Apatite Fission Track Constraints on Exhumation History of Basement Highs along the Northern Margin of the Danube Basin

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Fission track (FT) thermochronology used on apatites provides information about the cooling history of rocks in the temperature range between ~60 and 120 °C. Due to this fact, the fission track method has become a powerful technique which is able to reveal the low temperature evolution of exhuming crystalline complexes. This study presents 17 apatite FT ages, 6 measurements of track length distributions, and thermal modelling results in order to reveal the important issue of Tertiary thermotectonic evolution and possibly to understand the final phase of exhumation in the Western Carpathians. Three basement highs, presently forming horst structures separated by embayments of the Danube Basin, were investigated: the Malé Karpaty Mts., Považský Inovec Mts., and Tribeč Mts. The horst and graben structural pattern was created in a transpressional regime induced by oblique collision of the North Pannonian Microplate with the North European Platform during the Early Miocene (e.g., Ratschbacher et al., 1991a,b).

The apparent apatite FT ages group into two clusters – Eocene and Miocene, indicating two domains with different thermal histories within the study area. The first age cluster, ranging from ~29–44 Ma, covers the southern half of the study area, the latter one, ranging from ~13–21 Ma, covers the northern half. Confined track length distributions display variability within the study area, basically the mean confined track lengths of the samples range between 12.8–13.8 μm with standard deviations between 1.0–2.0 μm, suggesting a complex thermal history. Thermal modelling results, based on FT data and sedimentary successions from the surrounding basins, imply that Palaeogene sediments significantly affected the exhumation/burial history of the studied structural highs and that the entire study area was a part of the Central Carpathian Palaeogene Basin. Based on our results, we propose the following scenario for the study area: during the Eocene, faster subsidence in the north led to a northward tilt; in the Late Oligocene, the entire area experienced exhumation; in the Miocene, collision in the north, together with rifting in the hinterland, reversed the direction of the Palaeogene tilting, resulting in fast exhumation in the north and slow exhumation or even local subsidence in the south.

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The Outline of the Tectonics of the Hranice Palaeozoic Carbonates (Moravosilesian Palaeozoic)

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The Variscan acretionary wedge consists of Culm flysh sediments with tectonic slices of pre-flysh rocks. The Hranice Paleozoic limestones are incorporated into Culm rocks in the easternmost part of the wedge. Homola (1950) presented the first mobilistic interpretation of this area and documented fold thrusts. On the other hand Dvořák and Friáková (1978) introduced the idea of synsedimentary faults and blocks with different sedimentary facies. Later, the stratigrafic inversion was found in the Opatovice-1 borehole (Dvořák et al. 1981) implying the existence of the overthrust. Nevertheless, the large structure of the area has not been satisfactory explained.

New researches in this important area are concentrated on geological mapping, stratigraphy and tectonics. Based on lithological character of the limestones as well as on different tectonic structures it was possible to distinguish two litho-tectonic types of the limestones: low- and high-strained rocks.

The low-strained limestones are rocks with brittle-ducitle to ductile cleavage or solution cleavage. The moderate solution cleavage (Alvarez et al. 1978) originates in the limestones especially with higher contents of the clay components. It is characterized by abundant subparalel smooth pressure seams in the microscopic scale that truncate the carbonate nodules of the

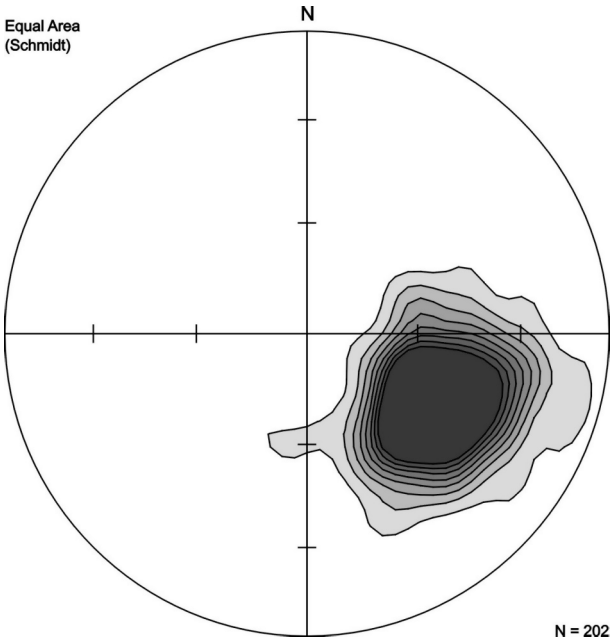

Fig. 1. Contoured plot of equal-area projection for the poles of foliations.

