The Magnetic Fabric in the Šumperk Granodiorite and its Tectonic Implications

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The Šumperk granodiorite represents a granitoid intrusion showing features of both magmatic and deformational fabrics. Its magnetic fabric was investigated on semi-oriented cores (with respect to the borehole axis) from two boreholes and on oriented specimens from four surface outcrops.

The bulk magnetic susceptibility of the Šumperk granodiorite is very variable, ranging from the order of 10^{-4} to the order of 10^{-2} (in SI of units). In strongly magnetic specimens, it is dominantly controlled by magnetite, while in weakly magnetic specimens it is also controlled by paramagnetic silicates (biotite). Secondary effects, as chloritization and hematization, have only negligible influence on bulk susceptibility. The above magnetic minerals were identified through the investigation of the temperature variation of bulk susceptibility. The magnetization curves of strongly magnetic specimens correspond very well to those of magnetite, while in weakly magnetic specimens paramagnetic hyperbola can be clearly observed.

The anisotropy degree of the Šumperk granodiorite is relatively and the magnetic fabric is clearly linear both in borehole and in surface outcrops. Such a magnetic fabric is rare in granitic rocks where planar magnetic fabrics are very frequent. In surface specimens, the magnetic lineations, very well concentrated along its mean direction, are oriented WSW-ENE and plunge WSW 10° to 20°. The magnetic foliation poles are concentrated less perfectly, but still relatively well, moderately plunging SE. In borehole specimens, the plunge of magnetic lineation is also gentle (about 15°). The dip of magnetic foliation is variable, ranging from gentle to steep.

In order to better discover the origin of the magnetic fabric in the Šumperk granodiorite, we studied also the magnetic fabric of phyllonite and metagranite surrounding the Šumperk granodiorite and having no doubt deformational fabric. The anisotropy degree in those rocks is also relatively strong, the magnetic fabric varies from moderately linear to moderately planar. The magnetic foliation is parallel to the mesoscopic metamorphic schistosity and magnetic lineations are well grouped, gently plunging SW. The orientations of both magnetic foliation and magnetic lineation in phyllonite and metagranite are very near those in the Šumperk granodiorite. Consequently, the magnetic fabric of the Šumperk granodiorite was controlled by principally the same processes as those controlling the origin of the magnetic fabric in the phyllonite and metagranite, i.e. ductile deformation. The unsolved problem is the rheological state of the Šumperk granodiorite during this process. In principle, the tectonic processes could affect either the solidifying magma or the already solidified magma.

Youngest Tectonic Activity on Faults in the SW Part of the Most Basin

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The problem of the presence and significance of tectonic movements of Quaternary age in N Bohemia has been discussed since the 19th century. While many authors assume extensive tectonic activity in the Quaternary (e.g., Kopecký 1970, 1989; Malkovský 1979), some others refuse larger-scale movements in this period (Prosová 1975, a.o.). This disagreement is caused by the difficult identification of tectonic origin of the numerous deformations in Quaternary sediments. Although some of these ductile and brittle structures were interpreted as resulting from tectonic stress (Kopecký 1972), most of them can be explained as products of gravitational and freeze-and-thaw processes.

The problem of the existence of Quaternary tectonics became increasingly important in relation to choosing convenient sites for nuclear power plants, radioactive waste repositories and gas storages, or in safety assessment of the Temelín nuclear power plant in S Bohemia. This problem is essential for the reconstruction of Neoidic tectonic history of the Bohemian Massif.

Syn-depositional and post-depositional tectogeny of the Most Basin (MB) is a process, which can be subdivided into several separate stages – tectonic phases. Each of them was characterized by regional stress of certain parameters generally uniform across the whole basin, and a specific deformational pattern. The presented results are primarily based on the observations and measurements from years 1991 and 1992 (see reports of Coubal et al. 1991 and Coubal 1992), later refined and supplemented.

The MB was filled and subsequently deformed under prominent tensional stress field. The effects of this stress field were found also in other parts of the Bohemian Massif and designated as phase β (Coubal et al. 1991, Adamovič and Coubal 1999). Movements on marginal faults of the basin did not exceed 80 m in the Oligocene as suggested by e.g. equal thicknesses of the Střezov Formation on both sides of the Střezov Fault. During the deposition of the Most Formation in the Lower Miocene, the basinal area subsided by 140–200 m relative to the Střezov Horst and by 140 m relative to the Měcholupy area. However, the most significant movements along major faults of the MB occurred only after the deposition of the Most Formation, when a flexure was formed in the Ohře Fault Field area with basin subsidence by 300 to 600 m.

