Per. Mineral. (2003), *72*, SPECIAL ISSUE: *Miocene to Recent...*, **203-210** http://go.to/permin

PERIODICO di MINERALOGIA
established in 1930

An International Journal of
MINERALOGY, CRYSTALLOGRAPHY, GEOCHEMISTRY, ORE DEPOSITS, PETROLOGY, VOLCANOLOGY
and applied topics on *Environment, Archaeometry* and *Cultural Heritage*

Chapter 6
The Monte Cimino volcano

Diego Perugini[1] and Giampiero Poli[1]*

[1] Department of Earth Sciences, University of Perugia, Piazza Università, 06100, Perugia, Italy

6.1 Historical perspective

The first traces of human presence in the Viterbo area are scarce, owing mainly to the non-stop presence, in the same places, of human settlements, erasing, effacing and covering traces of the past, and secondly, to the relative lack of systematic researches on the territory focused to locate witnesses of the oldest periods. Among them we can mention some stone tools from the Middle Paleolithic (from 700.000 to 125.000 years ago) found in Corchiano in the so-called «Cavernette Falische» (small caves), and from the Upper Paleolithic (about 125.000 – 10.000 years ago) found inside a shed under a rock, in Norchia (Vetralla), near Biedano river. During the Neolithic Age (about 5.000 b.C.) in western Mediterranean, a thousand years before than in the Near East, a revolution took place. Earliest villages rose owing to the development of agriculture and cattle-breeding, as well as the need for a fixed abode where to dwell; life conditions grew better, human diet enriched, men's discoveries increased. According to some authors, this basic change is probably due also to the coming of people from the Aegean Sea: they were farmers, bringing with them new tilling techniques, tools, tamed animals, eatable plants (above all cereals) and pottery. From the IX century b.C., the area has been the cradle of the Etruscans, the pre-Roman culture which influenced Tuscany and Latium, and for some respects is still widely mysterious. This area on the whole has Etruscan origins and very important witnesses can be found in many cities. Among others Tarquinia, one of the main cities of the Etruscan Dodecapoli, was particularly important for its harbour. The Etruscan period ends with the coming of Rome, which brought the area under its rule. The plenty of thermal springs and the closeness to Rome made of Viterbo and its area one of the favourite holiday sites for Roman people, owing to the easy access through the Cassia road. After falling of the Roman Empire and the barbarian invasions the area was under the rule of Langobards. During this period started the temporal power of the Pope. Viterbo was the capital city of the Papal State. Together with Rome and Avignon, Viterbo can be called the «city of popes». Influence of this period can be seen in many buildings, masterpieces of the Italian renaissance.

* Corresponding author, E-mail: diegop@unipg.it

6.2 Geological setting

The «Monte Cimino Volcanic Complex» (MCVC) crops out in Northern Latium near the town of Viterbo (Fig. 1). Its activity was characterized by the eruption of viscous

