Creation of the Temporal and Spatial Data Base for Land Use on the Example of Post Mining Areas

Introduction

The mapping of landscape changes of postmining areas are applied in two fields: 1) in land use planning – where it is important to present the state of the landscape in different stages of exploitation, especially the stage previous to mining; 2) in environment protection – the maps document the process of renaturalisation of postmining areas, which may indicate further reclamation activities. The conclusions which come out from investigations of landscape changes may refer to the history of material culture, as landscapes, especially monumental ones, like post mining landscape in this case, represent the records of the history of culture development. The comparative analysis of the maps of differentiates age and the different subjects based on the sources, which may be transformed to a uniform co-ordinate system makes possible to study the development of the landscape.

Cultural landscape in understood here as a material and spatial evidence of various natural conditions influencing human lives together with their economic and social spheres. The features of cultural landscape include:
- spatial differentiation conditioned by geodiversity,
- cultural differentiation manifested by the created evaluation systems,
- continuous transformations conditioned by both natural processes and civilisation development.

The state of each landscape is therefore the synthesis of natural processes and the assemblage of other processes (historical, economic, political) which occurred in the past and which are taking place at present.

The mapping method is one of those verified and recorded through centuries filters of perception, which is imposed by the culture. The importance of information on the selected elements of natural environment, which repeat on each map of different age should be emphasised. This information is the most important for a man.

Methods and materials

This paper concerns the areas of Bytom and Tarnowskie Góry (Tarnowice Plateau), where silver-bearing ores of lead-zinc and iron ores have been exploited for centuries. The investigations included landscape changes, which have occurred during the last 200 years (Lamparska-Wieland 2000, 2003).
The characteristics of maps, which describe the oldest period investigated.
Preussische Ur-Messtischblätter map and mining maps made by Rensch and Harnisch were used as a source material for the first (out of three) periods studied in the landscape analysis of Tarnowice Plateau. Their usefulness in landscape analyses is different, because of various subjects. The aim of this stage of the work included data gathering from the maps mentioned earlier and creation of the map with location of mining fields and works in Tarnowice Plateau. The result of this stage is the map of the landscape of Tarnowice Plateau at the turn of the 18th and 19th century. The topographic basis of this map are: Preussische Ur-Messtischblätter; Grad Abtheilung 50°/51°..., 36°/37°...; sections: Bande IV, Blatt 3; Bande IV, Blat 4; Bande V, Blatt 3; Bande V, Blat 4. These sheets cover the whole area of Tarnowice Plateau. The map of location of mining works was printed on a modern topographic base-map.

1. Preussische Ur-Messtischblätter maps. At the turn of the 18th and 19th century Prussian cartography and land surveying developed significantly which was associated with the measurements of the Earth globe and development of new cartographic projections. The maps based on triangulation were produced in Prussia. Also works with the introduction of mathematical basis of drawing were written, which influenced the way of landform presentation (Jankowska, 1993a,b). All these resulted in the production of the assemblage of topographic maps of the former Prussian sector of partitioned Poland. They include manuscriptal maps at the scale 1:25 000 (1826, 1827). These maps were produced by Quartermaster Department of General Staff under direction of C.V. Muffling basing on the surveying of V. Decker (Muffling, 1821). The Berlin meridian was assumed as the prime one. A polyhedral projection was used, which was introduced by Benzenberger in 1813 (Jankowska, 1993a,b). In this projection the globe was assumed as a polyhedron, which consists of innumerable number of surfaces. A geographical unit represented an area of dimensions 1° x 1° (Grad abteilung). The map contained objects important from the military point of view (Jankowska, 1993a,b). They included hard-surface roads and ground roads, water reservoirs with lakes, ponds, dry ponds, wet and dry ditches, working and closed quarries, mines with marked shaft entrances, heaps, iron works, water mills and windmills. As far as agricultural land is concerned, only these were mapped which were important for military reasons (Jankowska, 1993a,b, 1994). This is why they include only wet meadows and swamps, and there is no division into other types of agricultural land. In towns, the districts with timber buildings and with stone buildings were distinguished; also town’s walls and more important buildings like hospitals are mapped. Industrial developments are marked with special cartographic symbols and description. A zero level was represented by the altitude of the lowest point measured in a given area, e.g. water level at the bridge or at the flood-gate (Jankowska, 1993, 1994). Altitude points are not mapped. In fact, they
were measured using altimeters method, but they were not marked on the map. The relief is shown as a combination of heave, fine, dash and zigzag lines, depending on the angle of the land slope according to the instruction of C. Muffling (1821).

