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Massive degassing-derived eruptions at Deception Island (Antarctica): Evidences from noble gas isotopes

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Analysis of noble gas isotopes is an excellent tool 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 (1).

We have analysed noble gas composition in melt inclusions in olivine phenocrysts and glass (bulk-rock) of volcanic ejecta from Deception Island's volcano with the aim to trace noble gas evolution from its magma source to eruption. Deception Island is one of the most active volcanoes in Antarctica, characterised by three main eruptive episodes, namely pre-, syn- and postcaldera, which magmatic system is widely characterized from the petrologic and geochemical perspectives (2). 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.

$^{4}He/^{40}Ar^{*}$ ratios in Deception Island (0.15-0.25), where $^{40}Ar^{*}$ indicates non-atmospheric ^{40}Ar,are significantly 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 magmas as He is more soluble than Ar within silicate melt. Hence, the previous or primitivemagmashould have $^{4}He/^{40}Ar^{*}$ lower than 0.15, due to diffusivity-controlled fractionation in its source mantle by precedent 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= 8, i.e. mantle signal), thus revealing intensivedegassing episodes that led to the pre- and syn-caldera eruptive events, responsible forboth the island formation and the caldera's collapse, respectively. This is coherent at least with (i) the enormous eruption described in the island of over 60 $km^3$of magma erupted (3)during the caldera event (4); and (ii) the current $^{4}He/^{40}Ar^{*}$ values(5)of fumaroles in the island (3-8) that represent degassing of the present magma and are also higher than in the melt inclusions, thus implying significant degassing possibly during the caldera event.

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

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