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Chemistry of amphiboles and clinopyroxenes from Euganean (NE Italy) cumulitic enclaves: implications for the genesis of melts in an extensional setting

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The magmatism of the Euganean Volcanic District (Veneto Volcanic Province, VVP) developed in the last phases of the Alpine orogenesis; the geochemical and geophysical data are consistent with an extensional geodynamic context (Milani *et al.,* 1999). Cumulitic gabbroic enclaves occur within the Euganean trachytes, and Bartoli *et al.* (2008) pointed to their cogenetic origin with the Euganean host lavas. Sr isotopic data suggest that these cumulates derived from uncontaminated mantle-derived liquids. We analysed both cumulus and intercumulus amphiboles and clinopyroxenes by electron microprobe and LA-ICP-MS.

The cumulus-intercumulus Cpx are diopsides and augites. The Mg$\#_{Cpx}$ varies in a wide range (Mg$\#_{cumulus-Cpx}$= 0.74-0.84 and Mg$\#_{intercumulus-Cpx}$= 0.67-0.68). They show a MREE enrichment relative to LREE and HREE (La_N/Sm_N= 0.46-0.68 and Tb_N/Yb_N= 2.18-4.77). No significant Eu anomaly (Eu/Eu* = 0.78–1.23) was observed. On a chondrite-normalized spiderdiagram Cpx exhibits significant Pb and Co negative anomalies, and less evident negative anomalies for Sr and Zr. La, Sm and HREE increase, whereas Ba, Ti, Li and V decrease from core to rim. These Cpx exhibit high Cr contents (701-2958 ppm). Moreover, they display trace element differences when compared to Cpx from MORB gabbros. We analyzed also amphiboles: pargasites, edenites and kaersutites. In the cumulus Amph Mg# varies in the range 0.60-0.69, whereas in the intercumulus assemblage from 0.57 to 0.63. The high K_2O and TiO_2 contents are distinct from that of amphiboles in MORB gabbros. LREE are enriched relative to HREE (La_N/Yb_N = 5.07-7.56). Moreover, Tb_N/Yb_N = 2.50-4.02 indicates a HREE depletion relative to MREE. REE patterns lack a significant Eu anomaly (Eu/Eu* = 1.06–1.19). From core to rim Th and U decrease in cumulus crystals, but they increase in the intercumulus Amph. Ba (258-282 ppm) is enriched relative to other LILE and Nb-Ta are enriched relative to LREE. Cr varies in the range 423-594 ppm. The similar REE and HFSE content of intercumulus and cumulus Amph may suggest the existence of some post-cumulus processes.

We calculated the chemistry of the liquids which should have been in equilibrium with cumulus phases, employing a set of $D^{s/l}$. In the liquid in equilibrium with Cpx LREE and MREE are enriched up to 40 and 11 times respectively relative to HREE, which are at about N-MORB concentrations (La_N/Yb_N = 42.5 and Sm_N/Yb_N = 11). Some LILE (*i.e.*, Rb and Ba), Th and U are enriched relative to HFSE and REE. The theoretical composition of the liquid in equilibrium with Amph differs from Cpx-liquid in the marked enrichment of U and Th over LILE and HFSE. A LREE and MREE enrichment is observed (La_N/Yb_N = 35.4 and Sm_N/Yb_N = 3.6). The discrepancies of calculated liquid compositions cannot be ascribed only to the uncertainty in the choice of $D^{s/l}$. This may indicate trace element modifications in response to post-cumulus processes involving the amphiboles. The concentrations of HFSE in the calculated liquids (Zr/Hf = 60.2-72.7, Zr/Nb = 1.7-6.5 and Th/Hf = 3.8-6.9) and the incompatible element ratios, (*e.g.*, La/Nb = 0.5-0.7, Pb/Ce = 0.01-0.05, La/Y = 2.3-2.8 and Ce/Nd = 1.9-2.8), are not comparable to those of N-MORB but to those of HIMU-OIB suggesting that typical MORB-type mantle couldn't be the source of these liquids. Nb and Ta are variable, possibly due to an heterogeneity in the lithospheric mantle.

The existence of some peculiar trace element signatures of the recalculated liquids (LILE enrichment, high LREE/HREE ratio and abrupt enrichment in U and Th) has been attributed to slab-derived melts/fluids with an abundant sedimentary component. Our estimates are in agreement with the geodynamic scenario proposed by Macera *et al.* (2007), who explained the occurrence of both HIMU-OIB-type magmatism and subduction-related metasomatism in the VVP mantle lithosphere. According to their model, a mantle plume with HIMU-OIB geo-

chemical signature rose from the deep mantle twice with subsequent partial melting episodes of the plume material: the first time during Paleocene, before the subducted European lithospheric slab (from which the LILE-, U- and Th-enriched fluids/melts derived) intercepted the mantle plume, and the second time during middle Eocene, after slab detachment and opening of a plate window.

The liquids we have modeled can derive from partial melting of a subcontinental mantle source percolated by HIMU-OIB- and subduction-related fluids/melts with an abundant sedimentary component. Similarly, our recalculated liquids display some trace element signatures close to those shown by the liquids computed by Tiepolo & Tribuzio (2005) for cumulates of the Adamello batholith during alpine orogeny.