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Permian-Early Cretaceous Opening of the Carpathian Basins

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Many of the continental collisions, which began in the Carboniferous, reached maturity in the Early Permian. A major part of Pangea was assembled, and the new supercontinent, ringed by subduction zones, moved steadily northwards. North-dipping subduction developed along the Paleotethys margin. The oceanic system was established in Southern and Central Europe during the Permian-Triassic time. The narrow branch of Neotethys separated the Apulia-Taurus platform from the African continent. The Vardar-Transilvanian Ocean separated the Tisa (Bihor-Apuseni) block from the Moesian-Eastern European Platform (Săndulescu, 1988) and its embayment presumably existed between Inner Carpathian and European Platform (Golonka, 2000; Golonka et al., 2000). The embayment position and its relation to the other parts of Tethys, Vardar Ocean, Meliata-Halstatt Ocean, Dobrogea rift and Polish-Danish Aulacogen remain quite speculative. According to Rakús et al. (1998) two oceanic units were located south of the Inner Carpathian plate. One was open during the Triassic time, closed during the Late Triassic as a result of the Early Cimmerian collision. Another, represented by sequences at the classic profile of Meliata in Southern Slovakia opened during the Early-Middle Jurassic as a back-arc basin and closed during Late Jurassic time. The position of the Meliata Ocean, time of closing and a role of the Tisa unit in the Mesozoic collisional events is still the subject of lively discussion.

Continued seafloor spreading occurred during the Jurassic time within the Neotethys. The Neotethys Ocean was divided into northern and southern branches. The Ligurian Ocean, as well as the central Atlantic and Penninic Ocean were opening during the Early-Middle Jurassic. The oldest oceanic crust in the Ligurian-Penninic ocean is dated as late Middle Jurassic. The Pieniny data fit with the supposed opening of the Southern Penninic Ocean basin (Golonka et al., 2000). Birkenmajer et al. (1990) postulate the earlier - Triassic opening of the Pieniny Klippen Belt Ocean. The Triassic pelagic limestones are known only from exotic pebbles transported from the enigmatic Exotic Andrusov Ridge.

Stampfli et al. (2001) recently postulates single Penninic Ocean separating Apulia and Eastern Alps blocks from Eurasia. We proposed similar model for the Pieniny Klippen Belt Ocean in the Carpathians. The orientation of the Pieniny Ocean was SW-NE (see discussion in Golonka and Krobicki, 2001). This ocean was divided into the northwestern and southeastern basins by the midoceanic Czorsztyn Ridge. The deepest part of the southeastern basin is documented by deep-water Jurassic-Early Cretaceous deposits (radiolarites, Maiolica pelagic limestones) of Złatna unit (Golonka and Sikora, 1981) later described also as Branisko-Pieniny unit or Vahicum (e.g., Plašienka, 1999). The shallowest ridge sequences are known as the Czorsztyn Succession with typical Tethyan facies (e.g., Fleckenkalk/Fleckenmergel, crinoidal limestones, red nodular ammonitico rosso-type limestones, Scaglia rosa marls). The deepest part of the northwestern basin is represented by deep-water, strongly condensed Jurassic-Early Cretaceous deposits (especially radiolarites and Maiolica facies) of the Magura (or Grajcarek or Hulina) unit (Golonka and Sikora, 1981; Birkenmajer, 1986; Golonka et al., 2000). Ridge sequences as well as transitional slope sequences are also called Oravicum (e.g., Plasienka, 1999).

In the Alpine-Carpathian area the subduction of the Meliata-Halstatt Ocean and the collision of the Pelsonian block with the Inner Carpathian terranes was concluded at the end of Jurassic. Major plate reorganization happened during the Tithonian time. The Central Atlantic began to propagate to the area between Iberia and the New Foundland shelf. The Ligurian-Pieniny Ocean reached its maximum width and stopped spreading. Subduction jumped at this time to the northern margin of the Inner Carpathian terranes and began to consume the Pieniny Klippen Belt Ocean (Birkenmajer, 1986, 1988). The Outer Carpathian rift (Silesian Basin) was accompanied by the extrusion of basic lavas (teschenites) in the Western Carpathian and diabase-melaphyre within the „black flysch“ of the Eastern Carpathians.

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Perpendicular Magnetic Fabrics in Granitic Rocks of the Bratislava and Modra Massifs (Malé Karpaty Mts.) and their Tectonic Origins

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The Malé Karpaty Mts. represent the southwestern geomorphic unit of the Central West Carpathians. Despite their moderate extent, 91 km in length and 15 km in width, their geological structure is rather complex, i.e. their Variscan crystalline complexes are overlain by Alpine sedimentary formations, both showing nappe structures. Among Variscan granitoids, two major bodies are distinguished: the older Bratislava Massif (347 ± 4 Ma, using Rb-Sr isochrone method), consisting of peraluminous muscovite-biotite (± garnet) monzogranites and granodiorites, and the younger Modra Massif (326 ± 22 Ma) built up mainly of metaluminous biotite (± hornblende) granodiorites and tonalities. Both the granitoid massifs occur within metamorphic rocks. Detailed investigation of the anisotropy of magnetic susceptibility (AMS) was made (more than 500 orientated specimens were measured) in order to reveal the magnetic fabric patterns in both the massifs and the structural relationship between the granitic and surrounding metamorphic rocks.

The bulk magnetic susceptibility ranges from about 60 to 200×10^{-6} SI units in the Bratislava massif and from 100 to 250×10^{-6} SI units in the Modra massif indicating that the magnetic fabric is carried to a relatively large extent by paramagnetic minerals (biotite). The degree of AMS is relatively low ($P = 1.03 - 1.12$) and homogeneous within each massif, the magnetic fabric being mostly planar. The orientations of magnetic foliation and magnetic lineation are relatively homogeneous within each massif. In the Bratislava massif, the magnetic foliation poles create a girdle oriented NW-SE and the magnetic lineation creates a cluster oriented NE-SW, like in surrounding metamorphic rocks. In the Modra massif, the magnetic foliation poles create a girdle oriented NE-SW and the magnetic lineation creates a cluster oriented NW-SE, like in surrounding metamorphic rocks of the Pezinok-Pernek Crystalline unit.

The conformity in magnetic fabrics of the granitic and surrounding metamorphic rocks with undoubtedly deformational magnetic fabrics within each massif indicates that the magnetic fabric in the granitic rocks is not intrusive, but rather deformational in origin. The perpendicular orientations of the magnetic fabrics in the Bratislava and Modra massifs are probably a consequence of mutual rotations of both the massifs.