EGU24-1116, updated on 16 May 2024
https://doi.org/10.5194/egusphere-egu24-1116
EGU General Assembly 2024

Control of effusive and explosive eruptions of Ciomadul volcano: constraints by apatite composition

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The Ciomadul Volcanic Complex, Eastern Carpathians, Romania is the youngest volcano in the Carpathian-Pannonian region, eastern-central Europe, where volcanic activity occurred between 160 ka and 30 ka. It is a typical long-dormant volcano, where active stages were divided by several 10's ka quiescence. Geophysical studies indicate that it is still underlain by a potentially active magma storage (PAMS volcano). Two main stages of volcanism are distinguished that was separated by ca. 40 ka dormancy: the first one (160–95 ka) was characterized by lava dome extrusions, whereas the second one (56–30 ka) was mostly explosive. Magma composition, however, remained homogeneous, i.e., high-K dacitic, which contains plagioclase, amphibole, biotite as well as accessory apatite, titanite and zircon. In this study, we focus on the variation of apatite composition, particularly the changes in the volatile content and its effects on the type of eruptions.

We analyzed the chemical composition of apatite microphenocrysts and inclusions enclosed by amphibole and biotite phenocrysts by microprobe, with special attention to the volatile contents (Cl, F, OH). Samples represent different eruption ages, and both effusive and explosive eruption types. In the xCl/xOH vs. xF/xOH diagram, a breakpoint in the compositional variation of apatite indicates the change of water-saturation state in the magma reservoir, due to the different behavior of Cl and F in water-saturated and unsaturated magmas. Fluorine remains in the melt during water-saturation state, and follows the same trend as in water-undersaturated conditions. In contrast Cl shows similar incompatible behavior in water-undersaurated state, but in water-(over)saturated conditions it enters to the gas phase, so its content in the melt (and in crystal lattice of apatite) is buffered or decreased. We also used MgO content of apatite to follow the behavior of the halogens during the magma differentiation, where high amount of MgO represents the less evolved magma.

We interpret our results that effusive eruptions occurred when the magma reached

water-(over)saturated state (constant Cl content). In that case, the eruption triggering recharge event was not able to return the magma to water-undersaturated condition. On the other hand, the explosive events were characterized by magmas became in water-undersaturated state. In the case of the three oldest explosive eruptions the less evolved recharge material was able to return the already saturated magma to water-undersaturated state before the eruptions. The or one of the youngest explosive eruption of the Ciomadul (Bixad) was also explosive, but in this case water-saturated state was not detectable by the apatite record. Similarly to earlier studies of the Ciomadul, our results on apatite composition also indicate the role of mafic magma recharge in the petrogenesis of the rocks and shows that it could have turned the system to water-undersaturated state that eventually led to explosive eruptions.

This study belongs to the K135179 NKFIH-OTKA research project.