Generation and crystallization conditions of the Colle Fabbri melilitite melt, Italy: melt inclusion data

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The Colle Fabbri volcano consists of 4 m thick freatomagmatic breccia and volcanic neck of fine-medium grained leucite - wollastonite melilitolite. The wollastonite – anortite – pyroxene igneous rocks are located at the contact of the melilitolite body and the pelite country-rock. (Stoppa and Sharygin, 2009; Stoppa and Rosatelli, 2009).

The Colle Fabbri melilitolites are rocks of the kamafugite series (Stoppa et al., 2002). However, they differ with the presence of wollastonite, which is not characteristic of common kamafugites.

Leucite – wollostonite melilitolite contains almost equal amounts of (35 – 40 vol%) melilite and wollastonite, as well as small amount of leucite, plagioclase, Ti-garnet, apatite, magnetite and Fe-Ni-sulphides. The chemical composition of leucite – wollastonite melilitolites is Si-undersaturated (about 42 mass% SiO_2) with a low content of Al_2O_3 (10.7 – 11.2 mass%) and extremely high content of CaO (37.3 – 38.5 mass%). Despite the presence of leucite in the rock, the total amount of Na_2O+K_2O is low (about 1.4 – 1.9 mass%.) The contents of MgO (1.6 – 2.4 mass%) and FeO (3.3 – 3.7 mass%) are also low.

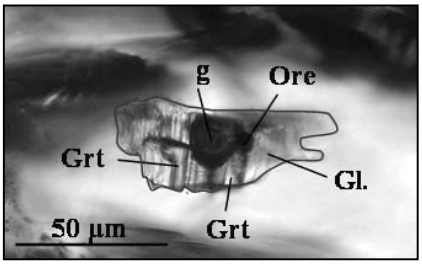

Fig. 1. Inclusion in melilite (transmission light).

The single partly crystallized melt inclusions are found in the grains of melilite (up to 50 µm). Their phase composition is glass, garnet, ore phases, and a gas bubble (Fig. 1). T_h = 1320 ± 15 °C.

The chemical composition of unheated glasses varies considerably in the contents of (mass%) 36.76 – 58.69 SiO_2, 19.89 – 29.65 Al_2O_3, 2.17 – 11.42 CaO, 0.23 – 1.68 FeO, 0.03 – 0.58 MgO and 7.79 – 26.42 K_2O. The amounts of TiO_2 (up to 0.67 mass%), Na_2O (up to 0.59 mass%), BaO (up to 0.98 mass%), P_2O_5 (up to 2.91 mass%) and SO_3 (up to 1.84 mass%) are also appreciable.

The chemical composition of heated glasses varies as well and are compared to unheated ones characterized by lower values (mass%) of SiO_2 (38.04 – 39.57), Al_2O_3 (mostly 14.4 – 17.6), K_2O (mostly 0.21 – 5.7) and higher CaO (21.63 – 30.59), FeO (5.59 – 6.65), MgO (0.44 – 2.83), Na_2O (0.37 – 0.75) and SO_3 (up to 1.29).

Wollastonite also contains single, partly crystallized melt inclusions (< 40 µm). Their phase composition is glass, garnet, ore phases and gas bubble (Fig. 2). T_h is higher than 1230 °C.

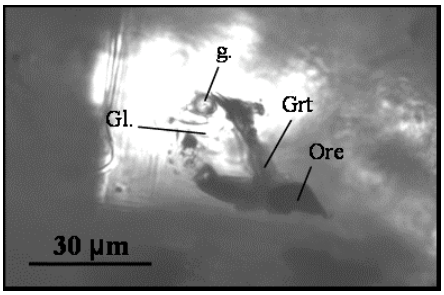

Fig. 2. Inclusion in wollostonite (transmission light).

