Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 672

Nitrogen Isotope Systematics of the Mantle and the Fate of Organic Matter Through Time

Bernard Marty (bmarty@crpg.cnrs-nancy.fr)[1] & **Nicolas Dauphas**

[1] Centre de Recherches Pétrographiques et Géochimiques, CNRS EP 2031, 15 rue Notre-Dame des Pauvres, BP 20, 54501 Vandoeuvre-lès-Nancy Cedex, France

The nitrogen isotopic composition of the mantle has been a matter of debate for decades. Nitrogen in the MORB mantle and in the diamond-forming subcontinental mantle is depleted in ^{15}N by ~ 4 parts per mil relative to atmospheric nitrogen, a signature that has been regarded as a remnant of the nitrogen isotopic composition of Earth-forming planetesimals (e.g. Javoy et al., 1986, Marty and Humbert, 1997). Biologic activity fractionates nitrogen isotopes by several parts per mil during denitrification which results in the residual nitrogen being enriched in ^{15}N. Consequently, nitrogen in sediments and crustal rocks exhibits positive $\delta^{15}N$ values relative to ATM (average ~ + 6), making this element a potentially powerful tracer of crustal recycling into the mantle. N-Ar isotope data for fluid inclusions in 370 Ma-old carbonatites from the Kola Peninsula characterized by plume-type He and Ne together with high $^{40}Ar/^{36}Ar$ ratios (up to 5,000) show $\delta^{15}N$ around + 3 which was interpreted as reflecting either crustal recycling or metal-silicate partitioning of nitrogen (Dauphas & Marty, 1999). It was not clear however if these data characterized solely carbonatitic magmas or specific processes linked with carbonatite generation, or if they were representative of the plume mantle. Here we present new N-Ar data for selected plume-associated lavas from the Society Islands, Hawaii, Iceland, the Afar triple junction (Gulf of Tadjoura) and the East Pacific Rise at 20ºS that show that such ^{15}N enrichment is world-wide distributed in the deep mantle and is likely to reflect recycling of organic nitrogen from the Proterozoic to Present.

Submarine fresh glasses were selected on the basis of the occurrence of solar-like, plume-type Ne (EPR, Hawaii, Iceland, Afar) associated with low $^4He/^3He$. For some of them (EPR, Iceland), high $^{40}Ar/^{36}Ar$ ratios evidence limited contribution of surface-derived volatiles. Society islands -SI- (Teahitia, Mehetia, Cyana, Rocard) lavas show high $^{40}Ar/^{36}Ar$ but variable and often high $^4He/^3He$ which, together with Sr-Nd-Pb isotopes, indicate clearly contribution of recycled crustal material for this off-ridge plume province. Gases were extracted by crushing in order to minimize contributions of surface-derived nitrogen (Marty & Zimmermann, 1999).

$\delta^{15}N$ values for samples with low $^{40}Ar/^{36}Ar$ may be compromised by assimilation of marine sediments but, for samples with high (e.g., >1,000) $^{40}Ar/^{36}Ar$ ratios, N-Ar data show that the field defined by the Society Islands, representing the recycled component end-member, is clearly distinct from that of MORB in having $\delta^{15}N$ between 0 and +6. The N isotope composition of the deep mantle appears dominated by recycled crustal N since (i) there is not correlation between N and He isotopic ratios and (ii) the SI field is not resolvable from that defined by Kola carbonatites, although for the latter radiogenic isotope systematics show lower crustal contribution than for SI. In detail however, Icelandic samples [DICE 10 and 11, $^{20}Ne/^{22}Ne$ up to 13.7 (Harrison et al., 1999)] and EPR samples (not shown) show $\delta^{15}N$ intermediate between the MORB and the SI-Kola fields, consistent with source mixing between these two end-members independently seen in other isotope and trace element tracers, and reflecting progressive mixing of different mantle regions through entrainment of MORB-type mantle by plume mantle.

