INTRODUCTION

Ciomadul volcanic system is located in the southernmost end of Harghita Mountains and part of the 700 km-long Inner Carpathian Volcanic Arc where the last eruption occurred at 30 ka (Szakács et al., 1993; Harangi et al., 2010; Seghedi and Downes, 2011). Although the long quiescence period seems to imply that this volcano is already inactive, there are several indications that a hot magmatic body could still reside beneath the volcano.

The present knowledge the volcanism of the Ciomadul is mainly based on the studies of Szakács and Seghedi (1989, 1995). The age of the explosive volcanic events still has not been clarified but youngest eruption of Ciomadul was dated at 42–35 14C ka BP (Moriya et al., 1996) and by radiocarbon method at 43,250±1000 cal yr BP (Harangi et al., 2010).

In this study, we performed magnetotelluric (MT) investigation with aim to prove the petrologic suggestion about open-system processes at a deep magma chamber and the suggested repeated intrusion of primitive mantle-derived basaltic magma into this magma chamber (Figure 1). The seismic tomography is proved the clear connection to the seismically powerful region to the Vrancea zone (Popa et al, 2011). A Low-velocity lithosphere has been detected beneath the volcanic system related to a thermal anomaly (800 C°, 20 km depth) and concluded that the more probable explanation of this anomaly is generated by migrating fluids, magma ascent and magma chamber processes.

GEOLOGICAL BACKGROUND

The Ciomadul volcano is located at the southern termination of the Câlîmani–Gurghiu–Harghita (CGH) andesitic-dacitic volcanic chain, at the southeastern edge of the Carpathian-Pannonian region (Szakács et al., 1993). The geodynamic setting of the CGH volcanism and particularly the volcanic activity of southern Harghita and Ciomadul is still highly debated. The active geodynamic situation is clearly indicated by the continuous seismic hazard attributed to the descent of a near vertical slab beneath the Vrancea zone about 50 km southeast from Ciomadul.
PETROLOGY OF THE CIOMADUL VOLCANO

The lava dome rocks and the pumices of the Ciomadul volcano have uniformly dacitic composition (62-66 wt% SiO2) and contain the same mineral assemblages (Szakács and Seghedi, 1986; Kiss et al, 2011). The crystal-rich lava dome dacites (30-40% phenocrysts s.l.) contain a large number of mineral phases (15) as phenocrysts (s.l.): plagioclase, amphibole, biotite, K-feldspar, quartz, titanite, apatite, zircon and allanite. Olivine, clinopyroxene and tiny Cr-spinel xenocrysts s.l. occur also in the dacites and represent constituents from mafic magmas intruded into the crystal mush body.

Most of the studied rocks contain felsic and mafic inclusions. These inclusions represent a granodioritic crystal mush which had been heated up and was partially remelted by upwelling hot mafic magmas. Thermobarometric calculations were performed to estimate the pre-eruptive temperature and pressure of the studied dacitic magma. The calculation yielded a pre-eruptive temperature and pressure were 840±11 °C and 2.88±0.47 kbar. Antecrystal amphibole-plagioclase pairs and plagioclase-K-feldspar pairs were used to estimate the T-p of the crystal mush. This resulted equilibrium temperature of 735±26 °C at a pressure of 2.68±0.47 kbar. Thus, according to the pre-eruptive pressure estimate the magma chamber could have been at 10-11 km depth. Clinopyroxenes often show oscillatory zoning suggesting that they were formed by open-system processes at a deep magma chamber. Zoning patterns suggest repeated intrusion of primitive mantle-derived basaltic magma into this magma chamber.

MAGNETOTELLURIC RESULTS

The aim to define the electrical resistivity distribution of the volcanic system we carried out magnetotelluric soundings around the Ciomadul volcanic system. 12 sites were collected with average spacing 1-4 km using LEMI-417 acquisition system (Figure 1). The average recording time was approximately 4 days at a station and measured electric (Ex, Ey) and magnetic (Hx, Hy and Hz) fields at the surface of the earth. Electromagnetic time variations were observed between 0.25-15,000 sec period range. The data were processed using robust single-site and in some cases remote reference processing code to eliminate artificial noises and estimate MT transfer functions (Egbert and Booker 1986, Egbert and Livelybrooks, 1996).

We performed a 2-D modeling by inverting MT impedances using non-linear conjugate gradient
algorithm of Rodi and Mackie (2001) with identifying three different elongation profiles (a) N-S, b) NNE-SSW) c) NW-SE. Separation of the two polarization modes (TE and TM) and the bimodal (TE and TM with Hz conjugate gradient) inversion was also carried out. By 2-D inversion a well conductive structure is observed between 5-20 km depth. Lateral distribution of the conductive anomaly (< 10 Ωm) is less than 5-6 km long in both direction (Figure 2).

This anomaly is located near the main volcanic crater and related to the dacitic magma reservoir marked as DMR. The conductive feature is associated with the dacitic magma reservoir or the magma chamber with intrusion of primitive mantle-derived basaltic magma which may be has continuation with depth (30-40 km, BMS) to the direction of Mohos bog (Figure 2). Supposedly, if the magma reservoir is exist, then the storage of providing the magma intrusion should be continue with the depth to the northeastern direction.

For supporting the 2-D results we performed the 3-D inversion by using WSIN3DMT inversion code (Siripurnvaraporn and Egbert, 2000; Siripurnvaraporn et al, 2005a). The 3-D inversion represents in many aspects similar results as the 2-D inversion, mainly the indication of dacitic magma reservoir in 5-20 km depth range (Figure 3). The significant difference is observed at deeper part of the results where there was not any indication of the basaltic magma storage. Supposedly the 3-D inversion, due to the lack of the vertical magnetic field integration provide different resistivity model against the 2-D inversion.

As it was shown by induction arrows the conductive anomaly is shifting with depth to S-E to N-E direction. Although the 3-D inversion does not manifest the basaltic magma storage there is sufficient evidence of existence of it by 2-D inversion, induction arrows and phase tensor ellipses (Figure 3).

**CONCLUSION**

The 2-D and 3-D inversions of magnetotelluric data provided imaging about well conducting anomalies beneath the Ciomadul volcanic complex with two different depth range. The indications of crustal depth related to the open-system processes dacitic magma reservoir and the suspected magma storage at deeper part. This structures is recovered in all tested models, in 2-D as well as in 3-D inversions. The estimated depth of shallow magma reservoir is in good agreement with the seismic tomography results by Popa et al (2011).

A number of supposed features of the Ciomadul volcano and its environments are strongly suggested that the magma plumbing system of this volcano is not definitely frozen.
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