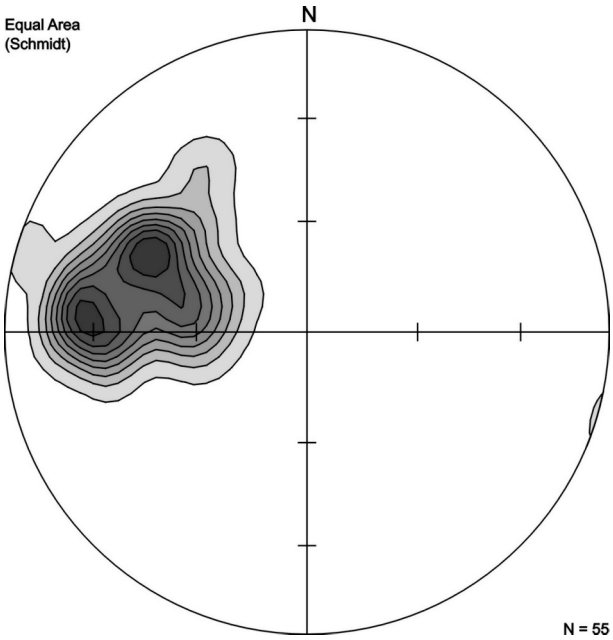

Fig. 2. Contoured plot of equal-area projection for the lineations.

Křtiny limestones or the organic fragments (e.g., crinoidal segments). The brittle-ductile to ductile cleavage and stretching lineation often occur in the massive homogeneous limestones. The width of cleavage domains depends on the carbonate litotype and corresponds mostly to several milimetres. The intraclasts in limestone breccias are elongated in lineation trend. The peaked stylolites originated in the compressional zones on the contacts of relatively rigid intraclasts with surrounding soft carbonate matrix. Some parts of low-strained limestones are folded and the axial planes of folds are parallel with the cleavage. Minimal shortening is about 27 % in the normal section to the fold axis.

The ductile foliation is present in the high-strained limestones as banding, tectonic laminations or composite foliation. The plate structures were created by intraclast flattening. The high-strained rocks compose shear zones. Budinage of porfyroclasts indicates the 250-300 % minimal elongation in these zones. The calcite twins with lamellae geometry of type I, II and IV (Burkhard 1993) frequently occur in the recrystallized carbonate material. Based on the deformation, the temperature could be estimated from 250 to 300 °C during the ductile foliation origin. The pressure solution is a dominant mechanisms of microstructural deformation (e.g., the presence of stylolites, solution cleavage, veins) besides calcite twinning mechanism.

The bedding is mostly subhorizontal with moderate dips to ESE or W in the low-strained rocks whereas the bedding is rotated to the position parallel with the ductile foliation in the shear zones. The simple shear caused the high reduction of the original sedimentary thickness. The tectonic foliation planes strike NNE-SSW and dip to WNW (Fig. 1). The lineation dips to WNW (Fig. 2). The maps of their average orientations show a quite uniform structural scheme in the studied area. The rotated σ- and δ- porfyroclasts indicate the top-to-the-ESE thrusting. The shear zones striking NNE-SSW represent basal parts of the tectonic sheets that developed between upper Viséan and Westphalian. The trend of maximal shear stress σ1 could be estimated WNW-ESE. The origin of the mentioned shear zones probably represents the reaction to movements along the Moravian shear zone.

Acknowledgement

This research was supported by FRVŠ grant project 578/2003.

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