A methodological study of applications of high-resolution LiDAR-derived digital elevation models for the identification of geological features on the example of a selected area of the Outer Carpathians

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Abstract

This thesis presents a set of advanced methods, and some novel techniques, applied to LiDAR digital terrain models for the recognition and interpretation of the structural relief. The test area was located in the Otryt mountain range, where a complex structure of the Krosno Beds of the Silesian nappe is recorded on LiDAR DTM as linear morphological features defined in this thesis as lithological lineaments. Lithological lineaments are the result of the intersection of sandstone-shale packages with the topographic surface and their visibility is controlled by lithofacies variations, morphological characteristics, and the presence of tectonic structures in the test area. The processing method of the source LiDAR DTM determines the degree of visibility of the lithological lineaments. In order to achieve the best visibility of the lineaments, several topographic surface parameters (LIDAR DTM derivatives) were tested by means of comparative and analytical methods. This included a parameter previously unknown, developed in the course of this work and named the topographic index aspect (TPI-A). For each parameter, a visualisation method was worked out to maximize its information potential. In the comparative method, the subjective visibility of lithological lineaments was evaluated, firstly with the synthetic DTM, and then within the test area. The results of the comparative method, the advantages and disadvantages of each topographic surface parameter are summarised and discussed in a table. The analytical method allowed to identify the topographic surface parameter with maximum contrast variability among the lithological lineaments, which translates directly to their visibility. The applied set of analyses demonstrates the greatest effectiveness of TPI-A and the topographic index in the imaging of lithological and tectonic lineaments when computed within a radius of 10 or 20 m from each pixel of a raster image.

The precise lineament modeling enabled the calculation of geological surface orientation parameters using the three-point vector method, and consequently their detailed 3-dimensional reconstruction. The geological surface orientation parameters of the 3D models obtained in this study are more representative than the point-based measurements in the field, which often reflect local irregularities of the bedding surface. To automate calculations of the

geological surface orientation parameters and to normalize topographic surface parameters, new tools in the *Python* language were designed. They are available for download as a source code, and as a toolbox ready to use in ArcGIS software.

This thesis demonstrates that the LiDAR DTM enables to fill the gaps inherent for traditional geological mapping with reliable data, especially in those areas where direct geological measurements are impossible or very difficult. The analysis of topographic surface parameters performed on this basis reveals structural and lithostratigraphic details with the level of precision unattainable with traditional mapping techniques. Application of the modern methods presented in this thesis will not only augment the geological mapping process but will provide much more reliable background data for imaging and interpretation of areas with complex geological structure.