Detection of primordial heavy noble gases in Yellowstone National Park

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The preservation of primordial noble gas signatures in the Earth's mantle can provide a wealth of information on the origin and evolution of volatile elements on Earth. Neon isotopes measured within samples originating from the deep plume mantle indicate the Earth accreted volatiles directly from the solar nebular[1]. While, neon in the deep mantle is dominated by a solar nebular component, the heavy noble gases (Kr and Xe) in the MORB mantle reservoir appear to have a chondritic composition[2,3]. The origin of this dichotomy in accretionary noble gas signatures between the deep plume source and the MORB mantle remains to be resolved.

Here we present high precision noble gas measurements on a suite of hydrothermal gas samples collected in the Yellowstone National Park. Helium and neon isotopes confirm that volcanism in Yellowstone is driven by a deep-seated mantle plume. Resolvable excesses of ^{129}Xe present in the samples confirm that they have retained mantle-derived heavy noble gases. The krypton and xenon isotopic signature measured in Yellowstone points towards a chondritic origin for the heavy noble gases in the deep mantle.

The preservation of chondritic noble gases in the deep primordial mantle indicates that the contribution of volatiles from the solar nebula to Earth must have been limited to light noble gases such as neon[1]. The identification of similar heavy noble gas signatures in the deep plume source and convecting upper mantle indicates that chondritic material provided volatiles to the Earth throughout accretion and removes the removes the requirement for chondritic noble gases to be added to the upper mantle late in the accretionary process.

[1] Williams, C.D. and Mukhopadhyay, S., 2019. Nature, 565 [2] Holland et al., 2009. Science, 326 [3] Caracausi et al., 2016. Nature 533.