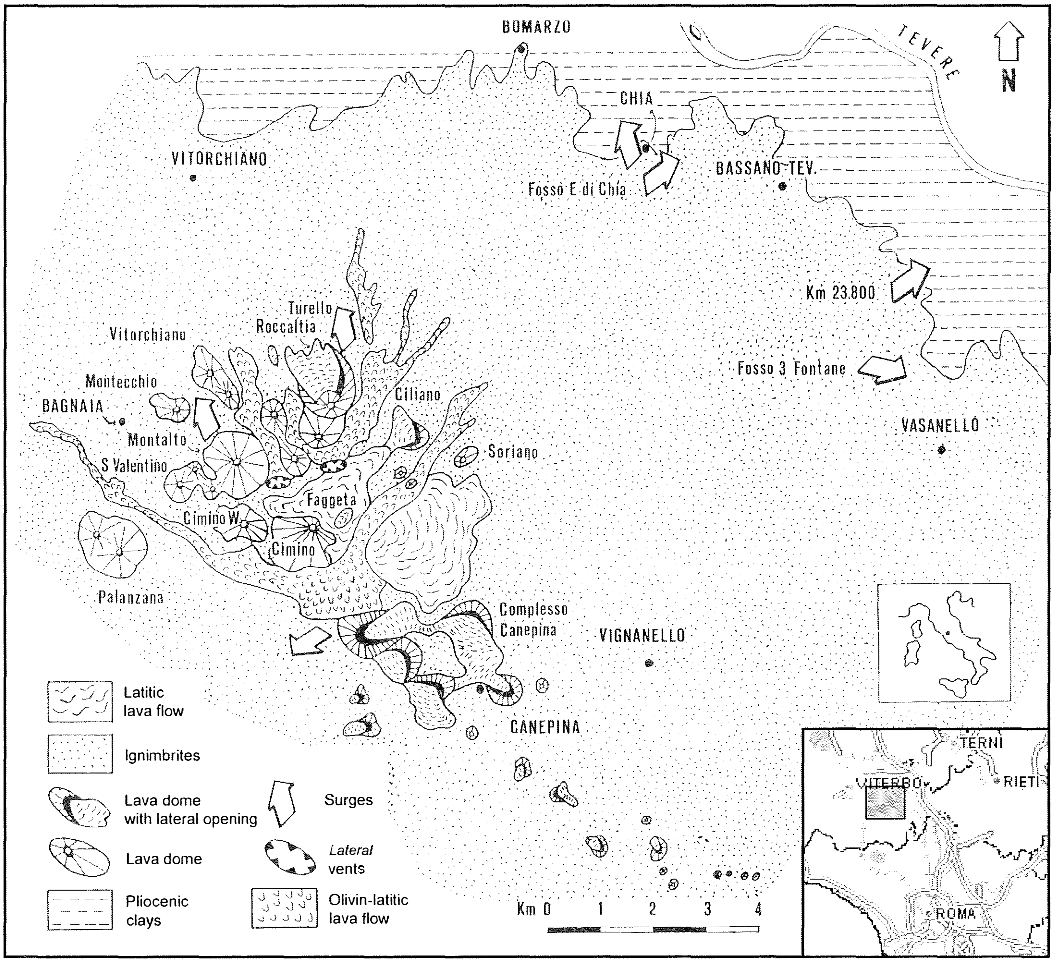

Fig. 1 – Schematic geological map of the Mt. Cimino area. Modified after Landini and Nappi (1987).

trachytic magmas along regional fissures leading to the formation of numerous lava domes. Growth of many of these domes was accompanied by violent explosive activity and probably, by collapse and avalanching from the domes, and produced voluminous ignimbrite plateau around the Cimino dome complex. Ignimbrite is locally known as «Peperino», a hard material well suitable for building. More than fifty lava domes are still recognizable in the Cimino area, and many more are supposed to lie buried below younger domes and their pyroclastic flow or have been annihilated by final explosions. The domes still present give to the Cimino area its characteristic hilly morphology. During the final phase of Cimino activity much more fluid latitic to olivine-latitic lavas were emitted from eruptive centres in the higher part of the complex.

On the basis of K/Ar ages performed by Evernden and Curtiss (1965) and Nicoletti (1969) the activity began during Late Pliocene (1.35-1.19 Ma) with emission of the «Peperino Tipico» ignimbrite and continued with emplacement of lava flows and domes of «Peperino delle Alture» at 1.01 Ma, for ending with the emission of several latitic lava flows at 0.94 Ma. Ventriglia (1963) and Borghetti *et al.* (1981), also on the basis of new radiometric data, suggested that some of the lava domes were older than the «Peperino Tipico» ignimbrite. This was confirmed, on the basis of a field study, by Lardini and Nappi (1987) who also recognised the occurrence of two pyroclastic flow unit inside the «Peperino Tipico» ignimbrite. Final olivin-latitic lava flows outpoured at 0.94 Ma. Tanking into account the temporal evolution of the area, the Monte Cimino Volcanic Complex can be divided into four different periods, namely (Landini and Nappi, 1987):

1) the first period, which was characterised by the ascent of highly viscous magma that brought to the emission of trachytic lava flows and domes along a NNW-SSE alignment (Fig. 1).

