



APPLICATION OF OTT'S MINE COORDINATE SYSTEM IN THE PAST AND IN PRESENT DAY

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Abstract. The coal district system of coordinates for mines located in the Ostrava region was established in 1858 by Dipl. Ing. František Ott, Surveyor of the Emperor Ferdinand Northern Railway (Severní dráha Ferdinandova). Coordinates of all significant points of existing mine shafts, characteristic mine surface points, and points in terrain, were determined by establishing mine triangulation within the Western part of the Ostrava-Karviná Coal District (OKR) on an area comprising almost 58 km². Said points were stabilized by granite stones. The reason to establish this system of coordinates was to determine the points of a uniform basis of coordinates for making surveys both on the mine surface, i.e. for connecting the underground mine working, and simultaneously for removing any discrepancies occurring with respect to mine boundaries among particular proprietors, i.e. to allow for exact demarcation of mine areas bestowed to them by the state. Thus, nowadays Ott's system of coordinates that used to be applied during the period, in which within the OKR redevelopment works took place, like abatement the coal mining consequences.

Keywords: underground mine working, boundary, coal mining, mine coordinate system, redevelopment.

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Introduction

Ott's triangulation was designed for purposes of mines belonging to the Emperor Ferdinand Northern Railway and on agreement with other miners also for mining fields belonging to Baron Salomon Mayer Rothschild, Count Wilczek, Duke Salm-Reiferscheidt and Zwierzina's mining company. Triangulation was used to determine trigonometrically the coordinates of significant points of the existing shafts (midpoints of mine shafts or middle hauling ropes), characteristic surface points (church towers, town halls, factory stacks) and points in terrain which were stabilized with granite stones.

The coordinate axes of Ott's system of coordinates were parallel to the axes of the Austrian St. Stephen datum of cadastre coordinates effective for the territory of Lower Austria, Moravia, Silesia and Dalmatia. Due to frequent use of a compass, the choice of coordinate axes adapted to mine mapping habits; thus the positive X-axis pointed toward the North and the posi-

ve Y-axis pointed toward the East. The coordinates of Ott's system of coordinates were expressed in Vienna fathoms and values lower than 1 fathom in decimal fractions of a fathom.

To calculate the surface area of mine fields displayed as units, corrections from cartographic distortion in length or angles were not introduced due to small surfaces. Values of interest for mine surveyors included convergence of meridians, magnetic declination and convergence of medians.

All calculations were performed in fathoms (°); it was not until after 1876 that Ott's whole study was recalculated in the metric system. When we refer to Ott's study, we are referring to the book written in Kurrent, i.e. a German neo-Gothic script, dating back to the period of 1870–1880, which containing calculations and coordinates of all mine outlets in Ott's grid of coordinates. A copy of the study with a general map was distributed to all mining companies involved.

In some mines of the OKR, Ott's system of coordinates was still in use in 1970s; even today, its practical value consists in the ability to trace and dispose of old mine outlets or test and verify pits surveyed with the use of this system.

The chances of obtaining information on Ott's system of coordinates are very limited, an exception being K. Neseť' s publication *Mine Surveying* (Neseť 1966), which dedicates one paragraph to the topic, and monographs published at the occasion of the "OKR Directors' Conference" organized in Moravská Ostrava in 1928. Detailed information can be found in Ott's study, which was distributed along with a copy of a general map to all appropriate mining companies at the time (1848). The study is written in the German language and in the Kurrent script, and it is basically unusable without an elaborate translation. Ott's system of coordinates gained in importance when the DIAMO Company carried out rehabilitation works due to a possible gas leak in the original mine outlets. Therefore it was necessary to mark out the location of the original shafts and outlets in the terrain. The whole situation was solved by a graphical transformation through identical points in the cadastral maps. However, there was a problem in terms of the accuracy of the marking; in fact the difference between the real location of the shafts in the terrain and their marked location was up to 12 m. This process resulted in the "catalogue of mine shafts" which indicated approximate coordinates in the JSTK system with accuracy of 1 m; individual shaft mouths, mine outlets, adits etc. were photographically documented.

1. Ott's triangulation and choice of coordinate system

In Ott's system, the method of triangulation was used for all measurements of mine fields within the Ostrava coal district. In compliance with the planned openings of mine fields, triangulation networks were set up and their culmination points were located on elevated places if possible. The points of the triangulation network were stabilized with worked stones.

