Acta Montanistica Slovaca
ISSN 1335-1788
actamont.tuke.sk

Possibilities of exploitation of graphite deposit in the Czech republic

Vlastimil HUDEČEK[1], Jindřich ŠANCER[2] and Václav ZUBÍČEK[3]*

Authors' affiliations and addresses:
[1]VŠB – Technical University of Ostrava, Faculty of Mining and Geology, 17. listopadu Ostrava Poruba, 708 33, Czech Republic

[2] VŠB – Technical University of Ostrava, Faculty of Mining and Geology, 17. listopadu Ostrava Poruba, 708 33, Czech Republic

[3] VŠB – Technical University of Ostrava, Faculty of Mining and Geology, 17. listopadu Ostrava Poruba, 708 33, Czech Republic

***Correspondence:**
Václav Zubíček, Faculty of Mining and Geology, 17. Listopadu, Ostrava Poruba, 708 33, Czech Republic
e-mail: vaclav.zubicek@vsb.cz.

Funding information:
Technology Agency of the Czech Republic (TA CR)
Grant Number TE02000029

How to cite this article:
Hudeček, V., Šancer, J. and Zubíček, V. (2023). Possibilities of exploitation of graphite deposit in the Czech republic. *Acta Montanistica Slovaca*, Volume 28 (1), 191-200.

DOI:
https://doi.org/10.46544/AMS.v28i1.15

Abstract
This article deals with mining technical proposals for the renewal of graphite raw material mining in the immediate vicinity of the town of Český Krumlov, where there are three sub-locations called Městský Vrch, Lazec-Křenov and Bíca. These sites are significant in terms of the quantity of natural graphite reserves, a raw material listed as a critical raw material by the EU. This list is regularly updated to reflect changing economic importance and supply challenges based on industrial availability. The article describes possible alternatives for the resumption of graphite mining in the Český Krumlov deposit (Městský Vrch and Lazec – Křenov localities). It describes the initial situation at the Český Krumlov deposit after the end of mining and the alternatives for the design of opening and mining operations. The authors conclude by comparing the advantages and disadvantages of the proposed alternatives.

Keywords
Graphite, Underground Mining Method Selection, Mine opening.

Introduction

Within the framework of the Technology Agency of the Czech Republic (TA CR) national project "Competence Centre for Effective and Ecological Mining of Mineral Resources", the knowledge of potential sources of critical raw materials in the Czech Republic was processed. The project showed that one of the promising locations in the Czech Republic was the Český Krumlov locality, specifically graphite deposits in the areas of Městský vrch, Lazec and Bíca (Collective of authors, 2017).

From the study of the research materials (Tichý, 1984; Kadounová, 1987; Geoindustria, 1964) and operational descends into mines at the above-mentioned localities, it was found that there are recoverable graphite reserves in this area, which are also accessible by mine workings from previous mining. Rock samples were taken at the concerned locality to determine the basic physical and mechanical properties of the rocks, focusing on properties related primarily to the treatment of the graphite raw material and the selection of an appropriate mining method. Due to the fact that the majority of the deposit is located in the Blanský les Protected Landscape Area, in addition to the proximity of UNESCO-protected monuments, it is improbable that the original mining method (directional descending mining by means of sublevel caving) would be applicable for future mining. It is a caving method with significant surface effects. For this reason, the project focused on selecting a new, suitable mining method that would be potentially applicable to the deposit. The mining method was selected using tools used in foreign countries (Boshkov & Wright, 1973; Morrison, 1976; Nicholas, 1981; Hartman, 1987). The most suitable mining method for the Český Krumlov site was selected Cut and Fill Stoping.

Material and Methods

1. Historical mining and current status

The research materials showed that there is still a relatively large amount of recoverable graphite reserves on the locality, which can be divided into three locations, namely Městský vrch, Lazec and Bíca, which are interconnected by the main crosscut and accessible from the Městský vrch site.