The large-scale mantle N isotope heterogeneity may reflect change in N biologic fractionation mechanism and therefore environmental conditions through time. Radioactive tracers indicate that residence time of crustal material recycled deep in the mantle is significantly lower (<2 Ga) than the age of the Earth, suggesting that nitrogen with positive $\delta^{15}N$ now seen in the source of plumes was derived from organic matter produced during the Proterozoic or later. The organic matter in cherts follows a N isotope evolution that parallels that the mantle : its $\delta^{15}N$ was apparently negative during early to middle Archean and shifted towards positive value later on (Beaumont and Robert, 1999). In this case the MORB N values may not be primordial, but may rather reflect Archean recycling of light N in a depleted mantle region exhausted in volatiles. This possibility is consistent with the MORB source having a $N_2/^{36}Ar$ end-member (up to $5x10^6$) one order of magnitude higher than that of plume ($3x10^5$) and sets strong constraints on the convective regime of the mantle through time.

Samples were kindly provided by H. Staudigel, S. Niedermann, I.N. Tolstikhin, J.A. Barrat and IFREMER-BRGM.

Journal of Conference Abstracts
Volume 5(2), 673

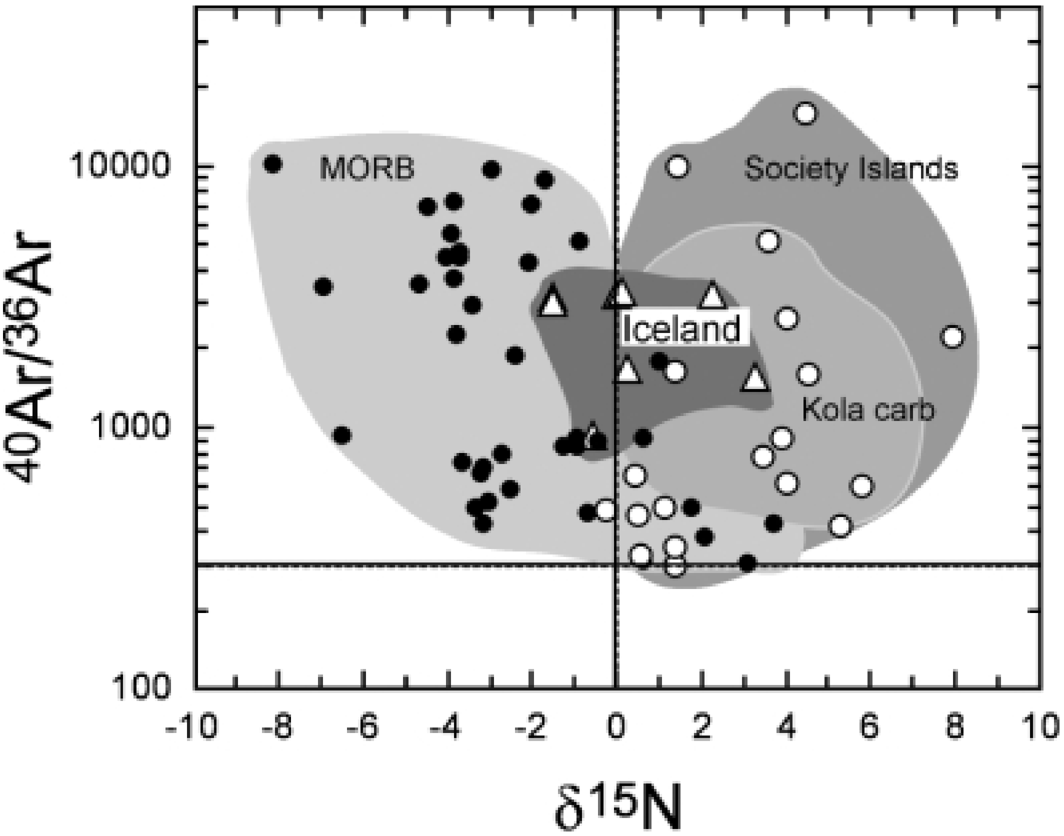

Figure 1

Dauphas N & Marty B, *Science*, **286**, 2488-2490, (1999).
Harrison D, Burnard P & Turner G, *Earth Planet. Sci. Lett*, **171**, 199-207, (1999).
Marty B & Humbert F, *Earth Planet. Sci. Lett*, **152**, 101-112, (1997).
Javoy M, Pineau F & Delorme H, *Chem. Geol*, **57**, 41-62, (1986).
Marty B & Zimmermann L, *Geochim. Cosmochim. Acta*, **63**, 3619-3633, (1999).
Beaumont V & Robert F, *Precambrian Res*, **96**, 63-82, (1999).