Miocene development of the Carpathian chain and the Pannonian Basin: Movement trajectory of lithospheric fragments, subduction and diapiric uprise of asthenospheric mantle

MICHAL KOVÁČ[1], EMÖ MÁRTON[2], JÁN ŠEFARA[3], VLASTIMIL KONEČNÝ[4] & JAROSLAV LEXA[4]

[1]Department of Geology and Paleontlogy, Faculty of Sciences, Comenius University, Mlynská dolina G, SK-84215 Bratislava, Slovakia, kovacm@fns.uniba.sk
[2]Eötvös Loránd Geophysical Institute of Hungary, Paleomagnetic Laboratory, Columbus 17-23, H-1145 Budapest, Hungary, paleo@elgi.hu
[3]Departement of Applied Geophysics, Faculty of Sciences, Comenius University, Mlynská dolina G, SK-84215 Bratislava, Slovakia, geofyzika@fns.uniba.sk
[4]Geological Survey of Slovak Republik, Mlynská dolina 1, SK-817 04 Bratislava, Slovakia, lexa@gssr.sk

Abstract: The Miocene developmentof the Carpathian chain and pannonian basin system was controlled by retreating subduction in front of the orogene and which back-arc extension associated with the diapiric upraise of astenosphere. The differencesin geodynamical behavior between western and central and eastern parts of the area, as well as the different movemet trajectories of the individual lithospheric fragments (Alcapa and Tizsa-Dacia microplates)mirrors the subducting slab segmentation into at least three parts, the oblique collision with the platform margin combined with rotation of overriding plates and heterochronous diapiric upraise of the asthenosphearic mantle. Tming of the mentioned processes is given in following text.

Key words: Western Carpathian - North Pannonian region, Miocene, microplates movement trajectory, subduction, upraise of asthenospheric mantle

The Tertiary evolution of the Carpathian arc and Pannonian Basin (Fig. 1) is generally interpreted as a coupled system of the gravity driven subduction of oceanic or suboceanic lithosphere underlying former flysch basins, back arc extension associated with the diapiric upraise of asthenospheric mantle and lateral extrusion of lithosphere fragments from the Alpine collision assisted by transform faults (Vass et al 1988, Csontos et al. 1992, Meulenkamp et al. 1996, Kováč et al. 1998, Lexa & Konečný 1998).

Division of the subducting slab into three major segments, corresponding roughly to the West Carpathians, northern part of the East Carpathians and southern part of the East Carpathians testifies the arc type andesite volcanism. Subduction affected first during the Late Oligocene to Early Miocene time internally situated Penninic/Magura and Transcarpathia/Szolnok flysch zones (Fig. 3), later during the Early Miocene to Pliocene time externally situated Silesian/Krosno/Moldavian flysch zone (Fig. 3, 4, 5, 6). Subduction in the external zone started at the West during Early Miocene (20 Ma) and sinking slab has reached the magma generation depth of 120 - 150 km during the Early Sarmatian (12.5 Ma), while at the East it started during Badenian (16 - 15 Ma) and sinking slab has reached the magma generation depth during the Late Pannonian to Pleistocene (9 - 1 Ma). Such the timing sets the average subduction rate at 1.5 - 2 cm a year. With exception of the NE Carpathians the subducting slab has reached the "magma generation" depth during the last stage of convergence in the almost vertical position. The short-term volcanic activity implies a limited width of the subducted crust (less than 150 km) or a progressive detachment of the sinking slab from the platform margin. The final detachment of the sinking slab is confirmed by results of seismic tomography, while it is still in progress at the Vrancea seismic zone.

Migration of subduction processes eastward was reflected in corresponding migration and reorientation of back arc extension zones (Fig. 3, 4, 5, 6). The arc type andesite volcanism associated in individual segments with the subsidence of extension basins, which are situated at the back of the accretion prism, as an immediate product of the subduction pull in the orogene hinterland. The areal type silicic and andesitic volcanism associated with the evolution of the pull-apart and basin & range (horst/graben) type structures. Areas of thinned Crust and Lithosphere, corresponding to Neogene extension basins, localize places of the diapiric upraise of asthenospheric mantle, which was coupled intimately with subduction processes in the outer flysch zone of the Carpathian arc. Late stage alkali basalt volcanics testify, that during the final stage in evolution of the arc the compensating asthenospheric flow has reached the zone of back arc extension and diapiric upraise of asthenosphere incorporated unmetasomatized mantle material (Fig. 5, 6).