A search of the materials showed that although the individual localities are interconnected by the main crosscut, the state of reserves, readiness for mining and geological conditions differ. A brief description of each area in relation to choosing the appropriate mining method will be given in the following subsections.

1.1 Městský vrch locality

The deposit is located in the vicinity of the town of Český Krumlov at the southern foot and slope of Městský vrch (567 m above sea level) and is accessed by an adit (the Krumlov Mine), located at the foot of the valley south of the deposit at 495.08 m above sea level. Mining at the Městský vrch deposit has been going on since 1975. The main mining method was directional descending shortwall slice mining. After the privatisation of the separate part of the state-owned enterprise Rudné doly Příbram in 1992, an independent enterprise Grafit Netolice was established, which continued to mine the already open deposits. However, no new advances, openings or further exploration took place.

By the end of the 1990s, basically, only the open stopes were extracted, and, given the prices of imported raw material from abroad, mining gradually became uneconomical, and it was decided to close the mine. The deposit was closed in 2003. In 2011, in accordance with the approved liquidation plan (the District Mining Authority in Příbram), the company FONSUS první těžební, a.s. liquidated the main mine workings and thus ended all mining activities at the mine. However, a part of the mine is now open to the public and serves as a museum. In view of this fact, rock samples could be taken from the concerned locality (see Figure 1), and an in situ survey of the deposit was carried out. This survey showed that almost all of the graphite reserves accessed by the main crosscut (Krumlov horizon) had been mined in the locality.

Therefore, the majority of the graphite reserves are located below the existing adit horizon, and a new development mine working would be required to access them. Either a new mine working from the surface would be considered, or a development raise would be driven from the existing crosscut.

The current reserve of graphite at the Městský vrch deposit, taken from the Geo(MoE)V3-01 report, is 1472 thousand tonnes of graphite. However, the residual reserves have been written off based on the decision of the Ministry of Industry and Trade in Prague No. 771/2013/31100. According to this decision, 178 thousand tonnes of balance explored free, 37 thousand tonnes of balance explored fixed, and 1,435 thousand tonnes of balance explored free reserves were transferred to non-balance reserves.

However, the above-mentioned decision of the Regional Office in Pilsen did not lead to the cancellation of the Protected Deposit Area Český Krumlov No. 14780000.

