Discriminating magmatic sources from fractionation processes using N, Ar and Pb: the Monteregian Hills alkaline province

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N, He, Ar and Pb isotopic compositions were measured in pyroxenes and amphiboles from Monteregian Hills (Québec, Canada) rocks in order to constrain the mantle sources that originated this alkaline igneous province, a controversial issue lasted for more than 30 years. Most common hypothesis is that Monteregian Hills formed by the passage of the North-American craton over the Great Meteor hotspot [1]. However, melting of subcontinental mantle and magma rising through faulting related to the Cretaceous North-Atlantic opening has been also advocated [2].

Noble gases and N were extracted by crushing. Measured He, Ar and N isotopic and elemental compositions are partially fractioned by magma degassing and fluid-rock interactions during magma ascent. In contrast, $^{40}Ar/^{36}Ar$ ratios are not fractionated, but diluted by an atmospheric/crustal source. An observed correlation between the $^{40}Ar/^{36}Ar$ and $^{208}Pb/^{206}Pb$ ratios suggests two-component mixing. The first component may be related to a plume source with high $^{208}Pb/^{206}Pb$ ratios ($\leq$ 2.06) and moderate $^{40}Ar/^{36}Ar$ ratios (~ 1,200) that are less than the values of depleted mantle ($^{40}Ar/^{36}Ar$ =35,000). The second component shows lower $^{208}Pb/^{206}Pb$ ratios ($\leq$ 1.95) and near-atmospheric $^{40}Ar/^{36}Ar$ ratios (~ 300) and could be related to a recycled source such as HIMU.

Although measured $N_2/^{36}Ar$ ratios are diluted by an atmospheric-like source, they show an inverse correlation with $^{206}Pb/^{204}Pb$. This correlation is interpreted as the mixing between a recycled component (HIMU) and an ambiguous mantle source that could be either a plume source or the depleted mantle. Indeed, the non-fractionated $\delta^{15}N$ values for this mantle source are close to -8‰, which favors a depleted mantle source similar to that feeding N-MORBs ($\delta^{15}N$ = -5±2‰). Consequently, a part of the volatile budget might have a depleted mantle isotopic signature. This study shows the great potential of coupling radiogenic isotopes together with Ar and N isotopes. Nitrogen and argon are efficiently recycled in the mantle and thus can be helpful in discriminating the crustal and mantle sources in oceanic and continental volcanism.

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The nearly-primary magmas at the Phlegraean Volcanic District (Italy): new insights by the isotope and trace element whole-rock and in-situ melt inclusion geochemistry

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The Phlegraean Volcanic District in Italy, including Procida and Ischia islands and the Campi Flegrei caldera, homes to recent volcanism, impressive geothermal system and high volcanic risk. Here, as well along the eastern Tyrrhenian Sea edge, the role of genesis and evolution on magma compositions is continuously debated because of the lack of mantle-derived xenoliths, the paucity of primary rock compositions and the large variability of isotope rock geochemistry. The debate also extends to the significance of high-temperature fumaroles, the origin of which is directly attributed to a deep source, as to the mystery of its geochemical features beneath the Campania. We focus on the least evolved shoshonite that belongs to the sole Procida and defines a roughly common whole-rock chemical trend with the Campi Flegrei products. The new data concerns with: 1) O isotopes for whole-rocks and mineral phases; 2) mineral and glass in-situ major oxide geochemistry by Electron Microprobe; 3) in-situ trace element geochemistry on olivine-hosted melt inclusions and glassy matrix by Laser Ablation Inductively Coupled Plasma Mass Spectrometry and 4) in-situ halogen and B isotope in the olivine-hosted melt inclusions by Secondary Ion Mass Spectometry. These new data on glass and mineral have incremented the diagnostic power of the available information on the geochemistry and isotope Sr, Nd, Pb, B, O and He-systematics of the Phlegraean whole-rocks, supporting the idea that the Procida magmas are the primitive end-member for the Campi Flegrei caldera volcanism. The $\delta^{18}O$ values are <5.88‰ for the Procida samples, wherea the highest values (>7.79‰) characterize the Campi Flegrei samples. The lowest $\delta^{18}O$ is associated with low $^{87}Sr/^{86}Sr$ ($\geq$0.70561), high Mg#, Cr, Ni and $^{3}He/^{4}He$ ($\leq$4.76-5.47Ra) values and Fo-richer olivines; instead, the heavy Sr and He isotopes always increase in the Campi Flegrei rocks. Procida also shows $^{143}Nd/^{144}Nd \leq 0.512553$ and $\delta^{11}B$=-3÷-8‰, higher with respect to the Campi Flegrei. REE produce fractionated patterns with Eu negative anomalies that are absent in the Procida melt inclusions and variously developed in the most evolved Phlegrean glassy matrix and whole-rock. Trace elements are typically enriched with respect to the Enriched MORB composition, with positive spikes for Pb. Interestedly, analyzed Procida melt inclusions mime the OIB composition, although showing very high Cs and Pb and moderate Rb, Ba, Th and U enrichments, as well as Nb and Ti depletions. The detected variation appears correlated to crystallization depth of mineral phases suggesting the main role of evolutionary processes within the crust at the Campi Flegrei caldera.