GEODYNAMIC EVOLUTION OF THE CARPATHO — PANNONIAN REGION DURING THE NEOGENE

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Abstract: Neogene geodynamic evolution of the Carpathian arc and Pannonian basin system is presented in the form of structural and paleogeographic/palinspastic maps. A role of the subduction and uprise of asthenospheric mantle in the development of the accretionary prism and back-arc basins is emphasized. Subduction took place in three segments successively from the West eastward, being compensated by asthenospheric flow and related mantle diapirism.

Key words: Neogene, Carpatho–Pannonian region, geodynamic evolution, palinspastic reconstruction, subduction, asthenosphere uprise

Introduction

The Neogene geodynamic evolution of the Carpathian arc and Pannonian basin is presented in terms of a coupled system of: (1) Alpine (A – type) subduction and compressive orogene belt development owing to collision of the Adriatic microplate, (2) lateral extrusion of ALCAPA lithosphere from the Alpine collision assisted by transform faults, (3) Carpathian gravity driven (B – type) subduction of oceanic or suboceanic lithosphere underlying former flysch basins and (4) back arc extension associated with the diapiric uprise of asthenospheric mantle. Though the subduction and related asthenospheric mantle upwelling were always contemporaneous in any given segment of the Carpatho – Pannonian system, we observe a progression from the west eastward.

Neogene evolution of the Carpathian arc

The Neogene evolution of the Carpathian arc was driven by subduction of lithosphere underlying flysch basins, in three stages: (A) Late Oligocene to Early Miocene subduction of the remnant oceanic lithosphere of the internally situated Peninnic - Magura flysch zone basement, (B) late Early Miocene to Sarmatian and (C) Pannonian to Pliocene subduction of suboceanic(?) lithosphere of the externally situated Krosno-Moldavian flysch zone basement. Related contrasting evolution of the accretionary prism, as well as timing of initial inversion in the Outer Carpathian flysch basins and final thrusting of the accretionary prism over foredeep sediments, allows one to distinguish three segments with a different history of subduction, roughly corresponding to the Western Carpathians, northwestern part of Eastern Carpathians, and southeastern part of Eastern Carpathians.

The final subsidence of the detached lithospheric fragment, representing former basement of the Magura nappe (eastern segment of the Penninic – Magura plate) and the initial stage of subduction in the outer Krosno – Moldavian flysch basins, limited at this time to its northwestern part, accelerated the lateral extrusion of the ALCAPA microplate from the East Alpine collision zone. The northward drift of the ALCAPA microplate (West Carpathian orogene) was marked at its NW side by a system of left-lateral transform faults responsible for initial opening of the Vienna Basins by a pull-appart mechanism.

Constrains by andesitic volcanism

The timing and spatial distribution of the arc-type (subduction-related) andesite volcanics of the Eastern Carpathians indicate either a limited width of the subducted lithosphere in this part of the orogene chain (300 – 200 km in the NW segment of the Krosno – Moldavian zone and less than 200 km in the SE segment of the same zone) or a progressive detachment of the sinking slab from the platform margin during the volcanic activity. The time interval of 8 - 10 Ma between the initial stage of subduction and onset of the arc type basaltic andesite to andesite volcanic activity along the Carpathian arc suggests an average subduction rate of 1.5 – 2.5 cm a year. The low subduction rate implies obstacles for the compensating asthenosphere flow, perhaps represented by confining thick lithosphere at the NW and SE sides of the arc (the Bohemian massif & Moesian platform).

Evolution of back-arc basins

Subduction in the Outer Carpathian flysch basin was since its beginning compensated by asthenospheric mantle upwelling (diapiric uprise) and related rifting in the back arc realm. Spatial distribution and timing of back-arc basins reflected the segmentation of sinking slabs, as well as the final verticalization of subduction zones. This segmentation should be understood as a gravity driven process allowing for asthenospheric side flow to take place and hence to speed up gravity driven overturn (subduction).

Areas of thinned crust and lithosphere corresponding to the Neogene extensional basins localize places of the diapiric uprise of asthenospheric mantle. Its position is documented also by thermal modeling and by the spatial distribution of the widespread (extension-related) rhyolitic and andesitic volcanism. Diapiric uprise of asthenospheric mantle started in the West following subduction in front of the Western Carpathians in Early Miocene times, then continued towards the northeast following subduction in front of the NW part of the Eastern Carpathians at Early / Middle Miocene times, and finally it affected central and eastern regions during Middle / Late Miocene times following initiation of subduction in the front of the SE part of the Eastern Carpathians.

Late stage evolution

Late stage alkali basalt volcanics testify that during the late stage of the back arc basin evolution extensional environments persisted (before the final tectonic inversion) and that the diapiric uprise of asthenospheric mantle incorporated unmetasomatized mantle material, perhaps brought into the area of the diapiric uprise by compensating asthenospheric mantle counterflows. Pliocene development of the Carpatho – Pannonian region is characterized by a tectonic inversion of the back-arc basin area.