2. Mining maps from the turn of the 18th and 19th century. Apart from the maps discussed above, the mining maps were also used. They were produced by the staff of the Major Mining Office and apart from the topographic elements, they contain large number of mining elements. Harnish and Rensch prepared them. Their topographic base-maps are older than these used in Preussische Ur-Messstischblätter maps; the elements not connected with mining come from the turn of the 18th and 19th century. The origin of these maps is associated with the incorporation of Silesia into Prussia Kingdom and economic activation of Tarnowskie Góry ore region (Łabędzki, 1842; Molenda, 1972; Greiner, 1983a,b).

The first map is entitled: “Situation Plan von dem Blei und Silber Erz Berg Bau der Fridrichs Grube bei Tarnowitz...” and it includes the period 1802-1837. Rensch prepared it and the work on this map started at the end of the 18th century. The mining elements of the original map were updated every couple of years until the 1830s. The map is manuscriptal. The mining content was updated 9 times (probably by Rensch himself) until 1837. The map is at the scale 1 : 14 980. (In the investigations, the copy of the map was used). The map shows an irregular area of 58 km² with the Soła valley on the north (as far as Piaseczno), Laryszów and Ptakowice on the west, Stolarzowice on the south and Sucha Góra, Bobrowniki and Lasowice on the east. The map was based on the instructions of Mining Office from 1780 (Greiner, 1983a,b). The mining elements include location of mines and mining shafts with their names and use: skylight pits, water shafts, lift shafts, ventilation shafts, together with the information whether the shaft is working or not. Pits and quarries are marked with the description of the exploited mineral and with the division into working and closed ones. Different symbols are used to mark old works of various types. Basing on additional sources: descriptions, drawings it may be assumed that at least part of them (marked with “alte” description) is related to the works from the turn of the 17th and 18th century. Also draining ditches, drilling muds and different types of heaps are mapped. The buildings are divided into house buildings and industrial buildings and their functions are described. These are topographic units and belong to topographic base. The roads are mapped in detail. River network is marked using line symbols and water reservoirs using surface symbols. Also forested areas are shown on the map. There is no however information about the ways of land use.

3. The second mining map entitled “Situation Plan von dem Oberschlesischen Gallmei Revier” of the unknown authorship (probably Harnisch) comes from the period 1830-1840. The map is in the scale 1 : 20 130 with northeastern orientation. Side by side with topographic content it shows mining fields of zinc ore mines and most important shafts. The map covers the area shown on the Rensch’s map with some additional area towards the east as far as Nakło, Chechło.
and Świerkłaniec and the area on the right bank of the Brynica river as far as Przełajka. On the south it reaches Siemianowice, Bytków and Chorzów and on the south-west Łagiewniki, Karb, Miechowice and Stolarzowice. This map, as opposed to the maps discussed above, is an administration map, but it was prepared similarly to other mining maps from the turn of the 18th and 19th century, for the order of Mining Office according to instruction from 1780 (Greiner, 1983 a,b). Mining elements included in this map are rather poor. Topographic content includes forests and elements of relief marked similarly to Preussische Ur-Messtischblätter by combination of lines of different thickness and pattern depending on slope gradient. River network is marked but there is no information on the way of land use. Buildings are marked with symbols and description, but there is no differentiation between house buildings and industrial ones. Mining buildings are located within mining fields, next to the name of the mine, which enables to assume their function. This map was used in the investigation to identify, compare and verify different objects on Preussische Ur-Messtischblätter map and on mining maps.

The characteristic of maps describing the turn of the 19th and 20th century. The next investigated period is the turn of the 19th and 20th century. It is documented in the series of topographic and mining maps of the Prussian Kingdom. The map of landscape of this period was produced using the base-map of Messtischblätter transformed into modern co-ordinate system.

