Pliocene to Quaternary stress field change in the western part of the Central Western Carpathians (Slovakia)

Rastislav VOJTKO[1], Jozef HÓK[1], Michal KOVÁČ[1], Ľubomír SLIVA[1], Peter JONIAK[1] and Martin ŠUJAN[2]

[1]*Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University, Mlynská dolina, pav. G, 842 15 Bratislava, Slovakia*
[2]*EQUIS LTD., Račianska 57, 831 02 Bratislava, Slovakia*

Knowledge of the current tectonic regime plays an essential role in natural hazard assessment, especially in the risk–assessment of fault activity. Structural analysis of brittle deformations (using inversion techniques) was used to determine the stress field state occurring within Pliocene and Quaternary sediments in the western part of the Central Western Carpathians. The deformation pattern of the reduced stress tensor showed that all structural measurements could be separated into two groups. The older, Upper Pliocene fault population was activated under a NNW–SSE oriented extension. The younger, Quaternary fault population indicated an origin in a NE–SW extensional tectonic regime and it distinctly showed a change the orientation of the S_3 of about 70°. The change in tectonic activity, as well as the stress field orientation, is dated to the Pliocene–Pleistocene boundary. The Quaternary stress field develops during the post–collisional stage of the orogen. Our study proved that the Western Carpathian internal units document a NE–SW to NNE–SSW extension in the broader surroundings of the northern Danube Basin area.

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Strain-analysis and balanced cross-sections of the middle part of Tallas Alatau Ridge (Middle Asia, Kyrgyzstan)

Vyacheslav N. VOYTENKO, Andrey K. KHUDOLEY and Fedor L. YAKOVLEV

Saint-Peterburg State University, Institute of Physics of Earth RAS, Russia

The Tallas Alatau Ridge is located in the Middle Asia, Kyrgyzstan, forming the westernmost part of the Northern Tien-Shan. The main task of the paper is to discuss results of strain analysis and restoration of pre-folding structure of the study area following technologies presented by Ramsay and Huber (1983) with modifications suggested by Yakovlev (2007).

Structurally the Tallas Alatau is related to the outer part of Caledonian fold and thrust belt of the Northern Tien-Shan. Complicated structure and absence of crystalline basement exposures makes correlations of sedimentary units and their thickness estimation ambiguous. Two tectonic zones with different structural style, stratigraphy and metamorphism were identified: the Uzunahmat zone with greenschists, and Karagoin zone with terrigenous flysch-like and carbonate succession. The Usunakhmat zone is separated from the Central Tien-Shan structures by the Tallas-Ferganian Fault (TFF) whereas its north-east contact with the Karagoin zone is represented by the Central-Tallas Thrust (CTT) being well defined only in central and east parts of the study area.

Structural style of the Uzunahmat zone is defined by folds and associated thrusts, as well as widespread cleavage with intense pressure solution. Long axes of clasts in conglomerates and coarse-grained sandstones form lineation, which is parallel to fold axes and thrusts' strike (Khudoley, 1993).

Strain-analysis was applied to greenschists of Uzunahmat zone only. We studied 118 oriented samples which were sampled along three cross-sections through the whole Uzunahmat zone (5-7 km in width) from CTT to TFF. Rf/φ', MRL and ENFry techniques for 2D strain-analysis of planes, oriented normal and parallel to mineral lineation were applied using software developed by D. Chew (2003), K. Mulchrone (2003) and INSTRAIN by E. Erslev (1990). The number of analyzed objects in each plane varied from 150 to 250. Strain ratios and axes orientations of local strain ellipsoids were calculated with software developed by M. Brandon.

The main results of the study are the following. Despite of variations in strain ratios, orientation of the elongation axis (X) in local strain ellipsoid is always parallel to axes of regional-scale folds and thrusts strike. Variations in Lode coefficient v and magnitudes of natural deviatoric strain (Ed) shows that in north-east direction (from TFF to CTT) Ed decreases and the strain ellipsoid shape gradually changes from prolate to oblate shape.

Within the Uzunahmat zone we estimated shortening of a few large folds using strain-involved cross-section balancing method by Ramsay and Hubert (1983) and method by Yakovlev (2007). According to plane-strain estimations, close to CTT shortening of beds in domains bounded by thrusts varies from 51.9 to 57.2 %. Close to TFF, shortening reaches 37.5-41.8 %. Involving estimation of non-plane component (F-factor by Ramsay and Hubert, 1983) increased amount of shortening, and close the CTT it is estimated as 64.2-66.3 %, whereas close to TFF it is estimated as 55-56.2 %. The difference between these estimations increases in accordance with Ed variations, but increasing of total shortening correlates with decreasing of Ed.

The amount of shortening calculated by methods of Ramsay and Hubert (1983) and Yakovlev (2007) has been compared. For upright folds shortening estimated by both methods is similar, whereas for inclined folds estimations based on F-factor are approximately 10 % less than those based on Yakovlev's approach as the latter involves regional-scale rotation of domains.

Restoration of pre-folding structure of middle part of the Tallas Alatau was done for three regional-scale cross-sections using software developed by Yakovlev (2007). The initial length of beds of all three cross-sections has been estimated to 92 km. Although total shortening (65-75 %) was similar throughout the study area, mechanism of regional-scale deformation was different and in its western part (deep units are exposed) the shortening is related to intense folding, whereas in its eastern parts (shallow units are exposed) significant amount of shortening is related to displacement along thrusts. This implies that, despite of variations in tectonic styles, the main structural domains were formed in the same stress filed during the same deformational stages.

References

Chew, D. M., 2003: An Excel spreadsheet for finite strain analysis using the R_f/□' technique. *Computers & Geosciences*, v. 29, 795-799.

Erslev, E. A. & Ge H., 1990: Least-squares center-to-center and mean object ellipse fabric analysis. *Journal of Structural Geology*, v.12, 1047-1059.

Khudoley, A. K., 1993: Structural and strain analyses of the middle part of the Tallasian Alatau ridge (Middle Asia, Kyrgyzstan). *Journal of Structural Geology*, v.15, 693-706.

Mulchrone, K. F., O'Sullivan, F. & Meere, P. A., 2003: Finite strain estimation using the mean radial length of elliptical objects with bootstrap confidence intervals. *Journal of Structural Geology*, v.25, 529-539.

Ramsay, J. G. & Huber, M. I., 1983: The Techniques of Modern Structural Geology, v.1: Strain Analysis. London, Academic Press, 1-307.

Yakovlev, F. L., 2007: Common principles of construction of 3D structural model for sedimentary cover of the hinterland part of a thrust-folded belt and the f its first application to the North-West Caucasus. *Geophysical Research Abstracts*, v. 9, 09790.

Measurements of shortening values of similar type separate folds: Methods and results

Fedor L. YAKOVLEV

Institute of physics of the Earth, Moscow, Russia; yak@ifz.ru

The geometry of similar folds contains the important information about the types and values of strain of collision zones. Correct models of folds formation are the basement of the quantitative study methods. Finally the estimation of the folds strain allows us to reconstruct the common structure of hinterland on the depth 20-40 km. Two types of folds (single viscous layer folds and multi-layer folds), were studied in Chiaur tectonic zone of Greater Caucasus.

The mechanical final element model of single viscous layer folds (Hudleston, 1973) includes the exact calculated geometry of a single layer fold (SVLF). Parameters of these folds geometry are the angle between flanks (**α**), thickness of the layer on the flank (**t**) and on the hinge