3D Model of Carbon Relief in the Czech Part of Upper Silesian Coal Basin

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Abstract. Coal mining in the Czech part of Upper Silesian basin with an area of approximately 1600 km2 is operated more than 200 years. Approximately 255 coal beds with a total coal thickness of about 150 m were identified. Coal mining and geological exploration have been conducted to the depth of about 1 300 m below the surface and gradually refined the knowledge of the coal deposit including the Carboniferous relief.

In 2009 Green Gas DPB's department for calculation of coal reserves carried out the unification of incremental maps to a single digital map and the transfer of contours in 3D model using company's GIS. For this the data collected from exploratory surface boreholes, mine shafts and local coal mines were utilized.

Model has been created in the CAD-GIS software Microstation V8i. Surface contours has been processed by using the "b spline". The smooth curves and their simpler editing for model adjustments represents the main advantages of this attitude. The contour step of 10 m within the mining licence areas and of 50 m for outside areas was selected. Due to the quantity of data processed the contours for each mining licence are saved in the individual files and in one file for the targeted areas outside the mining licences.

The future use of 3D model is related to the planned coal extraction in the local active coal mines.

Another option how to use the Carboniferous model is linked with mine gas extraction operated by Green Gas DPB at its licence areas. 3D model will become the part of GIS data for the surface boreholes projects focused both on commercial mine extraction and the protection of urban areas from mine gas surface emissions.

Keywords: template, symposium proceedings, geoinformatics, model

1 Introduction

Upper Silesian coal basin covering the part of the territory of Poland and the Czech Republic is currently the site of the largest underground coal mining in EU. Such a strategic raw material base for energy, metallurgical and chemical industries of both countries cannot be replaced in the term of the next few decades. Coal extraction at an average depth of about 1000 m below the surface continues to deploy advanced technology of longwall mining. The peak of exploitation has already been achieved and recently there is a gradual decline.
The detailed knowledge of the geology is required for effective utilization of coal resources. Information gathered from the geological survey is to be stored in a GIS with the possibility of their interpretation through modeling in 3D. Creating a model of geological objects is a matter of specialized software and powerful hardware of supercomputers for spatial visualization. This requires interaction of a number of specialists in the field of geology and IT. In the world there are many solutions to both commercial and open source software models. Very interesting example represents the project of GOCAD consortium, which consists of 19 companies and 124 universities and is widely open to industry and universities of throughout the world.

2 Creation of the geological model of Carboniferous massive

Nowadays 3D modeling in Green Gas DPB company is in the stage of creation of the first applications. These applications based on the available HW and SW form the part of company's GIS system focused on the production of the coal mine gas.
In 2009 Green Gas DPB's department for calculation of coal reserves carried out the unification of incremental maps of Carboniferous relief to a single digital map and the following transfer of contours in 3D model.
Model of the Carboniferous relief has been created in the CAD-GIS software Microstation V8i. Surface contours has been processed by using the "b spline". The use of "b spline" in the geological models is not too spread. The smooth curves and their simpler editing for model adjustments represents the main advantages of this attitude. The shortage of data points in connection with the vast area of the territory resulted in partly „manual" creation of contour lines based on the estimated surface incline of the processed point.

3 Geological and geomorphological situation

Coal mining in the Czech part of Upper Silesian basin with an area of approximately 1600 km 2 is operated more than 200 years. Approximately 255 coal beds with a total coal thickness of about 150 m were identified. Coal mining and geological exploration have been conducted to the depth of about 1 300 m below the surface and gradually refined the knowledge of the coal deposit including the Carboniferous relief.
These findings have been drawn into the mine maps of various scales. Database of Carboniferous relief has emerged gradually from the surface boreholes, mine shafts and underground gates of the local coal operator OKD, a.s.
Carboniferous relief is a result of numerous geological exogenous and endogenous factors since the Variscan orogeny in the Carboniferous. Tertiary Alpine orogeny has represented the profound influence proceeding to the present.
The Carboniferous relief in the places of interest has a character of buried mountain range with the ridges of W-E direction. Ostrava-Karvina ridge rises to the surface in a small part of the territory (Landek, Silesian Ostrava, Orlova, Doubrava). In these places coal mining has began and gradually spread to the whole ridge. Mining also took place on Paskov and Staric ridges, which, as well as Pribor-Tesin ridge, do not come to day. - see Figure 1.
The main valleys between the ridges are called Bludovicky and Detmarovicky washouts with W-E direction and combine on the territory of Poland. Altitude difference with the maximum at the Ostrava-Karvina ridge and minimum at bludovicky washout can be estimated at about 1500 m. The ridges are divided by the partial washouts of N – S direction. - see Figure 2.
Carboniferous relief is covered with a mantle of weathered rocks with the thickness of tens of meters on its slight slopes. The mantle is not usually developed on the sharp slopes. This fact is crucial in terms of gas permeability.
Another important factor associated with Carboniferous relief of are the bodies of so called varied layers that are likely the result of coal seams burning or by their surface weathering. They occur predominantly in coal seams of Karvina Formation in the contact zone with the relief to a depth up to about 200 m.

