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Research paper

3D representation of geological observations in underground mine workings of the Upper Silesian Coal Basin

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A R T I C L E I N F O

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A B S T R A C T

The purpose of the paper is to present the possibilities of the three-dimensional representation of geological strata in underground (access) workings in a hard coal deposit in the SW part of the Upper Silesian Coal Basin, using CAD software and its flagship program AutoCAD. The 3D visualization of the results of underground workings' mapping is presented and illustrated on two opening out workings (descending galleries). The criteria for choosing these workings were based on their length and the complexity of geological settings observed while they were driven. The described method may be applied in spatial visualization of geological structures observed in other deposits, mines and existing workings (it is not applicable for designing mine workings), also beyond the area of the Upper Silesian Coal Basin (USCB). The method presented describes the problem of the visualization of underground mine workings in a typical geological aspect, considering (aimed at) detailed visualization of geological settings revealed on the side walls of workings cutting the deposit.

1. Introduction

Mapping underground mine workings means following their definition and presenting rock complexity revealed by the mine workings in a graphical form.

Methods of mapping individual mine workings differ, because they include mapping of vertical access workings (shafts and staple shafts), horizontal access workings (dog headings), roadways driven in coal and extraction mine workings (mainly longwalls).

Results of mapping are entered into geological logs which are a basic mapping document and are usually very specific for given workings, but currently they usually cover one seam or level. Geological information obtained through mapping is used to update information about the main coal seam and level maps. Basic and special geological cross-sections are employed to prepare special geological maps (e.g. isopach maps, i.e. lines of equal thickness in a seam). This information is also the base to identify seams and assess deposits.

Preparing data from mapping underground mine workings provides proper recognition of the deposit structure, which is crucial for designing and conducting safe mining operations (Dudek, 2013; Winkler, 2002; Winkler, Michalak, Jaszczyk, & Bojara, 2007). The scope of the work usually includes: determining actual parameters of seam structure (thickness, strike direction, dip direction and angle), reconstruction of fold structures (recognising the style of structural folding), determining fault displacements (strike direction and fault plane dip angle, stratigraphic throw and separation of the fault, influence of the fault on designing and maintaining mine workings: detecting the moment of approaching the fault while driving a working, determining displacement direction in the area across the fault), determining the course of geological disturbances (changes in the thickness of seams and layers, seam splits and erosive wash-outs) (Duźniak & Gabzdyl, 1991; Nieć, 1982, 2012).

Graphic structures, projection rules, trigonometric equations, dependences, nomograms, theorems and lists (profiles, maps, cross-sections, diagrams, models) were a great help to realise them (if it was not possible directly in a working).

Development of IT tools made it possible to document geological phenomena in a digital form, enabling the preparation and interpretation of all the aforementioned materials (Maciaszek, Wąsacz, & Szewczyk, 2015). In a digital recording there is no data simplification and generalisation, resulting in the description of a phenomenon losing its accuracy and resulting from the complexity of the geological structure of multi-seam deposits. Today's

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software, to a varying degree dedicated to mining and deposit geology, is equipped with techniques which enable 3D images of various objects (single ones) or sets of them to be obtained (Kecojevic, Willis, Wilkinson, & Schissler, 2005; Maciaszek, Gawałkiewicz, & Gawałkiewicz, 2010). These capabilities are also applicable to mine workings, existing or ones being designed (treated as an object or a set of objects). On today's software market there are many programs specifically dedicated to creating 3D models, yet the sheer number of options and modules available means that there are significant costs of purchasing licences and then further subscriptions.

For many years, the Polish hard coal mining industry has been successfully using CAD software and its flagship – Autodesk's AutoCAD program. The options within this program together with available overlays and the possibility to exchange data with other applications suit the specific conditions of Polish hard coal deposits and meet (even combine together) most of the requirements posed by geological and survey services, i.e. by both mine surveyors and geologists. They also enable a 3D approach to geological and deposit issues (Marcisz, Ignacok, Knapik, & Ostrowska-Łach, 2017; Probierz, Marcisz, & Ignacok, 2017).

This article presents a fraction of AutoCAD's 3D capabilities in the representation of geological units in (access) mine workings in a hard coal deposit in the SW part of the Upper Silesia Coal Basin. The authors are aware of many software packages which are used for the 3D graphical representation of rock strata. Additionally, it is known that there are also many programs capable of this and the same is true with the modelling environment (CAD, GIS). The method presented in the article approaches the problem of modelling underground mine workings in its typically geological aspect, paying attention to (aiming at) a detailed analysis of a geological structure revealed in the sidewalls of mine workings driven through the deposit.

2. General characteristics of the study area

The study area is located at the SW slope of the main trough of the USCB (the largest element of the basin's geological structure in terms of area), between the Jastrzębie saddle and the Gorzyce-Bzie-Czechowice regional fault (Fig. 1).