Migration of subduction processes eastward caused also a reorientation of the upper plate movement and the lateral extrusion of lithosphere fragments from the Alpine collision zone. While it was northerly during the Early

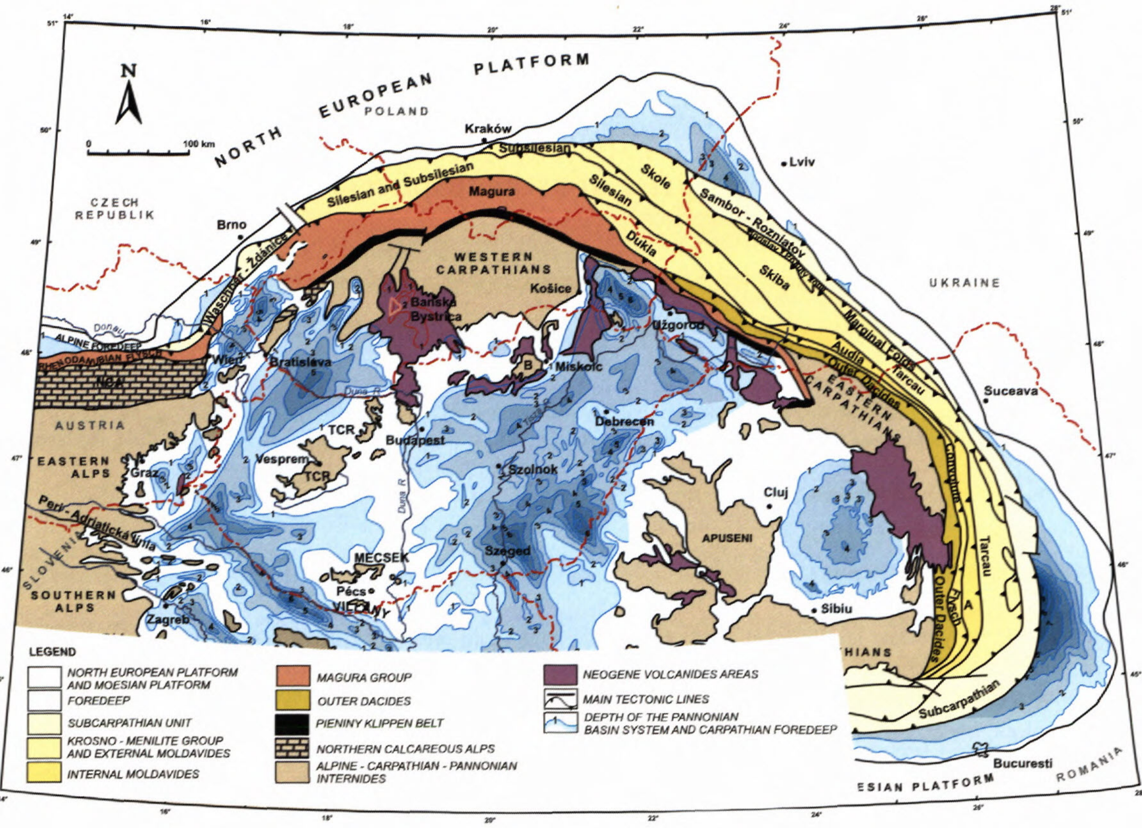

Fig. 1 Geological map of the Carpathian - Pannonian domain, volcanites and thickness of the Neogene basin fill is marked (modified after Kilényi & Šefara, 1989; Horváth, 1993).