4 Creation of model

The contour step of 10 m within the mining licence areas and of 50 m for outside areas was selected. Due to the quantity of data processed the contours for each mining licence are saved in the individual DGN file and in one file for the targeted areas outside the mining licences.
Contour lines in the original digital maps were created as a 2D line with the description. Their transfer to the 3 D b spline was created by the application program in VBA for Microstation, which is made using a text description of the operation. For B spline, which, for various reasons, was transferred to a program that allows the user entering dimensions and choosing the contour lines move to the appropriate dimension.
For visualization the program has been developed covering the color depth range within interval of e.g. 200 m. The program for a description of contour lines at the set interval was also prepared.

Another program allows the creation of relief at specified sections by retrieving data from the reference attached files of contour lines. The unification of data into one file will be considered for further processing. Maps for the mining licences will then be generated using the reference connection and the subsequent trimming by the area of interest.
If necessary, the body of Carboniferous massif can be created contour lines by assigning the specific altitude values to the contour lines.
This procedure has been used to model the body of varied layers in Orlova fold. Varied layers represent the potential risk for flooding of active mines by mine water coming from Ostrava and Petřvald coal basins. - see Figure 3.
The future use of 3D model is related to the planned coal extraction in the local active coal mines.
Another option how to use the Carboniferous model is linked with mine gas extraction operated by Green Gas DPB at its licence areas. 3D model will become the part of GIS data for the surface boreholes projects focused both on commercial mine extraction and the protection of urban areas from mine gas surface emissions. The effort will be developed to create the model of the weathered Carboniferous mantle that might contain mine gas deposits.
Recently these gas structures are partly exploited Green Gas DPB and used as underground gas storage by RWE Transgas company.
Underground gas storage Třanovice is planned to be extended by drilling the new surface boreholes. For this purpose DMT Geosurvey company (Germany) has conducted reflexive 3D-seismic measurments. Except from boreholes this represents the only way how to refine the Carboniferous relief outsider the mining licences.
The discussed digital model may be also used for the development of another model of so called detritus horizon. The horizon represents the important hydrogeologic sand structure lying on the Carboniferous relief and containing sea water with gas. We are creating a model of detritus with the Department of Hydrogeology GG DPB.

5 Presentation of model

In addition to its own software model can be presented to a regular user as a 3D PDF file thus allowing the spatial views on the current computers.
Alternatively, you can flesh out the body by means of the so-called 3D printer into a topographic model. 3D printers are devices that produce realistic digital models from CAD data as follows: powder applied in a thin layer (0,1-0,2 mm) is bonded with glue that is forced out of the print heads. This leads to the creation of full colour model in the way layer by layer. - see Figure 4. The model could be located for example in Mining museum Ostrava-Petrkovice or in geological museum of Mining University Ostrava.

6 Perspective use

Geologists from Poland are preparing several large projects that require modeling of Carboniferous massif. The effort to address the energy and environmental problems is the primary mover. First projects of underground coal gasification, production of methane from coal seams and CCS - CO2 storage in coal seams appear in the Polish part of the Upper Silesian basin.
These include the EU project Hydrogen-Oriented Underground Coal Gasification for Europe (HUGE) research project and commercial project Super Daisy Shaft - underground gasification using the sub-horizontal boreholes drilled from shaft, which would be implemented near the state border with the Czech Republic.
The option of storage of CO2 from the newly built power plants in coal seams in response to the EU project RECOPOL are also examined.
These projects may be attractive for Czech companies, which may be involved in various stages of implementation. Geological modeling is a prerequisite of every project. The planned deployment of a supercomputer at the University of Mining Technical University of Ostrava will allow the creation of geological models to scale across the Upper Silesian coal basin and effective collaboration of experts.

