SEARCHING FOR OLD MINE WORKINGS THROUGH THE USE OF HANDHELD GNSS RECEIVERS

VYHLEDÁVÁNÍ STARÝCH DŮLNÍCH DĚL POMOCÍ RUČNÍ APARATURY GNSS

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Abstract

Old mine workings situated in a landscape pose a very serious problem from the point of view of people security and property protection. For that reason it is necessary to look for these mine workings and liquidate them. The use of handheld GNSS receivers is one of alternative methods of searching for old mine workings. The accuracy of handheld GNSS receives does not reach the level of accuracy of geodetic apparatuses, but it is sufficient for the purpose of searching for locations of old mine workings as is clear from the considerations given in this article. The test was performed at points of fundamental geodetic control.

Abstrakt

Obsahem článku je test polohové přesnosti ruční aparatury GNSS. Využití této aparatury může být jednou z alternativ pro vyhledávání starých a opuštěných důlních děl, které se nacházejí v hojném počtu na území České republiky a jsou problémem z hlediska bezpečnosti lidí a ochrany majetku. Přesnost ručních souprav GNSS nedosahuje úrovně geodetických aparatur, ale pro účely vyhledávání starých důlních děl je dostačující, jak vyplývá z následujících úvah, uvedených v tomto článku. Test byl proveden na bodech základního polohového bodového pole.

Key words: handheld GNSS receiver, old mine workings, positional accuracy, people security, property protection.

1 INTRODUCTION

A negative phenomenon accompanying mining activities in the CR is a large number of open old mines, immediately or potentially endangering the lives and health of visitors of the landscape or property (Kočandrle, Tyrner, 1998).

According to Act No. 44/1988 Coll., on Protection and Utilization of Mineral Resources (Mining Act) an old mine working is such an abandoned underground mine working or abandoned quarry, whose original operator or legal representative does not exist or is not known.

In the course of time in old and abandoned mine workings a gradual loss of stability occurs, which is a function of physical and mechanical and deformable properties of rock mass and the depth of mine working below the surface. Exceeding the ultimate strength of overlying rocks gradually leads to a cave-in of mine working, which may become apparent only on the surface in the form of a subsidence trough, break lines or the reopening of the old mine working (Kočandrle, Tyrner, 1998). An example of such an old mine working is shown in Fig. 1 below. This is the Mariahilf location - Pit 5, which is situated in the immediate vicinity of the Church of Saint Virgin Mary in the cadastral area of Zlaté Hory about 50 meters on the southern slope below the church.

Fig.1 Mariahilf Location - Pit 5

The Geofond carries out a function of an archive, documentation and study centre of the state geological survey in the Czech Republic as a legal entity authorized by the Ministry of the Environment (Act No. 44/1988 Coll.) and keeps the register of old mine workings, which includes:

- records of old mine workings, or their files,
- file documentation to the records,
- synoptic maps of old mine workings occurrences or their files.

In order to keep old, or abandoned mine workings recorded, it is necessary to carry out their review in situ with the aim to determine their current situation, assess the degree of threat to life, health or property related to the existence of these mine workings and propose a method of their disposal and securing. For this reason, the surveying, geological, mining and technical documentation is looked for either in the archive of the Geofond or in the State Archives, and then based on this documentation available the terrain reconnaissance is carried out and such an old mine working is searched out.

2 HANDHELD GNSS RECEIVER TEST

One of the possible methods for finding old and abandoned mine workings can be the use of a handheld GNSS receiver. To get an idea of how quality data can be obtained by means of the handheld device, a little test was made whose results are presented in this article. The positional accuracy was verified at points of fundamental geodetic control (FGC). The test points were chosen to represent the searching for places both in an exposed terrain and in forests, where a large part of old and abandoned mine workings is located. In the test, the points were first checked for damage or deterioration.

The test was conducted through the use of the Navilock BT-338 antenna with the HP Ipaq hx4700 pocket PC. The antenna by the Navilock company is equipped with the 20-channel SiRFStar III chipset. The signal from the satellites is received on the L_1 frequency in C/A codes. The pocket PC is equipped with a 4" touch screen with a resolution of 640 x 480 pixels (VGA) and an internal memory of 128 MB not allowing sufficient comfort to work with a map, therefore the pocket PC has been extended by an 2GB memory card.