Two post-depositional compressional phases γ (WNW–ESE compression) and δ (NNW–SSE to NNE–SSW) were identified in the MB, clearly post-dating the β-extension and possibly coinciding with the minimum in radiometric ages of volcanic rocks in N Bohemia of around 14 Ma. Their effects are difficult to be quantified and their mutual superposition is still questionable as no sediments of this age were preserved. Only reverse and strike-slip movements occurred on marginal faults of the MB, such as the Ohře Fault Field. Faults dipping NW to N were formed north of the MB; reverse movements on these faults probably correspond to the period of most intensive uplift of the Krušné hory Mts.

Cross-cutting relationships in the Ohře Fault Field indicate the existence of another tensional phase younger than β. This phase (ε_1 in Coubal et al. 1991) is characterized by normal movements on faults dipping SE, with the displacement magnitudes usually exceeding 50 m. According to the present knowledge, the age of phases γ, δ and ε_1 can be constrained to the Middle Miocene–Pliocene interval.

The youngest, post-Pliocene tectonic deformations seem to be evidenced by the following phenomena observed in the SW part of the MB: 1. slickensides observed in older types of loess (0.5–0.75 Ma) at several localities, documenting SSW–NNE extension; 2. southeasterly drops in bases (not surfaces) of sand and gravel accumulations of Upper Pliocene age N of Stranné and Přívlaky and near Hrušovany by 3–10 m along a 5.5 km

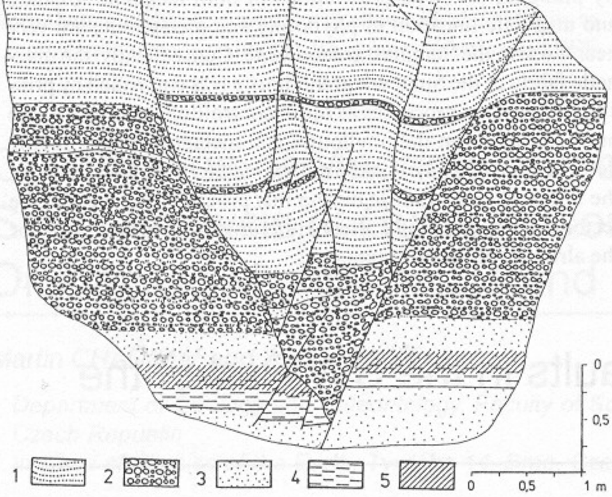

Fig. 1. Graben-like structure in the Upper Pliocene sands and gravels and the underlying Lower Miocene sediments at Vysočany (situation in May 1992). 1-2 = sand and gravel (U. Pliocene); 3-4 = sand and clay (L. Miocene); 5 = oxidic pigmentation.

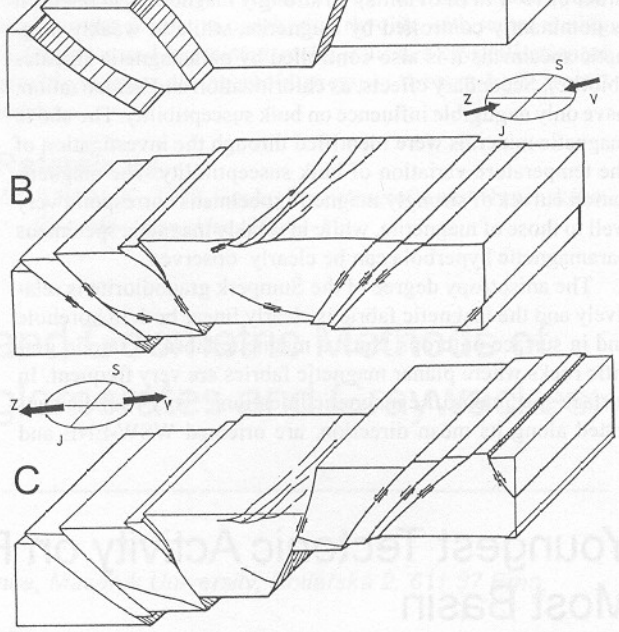

Fig. 2. A block-diagram showing the youngest tectonic deformations of Lower Miocene claystones in the Erdbrand Gorge near Poláky, west is to the left. A = NNW-SSE compression of phase ä (U. Miocene?); B = post-Pliocene ENE-WSW compression; C = post-Pliocene ENE-WSW extension.

long line coinciding with the Libědice Fault. Southeasterly drops in bases of Upper Pliocene sediments by 5 and 10 m can be observed along lines parallel to the Střezov Fault between Droužkovice and Hrušovany; 3. normal faults forming small grabens (Fig. 1) documented in a sand-pit in Upper Pliocene sand and gravel terrace at Vysočany with vertical displacement of 0.3–1.5 m. The faults strike E–W to WNW–ESE, reach to the underlying Lower Miocene sediments but do not deform the overlying younger-type loess. Slickensides measured in loess of older type in the same sand-pit indicate SSW–NNE extension.