1. Messtischblätter maps. The main feature which distinguish this edition of topographic maps from Preussische Ur-Messtischblätter is more dense triangulation base line, changes in measurement technique, introduction of contour lines, reference of the point heights to the sea level, increase of the range of elements included in the map (Jankowska, 1993a,b). In this paper the following maps were used: 3257 Broslawitz, 3258 Tarnowitz, 3308 Zabrze, 3309 Beuthen. Field measurement was carried out using the method of plain-table survey basing on triangulation base line of the density 22-23 points per sheet. The scale of the map is 1 : 25 000. The first issue of the maps appeared in the period 1883-1885 and then it was updated many times. The map is well preserved (cardboard). In the investigations original sections from the 1890s were used; in case of the sheet Tarnowitz the issuing date is 1902 and also the issue from the period 1910-1914. Messtischblätter maps include much more details than the earlier maps. In this paper their content was divided into mining part and other content. The mining content includes symbols, which describe the surface and type of works. They inform also about the type of the excavated mineral. In case of quarries, their size and shape is given, the type of the excavated mineral is described, and also the information is given weather it is a working quarry or closed. The height of the walls of the quarries is not given. This information is also not available from
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contour lines. The location of dumps and places after old pits in the bottoms of quarries are shown. Different symbols are used for postmining areas, with the information about the excavated mineral. The areas of older shaft mining are described as fields of dumps. The heaps are shown as a combination of lines with the information of their area, slope inclination and shape. In case of high heaps, their altitude (in m. a.s.l.) is given. Shaft entrances are marked with separate symbol with the information whether the shaft is working or not and what is their function. The names of more important shafts are given. All names of mines are given and mining infrastructure is described in details. Buildings are marked with symbols with description about their function. The map contains basins of drilling mud and settling tanks, draining ditches, channels of draining ditches. 

Other elements of the map content are also very rich. Forest areas are marked with the division of their type, age and density. The following green areas were distinguished: bushes, bush planting areas, tree planting areas, orchards, parks, dry meadows, wet meadows and pastures. Areas of bogs and marshes are shown. The information included in the topographic content, the method of presentation of landscape elements and description is not inferior to modern maps. Apart from Messtischblätter maps in this research two mining atlases were used. They were also produced basing on land surveying and they include:
1. Spezial Karte der Oberschlesichen Bergrevier 1883, containing detailed information about anthropogenic elements of the landscape such as ditches, embankments, water sluices, ponds, regulated sections of rivers, basins. Different kinds of heaps, mining works and metallurgical works are distinguished. 20 sections of the map were used in this paper.
2. Karte des Oberschlesischen Ersbergbaues 1 : 10 000, 1911, Breslau, this map was used because of its reach geological and mining content. Data gathered from this map was used to supplement the content of anthropogenic elements of the landform and mining areas. Twenty sections of the map were used containing information about the type, depth and limit of the exploited resources (both exploited ones and probable ones) and numerous information about kinds of old mining, such as exploitation method, location of shafts, excavations and old quarries. Also geological cross-section included in the atlas was used.

Modern maps. Modern investigation period includes the years 1987-1997. This is the period of very dynamic changes of the relief and other elements of the landscape. The following maps were used: topographic maps from 1987 at the scale 1: 10 000 in projection system 65 in digital versions and an analogous map in projection system 42 from 1995. From technical causes, the maps of the projection system 65 represented a reference level for all the other maps used in the research so the co-ordinates of the other maps were transformed into 65-projection system. For future researches all spatio-temporal databases will be transformed to 42-projection system.
The comparative analysis concerned the elements describing kinds of land use in the versus of these elements which are shown on the maps of Preussische Ur-Messtischblätter and of the map's accuracy. Newer editions of maps contain more information as, for example, these kinds of land use, which originated later eg. orchards, railway lines. The new kinds of land use were added to the work because it is self evident that the landscape changes also by the appearance of new elements.

Methods of data elaboration, gathered from the source maps

Transformation of maps to the selected co-ordinate projection system (65) was carried out in the following way: first the maps were scanned using the table scanner, the obtained raster images were calibrated, i.e. transformed into one co-ordinate system using RasterEDIT software. Because lack information on the map about cartographic projection parametric calibration, was conducted using selected points (datum points). The reference level is represented by modern topographic map. Typical points were selected, which were present both on the calibrated map and the master map and they were transformed into co-ordinates of modern reference system. The effort was made to select well defined points, e.g. cross roads and uniformly distributed on the map.

The number of points selected to calibration depended on the area projected on an individual sheet. In case of mining maps it was 15-25 points on a sheet and in case of topographic maps Messtischblätter it was about 30 points on a sheet. The points of the largest calibration error were not included so that the mean square error did not exceed 3-5 m. Finally the calibration of a sheet was conducted basing on 10-15 points in the first case and 20-25 points in the second case. The simplest anisotropic model of calibration was chosen. The calibrated rasters were recorded using MapInfo software and 1-3 points of the largest displacement were excluded from each sheet.

