by the intersection of a tightly folded (F2) early metamorphic fabric S1 and the axial planar foliation S2 marked by the parallel alignment of flattened carbonates and plate- and needle-shaped silicates (Phl-Ms±Tr±Czo). On the folded planes, the intersection lineation manifests as frequently arranged thin trails of this new metamorphic lamination. On the exposed axial planes of tight folds F2, the lineation occurs as differently thickened and shaded bands, depending on the thickness and colour of the folded beds. The folding is interpreted to be induced by the E-W shortening leading to the lithospheric thickening (in accordance with Dumicz 1979). Tight folds formed during orogenic uplift related to relaxation of the lithosphere (also documented by the flattening of the inclusion trails in garnets in mica schists). At the onset of this uplift temperature peak of metamorphism in the upper amphibolite facies conditions took place.

The axial planes S2 are overprinted by locally observed new meridionally trending stretching lineation. This lineation is defined by elongated carbonate clasts and linearly accumulated carbonates in pressure shadows of less ductile domains e.g. boudinaged Czo porphyroclasts. Products of this tectonic stage have been recorded by locally developed dynamically recrystallized shear zones, which are characterised by strong grain size reduction and elongation of carbonate grains. Angular relations between developed S- and C'-type planes as well as geometry of σ-clasts point to top-to-the-N shearing along the reactivated former axial grain shape fabric. Due to progressive deformation rocks were locally transformed into the L-tectonite. These processes took place during retrograde conditions, at temperatures lower by ~100 °C than those accompanied with the folding stage. The top-to-the-N shearing recognised within the OSD can be correlated with the sinistral movements in the Złoty Stok – Skrzynka Zone, as stretching lineations in these areas have the same position in the sequence of deformation. This deformational stage could be possibly linked to NNE-directed thrusting of the OSD, when OSD interacted with adjacent domains. Within the OSD, the deformation was heterogeneous and partitioned into laminae, hence parallel to the former axial planes.

In conclusion, two generally N-S trending lineations could be distinguished in rocks of the Stronie formation. The orientation of the foremost intersection lineation delineates the Y-axis of the strain ellipsoid representing the tectonic stage related to the temperature peak of metamorphism. Formation of the subsequent stretching lineation was related to uplift and retrogression. Contrary to the intersection lineation, its orientation shows the direction of the maximum strain component. These observations could partially explain controversy regarding the presence of the mineral lineation nearly parallel to the fold axis. In orthogneisses, high temperature conditions, at which the rodding lineation was formed, point to its connection with the N-S directed tectonic escape induced by E-W shortening (according to Żelaźniewicz 1988). Transition from prolate to oblate shapes of the rodding lineation (Żelaźniewicz 1991) could be related to the flattening strain responsible for folding in the Stronie formation. Later top-to-the–NE reactivation at greenschist facies conditions (Żelaźniewicz 1991) concurs with the late shearing that gave the stretching lineation in the Stronie formation.

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Application of Newly Developed ArcGIS Software Extensions for Localization of Faults and Natural Zones of Methane's Escape by Morphotectonic Analysis (Moravosilesian Region)

