Noble gas isotopes reveal intensive degassing-derived eruptions at Deception Island (Antarctica)

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Deception Island is one of the most active volcanoes in Antarctica, characterised by three main eruptive episodes: pre-, syn- and postcaldera. The magmatic history of this volcano has been widely studied from the petrologic and geochemical perspectives *(1)*. We combined this information with the analysis of noble gas composition in melt inclusions in olivine phenocrysts and glass (bulk-rock) with the aim to trace noble gas evolution from its magma source to eruption. In pre- and syn-caldera samples, we have extracted the gas from the glass, and the melt inclusions in the olivines, by step-heating (up to 2000ºC) and crushing (hydraulic press) in an ultra-high-vacuum mass spectrometer. Analysis of noble gas isotopes is an excellent tool helping to decipher the origin of the Earth materials due to their particular isotopic ratios for each geochemical reservoir. In addition, they are particularly useful for tracing the evolution of these materials as their elemental ratios record modifications produced by key magmatic processes such as degassing, melting and crystallization *(2)*.
The results of $^{4}He/^{40}Ar^*$ ratios in Deception Island (0.15-0.25) (where $^{40}Ar^*$ indicates non-atmospheric ^{40}Ar), are notably lower than the mantle ratio (1-5). If this $^{4}He/^{40}Ar^*$ variation resulted from fractionation during degassing, the residual magma (i.e., olivine melt inclusions) should have higher $^{4}He/^{40}Ar^*$ ratio than the previous magma as He is more soluble than Ar within silicate melt. Therefore, the previous or primitive magma should have $^{4}He/^{40}Ar^*$ lower than 0.15, due to diffusivity-controlled fractionation in its source mantle by preceding melt extraction stages. However, local pre- and syn-caldera olivines show $^{4}He/^{40}Ar^*$ values as high as c. 20 (with $^{3}He/^{4}He$ R_A of around 8, i.e. mantle signal), thus revealing intensive degassing episodes that led to the pre- and syn-caldera eruptive events. In fact, these two eruptions were responsible for both the island formation and the caldera’s collapse, respectively. A preliminary evaluation of $^{4}He/H_2O$ in melt inclusions is also in line with this argument. Such as massive degassing episodes match with (i) the enormous eruption described in the island of over 60 km^3 of magma discharged *(3)* during the caldera event *(4)*; and (ii) the existing $^{4}He/^{40}Ar^*$ values of fumaroles *(5)* in the island (3-8), which not only reveal degassing of the current magma, but possibly also significant degassing during the caldera event because of being higher than in the melt inclusions.

(1) Geyer et al., 2019. Sci.Rep.; (2) Burnard, 2001, GCA; (3) Geyer & Martí, 2008. JVGR; (4) Antoniades et al., 2018. Sci.Rep; (5) Padrón et al., 2015. Antarct Sci.

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