Chondritic xenon in a mantle plume beneath Eifel (Germany): Implications for early Earth's differentiation

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Noble gases are powerful tracers of the origin of terrestrial volatile elements and of the processes that controlled their distribution between the Earth's interior and the terrestrial atmosphere over geological ages. We will present xenon isotope measurements of CO_2-rich gases emitted in the Eifel magmatic region (Germany).

Xe isotope ratios, determined at high precision, present excesses on light isotopes ($^{124-128}$Xe) signing the presence of a chondritic component in Eifel source [1]. This chondritic signature is consistent with an asteroidal origin of volatile elements in the whole Earth's mantle[2]. Because atmospheric Xe is not derived from a chondritic component [3], this result demonstrates that the atmosphere cannot be simply produced by mantle degassing through geological eras.

Heavy Xe isotopes in Eifel gas contain fissiogenic excesses entirely derived from the spontaneous fission of ^{244}Pu ($T_{1/2}$ = 82 Ma) highlighting the undegassed nature of the Eifel magmatic source. In addition, ^{129}Xe* excess permits to compute a ^{129}Xe*/^{136}Xe(Pu) ratio fully compatible with other oceanic plume sources [4]. These observations, very different from MORB features, suggest that Eifel Xe originated from a plume source located in the deep mantle. Our results are also in agreement with previous geophysical and geochemical studies that suggested the presence of a mantle plume beneath the Eifel volcanic region [e.g., 5].

Radiogenic and fissiogenic excesses allow us to compute that the plume mantle source sampled by Eifel Xe remained isolated from whole mantle convection during the last 4.45 Ga. This result is in agreement with models calling for an early isolation of mantle domains that preserve the early stages of Earth's accretion. Furthermore, the difference of ^{129}Xe*/^{136}Xe$_{Pu}$ between the upper and lower mantles could be explained by addition of volatile rich material to the proto-Earth.

[1] Caracausi et al. (2016), *Nature* in press. [2] Holland et al. (2013), *Nature* **497**, 357-360. [3] Pepin (1991), *Icarus* **92**, 2-79. [4] Parai & Mukhopadhyay (2015) *G*-cubed **16**, 1-17. [5] Buikin et al. (2005), *EPSL* **230**, 143-162.