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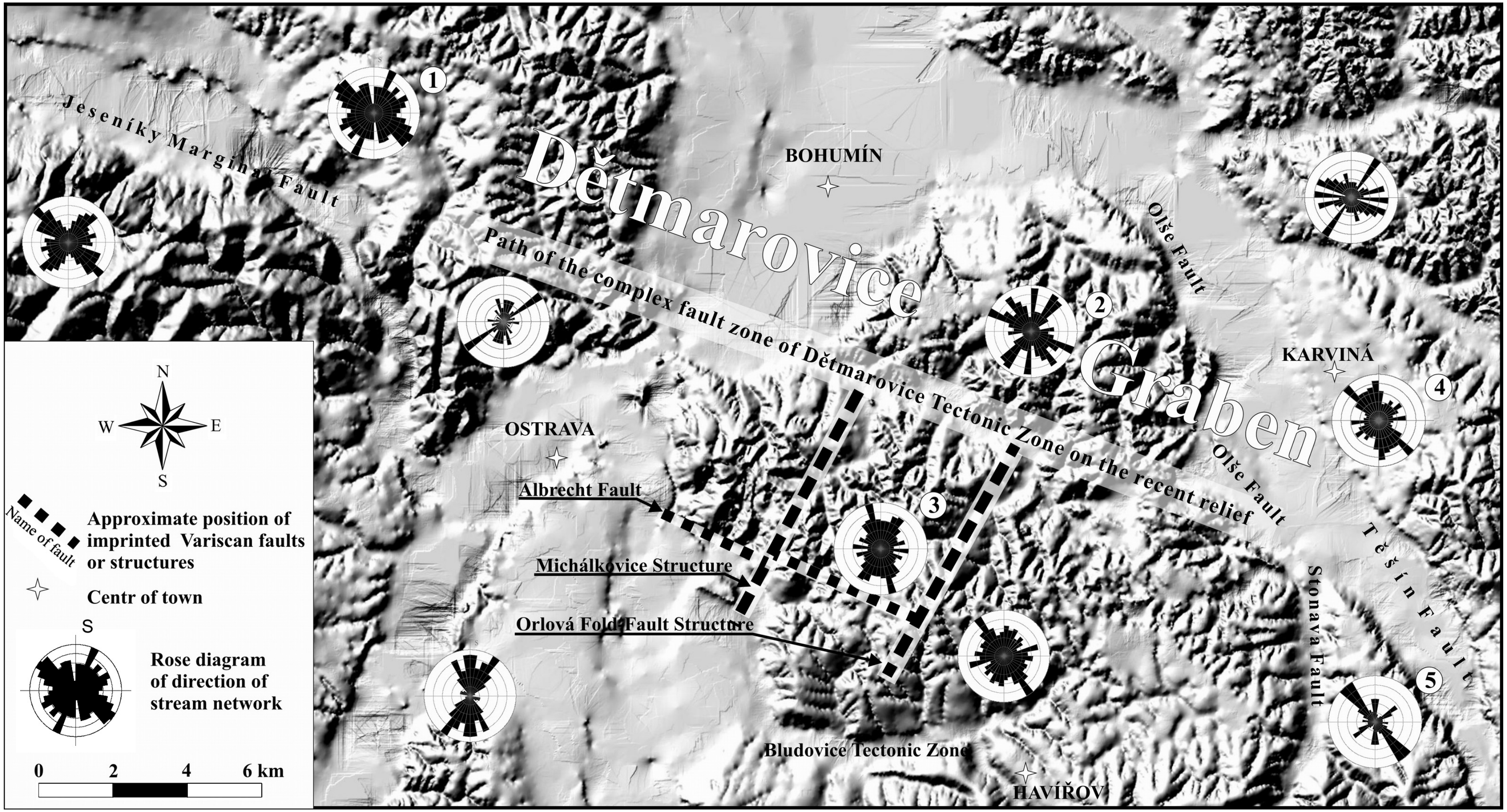
The framework of Variscan coal-bearing molasses represented in the Moravosilesian region by the Czech part of the Upper Silesian Coal Basin (USCB) was reactivated and modified by a sedimentary loading of the Inner Carpathian molasses and tectonic movement of accretion wedge of the Outer Carpathian nappes during the period of Alpine orogeny. The sedimentary and tectonic loading initiated significant rejuvenation of older Variscan structures. A lot of reactivated Variscan faults of the USCB were imprinted



■ **Fig. 1.** DTM (shaded relief) of the Ostrava-Karviná coalfield – the recent relief. A resolution of the DMT is 10 meter / grid cell. In figure imprinted main Variscan structures of the Czech part of the Upper Silesian Coal Basin into recent relief are marked. Rose diagrams are put to centre of analysed polygons of stream network. Minimum length of each stream segment is 100 meters.

through the Outer Carpathian nappes and sediments of Inner Carpathian molasses to recent relief (Jelínek and Grygar 2002). There is assumption about escape of methane up to relief by Alpine reactivated Variscan tectonic zones. In the fifties Petránek (1954) pointed up this hypothesis about methane's escape by reactivated tectonic zones as the first. His early ideas about the influence of young Tertiary tectonic on structural-tectonic conditions of Variscan accretion wedge of the USCB have been overlooked.

