From extreme CO_2 venting to ocean acidification – Experimental approaches to assess the fate of deep sea ecosystems

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Human activities are expanding and intensifying hypercapnic regions of the world ocean. The passive influx of fossil fuel CO_2 from the atmosphere to the ocean is leading to a massive change in ocean chemistry, including increased ocean carbon levels and pH reductions unseen on Earth for perhaps >30 million years. In addition, ocean carbon sequestration by direct deep-sea CO2 injection could produce extremely low pH near disposal sites. What consequences for deep ocean ecosystems will accompany anthropogenic changes in ocean chemistry?

Tolerance of marine animals to environmetnal hypercapnia and acidified ocean waters is coupled to their phylogeny and to physiological repertoires shaped by adaptation during their recent evolutionary history. Metazoans exposed to hypercapnic waters from deep-sea vent sites, and to a lesser extent cold seep environments, must be tolerant of environmental hypercapnia caused by venting fluids, which can include high levels of CO_2, CH_4, and HS^-, in addition to other compounds. In general, phyla with well-developed respiratory systems and capable of internal acid-base control (e.g. Mollusca, Crustacea, Annelida) are more sucessful in low pH vent sites than taxa with poor ion-regulatory capacity and weak oxygen transport systems (e.g. Echinodermata).

Deep-sea ecosystems may be particularly vulnerable to future ocean acidification. Although we have a general understanding of variation in hypercapnic tolerance among phyla, and several examples of metazoans tolerant of low pH waters near vent sites, deep-sea taxa are thought to be considerably less tolerant of environmental stress of any kind than surface-dwelling taxa.

Here we discuss expected future changes in ocean chemistry and experimental methods enhancing our understanding of the impacts of future ocean acidification on deep-sea ecosystems. Recent experimental approaches to investigate the impacts of extreme hypercapnia range from studies of natural CO_2 vent sites to *in situ* and laboratory experiments evaluating the physiology, development, and survival of animals exposed to low pH waters.

Nitrogen isotopes and plume-ridge interaction: The Central Indian Ridge and the Reykjanes Ridge

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We present new N-isotope data for a suite of basaltic glasses from the Central Indian Ridge (CIR), the Reykjanes Ridge (RR) and Iceland. All samples are well characterized for $^3He/^4He$ ratios and C-isotopes. Our aim is to ascertain the $\delta^{15}N$ characteristics of plume-ridge systems.

The CIR from ~ 17 – 20 °S is a spreading ridge at ~ 2.5 km depth marked by $^3He/^4He$ ratios ranging from MORB ratios (~8 R_A) to plume-like values ~11 R_A [1]. $\delta^{15}N$ values range from +2 ‰ to -6 ‰ (n=21) and exhibit a negative correlation with He isotopes. The two highest $^3He/^4He$ samples have the lowest $\delta^{15}N$, probably indicating a plume endmember with isotopically-enriched He and depleted N characteristics. The most enriched $\delta^{15}N$ samples (~ +2 ‰) have $^3He/^4He$ from 7 – 10 R_A, while samples clustered ~8R_A range from -4 ‰ to +2 ‰. This suggests a heterogeneous MORB endmember that is either decoupled for N-He isotopes or affected by degassing and/or alteration.

The RR shoals towards Iceland (sample depths 1.5 – 0.8 km) and is marked by high $^3He/^4He$ ratios (11-17 R_A) [2]. $\delta^{15}N$ values range from ~ -5 ‰ to +6 ‰ (n=10) and also show a negative correlation with $^3He/^4He$. Two subglacially erupted Icelandic basalts show an opposite trend: $\delta^{15}N$ values of -6 ‰ and +3‰ are associated with $^3He/^4He$ ratios of 9 R_A and 17 R_A respectively – a positive correlation. Is this apparent decoupling an intrinsic property of the Icelandic mantle or is degassing responsible? To help address these questions, we are currently targeting various tracers - C/N, $\delta^{13}C$ and $^4He/^{40}Ar$* - on the same sample suite.

[1] Füri *et al*. (2008) *InterRidge News* **17,** 28-29. [2] *Hilton et al*. (2000) *EPSL* **183**, 43-50.