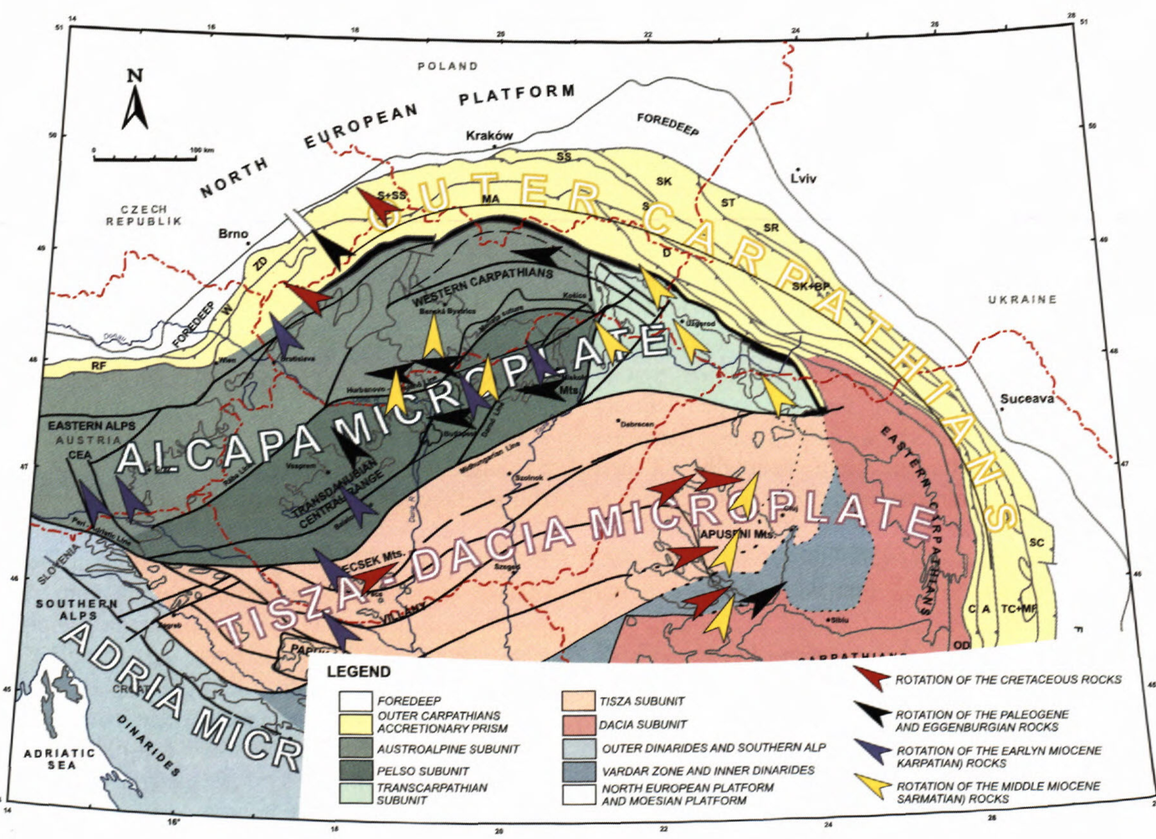

Fig. 2a The Alcapa and Tisza - Dacia microplates, orientation of the paleopoles is marked by arrows. (Modified after Kováč and Márton, 1988)

