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Triple oxygen isotope composition of the Campi Flegrei magma systems

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Sr-O isotope relationships in igneous rocks are a powerful tool to distinguish magma sources and quantify assimilation processes in magmatic rocks. Isotopic ($^{87}Sr/^{86}Sr$ and $^{18}O/^{16}O$-$^{17}O/^{16}O$) data have been acquired on whole rocks and separated minerals (feldspar, Fe-cpx, Mg-cpx, olivine phenocrysts) from pyroclastic products of the Campi Flegrei volcanic complex (Gulf of Naples, Southern Italy). Oxygen isotope ratios were measured by infrared laser fluorination using a Thermo MAT253 gas source isotope ratio mass spectrometer in dual inlet mode, on ∼2 mg of hand-picked phenocrysts. Variations in triple oxygen isotope ratios ($^{17}O/^{16}O$, $^{18}O/^{16}O$) are expressed as the δ notation relative to VSMOW. Sr isotopic compositions were determined by thermal ionization mass spectrometry after standard cation-exchange methods on separated hand-picked phenocrysts (∼300 mg), and on whole rocks, in case of insufficient sample size to separate crystals. Sr-isotopes in Campi Flegrei minerals range from 0.707305 to 0.707605 and $\delta^{18}O$ varies from 6.5 to 8.3‰ . Recalculated $\delta^{18}O_{melt}$ values accordingly show a large range between 7.2 and 8.6‰ .

Our data, compared with published $\delta^{18}O$-isotope data from other Italian volcanic centers (Alban Hills, Mts. Ernici, Ischia, Mt. Vesuvius, Aeolian Islands, Tuscany and Sardinia) and from subduction zones worldwide (Kamchatka, Lesser Antilles, Indonesia and Central Andean ignimbrites), show compositions that are very different from typical mantle values. Distinct trends and sources are recognized in our compilation from global data: (1) serpentinized mantle (Kamchatka), (2) sediment-enrichment in the mantle source (Indonesia, Lesser Antilles, Eolian arc), (3) assimilation of old radiogenic continental crust affecting magmas derived from sediment-modified mantle sources (Tuscany, Sardinia), (4) assimilation of lower crustal lithologies (Central Andes, Alban Hills, Mts. Ernici, Ischia). Sr-O-isotope values of Campi Flegrei and Vesuvius magmas together form one vertical trend in Sr-O isotope space that deviates profoundly from all other subduction-related magmas. These results suggest that magmas could be derived from (a) a mantle source variably modified by pelagic sediments and later (b) assimilated high $\delta^{18}O$ crustal material that did not significantly affect the Sr-isotope composition.

In addition, $\Delta^{17}O$ variations in hand-picked minerals and some possible contaminants (contact metamorphic skarns, altered Campi Flegrei pyroclastic rocks, marine pelagic shales and cherts) have been analyzed in order to identify the endmembers/contaminants for the Campi Flegrei volcanic complex. $\Delta^{17}O$, calculated as (1000*LN($\delta^{17}O$/1000+1))-0.5305*(1000*LN($\delta^{18}O$/1000+1)), vary between -0.03 and -0.1‰ in minerals, and between -0.07 and -0.2‰ in contaminants. Limestone assimilation is a possibility but can be ruled out by the absence of a positive correlation between $\delta^{18}O$ and CaO. Assimilation of altered high $\delta^{18}O$ older volcanic deposits of similar Sr-isotope composition or, alternatively, shallow assimilation of Sr-poor partial melts derived at low pressure from crustal silicate rocks are possible explanations for the observed trends and need to be further tested.