Seawater subduction controls the heavy noble gas composition of the mantle

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Noble gas isotopes in magmatic CO_2 well gases provide a unique insight into mantle volatile origin and dynamics. Previous work on CO_2 well gas from Bravo Dome, New Mexico has for the first time enabled the mantle He/Ne/Ar/Kr isotopic and elemental abundance to be determined without the ambiguity associated with air contamination in typical mantle samples. This has allowed: i) resolution of the mantle $^{20}Ne/^{22}Ne$ ratios; ii) determination of the mantle $^{40}Ar/^{36}Ar$ ratio and; iii) determination of the relative elemental abundance of He/Ne/Ar/Kr in the well gas mantle source [1]. We have re-sampled this gas field with more focus on the mantle rich portion of the field and extended the analyses to include Xe abundance and isotopic composition. With multiple samples we can now correct for localised air contamination to show 80% of the Xe in the convecting mantle is air-like Xe. The remaining 20% is due to a planetary/solar component. After correction for the planetary/solar Xe, we further show that the elemental composition of the non-radiogenic heavy noble gases in the convecting mantle is very similar to a seawater+sediment mixture [2].

We discuss the consequences of seawater recycling for other volatiles and argue that this is indeed the most likely source of heavy noble gases in the mantle. This requires that the noble gas subduction barrier is not effective [3]. Simple calculations show that a primitive, volatile rich reservoir fluxing to a seawater dominated, steady state mantle explains the isotopic and elemental composition of heavy noble gases in the convecting mantle. In addition, enhanced concentrations of recycled volatiles by subduction into the plume source are suggested by numerical models of mantle convection [4] which then accounts for the lower ratio of radiogenic to non-radiogenic heavy noble gas isotopes, higher water content and variable deuterium abundances in ocean island basalts. Thus, a seawater recycling model is proposed which provides a geochemically consistent explanation for MORB and OIB elemental and isotopic compositions and enables us to provide a quantitative estimate of the seawater flux over geological time to the whole mantle reservoir.

References

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