

STAGES IN CREATION OF GRAPHIC DOCUMENTATION OF UNDERGROUND MINES

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Abstract: Graphic documentation of a mine is a set of a certain number and type of graphically shown data giving information on spatial position and geometry of mining structures, mining production, starting with the designing stage, through exploitation up to its termination, i.e. till closing of a mine and post-exploitation activities in connection with reclamation and revitalization.

Characteristic mark of underground mining of mineral raw material, in terms of defining and monitoring of changes of conditions in space, primarily refers to the inability to recognize the position and geometry of underground chambers, facilities and appearances in the way it is possible to do on the surface, for example, as with surface mining. Beneath the surface, visibility and recognition of the space is limited only to the underground chamber where the observer is located. If the diversity of geometrical shapes of underground chambers, their different position in space, constant change of conditions and complexity of mining works is added to this fact, it may be established that the contents of graphical documentation of underground mine is very diverse and complex. Creation of graphical documentation represents continual process of collecting, processing and presentation of data in real space and time, throughout all stages, which a mine must pass during its life, which was shown in this paper.

Key words: mine, underground mining, graphic documentation

1. THE CONTENTS OF GRAPHICAL DOCUMENTATION OF UNDERGROUND MINE

Within the contents of graphical documentation of an underground mine (hereinafter referred to as GDM) (Figure 1) there is a large number of graphical displays classified as per basic and thematic contents (Službeni glasnik Republike Srbije, 2011). The GDM of underground mine includes graphical displays presenting information on the following:

- natural structures and infrastructure facilities, communications and land contour within the exploitation field of the mine;
- spatial position and geometry of underground chambers and structures;

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- machinery, equipment and devices;
- technical and technological activities and
- geological features of deposits and natural conditions of exploitation.

This documentation is characterized by specific features and diversity emerging from its purpose, shape, contents, dimensions and geometry of the displayed structures, different appearances, influences on the field plane above mining works, constant changes of the situation and similar.

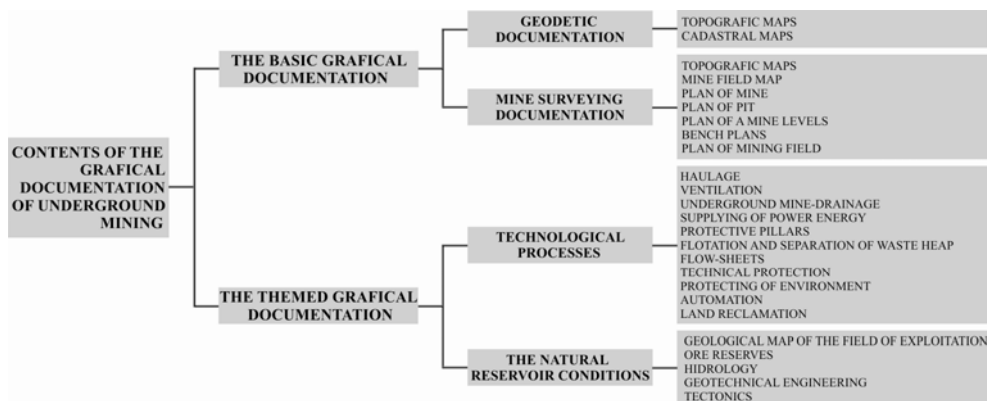


Figure 1 - Schematic display of the contents of graphical documentation of underground mine

For the purpose of creation of graphical documentation of the mine, the surveying and mining and measuring works are performed, which provide a large number of spatial data, beginning with opening, exploitation up to closing of a mine. Surveying documentation plays a significant role at the pre-exploitation stage, at which the activities concerning data collection and graphical presentation are being performed on the field surface (Dimitrijević and Milutinović, 2007).

2. STAGES IN CREATION OF GRAPHICAL DOCUMENTATION

Based on the contents, the way in which graphical documentation is being created and specific features of underground exploitation, creation and keeping of graphical documentation of a mine include three stages involving certain activities. Figure 2 shows schematic display of stages in creation of graphical documentation of an underground mine (Dimitrijević and Milutinović, 2001).