The lithostratigraphic profile of the study area is constituted by bed-rock formations (Precambrian, Cambrian, Devonian and Lower Carboniferous rocks), Upper Carboniferous formations making up the productive series (Fig. 2, Table 1) and overburden strata – constituted by Miocene and Quaternary deposits. In the study area, the productive formations of the Carboniferous are represented by Paralic Series (Namurian A), the Upper-Silesian Sandstone Series (Namurian B-C) and the Mudstone Series (Westphalian A-B).

The Carboniferous formations generally dip towards the NE direction with an angle from several to ten or more degrees (the steeper dip angles, exceeding 15°, are observed in the S part of the studied area). Within the deposit, both continuous tectonic forms

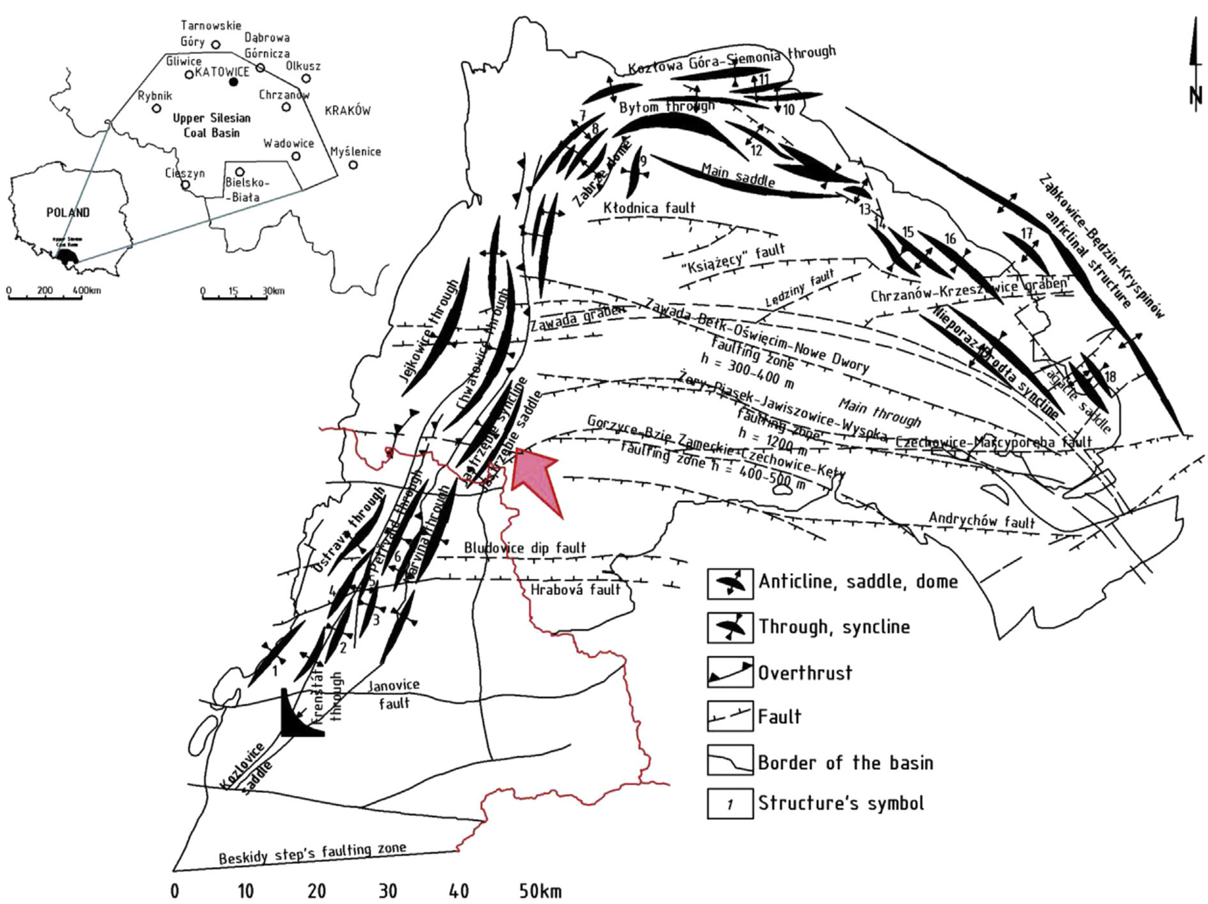

Fig. 1. Location of the study area against the background of the USCB tectonics, after (Probierz et al., 2012).
1 – Příbor trough, 2 – Stařice trough, 3 – Svinov trough, 4 – Paskov saddle, 5 – Michałkowice saddle, 6 – Orlova fold, 7 – Sośnica-Knurów fold, 8 – Concordia trough, 9 – Ruda syncline, 10 – Malinowice trough, 11 – Sarnów saddle, 12 – Grodków saddle, 13 – Maczki dome fold, 14 – Długoszyn-Wilkoszyn syncline, 15 – Ciężkowice-Trzebinia saddle, 16 – Siersza trough, 17 – Miękinia antycline, 18 – Nowa Wieś Szlachecka trough (only the structures marked by numbers have been explained).

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