THE MOST RECENT VOLCANISM IN THE CARPATHO-PANNONIAN REGION. IS THERE ANY VOLCANIC HAZARD?

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Abstract: The most recent volcanic activity in the Carpatho-Pannonian Region occurred in the Central Slovakian volcanic Field (Putikov vrsok alkali-basaltic volcano, 130-140 Ka) and at the southeastern end of the Carpathian volcanic arc (Persani Mts. alkali-basaltic field, 1.2-0.6 Ma, and Ciomadul volcano). The last eruption of Ciomadul volcano took place ca. 35-42 Ka ago. Geological and geophysical evidence suggest possible volcanic hazard in this area.

Key words: Carpatho-Pannonian Region, Volcanism, Pleistocene, Hazard

1. Introduction

Although the Carpatho-Pannonian Region (CPR) is not viewed as an active area from the standpoint of magmatism, a number of facts indicate that volcanic activity lasted up to very recent times. Thus, the possibility of awakening of magmatism in an unforeseeable future is not at all a trivial and obsolete issue. Thus, this paper intends to review the most recent volcanic activity in the CPR and to discuss it terms of future volcanic hazard for the region.

2. Outline of time-space distribution of Neogene/Quaternary magmatism in the Carpatho-Pannonian Region

Neogene/Quaternary volcanism developed in the CPR from 21 Ma up to <100 Ka closely related to the evolution of the Carpathian thrust-and-fold system and of the Pannonian Basin. Three types of volcanism can be distinguished (1) large-volume felsic calc-alkaline, mostly explosive volcanism, (2) large-volume intermediate calc-alkaline magmatism, mostly represented by composite volcanoes, and (3) small-volume alkaline volcanism, mostly represented by monogenetic volcanic fields. They display different time-space distribution patterns.

The products of the felsic explosive volcanism are mostly distributed in the Intra-Carpathian areas belonging to the Pannonian Basin and the Transylvanian

Basin, and represent the oldest (11-21 Ma) activity in their respective occurrence areas.

The intermediate calc-alkaline rocks are mostly distributed along the inner side of the Carpathians as a volcanic arc paralleling the thrust-and-fold range, but they also occur in the Intra-Carpathian area, buried beneath younger sediments of the Pannonian Basin or outcropping in the Apuseni Mts. Excepting the south-western part of CPR, most of this type of volcanism is younger than 17 Ma in the Western Carpathians, and younger than 14 Ma in the Eastern Carpathians. It ceased along the Western Carpathians and most of the Eastern Carpathians before 7 Ma. The only part of the Carpathian volcanic arc where calc-alkaline volcanism continued after 7 Ma, until Pleistocene times, is its southeastern segment, the Calimani-Gurghiu-Harghita volcanic chain in the East Carpathians, Romania.

The alkaline volcanism consists of mostly alkali-basaltic rocks, but tiny amounts of shoshonitic and ultrapotassic rocks are also present in places. They form clusters of monogenetic volcanoes with apparently random distribution in the Intra-Carpathian areas, in places spatially associated with calc-alkaline volcanics. Alkali-basaltic magmas erupted in the latest stages of volcanic activity in their respective occurrence areas, excepting for the southeastern end of the Carpathian volcanic arc where the Persani basalts are coeval or even older than the youngest calc-alkaline volcanics.

3. The most recent volcanic activity in the CPR

The three most recent eruptions in the CPR occurred during the Upper Pleistocene, and represent two different types of volcanism located in two different areas of the CPR: in the Central Slovakian Volcanic Field, and at the south-easternmost end of the East Carpathian volcanic arc (Harghita Mts. and Persani Mts).

3.1. Putikov vrsok volcano (acc. to Simon, 2001)

The second youngest eruption in the CPR occurred at the Putikov Vrsok volcano in the Central Slovakian Volcanic Field and is alkali-basaltic in composition. It is a typical monogenetic volcano whose eruption included phreatomagmatic, strombolian and hawaiian phases. The age of the volcano is constrained on stratigraphic grounds to the Late Riss glacial stage at ca. 140-130 Ka (Simon and Halouzka, 1996).

3.2. Persani Mts

The third youngest volcanic activity in the CPR took place in the Persani Mts. at the southeastern terminus of the Carpathian volcanic arc, some 40 km to the west from the South Harghita Mts., where the youngest eruption of the whole CPR is known. Volcanism in the Persani Mts. developed as a small (22x8 km) alkali-basaltic monogenetic field, consisting of a number of maar structures, scoria cones and surrounding lava fields (Seghedi and Szakacs, 1994). Phreatomagmatic eruptions followed by strombolian activity and lava outpourings were dominant. According to new K-Ar dating and paleomagnetic data, this volcanism developed in two main stages: between 1.5-1.2 Ma and 0.6 Ma (Seghedi et al., 2001). Most of the older-stage lavas are well-constrained to the Cobb Mountain paleomagnetic event (1.2 Ma). The younger stage activity is constrained by K-Ar dating of two lava samples from the Bogata-Barc area. It is noteworthy to mention that, according to these data, there is a time gap of ca. 0.6 Ma in volcanic activity between the two eruptive stages in the Persani Mts. monogenetic volcanic field.

