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Volcanic hazard in the Carpathian-Pannonian Region: A discussion.

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Volcanic hazard has not traditionally been considered as a natural risk factor in the Carpathian-Pannonian Region (CPR) and thus has never been included in long-term land and urban management and planning activities. However, recent site identification projects for nuclear waste repositories in the area require more cautious approaches to natural hazard issues.

Although there is no record of Holocene volcanic activity in the CPR, volcanism has been one of the major geodynamic processes accompanying the tectonic development of the Carpathian orogenic and its related back-arc basin systems. Volcanic eruptions occurred intermittently during the last ca. 23 Ma with most recent manifestations less than 50 Ka ago. Based on partly published data, this contribution attempts to an evaluation of volcanic hazard in CPR from internal hazard sources. It considers 1) timing, location and style of most recent volcanic activity, 2) time-space evolution patterns of Neogene/Quaternary volcanism, 3) sources, development and current state of magmagenetic processes, and 4) current state of lithospheric stress fields. Our conceptual approach considers volcanic hazard on a target-specific basis: CPR as a whole is the areal-type hazard target considered and the potential hazard sources are located inside CPR ("internal hazard sources") according to specific spatial distribution patterns.

The most recent volcanic events in the CPR took place in two regions: 1) in the southeastern segment of the subduction-related Carpathian volcanic arc (Ciomadul volcano at the southern termination of the along-arc migrating Calimani-Gurghiu-Harghita volcanic range (CGH) in the East Carpathians and basaltic volcanoes of the Persani Mts.), and 2) in the Northern Pannonian Basin within the Central Slovakian Volcanic

Field (Putikov Vrsok volcano) and in the Nógrád-Gemer monogenetic basaltic volcanic field.

The Ciomadul volcano is a dacitic lava-dome complex with a double craters inside, the sites of the most recent subplinian explosive volcanic eruptions (the last one occurred at 35-42 Ka or 11.7 Ka, according to different radiocarbon datings). There are several indications that the shallow-crustal magma chamber could be still incompletely consolidated. Petrologic and geochemical studies suggest involvement of mantle-derived melts in the genesis of the dacitic magma. We emphasize that Ciomadul could be considered as a potentially "capable", and hence potentially hazardous volcano if its magma-plumbing subsystem is still active. Present-day continuation of mantle-level magma production as an extension of the southward younging volcanism in the CGH cannot be ruled out, and trans-tensional stress-field at upper crustal levels controlling Pleistocene/Holocene intra-mountain basin formation in the area (Lower Ciuc basin) is a favorable circumstance for magma ascent. Just in few tens of kilometer distance from the Ciomadul volcano the Persani Mts. monogenetic alkaline basaltic field is found that was active from 1.3 Ma to 0.5 Ma. The volcanism took place in two short phases: 1.2-1.3 Ma and then after a long quiescence, 0.6-0.5 Ma. The basaltic magmas have an asthenospheric origin with some influence of subduction-related fluids. Considering the repose period of the volcanism, as well as the magmagenesis of the basaltic melts a new eruption phase in the near future also cannot be excluded.

The Northern Pannonian Basin is the area, where eruptions of various magmas occurred intermittently through the last ca. 20 Ma. The last eruption took place within the Central Slovakian Volcanic Field (CSVF) 130-140 Ka. The Putikov Vrsok volcano is a Strombolian cinder cone with related basaltic lava flow. Geochemistry of the basalts suggests a fairly primitive composition and derivation from the asthenospheric mantle. It is remarkable that this volcanic eruption occurred after a several Ma long quiescence period in the area. However, not far from the CSVF, basaltic volcanism was fairly active from 6.5 Ma to 0.5 Ma in the Nógrád-Gemer Volcanic Field. The volcanic eruptions occurred at least in six phases with repose intervals of 100-800 Ka. Considering the periodicity of the active phases and the fairly primitive nature of the erupted magmas, we may consider this volcanic field also as a potentially "capable" area.

Within the CPR, a number of 9 monogenetic basaltic volcanic fields are found, mostly located in the western half of the Pannonian Basin. This basaltic volcanism occurred mostly during the post-rift phase of the Pannonian Basin, several million years after the main extensional period, thus it couldn't be related directly to the thinning of the lithosphere. A widely accepted explanation for the reason of the basaltic volcanism is the presence of hot finger-like mantle plumes beneath the Pannonian Basin that de-

rived from a large deeper mantle reservoir, which fed several further localized mantle plumes in Western and Central Europe. Thus, it is important to understand the origin and the condition of this mantle reservoir to evaluate its surface expression and the specific time-space evolution pattern of the related volcanism. Start of its surface manifestation appears to be progressively younger from southwest to northeast and east across the CPR. Since the most recent eruptions occurred in the Northern Pannonian Basin and in the Eastern Carpathians (130 Ka and 650 Ka, respectively) any of the small shallower plumes can be reactivated, hence hazard source location can be considered at any site within known monogenetic volcanic fields in the CPR. As a whole, the plume-related basaltic volcanic system of CPR is a low-frequency system with recurrence intervals (order of 500-600 Ka) larger than the time passed since the last eruption. Thus, we may conclude that occurrence of small-scale cinder cone building eruptive activity could be possible in the CPR within the timescale of safe nuclear waste disposal (5-10 Ka) even at presently unpredictable sites.

In this contribution, we demonstrate that one cannot exclude the potential of future volcanic eruptions in the CPR based on the available volcanologic, petrologic, geochemical and geochronological data. More detailed studies are needed to evaluate more precisely the possible volcanic hazard in the CPR involving integrated geochemical, geophysical and tectonic investigations.