

Systematic variations in radiogenic noble gas isotopes measured in MORB and plume samples

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Noble gases are powerful tracers of mantle processes. Helium, neon, argon, and xenon isotope ratios are all affected by decay of radioactive isotopes of lithophile elements. Compared with other radiogenic isotope systems (*e.g.*, Sr, Nd, Pb, Hf, W), the noble gases trace slightly different geochemical aspects of the same geodynamical processes that have generated chemical heterogeneity in the mantle. Accordingly, noble gas signatures don't easily fit into the framework of depleted and enriched components: enriched recycled oceanic crust and depleted lithospheric mantle are both gas-poor subducting slab components that would carry very low concentrations of isotopically radiogenic gas, and potentially an influx of atmospheric noble gases, into the mantle upon subduction.

Some mantle-derived samples provide data arrays suitable for determination of a mantle source composition corrected for syn- to post-eruptive atmospheric contamination (based on measured $^{20}\text{Ne}/^{22}\text{Ne}$ ratios and a model mantle $^{20}\text{Ne}/^{22}\text{Ne}$ similar to solar). Mantle source $^4\text{He}/^3\text{He}$, $^{21}\text{Ne}/^{22}\text{Ne}$, $^{40}\text{Ar}/^{36}\text{Ar}$, and $^{136}\text{Xe}_{\text{pu}}/^{136}\text{Xe}_{\text{TF}}$ (where TF is total fission) record the long-term outgassing of mantle reservoirs through incorporation of gas-poor slabs [1,2]. Ar and Xe isotopes also record atmospheric influx carried by subducted surface materials into the mantle over time.

A small number of mid-ocean ridge basalt (MORB) and plume-influenced samples (ocean island basalts and MORB glasses from plume-influenced ridge or back-arc segments) have provided mantle source heavy noble gas compositions (see compilations in [2]). Here we discuss new data from modern mantle-derived samples (*e.g.*, Central Indian Ridge near Réunion, East Pacific Rise, Azores) and discuss these in the context of global radiogenic noble gas isotope variations among MORB and plume samples. Two dominant signatures are clear: a more-outgassed MORB source mantle, and a less-outgassed plume source. Pronounced signatures of atmospheric influx are found in both MORB and plume sources. The geodynamical picture that emerges is one of differentially-processed mantle reservoirs that have both retained a portion of their primordial gas budgets, but have incorporated recycled slabs to differing degrees.

[1] Gonnermann and Mukhopadhyay (2009) *Nature* 459, 7246: 560-563; [2] Parai (2025), *Treatise on Geochemistry* (3rd ed.), Elsevier, 513-564.