# A Kinematic Model of Structural Development of the Moldanubian Root during the Variscan Orogeny Based on Correlation of Crustal and Mantle Lithosphere Fabrics

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We correlate the geometry of major Variscan crustal units and their orogenic fabric of Devonian to Carboniferous age with seismologically determined fabric of the mantle lithosphere in the area of the Moldanubian root domain. The NE-SW trending boundaries between the Saxothuringian and Teplá-Barrandian, and between the Teplá-Barrandian and Moldanubian crustal domains to the west, as well as between the Moldanubian and Brunovistulian platform to the east, are truncated by the system of dextral lithospheric NW-SE faults (Elbe and Sudetic fault systems). The oldest (380–370 Ma) deformational fabrics occur in the Teplá-Barrandian complex. The fabrics trend NE-SW and dip to the SE. The development of these structures is associated with earliest stages of the Saxothuringian eastward subduction and shortening of the hanging-wall plate. The upper plate progressively evolved into a lithospheric scale arc system which culminated at around 350–345 Ma. It is manifested by intrusion of the Central Bohemian Plutonic Complex. The intrusion fabrics of this intrusive complex are steeply dipping to the east and parallel to the western boundary of the Teplá-Barrandian domain. The eastern tectonic border of the crustal root of the Moldanubian domain is younger (345–330 Ma) and is represented by the generally W-NW dipping thrust-related fabrics. These fabrics are developed both in the high-grade root rocks and in the highly reworked eastern border of the Brunovistulian basement. The crustal root itself, shows nearly vertical NE-SW trending fabrics developed mostly in granulites and associated mantle slivers. The age of these fabrics is estimated at 370–330 Ma using existing Nd-Sm dating of garnet pyroxenites, eclogites and garnet peridotites (Brueckner and Medaris, 1998). The steep fabrics within HP granulites are estimated to be of Early Carboniferous age (355–340 Ma) (Svojtka et al., 2002). The whole root was later affected by widespread flat fabrics, which are generally attributed to the collapse of the thermally weakened and gravitationally unstable partially molten rocks. The fabrics are associated with NE-SW directed movements parallel to the eastern margin of the crustal root and to the major NW-SE dextral faulting (Elbe and Sudetic). The well-constrained age of the fabrics varies between 330–325 Ma by dating of syntectonic intrusions.

Seismological studies of anisotropic propagation of body waves through the Earth resulted in models of large-scale fabric of the continental mantle lithosphere and its thickness (Babuška and Plomerová, 1992; Plomerová et al., 2000). The isothickness contours follow the NE-SW trend of the Variscan fold belt in central Europe. The distinct lithosphere thickening southward of the Saxothuringian-Moldanubian contact mark the lithospheric root beneath the Moldanubian extending down to about 150 km. Several domains of the mantle lithosphere, with differently oriented large-scale anisotropic structures, were retrieved from studying travel-time deviations of the teleseismic longitudinal waves and the shear-wave splitting. The boundaries of anisotropic lithospheric domains are related to prominent tectonic features recognized on the surface as sutures, shear zones, transfer fault zones, or grabens, thus indicating that some of them extend deep through the entire lithosphere and separate rigid blocks of the mantle lithosphere retaining their frozen-in fabrics. The so-called Saxothuringian and Moldanubian anisotropic fabrics, with divergently dipping high velocities, dominate in the central European mantle lithosphere. The first one is observed in the mantle NW of the surface trace of the Saxothuringian-Moldanubian contact, while the second one has been found in large area southward of this contact and continues to the south beneath the Alps. The large-scale fabric of the root of the Moldanubian lithosphere, resulting from a joint inversion of anisotropic parameters evaluated from body-wave propagation, is modelled by the (a,c) high-velocity foliation of a peridotite aggregate striking approximately E-W and dipping to the south at angles between 30° and 60°.

