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Unraveling the composition of mantle noble gases from CO_2-rich geothermal emanations, Homa Hills, Kenya

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Within the framework of the “Geothermal Village” program (an action of LEAP-RE, an Europe-Africa Partnership for Renewable Energy), we conducted a multidisciplinary study of CO_2-rich fluids sampled at Homa Hills, Kenya. This volcanic zone, located close to Lake Victoria along the Nyanza transverse rift, is dominated by Tertiary to Pleistocene carbonatitic volcanism. Abundant bubbles in geothermal waters occurring at three sites - Abundu, Ayombo, Balla - around the volcano were sampled in copper tubes and in 0.25 L-1.5 L Giggenbach-type bottles in order to concentrate large amounts of noble gases for precise isotope analysis. The Balla site was previously sampled by Darling et al [1], who reported $^{40}Ar/^{36}Ar$ ratios around 800, the highest values recorded so far in Kenyan rift gases. We confirmed high $^{40}Ar/^{36}Ar$ ratios between 726 (Ayombo) and 931 (Balla) for the three sites, despite variable gas compositions (CO_2 content between 97.2% and 99.6 %, the rest being mainly N_2 and noble gases), implying limited atmospheric contamination. The observed $^3He/^4He$ ratios (1.6-2.6 R_A) demonstrate the presence of mantle-derived noble gases mixed in different proportions with radiogenic He produced in the adjacent Meso-Proterozoic craton.

The ultra-precise analysis of xenon isotopes by dynamic mass spectrometry done in Seltzer laboratory at WHOI [2] shows excesses of ^{129}Xe ($^{129}Xe_{XS}$) from extinct ^{129}I ($T_{1/2}$ = 16 Ma) and $^{131-136}Xe$ from fission of either extinct ^{244}Pu ($T_{1/2}$ = 82 Ma) or extant ^{238}U ($T_{1/2}$ = 4.45 Ga). Two remarkable features emerge: (i) the $(^{136}Xe/^{129}Xe)_{XS}$ ratio (where suffix XS refers to "excess" relative to atmospheric composition) is very similar to those of other CO_2-rich gases [3] and of MORBs [4]; (ii) The $^{131-136}Xe_{XS}$ spectrum points to ^{238}U, and not ^{244}Pu, being the fission progenitor, contrary to what has been advocated for MORBs and OIBs ([4] and refs. therein). These signatures represent processes that took place during Earth's early evolution, providing insight into the origin of terrestrial volatiles and mantle dynamics.

[1] Darling et al *GCA* **59**, 2501 (1995); [2] Seltzer and Bekaert, *IJMS*, **478**, 116873 (2022); [3] Bekaert D.V. et al Submitted; [4] Mukhopadhyay, S. & Parai, R. *AREPS* **47**, 389 (2019).