PLIO-QUATERNARY MAGMATISM IN ITALY:

ROMAN, ERNICI-ROCCAMONFINA, INTRA-APENNINE AND VULTURE PROVINCES

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ABSTRACT

Central Italy contains a large area of potassium-rich volcanism. Early in the 20th century, Washington (1906) recognised various magmatic regions (or provinces), including the Roman Region, the Apulian Region and some small volcanoes in the internal zones of Apennines (San Venanzo and Rieti), which were suggested to be "possibly connected with those of the main line of Roman volcanoes which extend from the Lake Bolsena southeast to Vesuvius and the Phlegrean Fields".
Extensive major, trace element and isotopic studies in the last century have changed the original subdivision of Washington only slightly and essentially for the Roman Region or Province. This is now believed to be more restricted in extent, and only includes the belt of potassium-rich volcanoes of Vulsini, Vico, Sabatini and Albani (Fig. 1). This is also called as the Latium Province (Peccerillo, 2003, 2005). Ernici-Roccamonfina and the Campanian volcanoes have different major, trace element and radiogenic isotope signatures than the Roman volcanoes and are considered as forming two distinct volcanic regions.

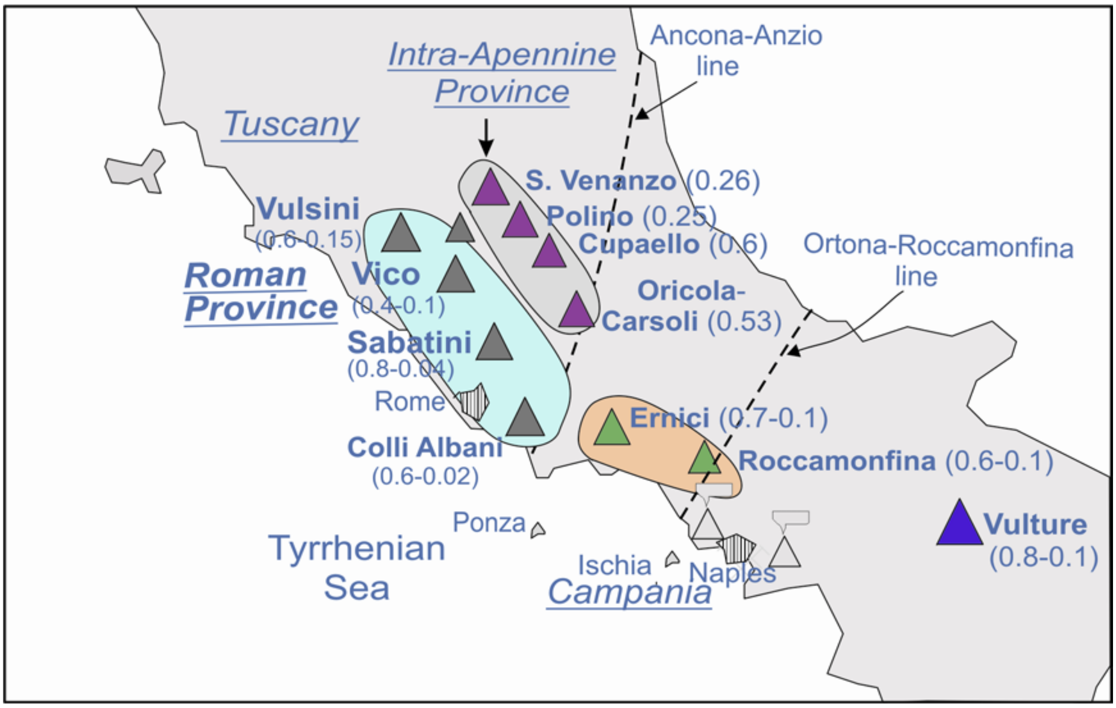

Figure 1. Distribution and ages of Roman, Intra-Apennine, Ernici-Roccamonfina and Vulture volcanoes.

