

Evaluation of the rare gas contents in the mantle and the “helium paradox”

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The rare gas content in the mantle is a key aspect of mantle geochemistry. It has some huge consequences on the understanding of the Earth dynamics but is still under vivid debate. We propose here three evaluations of the rare gas contents in the mantle based on a coupled geochemical and geophysical approach.

(1) The first method lies on the appraisal of different models of the degassing processes in oceanic basalts (OIB and MORB).

(2) The second method is based on the study of the degassing of ^3He on the mid oceanic ridges and the elemental ratios of the rare gases in the mantle. The calculation is consistent with a closed system vesiculation for MORB. (3) The last approach uses the constraints from the plume-ridge interaction between low $^4\text{He}/^3\text{He}$ plumes and ridges. We use the scaling laws developed by Ribe et al. for the plume-ridge interaction to deduce the He and Ne concentrations in both MORB and plume magma.

We compare these estimates with the predicted ^3He content, based on a closed system lower mantle evolution with uranium content between 10 and 20 ppb.

This estimate indicates a clear missing helium; this is known as the “helium paradox”. We review different solutions that can explain this paradox.

Hydrogeochemistry of a Modern Dolomite-Forming Lagoon System (Cabo Frio-RJ, Brazil): Role of sulfide oxidation

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A comparative porewater and sediment study was conducted on two hypersaline lagoons near Cabo Frio, Brazil. These lagoons, Lagoa Vermelha (LV) and Brejo do Espinho (BE), have been examined as environments of microbial dolomite precipitation (Vasconcelos and McKenzie, 1997) associated with sulfate reducing bacteria, as supported by microbial culturing studies. Our study indicates that sulfide oxidation and hydrological parameters may be equally important to dolomite formation in these shallow systems.

LV and BE are flanked by dunes to the north and south, which separate the lagoons from Atlantic open seawater towards the south and from Araruama lagoon, a large, hypersaline water body with restricted access to the open ocean, to the north. BE has a more proximal relation to Araruama, while LV is more closely associated with meteoric waters. Sediment chemistry indicates that LV sediments contain a significantly lower percentage dolomite than those of BE. All sediments have very low Fe contents (<20 $\mu\text{mol/gr}$).

Porewater element profiles of LV suggest evaporation of seawater with concomitant sulfate reduction and Ca loss with sediment depth. In contrast, BE overlying waters appear to be derived from Araruama recharge via evaporative concentration. No net sulfate reduction is observed in BE, possibly due to sulfide oxidation observed in upper sediment intervals in close contact with the atmosphere. During anoxic closed sediment incubation experiments conducted using sediments from both lagoons, no significant depletion of porewater sulfate was observed, indicating low rates of microbial sulfate reduction in these sediments. In fact, less than 3% of total available sulfate is reduced in lagoon porewaters. Thus, high sulfate concentration does not appear to have inhibited dolomite formation in these waters.

The sediment and porewater results of this study suggest that the environmental parameters of BE are more favorable to dolomite formation. As a working hypothesis, we propose that dolomite precipitation in these lagoons may be coupled to sulfide oxidation processes, which maintain relatively low porewater saturations with respect to aragonite.