Compositional variations of Plio-Quaternary magmatism in the circum-Tyrrhenian area: Deep versus shallow mantle processes

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ABSTRACT

The Tyrrhenian Sea area is the site of complex Plio-Quaternary volcanic activity whose products range from mafic to felsic and from subalkaline to ultra-alkaline. Mafic rocks display variable trends of incompatible-element abundances and ratios that depend on the geographic distribution of volcanoes and delineate several distinct magmatic provinces. These are bounded by important tectonic lines and show distinct geophysical characteristics in the mantle-crust system.

The mafic rocks from the various igneous provinces display moderate internal isotopic variations. However, when considered collectively, they define continuous trends that connect distinct extreme compositions. These include high m (i.e., high U/Pb) mantle (HIMU), depleted MORB mantle (DMM), and enriched mantle type 1 (EM1) end-members and a strongly radiogenic $^{87}Sr/^{86}Sr$, unradiogenic $^{143}Nd/^{144}Nd$, and mildly radiogenic $^{206}Pb/^{204}Pb$ composition that resembles upper-crustal estimates.

The smooth trends of radiogenic isotopes have been interpreted as mixing involving deep reservoirs emplaced into the upper mantle by uprising plumes. However, the plume hypothesis is unnecessary and insufficient to explain the compositional characteristics of the igneous rocks in the Tyrrhenian area. Extremely heterogeneous and anomalous upper-mantle compositions and the occurrence of abundant rocks with arc geochemical signatures (i.e., high large ion lithophile element/high field strength element ratios) are best explained by multiple episodes of mantle metasomatism, mostly linked to subduction processes. These likely occurred at various stages in the complex geodynamic evolution of this area, which has been affected by various phases of rifting and subduction over the last 300 m.y. DMM compositions likely derive from depleted mantle sources, which have suffered extraction of mafic melts during rifting phases. The EM1 and upper crustal-like compositions may reveal introduction of crustal material into the upper mantle during pre-Hercynian or Hercynian and Alpine orogenies, respectively. The origin of the HIMU-type composition is more controversial. Its occurrence in most of the Cenozoic igneous rocks in western-central European and in the circum-Mediterranean area requires a wide geochemically uniform reservoir, whose nature is still debated but may represent a rather homogeneous asthenosphere.