3.3 Ciomadul volcano

The most recent volcanic eruption in the whole CPR belongs to the Ciomadul volcano in the South Harghita Mts., located at the southeastern end of the East Carpathians. Unlike the alkali-basaltic volcanoes discussed above, Ciomadul volcano marks the terminus of the south-eastern segment (the Calimani-Gurghiu-Harghita volcanic chain, CGH) of the Carpathian calc-alakaline volcanic arc. Volcanism migrated and progressively diminished along-the-arc from northwest to south-east in CGH with concurrent changes in its chemical and petrogenetic features. The detailed description and quantification of this process as well as its mechanism and possible explanations are summarized elsewhere (Szakacs et al., 1993, Seghedi et al., 1998, Mason et al., 1998, Szakacs et al., 2002,). Ciomadul volcano is, thus, part of a special trend of along-arc younging of volcanic activity, moreover, it marks the end-point of this space-time distribution pattern.

Ciomadul volcano essentially consists of a number of high-K dacite domes, most of which cluster in a central dome complex surrounded by a few isolated peripheral domes. The K-Ar ages of the domes range between ca. 1 Ma and 0.2 Ma, with the upper age limit less well-constrained than the lower one. The oldest

domes are those of peripheral position. The central dome complex hosts two craters resulted from post-dome-emplacement eruptions. The shallower Mohos crater is leveled by a pit-bog overlying infill from the most recent eruption from the neighboring St. Ana crater. Accretionary lapilli bearing cross-bedded coarse ash beds cropping out at the borders of the Mohos swamp points to a phreatomagmatic eruption as its genetic mechanism. Although there is no age constraint on the timing of this eruption, one may assume that it could be in the 200-100 Ka age range.

The youthful, unbreached crater hosting the St. Ana lake has been left behind by the most recent eruption of Ciomadul volcano and of the whole CPR. The St. Ana explosive eruption gave rise to phreatomagmatic and subplinian pumice fall deposits overlain by pumice-and-ash-flow deposits and debris flow deposits cropping out on the flanks of the Ciomadul volcano as well as in its surroundings. Recognizable pumice fall deposits have been preserved up to ca. 40 km distance to the east, but distal ash deposits of this eruption have not yet been recorded unambiguously. Although the published age data are somehow controversial, they unambiguously demonstrate the very young age (less than 50 Ka) of this eruption. Juvigne et al. (1994) measured a ^{14}C age of 10,700±180 years BP on a charcoal fragment found in a pyroclastic flow deposit and a ^{14}C age of 7.610±70 years BP on a pit sample overlying the infill of the Mohos crater. On the other hand, the ^{14}C age determination achieved on another charcoal fragment from the same pyroclastic flow deposit yielded an age of 35.52-35.67 Ka (Moriya et al, 1996), while the organic matter from the paleosoil underlying the pumice-fall deposit yielded a ^{14}C age of 36.77-42.65 Ka (Moriya et al., 1995). We consider the age range of 42-35 Ka as being closer to the real age of the last eruption of the Ciomadul volcano.

The Ciomadul area display a series of relevant geological and geophysical features compatible with the recent age of volcanism and possibly ongoing magmatic activity in depth. The area hosts the highest density of thermal and mineral water springs as well as dry CO_2 emanations in the whole Carpathian volcanic arc. The highest heat-flux values in Romania have also been measured here (Veliciu et al., 1981). Local microseismicity and attenuation of teleseismic waves have been pointed out (Lazarescu, personal communication, 1982).

Recently acquired seismic tomography shows a lower velocity zone, suggesting weaker and hotter mantle beneath the southeastern corner of the Transylvanian Basin, extending between 70-200 km depth (Martin et al., 2002, submitted). This feature includes both Persani Mts. and the southeastern end of the CGH volcanic chain.

4. Discussion: possible volcanic hazard?

According to the data presented above, future magmatic activity including volcanism, cannot be ruled out in the area of most recent Carpathian volcanic activity i.e. the area which includes both Persani Mt. alkali basaltic volcanism and the youngest South Harghita volcanoes. The presence of a “weak mantle” portion in depth, pointed out by seismic tomography, together with seismic wave attenuation and presence of heat-flow anomalies strongly suggest that mantle processes, including mantle flow and a certain amount of partial melting, are still active beneath the inner part of the Carpathian bend. The presence of a mantle-derived He component in gas samples (Althaus et al., 2000) as well as the spatial overlap between maximum $^{3}He/^{4}He$ isotopic ratio values and youngest volcansim and related heat-flow anomaly (Vaselli et al., 2002) are further arguments in favor of ongoing mantle processes in the area considered. As the age data demonstrate, the inactive intervals between the last two eruptive phases in both Persani Mts. and Ciomadul volcano are equal or longer than the time passed since the last eruptions in the two areas, respectively. However, taking into account the style of volcanic activity and the overall time-space distribution pattern of volcanism, hazard estimations should be distinct for the two areas. Whereas a still active crustal magma chamber is needed for possible future eruptions in the Ciomadul area, in the extension of the last activity, in the Persani Mts. ascension of alkali-basaltic magma to the surface would take a shorter and quicker path, provided sufficient magma is produced at depth. No time estimation could be made at the present state of knowledge about possible future eruptions at the interior of the Carpathian bend. Further specialized research and monitoring is needed to enable more accurate hazard estimation.

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