Multiple origins of carbon in Italian kamafugite melt

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Despite ongoing discussion on magmagenesis and geodynamic controls, there are compelling indications that small volumes of kamafugitic magma in the Intra-Apennine Volcanic Province of peninsular Italy were derived from sources that had been affected by (past) subduction of the Adriatic lithosphere. A close association with carbonatitic rocks has posed the question concerning the origin of carbon, which may have been derived from the mantle sources or from interaction with Mesozoic carbonates residing in the crust. We explored the crystallization history of olivines and their melt inclusions, separated from a representative specimen from San Venanzo, which enables us to (1) determine the primary composition(s) of mantle-derived kamafugite melt and (2) to trace the effects of crustal interaction on melt composition and magma evolution. Complex textures of olivine phenocrysts and their trace element compositions provide a framework for the sequence in which melt evolved within a single plumbing system.

Pristine core parts, characterized by high Fo_{93-90}, low CaO, (0.2-0.3 wt.%) and Cr-spinel inclusions (Cr# ~0.7) are considered to have crystallized from primary mantle-derived melt. Compositions of melt inclusions in these cores are consistent with mantle derivation (8-12 wt.% MgO), but span a continuous range between 3 and 9 wt.% K_2O. The K-richest MI have compositions are relatively enriched in Na_2O, P_2O_5 and TiO_2, while the K-poor endmember is characterized by very high CaO contents (up to 21 wt.%). Rim parts show a strong compositional gradient of decreasing forsterite (down to Fo_{70}) and increasing CaO (up to 1.8 wt.%). Profiles of phosphorous contents in the olivines point to steep increases in the rim parts, indicating that they originated as rapid overgrowths onto phenocryst cores. The combined signatures suggest that the rim parts crystallized from an evolved melt that was contaminated through interaction with carbonate-rich lithologies. Fluid inclusions indicate that this interaction occurred at relatively shallow crustal levels (2 – 10km).

From major and elements contents of core-hosted MI we infer that the kamafugite represents an assembly of primary melts with differented compositions, controlled by low-degree melt extraction from a mantle source with mineralogical variations. Our observations are consistent with a mantle source affected by siliceous K-rich and carbonate/apatite-rich metasomatic agents derived from subducted carbonate-bearing metapelites.

Modeling soil structure and nutrient dynamics using the 1D-Integrated Critical Zone Model

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Model Development

Soil structure has a strong influence on the physical, chemical and biological processes that take place within the soil, and these processes can in turn influence soil structure. The aim of this work was to develop a tractable and defensible mathematical model, the 1D Integrated Critical Zone (1D-ICZ) Model, that links soil aggregate formation and soil structure to nutrient dynamics and biodiversity. Models of flow and transport (Hydrus 1D); bioturbation; Chemical equilibrium, weathering (SAFE); C/N/P dynamics and soil structure, CAST; and vegetation dynamics, PROSUM, were integrated to formulate the 1D-ICZ Model. This model can simulate and quantify the dynamics of C, N and P sequestration in soils in relation to soil structure and organic matter protection, the effects of exudates and mycorrhizae on nutrient mobilisation and acquisition, above and below ground C stocks including microorganisms, fungi and consumers, and water transformation and filtration in soils.

Model Application Results

Theoretical model simulations will be presented to illustrate the sensitivity of nutrient dynamics to dynamic changes of soil structure due to carbon amendments in the system. The inter-relationships between nutrient dynamics and soil structure dynamics will be elucidated. Soil structure and nutrient content data from cropland to set-aside land conversions will be used to validate the 1D-ICZ model. It will be shown that the 1D-ICZ model can quantify four of the most important soil functions: biomass production, C sequestration, water filtration, and biodiversity and thus be an integral component of soil Life Cycle Assessments and Ecosystem Valuation Analyses by linking inventory data to midpoint indicators for soil functions and services.

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