity (250 to 821 mM), but show very constant $\delta^{37}$Cl, indistinguishable from the SW $\delta^{37}$Cl (0.0‰). This $\delta^{37}$Cl homogeneity suggests that the phase separation process, responsible for chlorinity variation at HT, does not fractionate Cl isotopes [1]. In contrast, despite very small variations of chlorinity (550± 6mM), LTF (T ≤60°C) show $\delta^{37}$Cl = -0.71± 0.67‰ (1σ). Moreover, $\delta^{37}$Cl values show positive covariations with $\delta^{36}$O (mainly modified by water-rock interactions) suggesting that a single process leads to a depletion in $^{37}$Cl of the interacting fluids.

Basalts, both fresh and altered at LT, are also depleted in $^{37}$Cl relative to SW (-2.8 <$\delta^{37}$Cl < -0.2‰), but show very constant $\delta^{37}$Cl, indistinguishable from the SW $\delta^{37}$Cl (0.0‰). This $\delta^{37}$Cl homogeneity suggests that the phase separation process, responsible for chlorinity variation at HT, does not fractionate Cl isotopes [1]. In contrast, despite very small variations of chlorinity (550± 6mM), LTF (T ≤60°C) show $\delta^{37}$Cl = -0.71± 0.67‰ (1σ). Moreover, $\delta^{37}$Cl values show positive covariations with $\delta^{36}$O (mainly modified by water-rock interactions) suggesting that a single process leads to a depletion in $^{37}$Cl of the interacting fluids.

Interaction of SW ($\delta^{37}$Cl = 0‰) with fresh OC ($\delta^{37}$Cl < 0‰) produces fluids and rocks with $\delta^{37}$Cl ≤ 0‰. These data expose a mass balance problem.

References