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Paleo-Stress Determination in Boreholes Drilled in the Boda Siltstone Formation (Mecsek Mts., Hungary) with the ImaGeo® Corescanner System

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In the frame of the geological research for final disposal of high-level radioactive waste, several boreholes were drilled in the Boda Siltsone Formation (Mecsek Mountains, Southern Hungary).

The Boda Siltstone Formation is an upper Permian (250 to 260 Ma) shallow lacustrine facies, reddish brown, monotonous, albititic, partly cross-bedded or laminated but mainly poorly bedded siltstone with conglomerate, sandstone, and dolomitic intercalations. It was deposited in continental sedimentary conditions, in arid-semiarid climate. The thickness of the whole formation is ~1000 m. The sedimentary basin cyclically dried out. Tepee structures, ripple marks, ichnofossils, concretions are common (Hámos 1999).

In several boreholes structural geologic investigation was carried out (Bat–4, D–5, D–6, Bak–5, Eg–1, Eg–2). With the help of the Imageo Coresanner system the cores were oriented with the help of borehole televiewer (BHTV) images (Maros and Palotás 2000, Maros and Pásztor 2001). When no BHTV images were available in a borehole, the orientation was done upon the assumption of the dip of the bedding, which is locally quite monotonous. Boreholes D–5 and D–6 were horizontal, drilled from an underground shaft, the others were vertically drilled from the surface.

The detailed tectonic description and the stress field analysis based on slickenlines revealed the main brittle deformational phases from a synsedimentary Permian event to Neogene deformation events. The spatial distribution and frequencies of the sedimentary phenomena, the different fractures, infillings, and slickensides were analysed and correlated across the boreholes. The different infilling generations were bound to different joint sets.

The Permian synsedimentary deformation was probably characterised by a NNW-SSE tension. Fractures and calcite filled tension gashes were formed parallel to the bedding. Bedding planes were reactivated by a NW–SE compression during the middle Cretaceous. This deformation led to the formation of the West Mecsek anticline. Some drillholes (Bat–4, D–5, D–6) were located on its NNW dipping northern limb, boreholes Bak–5, Eg–1, Eg–2 represent the SSE dipping limb. This deformation can be the same as described by Benkovics et al. (1997). The fold was overprinted by a strike-slip type deformation, with NNE-SSW compression and ESE-WNW tension. A prominent NE-SW trending fault zone formed in this stress field (e.g. Büdöskút zone). This zone was composed of transtensional and transpressional segments. The former was characterised by narrow graben-like structures, one of which was penetrated by one of the horizontal boreholes. In the fault zone part of the northern limb of the West Mecsek anticline was rotated to a SE dipping position. The deformation might have occurred in the late Cretaceous, but the zone could be reactivated in the Tertiary as well. The youngest phase was marked by a NNE-SSW compression, inducing N-S trending dextral and NE-SW trending sinistral faults, often coated with calcite infillings. This deformation was also noted by Csontos and Bergerat (1992).

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Post-Sedimentary Mesozoic – Cenozoic Thermotectonic Evolution of the Krkonoše Piedmont Basin (Bohemian Massif) Interpreted from Apatite Fission-Track Analysis

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We have studied the low-temperature history of the sediments in the Krkonoše Piedmont Basin (KPB) using fission-track (FT) dating of detrital apatites. The Krkonoše Piedmont Basin belongs to a system of post-orogenic extensional / transtensional basins which main part formed in the Bohemian Massif in the early post-orogenic phase, between the Westphalian and Saxonian times (c. 310 – 280 Ma). Most of the basins in Western and Central Bohemia are aligned along the NE-striking boundary of the Saxothuringian Zone of the Variscan orogeny, with minor modifications of the structural picture caused by NW-oriented fault zones and small basins formed at a later stage (Stephanian) along NNE-oriented faults such as the Rödl / Blanice Fault Zones. The older parts of the KPB fill (Westphalian-Autunian) underwent partial deformation during the formation of the Trutnov-Náchod sub-basin (Saxonian-Triassic), which is indicated by the angular unconformity at the base of the Trutnov Formation, the lowermost unit of the sub-basin infill. Deformation was governed mainly by dextral strike-slip along the northwest oriented faults parallel with Lusatian and Hronov-Poříčí fault zones. Further reactivations of the same fault systems in similar kinematic regime occurred during the mid-Cretaceous opening of the Bohemian Cretaceous Basin. The last phase of major deformation is attributed to the Palaeogene when several phases of NNE-NNW-oriented compression caused thrusting at the Lužice and Hronov-Poříčí Fault Zones and some adjacent structures. No firm evidence is found in the KPB of significant involvement of the later phases of deformation, recorded in the northern part of the Bohemian Massif: the opening of the Ohře Rift during the late Oligocene-early Miocene, and subsequent deformation phases of the Late Cenozoic. This kinematic hypothesis presented by Uličný et al. (2002) consider for the timing of major events mainly intervals, where stratigraphic or structural record exists. The apatite fission track data reveal low-temperature information about complicated post-sedimentary history of the KPB, especially from periods lacking stratigraphic record.

Five studied samples dated by fission-track technique come from outcrops from alluvial-fluvial Trutnov Formation. Outcrops of the Trutnov Fm. are dominated by brown-red conglomerates, sandstones with minor siltstone and mudstone interbeds and carbonate-cemented intervals. The apatite fission track lengths in all studied samples are very homogeneous and range from 12.1 ± 1.9 to 13.1 ± 1.5 micrometers (1 σ). All horizontal confined track distributions are unimodal with a negative skewness, interpreted as resulting from a slow cooling through the apatite partial annealing zone (PAZ, 60–120 °C). The measured FT apatite average cooling ages range from the Early Cretaceous to Cretaceous / Palaeogene and varies from 60 ± 5 Ma to 114 ± 11 (1 σ), corresponding to an average cooling rate 0,5 to 1,1 °C/Ma from the Early Cretaceous to the present, while average erosion rate of the exposed rocks varies between 24 to 54 m/Ma. These results indicate pre-Cretaceous burial of Permian rocks below 120 °C, which is interpreted, assuming present-day thermal gradient of 25 °C/km, burial deeper than 4 km.

The confined track length distribution together with the fission track age of four samples was taken to model the individual thermal history of sub-basins (Figure 1). Time-temperature modelling by AFTSolve program (Ketcham et al. 2000) reveal two areas with different T-t histories in Trutnov-Náchod sub-basin. Different timing of three main stages and differences in erosional rates are interpreted as earlier major uplift (1st stage) in northern part of the sub-basin (Jurassic – Early Cretaceous) comparing to southern part, where major phase of uplift took place in Late Cretaceous. Last phase of rapid uplift (3rd stage) is similar in both areas (northern and southern), and is dated to c. 25 Ma – present, which corresponds to Miocene deformation phases in the Ohře Rift.