The antenna of the hand-held GNSS device was placed in the middle of the stone surface of a FGC point and within one minute the current receiver location was saved in the DziExplorer CE programme. In this way, the geographic coordinates were obtained at each selected point of FGC. Furthermore, the data on the point height, measurement time, number of satellites and HDOP data were recorded. For a covered or otherwise shielded point the horizon line was plotted (Fig. 3). The geographic coordinates obtained at all test points were transformed into S-JTSK using the Leica Geo Office software and compared with the valid coordinates. Fig. 2 shows an example of a test point with a positioned GNSS receiver.

Fig.2 Trigonometric point on Velký Kosíř

For the test of positional accuracy, the differences of coordinates in meters were calculated

$$\Delta x = x_m - x_k \ ; \ \Delta y = y_m - y_k \qquad (1)$$

where:

x_m, y_m are the resulting coordinates of FGC points determined by the hand-held GNSS receiver [m],

x_k, y_k are valid coordinates of the same point of FGC [m].

When assessing individual points the positional variation *Ap* was calculated in meters according to the relation

$$\Delta p = \sqrt{\Delta x^2 + \Delta y^2} \qquad (2)$$

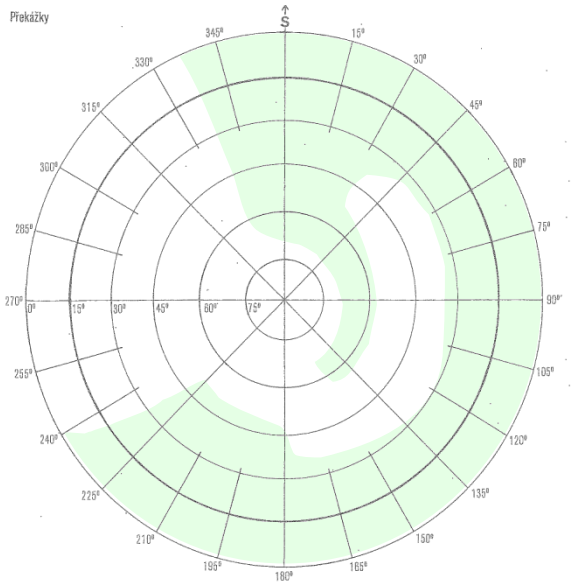
The results obtained in the test are shown in Tab. 1 and 2.

Geodetic data			
point number	**Y**	**X**	**elevation (Bpv)**
3408-19	561286.79	1125131.43	441.91

Measurement					
φ	**λ**	**H (elips.)**	**time**	**number of satellites**	**HDOP**
49° 32' 54,172"	17° 03' 42,606"	410	14:28	8	1

Conversion to S-JTSK		
Y	**X**	**elevation (Bpv)**
561279.69	1125126.47	366.13

Δy	**Δx**	**Δp**
7.10	4.96	8.66



Note: mixed forest around

Fig. 3 Records of the situation at points

Tab.1 Coordinate values and deviations obtained in the test at unshielded points

point	measured coordinates		valid coordinates				
	y_m [m]	x_m [m]	y_p [m]	x_p [m]	Δy [m]	Δx [m]	Δ_p [m]
3402-10	555657.01	1113285.77	555658.40	1113288.15	-1.39	-2.38	2.76
3402-7	554176.21	1112074.73	554178.38	1112078.05	-2.17	-3.32	3.97
3401-35	550877.13	1109411.58	550878.58	1109411.18	-1.45	0.40	1.50
3408-7	561057.48	1121910.92	561059.34	1121911.11	-1.86	-0.19	1.87
3403-14	550006.58	1123721.24	550006.20	1123720.62	0.38	0.629	0.73
3402-15	552371.66	1114899.65	552372.58	1114900.33	-0.92	-0.68	1.14
3402-203	552626.67	1115772.80	552627.63	1115774.22	-0.96	-1.42	1.71
3402-31	551960.61	1119207.42	551962.07	1119209.73	-1.46	-2.31	2.73
3407-49	564255.85	1111889.68	564257.41	1111891.34	-1.56	-1.66	2.28