The glasses of unheated inclusions contain (mass%): 43.37 – 47.49 SiO_2, 10.78 – 16.71 Al_2O_3, 0.78 – 0.97 FeO, 0.06 – 0.09 MgO, 20.79 – 29.92 CaO, 3.94 – 5.75 K_2O, 1.18 – 2.24 Na_2O and minor TiO_2 (up to 0.17), P_2O_5 (up to 0,10) and SO_3 (up to 0.09).

The chemical composition of heated glass compared to unheated ones are characterized (mass%) by high FeO (4.27 – 14.39), MgO (0.14 – 0.45), TiO_2 (up to 4.75), P_2O_5 (up to 1.17) and SO_3

(up to 0.78), equal Al_2O_3 (11.62 – 25.03), CaO (25.18 – 36.64) and low SiO_2 (28.61 – 36.7), K_2O (0.31 – 1.63) and Na_2O (0.80 – 1.83).

It is noteworthy that the chemical composition of heated glass in wollostonite compared to ones in melilite has less amounts of Si, Al, K and more values of Fe, Mg and Ti at similar Ca and Na contents.

According to the geochemical data melilite (gehlenite – akermanite) contains about an order of magnitude more LILE and much less HFSE compared to the primitive mantle (PM). The pattern for melilite (Fig. 3) normalized to primitive mantle has a negative slope with positive anomalies of Ka and Sr and negative anomalies of Nb, Zr and Ti.

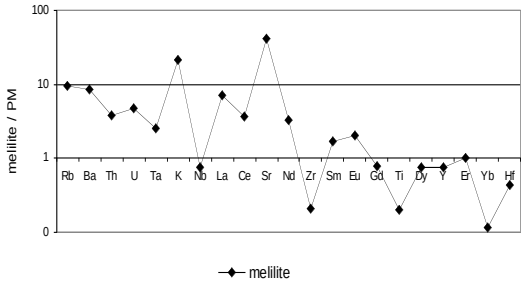

*Fig. 3. Primitive mantle-normalized (*Taylor, McLennan, 1985*) spider-diagram for melilite.*

The content of trace elements in the rock and in the glasses of heated inclusions in melilite are similar (Fig. 4). They are considerably enriched in incompatible elements, whose concentrations are 2 for Rb and Ba, 1,5 for K or 1 of HFSE orders of magnitude higher than the mantle norm. The patterns of the rock and the glass of heated inclusion have a negative slope owing to the high LILE and LREE and low HREE. This indicates the possible presence of garnet in the mantle source. It is known that in the primitive melt LREE increase and HREE remain in the garnet during partial melting of a garnet-bearing source located at the depth between 30 – 60 km (Sklyarov et al., 2001).

The considered pattern (Fig. 4) as well as the pattern for melilite (Fig. 3) display negative Nb and Ti anomalies, which possibly indicate the involvement of crustal material in magmatic process. Moreover, on the Nb/Ta - La/Nb diagram (Barth et al., 2000) the rock and melilite-hosted melt are localized in the same region of the continental crust influence.

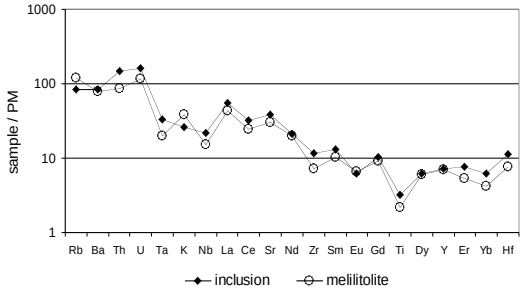

*Fig. 4. Primitive mantle-normalized (*Taylor, McLennan, 1985*) spider-diagram for melilitolite and melt inclusion in melilite.*

Thus, thermometric data suggest that the crystallization of melilite in the studied rocks started at 1320 ± 15 °C and crystallization of wollostonite occurred above 1230 °C.

The initial magma for leucite – wollostonite melilitolite was a Ca-enriched melilitite melt.

Geochemical data indicates that the studied rocks are enriched in trace elements and the crustal material was involved in the magmatic process during their formation.

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