Roman (Latium) Province (~0.8-0.04 Ma) includes the large stratovolcanoes and volcanic complexes of Vulsini, Vico, Sabatini, and Alban Hills. These erupted mafic to felsic rocks belonging to the potassic series (KS) and to the highly potassic series (HKS). Potassic rocks have

K_2O/Na_2O around unity in the mafic rocks; they are nearly saturated in silica and range from potassic trachybasalt to trachyte. HKS rocks are ultrapotassic (i.e. $K_2O/Na_2O > 2.5$ in the mafic rocks), strongly undersaturated in silica and range from leucite-tephrite and leucitite to leucite-phonolite. The mafic rocks of this province have strongly fractionated incompatible element patterns, with negative anomalies of HFSE (Nb, Ta, Hf, Zr, Ti) and positive spikes of LILE and Pb (Fig. 2a). The Roman KS and HKS mafic rocks have poorly variable radiogenic isotope compositions, which are intermediate between mantle and crust (Fig. 3). $^{87}Sr/^{86}Sr$ is typically around 0.710, $^{143}Nd/^{144}Nd \sim 0.5121$; $^{206}Pb/^{204}Pb \sim 18.6$-18.8 for both KS and HKS (e.g., Conticelli and Peccerillo, 1992; Conticelli et al., 2002).

Intra-Apennine Province (~0.6-0.3 Ma) consists of numerous monogenetic mainly explosive centres (San Venanzo, Cupaello, Polino, etc.) scattered though the internal zones of Apennines in Umbria and Abruzzi. Typical rocks of this province are olivine- and clinopyroxene-melilitites (kamafugites) containing olivine, pyroxene, melilite, leucite, kalsilite, monticellite, and several accessory minerals such as perovskite, zirconian schorlomite, etc. Remarkable characteristics of the most mafic rocks are a strong SiO_2-undersaturation, very high CaO, MgO contents and K_2O/Na_2O ratios, and low Al_2O_3 and Na_2O (Peccerillo et al., 1988; Conticelli and Peccerillo, 1992). Incompatible element patterns, LILE/HFSE and radiogenic isotope signatures (Sr, Nd, Pb, Hf) are similar to the Roman rocks (Figs. 2b, 3). Intra-Apennine volcanism, however, is considered as a separate magmatic province on the basis of the kamafugitic affinity of volcanic centres, a feature that is not found in other Italian volcanoes. Carbonate-rich pyroclastic rocks are also present in the internal zones of Apennines, and are believed to represent carbonatitic magmas (e.g. Stoppa and Woolley, 1997). However, there are several objections to this hypothesis, as discussed by Peccerillo (1998, 2004).

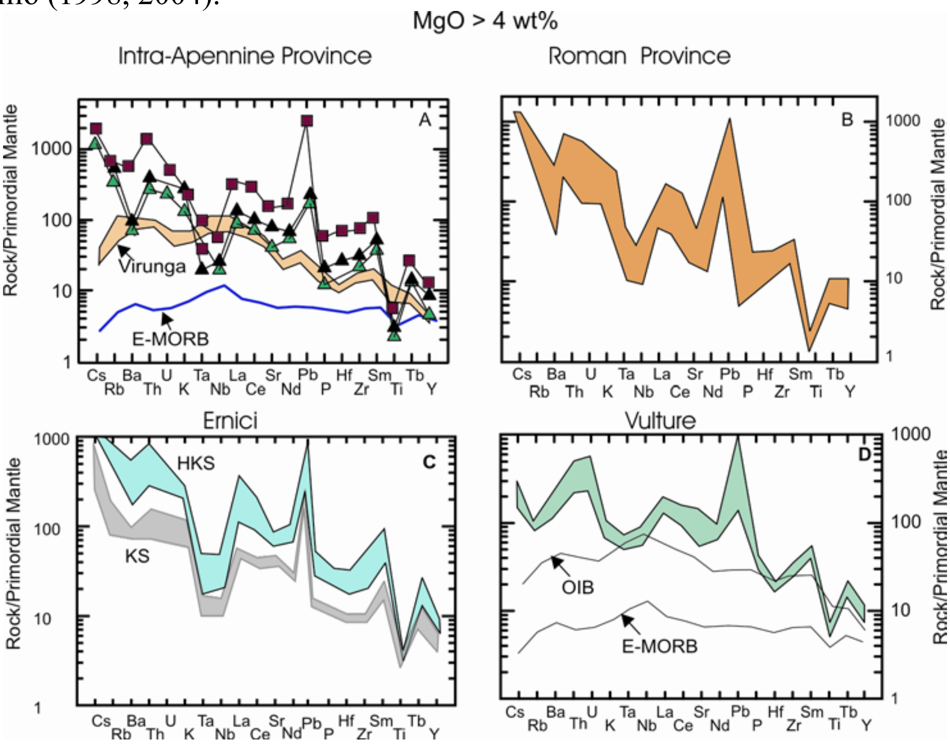

Figure 2. Mantle-normalised incompatible element patterns for Roman, Intra-Apennine, Ernici and Vulture mafic volcanics. Compositions of MORB, OIB, and ultrapotassic rocks from the Virunga volcanic field (East Africa) are also shown.

