# Implication of the global and regional tectonics and eustasy on the Central Paratethys paleogeography: Reflection in the regional and standard time scale correlation

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**Abstract:** Paleogeography of the Central Paratethys (CP) realm was strongly influenced by the global and regional tectonics and eustasy. Over the past decades these attributes were not sufficiently taken into account what led to misconceptions in CP regional time-scale evaluation. The CP stage boundaries need to be dated by biostratigraphic approaches validated by point-based geochronological data. It would be beneficial to revise the CP time-scale in respect to geodynamics of the orogenic systems. The role of gateways between the Central Paratethys, the Mediterranean, and the Eastern Paratethys should be considered both as a function of local tectonics and the global sea-level changes. To understand original layout of sedimentary basins during distinct time spans an improved paleogeographic–palinspastic model based on an interdisciplinary study is needed in the future.

## The Central Paratethys

The Cenozoic convergence between the African and European plate led to geodynamic processes causing extreme changes in paleogeography, such as uplift of the Alpine type mountain chains and subsidence of the Paratethys basin systems. The Paratethys sea spread from the foreland of the Alps, towards the Carpathians, Dinarides, Balkan, Pannonian domains, and regions of present Black and Caspian Seas on the east. Connections between the Western, Central and Eastern segments of the Paratethys, as well as between its individual depocentres were very unstable. The marine straits/gateways developed and were destroyed depending on tectonics and climate.

## Geochronological data

Depositional sequences originating in semi-enclosed basins, partly or completely isolated from the open ocean, and frequently with endemic biota, do not allow accurate biostratigraphic correlations with the standard geological time-scale (GTS). Exact definition of correlation levels between the Mediterranean, Central Paratethys, and Eastern Paratethys should be based both on biostratigraphy and geochronological dating. The increase in spatial and temporal coverage of geochronological data is therefore an essential task. In broad-scale paleogeographic analyses requiring correlation of the CP with the Mediterranean, the standard GTS should be used as a reference to avoid problems with the definition of regional stages.

## Eustasy and regional sea-level curve

The Central Paratethys regional time scales often comprise correlation with the global sea-level curve, and the stage boundaries are correlated with boundaries of the 3$^{rd}$ order sequence stratigraphy cycles of GTS (Haq et al. 1988; Hardenbol et al. 1998; Piller et al. 2007). However, the research carried out in semi-enclosed basins has shown that the global sea-level change is captured by the sedimentary record only to some degree (Kováč et al. 2018 and references therein). The active tectonics and/or a huge amount of sediment input can intensify, reduce, or completely hide the signal of the global sea-level changes (forced vs. normal regression). In addition, the 3$^{rd}$ order sequence stratigraphy cycles recorded in the CP respond not only to the effects of the Mediterranean, but also to the Eastern Paratethys water masses (Kováč et al. 2017a).

The global trends of the climate changes were found to be obscured by tectonics and by local precipitation patterns, both resulting in the deposition of often coeval coal seams and evaporites in various parts of the CP realm. Nevertheless, dated "disoxic" and "evaporate" events can be used as time correlation levels during the Burdigalian, Langhian/Serravallian boundary, and Early Serravallian time intervals.

The differences between the Mediterranean and Eastern Paratethys sea-level curves indicate that the 3rd order sea-level cycles in the CP need to be further validated and the climate evolution should be better resolved.

## Geodynamics and paleogeography

The paleogeographic maps reveal a significant impact of geodynamic processes on the ratio of water covered and continental areas (Kováč et al. 2017b; Sant et al. 2017 and references therein). Similarly, the regional tectonic activity controlled the origin of straits/gateways allowing circulation of water masses between different basin systems. Present-day anti-estuarine and estuarine water exchange regime between the Atlantic, Mediterranean and Black Sea can be used as an example. The sequences deposited during circulation regimes suitably influencing the plankton migration are a prerequisite of a correct correlation between the regional CP and standard Mediterranean biostratigraphic zonations (Fig. 1). Encouraging results were obtained from periods with an anti-estuarine circulation regime, while estuarine circulation led to inaccuracies, or abrupt changes of environment leading to extinction events (Kováč et al. 2017a and references therein).

