Published Sm/Nd ages on garnets from metapelites (Thöni, 2002) give mid-Cretaceous (93–87 Ma) ages interpreted as time constraint of the high-pressure Alpine metamorphism. New thermochronological data show two major cooling events, which affected metamorphic rocks in different geographic and geologic position (Fodor et al., 2003a). In the northern Kozjak area muscovite K/Ar ages on medium-grade (102–96 Ma) and low-grade rocks (91Ma) and zircon fission track ages (27–22 Ma) show fast cooling immediately after mid-Cretaceous metamorphism and some thermal effects at the Oligocene/Miocene boundary.

In contrast, in the southern Pohorje area all thermochronological data (below ~350 °C) demonstrate Miocene cooling. Probably the oldest non-reset fission track ages of grains in Karpatian sediments show cooling of source rocks at 22–20 Ma (Sachsenhofer et al., 1998). Muscovite and biotite K/Ar ages (from 21 to 13 Ma), zircon and apatite fission track ages (19 and 10 Ma, respectively) indicate early to mid-Miocene cooling of metamorphic rocks. Identical K/Ar biotite, feldspar and hornblende ages of magmatic rocks (19–15 Ma) and fission track ages (18–15 Ma) demonstrate that the two rock types cooled together after magma emplacement and eventual hydrothermal-metasomatic alterations. Cooling ages of dacite are nearly equal true formation age while Karpatian sediments contain tuffs and are locally intruded with small dacite bodies. Granodiorite formation age remains questionable. However, granodiorite pebbles in Karpatian sediments give an upper time constraint and show fast exhumation for granodiorite (Fodor et al., 2003a). Thermal effect at early mid-Miocene is indicated by high vitrinite reflectance values and partially reset fission track ages from Karpatian sediments (Sachsenhofer et al., 1998).

Difference of cooling ages can be attributed to Miocene extension; the Kozjak Mts. seems to represent a major hanging wall fault block of a Miocene normal or oblique-slip fault, namely the Lovrenc fault. Early phase of Miocene cooling of the Pohorje can be connected to ductile extensional exhumation while low-temperature part was associated with brittle normal faulting. Kinematic directions did not change considerably during the deformation and cooling. Because of unclear timing, we have no exact data for tectonic regime for granodiorite magmatism. However, emplacement of all other magmas and their post-solidification ductile to brittle deformation also occurred in extensional settings. All deformation features are part of a prolonged Miocene extensional deformation.

The structural and thermochronological data suggest two ductile extensional exhumation events for the Pohorje-Kozjak rocks. The late Cretaceous event was responsible for extensional disintegration of the East Alpine nappe pile, including the Transdanubian Range ("Bakony") nappe of western Pannonia as the highest unit (Fodor et al., 2003b). Miocene exhumation is connected to extrusion tectonics, rotation and rifting of the Pannonian Basin; processes included the easternmost Eastern Alps and Western Carpathians. Magmatism are mainly related to Neogene extension, and contributed to heating at late stage of ductile to brittle tectonic exhumation.

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What Are the Tectonic Units in the Pannonian–Carpathian–Eastern Alpine Domain: Terminological Question or Key to Understand Structural Evolution?

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Tectonic units are three-dimensional rock bodies with distinct physical boundaries and unique structural characters including temporal evolution. One of the main tasks of structural research is to define boundary surfaces or zones (structural elements), describe their geometry, characterize kinematic nature and determine temporal evolution. On the other hand, the presence of certain rock formations, their special facies or paleogeographic similarities are not distinctive features, although they can occasionally be useful to establish or better characterise some tectonic units.

Tectonic units are evolving in time. Their boundaries can be shifted, their size can be increased or reduced. Frontal accretion, underplating versus out-of-sequence thrust, low-angle normal detachment, etc. may contribute to volume increase/decrease of a unit. Changing volumes are particularly striking at strike-slip boundaries where activation or abandonment of certain branches could lead to shift of boundaries, formation of exotic strike-slip duplexes, etc.

