New Approach to Interpretation of Superposed Cleavage Patterns in Weak Rocks: Result of Independent Movements of Rigid Basement Promontories on an Example of the Gemer Unit

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We examine the role of shapes and spatial distribution of rigid basement blocks on the progressive development of superposed cleavage patterns within surrounding weak metasedimentary rocks. This complex evolution is first defined by standard structural field mapping and verified using finite element modeling of deformation of thin viscous sheet surrounded by rigid indenters.

Cretaceous tectonic evolution of the Gemer unit is marked by three major distinct tectonic events: 1) Formation of the Gemer Cleavage Fan (GCF) structure affecting central part of the Gemer unit, 2) transpressional shearing affecting the western Vepor promontory and development of the Trans-Gemer Shear Zone (TGSZ), 3) extrusion of the Gemer complex over the eastern Vepor promontory along the Eastern Gemer Thrust (EGT). Each of these above-mentioned events resulted in the recent complex shape of the whole structural succession.

The GCF represents the most spectacular structure overprinting pre-Mesozoic metamorphic fabric of the Gemer unit. This cleavage forms asymmetrical positive fan structure developed across the entire length of the Gemer unit. The intensity and metamorphic grade of cleavage are highest in ~5 km wide E-W trending axial zone of fan structure. Here, the lower greenschist facies steep slaty cleavage contains only rare relics of pre-Mesozoic fabric in form of rootless folds. The main cleavage of the GCF is in the axial zone affected by kink bands with kink planes perpendicular or oblique with respect to strongly developed vertical anisotropy. These structures are interpreted as a result of vertical collapse of steep cleavage associated with mechanical evolution of GCF. Above described features of GCF are developed prominently along the central part of the Gemer unit. Lateral extension of GCF towards the western and eastern Vepor promontories is marked by change in trend of cleavage, so that it becomes parallel to their boundaries. In addition, positive fan structure disappears and the cleavage is dominantly vertical and very intense. We suggest that the GCF resulted from indentation produced by northward movement of sub-Gemer basement along deeply rooted thrust.

Along the western Vepor promontory in the strongly attenuated Gemer unit, relics of E-W trending GCF fabric and new NE-SW trending cleavage form map-scale sigmoidal shape surrounded by highly sheared Upper Paleozoic rocks. Locally, early-developed foliation is refolded by synschistose noncylindrical folds with steeply to sub horizontally plunging hinges which become sub parallel with horizontal stretching lineation. These features are consistent with progressive folding in transpressional shear zones. Towards the NE, this 5 km wide zone of steep cleavage continues into central part of the Gemer unit. This NE-SW trending zone of shear deformation (TGSZ) overprinted all previously developed metamorphic fabrics and exhibits ~20 km sinistral offset of lithological stripes and axial zone of GCF. The displacement and intensity of deformation gradually disappears towards the NE edge of the Gemer unit.

The southern part of the Gemer unit is displaced along the sinistral TGSZ towards the NE, and consequently is thrust over eastern Vepor promontory along large-scale compressive shear zone – Eastern Gemer Thrust (EGT). This zone is marked by imbrications of basement and cover (both Paleozoic and Mesozoic), intense lower greenschist mylonitization of all lithologies across a width of several kilometers. Important feature is the incorporation of the Gemer Permo-Triassic cover as well as Triassic – Jurassic Vepor cover into imbricated thrust system in form of large-scale isoclinal synclines. The foreland dipping duplexes and mylonitic foliation of the EGT system are dipping to the SW, bear intense stretching lineation plunging to the SW and show top to the NE sense of shearing.

Based on the above – described structural features we have developed a numerical model (Ježek et. al, poster session) which allows us to verify a consistency of the proposed tectonic model. Numerous aspects and consequences will be briefly discussed.

Depositional Processes in a Low-Sinuosity Fluvial System: Facies and Depositional Geometries of the Permian Havlovice Member, Krkonoše Piedmont Basin

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The Krkonoše Piedmont Basin formed in the northern part of the Bohemian Massif as a post-orogenic basin of inferred extensional/transtensional regime, records a long history of continental sedimentation between the Late Carboniferous and Early

Triassic. Reconstructing the evolution of the basin fill involves the analysis of facies and architectures of individual alluvial, fluvial, lacustrine, and eolian units. The aim of this study is to reconstruct the depositional system of the Havlovice Member and to decipher the main factors controlling its fluvial style.

The Havlovice Member of the Trutnov Formation is the relatively best-exposed fluvial system in the Trutnov-Náchod sub-basin, a structure formed in the eastern part of the Krkonoše Piedmont Basin during the Permian (Saxonian) – Triassic period. Outcrop sections of the Havlovice Member are dominated by brown-red sandstones with minor siltstone and mudstone interbeds and carbonate-cemented intervals. The sandstones are moderately to poorly sorted, very coarse- to medium-grained litharenites. Sedimentary facies distinguished within the measured sections were grouped and interpreted as channel-fill sandstones, crevasse splay deposits, floodplain fines and calcretes/dolocretes developed in the sandy facies. The strata are interpreted to have been deposited by a low-sinuosity river system, based on the overall high sandstone/mudstone ratio, the coarse grain size of many sandstone units, a lack of observed lateral accretion, evidence of unstable banks, sheet-like nature of most sandstone bodies, and the low dispersal of paleocurrent vectors.

