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Amphibole trace element signatures of magmatic environments within the magmatic plumbing system of the 160–30 ka Ciomadul volcanic complex, Eastern Carpathians

Barbara Cserép[1,2], Saskia Erdmann[3], Réka Lukács[1,4], Olivier Bachmann[5], Ioan Seghedi[6], Máté Szemerédi[1,7], and Szabolcs Harangi[1,2]

[1]Eötvös Loránd University, Institute of Geography and Earth Sciences, Petrology-Geochemistry, Budapest, Hungary (cserep.barbara@gmail.com)

[2]Department of Petrology and Geochemistry, Eötvös Loránd University, Pázmány Péter sétány 1/C, 1117 Budapest, Hungary

[3]Université d'Orléans-CNRS/INSU-ISTO-BRGM, UMR 7327, Orléans, France

[4]Institute for Geological and Geochemical Research, HUN-REN Research Centre for Astronomy and Earth Sciences (MTA Centre of Excellence), Budaörsi út 45, H-1112 Budapest, Hungary

[5]Department of Earth Sciences, Institute of Geochemistry and Petrology, ETH Zürich, Zürich, Switzerland

[6]Institute of Geodynamics Sabba S. Ştefanescu, Romanian Academy, 19-23 Jean-Luis Calderon St., Bucharest-37, Romania

[7]Department of Mineralogy, Geochemistry and Petrology, 'Vulcano' Petrology and Geochemistry Research Group, University of Szeged, Egyetem st. 2, H-6722 Szeged, Hungary

Amphibole is a common mineral in arc magmas, occurring in a wide temperature and pressure range. Its composition is sensitive to the crystallization condition that helps to quantify the magma storage depth, temperature, and redox conditions as well as to characterize the equilibrium melt composition including the water content. It can also be used to reveal the magma evolution pathways and processes occurring in the magmatic reservoir system. We provide here a comprehensive characterization of amphibole formed at different stages of magma evolution in the complex magmatic plumbing system of Ciomadul volcano, the youngest one in eastern-central Europe. A central dacitic lava dome complex built-up 160–96 ka ago, and it was partly destructed by explosive eruptions in the youngest volcanic stage (56–30 ka). We have characterized amphibole compositions both for major and trace elements in the dacitic lava dome and pumice samples.

Amphibole populations can be well discriminated by major and trace element compositions. Amphibole compositions of the 160–90 ka dacites suggest two distinct magmatic environments. (1) A cold (670–750 C°), silicic (70–77 wt% $melt_{SiO2}$) crystal mush with high crystallinity emplaced in the shallow crust at 8–15 km depths. These low-Al-Mg amphiboles show low Zr, Hf, Ti, Sr, Ba, Cr, and Ni concentrations, a negative Eu anomaly, moderate La/Sm ratio and high Nb, and Dy concentrations reflecting the evolved nature of the host melt. (2) A relatively mafic (52–60 wt% $melt_{SiO2}$), hotter (940–980 C°) magma, accumulated presumably in the lower crust. Amphibole crystallizing within this environment has high Al-Mg content and low Ni and Cr, moderate La/Sm ratio, lack of negative Eu-anomaly, and high Nb, Ta, Dy, Zr, Hf, Ti, Sr and Ba concentrations.

During the explosive eruption-dominated period (56–30 ka), the cold crystal mush environment remained, but amphibole records the presence of two additional, more primitive, hydrous and oxidized recharge magmas: (3) A magma with 56–69 wt% melt$_{SiO2}$, 880–980 °C, with high Al-Mg amphibole having moderate Zr, Hf, Ti, Sr, Ba, Nb, Ta, Dy, Cr, Ni and without negative Eu-anomaly. (4) A mafic magma containing unique low-Al, high-Mg amphibole with high Cr–Ni concentrations. It crystallized at >800 °C temperature and has low Zr, Hf, Ti, Ba, Nb, Ta, Dy, and La/Sm ratio. Recharge of these mafic magmas into the felsic crystal mush initiated rapid remobilization, hybridization and thin amphibole overgrowth with transitional compositions during magma ascent. We demonstrate how amphibole compositions can be used to track deep to shallow fractionation within the magma plumbing system at various conditions. Notably, a compositional shift can be observed in the recharge magma amphibole compositions from the extrusive to the younger explosive eruption stage. The mafic magmas became more hydrous and oxidized with time that could contribute to the change in eruption style.

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