Calibration of maps Preussische Ur-Messtischblätter was carried out on a similar way by evaluation these same points for analogous section. It appeared, however, that only part of them exists on the maps from 1827. In such cases the points from the calibrated and recorded earlier Messtischblätter maps were used. Despite this, the number of the points chosen for calibration is smaller, i.e 15-18 points per sheet.

Maps Situations Plan and Gallmei Revier were calibrated only basing on the co-ordinates taken from the maps Preussische Ur- Messtischblätter. The number of calibration points is 13 ad 15. Mean square error of both maps was 7-8 m².

Calibration was often difficult to carry out due to considerable range of changes of the land use. Mining damages, location of new mines and exploitation areas sometimes caused displacement of cross roads or other points, which could have been used as datum points for calibration. As compared to the maps analysed by Jankowska (1984) and Kozica (1998) it may be assumed that maps containing
mining elements are the most difficult in transforming them to modern co-ordinate system (Wieland 1997).

The next step included digitalisation of information from individual maps. Data gathered in this stage of the work made temporal and spatial model database of the landscape of Tarnowice Plateau.

Conclusions

In result of conducted investigations stand up temporal and spatial database for land use, which has the next features:
- is open, can be supplemented by cartographic materials and other documents, as air photography, space photography, and geophysical investigations;
- enable to investigate the dynamical changes in the kinds of land use on definite areas in all researching time rangers,
- enable the construction of thematic maps, what has the application in different spheres of researching or economy.

Landscape investigation of mining areas, especially the oldest ones, must be carried out basing on historical cartographic materials. Detailed field investigations (observation, electro-resistance investigations) should start from delimitation of the range of mining works basing on these historical sources. They help to establish location of exploitation, its type and method. However the following facts should be emphasised:

1. The image on the map has certain degree of generalisation, which depends on the scale of the map. Also the type of projection, the applied geodetic co-ordination system significantly influences the intensity of deformation of information, which is shown on a map. This is why, considering the landscape changes, which occurred in the past, the aim of these investigations has to be taken into consideration. It they aim to prepare certain plans of spatial management, the cartographic information has only preliminary character and has to be supported by more detailed investigations. If these investigations are carried out in order to describe landscape changes in larger scale, they may become one of the stages of investigations on changing cultural landscape. Maps at the scale 1: 10 000 and 1: 5 000 are good enough to determine the state of the landscape, ways of land use and changes in kinds of land use.

2. Works based on historical maps will be a good supplement to other landscape investigations such as fractal analysis or photography in different ranges of spectrum, which should include “younger” information layers of temporal-spatial database. Fractals are measurements, which connect the information about the shape and the associated process. Modelling in order to give more detailed source data is applied in geodesy and cartography to describe irregular shapes. It also may be used to model processes and phenomena (Olszewski, 2002). This may therefore help to find details of the shape of the disappearing old mining fields or reconstruct
the limit of underground excavations (basing on data from air photographs of postmining areas. This, of course, gives broad possibilities for further analyses.

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Summary
The paper presents the methods of creation the temporal and spatial data base concerning the post mining areas, put together on ground of cartographic materials, from different times. On ground of those data base it is possible to analyse the changes in the kinds of land use on Tarnowice-Plateau during the last 200 years. It is also possible to define with an approximation the location of hazards connected with the old underground mining.

Keywords: temporal and spatial data base, analysis of cartographic materials, changes of land use, post mining areas

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Tworzenie Czaso - Przestrzennej Bazy Danych dla Terenów Objętych Określonymi Formami Użytkowania Ziemi na Przykładzie Terenów Pogórniczych

Streszczenie
Artykuł przedstawia metody tworzenia czaso-przestrzennej bazy danych dotyczącej terenów pogórniczych, zestawianej na podstawie materiałów pochodzących z różnych czasów. Na podstawie takiej bazy danych można przeanalizować zmiany w sposobach użytkowania ziemi w czasie ostatnich 200 lat. Można także określić z pewnym przybliżeniem miejsca występowania zagrożeń związanych z dawnymi robotami górniczymi.

Słowa kluczowe: czaso-przestrzenna baza danych, analiza materiałów kartograficznych, zmiany użytkowania ziemi, tereny pogórnicze