

He-N-H isotope geochemistry indicative of the January 15, 2022 explosive eruption of the Hunga Tonga-Hunga Ha'apai volcano

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At the Hunga Tonga-Hunga Ha'apai volcano (Hunga volcano), located in the Tonga-Kermadec Arc, an explosive eruption with a volcanic eruption index (VEI) of 5 occurred on January 15, 2022. Due to this eruption, the maximum altitude of the eruption column was to be 57 km, reaching the mesosphere and supplying a huge amount of water vapor and volcanic ash to the entire stratosphere. To probe the origin of volatiles and the mechanism of the explosive eruption, this study investigated volatiles of volcanic rocks obtained from the inside Caldera and the southern seamount. Here, we report the measured He and N isotope compositions of glass chips, olivine, and CPX phenocrysts as well as H isotopes and water contents of glasses and whole rocks. According to the ranges of $^3\text{He}/^4\text{He}$ ratios (2.3 to 6.5 Ra) and $\delta^{15}\text{N}$ values (-2.3 to 5.6‰), there is a mixing relationship between the upper mantle, crustal material, and atmospheric components. This indicates that volatiles derived from slab fluids evolved by mixing with the upper mantle volatiles and interacting with crustal materials within the thick crust beneath the Tonga-Kermadec Arc. In addition, the D values (-81 to -40‰) and the water contents ($\text{H}_2\text{O} = 0.3$ to 1.8 wt.%) are interpreted to record a rehydration trend after reaching the degassing maximum, which may provide evidence for the phreatomagmatic eruption. Therefore, our results to date suggest that the magma that led to the explosive eruption of this volcano underwent crustal assimilation at the subduction zone and subsequent interaction with seawater.