The Cadastral Map Correction in an Undermined Cadastral Area

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Abstract

This article deals with the possibilities of cadastral map correction in an undermined area. The cadastral area of Muglinov in the municipality of Ostrava was chosen as a model area. The problem of inaccuracy of maps is caused by the influence of undermining and historical development.

From the technical point of view, the way of correction consisting in surveying a larger number of identical points, using the coordinates of the position of the change points from the period after the withdrawal of mining influences and transformation by blocks using Jung's up-transformation in the way used in the restoration of the cadastral register by reworking seems to be feasible and provides good results.

Keywords: *cadastral map correction, undermining, identical points, transformation*

Introduction

When considering the solution for the correction of the cadastral map in the cadastral district of Muglinov, it is necessary to assess and realize not only how the maps were created in the cadastral district of Muglinov but also in the surrounding cadastral districts, according to [1], triangulation work in Ostrava was started as early as 1924 and continued in 1927, when triangulation points of the second to fourth order were determined. In 1926, Professor Semerád carried out triangulation in the east of the Ostrava Region for Orlová and Karviná, and in 1932, this was extended to include the so-called district triangulation, which was carried out by the then measurement authorities. Both of these triangulations were taken over by the former triangulation office of the Ministry of Finance. The triangulation work was then continued in 1935 and in 1941 and 1942 when triangulation to the fifth order was carried out in the entire Ostrava headland, which was then formed by the borders of the Protectorate of Bohemia and Moravia.

When calculating the coordinates of the triangulation points, inconsistencies in the coordinates of the given triangulation points were detected, making the calculations difficult. The cause of these discrepancies was, therefore, sought, and it was found that the orientations made on the triangulation points showed large deviations, which suggested movements of these points and, therefore, movements of the soil. The magnitude of the movements and their direction were explained in detail by Ing. Vladimír Forman in [2].

In 1949, it was decided that a new triangulation would be carried out in the areas where Professor Semerád's triangulation (1926) and the district triangulation (1932) had been carried out because it was in these areas that the greatest surface displacement was observed.

The trigonometric network was newly spread over the area at a distance of triangulation points averaging 2 km. This removed the deficiency of the 1926 grid, where 500 m long sides were interspersed with sides of several kilometres. The original triangulation points were preserved in the landscape and in the triangulation documentation, as the polygon measurements were linked to them. The new triangulation points were numbered with connecting numbers, and new triangulation sheets were created for them. The triangulation network in the western part of the Ostrava Basin was rebuilt in a similar way in 1950.

As can be seen from [1], in 1950, the whole of the then Ostrava-Karviná Coalfield was newly triangulated since triangulations were originally carried out in this area in 1924, 1929, 1932, 1935, 1944, and 1949, as already described above, and these lacked any internal connection with each other. It was found that after the alignment of the triangulation points, the mean error of the alignment increased on average by 62%, which was due to the fact that the original network, as mentioned above, was built in 6 stages between 1924 and 1949 using disparate bases, often independent of each other and with different accuracy; these triangulations were carried out by several offices, which were taken over into a single trigonometric network from 1927 onwards and recalculated in it.

According to [2], the triangulations had different densities of points, and the position of these points was changed

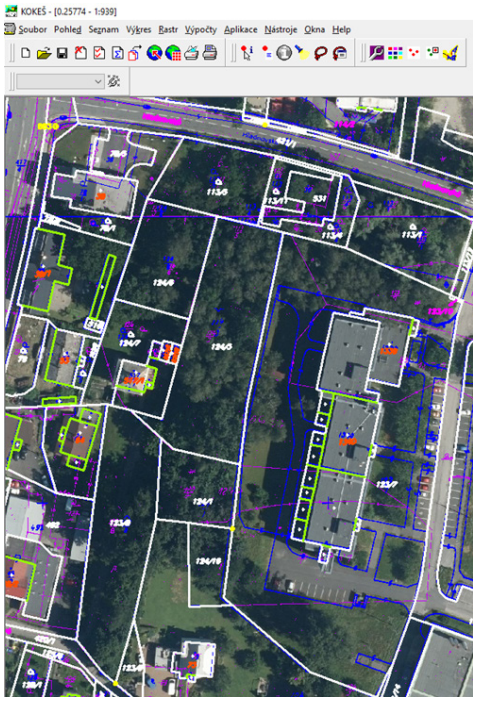

Fig. 1. Comparison of the land cadastre map, DCM from 1997 and current digital map. Legend: Purple grid: land cadastre from 1942; Blue grid: cadastral map (as of 1998); Vector drawing (contemporary digital map)