The object of resolved project is aimed at detection of features extent of Variscan structures to recent relief in Moravosilesian area. Preliminary results of the study of character manifestation of tectonic pattern in recent relief by morphotectonic analysis are helpful for localization of potential natural zone of methane's escape. Modern methods of morphotectonic analysis make use of results of morphometric analysis of digital terrain models (DTM) confronted with results of structural-tectonical analysis (Jordan et al. 2003). Application of digital terrain analysis in GIS environment enables fast mutual confrontation of results of geomorphologic analysis with geological data. Unfortunately there is no accessible software at GIS, which would be able to perform combined morphotectonic and structural analysis on DTM data. It was necessary to create user friendly software for simultaneously statistic analysis of field structural data and morphostructural DTM data at ArcGIS 9.0 by ESRI company. The ArcGIS 9.0 software was chosen as common GIS software. An asset of ArcGIS is facile linkage with Visual Basic, which was used as programming language for created extensions. The standard software from ESRI does not include appropriate extensions, which would be able to resolve specific problems of structural and morphotectonic analysis. A disadvantage of ArcGIS is also a limited set of interpolation methods for calculation of DTM. For that reason DTM were calculated by Surfer 8 software. This program is more suitable for interpolation of DTM. Unfortunately at the present-day no software module for transforming grid data from GRD file format of Surfer to grid data ESRI format of ArcGIS exists. The first developed extension is conversion of grid data from Surfer 8 software into ESRI ArcMap. The function transfers feature data into ESRI shapefile format and grids into ESRI grid file format. The second extension is used for interactive fast saving of structural data of map to existent structural database. Another extension uses statistic methods for analysis of structural data or analysis of azimuths of polylines in different coverages. Typical examples are stream network (Fig. 1), contour lines, morpholineaments, photolineaments etc. Application finds out azimuth of each segment of polyline (e.g. river stream) located in defined polygon. Azimuths are shown in rose diagrams for each separate polygon. The orientation of each segment of polyline is picked out by different colour for easier confrontation with results of other directional analysis.

Until recently studies of geomorphological and structural-geological character of relief were resolved without mutual confrontation of results of morphological and geological analyses. Modern morphological methods of study of relief comprise structural-geological analysis of structure framework (Pánek 2004). For easier mutual confrontation of results of morphostructural methods with structural–tectonical methods, it was necessary to create a new modulus. The selection of analysed data in the created modulus proceeds simultaneously at all coverages of polylines or structural data. Till this time the selection has been proceeded individually for each polygon and for each coverage. Correctness of function and suitability of using created extensions at a morphotectonic analysis was tested in the Ostrava-Karviná coalfield.

Suitability of using the first module was tested not only at generation grid of DTM, but also at transmission, a grid data of second directional derivation of DTM. This analysis is employed at study of curvature relief and study of morpholineaments (Jordan et al. 2003). The impossibility to implement morphotectonic methods for analyses of DTM from ArcGIS to Surfer (and on the contrary) extends field of usage of created extensions. The possibilities of transforming various grids offer their uses in all series of other field of study not only in morphotectonic analysis. The GRD grid format with a square cell is the requirement for correct function of the first extension at transmission data grid from Surfer to the ArcGIS. Format ESRI is able to save only regular grid with square cells in contradistinction to GRD format, which allows storage of an irregular grid formed from rectangular cells. The user must already take into account this fact at generation of the grid in Surfer. Surfer normally sets maximum and minimum X and Y on the base of border input points at automatically loaded input data. Exactly square matrix cell grid will originate only quite rarely at partition data spaced on integer number of lines and columns. Therefore it is more suitable to order the same size of the grid cell along both X and Y axes and to adjust subsequently maxima and minima upon this axis.

