Helium and neon isotopes as mantle tracers

N. A. STRONCIK[1], S. NIEDERMANN[1] AND K. M. HAASE[2]

[1]GeoForschungsZentrum Potsdam, Telegrafenberg, D-14473 Potsdam, Germany (nicole@gfz-potsdam.de, nied@gfz-potsdam.de)

[2]Department of Earth Sciences, University of Aarhus, Høegh-Guldbergs Gade 2, DK-8000 Aarhus C, Denmark (karsten.haase@geo.au.dk)

Noble gas isotopes, especially He isotopes, are widely used tracers for the formation and evolution of the Earth's mantle and atmosphere. Basic concepts on mantle structure and evolution are primarily based on the interpretation of mantle ^{3}He as reflecting primordial, undegassed mantle material. In general, the relative enrichment of ^{3}He observed in MORBs and OIBs, compared to atmospheric values, is interpreted in terms of the retention of primordial He by the mantle throughout the history of the Earth. Primordial He isotopic ratios in terrestrial matter are largely thought to be solar-like, with the deviation from those solar-like ratios increasing during Earth's history caused by the production of radiogenic ^{4}He. Thus high ^{3}He/^{4}He ratios are interpreted to represent deep mantle material, whereas ratios around 8 R_A (R_A stands for the atmospheric ^{3}He/^{4}He ratio of 1.39 x 10^{-6}) are thought to be representative for the upper mantle. Based on He, Ne and Ar fusion data of fresh, submarine volcanic glasses of a number of Mid-Atlantic Ridge off-axis seamounts we show that melt formation and evolution can have a larger impact on He than on e.g. Ne resulting in a decoupled behavior of He from other elements, such as e.g. Ne or Pb. All obtained He data are indistinguishable from the MORB range. In contrast, Ne isotopic compositions are much more primitive than MORB. Combined He, Ne and Ar systematics show that the source region of these seamounts experienced a preferential loss of He compared to Ne and Ar. This He loss, combined with subsequent ^{4}He production, resulted in the decoupling of the He isotope systematics from Ne and Pb. Thus, among He and Ne only Ne has preserved the evidence that a primitive mantle component contributed to the formation of the investigated seamounts. As these seamounts are not fed from a mantle plume being derived from the deep mantle, the primitive Ne component resides within the upper mantle, implying that primitive noble gases are not necessarily indicative for deep mantle material. Our studies point out the necessity of obtaining Ne data in addition to He for the modeling of mantle formation and evolution and correct source characterization.

He-Ne-Ar isotope constraints on the nature and origin of high ^{3}He/^{4}He mantle

F.M. STUART AND S. BASU

Isotope Geosciences Unit, SUERC, East Kilbride G75 0QF, UK (f.stuart@suerc.gla.ac.uk)

Olivine phenocrysts from early Tertiary picrites from Baffin Island (BI) and West Greenland have ^{3}He/^{4}He = 38-50 *R*a (*n*=24). The high ^{3}He/^{4}He are consistent with derivation from a mantle reservoir that is relatively undegassed compared to the depleted upper (MORB-source) mantle. Although Ne and Ar concentrations are typically 2 orders of magnitude lower than in basaltic glasses a low blank crusher is allowing Ne and Ar isotope determinations of high-^{3}He/^{4}He olivines. On a conventional 3-isotope plot, the BI picrites are indistinguishable from the Iceland and solar trends; the highest ^{20}Ne/^{22}Ne is 11.3. ^{40}Ar/^{36}Ar are typically less than 1,000. ^{38}Ar/^{36}Ar are indistinguishable from air values providing no evidence for solar Ar in the high-^{3}He/^{4}He mantle. Most samples define a trend in ^{20}Ne/^{22}Ne-^{40}Ar/^{36}Ar space that is consistent with mantle end-member with ^{40}Ar/^{36}Ar of 6,000-8,000. ^{4}He*/^{21}Ne* and air-corrected ^{3}He/^{22}Ne imply the magmatic noble gases have suffered intense fractionation. This is supported by co-variation of ^{4}He*/^{40}Ar* and ^{3}He/^{36}Ar. The elemental fractionation is consistent with recent magmatic degassing and provides no evidence for an ancient degassing event necessary if the high-^{3}He/^{4}He mantle was a residue of early Earth depletion. The BI picrites plot on a trend in ^{4}He*/^{21}Ne*-^{3}He/^{22}Ne space defined by basaltic glasses from Iceland. This is distinct from samples of Kola intrusives and we tentatively propose different degassing/depletion histories for the high-^{3}He/^{4}He mantle domains.