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Amphibole perspective to unravel pre-eruptive processes and conditions in volcanic plumbing systems beneath intermediate arc volcanoes: a case study from Ciomadul volcano (SE Carpathians)

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The Ciomadul is the youngest volcano in the Carpathian-Pannonian Region. The first eruptive phase was effusive and produced crystal-rich high-K dacites. The lavas contain abundant amphibole phenocrysts with large chemical and textural variation suggesting that they experienced different conditions during crystallization. They are in contact with all of the rock-forming minerals of the dacite providing a unique opportunity to unravel the processes in the volcanic plumbing system. The amphibole phenocrysts can be divided into two distinct populations according to their textural features and major, trace element compositions. Low-Al hornblendes with low Ba, Sr, Zr and Eu derive from a silicic crystal mush along with biotite, K-feldspar, quartz, plagioclase, titanite, apatite and zircon at low temperature (<800°C). This crystal mush was stored in the upper crustal magma storage, at 8-12 km depths. High-Al pargasites having higher trace element contents formed in a more mafic, high temperature (>900°C) magma. The two amphibole populations can be observed in single rock specimens and even in single crystals suggesting mixing of mafic and silicic magmas just before the eruption. The intruded fresh mafic magma extensively reheated and remelted the crystal mush causing thermal breakdown of hornblendes. The mixing of the partially remelted silicic mush and mafic magma produced a hybrid melt where a new pargasite population crystallized. The mixing could have been accompanied with convective stirring as suggested by the cyclic zoning of pargasites. Reheating and fluid flux into the silicic crystal mush lead to the formation of eruptible magma. The simple zoned amphiboles having low-Al core and high-Al rim provide an important implication on the conditions of the magma storage system and on the application of amphibole thermobarometers.
Our study demonstrates that large Al content variation in amphiboles does not necessarily indicate different pressures and spatially separated crystallization of amphiboles as it is often indicated at other volcanoes, even if Al-tschermak exchange is detected. Bimodal amphibole cargo has been described in many intermediate volcanic products, although it is rarely observed in singe crystals. The case study on the Ciomadul dacite suggests that bimodal amphibole compositions could be formed even in single magma reservoir and does not always implies distinct magma chambers in the crust.