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Problems and challenges of 3D modeling of regional geological structures in the Precambrian bedrock – a case study from the Outokumpu area, Finland

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3D geological modeling usually begins by digitizing of geological features from geological and geophysical maps and cross sections. 3D models are then built using these digitized points and lines, together with drill-hole data. Digitized points and lines are connected to surfaces representing lithological contacts, faults and shear zones using tectonic observations and taking into account the relative ages of formations. A profound understanding of the structural geology is essential because lithologies or faults may be connected in many different ways when based only on the drill-hole data. In this stage the main interpretation work is carried out. Every time a point is added outside the known objects (points, drill holes), an interpretation is made. There are several approaches to connect the lines and points into surfaces in 3D. The main approaches were applied to 3D geological modeling using data from Outokumpu mining area in Finland in order to demonstrate the important differences resulting from the application of different concepts and procedures and their effect on the whole 3D geological modeling process. The region is located in the North Karelia Schist Belt, which was thrust on the late Archaean gneissic–granitoid basement of the Karelian craton during the early stages of the Svecofennian Orogeny between 1.92 and 1.87 Ga.
The biggest problem in the surface building was the lack of data. Lithological contacts and shear zones are seldom planar or even continuous, so few known points are not sufficient. In addition, data sources are often restricted to depths above 1 km. Geophysical data, such as potential fields and seismic soundings were used to continue structures into deeper levels. However, geophysical potential fields and soundings can be interpreted in many ways. In addition, interpolation methods differ in how smoothly they connect the points and lines into surfaces but they do not add any new data. Without extensive drilling, the interpretation of the subsurface geology is more or less ‘informed guessing’, or simply the visualization of someone’s geological ideas. The few outcrop data may not be sufficient to build a unique model of the subsurface geology. Still the modeling and 3D modeling is the best way to get some idea about the subsurface structures or what kind of structures could be expected using all the available geological and geophysical information.
We conclude that the use of different approaches is necessary for comprehensive data capture and 3D visualization of a complex geology. It is also evident that purely technical visualization without involving geological ideas and interpretations is impossible. It is important to understand that all models contain a large degree of uncertainty, and very different models may be constructed from the same geological geophysical data.