When using triangulation, it is necessary to measure the exact length of at least one side of the triangulation network triangle first. Consequently, the length of all sides of the triangulation network triangle can be calculated on the grounds of the length and measured angles in the triangle. If the triangulation network covers a big area, it is necessary to choose and measure the exact lengths of more than one side. Due to of great lengths of triangulation sides, this problem is usually

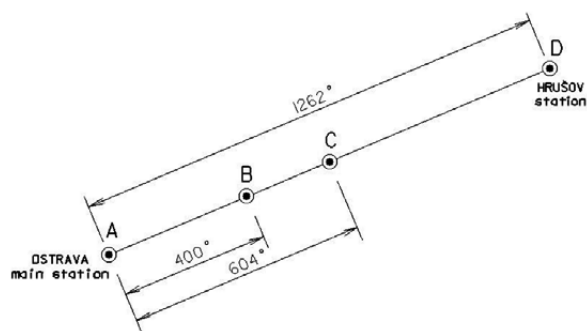


Fig. 1. Schematic representation of the main base in the Ott's triangulation network

solved by using a "geodetic base" which is shorter and serves to calculate the first triangulation side on the grounds of the measured angles and lengths.

The Emperor Ferdinand Northern Railway was used to choose and measure the base in Ott's triangulation network in the following manner: the direction of the base was set in parallel with said railway 3.66 fathoms (1.156 m) from the main yard. The point of departure of Base A was located to the East of the Ostrava main railway station and it was stabilized by the above mentioned stabilization of triangulation points.

The second base was located in Michálkovice, and it measured 103.251 fathoms (195.813 m). It was considered a check base for measurements carried out in the triangulation network. Both bases were measured repeatedly. The schematic representation of the main base including its lengths is displayed in Fig. 1. The general principles of the building and measuring of bases are to be found in (Böhm 1945; Novotný 1909).

From each triangulation point (position) all visible connecting points of the mine shafts were repeatedly measured. The measuring was carried out with the use of Breithaupt theodolites¹, which allowed to read directions with the accuracy of 4" (seconds of arc) and which were the first devices used for mining purposes. They were used in mines in the 1870s, for the first time in 1872 by the Wilczek mining company (Monografie OKR 1928).

The X-axis of Ott's system of coordinates was set in accordance with the third sheet line of the East column XIX to the West (dc) and the Y-axis in accordance with the fourth sheet line of the 9th layer to the South (hi) of the stable cadastre system (Fig. 2).

The intersection of the above mentioned column and layer is the origin of Ott's coordinate system and

¹ The first mine theodolite was supplied by the W. Breithaupt Company to the Impérial Brazilian Mining Association in London in 1832.

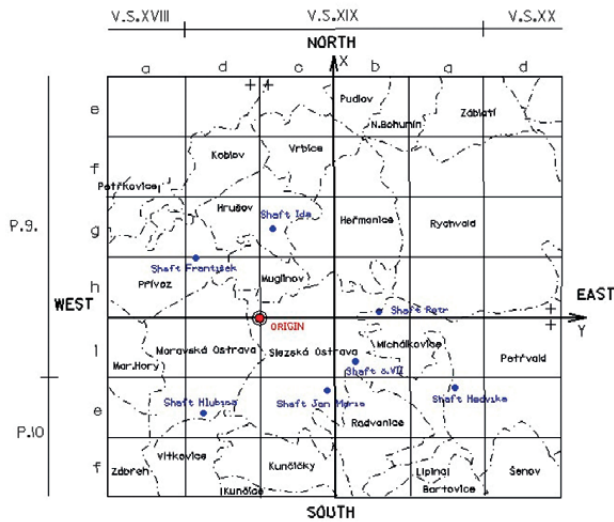


Fig. 2. Ott's system of coordinates

is marked on the map of the triangulation network (Fig. 3) as a red point. The origin was situated in the municipality of Záměst, 240 fathoms to the North from Josef-Schachte and 50 fathoms to the East from Rothschild's Uhelná Street leading to Hrušov.

The coordinates of the origin of Ott's system of coordinates in the stable cadastre system are as follows:

$$Y_{(0)Ott} = -138443,322 \text{ m,}$$

$$X_{(0)Ott} = -183579,651 \text{ m.}$$

The integration of Ott's system of coordinates to the St. Stephen datum of cadastre coordinates was assured by surveying the points from the cadastral triangulation of the 2nd order in the area of the "Ostrava region", where two geometers – Ploebst and Schmitt – worked between 1822 and 1824 (see Fig. 4). These were the churches (church towers) in the municipalities of Vratimov (Ratimow), Hošťálkovic (Hostialkowitz) and Vrbice (Wirbitz).

