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## THE SELECTED DUTIES OF A GEOLOGICAL SURVEY IN UNDERGROUND COAL MINES OF UPPER SILESIA COAL BASIN (USCB, POLAND)

**Summary.** The selected duties of a mining geologist performed in underground coal mines of USCB were presented. Mapping of underground workings, estimation of deposit structure influence (measurement of seam parameters, faults, folds and sedimentation dislocations), performing and documenting underground drillings and sampling of deposit were discussed. All abovementioned geological works provide information collected in the mining geological data base and their results are presented as cross-sections, profiles and maps. The setting-ups of cross-sections, profiles and maps allow to correlate and identify coal seams. The geological documentation of a deposit (with hydrogeological and geological-engineering documentations) made on the basis of mining geological data base was characterized. Other documents made on the basis of this documentation – like the project of deposit management, coal mine activity scheme and protocol of changes in resources – were shown as well. These documentation materials force the necessity of undertaking geological activity in other fields: estimation of coal quality in the seams, documentation, prevention and control of hazards, estimation of exploitation influence on the rock mass (roofs and floors classifications, prevention and control of rock bursts, prevention and repair of mining damages), classification and keeping record of resources (amount and spacing of coal in deposit).

**Keywords:** Upper Silesian Coal Basin, bituminous coal, underground workings mapping, geological maps, sampling, coal quality estimation, deposit management

## WYBRANE OBOWIĄZKI SŁUŻB GEOLOGICZNYCH W PODZIEMNYCH ZAKŁADACH GÓRNICZYCH GÓRNOŚLĄSKIEGO ZAGŁĘBIA WĘGLOWEGO (GZW, POLSKA)

**Streszczenie.** W artykule przedstawiono wybrane obowiązki geologa górniczego w podziemnych zakładach górniczych Górnośląskiego Zagłębia Węglowego. Omówiono: kartowanie wyrobisk podziemnych, wpływ struktury złoża na prowadzenie robót górniczych, wykonywanie i dokumentowanie

podziemnych otworów wiertniczych oraz opróbowanie złoża. Ukazano znaczenie prac geologicznych w: szacowaniu jakości węgla w pokładach, dokumentowaniu, zabezpieczaniu i kontroli zagrożeń, określaniu wpływu robót górniczych na masyw skalny oraz w klasyfikacji i szacowaniu zasobów. Pokazano także ich udział w dokumentacji geologicznej złoża, projekcie zagospodarowania złoża, planie ruchu zakładu górniczego oraz w operacie ewidencyjnym zasobów.

**Słowa kluczowe:** Górnośląskie Zagłębie Węglowe, węgiel kamienny, kartowanie wyrobisk podziemnych, mapy geologiczne, opróbowanie, szacowanie jakości węgla, gospodarka złożem

## 1. Introduction

The duties of a mining geologist performed in the Polish underground coal mines of USCB apply mainly to a mapping of underground workings, estimation of deposit structure influence (measurement of seam parameters, faults, folds and sedimentation dislocations), performing and documenting underground drilling and sampling of deposit. All abovementioned geological works provide information collected in the mining geological data base and their results are presented as cross-sections, profiles and maps. The setting-ups of cross-sections, profiles and maps allow to correlate and identify coal seams. On the basis of mining geological data base the geological documentation of deposit (with hydrogeological and geological-engineering documentations) is elaborated with other documents made on the basis of this documentation, like a project of deposit management, coal mine activity scheme and protocol of changes in resources. These documentation materials force the necessity of undertaking geological activity in other fields: estimation of coal quality in the seams, documentation, prevention and control of hazards, estimation of exploitation influence on the rock mass (roofs and floors classifications, prevention and control of rock bursts, prevention and repair of mining damages), classification and keeping record of resources (amount and spacing of coal in deposit) (*Duźniak & Gabzdyl, 1992; Nieć, 1982*).

## 2. The mapping of underground workings

Underground mapping is performed by a mining geologist during the recognition and exploitation of a coal deposit and consists in a graphic display of geological phenomena observed on the underground walls of underground workings in order to explain stratigraphic-tectonic relations, the structure and form of the deposit and its relation to surrounding rock formations in the extent sufficient to exploit the deposit safely and effectively.