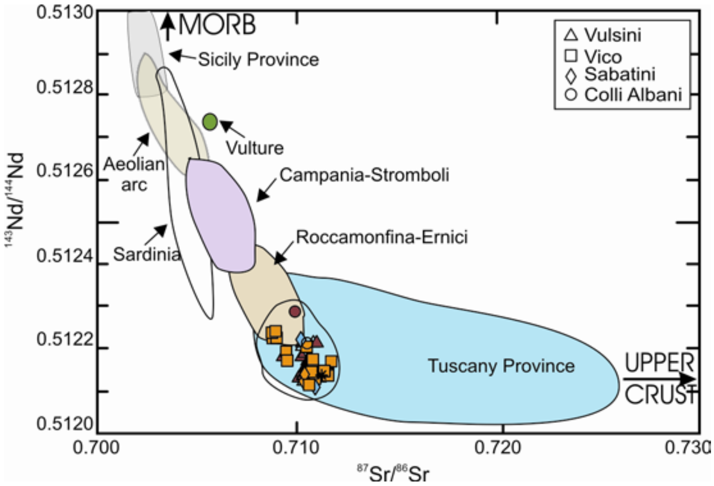

Figure 3. Sr-Nd isotopic composition of mafic rocks for Italian Plio-Quaternary volcanic provinces.

Ernici-Roccamonfina Province (~ 0.7-0.1 Ma) is characterised by the close association of KS and HKS rocks (Civetta et al., 1981). Rocks with K_2O contents falling in the range of calc-alkaline and shoshonitic basalts do also occur at Ernici and Roccamonfina. KS rocks have lower potassium, incompatible element contents and $^{87}Sr/^{86}Sr$ than HKS volcanics (Fig. 2c, 4), and show incompatible element ratios and isotopic signatures resembling those of the Neapolitan volcanoes. In contrast, HKS resembles Roman leucite-tephrites. Therefore, the Ernici-Roccamonfina Province is a zone which is transitional between Roman and Campanian volcanoes (Fig. 4).