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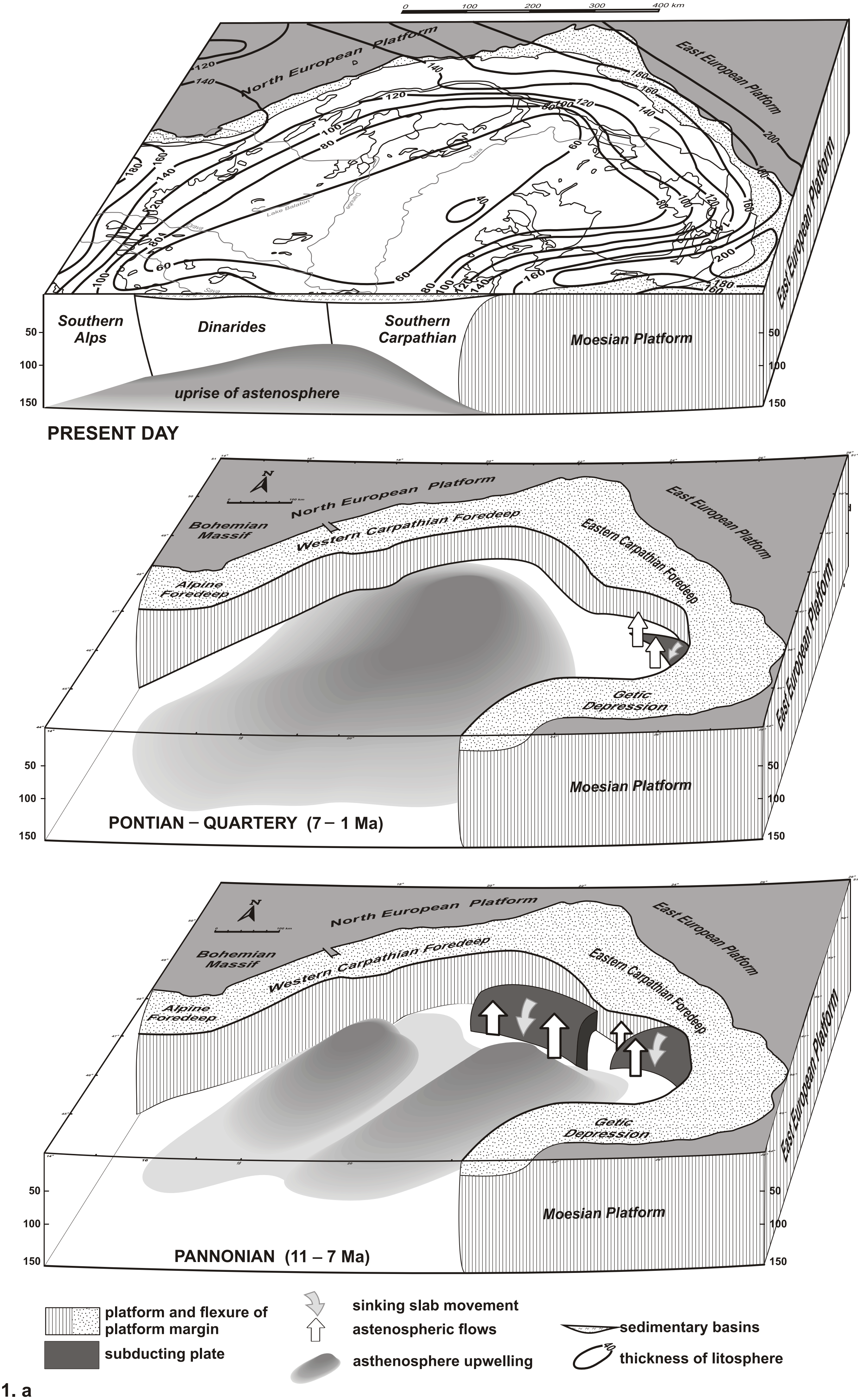
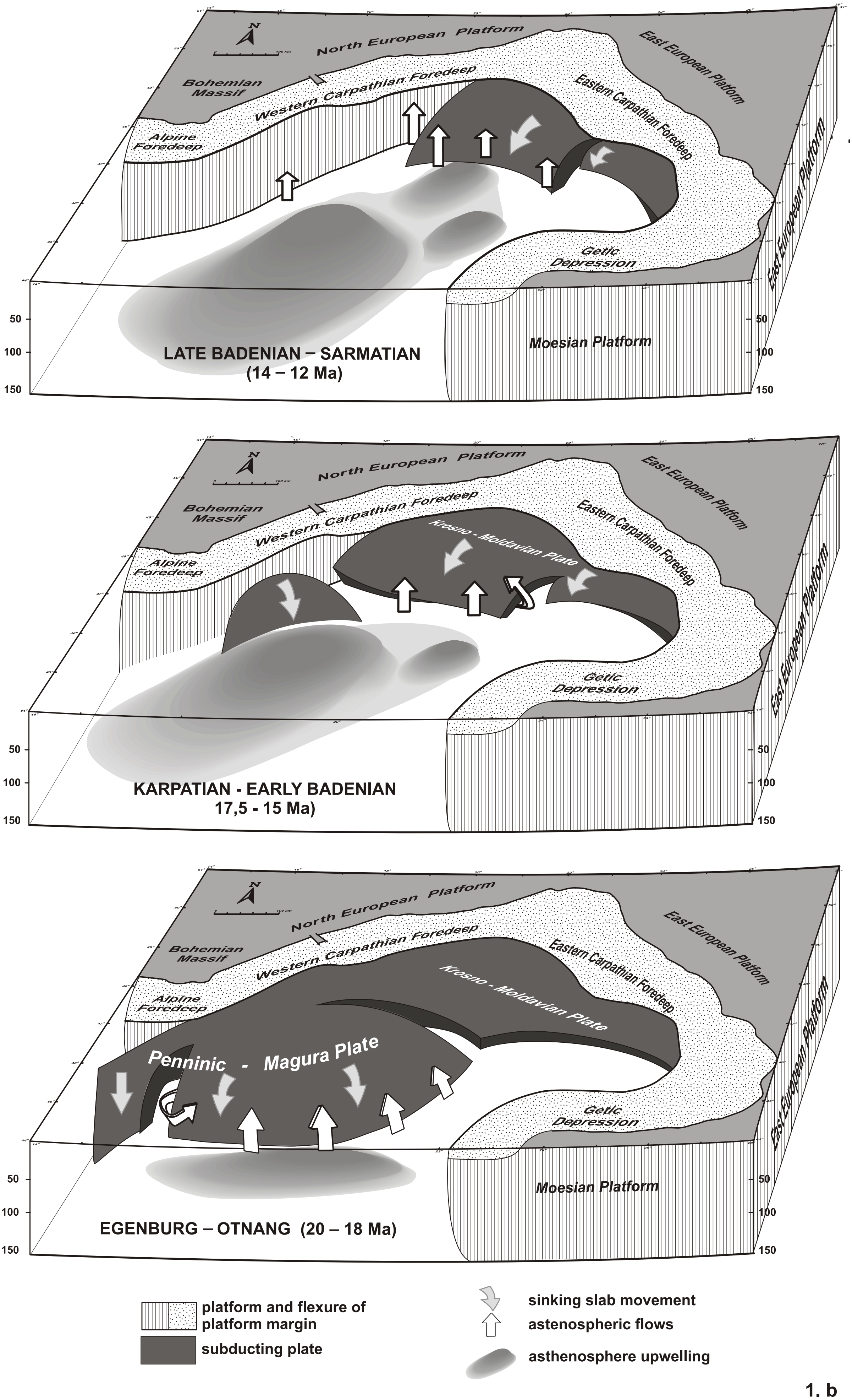
Fig. 1.A-B: Palinspastic reconstruction of the Carpathian – Pannonian region during the Miocene to Quaternary. Block diagrams showing the assumed position of subducted slabs, compensating asthenosphere flows and asthenosphere upwelling in the back-arc domain.