*The shafts mapping.* The basis of a proper shaft mapping is the coordination of shaft's section mapping with the process of its boring as the geological profile of each unmapped shaft's section, after installation of the support, is impossible to be re-created. The cross-sections of shafts are usually circular in shape, thus the results of shafts mapping are best to be presented in the so called developed view. The shafts mapping is completed by sampling. The results of mapping are marked on the profile being done (in the scale 1:100 or 1:200), and after the boring of the shaft is finished, a generalized profile is constructed (in the scale 1:1000 or 1:2000).

*The galleries mapping.* In the galleries the coal seam and segments of the floor and roof rocks are mapped. On the basis of the mapping results the cross-section along the gallery wall is constructed in the scale 1:100 or 1:200, while characteristic profiles are plotted on the basic maps. Galleries mapping is the most abundant source of information regarding the seam thickness, its pinches and fadings as well as the location and course of faults and the fault throws.

*The longwalls mapping.* The longwalls mapping is done usually when the exploitation is difficult because of geological aspects: folding of layers, seam's pinches and fadings, faults, rock slides in the roof and (or) side walls. Longwall workings are mapped in short, 10 – 20 metre segments. At the beginning of each of those mapped segments the inclination of the AFC is measured, for technical reasons (the impossibility to measure it directly on the floor) treating it as the dip of the seam. Besides, also at the beginning of each segment mapping a vertical profile of the longwall is made. In case of finding: changes in the seam thickness, its pinches or fadings, faults, folds, rock slides in roofs and (or) walls, additional measurements are made in order to present all those irregularities in geological structure in the wall cross-section – the final document, the result of mapping.

### **3. The estimation of deposit structure influence**

A proper recognition of geological structures and the determination of their parameters are significant for performing mining headings in the deposit and their progress. The significance is greater and greater with the continuous development and the mechanization in mining. Shearers, conveyor belts, powered roof supports can be used only in strictly determined seam thicknesses and dips. During underground workings mapping one should pay special attention to the tectonics which decides of the deposit accessibility and exploitation, excavation direction, roof strength, changes of mineral quality in the deposit and so on. That is why in justified cases special structural mappings are made in order to grasp all the elements of the deposit tectonics. The material collected during geological mapping often requires supplementation and more precise elaborations, in which the methods of descriptive geometry

are usually used. The main aims of those studies are related to the determination of the real parameters of the seam structure: real seam thickness and the real dip.

*The observation and reconstruction of the fold tectonics (structure).* They consist in the measurements of the layers position, the reconstruction of the stratigraphic succession, the recognition of the folding style (normal, inverted, concentric, regular and so on) etc. Special attention is needed in case of small amplitude disorders (fold microtectonics), which are one of the main causes of the cut of the roof in longwalls. The reconstruction of the fold structures requires drawing them on maps and cross-sections on the basis of seam position in the mine workings.

*The observation and reconstruction of the fault tectonics / fault dislocation.* They consist in: determining strike direction and the dip of the fault surface, the direction of the edge seam-fault, fault throw and stratigraphic throw (the relation between fault throw and stratigraphic throw are significant in case the fault cuts the mine working, the influence of the fault on the mine working driving, the recognition of the moment of approaching to the fault during the mine working driving, determining the direction of the mine working dislocation in the part of the seam placed after the fault, classifying and documenting the fault for mining purposes (depending on the reciprocal dislocation of layers, often very complicated: normal, inverted, transversed, rotated, hinged and combined. The surface, with the dislocation along, can be inclined in the range 0-90°. Very often not a single fault is found, but a fault zone — a series of surfaces located close to one another, along which the dislocation of layers occurred. The faults are grouped together creating fault systems).

Faults as one of the main factors obstructing mine working driving are the source of numerous hazards. Only those are detected where throws are at least a dozen of meters or so apart. Smaller faults, with throws a couple of meters apart are discovered only during exploitation. Tiny faults with throws <0.3 m have no influence on exploitation. Faults with throws <0.1 m are imperceptible and treated as cracks. Large and very large faults are the borders of separately exploited parts of the deposit.