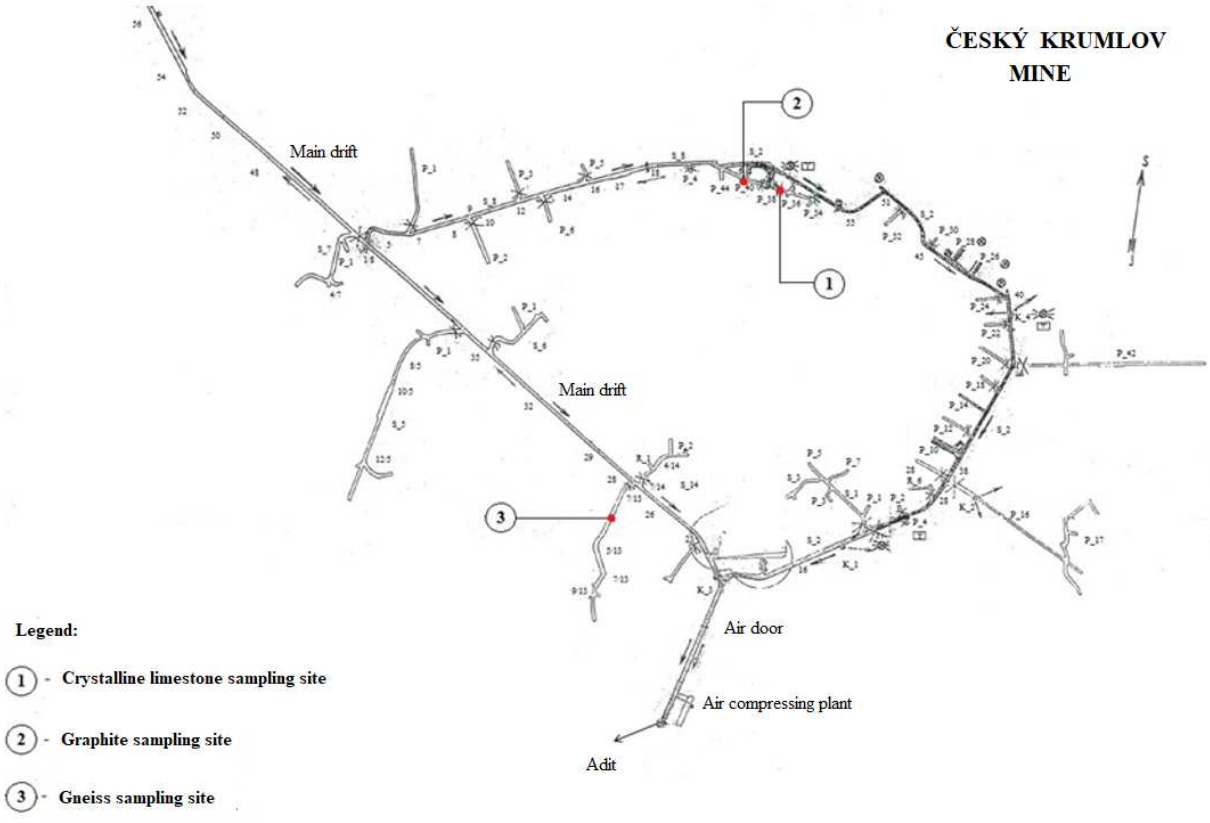

Figure 1. *Diagram of the main opening and preparatory mine workings of the Krumlov - Městský vrch Mine (Kadounová, 1987)*

The deposit area has a very complex geological structure. The average inclination of the deposit is 35° to the NW, and the development of the deposit continues to the depth below the level of the Krumlov adit, referred to as the Krumlov horizon at +505 m above sea level, and it was found at +195 m above sea level, about 300 m below the level of the adit. The length of the main position is approximately 800 m and is oriented in the NW-SE direction. The thickness of the deposit varies from 1 to 10 m (Tichý, 1984; Kadounová, 1987).

Graphite deposits are most often exposed at the interface between carbonate and paragneiss deposits or strata. Four strips (eastern, central, western and north-western) were recorded, but mining was only carried out in the eastern strip at a depth of 50 m below the surface. The raw material extracted was 1/3 crystalline flake graphite and 2/3 microcrystalline graphite. The Cgr content ranged from 5 to 40% (average in mining 17 to 20%), and the sulphur content did not exceed 4% (Tichý, 1984).

1.2 Lazec site

The Lazec deposit is located at the southern foot of Kleť Mountain, about 3 km NW of the Městský Vrch locality. This deposit was mined from 1970 to 2003. The deposit has a long-arched structure with a constant direction and dip. The basic general direction is NW-SE (approx. 30°), and the dip is 70° to the NE. The deposit bodies are strongly heterogeneous. In addition to the graphite ores themselves, they contain interbedded limestones, lime silicate rocks, amphibolite and other rocks. The nature of the deposit varies depending on the depth. The graphite ores change into graphite limestones; the change is continuous and is thought to follow the terrain, specifically in the deposit section of the above the Lazec II adit at a depth of approximately 50 metres(Geoindustria, 1965).

Here, graphite deposits form up to four separate zones, which are further subdivided by interbeds of non-graphitic rocks into partially unstable positions. The zones are counted in the direction from bedrock to the overburden. The zones are spaced approximately 30 to 60 metres apart; see Figure 2. In the part already opened by the Lazec Mine, the productive section in the first zone is developed over almost the entire length along the strike, in considerable thicknesses and in several positions. In its second zone, verification has occurred in two relatively short sections in one position of small thickness with irregular ore mineralisation. The bedrock of the first zone consists of an extensive limestone belt. Different types of ores occur between the zones and the overburden, although limestone positions are not rare. The graphitic positions are strongly affected by plastic deformation.