Tab. 2 Coordinate values and deviations obtained in the test at shielded points

point	measured coordinates		valid coordinates				
	$\mathbf{y}_m$ [m]	$\mathbf{x}_m$ [m]	$\mathbf{y}_p$ [m]	$\mathbf{x}_p$ [m]	Δy [m]	Δx [m]	$\mathbf{\Delta_p}$ [m]
3401-28	553412.97	1107166.93	553414.02	1107163.89	-1.05	3.04	3.22
3406-33	564905.33	1109555.67	564907.69	1109549.90	-2.36	5.77	6.23
3406-34	563279.70	1109304.85	563279.41	1109307.74	0.29	-2.89	2.90
3407-3	566550.10	1111668.69	566551.33	1111671.82	-1.23	-3.13	3.36
3407-27	564105.26	1117347.19	564109.63	1117355.53	-4.37	-8.34	9.42
3407-30	562107.32	1118945.87	562107.46	1118953.61	-0.14	-7.74	7.74
3408-19	561279.69	1125126.47	561286.79	1125131.43	-7.10	-4.96	8.66
3402-13	551478.34	1113385.02	551479.81	1113387.33	-1.47	-2.31	2.74
3403-19	553358.88	1124748.73	553356.90	1124755.91	1.98	-7.18	7.45

3 CONCLUSION

The issues of old and abandoned mine workings is still up to date. To protect property, and especially security of people, mine workings must be searched for and secured. From the data of the Geofond the appropriate documents are obtained, however even with these details it is often difficult to find the workings in situ. Therefore, as one of the alternatives, provided the old mine working position is known, obtained on the basis of the preserved documentation, the use of a hand-held GNSS receiver was selected.

In the test which was carried out to verify the accuracy of obtained positions through the use of a hand-held GNSS receiver, the facts resulting from the tables above were obtained. Under ideal conditions represented by unshielded points, a deviation of 1 to 4 meters between the current coordinates and the S-JTSK coordinates determined through the use of the handheld GNSS receiver is achieved. In case of points shielded partially or completely by vegetation or other obstacles the value ranges up to 10 meters. In both cases we get into the immediate vicinity of an old and abandoned mine working and that is then easy to find. To ensure the documentation on safeguarding these mine workings, the nearest neighbourhood of the workings is then surveyed and graphically processed and photographs of the state before and after their safeguarding are taken.

REFERENCES

[1] Kočandrle, J., Tyrner, M. : Old (abandoned) mines in Jeseníky Proceedings of the 6th surveying conference in Malenovice, 1998

[2] Act No. 44/1992 Coll.

[3] GPS-Antenna BT-338 Bluetooth „NaviLock“

RESUMÉ

Četnost starých a opuštěných důlních děl na území České republiky je velká a představují problém z hlediska ochrany majetku a bezpečnosti lidí. Stará a opuštěná důlní díla jsou evidována v Geofondu, který je archívem, dokumentačním a studijním centrem, a v němž lze nalézt informace nezbytné pro nalezení a následnou likvidaci tohoto nebezpečného pozůstatku dřívější hornické činnosti.

Pro snadnější a rychlejší vyhledávání starých a opuštěných důlních děl lze využít, jako jeden z možných způsobů, ruční aparaturu GNSS. Aby se zjistilo, jak přesně určí tato aparatura polohu, byl proveden test konkrétní ruční aparatury GNSS na známých bodech. Zvoleny byly body základního polohového bodového pole stabilizovány na různých místech s ohledem na prostředí, ve kterém se nacházejí stará a opuštěná důlní díla.

Test byl proveden aparaturou GNSS s anténou NaviLock BT 338, která byla vždy položena na střed kamene stabilizace příslušného bodu. Poloha, určená touto aparaturou v S-JTSK, byla porovnána se souřadnicemi daného bodu uvedenými v geodetických údajích. Z výsledků testu, vyplynulo, že na bodech stíněných porostem je přesnost určení polohy do 10 m, zatímco v případě, kdy na bodech nebyly žádné překážky pro signál, byla dosažená přesnost v určení polohy do 4 m. V obou případech přesnost určení polohy vyhovuje vyhledávání starých a opuštěných důlních děl. Dostaneme se totiž do blízkosti těchto objektů a jejich nalezení i v nepřehledném terénu již není tak obtížné.