Hf-Pb isotope systematics in MORB along the Reykjanes Ridge (50-64°N)

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To further elucidate interaction between the Iceland mantle plume and the Mid-Atlantic Ridge (MAR) with greater sampling density, coverage, and analytical precision, we report Hf and Pb isotope data for 56 basalt glasses from the Reykjanes Ridge (RR) covering its entire latitudinal extent from 64°N to 50°N. Hf and Pb were separated from the same leached sample dissolutions and measured for their isotopic compositions by MC-ICP-MS.

Overall, Hf and Pb isotope ratios display good negative correlations. Between 64°N and 61°N, both Hf and Pb isotope along-ridge variations confirm the major gradient previously established with fewer data and corroborate its binary nature in Pb-Hf-Nd isotope space. Along this segment, ε_{Hf} increases from a minimum value of +14 for subaerial RR peninsula samples to +18 for basalts dredged from 1000 meters below sea level. Meanwhile, Pb isotope ratios decrease from, respectively, 18.9, 15.5 and 38.3 to 18.3, 15.4 and 37.7 for $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$. This steep Hf-Pb isotope gradient, which correlates with the steep topographic gradient, reflects the direct influence of the Iceland plume on RR MORB. Further south, down to 52.5°N (Gibbs FZ), as the topography descends more gently from 1000 to 2500 meters below sea level, basalts show nearly constant isotopic compositions at ε_{Hf} of +18 and $^{206}Pb/^{204}Pb$, $^{207}Pb/^{204}Pb$, and $^{208}Pb/^{204}Pb$ at 18.3, 15.4, and 37.6, respectively. Contrary to the 64-61°N segment, the homogeneous isotopic signal for the 61-52.5°N segment is decoupled from the topography. A spike in ε_{Hf} breaks the isotopic homogeneity at 57°N where two samples have values of +21. No similar spikes are observed for Pb or Nd isotopes, suggesting local Hf isotope decoupling, but a change occurs in the ridge axis bearing bending it to a more southerly direction. In the leaky Gibbs TZ, two samples have Pb isotope ratios slightly higher than neighbouring basalts, perhaps reflecting sediment incorporation during lava emplacement. Finally, from the Gibbs FZ to 50°N, the boundary where the influence of the Iceland and Azores plumes on the MAR meet, ε_{Hf} climbs steadily toward values exceeding +23, a tendency mirrored by gradually decreasing Pb isotope ratios. As opposed to the relatively more enriched basalts of the plateau, which may be under the influence of the Iceland plume, MORB in the vicinity of 50°N appear mostly unaffected by either the Iceland or the Azores plumes.

Short lifetime for CO_2 in the atmosphere after a meteorite impact on sediments

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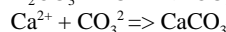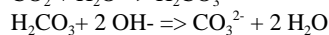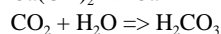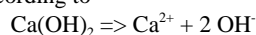[2] Univ. Münster, Münster, Germany
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Impacts of large meteorite on Earth, such as Chicxulub impact at the K/T boundary, have been invoked to severly affect the surface of the Earth, leading to mass extinction. Of the most important are the greenhouse effects due to CO_2 released by decomposition of sedimentary carbonates ($CaCO_3$). In result, an equal amount of CaO is dispersed on the Earth surface.

We review chemical reactions that consume CaO and describe their consequences on the Earth ecosystem.

At temperature below 1000°C, CaO is very unstable in presence of CO_2 and is rapidly and quantitatively ($\approx 50\%$) transformed to $CaCO_3$ at 100 second timescale. The diffusion of CO_2 through $CaCO_3$ controls the kinetics.

At lower temperature (≤ 100°C) CaO is not stable in contact of water and known to exothermically react to give portlandite : $Ca(OH)_2$. Then portlandite dissolves to buffer the water pH around 12.5 and in presence of CO_2, $CaCO_3$ forms according to

$$Ca(OH)_2 => Ca^{2+} + 2\ OH^-$$
$$CO_2 + H_2O => H_2CO_3$$
$$H_2CO_3 + 2\ OH^- => CO_3^{2-} + 2\ H_2O$$
$$Ca^{2+} + CO_3^{2-} => CaCO_3$$

which is controled by CO_2 diffusion in water and the dissolution rate of portlandite (S. Shih et al., 1999). Typical convertion rates are about 30 % of $Ca(OH)_2$ transformed into $CaCO_3$ within 20 minutes.

Such processes show that CO_2 lifetime in the atmosphere are controled by the CaO reactivities at high and low temperatures. These lifetime may be very short.

References

S. Shih et al., 1999, kinetics of the reaction of $Ca(OH)_2$ with CO_2 at low temperature; Ind. Eng. Chem. Res., 38, 1316-1322.