Construction and analysis of a 3D geological model by using voxelization for the Little Hungarian Plain

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Beside the classical vector models, the voxel based models play an increasing role in geological modeling. The voxel based models are less widespread than vector ones, because of quantitative character, thus are less able to prevail the individual geological knowledge. During the voxelization we define the horizontal and vertical 2D boundaries, then we fill the subsurface space with 3D cubes or any other space-filling bodies, often parallelepipedons (Fig 1.). We also give the value 'void' to any cube that means there are no sufficient or available data for that part of the space.

The aim of the present study is to build a sample 3D geological voxel database from deep boreholes and interpreted seismic profiles.

Voxels are 3D space-filling polyhedrons. In our study, voxels are not cubes, because the resolutions in horizontal and vertical senses are not the same. They are rather flat, tile-like features. Nevertheless, they are equally large, arranged in a rectangular order and they fill the model space completely.

Voxelization is normally used for interpolating numerical values, like density, porosity, resistivity or alike, but in our project we intended to voxelize formation information, that is, rock types and formations described in the boreholes. Since there is no one-software solution yet, we have used a combination of several softwares, creating a processing chain. The used software requires strict stratigraphic sequence of the formations to manage the data. Therefore, we have introduced a somewhat artificial enforced sequence, this way the heteropic facies cannot be taken into account. This is a known problem of our modeling.

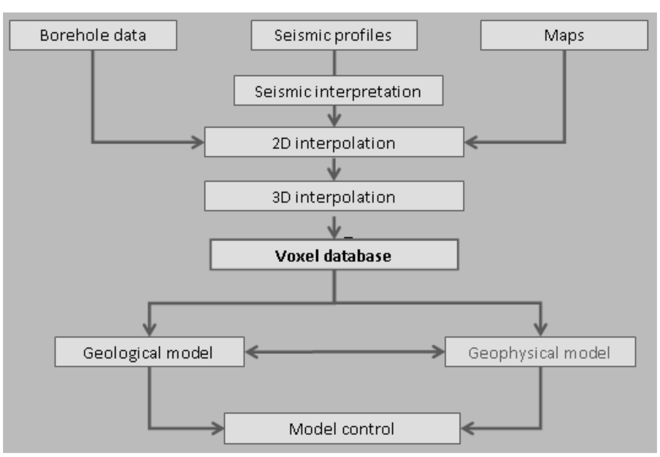

Figure 1.: Flow diagram of the voxelization: These steps are software-independent and in our model they are carried out by different software items indeed

The resolution of the model depends on the sample point density and the thickness of the formation. However the reliability depends on the sampling and types of the interpolation method.

The study area, a 10 km by 25 km rectangular area, is located in the Little Hungarian Plain (NW Hungary), close to Mihályi. In this area Paleozoic rocks form the basement and Miocene, Pleistocene and Holocene sediments fill the basin. The input data of the voxelization were borehole stratigraphic data and interpreted seismic profiles. In its northwestern part we had 6 seismic profiles, while our borehole data are situated along an approximately SW-NE axis. This also means that in the SE corner we do not have any input data: this area selection was intentional. Based on the available data, we got a robust estimate for this area.

We created a 700 × 700 × 10 m and 2500 × 2500 × 10 m models with kriging and nearest neighbour interpolation methods (Fig 2.). In the next step we made a quantitative analysis of the voxel models: (1) we calculated some models without some fixed borehole data and compared it with the original dataset then (2) we computed the voxel numbers of each formation in each situation.

The reliability of the voxel models was also examined. The results are in good agreement with the expectation: the reliability of the method decreases with using fewer borehole data. Omitting some crucial boreholes drastically deteriorates the results whereas some other boreholes have less effect on the outcome. Finally the voxel database provides a 3D geological model that can be a help for the 3D geological interpretation.

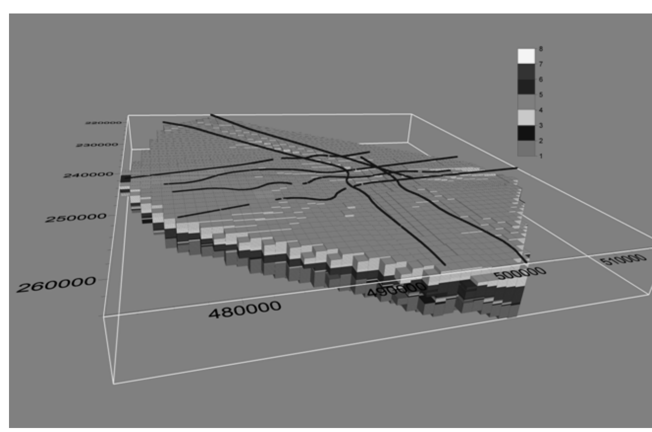

Figure 2.: Voxel model with kriging interpolation. Note that the voxel fill follows the envelope of the input data locations

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