GEOCHEMICAL AND ISOTOPIC VARIABILITY OF PLIO-QUATERNARY MAGMATISM IN ITALY : PLUME VS. SHALLOW MANTLE PROCESSES

BY

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ABSTRACT

Plio-Quaternary magmatism in Italy exhibits an extremely variable composition, which spans almost entirely the spectrum of magmatic rocks occurring world-wide (Fig. 1). Petrological and geochemical data provide a basis for distinguishing various magmatic provinces, which show different major element and/or trace element and/or isotopic compositions. The Tuscany Province (14-0.2 Ma) consists of magmas generated through crustal anatexis and of mantle-derived calcalkaline to ultrapotassic rocks; mantle-derived rocks in this province contain mantle xenoliths, but display very radiogenic Sr isotope signatures and LILE/HFSE ratios close to upper crust. The Roman and Neapolitan provinces (0.8 Ma to present) consist of dominant potassic to ultrapotassic, which still possess crustal-like geochemical and isotopic signature. The Aeolian Arc (1 Ma to present) consists of calcalkaline to shoshonitic rocks. The Sicily Province contains young to active centers (notably Etna) with a tholeiitic to Na-alkaline affinity. Finally, volcanoes of variable composition occur in Sardinia and, as seamounts, on the Tyrrhenian Sea floor. Magmas in the Aeolian arc and along the Italian peninsula have a subduction-related geochemical character, whereas the Sicily and Sardinia Provinces display intraplate signatures. Intraplate and orogenic volcanics coexist on the Tyrrhenian Sea floor.

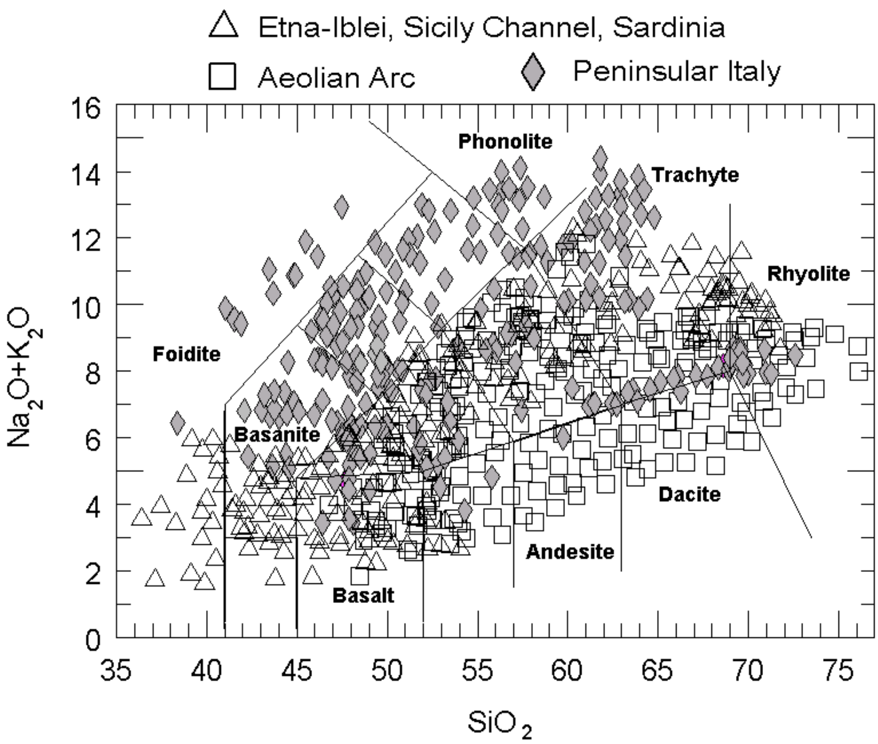

Fig. 1. Total alkali vs. silica diagram for Italian Plio-Quaternary magmatism. Note the extreme compositional variability that covers the entire spectrum of igneous rock compositions occurring worldwide.

Sr, Nd and Pb isotope ratios of mafic magmas (MgO > 4 wt%) from the various provinces are variable, and compositions akin to MORB, EMI, EMII, HIMU and FOZO are found. These geochemical and isotopic complexities reveal that the upper mantle beneath Italy consists of compositionally distinct domains, covering both orogenic and anorogenic characteristics. Explaining these diversities has profound petrological and geodynamic implications.

Sr vs. Nd isotope variations display a curved trend between MORB and upper crust, highlighting interaction between mantle and upper crustal reservoirs. On the other hand, Pb vs. Nd and Sr isotopic variations display more complex patterns, which reveal mixing between HIMU and EMI and between HIMU or FOZO and upper crust (Fig. 2). These complexities have been suggested to be related to a zoned mantle plume beneath the Tyrrhenian sea. A role for both plume and upper crustal materials brought into the mantle by subduction processes has been also suggested (Gasperini et a., 2002; Bell et al, 2003). The alleged occurrence of "carbonatites" in the Italian peninsula has been considered to strongly support the plume hypothesis.

