Paleostress analysis in the Mokrá quarries (Moravosilezian Zone, Czech Republic): Two methods, one result

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Extensive research on paleostress analysis based on both, fault-slip data and calcite twinning, recently yielded software tools, based on theoretical framework built up during past several decades, to effectively reconstruct the stress-states: TwinCalc for calcite twining (Rez and Melichar, 2010) and MARK for fault-slip data (Kernstocková, 2011).

Calcite *e*-twinning has been used for stress inversion purposes since the 1950s, because it is the main deformation mechanism at low temperatures, low confining pressures and low finite strains (<400 °C, 8 %; e.g. De Bresser and Spiers, 1997). An *e*-plane twins only if the shear stress τ_i along the glide vector **g** exceeds τ_c, which has been proven independent from normal stress, strain rate and temperature and its magnitude is approximately 10 MPa (e.g. De Bresser and Spiers, 1997). The most common stress inversion technique based on calcite twinning is the Lacombe and Laurent method (e.g. Laurent et al., 1981), which is based on applying 500–1 000 randomly generated reduced stress tensors [**T**] on data and selecting the best-fit one using a penalization function f_L. Recently, Rez and Melichar (2010) suggested improvements of this method: a total search instead of a random one and use of a different penalization function (f_R), which provides sharper maxima and hence has a better resolution. Using both functions for cross-checking the results is of course strongly recommended.

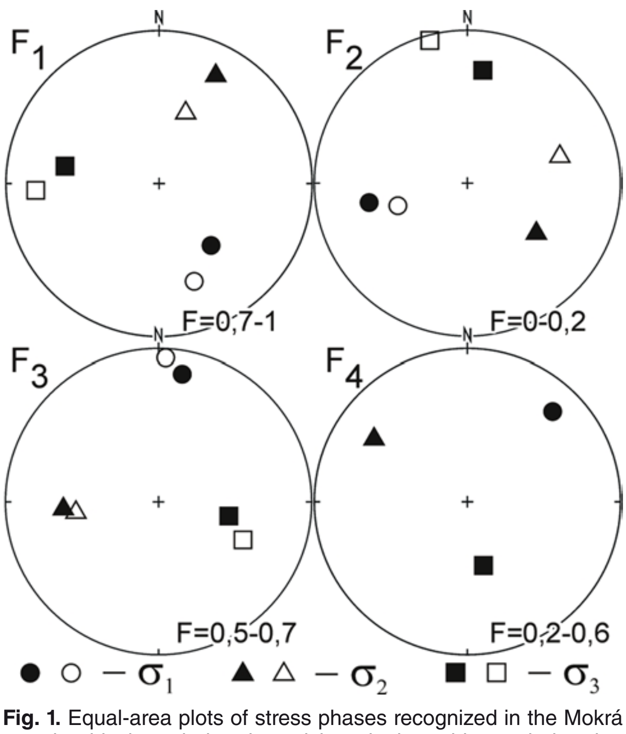

Fig. 1. Equal-area plots of stress phases recognized in the Mokrá quarries: black symbols using calcite twinning, white symbols using fault-slip data.

Stress inversion of fault-slip data underwent dramatic evolution during past several years (e.g. Kernstocková, 2011; Yamaji, 2000). Both most recent methods are based on multiple inversion of fault--slip data, which can be performed directly on heterogeneous data sets, thus eliminating data pre-sorting often introducing subjective view of the analysing geologist (even though the process should be supervised and the results thought about, otherwise one can get numerically correct solutions without any geological sense; e.g. Kernstocková and Melichar, 2010). The data is divided into fourths, each yielding a reduced stress tensor. Spurious solutions arising from fourths of faults of mixed up phases can be easily eliminated by "contouring" the results in 9D σ-space, because the solutions related to homogeneous phases tend to cluster. Each cluster represents a possible stress phase and can be used to separate data into homogeneous sets.

Four samples of calcite veins from the Mokrá quarries yielded several stress tensors (two samples four and two samples three stress tensors). 9D vectors of calculated stress tensors (for detail see Melichar and Kernstocková, 2010) cluster in 9D σ-space and thus define four stress states F_1–F_4 (black symbols in Fig. 1). The relative timing of these phases is uncertain, because despite of the asymmetry of Rose channels (crossings of twin lamellae), suggesting relative timing, no systematic relationship between phases has been found. Three deformation phases found by MARK 2010 using fault-slip data (white symbols in Fig. 1) nicely correspond to the ones found by TwinCalc. Direct evidence of relative timing was unfortunately not found, however, relationships of corresponding faults in the map scale suggest, that the F_2 phase is younger than F_3.

Despite this lack of time-relation data, excellent correlation of stress states estimated using two different techniques, based on fault-slip data and calcite twinning, validates the results and once again confirms calcite twinning as a useful stress inversion tool.

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