0
100
200
300
400 km
North European Platform
East European Platform
Southern Alps
Dinarides
Southern Carpathian
Moesian Platform
uprise of astenosphere
Lake Balaton
50
100
150
PRESENT DAY
North European Platform
Bohemian Massif
Western Carpathian Foredeep
Alpine Foredeep
Eastern Carpathian Foredeep
East European Platform
Getic Depression
Moesian Platform
PONTIAN – QUARTERY (7 – 1 Ma)
North European Platform
Bohemian Massif
Western Carpathian Foredeep
Alpine Foredeep
Eastern Carpathian Foredeep
East European Platform
Getic Depression
Moesian Platform
PANNONIAN (11 – 7 Ma)
platform and flexure of platform margin
subducting plate
sinking slab movement
astenospheric flows
asthenosphere upwelling
sedimentary basins
thickness of litosphere

1. a



North European Platform
East European Platform
Bohemian Massif
Western Carpathian Foredeep
Eastern Carpathian Foredeep
Alpine Foredeep
Getic Depression
Moesian Platform
50
100
150
LATE BADENIAN – SARMATIAN
(14 – 12 Ma)
North European Platform
East European Platform
Bohemian Massif
Western Carpathian Foredeep
Eastern Carpathian Foredeep
Alpine Foredeep
Krosno - Moldavian Plate
Getic Depression
50
100
150
KARPATIAN - EARLY BADENIAN
17,5 - 15 Ma)
North European Platform
East European Platform
Bohemian Massif
Western Carpathian Foredeep
Eastern Carpathian Foredeep
Alpine Foredeep
Krosno - Moldavian Plate
Penninic - Magura Plate
Getic Depression
Moesian Platform
50
100
150
EGENBURG – OTNANG (20 – 18 Ma)
platform and flexure of platform margin
subducting plate
sinking slab movement
astenospheric flows
asthenosphere upwelling

1. b