2) the second period, where the volcanic activity concentrated in the Monte Cimino area. This period was characterised by the emplacement of the «Peperino Tipico» trachytic ignimbrite, and of large domes around the Monte Cimino apparatus, which is constituted itself by coalescent domes (Fig. 1);

3) the third period was characterised by emission of lava flows, with latitic to trachytic compositions, from the Monte Cimino vent (Fig. 1). They flowed down the flanks of previous Monte Cimino dome cluster covering it partially. These are constituted mainly by thick viscous lava flows characterised by large K-feldspar megacrysts.

4) the fourth period was characterised by outpouring, from the top of Monte Cimino apparatus, of low viscosity mafic lava flows (Fig. 1), which flowed down along the flanks of the apparatus in five different narrow lava tongues. These products have shoshonite to olivine-latite compositions.

In the Monte Cimino Volcanic Complex fine-grained magmatic enclaves are very rare and restricted to few lava flows of the third period of activity; they have ellipsoidal shape with cuspate margins. Metasedimentary and metamorphic xenoliths, ranging from angular to irregularly-rounded, and mostly flattened in shape are quite abundant in the rocks of the first two periods of activity. These xenoliths have been studied in detail by Di Sabatino and Della Ventura (1982), where petrographic and mineralogical descriptions are reported. Detailed information on the thermometamorphic xenoliths are also reported by Sollevanti (1983).

6.3 Petrography

Generally Monte Cimino rocks are porphyritic, although some almost aphyritic rocks are present among shoshonites and olivine latites (Puxeddu, 1971; Conticelli *et al.*, 1995). Lack of feldspatoids is the main mineralogical characteristic of the Monte Cimino alkaline ultrapotassic rocks and this feature distinguish them by the youngest leucite-bearing rocks of the Roman district of the nearby Vico volcano. Tipically modal quartz is also not observed in any of the studied rocks.

Trachytes

According to the chemical classification scheme of Le Bas *et al.* (1986) the Monte Cimino rocks of the first and second period of activity are trachytes. They are strongly porphyritic and the sanidine is the main phenocrystic phase, which sometimes can be centimetric in size; plagioclase, biotite, hyperstene and augite are smaller but equally abundant. Micro-phenocrysts of biotite, plagioclase, orthopyroxene, ilmenite, apatite and zircon make up, together with variably amount of glass, the groundmass of these rocks. Clinopyroxene phenocrysts are commonly found in trachytes of the second period of activity. Xenocrysts are very rare in the trachytes of the first period of activity whereas they are almost ubiquitous in those of the second period.

Latites

This group of lavas is restricted to the third period of activity and it is characterised by rocks with large euhedral megacrysts of K-feldspar. Megacrysts latites have a porphyritic textures with phenocrysts of clinopyroxene, sanidine and ilmenites. Micro-phenocrysts of clinopyroxene, plagioclase, mica and accessory zircon and perrierite make up the olocrystalline groundmass of these rocks. Rounded plagioclase xenocrysts are ubiquitous in latites together with othopyroxene, biotite, K-feldspar, zircon and olivine. Xenoliths of partly molten basement rocks are rarely found.

Olivine-latites

These rocks are distinguished by latites because they have lower silica content, higher MgO and K_2O, and because olivine is almost exclusively the only phenocryst, although diopside can be observed. Olivine phenocrysts vary largely in size, the larger being euhedral to hopper and typically include euhedral dark brown chromite crystals. Clinopyroxene, similarly to olivine, cover all sizes down to those of the groundmass. The groundmass of olivine-latites is microcrystalline and is constitutes by plagioclase, olivine, clinopyroxene, sanidine, apatite and oxides. Significant but variable amounts of xenocrysts are represented by plagioclase, biotite, sanidine and orthopyroxene.

