Paleostress Analysis and Special Slip Indicators on Fault Planes in the Surroundings of Malenovice, W of Zlín Town (Rača Unit, Western Carpathians)

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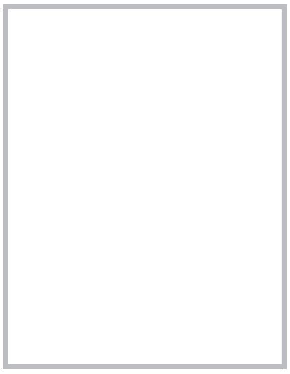

Fig. 1. Slurred pebbles (black) indicate different directions of slip on fault plane.

This abstract presents the first data on paleostress analysis from the Malenovice area (localities: Barabáš, Malenovice – cihelna, Malenovice – hrad, Skalka). The determination of the direction and sense slip on faults is the basic prerequisite for tectonic analysis. In the area under study, observed shear zones do not usually come hand in hand with large plastic deformation and represent a clear discontinuity between two blocks. The best way to determine the slip direction is to observe directly not only the slip surfaces but also additional structures indicating the sense of movement. Searching for fault planes with two and more different direction of striae is very important for the determination of stress fields with different orientation and age.

Base on field data, partial structures indicating the sense of the movement can be divided into several subgroups: tensile cracks, Riedel shears, tectonic slickensides and grooves by furrowing elements. Very interested structures are slurred pebbles. These pebbles are very small (2–10 mm), but theirs colour is black (graphitic admixture). So if they are slurred, they make a black path along a striae only on one side of pebble depends on sense of movement (Fig. 1).

There are observed two different directions of striae on some fault planes and three different directions on one fault plane. It was possible determine relative age one to another. Base on these facts and base on numerical analysis, it was possible to distinguish up to six paleostress stages, three of them take most of faults studied (Fig. 2). Interpretation of these phases is still under discussion.

Fig. 2. Equal area projection for ó$_1$-field of three main paleostress stages: a – phase D1; b – phase D2; c – phase D5.

Metabasites from the Stronie Schists in the Lądek-Śnieżnik Metamorphic Unit, West Sudetes: Geochemistry and P-T-d Path

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Metapelitic schists of the Stronie fm. in the Śnieżnik Metamorphic Unit (SMU), the West Sudetes, are accompanied by minor amounts of marbles, quartzites as well as acid and mafic metavolcanogenic rocks. Metabasites occur as small lensoid or irregular bodies, rarely exceeding 0.5 km^2. They form 3 petrographic types differing in mineral composition and texture: A – laminated biotite amphibolite, B – massive amphibolite and C – striped or banded amphibolites.

Amphibolites A have hornblende-tschermakite laminae with minor quartz and plagioclase and biotite-plagioclase-epidote laminae with poikilitic plagioclase porphyroblasts and some titanite. Plagioclase of the amphibole laminae is reversely zoned (An 17–25), plagioclase of the biotite laminae is normally zoned (An 32core–17rim) whereas plagioclase porphyroblasts are compositionally variable (An 3–28; An 25–31) and contain preferentially oriented, straight or folded biotite and amphibole inclusions. Amphibole are also zoned with hornblende in cores and tschermakite in rims. Zoned epidote has ps ratio dropping toward the rims of grains.

Amphibolites B are composed of uniformly distributed and parallel arranged prisms of hornblende and tschermakite, poikiloblastic plagioclase, subordinate titanite and minor epidote. Amphiboles do not show legible zonality, while plagioclase with random amphibole inclusions is reversely zoned (An 15–20, 27–36).

Amphibolites C contain characteristic strips or bands of light minerals. They often contain relics of primary diopside replaced by an assemblage amphibole-plagioclase±epidote. Hornblende dominates in striped amphibolites, whereas banded variety is overwhelmed by pargasite and edenite. Non- or only poorly poikiloblastic and reversely zoned plagioclase in the striped amphibolites (An 37–41) is less diversified than in the banded ones (An 25–28, 33–42) which also contain normally zoned blasts (An 75–37). Light bands are composed of coarse-blastic plagioclase and epidote separated from dark, fine-grained matrix of amphibole and plagioclase by a felt of coarse amphibole. The banded amphibolite represent a more advanced product of metamorphism and deformation than the striped ones.