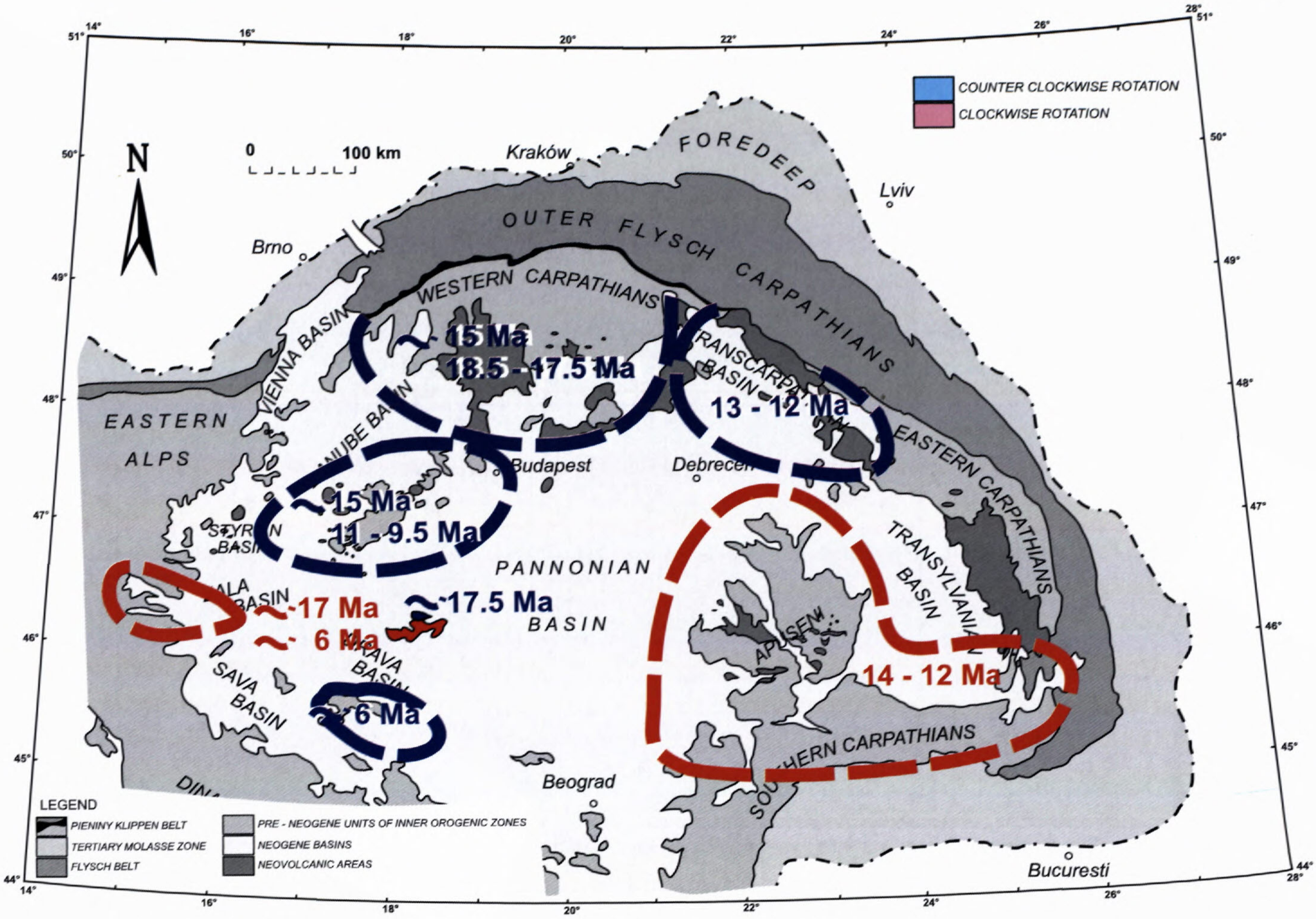

Fig. 2b Timing of the Miocene rotations of the Alcapa and Tisza-Dacia microplates

Miocene, it was northeasterly during the Middle Miocene and easterly during the Late Miocene time (combined with counter-clockwise rotation due to oblique collision with the continental margin).

In the last decade, the paleomagnetic study in the Carpathian-Pannonian domain brought a large number of new data which show a variability of the Neogene rotations in time and space mirroring the development of the Carpathian chain and Pannonian back-arc basin during this period (Fig. 2a, 2b). The paleomagnetic results document the general CCW rotation of the northern, the Alcapa megatectonic unit, while indicate both CW and CCW rotations in the southern, the Tisza- Dacia megatectonic unit (Kováč & Márton 1988).

In the Western Carpathian region of the Alcapa microplate two CCW rotations were registered in the Tertiary. The older one (50 - 60°), after the Ottnangian (17.5 Ma), can be correlated with initial rifting of the back-arc area, associated with high subsidence rates above all in the Vienna Basin. During this time, the Early Styrian thrust of the Flysch Belt over the North European Platform was followed by development of continuous foredeep in front of the orogene (depocentres in the west). The second CCW rotation (30°), during the Early Badenian (15 Ma), can be correlated with tectonically controlled transgression, followed by accelerated subsidence in the Danube Basin and the Late Styrian thrust of the Western Carpathian Flysch Belt over the foredeep. There is paleomagnetic evidence to show that the final emplacement of the Western Carpathian region is older than 14.5Ma.

In the Transcarpathian depression, in the Tokaj Mts. and in the Oas Mts. we know of a single CCW rotation (40- 50°) which must have taken place in the Sarmatian (13-12Ma). This rotation can be correlated with maximum subsidence in the in the East Slovakian Basin and accelerated subsidence in the foredeep at the Western-Eastern Carpathians boundary, followed by the last overthrusts of the Outer Carpathian Flysch Belt.

In the Transdanubiam Central Range a CCW rotation (30°) can be traced during the Eocene, mirroring the Paleogene development of the Southern Alps and Dinarids. A second CCW rotation (30°) occurred probably during the Early Badenian (15 Ma) which can be related to Danube Basin synrift development. The last CCW rotation (30°) is observed on Early Pannonian (11 - 9.5Ma) rocks. Though the exact age of this rotation is not yet known, it may be tentatively related to the new rifting period in the back arc basin and to the development of compressive structures from the zone of Sava folds to the south-eastern front of Transdanubian Range.

