Noble gas isotope composition of the Yellowstone mantle plume

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The Yellowstone Plateau volcanic field is commonly thought to originate from a deep-sourced mantle plume impinging upon old Archean continental crust[1]. Due to their inert nature, noble gas isotopes provide an ideal tool for distinguishing provenance and mixing processes of different volatile sources within the Earth. Here we present comprehensive noble gas isotope data for (n=34) gas samples collected from thermal areas across Yellowstone National Park.

Samples show a variable enrichment in primordial ^{3}He, with $^{3}He/^{4}He$ ranging from 0.66 to 13.6R_a. Samples located in the center of the caldera tend to exhibit higher $^{3}He/^{4}He$ ratios, with lower values found towards the rim and outside of the caldera. $^{40}Ar/^{36}Ar$ values in excess of atmosphere (up to 438) are observed in samples with both high and low $^{3}He/^{4}He$, indicative of ^{40}Ar contributions from both mantle and crustal sources.

We show that Ne isotopes in Yellowstone are derived from 3 components: atmosphere, a primitive mantle source, and crustal-derived nucleogenic Ne. Nucleogenic ^{21}Ne excesses are inversely correlated with $^{3}He/^{4}He$, suggesting a common source of crustal-derived radiogenic ^{4}He and ^{21}Ne. Samples with low nucleogenic ^{21}Ne contributions define a mixing trend between atmosphere and the purported plume-source endmember. This correlation falls close to that previously determined for the Iceland plume[2], which is known to be extremely enriched in primordial isotopes, with $^{3}He/^{4}He$ up to 50R_a[3].

Due to the high $^{4}He/^{21}Ne$ production ratio in the crust, He is likely more susceptible to overprinting by radiogenic additions during crustal interaction. We therefore conclude that the Yellowstone plume samples a more primitive mantle source than suggested by its relatively modest He isotope ratios,

[1] Huane et al., 2015, *Science*, **348:6236** [2] Trieloff et al., 2000, *Science*, **288:5468** [3] Stuart et al., 2003, *Nature*, **424:6944**