The large-scale fabric of the Moldanubian mantle lithosphere and of the earliest fabrics of the Moldanubian crustal root and the Teplá-Barrandian complex show that the subcrustal lithospheric fabric forms an angle of about 40° with the hanging-wall crustal structures. A similar angle exists between the mantle fabrics and the Elbe fault system. The question arises, whether the early crustal and mantle lithospheric fabrics have been originally striking in the same direction. In other words, whether during the early stages of the Saxothuringian lithosphere subduction and building of orogenic crustal root, both the mantle and crust were mechanically active and coupled. The problem depends critically on the age of the fabric of the Moldanubian mantle lithosphere root. If the Devonian to Carboniferous age is accepted, then the mantle fabric may be due to the Saxothuringian, subduction which could produce coherent fabrics both in the crustal and mantle lithosphere of the upper plate. Once the coherent-subduction related fabrics are produced on the entire lithospheric scale, the thermal and rheological state of a thickened and thermally unstable lithosphere further evolved. Thermal relaxation of the root system of the whole and thick lithosphere inevitably leads to a drastic weakening of the thickened crustal root. Based on a simple thermorheological modelling, we propose a tectonic scenario suggesting that during the Carboniferous the whole lithosphere root was vertically rheologically stratified with the strong uppermost mantle, and extremely weak and about 40 km thick lower crust and a brittle 15–10 km thick orogenic lid of the upper crust. Simple geometrical analysis shows that the upper crustal lid (the Teplá-Barrandian block) may have rotated anti-clockwise in a domino-like fashion, due to dextral movements along the Elbe fault during the Late Carboniferous. The development of the flat fabrics and dextral kinematics in root rocks in the vicinity of the Elbe fault strongly support this hypothesis. In such a way, the upper part of the lower crust could be considered a detachment zone, which accommodates both vertical and horizontal shears associated with rotation of the hanging-wall crustal block. It is possible that the mantle lithosphere also rotated, but in the clockwise direction and as a rigid block without strong internal strain. The global dextral rotation accommodated by the large-scale wrenching in upper crustal levels is a feasible model supported by paleomagnetic data (Edel et al., 2002). Hence, during the domino-like rotation, the upper crust of the root of the Teplá-Barrandian