Geochemically the studied metabasites form two groups: alkali basalts of WPB type and subalkali tholeiites similar to MORB, with typical ratios of characteristic elements. Metabasalts are characterized by $Nb/Y > 1.5$, $Ti/V > 50$, $Zr/Y > 4$, $Zr/Nb < 5$. In metatholeiites $Nb/Y < 0.7$, $Ti/V < 50$, $Zr/Nb > 20$.

Metabasites of WPB type occur as laminated biotite amhibolites which pass laterally into mica schists or calcareous schists next to marble bodies. At least part of these amphibolites likely originate from tuffitic protolith merged with clastic rocks and represent pyroclastic products of early stages of a continental rift volcanism. Marbles contain problematic fossils of early Cambrian age (Gunia, 1997), which suggests similar age for the studied metatuffs.

MORB-like metatholeiites are more frequent, though their occurrences are widely separated and differ in size. They have fine-grained gabbroic or diabasic protoliths interpreted as hypabysal lava bodies or dykes feeding individual volcanoes during more advanced rifting.

Temperature of metamorphism of the metabasites was estimated using amphibole-plagioclase pair (Holland and Blundy, 1994). The laminated biotite amphibolites were metamorphosed in the temperature range of 625–645 °C, the massive amphibolites at T = 618–643 °C, while the striped amphibolites underwent T_{max} at 669±32 °C. The calculations are valid for the pressure of 8 kbar, which is a common value obtained from geobarometric estimates for acid metavolcanics, marbles and micas schists of the SMU, which usually show the thermal peak around 600 °C. Systematic differences in core and rim compositions of respective pairs of matrix minerals testify to prograde metamorphism of these rocks.

Metamorphic progression, but mostly due to increasing pressure, is also confirmed by the results obtained using the plagioclase-hornblende geothermobarometer of Plyusnina (1982), although the calculated temperatures are lower than in the previous case. The laminated biotite amphibolites were apparently shifted from 530 °C and 6.8 kbar to 545 °C and 7.9 kbar, whereas the massive amphibolites from 530 °C and 6 kbar to 545 °C and 8.9 kbar. The striped amphibolites gave pressures between 1 and 6 kbar, which is probably caused by the lack of equilibrium seen in mineral textures of these rocks.

The prograde metamorphism of the metabasites was concurrent with polyphase shearing which gave rise to foliation spatially consistent with foliation S1 in the surrounding mica schists. Rocks foliated already during regional D1 event were later involved in D2 folds. Details of the deformations differ. All the studied metatholeiites have steep to moderately dipping foliation planes which contain relatively weak subhorizontal stretching lineation Lsh plunging at shallow angles to the NE or SW. It is associated with some oblique fabric and asymmetric porphyroclasts which testify to sinistral strike-slip regime, with intensity of shearing increasing toward the Skrzynka-Złoty Stok mylonitic zone characterized by sinistral wrench kinematics. The mylonitic foliation may also be folded by infrequent “z” or “s”-shape folds with subhorizontal axes, interpreted as the X-folds. They have neoblasts of biotite and localized shearing parallel to the axial planes. The subhorizontal lineation is overprinted locally by another set of mineral stretching lineation Ld-d plunging down-dip, associated with top-to-the-E shearing, which becomes conspicuous in plagioclase-epidote segregations of the striped amphibolites. In the study area, the metabasaltic (WP) rocks together with the surrounding mica schists were involved into F2 folds with the axial planar foliation dipping gently to moderately to the NE or N. More massive WPB bodies also show asymmetric boudins which developed in the sinistral strike-slip regime, followed by dip-slip normal and then reverse kinematics on the reactivated S2 planes.

Accordingly, the P-T estimations for the metabasites are consistent with those for the acid metavolcanics, marbles and mica schists of the varied series, which proves the prograde metamorphism of the Stronie fm. in the SMU, with the peak conditions reached at a depth of c. 25 km, without evidence of ever undergoing any higher pressures. Deformation history of these rocks consists of early subhorizontal shortening followed by local subvertical flattening and common sinistral shearing with top-to-the-N kinematics on the E- to N-dipping planes. Neither plagioclases nor amphiboles of the studied rocks have legible records of retrogression, which corroborates metastable behaviour of the Stronie metabasites during rapid orogenic uplift.

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