## Anti-estuarine vs. estuarine water circulation regime

In the early Burdigalian (Eggenburgian–Ottnangian, ~20.5–18–17.5 Ma) the final collision of Alps with the platform led to (re)opening of the western gateway in front of the Alps. For this time span an anti-estuarine circulation regime can be assumed due to warming and low precipitation in CP. Isolation of the eastern segment of Carpathian Foredeep led to evaporitic sedimentation. Coeval deposition of coal seams in the southern realm of CP indicates that precipitation was irregularly distributed. Fluctuations in humidity at the end of this period can be result of the uplift in the Alps and Dinarides.

During the late Burdigalian–early Langhian (Karpatian–earliest Badenian, ~17–15 Ma) the north-eastward movement of crustal segments in the CP realm led to (i) an oblique collision of the Western Carpathians with platform; (ii) the initial rifting in Pannonian domain; (iii) opening of the "pull-apart" Vienna and East Slovakia basins; (iv) thickening of the Outer Carpathian accretionary wedge; and (v) the Carpathian Foredeep subsidence. Marine connection with the Mediterranean through the "Trans-Tethyan-Trench-Corridor" situated between Eastern Alps and Dinarides (re)opened, while gateway towards the Eastern Paratethys was closed. A change from estuarine to anti-estuarine circulation regime was proposed for this time interval based on microfossil proxies. Uplift of the Central Western Carpathian mountain chain can be the reason of fluctuation in humidity and coal seams deposition in their hinterland.

During the Langhian (Early Badenian, ~14.5–13.8 Ma) the area flooded by the Central Paratethys sea reached its maximal extent. In front of the uplifted Western Carpathian mountain chain, the Carpathian Foredeep depocentres showed an eastward shift in subsidence, while a syn-rift subsidence the Pannonian back-arc basin area occurred. Communication of the semi-enclosed sea with the Mediterranean across the "Trans-Tethyan-Trench-Corridor" gained pronounced anti-estuarine pattern, likely due to aridification and salinity increase in surface water level.

At the ~Langhian/Serravallian (Early/Late Badenian) boundary the evaporite deposition, in the Carpathian Foredeep, Transcarpathian, and Transylvanian basins, referred as Badenian Salinity Crisis, took place (de Leeuw et al. 2018). Subsequently, at the beginning of the Serravallian time interval (~Late Badenian), a partial isolation of CP led to low oxic conditions in the whole area despite occasional open circulation regime with the Mediterranean and Eastern Paratethys realm during the Late Badenian (13.8–12.6 Ma).

In the Sarmatian (12.6–11.6 Ma) the water masses from the Eastern Paratethys entered again the semi-enclosed CP basin system resulting in the Badenian–Sarmatian Extinction Event (Harzhauser & Piller 2007). Uplift of the Outer Western Carpathians led to local increase in humidity in this area (coal seams).

In the early Pannonian (~11.6–10 Ma) sedimentation in the Western Carpathian Foredeep ceased. In the hinterland a new phase of subsidence led to the formation of the isolated Pannonian Basin System referred as Lake Pannon.