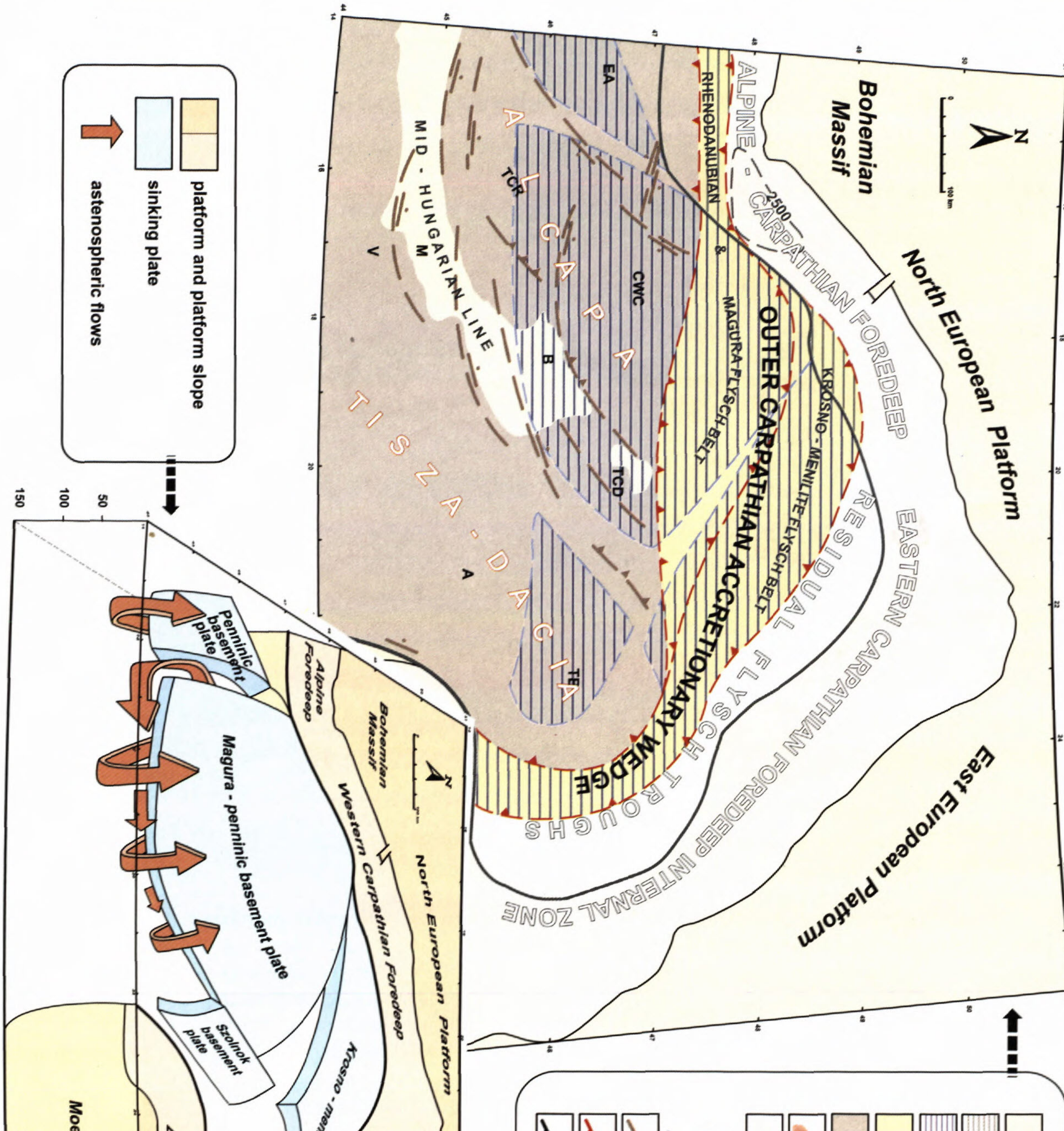

Fig. 3 Palinspastic reconstruction of the Alpine - Carpathian collision with the European Platform, subduction of the Outer Carpathians flysch troughs basement and diapiric uprisse of the asthenospheric mantle during the Eggenburgian to Ottnangian (20-18 Ma).