*The determination of sedimentation dislocations.* The sedimentation dislocations (changes of seam thickness, seam splitting and erosion washouts in the seams), like faults, are easy to determine on the basis of observations in mine workings, but the reconstruction of their course is more difficult due to the irregularity of their forms (drill-holes can be helpful here). Sometimes one kind changes into another, for example splitting in gradual shading and erosion washout sometimes leads to a total seam atrophy. The range of those dislocations is established on special maps, usually on maps of the seam thickness (isopachous maps), where isolines of seam thickness are drawn, as well a lines of a total shading and total atrophy of the seam. Sedimentation dislocations are usually connected with one seam and do not pass to higher and lower seams.

#### **4. The mining-geological maps**

All abovementioned geological works provide information collected in the mining geological data base and their results are presented as maps, profiles and cross-sections, whose combinations allow to correlate and identify coal seams (Marcisz, 2004; Probierz & Marcisz, 2000; Probierz et. al., 2003).

Mining maps belong to basic elements, which connect the work of a mining geologist and a mining surveyor — a surveyor creates the maps and a geologist fills them with content.

Regarding the scale, mining maps may be divided into: basic maps (made directly on the basis of mapping results), review maps (made through reproduction or reduction of basic maps, containing all or only some of their elements), special maps (made through reproduction, reduction or enlarging of primary maps, supplemented by details significant for the mine).

In respect to content of maps they are divided into: surface maps (topographic maps, mining area maps), mine working maps (showing the location of mine workings and some devices in those workings, as well as more important information related to the deposit structure inside the workings: seam profiles, dip angles, faults, folds, foldings and splittings of the seam etc. In coal mines two types of those maps are made: maps of the coal seam prepared separately for each of the seam and maps of the mine level with mine workings existing on the level) and geological maps.

All the information from underground mapping is also a basis for a correlation of seams and estimation of resources in the deposit.

#### **5. Performing and documenting underground drillings**

During mine working driving small-diametric drill-holes are made, which are divided into: exploratory drill-holes (whose purpose is to determine a geological structure of the deposit), hydrogeological (made to study hydrogeological conditions in the mine), drainage (dewatering) and methane drill-holes (drilled in order to suppress mining hazards, dewatering and degassing of layers), cable-pipe drill-holes (drilled in order to shorten the way of cables and pipes driving), backfilling drill-holes (sewing, made to drain and/or shorten the sewer of backfilling waters), exploratory, communication and ventilation (drilled for rescue or ventilation purposes), technological drill-holes (long holes used in case of blasting hard-to-cave roofs), drill-holes drilled in front of the longwall face in order to check the seam susceptibility to bump or to check the water level and blastholes (short drill-holes drilled for mining excavation by explosives).

Drill-holes are made with drilling machines and drilling rigs. In respect to the drilling method drillings are divided into percussion-rotary and rotary drillings. Rotary drillings, in turn, can be divided into core and solid, and as regards the method of the drillings removal they can be divided into dry or hydraulic.

During drillings, a drilling documentation is conducted, in form of a drilling report, devices and drilling equipment check book, staff training book, a list of staff qualifications as regards devices and drilling equipment maintenance. Another type of documentation are drilling reports with drill cores descriptions, on the basis of which a description of bored rocks is made, which in turn leads to the making of a drill-hole profile.

## **6. The sampling of deposit and estimation of coal quality**

A sample is some amount of material which was separated in a specific way from the mining working, taken from a drill-hole or the excavated material.

Depending on the place from where the samples are taken and the way of collecting them the following types can be distinguished: point samples (rock fragments are collected from one or several points in the longwall or excavated coal. They do not provide proper information because of the tendentiousness of the sample collection. To avoid this they are collected along the line or in a net system. Collection of these samples is cheap, fast and not very laborious.), pillar samples (regarded as the most accurate, collected by the cutting off an even, continuous piece of the seam along the line of seam thickness, and thus representing all the elements of the deposit), samples collected in a thin layer from the depth of several centimetres in the working face (they are very laborious to collect and thus they are rarely collected in mine workings.), samples collected for technological researches and checking the accuracy of sampling in the amount up to several tones and comprising systematically diminished output from the exploited mine workings (this type of sampling is the most expensive and laborious), samples from drill-holes (dust or mud from blastholes made in front of the working).