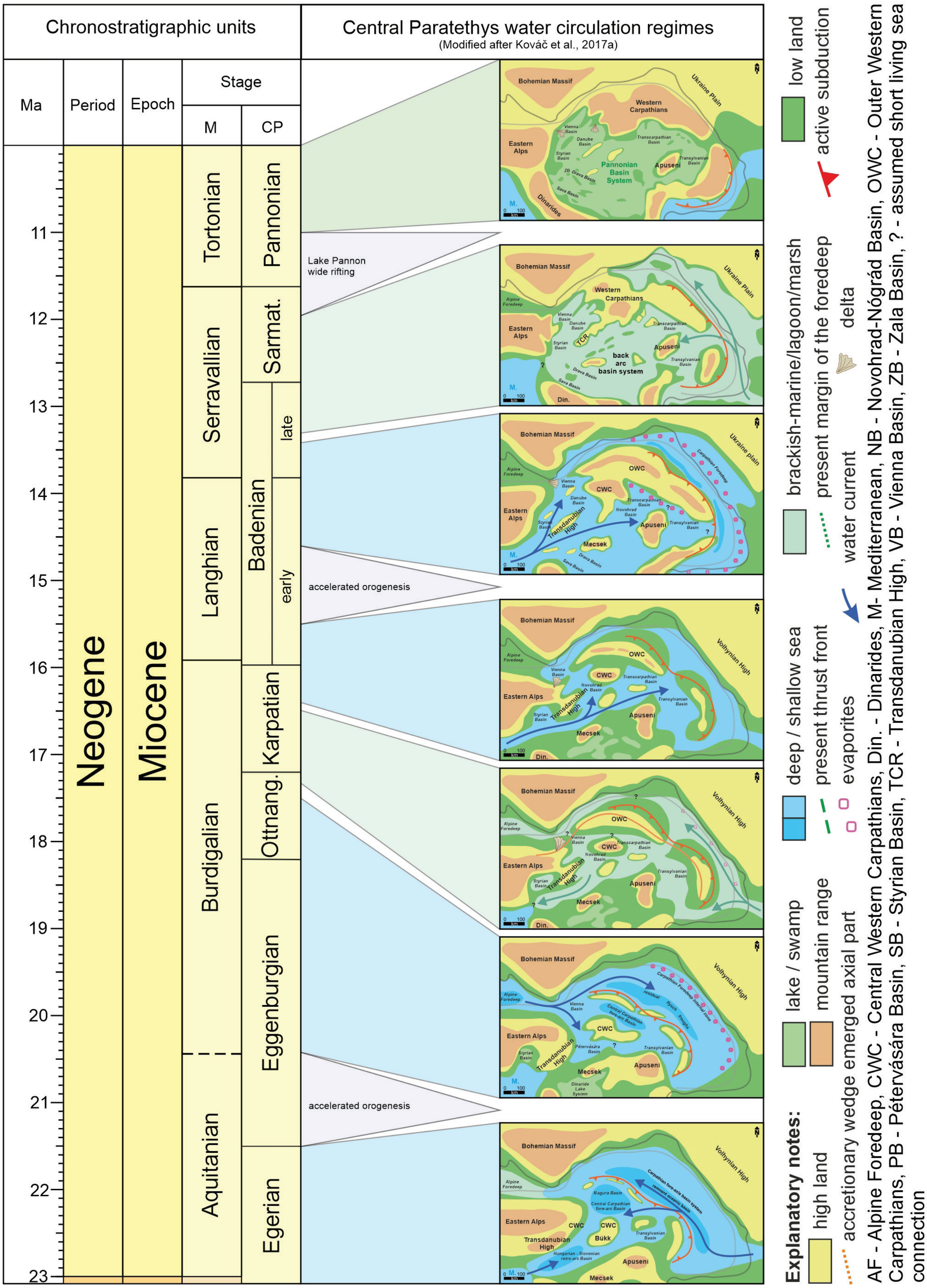


**Fig. 1.** The Late Cenozoic changes of the Central Paratethys paleogeography — coaction of geodynamic processes and eustasy.

## Conclusions

To conclude, several important factors need to be considered while evaluating regional time-scale in the Central Paratethys realm: (i) the geodynamics of the orogenic system and (ii) the role of gateways between the Central Paratethys, the Mediterranean, and the Eastern Paratethys as a function of both local tectonics and global sea-level changes, (iii) the regional stage boundaries dated by biostratigraphic approaches should be obligatory validated by geochronological methods.

To understand changes in the layout of sedimentary basins during distinct time spans an improved paleogeographic/palinspastic model based on an interdisciplinary approach reflecting the original position and extent of basins which fill was later deformed by folding and thrusting in front of the orogenic system or by the movement of crustal fragments along several hundred km long transform boundaries is needed.

**Acknowledgements:** This research was supported by the Slovak Research and Development Agency under contracts APVV-16-0121, APVV-15-0575, APVV-14-0118, APVV-SK-AT-2017-0010 and VEGA-1-0155-18 project.

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