Rys. 1. Porównanie mapy katastralnej 1942 r. z aktualnym stanem (DCM od 1997 r.). Legenda: Siatka fioletowa: kataster gruntów z 1942 r.; Niebieska siatka: mapa katastralna (stan na 1998 r.); Rysunek wektorowy (współczesna mapa cyfrowa)

by subsequent undermining; some were completely lost, and others had to be relocated due to mining or construction activities, which affected their accuracy. For example, one triangulation point was relocated twice – once because of the expansion of a spoil heap and the second time because of the high-voltage lines. It was relocated by up to 250 m, with a deviation of 10 cm at this new location. Therefore, the triangulation was carried out again in 1944, but only in the territory of the so-called Protectorate of Bohemia and Moravia. However, the cadastral districts of Muglinov, Hrušov, and Heřmanice were already part of the so-called German Reich, not the Protectorate; therefore, the new triangulation was not carried out in these cadastral districts in 1944. It can, therefore, be concluded that these are cadastral districts with similar historical development, and the correction of the cadastral maps should be carried out in these cadastral districts using the same method.

Map development in the Muglinov cadastral district and surrounding cadastral districts

The Muglinov cadastral district

The map at a scale of 1:2880, St. Stephen's coordinate system, created in 1836

The map at a scale of 1:2000, according to Instruction A, created in 1942

The EN map at a scale of 1:2000, as a result of the reambulation, created in 1972

The map at a scale of 1:1000, DCM (hereinafter also referred to as the digital cadastral map), created in 2000

The Hrušov cadastral district

The map at a scale of 1:2880, St. Stephen's coordinate system, created in 1836

The map at a scale of 1:1000, according to Instruction A, created in 1934

The map at a scale of 1:1000, DCM, created in 2000

The Heřmanice cadastral district

The map at a scale of 1:2880, St. Stephen's coordinate system, created in 1836

The map at a scale of 1:2000, according to Instruction A, created in 1946

The map at a scale of 1:2000, created in 1972

The map at a scale of 1:1000, DCM, created in 2003

The technicians thus measured continuously in these cadastral districts in the field only during the creation of the map, according to Instruction A, i.e. in the years 1934–1946, after which the actual field measurements were not carried out during the reworking of the maps.

From the above, it can be further stated that the cadastral boundary between the cadastral district designated for the cadastral map correction, i.e. Muglinov, and the cadastral district of Slezská Ostrava, Moravská Ostrava and Přívoz is more accurate, since in these three cadastral districts, the DCM was created only in 2010, 2014, and 2016 in a procedure that considers the specifics of the territory more. This fact will have to be further taken into account when implementing the map correction using the transformation.

Correcting the map

The reasons for the correction of the cadastral map in the cadastral district of Muglinov are mainly due to the fact that this cadastral district is located in the territory of undermining, i.e. in the territory of mining activity. During the preparation of the district cadastral map in 2000, the surveyed

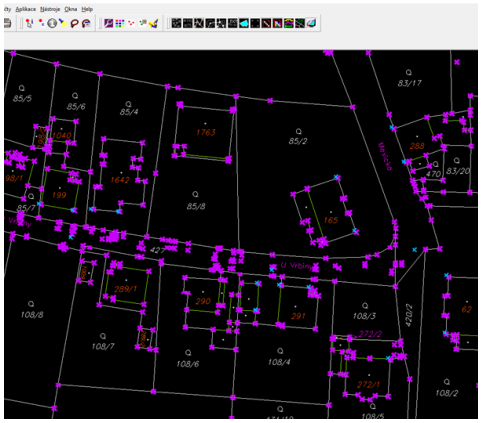

Fig. 2. Comparison of DCM points and newly located identical points
Rys. 2. Porównanie punktów DCM i nowych ich lokalizacji

