Noble gases in olivine melt iclusions reveal degassing state of magmas in Deception Island (Antarctica)

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Noble gas isotopes are powerful tracers to elucidate the origin of materials in the Earth as they have distinctive isotope ratios in geochemical reservoirs. On the other hand, noble gas elemental ratios can be modified by magmatic processes, such as melting, crystallization and degassing [1,2]. We analyzed noble gas composition in melt inclusions in olivines separated from volcanic rocks from Deception Island, Antarctica, where magmatic system has been thoroughly investigated [3], in order to trace noble gas evolution from magma source to final eruption.

Olivine phenocrysts separated from syn-caldera ignimbrite were doubly polished into thin slabs 300–400 μm thick. After investigation on melt inclusions and their water contents with micro X-ray CT and FT-IR, respectively, noble gases in the olivine slabs were extracted by heating in vacuum up to 1900 °C to be analyzed.

$^{4}He/^{40}Ar^{*}$ ratios (0.15-0.25), where $^{40}Ar^{*}$ denotes non-atmospheric ^{40}Ar, are significantly lower than the mantle ratio (1-5), and that of fumaroles in Deception Island (3-8) [4]. If the $^{4}He/^{40}Ar^{*}$ difference resulted from fractionation during degassing, the residual magma (i.e., olivine melt inclusions) should have higher $^{4}He/^{40}Ar^{*}$ than the others as He is more soluble than Ar within silicate melt. This indicates that the primitive magma should have $^{4}He/^{40}Ar^{*}$ lower than 0.15, which could be the nature of its source mantle having low $^{4}He/^{40}Ar^{*}$ due to diffusivity-controlled fractionation by previous melt extraction stages. A rough correlation of water content in melt inclusions with $^{4}He/^{40}Ar^{*}$ is consistent with this interpretation. The high $^{4}He/^{40}Ar^{*}$ of fumaroles suggest that the volcanic gas could be derived from a shallow magma having elevated $^{4}He/^{40}Ar^{*}$ due to extensive degassing.

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