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 direction with a steep dip on both sides, NNW-ESE to NW-SE direction with a steep dip to the ENE, and NW-SE with a steep dip on both sides

Disintegrated rocks were also found in zones some meters thick, in Mesozoic sedimentary suites. Claystones and marlstones weathered to clay of medium to high plasticity. Dolomites disintegrated into pebble and sand. Open gaps and caverns up to 1 m were found in carbonates.

Crystalline as well as sedimentary rocks are much jointed, often with striation of sub-horizontal to vertical dip. Sub-horizontal striation of NWN-SES direction was found even in limnic limestones of Upper Miocene age (Panonian) in the vicinity of the eastern pilot tunnel mouth. This indicates that horizontal tectonic movement took place at the end of the Miocene.

Concentrated inflow of ground water took place from fault zones as well as joints in granitic rocks with a yield up to more than 40 l per second. Fault zones were water bearing in their marginal parts. The central part of some fault zones is filled with clay gauge up to 1 m thick. Clay filling is also found in cracks in fault zones.

Multi-Stage Variscan Evolution of the Central Sudetes – Structural Evidence from the Kłodzko Metamorphic Unit

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The Sudetes display numerous features indicating the Late Devonian/Early Carboniferous age of their tectono-metamorphic evolution (e.g. recent review in Aleksandrowski et al. 2000). This time range is constrained, among others, by Carboniferous cooling ages of several metamorphic complexes, Carboniferous late- to post-orogenic plutonism and by a continuous basinal sedimentation until the Late Devonian or Early Carboniferous. However, these pieces of evidence seem to contradict the occurrence of the so-called pre-Upper Devonian unconformity in the Kłodzko unit, originally recognized by Bederke (1924). Folded and metamorphosed metamorphic series in that area are unconformably overlain by basal conglomerate and Late Devonian limestone. Since the work of Bederke, the unconformity has been frequently interpreted in favour of the Caledonian orogeny in the Sudetes (e.g. Bederke 1929; Don 1990; Oliver et al. 1993). Nevertheless, the Early Palaeozoic/Early Devonian tectonism in the Kłodzko unit was discredited by new palaeontological evidence indicating the Late Givetian age of the metamorphosed limestone from that area (Hladil et al. 1999). Consequently, the ages of folding and metamorphism in the Kłodzko unit seem to be restricted to a narrow time span of ca 10 Ma between the Late Givetian and Late Frasnian.

Metamorphic rocks of the Kłodzko unit below the angular unconformity, experienced three main deformation events D_1-D_3. Two following deformations, D_4-D_5 , were subsequently imposed both on the metamorphic basement of the Kłodzko unit and on the Late Devonian – Early Carboniferous sedimentary succession of the adjacent Bardo basin. The Devonian part of the structural evolution which took place between the Late Givetian and Late Frasnian involved: (1) top-to-WNW D_1 thrusting, (2) compressional D_2 folding due to NNE-SSW shortening and (3) dextral strike-slip displacement D_3 confined to WNW-ESE trending shear zone hundreds of metres wide. The first event in most cases took place under the amphibolite facies conditions and was followed by the latter two accompanied by greenschist grade metamorphism. The post-Devonian deformation sequence comprised: (4) WNW-ESE sinistral strike-slip shear D_4 associated with the emplacement of the late-tectonic Złoty Stok granite and (5) intense D_5 folding of the Bardo basin and of the adjacent part of the Kłodzko unit produced by NNE-SSW compression. The first deformation event D_1 formed the general structure of the Kłodzko unit representing a pile of thrust sheets characterized by tectonic inversion of the metamorphic grade. The whole stack rests on the essentially unmetamorphosed Nowa Ruda ophiolite and is overlain by a younger sedimentary succession of the Bardo basin.

Structural evolution of the Kłodzko unit started already in the early Late Devonian and was terminated by uplift and erosion in the latest Devonian followed by a period of basinal sedimentation in Early Carboniferous. The second deformation paroxysm took place at the end of Early Carboniferous times and was roughly coeval with the emplacement of the Złoty Stok granite. Consequently, the Variscan evolution of the Kłodzko unit seems to be split into two time intervals separated by short-duration phase of extension and sedimentation. Outside the Kłodzko unit in the central Sudetes, the first orogenic event can be correlated with deformation and uplift of the Góry Sowie massif as well as with the emplacement of the Sudetic ophiolites. The second one corresponds to the deformation and metamorphism of the Orlica-Śnieżnik dome. Both domains of the central Sudetes showing different timing of the Variscan convergence (i.e., Góry Sowie/Kłodzko and Orlica-Śnieżnik domains) are now juxtaposed along the late-orogenic sinistral Skrzynka shear zone. Despite of their present proximity, they appear to represent fragments of different collision zones successively involved in the Variscan accretion of the Sudetes. Hence, the complex structural history of the Kłodzko unit does not support a continuous continental convergence lasting from the Devonian to Early Carboniferous but a discontinuous evolution model. In the latter model the already exhumed Devonian collisional belt was folded once again during the Early Carboniferous event.

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