The definition of tectonic units (e.g. its boundaries and structural characters), proper use of this term in temporal evolution is not merely a terminological problem. Although a perfect agreement on certain terms can hardly be achieved but on the other extremity, completely different usage of a tectonic unit reflect misunderstanding of the structural, and in consequence, the whole geological evolution. Tectonic units can be figured on divers geological maps, thus they are useful and necessary "tool" to disseminate results of "purely" structural geological research. On the other hand, results of modern structural research modify considerably geological maps and general knowledge. It is particularly true in Central Europe, where despite long research, and extensive geological knowledge, structural interpretation was not always integral part of the research and/or mapping. These are the reasons that I feel important to clearly define the units, discuss their nomenclature and structural characteristics.

The presentation would like to concentrate on this problem, picking up certain elements from the Mesozoic-Cenozoic structural evolution of the Pannonian-Carpathian domain. With the selected examples I would like to illustrate the "terminological problems", the related future works to be done while emphasizing some major structural events in the evolution of the Pannonian-Carpathian domain, which were achieved during the last two decades of researches. Examples cover the whole structural evolution but not describe it in all complexities and details. Results were established by the clever reconstruction of Balla (1984), are coming from the first modern and forwarding structural synthesis of Tari (1994) from the genuine Frank Horváth and from his "working group".

Extrusion/escape tectonics is considered as a major event in the structural evolution. The displacing Alcapa unit is suggested to incorporate the Eastern Alps, Western Carpathians and the northern and western Pannonian basin (Csontos et al., 1992). The process resulted in eastward motion of substratum of future Pannonian basin toward the stable European platform and ultimately resulted in shortening within and subduction below the Carpathian orogen.

Despite considerable research, physical boundaries of the Alcapa and the time span of its existence still merit a debate. The birth of Alcapa coincides with the onset displacement along its boundaries. Extension of Penninic (and deeper?) units of the Eastern Alps and boundary strike-slips are generally considered to be active from Early Miocene (Ratschbacher et al., 1989) although dextral slip of the Periadriatic Line could start as early as mid-Oligocene.

New structural paleomagnetic data may show differences between the Alpine and Carpatho-Pannonian segments of the Alcapa during the late Early Miocene. While crustal extension ("orogenic collapse") and boundary strike-slip faults seems to persist in the early to mid-Miocene in the Eastern Alps, no notable extension existed before 19–18 Ma in Pannonia. The onset of upper crustal faulting coincides with the first rotation event, 30–50° counterclockwise rotation of the Western Carpathians – northern Pannonia between ~18–17 Ma. Because this rotation does not occur in the Eastern Alps, the rigid connection of western and eastern Alcapa terminated (Márton and Fodor, 2003). On the other hand, this rotation changed completely the southern boundary of the extruding Alcapa. While the Periadriatic Line does not seem to be rotated, its continuation to Hungary, the Mid-Hungarian zone sensu lato suffered the rotation. In consequence, the dextral slip along the Periadriatic Line was transferred from the Mid-Hungarian to other faults in southern Pannonia or in the northernmost Dinarides (Fodor et al., 1998).

The other problem is the physical definition of the evolving Alcapa unit and its boundaries. During the eastward motion, new nappes and slices of the former flysch basin(s) were accreted to the relatively rigid Alcapa. In a strict sense, the consolidated blocks became part of the Alcapa unit. The final "accretion" was the juxtaposition of Alcapa and the southern Tisza-Dacia unit some when in the early Mid-Miocene. From that moment, the Pannonian part of the Alcapa and the Tisza-Dacia units were moving eastward in a coordinated manner and their distinction as separate units largely weakened.

These considerations suggest that Alcapa was disintegrated around ~18 Ma in the west while increase by accreted new units in the east. We can keep the term Alcapa keeping in mind its continuous volume changes and accept at the same time that the rotations and rifting phases of the Pannonian basin (~18–13 Ma) is still part of the extrusion process. Or, we restrict the usage of Alcapa to pre-18 Ma extrusion and use the term "rifting of the Pannonian-Western Carpathian-Eastern Alpine domain".

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