The church towers were surveyed from point F, which belonged to Ott's system of coordinates, and was situated on an old spoil tip in Muglínov. Its coordinates were defined by the resection method and hence deduced the azimuths of individual sides of triangles and calculated the coordinates of individual points.

The X-axis of Ott's coordinate system was parallel to the X-axis of the regular datum of cadastre coordinates passing through the main tower of St. Stephen's Cathedral in Vienna. This cadastral system was effective for the following lands of the Austro-Hungarian Empire: Lower Austria, Moravia, Silesia and Dalmatia.

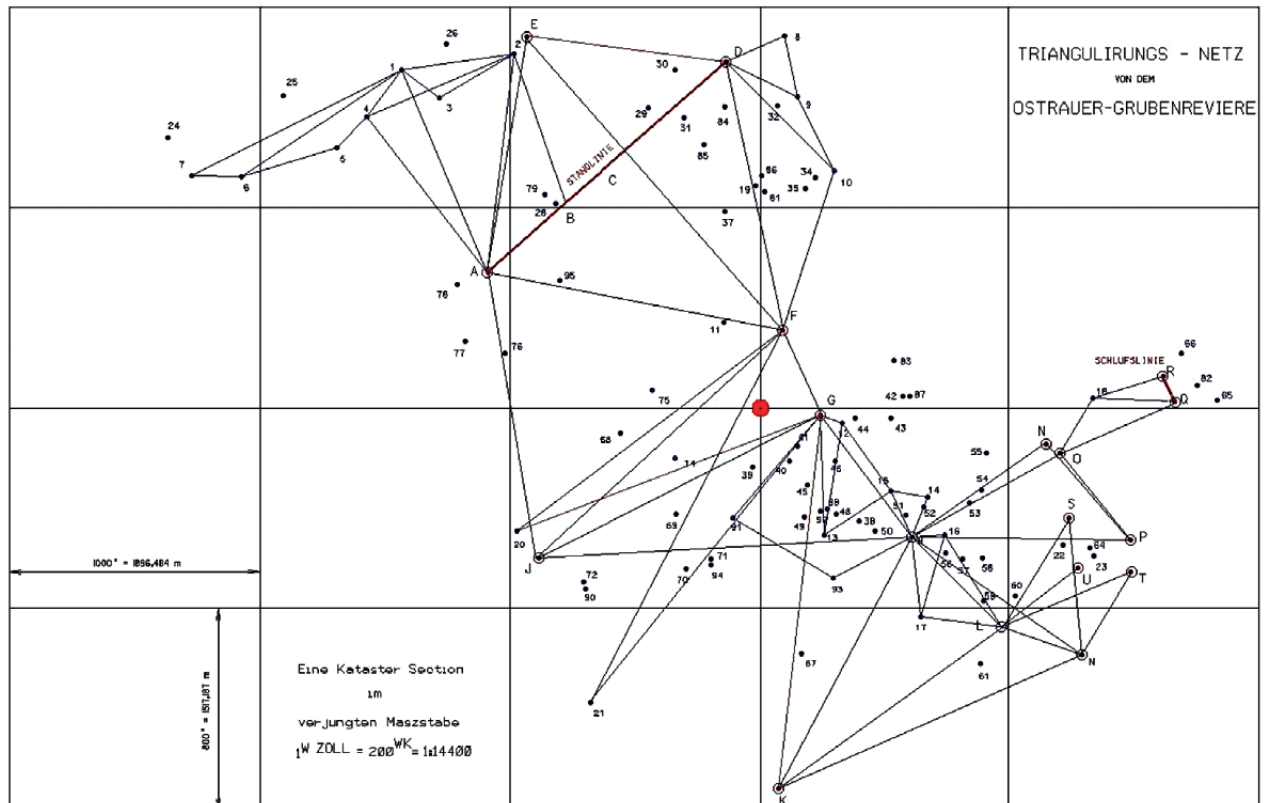


Fig. 3. Overall representation of Ott's triangulation in the OKR

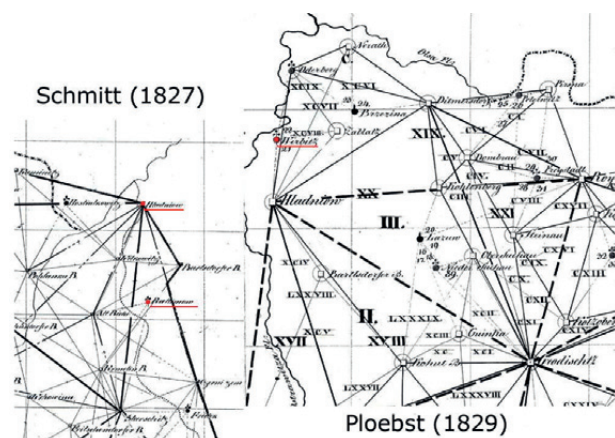


Fig. 4. Division of the Ostrava area into two parts for purposes of triangulation works in the stable cadastre system