2.1. Pre-exploitation stage

Data collecting, processing and presentation on the resources regarding the area of future mine, as well as on technical and technological solution for the purpose of exploitation of mineral raw material, is performed through a number of activities during pre-exploitation stage involving exploration, designing and preparation.

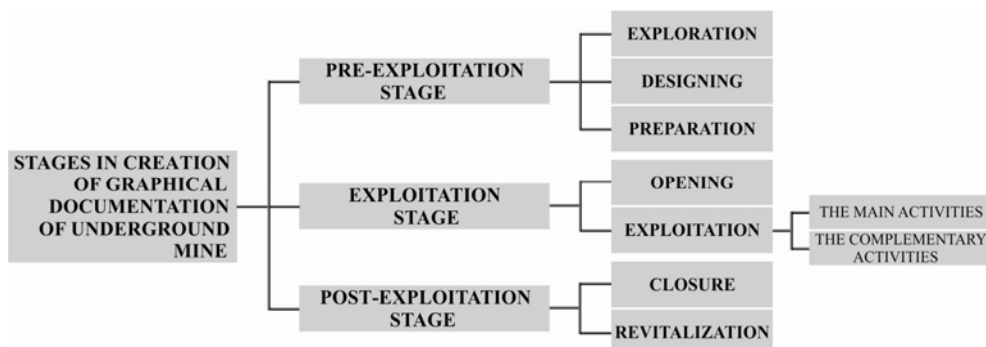


Figure 2 - Schematic display of stages in creation of graphical documentation of underground mines

EXPLORATION

For the purpose of a detailed geological field prospection and exploration drilling at the pre-exploitation stage, it is necessary that the existing graphical documentation on the potential location is available and to update it as required or to make new graphical background based on the data obtained by surveying measurements at the potential location. Depending on the size of the area representing the potential exploitation field, graphical documentation is made in different scales:

- maps in scale of 1:5000 to 1:25000;
- plans in scale of 1:250 to 1:5000.

Graphical documentation comprising of surveying background in scale 1:2500 exists for the entire area of the country and it is used at the exploration stage for the purposes of both surface and underground exploitation. Maps in scale of 1: 10000, obtained by photogrammetry exist for the larger part of the country's territory. Maps in scale of 1:5000 (basic state map) exist only for a part of the country's territory. All of those maps are used for geological explorations in the potential exploitation field regardless the type of exploitation to be applied. For detailed geological explorations (exploration wells), topographical surveying is often needed for working out of plans in scale smaller than 1:1000.

After finishing geological explorations, as soon as the area of exploitation of a future mine is defined, and for the purpose of good preparation of documents for the designing stage, geodetic surveying can be made for certain parts of the surface explored (locations where shaft construction is planned, gallery or downcast portal, processing facility etc.) and plans in scale 1:1000 and larger can be made.

DESIGNING

At the designing stage, the extent and diversity of surveying graphical documentation are reduced to surveying bases for the design of mine circle, within which the construction of the administration building, workshops, bathrooms, canteen, warehouses, raw material processing plants (flotation, screening), etc. is going to be done. The project documentation consists of the preliminary design and final mining design.

For the purpose of drafting of the preliminary mining design, apart from surveying basic documentation, a mining and surveying documentation (hereinafter referred to as MSD) is being created, which shows mining structures and technical and technological solutions, as well as conceptual designs of a future mine. The MSD is, at this stage, practically fundamental documentation and the basis for the creation of MSD for the final mining design. At the stage of preparation of preliminary design it is often necessary to perform some additional surveys and to make plans in scale larger than 1:1000 (for example for the purpose of locating of skip shaft as well as of ventilation shaft, entrance into the gallery or downcast etc.), if this was not made during the stage of creation of documents while exploring.

When preparing a design of a mine, the MSD is its component part and it contains plans, profiles, cross sections, diagrams, schemes etc. that define spatial position of the deposit of the mineral raw material, underground mine chambers, structures with their sizes, construction technology, excavation methods, drainage, ventilation, energy supply etc. The MSD contains, apart from the mine and pit plan, also the plans of horizons, ramps, dumps, major structures etc. Both basic and thematic documentation made in scales 1:1000 and larger are included in the contents of the MSD because of the complexity of mining structures to be designed.