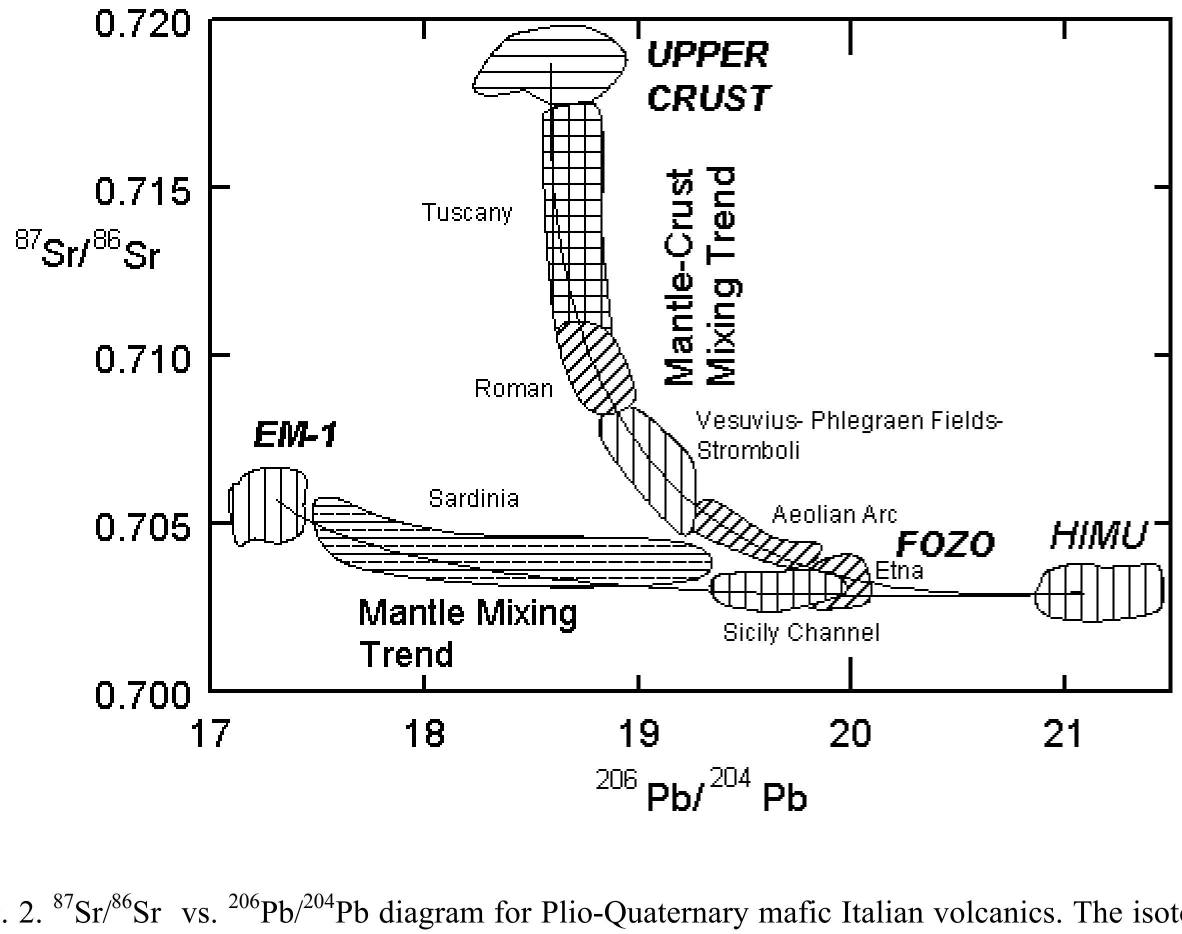

Fig. 2. $^{87}Sr/^{86}Sr$ vs. $^{206}Pb/^{204}Pb$ diagram for Plio-Quaternary mafic Italian volcanics. The isotopic variations can be interpreted as resulting from mixing between mantle and upper crust and between HIMU and EM1 mantle reservoirs.

However, the mafic rocks with high $^{87}Sr/^{86}Sr$, low $^{143}Nd/^{144}Nd$ have incompatible trace element patterns that resemble very closely the upper crust. This implies a genesis in an upper mantle contaminated by crustal material. However, the close gochemical similarity with upper crust suggests recent contamination and argues against a plume hypothesis. Moreover, rocks with FOZO-HIMU isotopic compositions are very widespread in the Mediterranean region suggesting that this represents a resident rather than allochthonous (i.e. plume) mantle material. Finally, scrutiny of geochemical data clearly indicates that the so-called "carbonatites" actually represent silicate potassic rocks affected by secondary replacement by carbonates from sedimentary wall rocks.

The complex petrological and geochemical variations of magmatism in central-southern Italy are best explained by assuming that various metasomatic events affected the upper mantle during the Apennine orogenesis (Peccerillo, 1999). The pre-metasomatic mantle rocks had a heterogeneous composition, as it is expected for a zone affected by several ancient orogenic cycles (e.g. Hercynian, Alpine etc.). The superimposition of multiple metasomatic events over a compositionally variable pre-metasomatic mantle is able to generate an extremely heterogeneous upper mantle, whose geochemical and isotopic variability is inherited by the erupted magmas.

References

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