The relationship between Ott's system of coordinates and the St. Stephen datum of cadastre coordinates is determined by the following linear transformation:

$$y = y_0 + Y' \cos \psi + X' \sin \psi,$$

$$x = x_0 + X' \cos \psi + Y' \sin \psi,$$

where $y_0 = -138443.332$ m, $x_0 = -183579.651$ m are the coordinates of the origin of Ott's system in the stable cadastre system; Y' , X' are the coordinates in the St. Stephen datum of cadastre coordinates and $\psi = 180^\circ$ is the angle between Ott's coordinate system meridian and the meridian of the St. Stephen datum of cadastre coordinates. More information about Stephen datum of cadastre coordinates can be found in (Staňková, Černota 2010).

2. Use of Ott's System of Coordinates in the Past

In later years, the "Ignát" mine (Šverma in present) in the municipality of Mariánské Hory, which belonged to the mining company Marie-Anne from Moravská Ostrava, was also integrated into Ott's system. The Eastern part of the OKR starting from Petřvald was not connected to Ott's system, and it was not subject to any homogeneous surveying. Almost all companies in this area carried out their own triangulation measurements and had a local coordinate system in which the coordinate axes were parallel to the St. Stephen datum of cadastre coordinates the mentioned local coordinate system originated in the midpoint or middle hauling ropes. The creation of Ott's triangulation network was motivated by the effort to build up common geodetic base points for measurements on the surface as well as for integration of mine underground and to eliminate discrepancies in mine boundaries between different owners.

Ott's triangulation was important for accurate georeferencing of mine fields bestowed by the state. This was executed in the following manner: the border stones of mine fields were surveyed, their coordinates were calculated, and other corners of mine measures and surpluses were determined therefrom with the use of lengths and directions defined in the demarcation protocols. The mine measure (§42, §46 in Imperial Patent, 1854) was an area in the shape of a rectangle with the surface of $45,116$ m² on the horizontal level of the gauge point. The gauge point (§45 in Imperial Patent, 1854) was a point from which the mine measure was measured and it had to be situated in an uncovered part of the deposit inside the mine field that was to be bestowed (the mining lease was an award of the right to extract assigned minerals). Each bestowed mine field had to be surveyed and landmarked on the surface according to the lease document and the measure position map one year after the conclusion of the lease at the latest. The executed land marking was reported in the so-called demarcation protocol in which each landmark position was described and plotted on the measure position map (§50 in Imperial Patent, 1854). The surplus (§71 in Imperial Patent, 1854) was an area enclosed with bestowed mine measures to which it was no longer possible to insert a whole mine measure. In case of new leases, the mine field corners were determined in coordinates; thus, a lengthy demarcation of bestowed mine fields pursuant to §64–§66 (in Imperial Patent 1854) could be eliminated. The demarcation lines, which defined the boundaries of the working face of different mining companies, were determined by the triangulation method. Thus, the required accuracy in demarcation of neighbouring mines boundaries was achieved.

The geodetic bases comprising points of Ott's triangulation were determined as entirely local systems. The integration of Ott's triangulation network into the cadastral triangulation was performed to define mutual relations between the St. Stephen datum of cadastre coordinates and Ott's system of coordinates which was necessary to demarcate the leases of mine measures and surpluses. These were plotted on cadastral maps in the scale of 1:2880.

3. Use and significance of Ott's system of coordinates in present day

Ott's system of coordinates also found its application in the present day; particularly during the land rehabilitation works, such as repairing the damages caused by coal mining in the OKR between 1996 and 1998.

