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Genesis of the Miocene to Pleistocene volcanism in the Carpathian-Pannonian Region - Is there any volcanic hazard?

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The Carpathian-Pannonian Region (CPR), Eastern-Central Europe, appears to be presently volcanologically quiet and thus, volcanic hazard has not traditionally been considered as a natural risk factor and it has never been included in long-term land and urban management and planning activities. Although there is no record of Holocene ($<$10 ka) volcanic activity in the CPR, volcanism has been one of the major geodynamic processes accompanying with the tectonic development of the Carpathian orogenic and its related back-arc basin systems during the Neogene to Quaternary. The most recent volcanic events in this area took place in two regions: 1) in the southeastern segment of the Carpathian volcanic arc (potassic rocks of the Ciomadul volcano and basaltic volcanoes of the Persani Mts.; 1.2-0.01 Ma), and 2) in the Northern Pannonian Basin (the basaltic Putikov volcano and the Nógrád-Gemer monogenetic basaltic volcanic field; last eruptions: 0.5-0.12 Ma). Considering the periodicity of the active phases and the nature of the erupted magmas, we may consider that these volcanic fields are potentially “capable” area. In order to evaluate the possible renewal of the volcanism, it is crucial to constrain the circumstances of the magma generation processes, particularly during the Quaternary period. Using major and trace element and Sr-Nd-Pb isotope characteristics of the volcanic rocks as well as their spatial and temporal distribution, we suggest that the Middle Miocene (17-12 Ma) lithospheric extension of the Pannonian Basin could have a major - direct and indirect - role in the

generation of magmas in the upper mantle. The Miocene silicic and the calc-alkaline volcanism at the northern part of the Pannonian Basin could be closely related to the syn-rift event. After rifting, the cooling of the upper mantle began, but the temperature remained high enough, that small increase in the temperature due to convection instabilities in the upper mantle or change in the mantle flow due to the sinking of the detached slabs could trigger melting. Such instabilities might cause also the sporadic alkaline mafic volcanism during the post-rift phase (Late Miocene to Quaternary). We propose that available observations do not support a mantle plume beneath the Pannonian Basin. The trace element and isotopic variation, both regionally and locally and the presence of HIMU-like composition can be explained also by a heterogeneous mantle model. The heterogeneous mantle explains also the occurrence of HIMU or 'EAR'-like magmas even during the Eocene-Oligocene and the Cretaceous in Europe. The genesis of the Miocene to Pliocene calc-alkaline volcanic rocks at the eastern segment of the CPR has probably a relationship with slab break-off process. At the final stage of slab detachment, an abrupt change in the source region of the magmas occurred about 2 Ma, probably due to the horizontal or toroidal mantle flow at the edge of the remaining slab. The relatively recent ($<$500 ka) volcanic eruptions in the CPR imply that these deep processes in the mantle may still operate and further melt generation and volcanic eruptions cannot be excluded unambiguously in the future.