PREPARATION

During the preparation stage, the acquisition of the land is done, whereby proprietary relations between the mine and natural persons or legal entities that are owners of the exploitation area of the mine are regulated. The regulation of relationships may be made by purchasing the real estate, by concession, by property swap or in some other way defined by two parties to the Contract and in accordance with the law. For those activities the documentation of the Cadaster of real estate (land and buildings) including alphanumeric and graphical data (real estate folio in the land register, cadastral plans etc.) is required. During the preparation stage, it is also necessary to perform topographical surveying of the land acquisition area and to mark the boundaries of the area acquired. During the preparation stage, data from the National real estate cadaster have a significant role.

The contents of the GDM from the pre-exploitation stage may be seen through the following schematic display (Figure 3).

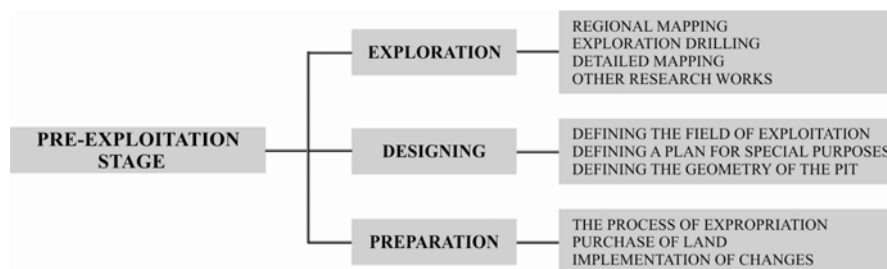


Figure 3 - Activities at pre-exploitation stage

The types and the volume of surveying and mining and measuring works and of the accompanying documentation at the pre-exploitation stage during the process of exploration, designing and preparation are (Milutinović, 2011):

1. The existing surveying and mapping documentation

- Geodetic network;
- Cadastral survey plans;
- Topographic maps and plans;
- Thematic maps and plans;
- Land register (land register documentation);
- Documentation of additional surveying works.

2. Bases for the design

- Geodetic (numeric) documentation:
 - List of coordinates of points;
 - List of benchmark altitudes;
 - Description of position, stabilization.
- Surveying and mining and measuring graphical documentation:
 - Cadastral plans (S=1:500 up to 1:2500);
 - Basic national map (S=1:5000 or 1:10000);
 - Topographic maps and plans;
 - Thematic maps and plans.
- Additional measurements:
 - New geodetic networks:
 - The form of the network;
 - Evaluation of accuracy;
 - Stabilization of points;
 - Selection of instruments and accessories.
 - Surveying of details and development of topographic and thematic plans:
 - Object of surveying;
 - Surveying method;
 - Digital interpretation;
 - Cartographic interpretation.
 - Development of marking project:
 - Accuracy;
 - Stabilization of points;
 - Instruments and accessories;
 - Marking method;
 - Evaluation of accuracy;
 - Calculation of marking elements;
 - List of coordinates and altitudes;
 - Enclosures (graphical and numerical).

3. Acquisition of the land

- Geodetic networks;
- Marking of boundaries;
- Surveying of the area of land acquisition:
 - Digital interpretation;

- Cartographic interpretation.
- Proprietary relationships:
 - Land and facilities register.

2.2. Exploitation stage

The excavation of useful minerals and digging of gangues, as well as their transport and haulage onto the surface of the field is being performed during the exploitation stage, where gangue is to be deposited onto dump, and ore is to be conveyed to screening or flotation plant. The exploitation stage includes activities regarding opening of a pit (construction of shaft, gallery, downcast, hydrological works, access roads for opening chambers etc.) and exploitation (excavation, transport and haulage of gangue and ore).