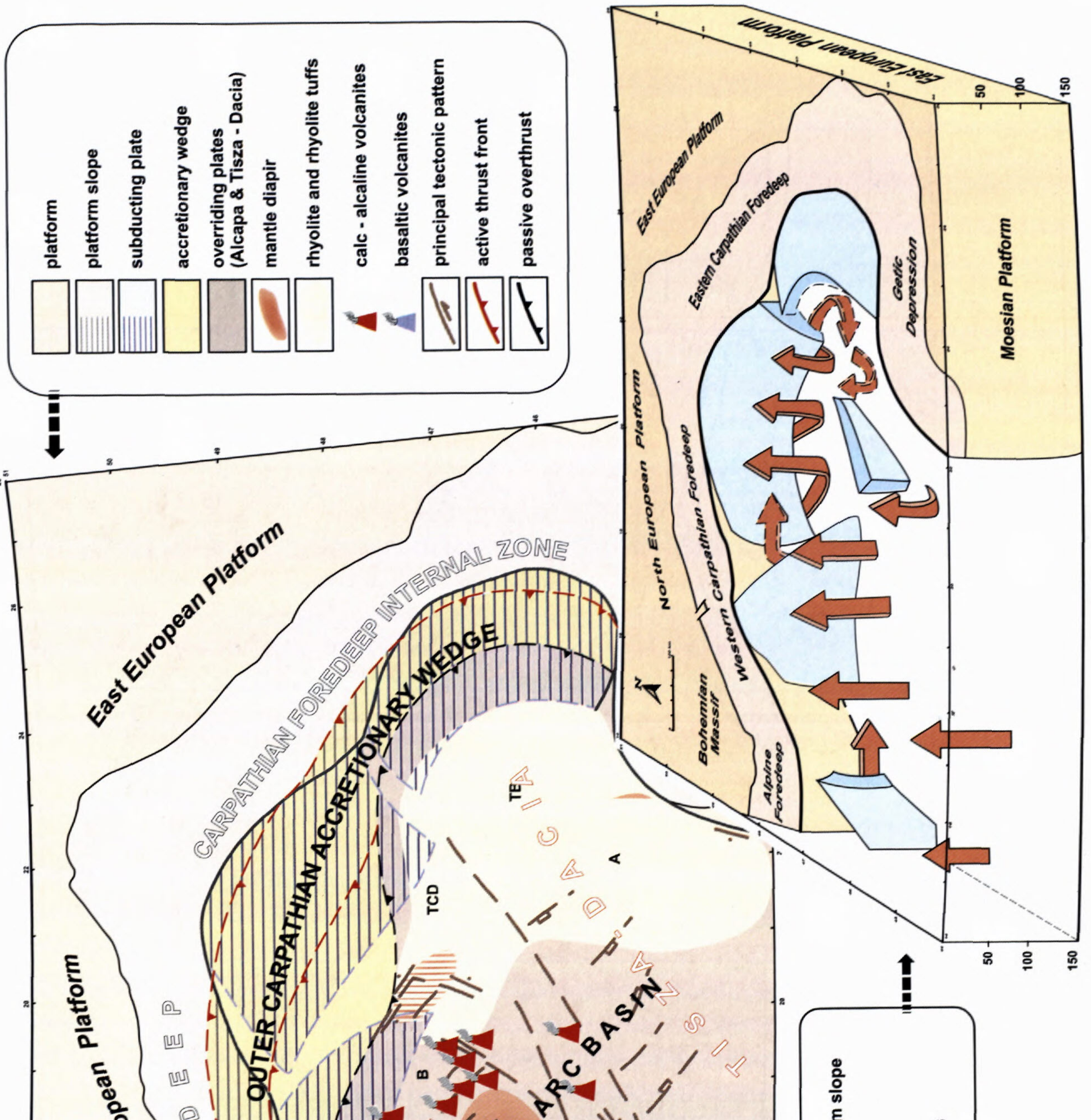

Fig. 4 Palinspastic reconstruction of the Alpine - Carpathian collision with the European Platform, subduction of the Outer Carpathians flysch troughs basement and diapiric uprisse of the asthenospheric mantle during the Karpatian to Early Badenian (17.5-15 Ma).

