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Chondritic Xenon in the Earth's mantle: new constrains on a mantle plume below central Europe

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Chondritic Xenon in the Earth's mantle: new constrains on a mantle plume below central Europe

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Due to their inertness, their low abundances, and the presence of several different radiochronometers in their isotope systematics, the noble gases are excellent tracers of mantle dynamics, heterogeneity and differentiation with respect to the atmosphere. Xenon deserves particular attention because its isotope systematic can be related to specific processes during terrestrial accretion (e.g., Marty, 1989; Mukhopadhyay, 2012). The origin of heavy noble gases in the Earth's mantle is still debated, and might not be solar (Holland et al., 2009).
Mantle-derived CO_2-rich gases are particularly powerful resources for investigating mantle-derived noble gases as large quantities of these elements are available and permit high precision isotope analysis. Here, we report high precision xenon isotopic measurements in gases from a CO_2 well in the Eifel volcanic region (Germany), where volcanic activity occurred between 700 ka and 11 ka years ago.
Our Xe isotope data (normalized to 130Xe) show deviations at all masses compared to the Xe isotope composition of the modern atmosphere. The improved analytical precision of the present study, and the nature of the sample, constrains the primordial Xe end-member as being "chondritic", and not solar, in the Eifel mantle source. This is consistent with an asteroidal origin for the volatile elements in Earth's mantle and it implies that volatiles in the atmosphere and in the mantle originated from distinct cosmochemical sources. Despite a significant fraction of recycled atmospheric xenon in the mantle, primordial Xe signatures still survive in the mantle. This is also a demonstration of a primordial component in a plume reservoir.
Our data also show that the reservoir below the Eifel region contains heavy-radiogenic/fissiogenic xenon isotopes, whose ratios are typical of plume-derived reservoirs. The fissiogenic Pu-Xe contribution is 2.26 ± 0.28 %, the UXe contribution is negligible, the remainder being atmospheric plus primordial. Our data support the notion that the fraction of plutonium-derived Xe in plume sources (oceanic as well as continental) is higher than in the MORB source reservoir. Hence, the MORB—type reservoirs appear to be well distinguished and more degassed than the plume sources (oceanic as well as continental) supporting the heterogeneity of Earth's mantle.
Finally this study highlights that xenon isotopes in the Eifel gas have preserved a chemical signature that is characteristic of other mantle plume sources. This is very intriguing because the presence of a mantle plume in this sector of Central Europe was already inferred from geophysical and geochemical studies(Buikin et al., 2005; Goes et al., 1999). Notably, tomographic images show a low-velocity structure down to 2000 km depth, representing deep mantle upwelling under central Europe, that may feed smaller upper-mantle plumes (Eifel volcanic district-Germany).

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