OPENING

During the mine opening stage, plans in scale 1:1000 and larger, made for the purpose of preliminary, i.e. final mining design are used. Geodetic documentation at this stage must be updated if conditions in the field have changed in the meantime (certain earthworks regarding preparation of the terrain for mine opening: construction of shaft, gallery and downcast). During opening stage, it is required to enter constructed portal of gallery or downcast, skip shaft, constructed structures within the mine etc. into geodetic documentation.

During the opening stage, MSD, apart from project documentation, also includes documentation with geometric elements for marking of mining structures. This documentation, if necessary, is to be supplemented and corrected according to the requirements arisen while executing works in opening chambers of a mine.

As works at opening proceed, it is required that state of executed works and their update is recorded in MSD. If it is necessary to make significant departures from the final design, the additional mining project or technical design are made, where MSD is included together with the contents corresponding to the departure in question.

EXPLOITATION

During the exploitation stage, geodetic documentation is to be updated according to the changes of the conditions in the field (changes of conditions within the mine, on flotation and screening dumps etc.). Those changes are to be updated in plans in scale 1:1000, and when necessary also in larger scale. The condition of the space within mining workings (corridors, raises, down-casts, chutes, blind shafts, chambers etc.) is shown in mining and measuring documentation.

During the exploitation stage, as during the opening stage, the MSD contains documentation with geometrical elements for marking of mining structures. Possible departures from the final mining design, if they are not too large, are to be entered in MSD, and the correction of geometrical elements for marking up is made. The need for larger departures requires an additional mining project or technical design where MSD is included as appropriate. During exploitation, simplified mining designs are to be made in order to resolve certain technical and technological discrepancies and

deviations. The MSD is also included in those designs, as well as graphical support when carrying out engineering tasks.

With the development of an underground mine (construction of new chambers and enlargement of lengths of the existing ones), the conditions existing in the area change as well, so that those changes are, according to the established time schedule, to be recorded as well as the changes of spatial position of mining machinery, equipment and devices and the changes of appearances (occurrence of water, gases, falling apart, cave-in, etc.). The aforementioned changes are to be updated in the MSD being the basis for interpretation of the conditions existing in the area. During the exploitation the MSD contains plan of mine, pit, horizons, level, excavation, dump etc. together with basic and thematic contents. The scales of the documentation are 1:2500 and larger.

The activities during the exploitation stage are schematically shown in Figure 4.

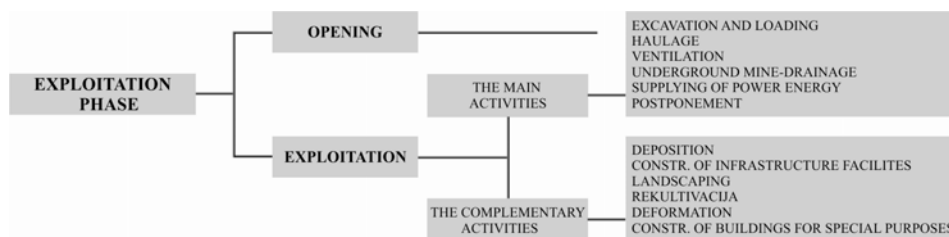


Figure 4 - Activities at the exploitation stage

The type and volume of surveying and mining and measuring works and of the accompanying documentation at the exploitation stage are as follows (Milutinović, 2011):

- Geodetic, mine, polygonal and elevation networks;
- Recording of details both on the surface and in the pit, development of topographic and mining basic and thematic plans:
 - The object of survey;
 - Surveying method;
 - Digital interpretation;
 - Cartographic interpretation;
 - Weight calculation;
 - Enclosures (graphical and numerical).
- Development of marking project:
 - Technical conditions;
 - Marking accuracy;
 - Stabilization of points;
 - Instruments and accessories;
 - Marking method;
 - Evaluation of accuracy;
 - Calculation of marking elements;
 - List of coordinates and altitudes;

- Enclosures (graphical and numerical).
- Proprietary relationships:
 - Land and facilities register.
- Observation of subsidence and deformation on structures:
 - Project of observation;
 - Accuracy;
 - Stabilization of points;
 - Instruments and accessories;
 - Measurement within the deformation model;
 - Evaluation of the accuracy of measurements executed;
 - Definition of the dislocation of points;
 - Enclosures (graphical and numerical).