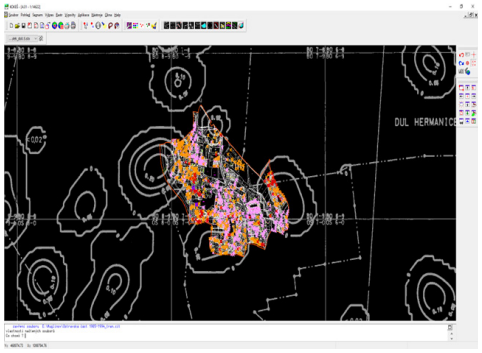

Fig. 3. Subsidence contour lines
Rys. 3. Warstwice osiadań terenu

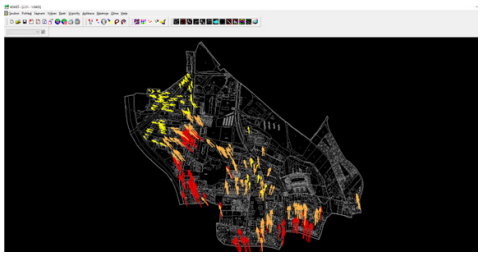

Fig. 4 The DCM after transformation
Rys. 4. DCM po transformacji

points originating from the long-term maintenance of the cadastral map and the map of the real estate registration, as well as from the maintenance of the analogue cadastral map, were used. However, 22 years have elapsed since the creation of the DCM, during which time these points have shifted due to undermining. In view of this fact, the result of the field measurements (position coordinates) does not currently correspond to the current DCM (image coordinates). The question was what approach should be taken to limit the further increase in the number of points for which different image and position coordinates are registered in the cadastre of real estate.

Legislative framework

Therefore, we first dealt with the possibility of modifying the current legislation, namely the search for an economically acceptable way to improve the conditions of cadastral map keeping in the areas affected by the deep mining of coal deposits. Deep mining is associated with mining damages and has an impact on the surface. These effects continue to reverberate for some time after the end of mining., according to the materials available to us from the Czech Mining Authority, all mining areas in the Ostrava part of the Coalfield have now been closed. Since the 1930s and 1940s, problems with the stability of points in the trigonometric network in the Ostrava Region have been described in specialist journals. Similarly, the land cadastre maps that were created in this period as a result of the new mapping, according to Instruction A were also affected. These are influenced by two factors: firstly, the inhomogeneity of the original trigonometric network and detailed position point field from the time of the map's creation with today's latest realisation of the trigonometric network from the late 1980s and early 1990s, and secondly, local movements due to the formation of subsidence basins.

Unfortunately, at present, the existing legislation on these possibilities is very scarce. The only regulation is found in [3] prov. § 95 "Areas in which, due to human or natural activities,

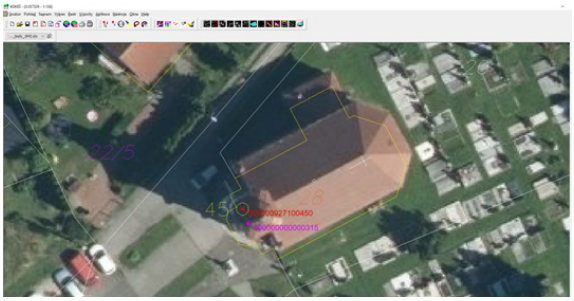

Fig. 5. The church in Heřmanic
Rys. 5. Kościół w Heřmanicach

Fig. 6. Comparison: Points from 1942 are marked in purple, and the basic point field is in red
Rys. 6. Porównanie: Kolorem fioletowym zaznaczono punkty z 1942 r., kolorem czerwonym zaznaczono podstawowe pole punktów

for example by undermining or landslide, there are shifts in the terrain that make it impossible to comply with the accuracy of the cadastral map established by this decree, shall be announced by the Cadastral Office and published by the Office on its website. In these areas, when marking the changes, the homogeneity of the detailed geometric basis shall be checked on selected identical points."