The most striking evidence of post-Pliocene deformation was observed on the Hořenice Fault Zone transverse to the Střezov Fault in the Erdbrand Gorge NW of Poláky. The gorge is drained east, to the Ohře River (Nechranice Res.). Clay-dominated sediments of the Most Formation with burnt coal seams are deformed by easterly dipping reverse faults with drag folds and younger, westerly dipping normal faults. Senses of movements on this zone relative to present-day topography exclude their gravitational origin.

The oldest stress field was responsible for left-lateral strike-slip movements on N-S-striking faults (Fig. 2A). Its characteristics, as interpreted from the different generations of superimposed striae, are very close to those of phase δ (NNW–SSE compression). A younger stress field (ENE–WSW compression) was responsible for the formation of reverse faults dipping east (W part of the gorge) or west (E part) and extensive drag folding (Fig. 2B). The youngest recorded stress field relates to normal movements on faults dipping mostly west (Fig. 2C). Its calculated parameters indicate approx. ENE–WSW minimum principal stress.

Some fault zones with striae pertaining to the younger compressional phase and the subsequent tensional phase enclose lenses of fluvial gravels containing pebbles of quartz, basaltic rocks (up to 25 cm large), tuffs, granulites and orthogneisses. These pebbles are derived from the Ohře River terraces of Upper Pliocene to Middle Pleistocene age.

The phenomena documented from the SW part of the MB point to the identification of two post-Pliocene stress fields of tectonic origin: an older ENE–WSW compression and a younger NNE–SSW to ENE–WSW extension, which were responsible for movements on the order of first metres.

References

ADAMOVIČ J. and COUBAL M., 1999. Intrusive geometries and Cenozoic stress history of the northern part of the Bohemian Massif. *Geolines (Praha)*, 9: 5-14.

COUBAL M., 1992. Datování nejmladších tektonických pohybů v severočeském regionu a posouzení jejich vztahu k seizmicitě oblasti. Archive Energoprůzkum, Praha.

COUBAL M., ADAMOVIČ J. and BENDL J., 1991. Kinematická, dynamická, genetická a časová analýza střezovského zlomu. Archive Čes. geol. úst., Praha.

KOPECKÝ A., 1970. Neotektonický vývoj severních a severovýchodních Čech. *Věst. Ústř. Úst. geol.*, 45: 339-346.

KOPECKÝ A., 1972. Drobné vrásové deformace v nezpevněných neogén-kvartérních sedimentech Českého masívu. Sbor. geol. Věd, Geol., 22: 117-151.

KOPECKÝ A., 1989. Neotektonika severočeské hnědouhelné pánve a Krušných hor. *Sbor. geol. Věd, Geol.*, 44: 155-170.

MALKOVSKÝ M., 1979. Tektogeneze platformního pokryvu Českého masívu. Ústř. úst. geol., Praha.

PROSOVÁ M., 1975. Geneze reliktního terciéru. Univ. Karlova, Praha.

What Happened to Quartz from the Izera Gneisses? A Possible Scenario

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Numerous theoretical, experimental and field studies have shown that the quartz c-axis CPO depends primarily on temperature and kinematic framework of the deformation. Temperature governs the active slip systems, manifested as charateristic maxima on the CPO pole figures, while kinematic framework is responsible for their symmetry. Thus, it can be expected that CPOs from rocks deformed in the rotational regime should exhibit asymmetric habit.

This is, however, not the case when the crystalline rocks from the northern part of the Izera-Karkonosze Block (IKB) are considered. Mica-schists and orthogneisses deformed during Variscan sequence of non-coaxial tectonic events yield quartz c-axis CPO with dominantly orthorhombic symmetry. Most of the pole figures (in stereographic projection) display strong maxima III (at circumference of the stereonet), located symmetrically with respect to the foliation and stretching lineation. Sometimes weak joining girdles form Type I or Type II crossed girdles or small circles. Few diagrams display the expected asymmetric girdles and some are unreadable.

The discrepancy between asymmetric rock fabrics and its symmetric quartz c-axis CPO can be explained by a number of reasons: strain partitioning, domainal fabric/texture, multiple deformation mechanisms and overprint by late deformation. In case of the IKB rocks, the following evidence supports the late overprint model:

- lack of relationship between lithology, grain size, intensity of deformation and the type of quartz c-axis CPO;
- occurrence of asymmetrical intensities of the maxima and/or relicts of asymmetric joining girdles in some diagrams;
- structures commonly observed on outcrops such as: folds, boudins, conjugate kink-band sets, tension gashes, reverse and thrust faults, pointing to tectonic event with generally coaxial, with respect to the IKB shear zones, geometry.

The structures listed above were formed during regional N ? S compression, in the lower greenschist facies temperature conditions and below. Strong alteration of rocks, abundance of quartz veins and fluid inclusions indicate high water activity during the deformation, which could have enhanced the hydrolitic weakening of quartz.

Thus, the symmetric quartz c-axes CPO are interpreted as