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Imaging the magma plumbing system of Ciomadul volcano and the Perşani Volcanic Field and constraining postcollisional magma dynamics

Matthew J. Comeau[1], Graham J. Hill[2], Svetlana Kovacikova[2], Jochen Kamm[3], Réka Lukács[4,5], Ioan Seghedi[6], Alexander Grayver[7], István Bondár[4], and Harangi Szabolcs[5,8]
[1]Department of Geoscience and Engineering, Delft University of Technology, Delft, The Netherlands. (m.j.comeau@tudelft.nl)
[2]Institute of Geophysics, Czech Academy of Sciences, Prague, Czechia. (gjhill@ig.cas.cz; svk@ig.cas.cz)
[3]Geological Survey of Finland, Espoo, Finland. (jochen.kamm@gtk.fi)
[4]Institute for Geological and Geochemical Research, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary. (lukacs.reka@csfk.org; bondar.istvan@csfk.org)
[5]HUN-REN-ELTE Volcanology Research Group, Budapest, Hungary. (lukacs.reka@csfk.org; harangi.szabolcs@ttk.elte.hu)
[6]Institute of Geodynamics Sabba S. Ştefanescu, Romanian Academy, Bucharest, Romania. (seghedi@geodin.ro)
[7]Institut für Geophysik und Meteorologie, Universität zu Köln, Köln, Germany. (agrayver@nuni-koeln.de)
[8]Department of Petrology and Geochemistry, Eötvös Loránd University, Budapest, Hungary. (harangi.szabolcs@ttk.elte.hu)

There are indications that some long-dormant or seemingly inactive volcanoes may have potentially active magma storage systems. One such system is Ciomadul volcano, which is located at the south-eastern terminus of the Carpathian volcanic chain (Romania). With the last eruption occurring at ~30 ka, this is the youngest volcano in eastern-central Europe. Understanding the nature and structure of the magma plumbing system is crucial to elucidating the evolution of the volcano and to assessing its hazard potential. This includes the depth, size, and geometry of the magma storage region, the amount and composition of the melt present, and the link between mantle and crustal processes.

Ciomadul is situated in a geodynamically active region about 50 km from the Vrancea zone, where deep earthquakes are frequent. These earthquakes may represent the descent of a dense lithospheric slab beneath a continental collision zone and this may imply an asthenospheric upwelling due to return flow of mantle material. To the north-west of Ciomadul lies a chain of older volcanic complexes, the Călimani–Gurghiu-Harghita volcanic complex; about 40 km west of Ciomadul towards the Transylvanian Basin, a monogenetic basaltic volcanic region was developed at 1.2–0.5 Ma (Perşani volcanic field). Seismic tomography has revealed low-velocity columns through the lithosphere beneath both Ciomadul and Perşani. However, high-resolution images of the complex geometry of the system are lacking.

We report here on a 3-D electrical resistivity model of the region that was generated from 41 magnetotelluric measurements acquired in 2022 that form a 75 km by 75 km array. The data typically had reliable periods from 128 Hz to 4,100+ s. Choosing appropriate locations for measurement was critical, away from sources of cultural electromagnetic noise that can contaminate the signals, as was careful data processing, including applying data pre-selection schemes and manual time windows in addition to standard approaches using robust statistics.

Phase tensor analysis suggests that the data are 3-D at all scales. The 3-D electrical resistivity model reveals conductive anomalies (<10 ohm-m) in the subvolcanic crust. These are interpreted as melt-bearing magma reservoirs distributed in the mid-lower crust (depths of ~10–25 km) and a quasi-vertical conduit extending to the near surface. The crustal reservoir is oriented north-south, has its western margin beneath the surface vent of Ciomadul, and extends ~20 km eastward. These results are consistent with the quantitative petrological models placing the upper melt-bearing silicic crystal mush reservoir at a depth of 5–20 km beneath Ciomadul, and a magma-generation area in the asthenosphere (85–105 km depth). In contrast, no strong conductive anomaly is observed in the crust below Perşani, which fits the magma evolution model, i.e. small batches of mantle-derived magmas ascend rapidly through the crustal column. Our results suggest that Ciomadul, a seemingly inactive volcano, is still underlain by a melt-bearing magma body and therefore can be regarded as having potential for reactivation and further volcanic eruptions.