The way of mine workings sampling is designed on the basis of guidelines contained in the standards which specify its parameters: size, shape, mass and the number of samples as well as their location in the deposit. Collected samples must enable to conduct laboratory analysis: chemical, mineral-petrographical, stratigraphical, physical features and technological. The sampling must be not only representative and the most accurate, but also as cheap as possible. Sampling costs depend on its laboriousness (the time to collect samples) and the preparation of samples to further analysis.

Samples collected in mine workings are registered in the samples and analyses book according to the order of their collecting. The ordinal number in the book is the number of the

sample. Continuous numeration is used in order to avoid the repetition of numbers of samples collected in the mine. During sample registration a date, place and the way of collecting is written down as well as the dimensions of each sample. Registered samples are packed into small sacks with labels stating the location and the number of the sample, as well as the reason for sampling, and then they are sent to the laboratory together with the sampling protocol.

After that the location of collected samples is marked on seam maps, together with their numbers and the results of given laboratory analysis, e.g. ash content, sulphur content, calorific value.

The sampling documentation done in such a way is a database for the estimation of coal quality in the deposit. Various ways of coal usage force to estimate its quality on the basis of chemical-technical methods. Parameters used thanks to these methods, called coal quality parameters, may be of a universal character, independent of the prospective coal usage (e.g. ash and moisture content) or they are of a special character, strictly determining coal destination and its usage in technological processes (e.g. Roga Index RI for coking coal).

Those parameters can be divided into five groups: technical analysis parameters (characterizing general coal features: moisture content  $W$ , %; ash content  $A$ , %; volatile matter content  $V$ , %; gross calorific value  $GCV$ , MJ/kg; calorific value  $CV$ , MJ/kg), elementary analysis parameters (characterizing elemental composition of coal:  $C$ , %; hydrogen content  $H$ , %; oxygen content  $O$ , %; nitrogen content  $N$ , %; sulphur content  $S$ , %; phosphorus content  $P$ , %; chlorine content  $Cl$ , %), coking parameters (characterizing the behavior and technological features of coal with its thermal catabolism: Roga Index  $RI$ , –; Swelling Index  $SI$ , –; dilatometric parameters: contraction  $a$ , %; dilatation  $b$ , %; expansion pressure  $P_{max}$ , N/m<sup>2</sup>; tar flow-off  $T_K$ , %), physical parameters (apparent density  $d_a$ , kg/m<sup>3</sup>; real density  $d_r$ , kg/m<sup>3</sup>, mechanical parameters: UCS, N/m<sup>2</sup>; grinding compliance  $GrH$ , –; optical parameters: random reflectance of vitrinite  $R_r$ , %), group analysis parameters (characterizing the division of heteromolecular substances, like coal, into group components: bituminous content  $B$ , %; humin acids content  $HA$ , %).

Apart from chemical-technical methods in coal quality estimation petrographical methods are used to determine the petrographic composition of coal, i.e. the content of macerals from vitrinite  $V_t$ , %; liptinite  $L$ , % and inertinite  $I$  group and mineral substance (MM – mineral matter)  $SM$ , %.

Each of the parameters is marked by the upper and lower index which informs about the state of fuel, by which the value of the given parameter was determined. Six states of coal were determined: raw  $r$  (the state with such content of moisture and ash as in the coal, from which the sample was collected), analytic  $a$  (the state with such moisture and ash content, as in the sample driven to the state of equilibrium with atmospheric moisture), dry  $d$  (the state with no moisture), dry, ash free  $daf$  (the state with no moisture or ash), organic  $o$  (the state with no moisture and organic substance) and mineral matter free  $mmf$ .

The most perfect method used to estimating coal quality in the deposit nowadays are coal quality parameters maps. They are the maps of isolines showing the values of given parameters applied on the background of a typical mine map. In the construction of these maps more and more often digital technologies are used (CAD or GIS software or combinations of such programs) with the usage of large-format scanners and plotters. All coal quality parameters are determined according to the Polish Standards (PN) and international standards (ISO). On the basis of given coal quality parameters the maps of the areas where the so called technological types of coal can be found are determined. The type of coal determines the utilization and possible destination of coal. Depending on the utilization possibilities, bituminous coal can be generally divided into two groups: coal for the power industry and coal for the chemical processing. More specifically, the most common types of coal utilization are: combustion, fumigation, degassing (coking), getting: regular coking coal, smokeless fuels, liquid fuels (fluidization), pulverized coal (PCI – Pulverized Coal Injection) (Marcisz, 2004; Probierz & Marcisz, 2000; Probierz et. al., 2003).