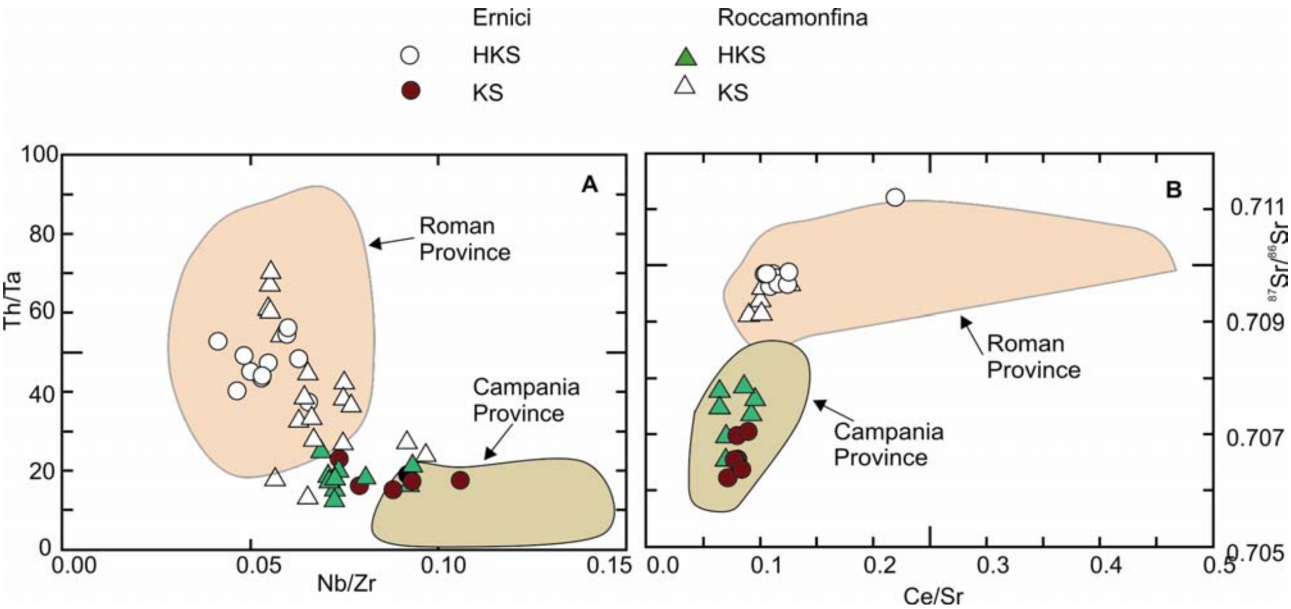

Figure 4. Trace element and Sr isotopic ratios in the Erncic and Roccamonfina mafic volcanics.The field of Roman and Campania provinces are reported.

Mount Vulture (~ 0.8-0.1 Ma) is the easternmost Plio-Quaternary volcano in Italy. Rocks range from basanite and foidite to tephrite, trachyphonolite, phono-tephrite and melilitite. These are moderately potassic but contain high Na_2O abundances and the main foid is haüyne rather than leucite. HFSE (High Field Strength Elements) contents and Nd and Pb isotopic ratios are higher than in the Roman, Ernici-Roccamonfina and Intra-Apennine volcanoes, whereas $^{87}Sr/^{86}Sr$ is lower (D'Antonio et al., 1996; Figs. 2d, 3). Therefore, Mount Vulture represents a distinct magma type than other Italian volcanoes, including those form the Intra-Apennine Province (De Astis et al., 2006). Incompatible element patterns show strong fractionation with negative anomalies of HFSE. However, negative spikes of K and Rb are also present (Fig. 2d), a feature that is typical of intraplate (OIB) Na-alkaline volcanoes. Therefore, the Vulture magma seem to possess both orogenic and intraplate geochemical characteristics.

Magmas in central Italy contain both mantle and crustal-like geochemical and isotopic signatures. However, they are of ultimate mantle origin. They were generated by various degrees of partial melting at variable pressures of a lherzolitic or clinopyroxenite mantle enriched in phlogopite by metasomatic processes. Geochemical data suggest that input of sedimentary material with a marly composition has been responsible for mantle contamination. This implies a subduction-related origin for magmatism in central Italy. The timing of contamination process is debated, and ages ranging from 2.0 Ga to very recent times have been suggested. However, the most likely hypothesis is that crust addition to the upper mantle occurred recently, during the Oligocene to present subduction of the Adriatic plate beneath the Apennines. Primary mantle-derived magmas underwent complex evolution processes during their ascent to the surface, giving large amounts of derivative products which were erupted at the surface by huge explosive eruptions.

The similar trace element and radiogenic isotope composition of Roman mafic rocks and the Intra-Apennine kamafugites suggests a genesis in a similar mantle-source, which underwent the same type and degree of metasomatic modifications. Differences in the degrees of silica undersaturation and major element chemistry point to different modal mineralogy for mantle sources and/or to variable pressure of partial melting.

The Ernici-Roccamonfina magmas had a similar genesis as in the Roman Province. The variable abundances and ratios of incompatible elements as well as the very distinct isotopic signatures between KS and HKS suggest that the mantle source was vertically heterogeneous and was probably modified by two temporally and compositionally distinct metasomatic events.

The intermediate geochemical signatures between OIB and arc-type rocks at Monte Vulture indicate a melt generation in a hybrid mantle source, formed by the interaction of various amounts of Intraplate OIB-type and arc-type components. These hybrid signatures can be explained by assuming that post-collisional slab breakoff of the Adriatic plate beneath southern Apennines generated mantle inflow from the Apulia foreland and contemporaneous contamination by fluids and/or melts coming from the sinking slab (Peccerillo, 2005). Other hypotheses suggest the presence of a deep mantle plume, which was contaminated by subduction components (Gasperini et al., 2002).

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