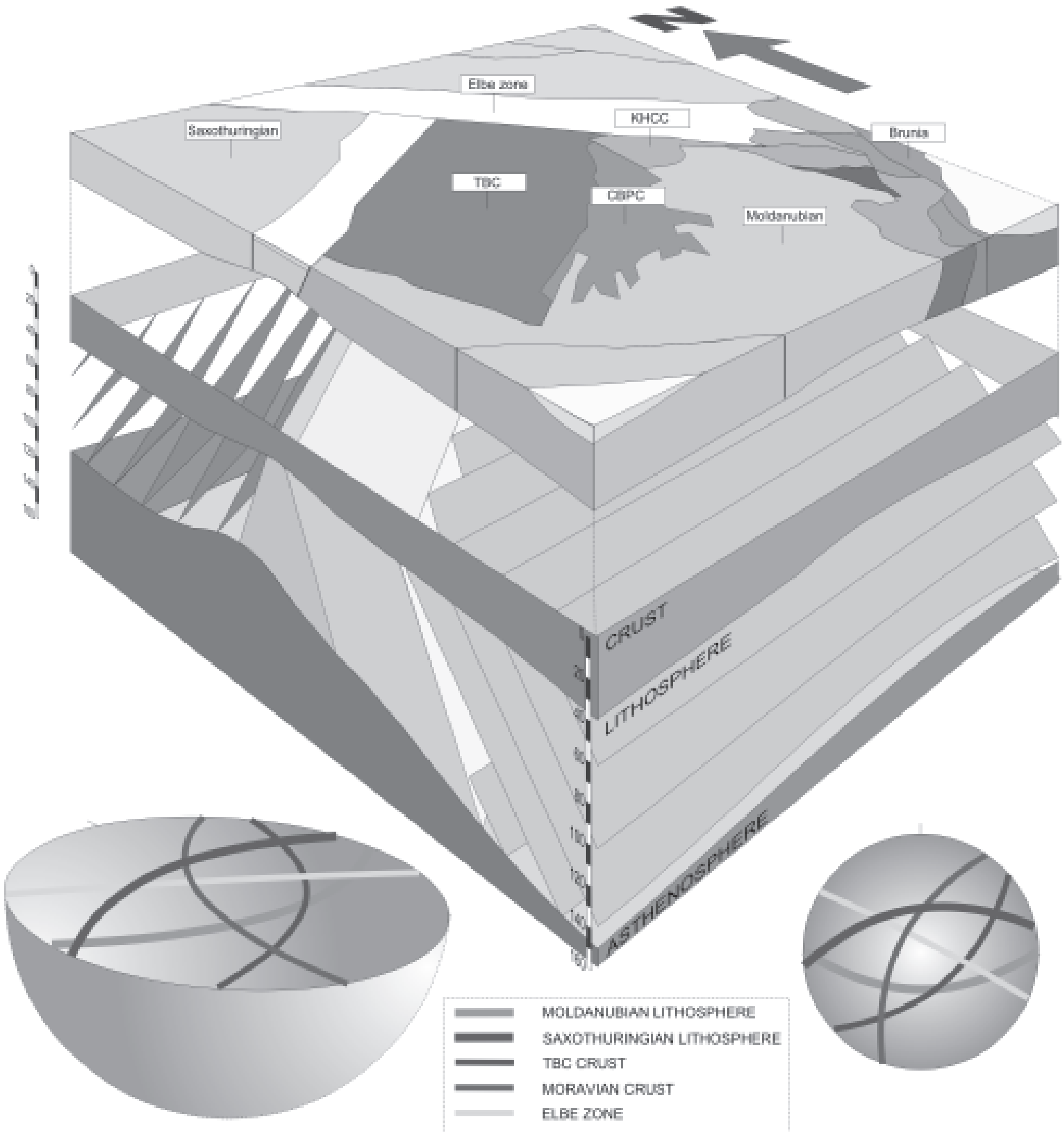


**Fig. 1.** Geometrical relationhip between subroot matle fabric and crustal scale structures of the Bohemian Massif

domain with frozen Devonian fabrics was decoupled from stabilised southward dipping fabrics of the mantle lithosphere along a flat rheologically weak lower crustal horizon. Thus, the observed discrepancy between orientation of the upper crustal boundaries and the deep crustal orogenic fabrics on one side, and the large-scale fabric of the mantle lithosphere root on the other side, may be explained by the proposed kinematic model.

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# Contacts Between High-P Eclogites and Gneisses in the Lądek-Śnieżnik Metamorphic Unit, the West Sudetes

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In the Lądek-Śnieżnik Metamorphic Unit (LSMU), amidst mostly orthogneises and metasediments, there are Carboniferous (U)HP rocks forming small dispersed eclogite bodies and a vast granulite massif. A mechanism for their exhumation from a depth of c. 100 km is poorly understood. It is unknown if and how much of the surrounding rocks have also undergone similar P-T paths. Having identified a Grt(Gros30-50)-Zo-Ti(Rt)-Qtz assemblage in quartz-plagioclase-mica rock immediately adjacent to eclogites, Bröcker and Klemd (1996) suggested that at least part of the LSMU gneisses also underwent the (U)HP metamorphism but the critical mineral assemblages have been obliterated during exhumation. Similar suggestions were made by Smulikowski (1979), Borkowska et al. (1990), Dumicz (1991, 1993) and Steltenpohl et al. (1993). Tectonic emplacement of eclogites inside the adjacent gneisses is also assumed but the interpretations of their exhumation differ in important details (Don, 1989; Żelaźniewicz and Bakun-Czubarow, 2002).

In hope for the elucidating the above problems, the present author has started detailed studies at the contact zones between eclogites and gneisses in the LSMU. Three occurrences have been examined: one in the Międzygórze gneiss unit, and two in the Gierałtów gneiss unit (Strachocin and Sowia Kopa near Stronie Śląskie – the last one was mapped earlier as amphibolites of the Stronie fm.).

In both the gneissic units, (U)HP metabasites occur as long, narrow belts inside gneisses, parallel to their foliation (Frąckiewicz and Teisseyre, 1973; Cymerman and Cwojdziński, 1986). The eclogites are usually mantled by amphibolites, often strongly deformed and showing signs of migmatisation. According to the present author, the surrounding gneisses are mylonitised and often migmatised metagranites. In Stronie Śląskie, post-eclogite amphibolitic rocks also occur within mica schists. Eclogites of both units strongly differ in their provenance, peak P-T conditions, textures and mineral composition (Smulikowski, 1967; Bakun-Czubarow, 1998). The eclogites from Międzygórze have MORB protolith and underwent the UHP metamorphism (P>29 kbar, T = 660–780 °C) followed by retrogression under the amphibolite facies conditions, whereas those from the Gierałtów unit (granulite massif) have calc-alkaline basalt provenance and underwent higher temperature metamorphism (P>28 kbar, T = 700–800 °C), but along different P-T paths involving granulite facies episode. In the case of eclogites from Strachocin and Sowia Kopa no evidence for UMPM has been found yet (Bakun--Czubarow, 1998).

In the Międzygórze unit, the inner parts of metabasitic lenses are built of fresh or weakly retrograded UHP eclogites, sometimes having laminated texture, with locally changing proportions within the assemblage of Grt-Omp-Rt±Qtz±Phe±Ky±Hbl±Dol±Zo (Bakun-Czubarow, 2001). The outer parts are built of amphibolites touched by migmatisation. They are composed of Amp-Pl--Bt-Qtz-Ti-Ep-Ap-Zr. Amphiboles occur as pargasite-magnesiohornblende and younger actinolite; plagioclases contain An15-35. P-T conditions for hornblende-plagioclase pairs are