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Sr-O isotope systematics in the Campi Flegrei magma systems

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Combined radiogenic Sr- and stable O-isotopes are a powerful tool to distinguish between (a) contamination of mantle magma sources by fluids and subducted sediment and (b) assimilation of magmas during ascent through the crust. Advance in laser fluorination mass spectrometry permits to measure small samples and single mineral grains. This allows to directly link Sr- and O-isotope measurements practically for the same sample material. Although isotopic heterogeneity remains a problem even at this level, this approach avoids problems of weathering and mineral-melt disequilibria.

We analysed mineral separates (feldspar, Fe-cpx, Mg-cpx, magnetite, olivine) from 37 samples covering the stratigraphic sequence of the Campi Flegrei volcanic field: Pre-Campanian Ignimbrite (Pre CI; >39.28 ka), Campanian Ignimbrite (CI; 39.28 ka), Post Campanian Ignimbrite/Pre Neapolitan Yellow Tuff (Post CI/pre NYT; <39.28 and > 14.90 ka), Neapolitan Yellow Tuff (NYT; 14.90 ka), and Post-Neapolitan Yellow Tuff (Post NYT; 12.8 ka-1538 A.D.) deposits. Sr isotopic compositions were determined using standard cation-exchange methods on separated hand-picked feldspar, clinopyroxene and olivine phenocrysts (~300mg) and on whole rocks, in case of not enough amount of crystals. By infrared laser fluorination was, instead, measured the oxygen isotopic composition of ~0.3 mg of hand-picked phenocrysts. Recalculating measured mineral O-isotope values to magmatic values to account for mineral-melt 18O/16O-fractionation at various SiO_2-contens of the melt should provide a data set that better constrains magma isotope compositions and magma sources. Sr-isotopes span a range from 0.7069 to 0.7082 that exceed the variations in the bulk rock samples (0.7071-0.7081). However, these ranges vary significantly between eruptive periods. For example the Sr-isotope variation in the Neapolitan Yellow Tuff is only between 0.70750 and 0.70754 for minerals and whole rocks. Similarly, recalculated δ18O-melt values show a large range mostly between 7 and 10 ‰ VSMOW, maximum and minimum values reach from ~11 to ~6 ‰ VSMOW. Our data obtained so far show compositions that are very different from typical mantle values and that span a very large range towards heavy δ18O values compared to other magmatic compositions from the Italian Peninsula.

We compare our clinopyroxene and olivine data with published clinopyroxene and olivine 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). Distinct trends and sources are recognized: (1) serpentinized mantle (Kamchatka), (2) sediment-enrichment in the mantle source (Indonesia, Vesuvius), (3) magma assimilation by old radiogenic continental crust (Alban Hills, Tuscany, Ischia), (4) assimilation by mafic crust (Andes). Sr-O-isotope values of Campi Flegrei and Vesuvius magmas fall on the same vertical trend in Sr-O isotope space that deviates profoundly from all other subduction-related magmas. This indicates that magmas are derived from (a) a mantle source variably modified by pelagic sediments (as for Vesuvius) that were later (b) assimilated by highly δ18O-enriched crustal material that did not further significantly affect the Sr-isotope composition.

From Sr-O isotope relations, this crustal signal could be introduced through interaction with Mesozoic limestone and/or low-T altered volcanic material from previous volcanic activity in the Campi Flegrei caldera.