

Chromium isotope fractionation during mobilization and transport in Sukinda Valley, India

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Abstract

The potential of stable chromium (Cr) isotopes as a tracer for the biogeochemical Cr cycle depends on understanding the fractionation Cr isotopes experience. Here we present Cr isotope analyses of different Cr reservoirs to elucidate the Cr isotope fractionation occurring during oxidative weathering in a natural system from Sukinda Valley, India.

Pristine chromite seams show Cr isotope composition similar to mantle inventory rocks [1]. Weathered chromites, highly weathered ultramafic rocks and soils consistently display light Cr isotope composition, indicating that oxidative weathering have preferentially leached and mobilized heavier Cr isotopes. The surface waters display variable Cr isotope signature. However, total dissolved Cr concentration correlate with Cr isotope composition so that high Cr concentration waters (<2.6 mg L⁻¹ Cr) show lighter Cr isotope values, possibly reflecting the presence of Cr in colloids, while low Cr concentration waters (>17 µg L⁻¹ Cr) have heavier Cr isotope values, reflecting dissolved Cr(VI).

These results show that heavy Cr isotopes are preferentially leached during oxidative weathering. The overall consistency between data indicate that oxidation of Cr(III) to Cr(VI) and subsequent mobilization leads to considerable Cr isotope fractionation, enriching the waters in the heavier isotopes. Contrary, reduction of Cr(VI) during transport enriches the produced solid phases in the lighter isotopes and the remaining solution, in heavier isotopes [2]. The variability of the Cr isotopic composition of natural samples including soil, rock and water samples demonstrates that significant fractionation is associated with Cr biogeochemistry in the environment.

[1] Schoenberg et al. (2008), *Chemical Geology* **249**, 294-306.

[2] Ellis et al. (2002), *Science* **295**, 2060-2062.

Pre-eruptive volatile contents of silicate melt inclusions hosted in the Grey Porri Tuffs of Monte dei Porri Volcano, Island of Salina, Aeolian Islands, southern Italy.

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The Aeolian Islands are an arcuate chain of submarine seamounts and volcanic islands, lying just north of Sicily in southern Italy. The eruptive products on the second largest of the islands, Salina, exhibit a wide compositional range, from basaltic lavas to rhyolitic pumice. The eruptions that produced the Grey Porri Tuffs (GPT) during the opening stages of the Monte dei Porri eruption cycle were among the most explosive in the history of the Aeolian Islands. Recent advances in microanalytical techniques permit quantification of the pre-eruptive volatile contents of magmas through analysis of silicate melt inclusions (MI). These data, in turn, provide valuable insights into magma dynamics and evolution, including the role of volatiles in controlling the style of eruption. To this end, lapilli pumice and scoria fragments were collected from the GPT and analyzed to determine the pre-eruptive volatile contents of the magmas as well as their compositional evolution.

Electron Microprobe Analysis (EMPA) of 38 naturally quenched (glassy) MI hosted in olivine, plagioclase and pyroxene define a complicated evolutionary history. Bulk-rock analyses identify the GPT host units as andesitic pumice (SiO₂ 59.9 wt %) and high-silica basaltic scoria (SiO₂ 53.4 wt%). MI hosted in the GPT pumice unit have basaltic compositions (SiO₂ 46.2 wt%) and MI hosted in the scoria unit have basaltic andesite (SiO₂ 56 wt%) compositions.

Secondary Ion Mass Spectrometric (SIMS) analysis of 23 inclusions reveals a similar bimodal distribution in volatile contents between the GPT scoria and pumice units. Olivine-hosted MI from the GPT pumice unit have higher average H₂O and S contents (4.53 wt % and 3790 ppm, respectively) compared to olivine-hosted MI from GPT scoria unit (2.7 wt % and 1772 ppm, respectively) but slightly lower F contents (659 ppm in pumice-hosted MI and 875 ppm in scoria-hosted MI). Cl contents are fairly uniform, averaging 3339 ppm in scoria-hosted MI and 3559 ppm in pumice-hosted MI. The higher H₂O contents of MI from the pumices compared to scorias is consistent with more explosive nature of eruptions that produced the pumices, compared to the less-explosive scoria eruptions.

Analysis of several spots within individual, large olivine-hosted MI shows CO₂ abundances of approximately 187-492 ppm in the GPT pumice unit and 233-576 ppm in the scoria unit. If the melt was saturated in CO₂ at the time of MI entrapment, CO₂/H₂O ratios indicate that the olivine in the pumices crystallized at approximately 6.5 km, whereas those in the scorias formed at 4.8-6.2 km.