Geophysical Research Abstracts
Vol. 18, EGU2016-8766-1, 2016
EGU General Assembly 2016

How mantle heterogeneity can affect geochemistry of magmas and their styles of emplacement: a fascinating tale revealed by Etna alkaline lavas

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Geochemical investigations of Mt. Etna magmas have led to notable findings on the nature of compositional heterogeneity of the mantle source beneath the volcano. Some of the observed features explain the short-term geochemical variability of volcanic rocks erupted at Mt. Etna in recent times, which are characterized by increase of LILE, 87Sr/86Sr and decrease of 143Nd/144Nd, 206Pb/204Pb,176Hf/177Hf. This compositional behavior has not attributed exclusively to differentiation processes such as fractional crystallization, crustal assimilation and effects of volatile flushing.

In this study, based on some geochemical similarities of the Etnean and Hyblean alkaline magmas, we have modeled partial melting of a composite source constituted by two rock types, inferred by various observations performed on some Hyblean xenoliths, namely: a spinel lherzolite bearing phlogopite-amphibole and a garnet pyroxenite in form of veins intruded into lherzolite that is interpreted as metasomatic high-temperature fluids (silicate melts) crystallized at mantle conditions.

Partial melting modeling has been applied to each rock type and the resulting primary liquids have been then mixed in various proportions. The concentrations of major and trace elements along with the water obtained from the modeling are remarkably comparable with those of Etnean melts re-equilibrated at primary conditions. Different proportions of spinel lherzolite bearing metasomatic phases and garnet pyroxenite can account for the signature of a large spectrum of Etnean alkaline magmas and for their geochemical variability through time. Our study implies that magmas characterized by variable compositions and volatile contents directly inherited from the source can undergo distinct histories of ascent and evolution in the plumbing system at crustal levels, potentially leading to a wide range of eruptive styles. A rather shallow source inferred from the model also excludes the presence of deep mantle structures. Partial melting should consequently take place as a response of shallow mantle upwelling induced by extensional tectonic structures that affect the eastern Sicily.