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The Western Carpathians – 200 Ma Record of Continuing Convergence

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The Meso-Cenozoic Western Carpathians (WC) represent a long-living, expanding orogen, which nucleated as a restricted Meliatic accretionary wedge at the Triassic/Jurassic boundary and developed into a broad and complex orogenic system by the Late Tertiary. In the meantime, the orogenic front propagated continuously, though episodically, from the Meliatic suture to both sides of the asymmetric, double-vergent Carpathian orogen. However, the narrower retrowedge (Internal WC) was inactivated soon after the Meliatic collision in the latest Jurassic, whereas the prowedge widened considerably during the Cretaceous (Central WC) and Tertiary (External WC). The WC units preserve very rich material (sedimentary, metamorphic, magmatic) and structural rock records of various tectonic processes, which all indicate a foreland-ward progradation during the orogenic wedge growth. This contribution summarizes record data on these rock and their paleotectonic interpretation, in order to define time–space constraints to any geodynamic models of the Alpine evolution of the WC.

The Mesozoic oceanic rifting was preceded by significant distensional tectonic events during the Permian and Early Triassic, suggested by rift-related red-bed basins and associated magmatism in several WC zones. The site of the future Meliatic oceanic rift was marked by strong Scythian subsidence and shallow marine terrigenous sedimentation. These features indicate that the terminal Variscan event – orogenic collapse and lithospheric attenuation – could have been genetically related to the early Alpine rifting in the southern WC zones, which ultimately led to the Late Anisian opening of the Meliatic Ocean.

The Jurassic was the time of extensive rifting of the northern, European passive margin of Tethys, which finally led to a disintegration of the European shelf crust into numerous elevated and subsiding domains, some of which were presumably floored by newly formed oceanic crust. The Liassic uniform stretching of the epi-Variscan continental lithosphere formed several broad, rapidly subsiding intracontinental basins separated by narrower highs. Subduction of the Meliatic oceanic lithosphere commenced at the same time. These processes were probably related to a change in the movement kinematics of large plates – SE drift of Africa and Adria relative to Europe during opening of Central Atlantic. The Western Carpathian orogenic wedge started to nucleate by accretion of material derived from the subducted Meliatic lithosphere to the upper

plate toe. The superimposed Dogger rifting phase initiated asymmetric extension, which ultimately led to the breakup of the Vahic (South Penninic) Ocean. The Neocomian distension phase marks further foreland-ward migration of rifting and records opening of the Magura Ocean.

The oldest Alpine structural association related to the Middle – Late Jurassic compressional event in the WC is fixed by a blueschist mineral assemblage in the Meliatic Bôrka Nappe, indicating an incipient collision after the closure of the Meliatic Ocean. Subsequently, the collisional retrowedge originated by shortening and obduction of the Szarvaskő back-arc basin crust, which was thrust over the distal Bükkian hinterland.

In the Early Cretaceous, orogenic shortening returned to the prowedge and its immense growth and northward progradation took place in several phases. The wedge advanced by episodic frontal and basal accretion of lower plate units attenuated by preceding rifting events. Only the upper crustal slivers were amalgamated with the orogenic wedge in the form of thick-skinned and thin-skinned thrust sheets, while the lower crust and the lithospheric mantle were consumed by subcrustal subduction. Collapse events within the wedge are marked by the emplacement of extensive Fatric and Hronic cover nappe systems over the Tatric substratum.

Starting from the Senonian, the Western Carpathian orogenic wedge prograded by an indentation-subduction mode, related to the conversion in drift kinematics of large plates in the western Tethyan realm, particularly the commencement of convergence between the Africa–Adria and Europe. Advancement of the Adriatic indenter brought about shortening and modification of the central, thermally softened parts of the original collisional wedge and triggered transpressional exhumation of the Veporic metamorphic dome. In higher structural levels, this exhumation was achieved by an orogen-parallel, extensional unroofing. At the same time, shortening relocated to the northern Tatric edge, below which the Vahic oceanic crust was consumed. In the latest Cretaceous – earliest Paleogene, units of the Oravic ribbon continent, presently constituting a substantial part of the Pieniny Klippen Belt, were accreted at the wedge toe. Then, the orogenic front reached the Magura Ocean, which was consumed during the Paleogene and Early Miocene.

During the Early Tertiary, the collapse (foundation of the Central Carpathian Paleogene Basin) and shortening pe-

riods repeated within the wedge. Seemingly, the advancing orogenic wedge prograded by alternation of extensional and compressional events, just like a caterpillar. However, the WC orogenic wedge lost the character of a mechanical continuum by the Middle Miocene and was disintegrated by whole-lithosphere stretching triggered by a change from the advancing to retreating oceanic subduction in its front. Therefore, the Late

Tertiary rifting and foundation of the Pannonian Basin system is interpreted as a hinterland, i.e., back-arc extensional event.