2.2. Post-exploitation stage

Post-exploitation stage includes documentation representing the combination of data from the National Cadaster of Real Estate and data of the final records of all previously monitored appearances and conditions. The documentation shows underground mine chambers, old works, dumps, infrastructure facilities etc. as well as the consequences of mining production.

During the closing stage, since the area is deteriorated and devastated (dumps, subsidence, processing plants etc.), the activities of technical and biological reclamation within exploitation field are being performed after exploitation is finished.

Apart from graphical documentation of the land reclamation project, the graphical documentation of rehabilitation of roads and facilities used during exploitation, which are going to be used after the mine is being closed (infrastructure of wider public significance), is made.

During the reclamation of exploitation field it is possible to make reassignment of the area in terms of: arable land, construction of industrial facilities, sport and recreation center, underground warehouses, storage facilities etc. Those activities are accompanied by graphical documentation, which partly is surveying documentation (mining and measuring one) and partly it falls under the fields such as agriculture, forestry, construction industry etc. depending on cause for reassignment.

During the revitalization of underground mine, graphical documentation, in terms of its content, does not differ from the documentation before closing of a mine, in other words, archived documentation is being used to develop the revitalization project with certain amendments in terms of update quality of data as the result of the change of conditions in the area since the moment of closing of a mine till restart of production.

Activities at the post-exploitation stage are schematically shown in Figure 5.

The type and volume of surveying and mining and measuring works and of the accompanying documentation at the post-exploitation stage are as follows (Milutinović, 2011):

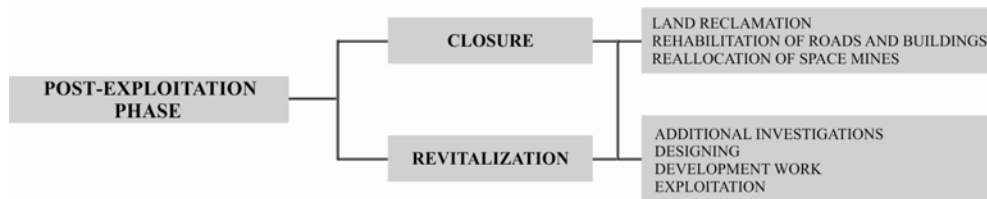


Figure 5 - Activities at the post-exploitation stage

- Geodetic, mine, polygonal and elevation networks;
- Recording of details and development and updating of topographic and mine plans of final state:
 - The object of survey;
 - Surveying method;
 - Digital interpretation;
 - Cartographic interpretation;
 - Weight calculation;
 - Enclosures (graphical and numerical).
- Development of the project of land reclamation and rehabilitation:
 - Technical conditions;
 - Marking accuracy;
 - Stabilization of points;
 - Instruments and accessories;
 - Marking method;
 - Evaluation of accuracy;
 - Calculation of marking elements;
 - List of coordinates and altitudes;
 - Enclosures (graphical and numerical).
- Proprietary relationships:
 - Land and facilities register.

3. CONCLUSION

Creation of GDM may be considered at three viewpoints: preparation of basis for the designing of mining works (pre-exploitation stage), monitoring of conditions within the exploitation area of a mine (exploitation stage) and updating of conditions after the exploitation (post-exploitation stage). The GDM in this particular case has certain specific features regarding the type of mineral raw materials to be excavated, i.e. specific features determine the categorization of documentation into: GDM of metals, GDM of nonmetals and GDM of coal, which in this paper was not presented.

Properly created GDM (implies monitoring all stages of mining activities and drafting of documents pursuant to regulations within the Law on State Survey and Mining Law), provides foundation for the most part of activities while designing, monitoring, technical and technological procedures, analyses etc.

Creation of GDM in digital form, pursuant to given stages, represents foundation for preparation of spatial information system of a mine, because the number, type and distribution of information contained fulfill requirements for quality interpretation of the area beneath the surface, dynamic of supplementation or entering of amendments of conditions as they occur.

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