Shoshonites

This group of rocks is characterised by the highest K_2O/Na_2O ratio (>4) among the Monte Cimino rocks. They are micro-vesiculated and slightly porphyritic to sub-aphyric. Olivine is the main phenocryst phase with subordinate clinopyroxene. Olivine is euhedral with polyhedral to hopper habit. Phenocrysts are set in a groundmass constituted by sanidine, olivine, clinopyroxene and oxides. The K-feldspar laths in the groundmass are usually flow aligned with olivine and diopside crystals. Primary plagioclase is completely absent. Xenocrysts are almost totally absent in this group.

6.4 GEOCHEMISTRY

Whole rock element compositions have been reported by Puxeddu (1971), Poli *et al.* (1984) and Conticelli *et al.* (1995). The volcanic rocks of Monte Cimino range from 52 to 65 wt.% silica, 5 to 6 wt.% K_2O and 1.5 to 9.6 wt.% MgO. Co-variations of major elements are clear: SiO_2 and Na_2O decrease strongly and TiO_2, FeO_{tot}, CaO and K_2O increase weakly with Mg-value (Fig. 2). Co, V, Sc, Cu, Ni, Zr, Sr, and Cr show clear positive correlations with Mg-value, although Sc, Sr, and V tend to strongly decrease with no Mg-value variations in the shoshonites; Nb, Nd, Rb and Hf show a weak positive correlation; Y, Ga, Yb, and Tb exhibit a weak negative correlation, whereas La, Ba, Pb, Th and Zn have more complex behaviour. Apparently very few trace elements behaved incompatibly in the Monte Cimino volcanic rocks, and Y, Ga and Tb that clearly did, are not strongly enriched in the rocks with lower Mg-values. However, most of the rocks of Monte Cimino volcano do not display large variations in the so-called incompatible trace element concentrations passing from olivine-latite to trachyte.

When trace elements, normalised to the primordial mantle values (Wood, 1979), are plotted in spider diagrams (Fig. 3) strong negative anomalies at Ba, Ta, Nb, Sr, P, and Ti and weak negative anomalies at Ce and Y are present (Fig. 3); these patterns mimic those of typical calc-alkaline rocks although they have higher concentration of LIL elements. They are similar to the trace element normalised patterns of Southern Tuscany lamproites (see Part IV, Chap. 8). With respect to Roman type rocks (Fig. 3) Monte Cimino rocks have higher total abundance of incompatible HFS elements and smaller negative anomalies of Ta and Nb.

Initial $^{87}Sr/^{86}Sr$ and $^{143}Nd/^{144}Nd$ values range from 0.7131 to 0.7156 and 0.51209 to 0.51214, respectively (Conticelli *et al.*, 1995). The lowest and the highest values have been found among olivine latites and shoshonites, whereas the range of latites and trachytes is much smaller.