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Seismic Velocity Structure of Mantle Lithosphere Beneath the Bohemian Massif

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Deep structure of the lithosphere of the Bohemian Massif (BM) is derived from tomographic images of teleseismic body-wave velocities and a joint inversion of anisotropic data (Plomerová et al., 1996) – P-residual spheres (Fig.1) and fast shear-wave polarizations and split times δt (Fig. 2). Data for this study were recorded by a portable array of digital three-component stations operating in the BM for 8 months within the co-operation between the geophysical institutions in Prague and Strasbourg (MOSAIC Project, 1998–2000; Plomerová et al., 2000). We observe that velocity anomalies within the mantle lithosphere are strongly affected by dipping anisotropic structures. Moreover,

distinct lateral variations of the shear-wave split time δt and the fast shear-wave azimuths were also observed. The shear-wave splitting, analogous to the birefringence in optics, occurs in case that the shear wave propagates within anisotropic medium, and is considered the most reliable diagnostics of anisotropy. The splitting means that a shear wave splits into fast and slow waves, the latter one being recorded with a time delay δt . Mapping lateral changes in the anisotropic parameters extracted from body waves allows us to determine domains of mantle lithosphere of similar velocity structures separated by sutures. At boundaries of domains with different anisotropic structures, we observe either an abrupt change in the P-residual patterns and/or a significant decrease in split time of sub-vertically propagating shear-waves sampling both units. Steep and narrow sutures sharply delimit domain boundaries, while inclined contacts, such as the Saxothuringian (ST) and Moldanubian (MD) contact in the westernmost BM, result in a broader transitional region above the suture (Babuška and Plomerová,

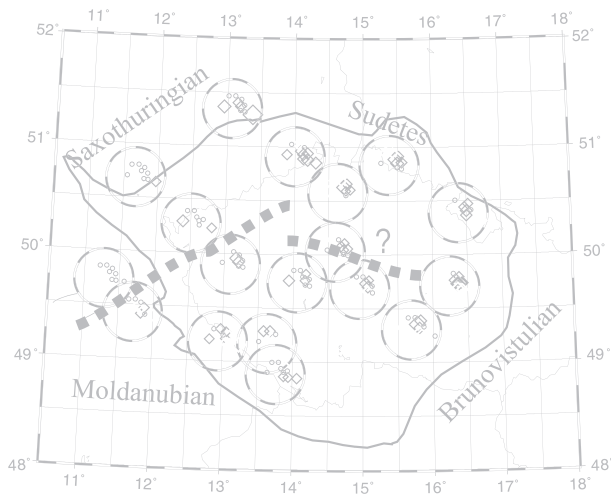


Fig. 1. P residual spheres showing directional terms of the relative P residuals constructed from 35 teleseismic events recorded during the MOSAIC experiment. Black diamonds show negative residuals (high-velocity directions), light grey diamonds represent positive residuals (low-velocity directions) and dots denote residuals close to zero. The outer circle of the spheres corresponds to an angle of propagation 60° below the M-discontinuity. Size of the signs is related to magnitude of the residuals.

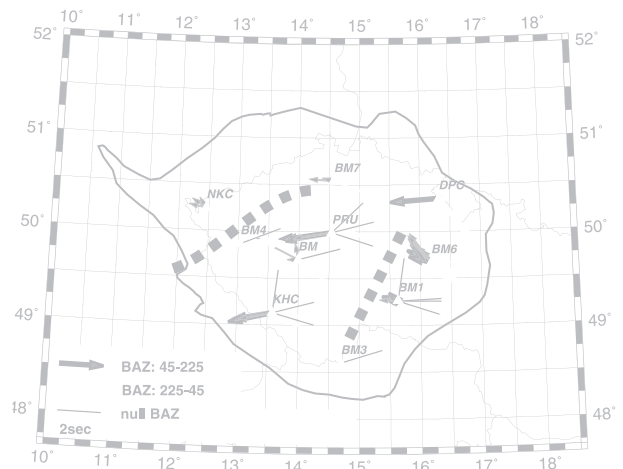


Fig. 2. Fast shear-wave polarization azimuths and split times δt of the SKS and SKKS phases. Arrows point in dip azimuths of the fast S polarisation vectors evaluated in 3D. Length of the arrows is proportional to the δt .