Mineralogical and spatial control of seawater-derived noble gases and halogens in the oceanic crust

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Recent studies have suggested seawater-derived noble gases and halogens are recycled into the mantle during the subduction of the oceanic crust. To better understand their behaviour in the material involved in the subduction process, we analysed 28 altered mid-ocean ridge basalts (MORB) and 8 sediments from the oceanic crust. These samples are from different Pacific IODP sites (504, 896, 801, 1149, 1256). Halogens (Cl, Br, I) and heavy noble gases (^{36}Ar, ^{84}Kr, ^{130}Xe) were analysed in neutron-irradiated samples using noble gas mass spectrometry.

The ^{130}Xe/^{36}Ar and ^{84}Kr/^{36}Ar ratios of the altered MORB are up to 10 times and 2 times higher than seawater. The higher values are associated with altered MORB containing from 5 to 50% clay minerals. The I/Cl ratio varies by 4 orders of magnitude and the Br/Cl ratio is 30% lower than in fresh MORB. I/Cl ratios below those of fresh MORB are attributed to Cl-rich amphibole crystallisation in altered basalts. In contrast, the higher I/Cl ratios could be related to a contamination by sediments. As a consequence of the mineralogical control and sediment contamination, the ^{130}Xe/^{36}Ar ratios and I/Cl wt ratios are higher in the upper 1100 m of the oceanic crust, with average values respectively 25×10^{-4} and 70×10^{-5}. At deeper levels, altered MORB are characterized by lower ratios, more similar to seawater (^{130}Xe/^{36}Ar = 8×10^{-4}, I/Cl=2×10^{-5}). Cl/^{36}Ar molar ratios in the upper layer (10^{6}-10^{7}) are slightly lower than in the deeper layer (5.10^{6}-10^{8}) and the seawater value (10^{7}).

Our results show that the oceanic crust is a significant carrier of noble gases and halogens prior to subduction. Also, because the oceanic crust is heterogeneous with depth for noble gases and halogens, the composition of the fluids released in the mantle wedge during subduction will strongly depend on the geodynamic context and on the slab thermal regime.