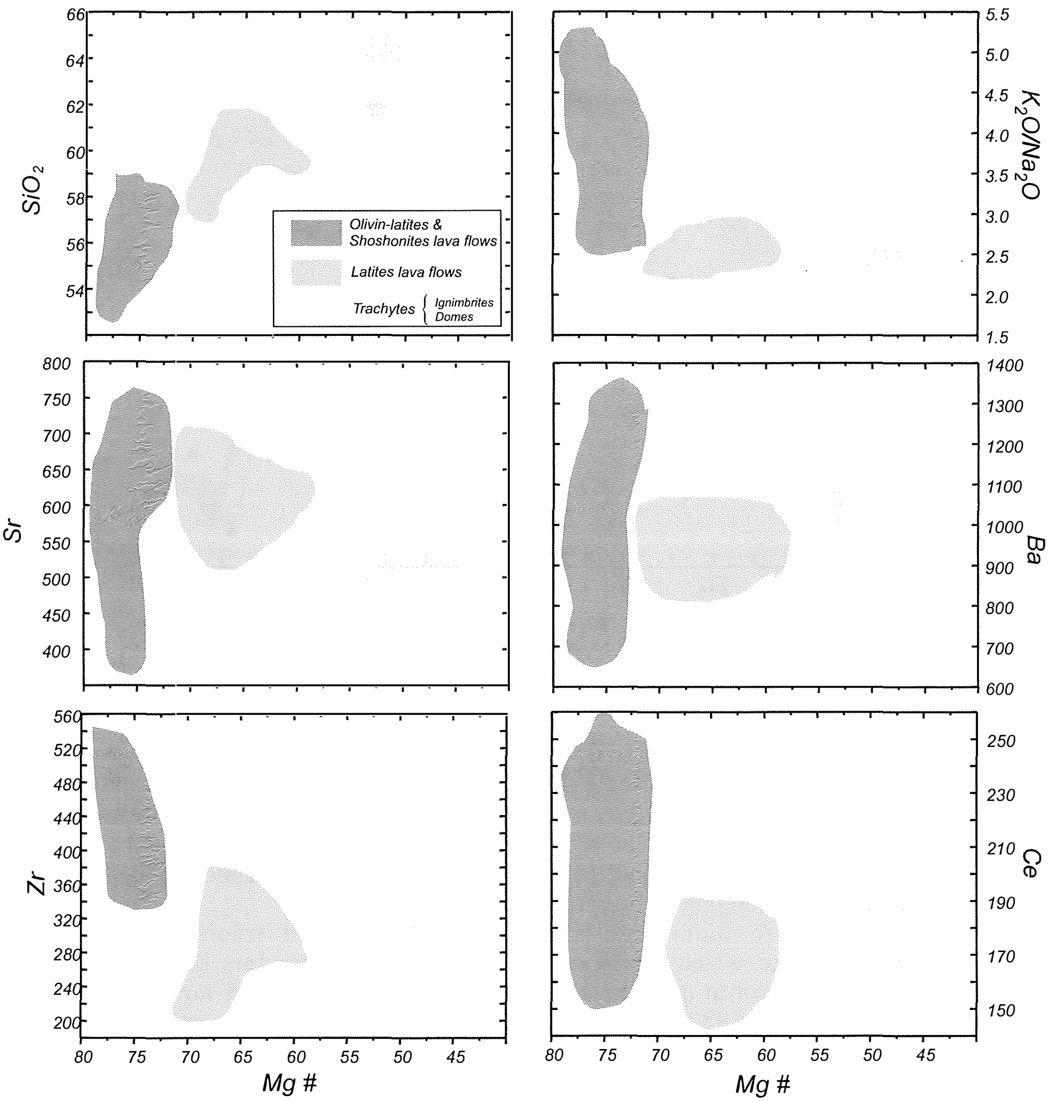

Fig. 2 – Selected major and trace element inter-elemental diagrams for the Mt. Cimino Rocks. Mg# is used as differentiation index because of its large variable contents within the studied rocks.

6.5 Petrogenesis

The Monte Cimino magmas describe peculiar trends, with scattered values of the majority of classic incompatible elements. This feature is particularly striking for the olivine latite and shoshonite groups. However on the basis of their high MgO contents, absence of petrographic evidence of olivine accumulation, and very low xenocrysts content they may be interpreted as having potential near-primary compositions, is spite of their relatively high