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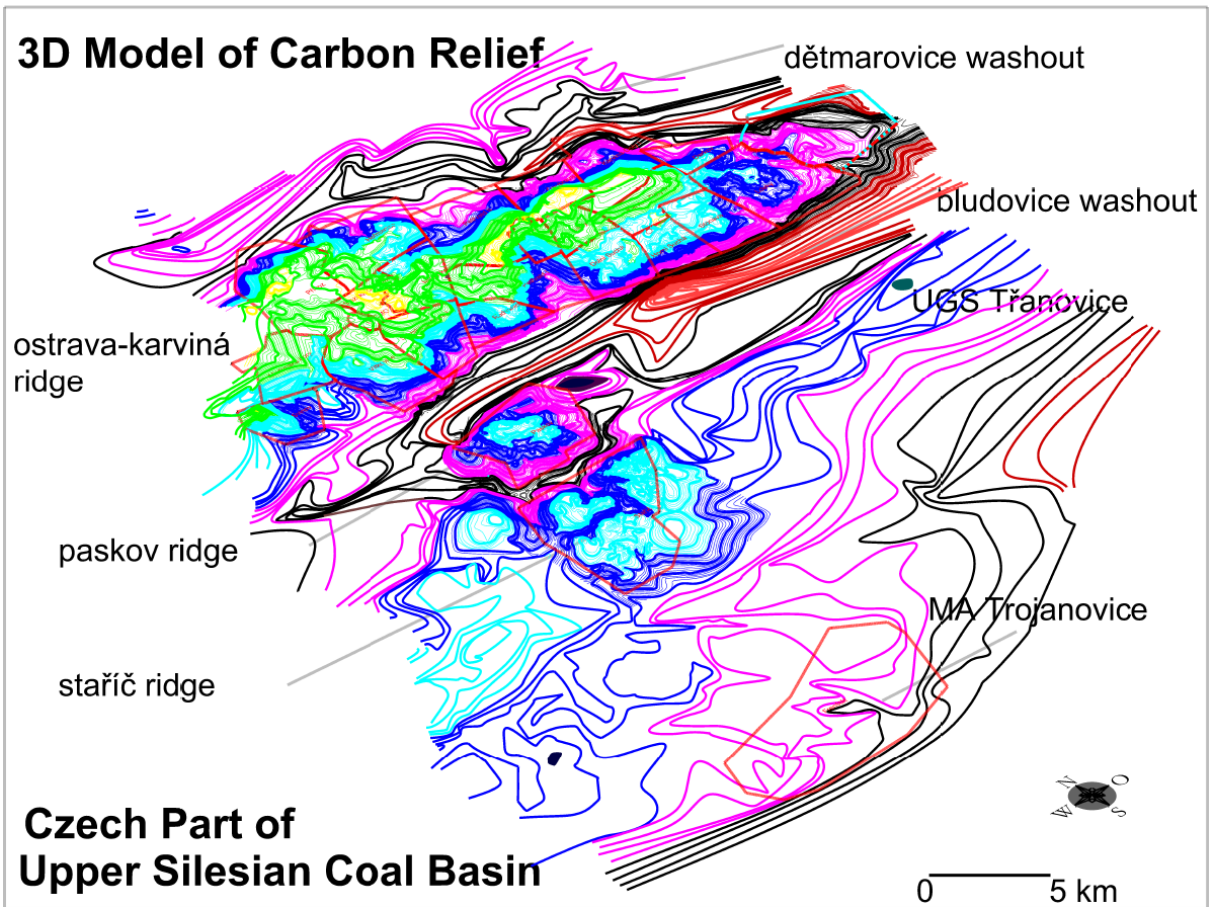
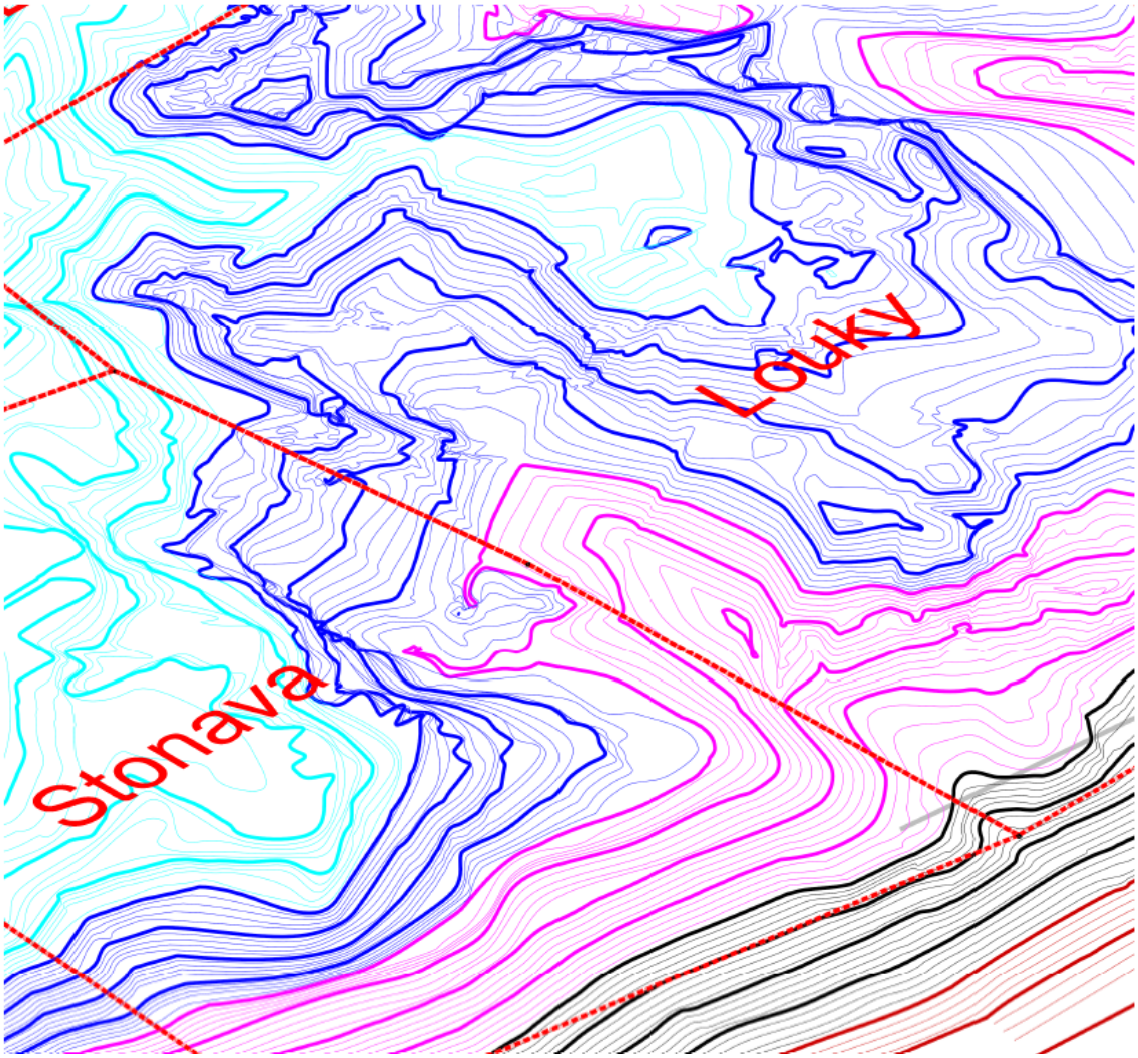