The deposit thickness is highly variable. In the first zone, the deposit was locally over 20 m in thickness, but on average, it was 13 m. In the second zone, the average deposit thickness was around 4.7 metres.

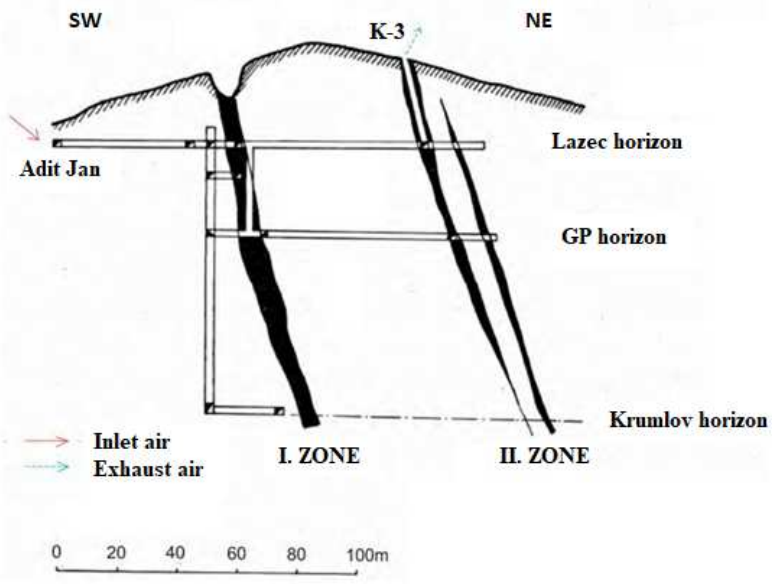

Figure 2. Cross section through the Lazec deposit (Boshkov & Wright, 1973)

1.3 The Bíca locality

Only a detailed geological exploration of the deposit was carried out at the Bíca locality, consisting in accessing the deposit through the Bíca adit at the level of the Krumlov horizon by an exploratory crosscut (P-17) and subsequent breakthroughs (S-17z and S17v), which confirmed the deep development of the Bíca deposit. The K 27 raise was also driven from the Krumlov horizon to serve not only for the exploration of the deposit but also as the main opening mine working of the locality. The K27 raise was intended to enable a more detailed verification of the shape of the deposit, as well as to be used for its development and subsequent mining. However, the actual mining at this locality did not take place, and the K27 raise was liquidated using unconsolidated backfilling.

1.4 Brief assessment of mining technical conditions

From the point of view of mining technical conditions, the main advantage of the localities described above is that they are mostly at least partially open (accessible from the surface). Another advantage is that detailed mining surveys have already verified a large part of the reserves and geological conditions.

A certain disadvantage is the relatively complex geological development of the deposit and its considerable variability (thickness, dip, content and C form), especially at the Městský vrch locality. From an operational point of view, the proximity of the locality to urban development and the UNESCO-protected centre of Český Krumlov is also a disadvantage. Furthermore, the Protected Deposit Area No. 14780000 Český Krumlov lies within the Blanský les Protected Landscape Area.

For these reasons, it is unrealistic to continue mining at the concerned locality using the mining methods used in the past, which had a significant impact on the surface due to the relatively shallow depth of the deposit below the surface.

If mining is to have a minimal impact on the environment, a mining method must be employed that will have a minimal impact on the surface and the environment. Closely related to mining are the treatment of the extracted material, its transport and the disposal of tailings and waste from mining. Therefore, a completely new mining method must be designed that will have a minimal impact on subsidence and the environment and be safe and economically viable. Given many quarrying methods and alternatives in operation worldwide, it was necessary to analyse the appropriate quarrying methods and design the most optimal method for the specific conditions.