However, this single provision alone is currently insufficient for further consideration or work on remedial mapping in undermined areas and would need to be amended. It does not take into account the fact that mining has now ceased in most areas; some areas have long since calmed down, so it would be possible to correct or start correcting the existing maps in these areas.

The problem is, therefore, the legislative framework for the solution. Although it is obvious that the optimal option would be the gradual renewal of the documentation by new mapping, it would be very difficult to implement the gradual renewal of the documentation by new mapping in 60 cadastral districts of urban and industrial character. This would require a significant increase in the capacity of the Cadastral Office or the allocation of substantial resources for this work.

It was, therefore, proposed to amend Section 95 [3], which should read as follows:

§ 95

(1) Areas in which, due to human or natural activity, for example, by undermining or landslide, there are shifts in the terrain that make it impossible to comply with the accuracy of the cadastral map established by this Decree, shall be declared by the Cadastral Office and published by the Office on its website. In these areas, when marking the changes, the homogeneity of the geometric basis of the detailed measurement with the cadastral map position is checked at selected identical points.

The following paragraph (2) is inserted after paragraph (1):

(2) "In areas where displacements caused by human activity have already ceased, i.e., for example, the receding of mining influences, the Cadastral office may check the homogeneity of the cadastral map with the geodetic foundations using GNSS technology and a network of permanent stations. In the event of failure to meet the accuracy criterion referred to in point 13.7 of the Annex to this Decree at the control measurement points, the Cadastral Office may correct the cadastral map by means of transformation."

However, this proposed amendment has not yet been implemented.

Work procedure for cadastral map correction in the Muglinov cadastral district

At present, within the revision of the cadastre of real estate in the Muglinov cadastral district, we have worked on the correction of the DCM in this cadastral district and in the neighbouring similarly affected cadastral districts, i.e. the cadastral districts of Hrušov and Heřmanice. From the technical point of view, the way consisting in surveying a larger number of identical points, using the position coordinates for the change points from the period after the withdrawal of mining influences and transformation by blocks using Jung's re-transformation in the way used in the restoration of the cadastral documentation by reworking the fathom maps seems to be feasible and provides good results. With an appropriate choice of blocks, only minor changes in the areas occur, corresponding to the fact that the existing DCM contains double coordinates for most points.

In the first phase, the technical department of the Cadastral Office for the Moravian-Silesian Region (hereinafter referred to as the "TD") surveyed a total of 1,030 points in the record of detailed changes surveying (hereinafter referred to

as the "RDCS") No. 2827,, according to the selection made by our workplace, i.e. the Ostrava Cadastral Workplace (hereinafter referred to as the "Ostrava KW"), thus obtaining identical survey points.

DCM map – purple points, blue points targeted in the RDCS No. 2827 by TD, the measurements show that the identical survey points (blue) show significant deviations from the display of the corresponding points in the DCM from 2000.

By successively selecting points from the original 1030, we ensured the exclusion of points that would cause deformation, points with a large deviation in the key, points with a significant deviation between the point focused in the RDCS and the point in the DCM, some points could not be correctly identified.

The individual deviations were colour-coded, according to the resolution given above, and then the subsidence contour lines were plotted on the map, with the expectation that the magnitude of the deviations would correspond to the subsidence magnitude, confirming the hypothesis that the magnitude of the deviation is dependent on the subsidence magnitude. However, this idea was not validated in practice.

Comparison of the DCM map position results after similarity and affine transformation.

In view of the similar direction of the arrows of deviation, the question arises whether there is any systemic influence in the cadastral district.

In order to assess the impact of the redetermination of the system of the unified trigonometric cadastral network (S-JTSK), the evolution of S-JTSK coordinates was requested from the Land Surveyor's Office at least from the period 1930–1950, then 1960–1975, before the renewal of the trigonometric network and after its renewal in 1990 for seven points.