The liquidation of mine outlets² in the Ostrava part of the OKR was performed in accordance with the Czech Mining Bureau regulation No. 52/1997 Coll., as amended (Decree No. 52/1997). The regulation stipulates the requirements to ensure the occupational safety and health of workers as well as operational safety during the liquidation of mine outlets leading to the surface and workings leading to outlets during mining and extracting of non-bestowed minerals underground. After the liquidation of these workings, a final report is drafted, its inseparable part being, among others, the passportization of mine outlets leading to the surface or approaching the surface. One element of the passportization is the record sheet of the mine outlet which must include apart from the name of the shaft (adit) also the X-axis and Y-axis coordinates of the shaft in the effective system of coordinates in accordance with Regulation No. 435/1992 Coll., as amended (Decree No. 435/1992). For the purposes of passportization, it was necessary to mark out the shaft mouths of all active and old mine outlets dating back to the period of the oldest mining activity in the terrain. The coordinates of old mine outlet positions were determined with the use of graphical transformation through identical points in the cadastre of lands and cadastre of real estate maps or with the use of linear transformation to the stable cadastre system and subsequently using the Helmert transformation to the Datum of Uniform Trigonometric Cadastral Network system. For safety reasons, after the determination and verification of the shaft mouth or adit position in the terrain (by geophysical measuring and drilling) an area was delimited on the surface, in which the mine weather could be rising and endanger people's lives or health because passportized mine outlets in the Ostrava part of the OKR rank among gassy coal mines with possible methane outlets to the surface.

For these purposes, the so-called Catalogues of Mine Shafts (or abandoned mine shafts and outlets with possible mine gas outlets to the surface) were compiled. These catalogues were drafted at the request of the OKD Company so that they can serve as a basis for resolution and stipulating adequate measures for individual old shafts pursuant to Art. 11 and 18 of the decree of the Czech Bureau of Mines No. 52/1997

Coll., on the Liquidation of Mine Outlets, i.e. in particular on measures of technical and safety-related, constructional, land planning and environmental character (Decree No. 52/1997). The mentioned catalogues were drafted by Jaroslav Klát (Mining research, consulting and environmental issues).

The objective of shaft catalogues was to draft an overview of old mine shafts which were liquidated or abandoned in the period of the oldest mining activity during the prospecting and exploratory stage and in the stage of drift mining which were situated in the territory of the mining area (Přívoz, Petřkovice, Slezská Ostrava, Vítkovice, Muglinov, Moravská Ostrava, Svinov, Michálkovice, Hrušov, Koblov etc.)

The purpose of prospective sinking was to find a workable seam in order to obtain a mine lease which would set the mineral rights. Some prospective shafts were later used during drift and underground mining. Drift mining took place within the first stage of the mining activity to extract the coal deposit placed superficially under the surface. In the next stage of mining, it was possible to open a more deeply placed coal deposit using the deep shafts (underground mining).

For the purposes of the catalogue drafting, all shafts were marked out in the terrain by means of graphical transformation through the cadastre of lands maps and the position of their mouths was also plotted to the draft. The demarcation outcome was plotted to the shaft situation and the demarcated place was photographically documented. In case of a depression documenting the shaft mouth in the terrain, its real position was marked with a flag pole.

The point of departure for all demarcation works was the documentation "Overview of Mine Workings with Mouths in the Ostrava Basin". The bases for the shaft demarcation were the plane coordinates Y and X of the shaft mouth midpoints stated for different shafts in the quoted overview. If the coordinates were unknown, the map of the cadastre of lands was used as a basis and subsequently the Y and X coordinates of individual shafts were determined by means of graphical transformation to the Datum of Uniform Trigonometric Cadastral Network system. The real position of shafts in the terrain could differ from the determined position up to 12 m.

Had the author of the catalogue known the coordinates of old mine shafts in Ott's system of coordinates, the accuracy would have been many times higher and the process less laborious. Data on the position of individual shafts comprise the content of Ott's study, including numbering.

² Mine outlet is a working leading to the surface. Mine outlets include test workings (blind shafts, chutes), opening workings (shafts, adits), air holes, drainage boreholes, exploitation wells and rescue holes. Prospecting wells and prospecting holes are not considered mine outlets.

Conclusion

A large number of Ott's original points of triangulation gradually disappeared because of new buildings, closures or reconstructions of surveyed shafts. By the same token, a number of these points ceased to be reliable due to the undermining of the area in which the points were situated; therefore, it was necessary to implant new points into Ott's network. Minor improvement for the mine surveying activity occurred with the state mapping carried out between 1889 and 1914 in the Western part of the coal district by surveying the municipalities of Slezská Ostrava, Moravská Ostrava, Vítkovice and Přívoz. A large number of new triangulation points integrated into Ott's system of coordinates was obtained as a result of the new mapping.

Ott's measurements were highly important for further surveying works undertaken in the Ostrava part of the OKR and the network was being used for more than 100 years (approximately until 1965).

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Research interest: cadastre of real estates, geodetic bases, technology GNSS, mining survey, cartography, adjustment calculation.

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Research interest: cadastre of real estates, geodetic bases, cadastral mapping, mining survey, magnetic measurement in mining survey, cartography of mining surveys.