2 Selection of a suitable extraction method

The research work carried out as part of the project showed that a number of mining methods could be used to exploit the ore deposits (Darling, 2011). The choice of a suitable mining method depends on a relatively large number of influencing factors, including:

- Geology (general shape of the deposit, thickness, dip, depth of emplacement, tectonics, ...)
- Geomechanical parameters (strength, E, φ, μ, RSS, RMR...)
- Mining technology (dimensions of the quarry, openings, control of overburden, technical equipment, flexibility, ...)

- Treatment of raw materials (selectivity of extraction, treatment plant capacity, leaching solutions, ...)
- Legislation and Work Safety (EIA, safety, surface effects,...)
- Economy (mine life, reclamation costs, capital expenditure on technology, operating costs, ...)

The selection of a suitable extraction method is, therefore, quite complex. However, there are a number of methods and procedures for selecting the most appropriate extraction methods for a particular site. A brief overview of the methods is given below:

- Boshkov and Wright (1973) (Boshkov & Wright, 1973);
- Morrison (1976) (Morrison, 1976);
- Nicholas (1981) (Nicholas, 1981);
- Hartman (1987) (Hartman, 1987);
- The UBC Method (University of British Columbia 1995) (Miller-tait et al., 1995; Mining Method Selection, 2021);
- AHP (Analytic Hierarchy Process) method (Ataei et al., 2008);
- PROMETHEE method (Bogdanovic et al., 2012).

The Hartmann and UBC methodologies were selected for the graphite deposits in the Český Krumlov region for the initial analysis and selection of a suitable mining method. These are relatively simple methods taking into account only the basic input data available at the time of the project.

2.1 Selection of a suitable mining method according to the Hartmann methodology

The selection of a suitable extraction method, according to Hartmann, is very quick and simple. The procedure is basically as shown in Figure 3. The diagram has a tree structure, at the end of which the most suitable extraction method for the assessed locality is indicated. In the first step, the depth of emplacement is assessed. Here it is necessary to decide and evaluate whether it should be opencast or deep mining. Even though the deposit is relatively shallow in our case, it is necessary to choose the deep mining method due to the location of the deposit in the Blanský les Protected Landscape Area.

The strength of the extracted material and the accompanying rocks is then assessed in relation to the self-supporting capacity of the massif and whether the excavated areas are to be left free of reinforcement, reinforced or backfilled. Due to the requirement for a subsidence-free mining method and the relatively low strength of the material to be mined, the reinforced option was chosen. The following step takes into account the deposit conditions (shape, dip, thickness and size). Here, due to the relatively high variability of the deposition ratios and the steep nature of the deposit, the following parameters were chosen – variable shape, high slope and small thickness. According to this scheme, the Cut and Fill Stoping method was recommended as the appropriate mining method (see Figure 3).

