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Construction of high-resolution Topographic-Bedding-Intersection-Angel (TOBIA) model for landslide susceptibility quantification

Andrea Werner (1) and Frieder Enzmann (2)

(1) Geosciences Institute, Johannes Gutenberg University, Mainz 55099, Germany (wernera@uni-mainz.de), (2) Geosciences Institute, Johannes Gutenberg University, Mainz 55099, Germany (enzmann@uni-mainz.de)

The Geological setting, especially spatial orientation of bedding planes and joint structures are important factors that controls the type, abundance and pattern of landslides. To understand landslide phenomena it is crucial to quantify the geometrical relationships between the bedding/joint conditions, the terrain morphology and rock geomechanical properties. However, mapping information for large areas need resource intensive fieldwork and are time-consuming.
In this study, geological bedding conditions were determined for a large Permo-Carboniferous basin (Saar-Nahe-Basin) in southwest Germany (size around 300x100km). We propose a semi-automatic GIS-based method to construct bedding conditions from the analysis of information captured through high-resolution digital elevation models (1x1m for large-scale area) which geological settings are perfectly visible by eyes in universal hillshade maps. These structures were digitalized as lines, which we call morpho-lines. Based in this lines, 3D vector attributed point data (location, height and if possible stratigraphic information) build up and automatically calculate dip and dip direction by least square plane equation fitting into the 3D vectors (over 3000 lines/planes for this area). The orientation of the fitted plane gives dip/dipdir and accuracy (r^2, rsme) of the fitting. We defined, if r^2>0.6 the planes must be geological planes and are basis for next construction steps. A first approach to propagate the fitting plane normal vector into geological/morphological subareas is the construction of 3D Thiessen polygons and watershed segmentations, which interpolates dip/dipdir attributes into the area. These spatial dip/dipdir vector polygons will be discretized into raster and are essential input data for calculation of the TOBIA model besides morphological slope and aspect of the terrain. Construction problems are caused by faults and anthropogenic overprints/influences. Because of that, break lines must be constructed into the model. The accuracy of the model can be quantified by spatial kriging variance. With help of this information, one can address special locations with potential outcrops to get dip/dipdir by field information and re-meshing the model. A special outcrop determination model was developed with an own index, that indicates perfect match location of outcrops (100% match by ground check). All these data and models are presented in GIS and help to quantify the risk of landslide susceptibility. To further our data pool, we also use landslide information for the area, to investigate the role of geological bedding in control of landslide distribution and abundance in the study area.
According to the classification of TOBIA the location and abundance of landslides are most abundant in underdip slopes, i.e. cataclinal slopes. This means that landslides preferably occur where the geological layer are inclined with the slope. This will contribute to a better understanding of landslide phenomena and the construction of a comprehensive susceptibility/hazard map.