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High-Resolution Geological Mapping in Three-dimensional Environments: A Case Study in Northern Taiwan

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Traditional geological mapping based mainly on fieldwork has certain limitations and disadvantages, such as non-reachable areas, limited outcrops and heavy vegetation. In this study, LiDAR-derived 1-m digital elevation model (DEM) and topographic slope were used for tracing the Miocene sedimentary beds in the fold-and-thrust belt of northern Taiwan in computerized three-dimensional environments. This study was done for demonstrating the effectiveness of using the 3D mapping approach, overcoming the limitations of traditional mapping and increasing the accuracy of the geological map. DEMs with removal of vegetation and buildings can clearly display the original surface terrain in 3D multi-perspective environments. Topographic slope shows the differential erosion effects of the sandstone and shale interlayers with the stripe distribution. Sandstone has better resistance to erosion and it commonly shows steep slope on the topography. In this case, the boundary of the beds and structures can be illustrated and mapped in comprehensive analysis to show the 3D geometry of the mapped boundaries. Comparing with the boundaries from previous studies and checked in the field, our mapped boundaries shown in zigzag lines differ from those in the existing map and appear to be more accurate and fitted with the terrain relief. Each geologic formation is separated into several members based on well-studied geologic columns and the features of slope and terrain. Moreover, the strikes and dips were calculated, which represent the overall bedding attitude without local variations, and were labeled into the new geological map. Also, the dip angles of fault planes can now be estimated more precisely at near surface from the bedding tracing results. In this study, high-resolution DEM derived slope images were used to illuminate the relationships of beddings, structures and topography, and to precisely generate new geological maps taking into account previous regional geologic studies. This new method of using high-resolution topography data is able to overcome the limitations of traditional geological mapping and improve the accuracy of existing geological maps. The improved mapping results from this method can enhance geological information and provide better constrained geological data for engineering applications in the future.

Keywords: 3D geological mapping, high-resolution digital elevation model, fold-and-thrust belt, northern Taiwan