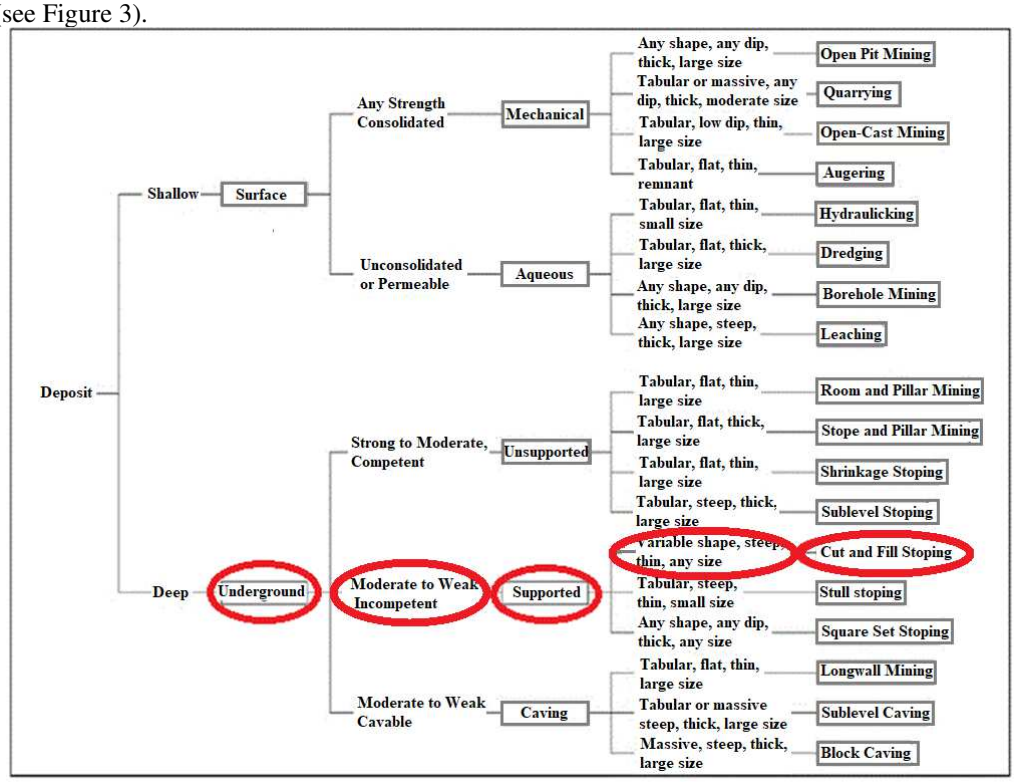

Figure 3. Selection of a suitable mining method (Darling, 2011)

2.2 Selection of a suitable mining method using the UBC (University of British Columbia) methodology

It is a slightly modified methodology originally introduced by Nicholas in 1981. The advantage of this method is its partial elaboration in the form of freeware software (Mining Method Selection, 2021), which was freely available on the website. The methodology is based on scoring parameters describing the storage and geomechanical parameters and their suitability for particular mining methods. The most suitable mining methods are considered to be those with the highest sum of points allocated.

Specifically, the general shape of the deposit (extensive – massive, **bench-shaped**, irregular), the deposit thickness (low <3 m, **3-10 m**, 10-30 m, 30-100 m, very strong >100 m), the dip of the deposit (area deposited <20°, inclined 20-55°, **steeply deposited > 55**°), grade of the material – metallicity (stable, gradually – predictably changing, **erratic**), depth below the surface (**low <100m**, medium 100-600m, high >600m).

Among the geomechanical parameters, the description of the accompanying rocks and the extracted material is evaluated by means of the geomechanical classification of the massif using the RMR (Rock Mass Rating) method (Bieniawski, 1976) and the rock strength in relation to the expected stress conditions in the massif RSS (Rock Substance Strength) (Miller-tait et al., 1995). The RMR values were given for each layer based on in-situ man winding and expert estimation as follows – deposit filling category soft (RMR 20-40), overlying gneiss rocks – medium (RMR 40-60) and underlying crystalline limestone – hard (60-80). The RSS values were calculated based on the average strengths of graphite and the accompanying rocks, as shown in Table 1, and the assumed stress at a depth of approximately 100 m below the surface, calculated from the density of the gneiss as the assumed overburden rocks. The assumed stress at a depth of 100 metres is 2,6 MPa.

Table 1. *Values of physical and mechanical properties of the deposit and accompanying rocks (Geoindustria, 1965)*

Name of rock	Strength [MPa]			Density [t.m^{-3}]
	pressure	thrust	shear	
Hard graphite	20,9	3,1	8,6	2,46
Soft graphite	9,7	1,8	0,3	2,39
Limestone	97,9	7,3	20,1	2,70
Gneiss	81,3	8,9	11,9	2,60

After completion and evaluation of the input data, the following mining methods were recommended by the UBC methodology (see Figure 4):

- Open-pit mining (34 points)
- Sublevel stoping (32 points)
- Shrinkage stoping (30 points)
- Cut and fill stoping (29)
- Square set stoping (19 points)
- Top slicing (18 points)

