

**CARBONATITE MELT + SOLID SILICATE OR SOLID CARBONATE + SILICATE MELT?
PETROGRAPHIC AND MINERAL CHEMICAL EVIDENCES FOR SHALLOW-DEPTH
CONTAMINATION AT POLINO (CENTRAL ITALY)**

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The Apennine Mts. in central Italy are characterized by the sporadic presence of Holocene alkali and lime-rich lithologies known in literature as ultrabasic-ultracalcic rocks belonging to the kamafugite clan [1]. In particular, two of these outcrops near San Venzano and Cupaello constitute the type localities of kalsilite-bearing rocks such as venanzite and coppaelite. Associated to these two outcrops is a diatreme ~10–15 m in diameter of 246 kyr-old CaO-rich rocks close to the village of Polino [2], ~100 km NE of Rome. These rocks have been classified as monticellite alvikite (volcanic Ca-carbonatite; [3–5]). Polino rocks have been considered as one of the most representative Italian carbonatites, and its mineralogy and isotopic composition are considered as typical of natural Ca-carbonatites.

The Polino volcanic rocks are characterized by abundant presence of forsteritic olivine, followed by monticellite and phlogopite, and Ca–Ti/Ca–Si perovskite and Fe–Ti oxides as accessories, coexisting with different generations of calcite. The forsterite content of olivine is very high, mostly clustering in the 91.5–94.2 range), much higher than the Mg# of monticellite (76–85), a typical feature of skarns (calcsilicate metamorphic rocks).

Several aspects make the classification of these volcanic rocks as carbonatite very questionable. The modal abundance of carbonate minerals is <50%, rendering the term “carbonatite” inappropriate. In literature the relatively high amount of silicates has been related to the presence of mantle debris in the form of xenocrystic forsterite and phlogopite. According to this view, silicate mineral fragments interacted with a Ca-carbonatitic melt, promoting the formation of monticellite according to the reaction: $\text{CaCO}_{3(\text{melt})} + \text{Mg}_2\text{SiO}_{4(\text{olivine})} = \text{CaMgSiO}_{4(\text{monticellite})} + \text{MgO}_{(\text{melt})} \text{CO}_{2(\text{vapor})}$.

We point out that forsterite and phlogopite might not be interpreted as mantle xenocrysts due to their euhedral to subhedral shape, with phlogopite mostly represented by tiny elongated euhedral laths. In addition, the absence of any deformation texture in olivine crystals would be in support of an origin as liquidus phase. In a CaO vs. Fo diagram, the Polino olivines plot in a completely different field compared to worldwide mantle xenolith olivines.

Worth noting, forsterite is not found in groundmass, but as phenocryst only, characterized by a variably thick monticellite rim. As monticellite is known to

be not stable at pressures >1 GPa, the hypothesis of monticellite formation after the reaction of mantle minerals with Ca-carbonatitic melt below the Moho appears improbable.

Based on textural and chemical analyses, we propose the origin of coexisting olivine and monticellite as resulting from a two stage process, where euhedral forsterite first grows in equilibrium from an ultrabasic melt, followed by phlogopite; then, monticellite starts forming at the expenses of forsterite around former phenocrysts and as groundmass phase in close association with microcrystalline calcite.

The late appearance of monticellite can be explained with the interaction of an ultrabasic magma at sub-liquidus conditions with sedimentary limestones representative of the >4 km thick Liassic limestone sequence of the Calcare Massiccio Formation cropping out in Polino area. The strongly radiogenic $^{87}\text{Sr}/^{86}\text{Sr}$ of the calcite component (0.710) corroborates this view.

In conclusion, our view overturns the classically accepted interpretation, based on which monticellite is the reaction product between a carbonatitic magma and mantle xenocrysts. We believe, instead, that the interaction occurred between an ultrabasic melt and the sedimentary carbonate wall rocks *en route* to the surface.

The extremely MgO-rich composition of olivine (up to Fo₉₄) and phlogopite (up to Mg# 94), could be related either to a strongly depleted (i.e., Fe-poor) mantle source or to an anomalously Mg-rich (e.g., dolomite/magnesite-bearing carbonated mantle) source. Alternatively, the classically accepted $\text{Kd}(\text{Fe-Mg})_{\text{ol/melt}}$ (0.30 ± 0.03) determined experimentally with C-free peridotitic starting material does not hold in presence of carbonated mantle. Experimental studies are in progress to estimate the influence of carbonates on the Kd.

The classification of the Polino volcanic rocks remains debated. It cannot be defined as alvikite (too low primary carbonate content), or basalt (no plagioclase), kamafugite (no kalsilite), melilitite (no melilite), foidite (no foids) or dunite (not a plutonic/metamorphic rock) or picrite (SiO₂ <30 wt%). It is a strongly ultrabasic melt whose original composition has been modified by the digestion of sedimentary carbonates.

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