

Summary of the bilateral ASO Project No. 2006.N.X.

Genesis of the youngest volcanism in the Carpathian-Pannonian region

The main aim of this bilateral research project was to have a better understanding on the genesis of the youngest volcanic rocks of the Carpathian-Pannonian region. The Carpathian-Pannonian Region (CPR) is one of the world's natural laboratories where the interaction of tectonic and volcanic activities can be studied among others. Volcanism has been taking place in this area for the last 20 Ma. The last volcanic eruptions occurred in the southeastern and northern parts of the Pannonian Basin. We investigated the Csomád/Ciomadul volcano, where the latest volcanic eruption occurred in this area. Radiocarbon analysis of a charcoal sample indicates that this volcanic eruption could be as young as 28 ka! Considering that the development of the Csomád/Ciomadul volcano started at about 900 Ma and the repose time between the active volcanic phase were several 100's thousand years, this would mean that renewal of the volcanism couldn't be unambiguously excluded. Thus, it is crucial to have a better understanding on the evolution of the magma system and the reason of the volcanic eruptions.

The Csomád/Ciomadul volcano consists of a lava dome complex with two explosive craters inside, occupied now by the Mohos swamp and the St. Anna crater lake. Based on the previous field experiments we carried out a new sampling campaign focusing mostly on the older lava dome rocks. We sampled all the main lava domes and collected the younger pumices from new localities.



the Csomád/Ciomadul volcano with the set of lava domes from south

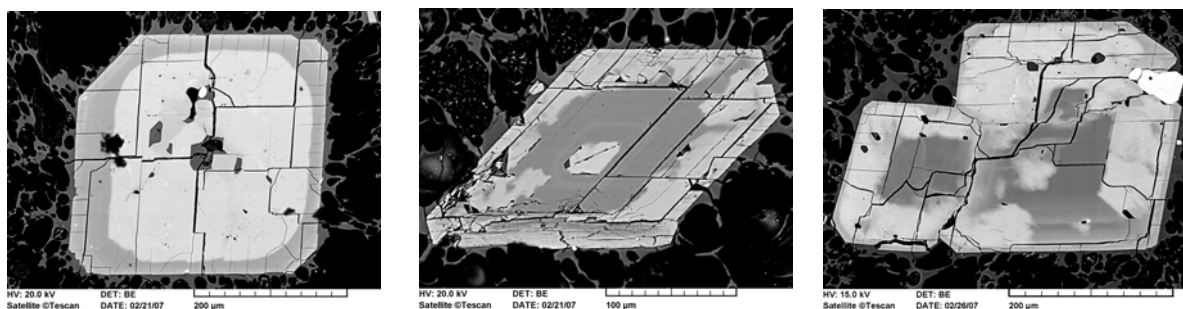


*The youngest volcanic rocks
of the Carpathian-Pannonian region*



Collecting lava dome samples

Our research strategy was to carry out a detailed, micrometer-scale investigation of the main mineral phases of the lava dome rocks and pumices as well as the enclosed glass inclusions to reveal the principal magmatic processes. Thus, we performed microprobe works both at the Department of Petrology and Geochemistry, Eötvös University and at the Institute of Lithosphere Sciences, University of Vienna. Composition of the lava dome rocks was determined by inductively coupled plasma mass spectrometry at the Institute of Lithosphere Sciences, University of Vienna. These rocks are potassic rich dacites ($\text{SiO}_2=63\text{-}69\text{wt}\%$, $\text{K}_2\text{O}=3.2\text{-}3.6\text{wt}\%$) with anomalously high Ba ($>1000\text{ppm}$) and Sr ($>1000\text{ppm}$) content and relative depletion of Y ($<15\text{ppm}$) and heavy rare earth elements. All of these geochemical features are identical with those of the younger pumices analysed before.

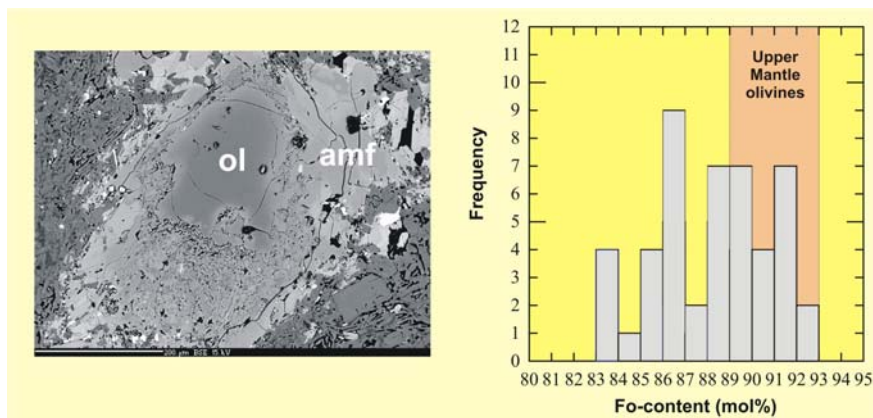


Compositional variation of the mineral phases tells us the history of the magmatic processes such as the tree-rings about the climate