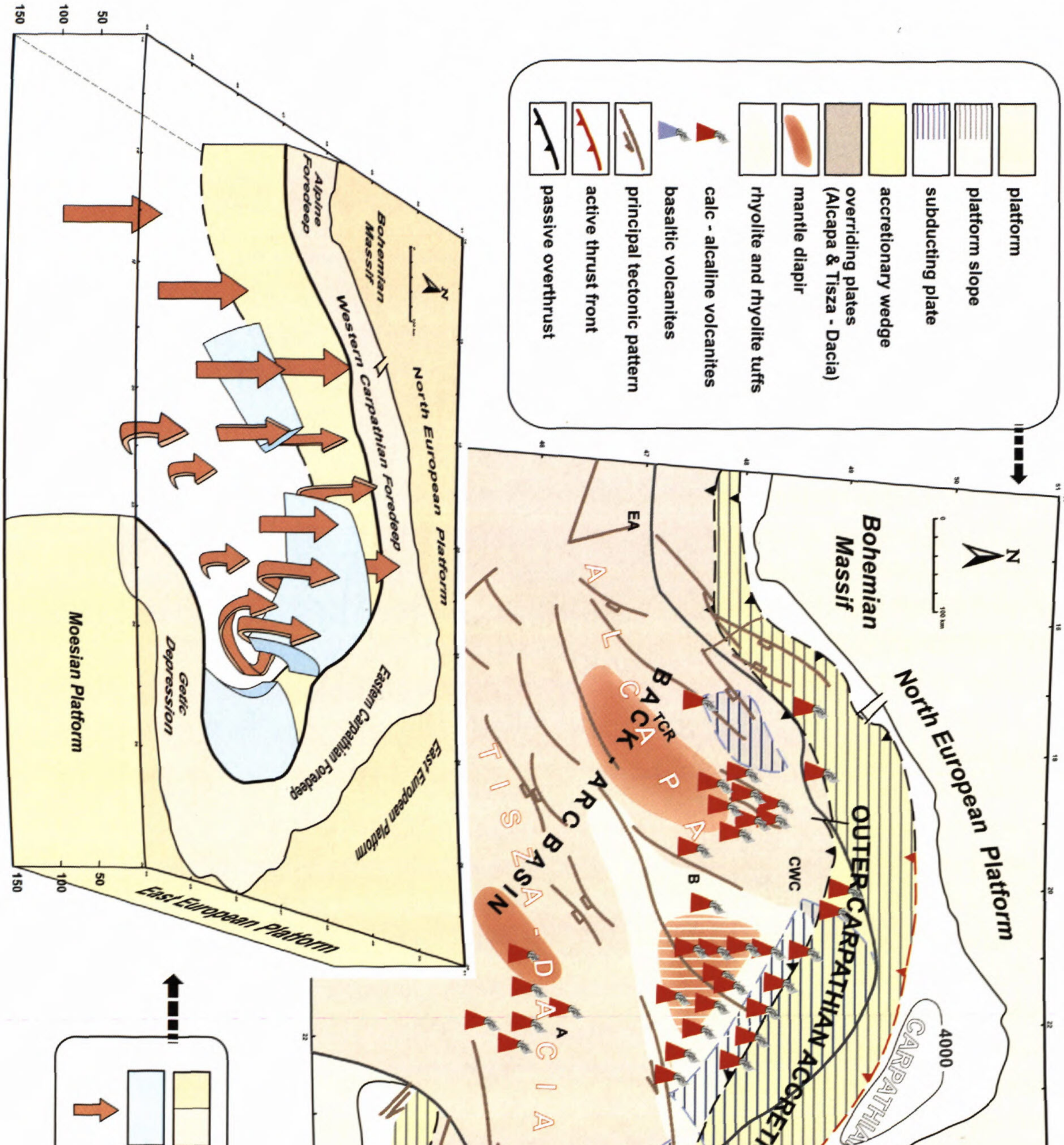

Fig. 5 Palinspastic reconstruction of the Alpine - Carpathian collision with the European Platform, subduction of the Outer Carpathians flysch troughs basement and diapiric uprisse of the asthenospheric mantle during the Late Badenian to Sarmatian (14-12 Ma).