## **7. Hydrogeological observations**

In coal mines there are several natural hazards, which may create danger for the staff and the mine itself. The sources of water hazards on the basis of their occurrence can be divided into superficial (superficial water reservoirs and water-courses) and underground (water-bearing layers, water-bearing faults, unliquidated drill-holes, underground reservoirs).

A hydrogeologist watches all the aspects of water hazards in the mine and on the ground. His main duties include: the measurement of the water outflows and collecting water samples for chemical analysis, the analysis of the water hazard condition on the surface and in the mine as well as their documentation, classification and determination of water hazard categories, the establishment of water hazard control methods, the supervision over safe exploitation in the water hazard zones, designing safety pillars for existing or projected water hazard zones, designing and controlling water dams, hydrogeological documentation.

## **8. Deposit management**

Deposit management means an activity leading to proper and full exploitation of a mineral deposit. It includes supervision over proper planning and exploitation. The basis for deposit management is geological documentation of the deposit and resources determined this way.

The main elements of the deposit management are: resources classification, resources calculation and geological documentation.

*Resources classification.* Resources are the amount of mineral in the deposit – a natural grouping of minerals and rocks, as well as other solid, liquid and gas substances, whose mining can be of economic benefit. The amount of resources is verified on the successive stages of the geological-mining activity.

*Resources calculation.* The choice of a method to calculate resources depends on many aspects: the character of variability in deposit parameters values, form, structure and dimensions of the deposit, the method and stage of deposit recognition, the method of deposit exploitation. Among the methods of deposit calculation there are the methods of arithmetical mean and weighted mean, the method of geological and exploitation blocks, the method of polygons, the method of triangles, the method of isolines and the method of cross-sections.

*Geological documentation.* Geological documentation (with hydrogeological and geological-engineering documentations) of the deposit, based on geological database of the mine, is a set of documents specifying geological structure of the deposit, the amount and quality of the mineral in the deposit, water and gas conditions, geotechnical and geothermal properties of the rock mass that can influence mining working. The main task of a geological documentation is to estimate amount and quality of mineral in the deposit as well as geological-mining conditions of its exploitation. On the basis of this documentation, the other documents, like a project of deposit management, coal mine activity scheme and protocol of changes in resources are made. All those documents are made in a traditional and electronic version and contain textual (description), tabular and graphical (containing maps) parts.

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## **Omówienie**

W artykule przedstawiono wybrane obowiązki geologa górniczego w podziemnych zakładach górniczych Górnośląskiego Zagłębia Węglowego. Omówiono kartowanie wyrobisk podziemnych, wpływ struktury złoża na prowadzenie robót górniczych (m.in. na rekonstrukcję struktur fałdowych, określenie: rzeczywistych parametrów struktury pokładu, przemieszczeń uskokowych, przebiegu zaburzeń sedymentacyjnych, rodzaju struktur podziemnych), wykonywanie i dokumentowanie podziemnych otworów wiertniczych oraz opróbowanie złoża. Wszystkie wymienione prace geologiczne dostarczają informacji gromadzonych w kopalnianej bazie danych geologicznych, a ich wyniki przedstawiane są w postaci przekrojów, profiliów i map, których zestawienia umożliwiają następnie korelację i identyfikację pokładów węgla. Ukazano znaczenie prac geologicznych w takich dziedzinach, jak: szacowanie jakości węgla w pokładach, dokumentowanie, zabezpieczanie i kontrola zagrożeń, określanie wpływu robót górniczych na masyw skalny (charakterystyka i klasyfikacja stropów i spągów, zapobieganie i naprawa szkód górniczych), podział i obliczanie zasobów (ilość i rozmieszczenie kopaliny w złożu). Przedstawiono udział prac geologicznych w materiałach faktograficznych regulujących działalność geologiczną, tj. w dokumentacji geologicznej, którą stanowią dokumentacja geologiczna złoża kopaliny, dokumentacja hydrogeologiczna i dokumentacja geologiczno-inżynierska, a kolejno w projekcie zagospodarowania złoża, planie ruchu zakładu górniczego oraz w operacie ewidencyjnym zasobów.