The morphotectonic analysis of DTM, which is oriented to localisation of natural methane's escape by brittle deformation, together with results of structural-tectonical analysis detect a complicated structure relation between recent relief and tectonic deformation of research area. The methodical procedure of morphotectonic analysis included representative morphometric and special terrain analyses of DTM (e.g. the second directional derivation, the slope aspect, the aspect of slope orientation, the aspect of drainage orientation, the digital determination of topolineaments, the aspect of morpholineament orientation, the aspect of brittle deformation orientation, etc.) and paleostress analysis of terrain data. The resolution of analysed digital model is 10 meter / grid cell.

The recent relief of the Ostrava-Karviná coalfield is much more markedly formed by exogenous factors than by endogenous factors. However results of executed morphotectonic analysis in many aspects proved neotectonic rejuvenation of the study area. In relief, where exogenous factors are dominant, a significant influence of structural framework to character of relief occurs (Ahnert 1998, Bloom 1998, Ritter et al. 2002). The most markedly imprinted Variscan structure in recent relief of the Ostrava-Karviná coalfield is the Dětmarovice Tectonic Zone. This wide graben is put together from many partial faults. There is interpretation of imprinted complex faults zone of the Dětmarovice Tectonic Zone in Figure 1. The azimuth analysis of stream network supports link between river system and imprinted Variscan structures. The main direction of rose diagrams No. 1 and No. 2 is identical with complex fault zone of the Dětmarovice Tectonic Zone WNW-ESE (Fig. 1). The Dětmarovice Tectonic Zone connects the west of Doubrava and Eleonora Faults with the fault systems of the same direction in the western part of the Czech part of the USCB and continues as a Jeseníky Marginal Fault as far as to Opava town. The intrusions of neovolcanites and the occurrence of mineral water rich in CO_2 (Dopita et al. 1997) along this tectonic zone are an evidence of the Neoidic geodynamic activities.

Results of comparative morphotectonic analysis confirm also Alpine reactivation of many other Variscan structures (Michálkovice Structure, Orlová Fold-Fault Structure, Albrecht Fault, Olše Fault, Těšín Fault, Stonava Fault, Bludovice Tectonic Zone, etc.). The second main direction of rose diagram No. 3 (NNE-SSW) corresponds with direction of imprinted Michálkovice Structur and Orlová Fold-Fault Structure (Fig. 1). Rose diagrams No. 4 and No. 5 show main direction of drainage system (NW-SE) identical with Těšín Fault and Olše Fault. The Těšín Fault is part of the Jablunkov Tectonic Zone which is noticeable also in DTM of paleorelief of the Brunovistulicum with its Paleozoic cover (Jelínek and Grygar 2002).

Described Variscan structures reactivated by Alpine orogeny could be potential natural zones of methane's escape. The project has significant asset not only for localisation of natural zones of methane's escape but also for morphotectonic methodology. Developed ArcGIS extensions supplemented methods of morphotectonic and structure-tectonic study in GIS environment.

Acknowledgements

This work was supported by the Grant Agency of the Czech Republic (Project #105/05/P545).

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Deformation Pattern Related to an Orogen Parallel Extension Event Recorded in the Vepor Unit, West Carpathians

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The Vepor unit composed of pre-Alpine basement and Late Palaeozoic to Mesozoic cover sequences is one of the major crustal segments incorporated into the Alpine structure of the Central West Carpathians. In this contribution we discuss deformation pattern related to Createaceous orogen parallel extension event recorded in the Vepor basement. The studied deformation heterogeneously affects late Variscan granitoids as well as Variscan high grade orthogneiss, migmatites and paragneiss. Cretaceous reworking of steeply inclined E-W trending Variscan fabric is characterized by the development of sub-horizontal mylonitic fabric in area of about 800 km^2 large. The mylonite foliation bears E-W trending stretching lineation, which is parallel to hinges of isoclinal folds preserved in low strain domains. The development of mylonitic fabric is associated with a prograde metamorphic mineral assemblage, which by using thermodynamic modelling in Perple_X indicates metamorphic P-T conditions 430–590 °C and 5–8 kbar. The distribution of P-T data in the central part of the Vepor Unit indicates an E-W metamorphic field gradient showing higher grade metamorphic conditions towards structural footwall in the west. This observation is in a good agreement with micro-structural analyses in this area showing higher temperature micro-structural features and bigger recrystallized quartz grain size in the west. Following