Orientation of Joints in the Western Bohemia Region, their Role during Post-Variscan Faulting

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The relationship between faults and joints can very considerably. En-echelon failures can originate during movement along fault plane as accompanying structures. On the other hand, pre-existing joints represent discontinuities, which can be subsequently reactivated and faulted. The reactivation of pre-existing failure with convenient orientation in relation to principal stresses is more easy than origin of authigeneic fault.

The study of joint orientation carried out in the Western Bohemia was focused on the investigation of relationship between orientations of joints and faults. Orientations of joints and faults were measured in postkinematic late-Variscan granitoids of the Karlovy Vary Pluton and the Smrčiny Pluton and in crystalline units north of the Cheb Basin (Svatava crystalline area and Vogtland-Saxonian Pleozoic complex). Several major joint systems were regognized in the studied region.

Particurarly in the case of granite bodies, the oldest joints, which were connected with pluton cooling, were formed already a few million years after emplacement of the host pluton (see e.g., Bergbauer and Martel, 1999). These joints must have existed during subsequent tectonic stages and represented weaked zones in the pluton body But the coincidence of fault pole orientation and orientations of poles of joint originated due to cooling of pluton was found only exceptionally in the Kyn•vart part of the Karlovy Vary Pluton and on the eastern margin of the Smrčiny Pluton. On the other hand, some fault poles are close to the poles of joints which belong to other systems. In all studied regions situated both in the Variscan plutons and in the metamorphosed rocks, some fault poles are close to poles of joints which belong to system of NW-SE steep joints. These faults were active under approximately N-S maximum compression and E-W maximum extension which can correspond to the Upper Cretaceous to the Paleogene NNE-SSW compression known from the Bohemian Massif (see Peterek et al., 1997; Coubal, 1990). Thus the system of NW-SE orientated steep joints probably played significant role during post-Variscan faulting in the Western Bohemia region.

Very accurately localised epicentres show that the recently active Nový Kostel-Počátky-Zwota line oriented NNW-SSE is formed by a number of about 1–2 km long en-echelon NNE--SSW faults (Nehybka and Skácelová, 1995). The predominantly NNE-SSW or WNW-ESE orientation of recently active faults in this tectonic zone follows also from the computed focal mechanisms (see Dahm et al. 2000; Skácelova et al., 1999). In the Kyn•vart granite body, the steep joints connected with cooling of pluton are oriented NNE-SSW and WNW-ESE, in the other studied regions the joints of these orientations exist but they are less frequent. But the NNE-SSW and WNW-ESE oriented faults, which were active under NE-SW maximum compression and NW-SE maximum extension (it means opposite orientation of principal stresses in comparison with recent stress), were found in the Nejdek part of the Karlovy Vary Pluton. This fact shows possibility of recent reactivation older (Tertiary) strike-slip faults with opposite sense of shear movement in the epicentral area near Nový Kostel.

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Variscan and Post-Variscan Paleostresses on the Southeastern Margin of the Nízký Jeseník Region (Czech Republic)

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The southeastern margin of the Nízký Jeseník region was significantly affected by both the Variscan and Alpine orogenesis. The Upper Devonian – Lower Carboniferous sediments were deposited during the Variscan Orogeny. The Neogene sediments of the Carpathian Foredeep represent molasse formed during the Alpine Orogeny. Eastwards, the Bohemian Massif with its sedimentary cover is dipping under the West Carpathian nappes.

The paleostress analyses based on the study of fault-slip

data and of the orientation of extensional failures were carried out mostly at sites situated in the Lower Carboniferous (Culm) sediments on the southeastern margin of the Nízký Jeseník region and in the Upper Devonian limestones and Lower Carboniferous sediments in the Block of Maleník. At localite Jerlochovice near Fulnek, the failures in the Lower Badenian psammites were also measured.

The determined results of analyses can be divided into several groups of paleostresses:

1. The first group of solutions has close relation to the Variscan folding. The solutions were determined from analyses of the reversed faults and slips along the bedding planes connected with the forming of the Variscan fold-thrust system in the eastern part of the Nízký Jeseník region. In the case of slips along the bedding planes, the computed orientations represent the principal axes of strain, not the principal regional stresses. The folds were probably formed during simple shear deformation accompanying the thrusting. Providing the shear plane of the simple shear deformation was parallel to thrusts and the shear direction was parallel to the dip of thrusts, the strike of maximum shortening should be parallel to the strike of the regional $ó_1$ axis. Only dip angles of these axes should differ from each from other. The simple shear deformation of volcanic rocks in the Šternberk-Horní Benešov Zone described by Hrouda and Přichystal (1995) corresponds with the discussed simple shear deformation accompanying the thrusting.
   The obtained results well document the late Variscan NW-SE to WNW-ESE compression. The dip of the $ó_1$ axis is unclear in the cases where faults were rotated during the Variscan folding. Solutions determined from the non-rotated faults have the dips of eigenvectors of the acceptable $ó_1$ axis in a range from 10° to 20°.
2. In three cases, the solutions were determined from the originally steep strike-slip faults, which were reoriented during the Variscan folding. Orientations of principal stresses of these three solutions differ from each other.
3. At several sites the failures affected not only the Palaeozoic but also the Neogene sediments were measured. In the quarries Pod Hůrou and Hranice situated in the Block of Maleník the thrusts of the Palaeozoic sediments over the Neogene (the Karpatian and the Lower Badenian) sediments were observed. The thrusts originated already during the Variscan Orogeny and were reactivated during the Neogene NW-SE or WNW-ESE compression.

Same compression affected the Lower Badenian sandstones at site Jerlochovice, where small reversed faults were measured. The age of this compression has to be the Lower Badenian or younger. Resulting principal stress orientations correspond to the Paleogene up to the Lower Badenian NW-SE to WNW-ESE compression on the SE margin of the Nízký Jeseník area considered by Fodor (1991, 1995).

1. At several sites, the orientation of tensional fractures shows the predominant NNE-SSW extension. Similar solution was determined also from one group of normal faults in a quarry near Hranice. This NNE-SSW could be connected with the Neogene NW-SE to WNW-ESE compression.
2. Seven solutions of paleostress analysis show the NE-SW to ENE-WSW orientation of the $ó_3$ axis. In a quarry near Pod Hůrou, the normal faults connected with this discussed extension are cut by thrusts of the Culm sediments over the Neogene sediments. It proves that the paleostress determined from these normal faults is older than the Neogene NW-SE compression.
3. At four sites, the normal faults connected with the WNW-ESE maximum extension were studied. In a quarry near Olšovec, the orientation of one set of the tensional joints agrees with this orientation of the $ó_3$ axis.
4. At two sites, the NE-SW maximum compression and NW-SE maximum extension were found.
5. The NNW-SSE to NNE-SSW orientation of maximum compression and the ENE-WSW to WNW-ESE orientation of maximum extension were found in the case of four solutions. At site near Týn nad Bečvou and at site north of Loučka, this result was developed by analyses of the strike-slip movements along the steep bedding planes. It proves that the discussed paleostress field is younger than the Variscan folding.
6. The stress field with the NW-SE orientation of the $ó_1$ axis and with the NE-SW orientation of the $ó_3$ axis is represented only by one solution determined at site near Týn nad Bečvou. This solution distinctly differs from the other solutions determined on the SE margin of the Nízký Jeseník region.

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