^{3}He excess in air, a new potential tracer for volcanic CO_2 emissions in the atmosphere

C. BOUCHER[1*], B. MARTY[1], T. LAN[2], J. MABRY[3], P.G. BURNARD[1], P. BOUCHER[4], L. ZIMMERMANN[1], D. AYALEW[5], T. FISCHER[6], JM. DE MOOR[6] AND M. ZELENSKI[7]

[1] CRPG/CNRS, University of Lorraine, Nancy, France.
[2] IES, Academia Sinica, Taïwan.
[3] Department of Earth Sciences, University of Oxford, UK.
[4] ÉTS of Montreal, Qc, Canada.
[5] Department of Geology and Geophysics. Addis Ababa University, Ethiopia.
[6] Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, USA.
[7] Russian Academy of Sciences, Moscow, Russia

Estimates of volcanic CO_2 emissions from the mantle can be obtained from both the primary volatile $CO_2/^3$He ratio and the helium fluxes [1]. This latter may be evaluated from local and regional variations of the atmospheric helium isotope ratio [R_A= $(^3He/^4He)_{ATM}$]. In 2011, we attempted to detect ^{3}He excesses in air due to subaerial release of magmatic gases enriched in ^{3}He. We focused on the Erta Ale region in Ethiopia, which presents a major volcanic activity marked by a permanent lava lake. We used an accumulation chamber placed on the soil surface to evaluate CO_2 fluxes [e.g., 2] from fumarolic sources. Air samples have been collected from this chamber, above the lava lake and from the crater and the rifting areas. They were analyzed for noble gases in the CRPG laboratory (Nancy, France). We found no evidence of variation of the R_A above the rifting area and the crater zones. However, air samples from the accumulation chamber and the lava lake show ^{3}He excesses (1.3±0.6% for the latter). Significant variations of the R_A with time in the accumulation chamber allows us to estimate for the Erta Ale caldera, a maximum ^{3}He soil flux of (0.022±0.002) mol/yr. This correspond to a CO_2 fluxes of (6.6±0.5)*10^7 mol/yr, which point to a $CO_2/^3$He ratio of (3.0±0.4)*10^9. Based on this ratio and assuming a plume moving at 7 m/s generated by the active zone lava lake (≈8m of diameter), we evaluate a lava lake ^{3}He and CO_2 fluxes of (0.19±0.10) mol/yr and (5.6± 3.0) x 10^8 mol/yr, respectively. A coherent CO_2 flux of 4.3 x 10^8 mol/yr is find based on a CO_2/SO_2 ratio of 1.3 from fumaroles [3] and a SO_2 flux of 11 mol/s for the active lava lake [4].

[1] Marty *et al*. (1989) *Chem. Geol*. 76, 25-40. [2] Perrier *et al*. (2009) *EPSL*, 278 (3), 198-207. [3] Fischer, T.P. (2008) *Geochem J*. 42, 21-38. [4] Oppenheimer *et al*. (2014) *Geol. Soc. Am*. 32, 509-512.