Deep diamonds: Geochemical constraints on mantle dynamics

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Deep diamonds (i.e. those believed to come from the transition zone and lower mantle) provide some of the most compelling geochemical evidence of material transfer between the upper and lower mantle (reviewed in [1]). The geochemistry of these diamonds and their mineral inclusions places a number of constraints on mantle dynamics.

The phase assemblages in the inclusions reflect primarily the conditions of diamond crystallisation, but the original source source rock material may leave some geochemical signature. For example, Ca silicate perovskite inclusions are enriched in trace elements many times above primitive mantle levels, suggesting an enriched source such as subducted crust. However, nearly all Mg silicate perovskite inclusions have low Al concentrations, which could only occur at the top of the lower mantle where garnet is also present. Together these observations support the idea that descending slabs pile up at the 660-km discontinuity.

Carbon isotopic compositions resemble those of the primitive mantle, in contrast to upper mantle diamonds, which show much lower and scattered values. This has been interpreted to indicate a lower mantle source for diamond carbon, with implicit implications for a restricted mixing of upper and lower mantle material. Recent suggestions, however, that redox conditions may play a role in carbon fractionation during diamond formation [2] introduce the possibility to account for observed carbon isotopic compositions through the redox dynamics of subducting slabs.

Nearly all lower mantle diamonds are classified as Type II, and the small amounts of nitrogen that are present show a high degree of clustering. Such behaviour generally indicates long mantle residence times and/or temperatures higher than are typical for diamond crystallisation.

To examine the degree to which deep diamonds and their mineral inclusions can be used to constrain mantle dynamics, I have compiled geochemical data from a number of sources. These include major and trace element geochemistry (including Mössbauer analysis) of the inclusions, carbon and nitrogen isotopic compositions of the diamonds, as well as information on growth and etching features. The result is a set of constraints on mantle dynamics that are consistent with the formation of deep diamonds with the observed geochemical signatures, their transport within the mantle, and eventual exhumation to the Earth's surface.

References

[1]. C. McCammon (2001), *Science* **293**, 813-814.
[2]. C. McCammon and M. Kopylova (2003), *8th Inter. Kimb. Conf.*, in press

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Compound-specific δ^{15}N measurements of amino acids in dissolved organic matter from the central Pacific Ocean

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δ^{15}N values were measured for individual amino acids from high molecular-wieght dissolved organic matter from surface to 4000m in the central Pacific ocean. To our knowledge these values represent the first compound specific δ^{15}N determinations for oceanic dissolved organic matter (DOM). Due to sample size and the complex DOM matrix, resolution was substantially more difficult than for other sample types we have examined, including particles and biota. However a subset of amino acids were resolved sufficiently to give reproducible values in most samples (Table 1). Overall, individual amino acid values tracked δ^{15}N of bulk DOM well. The similarity between amino acids whose nitrogen isotopic shifts tend to represent bulk protein suggests that despite the large fraction of nitrogen which cannot be identitified in DOM, proteinaceous material- or a nitrogen source that is isotopically very similar - makes up the majority of HMW-DON. The only distinct change in δ^{15}N of amino acids within the water column profile occurs at the Chl. maximum zone. However, DON preserved at the oxygen mimimum and in the deep ocean has both similar isotopic shifts and similar relative fractionation pattern to those in the surface Pacific. This suggests that, contrary to expectation, dissolved proteinaceous material that advects into the deep ocean is not substantially recycled. Very rapid mechanisms must act in the surface waters to protect this otherwise highly labile material from biological recycling processes over very long time scales.

δ^{15}N- AA Pacific DOM

12°S, 135°W

Depth (m)	**2**	**100**	**375**	**4000**
UDOM	*8.3*	*8.5*	*7.9*	*7.8*
Ala+Gly:	8.2	9.5	5.5	8.5
Ser+Thr	6.2	6.2	6.2	4.9
Val	9.5	9.9	5.0	9.9
Leu	**	11.6	5.7	4.9
Asp	8.8	12.6	4.9	12.0
Glu	4.7	6.3	7.2	10.3