

EXPERIMENTAL CONSTRAINTS ON LIMESTONE–ULTRABASIC/BASIC MELT INTERACTION AT 2 KBAR

V. Stagno¹, N. Luciani¹, S. Narzisi¹, D.B. Faraone¹, M. Lustrino¹, M. Masotta² and P. Scarlato³

¹Dipartimento di Scienze della Terra, Sapienza Università di Roma; ²Dipartimento di Scienze della Terra, Università di Pisa; ³Istituto Nazionale di Geofisica e Vulcanologia, Roma; michele.lustrino@uniroma1.it.

The worldwide distribution of carbonatites is generally associated with old Archean cratons. However, some of these lithologies occurring in central-southern Italy, Central Spain, Morocco, France and Germany are associated to more recent Cenozoic volcanic rocks intruded in basement rocks with variable composition and age. With the exception of the Italian cases, all the Mediterranean carbonatites are emplaced in foreland position or in intra-plate tectonic settings. Associated to these carbonatite occurrences a variable clan of moderate to strongly silica undersaturated igneous rocks (up to CIPW lamite-normative) and strongly ultrabasic compositions (e.g., SiO₂ content mostly ranging from ~10 to 40 wt%) is commonly found.

Despite partial melting of a carbonated mantle can produce carbonatites and hybrid silicate-carbonatitic magmas, alternative models have been proposed. At least in three cases (Calatrava, central Spain, Polino and Alban Hills, central Italy [1-3]) a shallow origin for carbonates in igneous rocks was interpreted as consequence of digestion of limestones by upwelling magma en route to the surface.

In the Polino village in central Italy, a small Holocene monticellite carbonatite diatreme (10–15 m in diameter) pierces more than 4 km of Triassic limestones. In other neighbouring volcanic districts, similar compositions, ranging from carbonatites to strongly ultrabasic melts such as kamafugites, crop out in the so-called Umbria-Latium Ultra-alkaline District (ULUD).

In light of recent chemical and textural investigation [2], the petrography and mineral chemistry of Polino rocks are interpreted as a secondary feature of the magma acquired during its ascent to the surface and substantial interaction with sedimentary carbonate. A key aspect is represented by the amount of Ca and CO₂ that a magma can dissolve at shallow conditions. An important contribution over the last ten years has come from experimental studies on the effect of melt composition on assimilation of limestones. All the previous studies focused on basaltic compositions (i.e., plagioclase-bearing melts) to reproduce assimilation paths as function of pressure. These experiments agree in the formation of olivine with relatively high Mg content (Mg# ~95) followed by the crystallization of clinopyroxene as result of the magma interaction with limestones according to the reactions: $2\text{CaCO}_3(\text{limestone}) + \text{Mg}_2\text{SiO}_4(\text{olivine}) + 3\text{SiO}_2(\text{melt}) = 2\text{CaMgSi}_2\text{O}_6(\text{cpx}) +$

$2\text{CO}_2(\text{vapor})$ [4] and $\text{CaCO}_3(\text{limestone}) + \text{SiO}_2(\text{melt}) + \text{MgO}(\text{melt}) + \text{FeO}(\text{melt}) + \text{Al}_2\text{O}_3(\text{melt}) = (\text{Di-Hd-Ca-Ts})_{(\text{cpx})} + \text{CO}_2(\text{vapor})$ [5]. In the case of Polino, the absence of clinopyroxene and the presence of a monticellite rim around liquidus Mg-Fe olivine and as groundmass phase would suggest the possible ultrabasic nature of the ascending magma. To test this hypothesis, we carried out an experimental study.

We performed experiments at 2 kbar and 1100, 1200 and 1300 °C using the Quickpress apparatus available at the HPHT lab of the INGV (Rome). The starting materials employed in this study were three glasses obtained by melting at 1450 °C three natural samples with increasing SiO₂ content: vesecite (monticellite-polzenite) from the Bohemian Massif (~30.3 wt% SiO₂; BM2), melilite-olivine-nephelinite (~38.5 wt% SiO₂; BM1, melilitite near the Great Devil's Wall), and basanite (~43 wt% SiO₂; BM3) near Górlitz village (Czech Republic). Each starting glass was then mixed with 10, 30 and 50 wt% synthetic pure calcite (CaCO₃). The experiments were quenched isobarically after variable time ranging from 1 to 12 hours. The recovered run products showed vesicles that testify CO₂ saturation. The results from runs at 1300 °C generally show the total dissolution of the added calcite, with formation of an increasingly Ca-rich, Si-poor melt coexisting with high-forsterite olivine (up to Fo₉₇). The CO₂ content of these melts (calculated by difference to 100% totals) also increases with the amount of added calcite, and ranges from ~3 wt% (10 wt% calcite added) to ~8 wt% (50 wt% calcite added) in case of BM1. Similarly, the CaO content of the coexisting olivine increases up to ~2 wt% in agreement with thermodynamic calculations derived from the olivine-monticellite solvus. In experiments were BM2 was used as starting material a monticellite rim formed around Mg-Fe olivine crystals similarly to what reported from Polino carbonatite rocks.

Our experimental results extend the knowledge on the effect of magma composition on carbonate assimilation in case of silica-undersaturated melt compositions, and provide an alternative explanation to the origin of CO₂-rich magmas at shallow depths. Further, our experimental constraints, combined with petrographic and mineral chemical evidences, apply as a model to explain the shallow origin of the Umbria-Latium Ultra-alkaline District carbonate-rich rocks.

References: [1] Lustrino et al. (2016) *GCA* **185**, 477-497. [2] Lustrino et al. (2016) *EMC2016 abstract* 5-18. [3] Gozzi et al. (2014) *Lithos* **190-191**, 191-203. [4] Iacono-Marziano et al. (2009) *Geology* **37**, 319-322. [5] Mollo et al. (2010) *Lithos* **114**, 503-514.