- Fig. 1. Izometric view of Carbon relief with mining areas



- Fig 2. Detail of 3d model carbon relief coal basin with stovava washout – izometric view

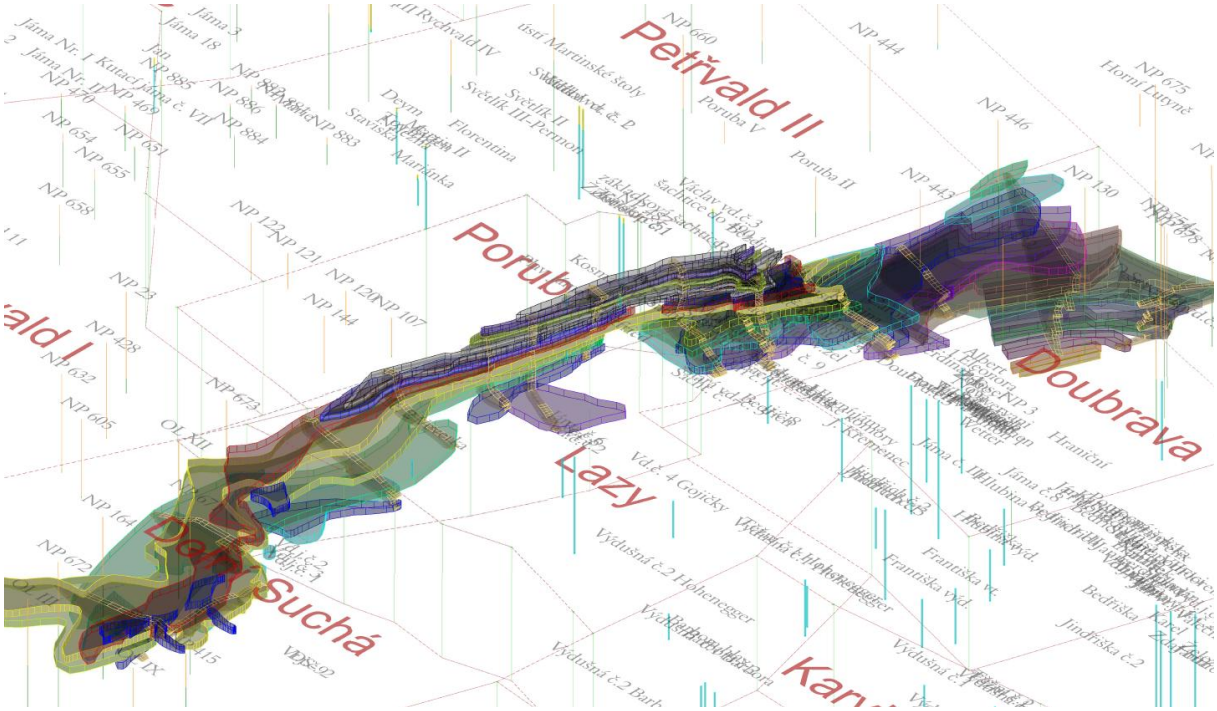
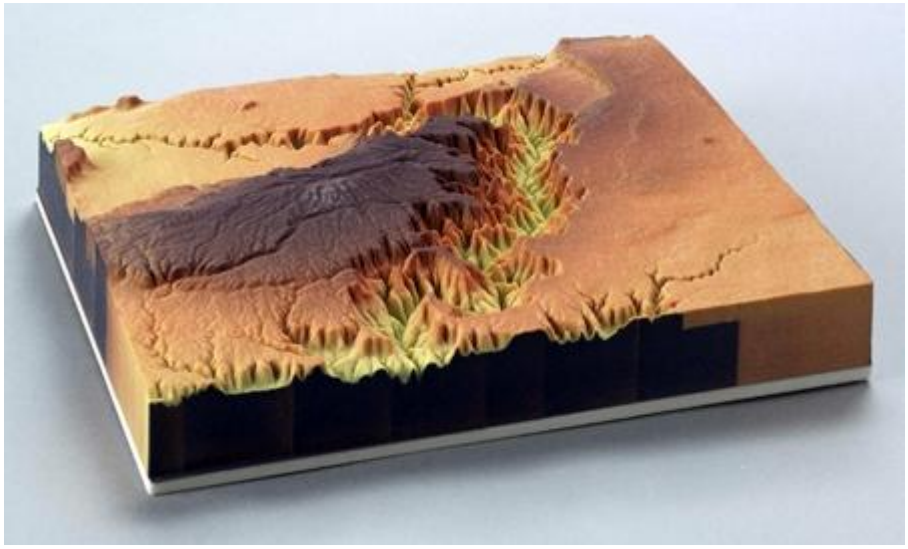


Fig 3.Solid model part of carbon massif (varied layers) on Orlova fold



- Fig. 4.Relief from 3D printer (internet picture)