

Incongruent dissolution of volcanic riverine particulate material in seawater: Consequences for global element cycling

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The world's rivers transport material from the land to the oceans in dissolved form and as particulate matter. Although particulate fluxes dominate over dissolved fluxes for the majority of elements relatively little attention has been paid to the role of riverine particulate material, both in the fluxes of elements to the oceans and moderating global climate [1]. The degree to which riverine particulate matter plays a role in the compositional evolution of seawater depends on its dissolution rate after arrival in the ocean. Volcanic islands supply the most easily weathered material to the oceans and are an important component of the global suspended flux. However, the apparent dearth of original volcanic minerals in oceanic drill cores suggests that the dissolution of riverine particulate material in seawater may be an important component of land-to-ocean element fluxes.

This study measured directly the initial element release rates of riverine particulate material in seawater through a series of closed-system batch reactor experiments. Large changes to the concentrations and isotopic ratios of elements are observed in seawater when mixed with riverine particulates. Elements such as Si, Ca, Mn and Ba show marked increases in seawater concentrations, indicative of particulate dissolution. Other elements such as Li become rapidly depleted in seawater, suggesting element exchange reactions or the formation of secondary phases. Sr and Nd display comparatively little change in seawater concentrations, but have large changes in isotopic ratios. Taken together, these results demonstrate a significant role of seawater weathering of riverine particulate material to the fluxes of elements to the oceans and have important consequences for the use of isotopes as tracers of global processes.

[1] Gislason *et al.* (2006) *Geology* **34**, 49–52.

Fluid and temperature conditions in an oceanic detachment fault footwall: Insights from late-stage mineral veins (ODP Leg 304/305)

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The Atlantis Massif is an oceanic core complex located at the Mid-Atlantic Ridge at ca. 30°N. During IODP Leg 304/305 Hole U1309D the footwall of the detachment fault, which is related to exhumation of the Massif, was drilled. It consists mainly of gabbros and troctolites, with minor amounts of basaltic and ultramafic rocks. The 1416 m long drilled section is fractured and shows a retrograde overprint recorded by granulite- to zeolite-facies mineral assemblages. Late-stage mineral veins (consisting of anhydrite, calcite, prehnite or zeolite) formed from sub-seafloor fluid-rock interactions. These veins were examined to further our understanding of the fluid regime and temperature conditions in detachment fault systems.

Abundant syn- to postkinematic calcite has low concentrations of incompatible elements (e.g. U, Sr, Li) as well as flat chondrite-normalized REE+Y pattern with a positive Eu anomaly. This indicates that the calcite precipitating fluids are similar to basalt-hosted high-T vents and indicate no affinity to the nearby serpentinization-derived Lost City vent field. The deep origin of the fluids is highlighted by low ⁸⁷Sr/⁸⁶Sr (0.704 to 0.708), mantle-like $\delta^7\text{Li}_{\text{LSVEC}}$ (+0.8 to +9.4‰) and $\delta^{13}\text{C}_{\text{PDB}}$ (-6 to -2‰). From $\delta^{18}\text{O}$ values, minimum calcite precipitation temperatures of 150–220°C are derived.

Anhydrite and anhydrite + zeolite veins have ⁸⁷Sr/⁸⁶Sr values consistent with anhydrite formation from down-flowing seawater which had leached only minor amounts of Sr from the basement. The REE pattern of anhydrite veins indicate that admixed hydrothermal fluids at depth played a minor role.

Silicate minerals (prehnite, quartz, plagioclase) predominate veins in the deepest section of Hole 1309D and indicate precipitation temperatures ranging from 270 to 145°C (estimated from $\delta^{18}\text{O}$ values). They are comparatively unradiogenic in ⁸⁷Sr/⁸⁶Sr (0.7033–0.7046) and demonstrate (in contrast to anhydrite) enhanced intensity of reactions between infiltration seawater and basement with increasing depth.