The Csomád/Ciomadul dacites are composed by amphibole, plagioclase and phlogopite/biotite phenocrysts. Sphene and apatite are important and relatively abundant accessory minerals. In addition crystal clots of clinopyroxene and olivine occur in some samples. Our detailed mineral-chemical investigations revealed that the amphibole crystals show complex zoning patterns, i.e. strong compositional variation. These compositional patterns provide important information about the magmatic processes such as the tree-rings about the climate. The most important conclusions were that this compositional variation in single crystals implies an open system magmatic evolution, when recharge by fresh mafic magmas occurred. Furthermore, the amphiboles can be divided into two groups. The Type 1 amphiboles, which occur often as relatively large broken crystals could crystallize during the early stage of the magmatic evolution presumably at high pressure and temperature. The Type 2 amphiboles are usually euhedral and could crystallize during the magma ascent. The euhedral shape of the crystals and the lack of resorption rims suggest a relatively fast ascent rate and formation not long before the eruption. Glass inclusions are fairly frequent in the amphiboles. Their compositions resemble those of the pumice glasses, which represent the liquid magma just before the eruption. This melt was rhyolitic in composition. Composition and texture of the glass inclusions imply that they were trapped in the amphibole crystals just before the eruption of the dacitic magma. Plagioclases also show compositional zoning implying fresh magma recharge and changes in the water content of the magma, as well.

The most unique feature of the Csomád/Ciomadul volcanic rocks is the occurrence of high-Mg-minerals, which could not be in equilibrium with the host magma. We performed a detailed microprobe work of these minerals, too. Olivines show a wide range of Mg-content and many of them have a composition that is fairly unique worldwide. Such a crystals are formed either in high-magnesian andesite or in lamproite magmas or they could be part of the upper mantle peridotite rocks. These high-Mg olivines occur usually within the amphibole phenocrysts of the Csomád/Ciomadul dacites. However, before overgrown by the amphibole

crystals, they reacted with the silicic melt forming a reaction zone composed of various minerals. Nevertheless, the preservation of the olivines indicates that the magma ascended quite fast, so there was no time to fully diminish these exotic minerals.



The forsterite (Fo)-content of the olivines in the Csomád/Ciomadul dacites is often resembling the olivines of the upper mantle peridotites.

These minerals are surely xenocrysts, whereas the olivines and clinopyroxenes in crystal clots could form from a little bit more evolved, but still mafic magma. They have often euhedral shape suggesting that they were incorporated into the dacitic magma not long before the eruption.

In summary, we can draw the following conclusions. The magmatic plumbing system beneath the Csomád/Ciomadul volcano could be fairly complex, where magma chambers could have formed at different depth. We infer that open system magmatic processes could lead to the peculiar composition of these rocks. The mantle control of the volcanism is supported by the occurrence of high magnesian minerals, which could be either xenocrysts picked up by uprising mafic magmas and/or liquidus and early-formed mineral phases crystallized from mafic magmas. The presence of these minerals as well as the high Mg content of the amphiboles and micas is not consistent with the high SiO₂ concentration of the host dacitic magma and the rhyolitic glassy groundmass. Thus, we propose that complex mixing between mantle-derived melt(s) and crustal melts could result in the dacitic magma fed the Csomád/Ciomadul volcano. There are a number of evidences that the ascent of the dacitic magma was often fairly fast preventing the resorption of the most magnesian mineral phases. It is remarkable that these magmatic processes could occur repeatedly during a fairly long period (over at least one million years) and took place even a few 10's ka!

This magmatic scenario appears to be consistent with the geophysical data. The heat flow around the Csomád/Ciomadul volcano is the highest in Romania, exceeding the 100 mW/m². The continental crust beneath this area is quite large, i.e. 45-50 km. Seismic studies revealed attenuation of seismic wave velocities at a depth of about 60-60 km. This can be interpreted either as partially melted zone or that the asthenosphere is at shallow level, just beneath the thick crust. In any case, the base of the thick crust could melt providing silicic magma, which could mix with the uprising mafic magma from the mantle. This condition may imply that the magmatic system beneath the Csomád/Ciomadul volcano is still active! Isotopic studies of the gases and hot springs support the magmatic influence.

Our bilateral research on the Csomád/Ciomadul volcanic rocks implies that careful investigation of mineral phases; often with micrometer scale could reveal the complex magmatic processes leading to volcanic eruption. Furthermore, we could provide scientific data that a possible future eruption of the Csomád/Ciomadul volcano cannot be unambiguously excluded and further integrated researches are necessary. Nevertheless, the time scale of the active and the quiescent phases suggests that reactivation of the magmatic system may occur in thousands or ten thousands years.

We would like to acknowledge the financial support of the ASO that made possible this novel research in this area. It forms a strong basis for further collaborations between the scientists of the Austrian and Hungarian scientists of the Institute of Lithosphere Sciences, University of Vienna, Austria and the Department of Petrology and Geochemistry, Eötvös University, Hungary. We presented the main results of this ASO project at international and national conferences as well as seminar talks in the partner institutes. Research papers are partly submitted and are partly in preparation for publication in national and international peer-reviewed journals.

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