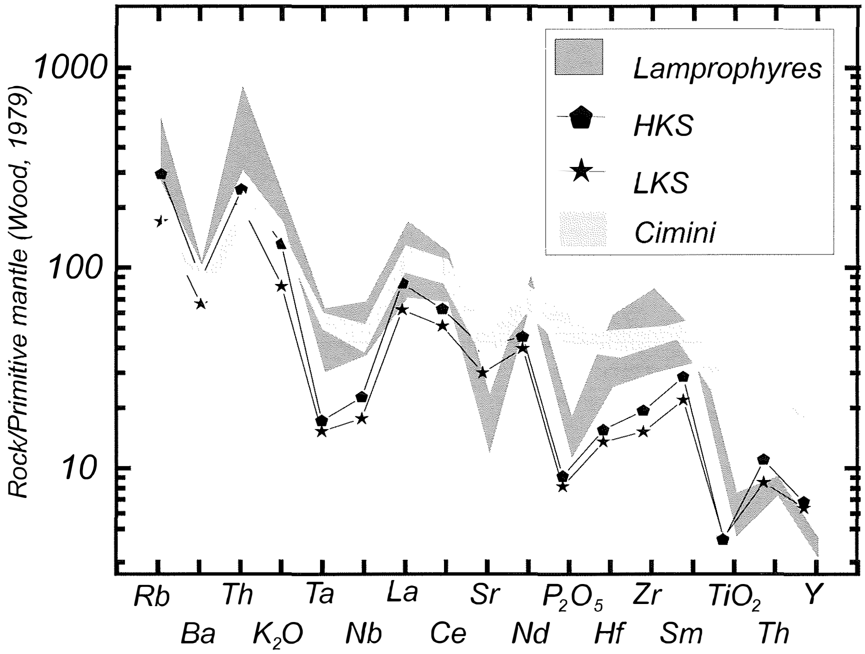

Fig. 3 – Spider diagram reporting Mt. Cimino rocks in comparison with lamprophyric rocks from Southern Tuscany and High K-Series (HKS) and Low K-Series (LKS) Italian rocks. Data from Poli *et al.* (1984), Peccerillo *et al.* (1987) and Peccerillo *et al.* (1988).

silica contents (52-55 wt.%). As shown in figure 3 these rocks resemble lamproitic rocks from Southern Tuscany. High-SiO_2 and -MgO lamproitic magmas can be originated by partial melting at low pressure under high H_2O activity of a mantle source, which experienced basaltic melt extraction prior to metasomatism (e.g. Arima and Edgar, 1983; Foley and Venturelli, 1989).

Olivine latites are probably very close to represent a primary melt composition, suggesting that they were equilibrated with a strongly restitic mantle source, with a lithospheric signature. These rocks have a high radiogenic composition for Sr and unradiogenic for Nd, but crustal contamination by itself, after magma segregation from the source, cannot account for these features because of the high Mg-value and ferromagnesian and compatible element contents. Then the isotopic signature observed might be inherited by either a strong crustal affinity for the metasomatising agent of the source of these rocks or it can be a peculiar feature of an ancient mantle acquired with time after isolation.

The latitic and trachytic rocks have petrographic characters indicating magma mixing processes. End-members of these processes could be the most evolved olivine latites and trachytes. However trachytes cannot be considered as pure anatectic melts owing to their chemistry. In addition, they contain mafic enclaves and cannot be considered as the acid end-member. Thus they represent rocks that underwent mixing phenomena with a more acid end-member. This end-member is difficult to envisage, because of the absence in the Cimini area of evolved rocks lacking evidence of magma mixing. Thus, according to suggestions made by many authors (e.g., Peccerillo *et al.*, 1987; Innocenti *et al.*, 1992; Serri *et al.*, 1993), the most probable end-member of the mixing

processes in the Cimini area is a «granitic» magma with a geochemical signature similar to that of the granites that constitute part of the Tuscan magmatic province.

Figure 4 reports K_2O vs. SiO_2 diagram in which compositions of rocks belonging to the Tuscan Magmatic Province (both intrusives and effusives) are plotted. It is shown that rocks from the Mt. Cimino area define a peculiar pattern that straddle the fields comprised between lamproitic melts and crustal melts similar to the acid rocks of the Tuscan Magmatic Province. In the light of this evidence the pattern defined by the Mt. Cimino rocks can be explained considering a geochemical evolution starting from a lamproitic magma (similar to Torre Alfina or Radicofani) generated by partial melting of a metasomatised mantle source that, successively, interacted with crustal components having compositional characters similar to the Tolfa more evolved rocks or the leucocratic facies found in granitoid rocks of the Tuscan Magmatic Province.