Late Miocene to Pliocene Sedimentary Environments of the Western Carpathians: Response to Tectonic and Climatic Changes

Michal KOVÁČ[1], Ľubomír SLIVA[1], Peter JONIAK[1], Marianna SLAMKOVÁ[1], Ivan BARÁTH[2] and Rastislav VOJTKO[1]

[1] *Department of Geology and Paleontology, Comenius University, Mlynská dolina G, 842 15 Bratislava, Slovakia*
[2] *Geological Survey of Slovak Republic, Mlynská dolina 1, 817 04 Bratislava, Slovakia*

The Late Miocene to Pliocene paleogeography of the Western Carpathians distinctly reflects geodynamic evolution of the Carpathian chain and Pannonian back-arc basin system development.

The Pannonian to Pontian compressive thrust tectonics is known only from the accretionary prisms of the Eastern Carpathians in this time. It was generated by the residual subduction, following detachment of the downgoing plate in front of the northern edge of the orogene. This tectonic event evidently also initiated a "new rifting phase" in the Pannonian back-arc basin during the Early Pannonian, which was followed by thermal subsidence stage.

After the Early Pannonian tectonic reactivation in the back-arc basin area, the post-rift subsidence started, accompanied by generally NW-SE oriented extension above the rising astenospheric mantle. The basin evolution characterized a restricted faulting as far as the basin margins. The Late Miocene basins formation was controlled by normal faults activity, rarely with character of oblique strike-slips here. In the western part of the Western Carpathians NE-SW to N-S fault direction was dominant, in the central part N-S oriented faults and the eastern part was dominated by NE-SW and N-S directed faults. The sedimentary sequences were characterized by conform deposition; only smaller depocentres have graben to halfgraben features (e.g. Turiec basin).

The Late Miocene aquatic environments of the Western Carpathian basins gradually changed from brackish to caspibrackish due to gradual isolation of the Pannonian Lake. The microflora of the Early and Middle Pannonian strata documents short time connections with the Eastern Paratethys. During the Early Pannonian the salinity of the northern Pannonian Lake was less than 10–15 ‰, in the Middle Pannonian below 10 ‰. During the Late Pannonian, due to total isolation, environment of freshwater ephemeral lakes, deltaic complexes and alluvial plains prevailed, followed by alluvial environments in the Pliocene time.

Relative sea level changes of 3rd order cycles, similar to the global sea level curve, can be recognized on the Pannonian Lake northern boundary. The Sarmatian to Early Pannonian (Late Serravallian-Early Tortonian) 3rd order cycle with sequence boundaries of SB 1 type is developed mostly in marginal facies, characterised by frequent sedimentary gaps. The next Middle Pannonian (Middle Tortonian) 3rd order cycle is mainly composed of caspibrackish offshore sequences. The last Late Pannonian (Late Tortonian) 3rd order cycle includes deposits of freshwater lakes and alluvial plains characterized by SB 1 and SB 2 type sequence boundaries.

The terrestrial record document paleogeographic, as well as climate changes, which were during the Pannonian characterized by retreat of subtropic vegetation and development of floras of the temperate zone. A gradual humidity decrease is also registered. The Early Pannonian swamp vegetation was replaced by the Middle Pannonian flora with typical high portion of mountain vegetation elements, which can be interpreted as a consequence of higher relief in hinterland of the basin or onset of seasonality leading to retreat of deciduous forest. The palynospectra point to frequent winds blowing towards the Pannonian Lake as well.

The changes in paleogeography documents also the Early Pannonian (Vallesian MN 9) extinction of the Middle Miocene faunal elements and a little bit later immigration of "hipparion" fauna dated approximately to 11 Ma. The Middle Pannonian (from MN 9 to early MN 10 Zone) can be characterized by the terrestrial ecosystems preferring open grassy areas with sparse forests. Subsequent reduction of the Pannonian Lake extent led to next important humidity decrease during the Late Pannonian and Early Pontian. Red beds were deposited.The Pontian vegetation with scarcity of evergreen elements could refer to more continental climate with winter and summer seasons with lower precipitation.

The Pliocene transtensional tectonic regime controling the isostatic uplift of the Western Carpathian orogene and tectonic inversion of the basins was accompanied by an onset of transpressional tectonic regime in the Pannonian back-arc basin system. Uplift of the orogene central part, accompanied with tectonic inversion of northern edges of the largest Neogene basins of the Western Carpathians is recorded as erosion and frequent angular disconformities below youngest sediments The paleostress field, similar to the present one, was generally defined by the main compression vector oriented perpendicular to the course of the Outer Carpathian arc (NW-SE to N-S).

Comparison of the Pontian and Dacian sites points to increase of humidity towards the Pliocene. Decreasing tendency of the mountain vegetation elements in comparison with the Pannonian strata, as well as swamp vegetation elements and herbs document a moderate temperate climate of wet lowlands during this time, which corresponds with the results of mammal paleoecology and sedimentary record of alluvial plains

The Late Pontian to Pliocene environment of alluvial plains, characterized by fossil remains dated to the Late Turolian-Ruscinian (MN 13–15, 6.5–3.6 Ma) suggests a restoration of the humid temperate zone climate, convenient for development of the woody land with rivers alternating with the open grassy areas. The Early Pliocene, Late Ruscinian (MN 15, 4.2–3.6 Ma) biocenosis indicates a presence of humid woodland with rivers and lakes in the temperate zone similar as the terrestrial environment of the somewhat younger locality Hajnáčka, belonging to the lower part of the Villafranchian (MN 16a, 3.3–2.8 Ma). Towards the end of the Pliocene the next lowering of humidity is assumed (Lukáčovce Member red beds).

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