The point of the basic geodetic control (BGC) No. 45 should correctly lie in the middle of the church (in the so-called "poppy head" of the church); however, on the given DCM, it does not lie there, it is displaced. This fact probably has its historical origin in the period of World War II, when the cadastral district of Moravská Ostrava belonged to the countries of the so-called Protectorate of Bohemia and Moravia, whereas the cadastral districts of Muglinov, Hrušov and Heřmanice were already part of the so-called German Empire, not the Protectorate of Bohemia and Moravia. Therefore, a new triangulation was carried out in these cadastral districts in 1944.

As was already mentioned, during the triangulation process, this was not interconnected between the neighbouring cadastral districts, i.e. Moravská Ostrava was not interconnected with the surroundings, the triangulation was not correct, short and long sides were alternated, and many inaccuracies were created. The triangulation on the edges of the cadastral district had worse accuracy.

Since Heřmanice was a so-called living area, the completion and redetermination of the fundamental horizontal control was completed here in 1990. In the creation of the DCM by reworking the analogue map made, according to Instruction A, the original detailed horizontal control linked to the trigonometric network from the 1940s was used. The basic geodetic control is then taken from the current database of the Land Surveyor's Office. In this case, it is a new triangulation point surveying completed in 1990. The example of the point described above documents the reliability of the DCM created using the original data without modifying it to be homogeneous with today's geodetic control.

Due to the nature of the territory, it is not possible to use the method of correction used previously in other territories, i.e. to find a larger number of preserved original polygon points from the time of mapping, according to Instruction A and to re-survey them, since they are not preserved in the territory.

The source points were the coordinates from the 1940s, and the target points were today's ones – the basic geodetic control. The base point of the geodetic control in the current map is located at the edge of the church, not in the middle of the church's poppy head because nobody took care of it during the digitisation. The geodetic control of the time of the original map was used for the whole reworking, i.e. according to instruction A. From the above, it follows that the current DCM is not correct with S-JTSK.

Therefore, another transformation was carried out using 7 triangulation points in the cadastral district of Heřmanice from 1942.

The displacement between the points alone is 1.85m. This transformation confirms the assumption that the current point of the detailed geodetic control, which was given by the post-1990 coordinates, actually lies off-centre of the church because the entire DCM was reworked based on the basis of the creation of the land cadastre map in 1942. The above image shows that the given DCM map in the cadastral district of Heřmanice after this transformation to only 7 points corresponds better to the current orthophoto.

Conclusion

In conclusion, it can be stated that during the preparation of this article, a search was carried out in professional journals from the 1930s to the present day, mainly using the Geoportal of the Land Surveyor's Office, but there are not many articles on this topic.

This article focuses mainly on the problems of the geodetic basis, and the findings presented in it will be furthermore a basis for the work on map correction in the undermined area, especially in the selection of blocks for correction, selection of identical points or selection of the transformation method.

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3. Decree No. 357/2013 Coll., on the Cadastre of Real Estate (Cadastral Decree)

Korekta map katastralnych na obszarze po eksploatacji górniczej

W artykule omówiono możliwości korekty mapy katastralnej na terenie pogórniczym. Jako obszar modelowy wybrano obszar katastralny Muglinov w gminie Ostrawa. Problem niedokładności map wynika z wpływu podziemnej eksploatacji górniczej i rozwoju historycznego.

Z technicznego punktu widzenia sposób korekcji, polegający na pomiarze większej liczby identycznych punktów, wykorzystaniu współrzędnych położenia punktów przemieszczonych z okresu po ustąpieniu wpływów górniczych i przekształceniu blokami z wykorzystaniem transformacji Junga, w sposób zastosowany przy przywracaniu rejestru katastralnego poprzez przetworzenie wydaje się wykonalny i daje dobre rezultaty.

Słowa kluczowe *korekta mapy katastralnej, tereny pogórnicze, punkty identyczne, transformacja*