3He excess in air, a new potential tracer for volcanic CO2 emissions in the atmosphere

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Estimates of volcanic CO2 emissions from the mantle can be obtained from both the primary volatile CO2/3He ratio and the helium fluxes [1]. This latter may be evaluated from local and regional variations of the atmospheric helium isotope ratio \(R_A=(^{3}{\text{He}}/^{4}{\text{He}})_{\text{ATM}}\). In 2011, we attempted to detect 3He excesses in air due to subaerial release of magmatic gases enriched in 3He. 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 CO2 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 3He 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 3He soil flux of (0.022±0.002) mol/yr. This correspond to a CO2 fluxes of (6.6±0.5) \times 10^8 mol/yr, which point to a CO2/3He ratio of (3.0±0.4) \times 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 3He and CO2 fluxes of (0.19±0.10) mol/yr and (5.6±3.0) \times 10^8 mol/yr, respectively. A coherent CO2 flux of 4.3 \times 10^8 mol/yr is find based on a CO2/SO2 ratio of 1.3 from fumaroles [3] and a SO2 flux of 11 mol/s for the active lava lake [4].