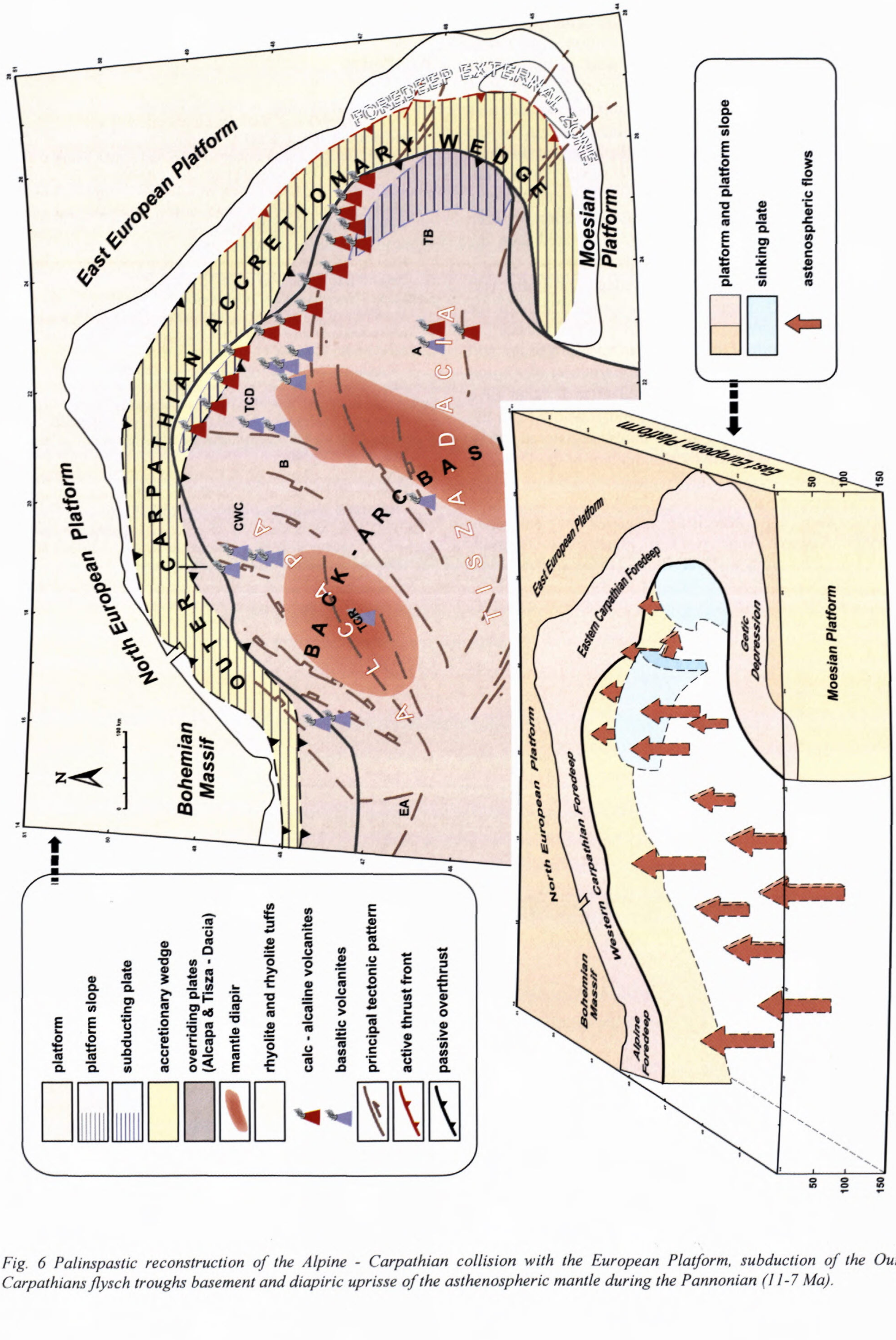

Fig. 6 Palinspastic reconstruction of the Alpine - Carpathian collision with the European Platform, subduction of the Outer Carpathians flysch troughs basement and diapiric uprisse of the asthenospheric mantle during the Pannonian (11-7 Ma).

In the southern, Tisza-Dacia megatectonic unit, the Tertiary paleomagnetic data complicated the picture of uniform CW rotations which had been based on Cretaceous paleomagnetic results. In the western part of the Tisza-Dacia unit, CCW rotations (about 50°) of Karpathian age (17.5 Ma) occur, probably connected to a left-lateral displacement at the northern margin of the Mecsek Mts. There are a few data indicating that the main body of the Mecsek rotated in the CW sense, but the timing is uncertain. In the eastern part of the megatectonic unit there is evidence for about 60° CW rotation between 14 and 12 Ma. This rotation can be correlated with the Late Styrian to Early Moldavian thrust of the Eastern Carpathian Flysch Belt over the foredeep and initial rifting stage (uplift?) of the Great Hungarian Plain. In the Transylvanian Basin increased subsidence took place.

In the SE margin of the Pannonian back arc basin, still in the Tisza megatectonic unit, CCW rotation (40°) was observed, which must have occurred after Pontian time (6 Ma) and was accompanied by rapid subsidence in the Drava and Sava Basins This youngest registered CCW rotation reflects compressive development of the Dinarids in the Pliocene.

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