Using coupled Fe-Mg chemical and isotopic diffusion profiles to model magma residence times of crystals

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Recent studies have shown that chemical diffusion at magmatic temperatures generates Fe and Mg isotope fractionation in olivine that exceeds potential equilibrium isotope fractionation by an order of magnitude [1,2]. Accordingly, diffusion-generated Fe-Mg chemical zoning in olivine should be coupled with Fe-Mg isotopic zoning. In this case, magma residence times of crystals can be derived by adequate modeling of both, chemical and isotopic zoning.

This approach has been tested on olivine grains in basaltic rocks from the Massif Central volcanic region (France). Large, chemically zoned olivines were analyzed by femtosecond laser ablation MC-ICP-MS. With this technique an external precision of ±0.10‰ (2 SD, based on replicate analyses of glass standards) can usually be achieved for both δ^{56}Fe and δ^{26}Mg.

Several olivines show significant Fe-Mg isotopic zoning (of up to 1.5‰ for δ^{56}Fe and up to 0.8‰ for δ^{26}Mg) that is coupled with the chemical zoning (i.e. Mg#). Furthermore, the zoning profiles of δ^{26}Mg and δ^{56}Fe are negatively correlated. This strongly indicates that the observed zoning was generated by diffusion of Fe into and Mg out of the olivine during magma evolution (e.g. [3]). Simplified and independent modeling of Fe- and Mg- chemical and isotopic zoning was used to estimate the duration of Fe-Mg inter-diffusion between crystal and melt, which may reflect the residence time in a magma chamber before eruption [4]. Our results point to minimum magma residence times between 0.5 and 10 years, which is similar to the short timescales determined by diffusion modeling of chemical gradients in olivines hosted in basaltic lava flows from Mt. Etna [5].

A major focus of our project is to apply our developed technique to olivine crystals in MORBs to improve our knowledge on magma evolution at mid-ocean ridge settings. Olivines from the Mid-Atlantic Ridge and the Costa Rica Rift show both normal zoning and reverse zoning of forsterite (up to 4 mole percent). Fe-Mg isotopic profiles will be determined to prove whether the chemical zoning was generated by diffusion and thus provides information on magma residence times of these olivines.

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The transport of toxic elements in river affected by acid thermal water and effect of dam against elemental distributions

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Acid waters accompanied by mining activities commonly cause environmental problems worldwide. The same is true for the acid thermal waters. The Shibukuro and Tama rivers in Akita Pref., northeast Japan, were one of the most contaminated river system in Japan due to discharge of the the Tamagawa thermal water. This thermal water has being neutralized before inflowing into this river system. The Tamagawa Dam was constructed, and the man-made lake is also contributing dilution of acidic river water. In this study, we investigated the changes in physico-chemical status of As, Cd and Pb originated from the Tamagawa thermal water and their fractionation during river transport.

The geochemical behaviors of As and Pb are mainly controlled by the pH-dependent sorption onto ferric and aluminum solid materials. At upstream region, As tends to be sorbed onto bedrocks and the suspended hydrous ferric oxide (HFO) during river transport. The suspended HFO sorbing As is transported to man-made lake, and the most As originated from the Tamagawa thermal water settled onto the lakebeds. Due to the pH increase, Pb is considerably removed at this lake, although the Pb spread toward the downstream is not completely suppressed. On the other hand, Cd sorption onto both Fe and Al solid phases is not observed in the entire study reach, but Cd concentration is diluted at the lake.

Downstream from the Tamagawa Dam, paddy fields are widely distributed. Accordingly, it is concluded that the Tamagawa Dam plays environmentally important role for not only the neutralization of acid thermal water but also the dilution of toxic elements and/or suppression of their spread.

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