The sheet-like sandstone bodies represent mostly multistorey channel fills. The channel margins are typically poorly defined, which is a consequence of easily erodible banks and significant lateral migration of channels. One observed exception is a narrow (c. 16 m) channel, incised 2.5m deep into a carbonate-cemented channel-belt sandstone. In this case, the calcrete cementation was important in preventing lateral erosion and focusing the erosion during a flood event into a narrow channel.

Metre-scale fining up successions forming the channel "storeys" are characterized by very coarse sandstones with abundance of rip-up floodplain clasts, which are overlain by trough to low-angle cross bedded, medium grained sandstones. Several of these successions can be amalgamated, with topmost sandstone usually overlain by floodplain fines and/or crevasse splay deposits. Such successions are interpreted in terms of decreasing energy of flow after high-energy erosional events. High variation in discharge and preservation of highly unstable rock fragments, as well as abundance of calcretes/dolocretes suggest seasonal to ephemeral flow and arid/semiarid climatic conditions.

The comparison of lateral distribution of sedimentary facies and geometries reveal two distinct areas in the sub-basin. The Trutnov area, situated near the northern basin margin, is characteristic of generally thinner stratal units, higher proportion of coarse-grained material, abundant calcretes and pronounced erosional features. Most of the sandstones in the Trutnov area are moderately cemented by calcite and dolomite. On the other hand, the deposits of the Úpice area, situated in the east-central part of the basin, show thicker stratal units, paucity of coarse--grained material, low proportion of calcretes/dolocretes, low carbonate cementation of the most of the sandstones, and a larger overall thickness of sandstones (up to 90 m) than in the Trutnov area (ca. 40 meters). Although the coverage by borehole data is not satisfactory, we infer from the above features that the central part of the basin was characterized by a higher rate of creation of accomodation (interpreted here as higher subsidence rate).

Tectonic Structures in the Tunnel Višňové in the Lúčanská Malá Fatra Mts., Slovakia

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The geology of Lúčanská Malá Fatra mountain is very complex, with Variscian pre-Upper Carboniferous crystalline core, Alpine Mesozoic mantle and overthrust units. Pre-Quaternary bedrock is covered by Quaternary, except for rock cliffs.

The central ridge is composed of crystalline rocks. Parallel ridges as well as the southern part of the central ridge consist of Mesozoic sedimentary strata. Foliation in crystalline rocks and bedding planes in sedimentary rocks incline generally to the northwest, with local anomalies. Mesozoic suits are built up by three tectonic units – the sedimentary mantle in transgressive position on underlying crystalline rocks, and two overthrust units – the lower Križňan and upper Choč nappes. Clastic and carbonate sediments alternate in all three units. They are intensively tectonically deformed. Mesozoic sediments are in tectonic contact with Cenozoic fill of the basins. The tectonic contact between the Mesozoic suits of Lúčanská Malá Fatra Mt. and Paleogene flysch of the Žilinská kotlina basin was detected by borehole V-9 (GEOHYCO 1998).

The 1.47 km long highway tunnel will cross the northern part of the Lúčanská Malá Fatra Mt. The western tunnel mouth is situated on the eastern margin of the Žilinská kotlina Basin, in flysch rocks. The eastern tunnel mouth is near to norhwestern edge of the Turčianske kotlina basin in granitic rock. Most of the tunnel will be driven through crystalline rocks, with about 2 km of the western section to be driven through Mesozoic sediments and the mouth itself, in flysch rocks and Quaternary colluvial deposits.

Data gained from the pilot tunnel showed a complex geologic structure as predicted.. Granits, tonalite, migmatite, gneiss, with quartz veins, and lamprophyre dykes up to 1 m thick, occur in the eastern part of the pilot tunnel. Landslides, indicated by field research and geoelectric resistivity methods at the western tunnel mouth, were proved by the pilot tunnel, driven from the western end. Mesozoic suites (Jurassic and Triassic) consist of limestone and dolomite, with marlstone, claystone and evaporite.

The pilot tunnel also showed the inhomogeneity of tectonic deformation of rocks, from slightly deformed rock by jointing, to greatly deformed zones disintegrated into gravel and fine soil. The thickest zone, up to 400 m, of disintegrated rocks was observed at the eastern pilot tunnel mouth. Many other fault zones up to some meters thick, have been found in the granitic rock mass. Some of them were filled with calcite. Three dominant systems of tectonic faults have been identified: NEN-SWS