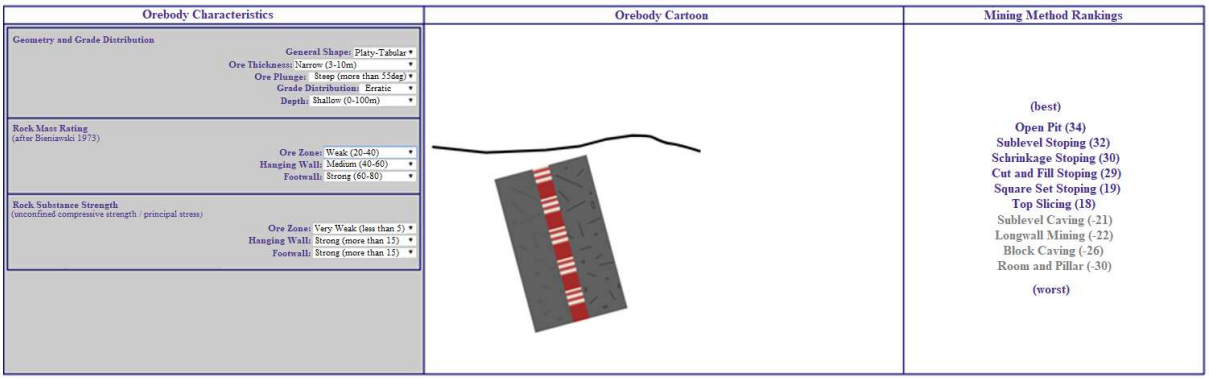

Figure 4. Selection of the appropriate mining method according to UBC (Mining Method Selection, 2021)

Surface mining is completely excluded due to the location of the deposit in the Protected Landscape Area and in the relative proximity of the UNESCO-protected centre of Český Krumlov. Various variants of stoping have been found to be the optimal methods. In view of the fact that, given the inappropriate location of the deposit near the historic centre of the town and the protected area, great emphasis should be placed on environmental protection when selecting the appropriate mining method, we recommend cut and fill stoping as the most suitable method. The main advantage of this mining method is the minimal impact of mining on the surface, and if the tailings from the graphite mining and treatment are used as backfill material, there will be no need to deposit this material, which usually cannot be used otherwise, on a surface dump heap. It is, therefore, recommended that tailings from the

mining operations, tailings material from the treatment plant, or inert material from nearby sources be used as suitable backfill material.

However, the disadvantages of this mining method are higher economic intensity and lower performance. However, it should be noted that due to the unsuitable location of the deposit and the considerable variability of the deposit's thickness and shape, high mining output cannot be expected at the concerned locality. Furthermore, it should be noted that it will be very difficult to build completely new infrastructure (access roads) in the Protected Landscape Area, which would have the capacity to transport large quantities of extracted raw material to the treatment plant. For this reason, the feasibility study should consider the option of a graphite treatment plant located directly underground. The tailings and waste material from this treatment plant could be directly used as backfill material without leaving the underground and the mine site. In the event that sufficient backfill material is not available, stoping (both sublevel stoping and shrinkage stoping) could be deployed in the areas where the deposit thickness is smaller than that.

Results and Discussion

Based on the analyses presented above in Section 2, cut and fill stoping was selected as the most appropriate mining method. Foreign experience (Villaescusa & Kuganathan, 1998; Villaescusa et al., 1994) has shown that the most suitable alternative to this mining method is the method known as AVOCA. For this mining method, we have proposed alternative methods of opening the Český Krumlov Mine locality below.

3 Proposal for a new opening of the Český Krumlov Mine locality

The resumption of mining implies the maximum use of the existing mine workings. The mine was originally opened by the horizontal adit Český Krumlov in the cadastre of Český Krumlov. A surface plant was built at the mouth of the adit. In the Lazec locality, the mine was accessed from the surface by the horizontal adit Lazec II at the level of +596 m. The adit is connected to the +500 m level by the vertical raise K 24. After the end of mining, a part of the mine near the mouth of the Český Krumlov adit is used for tourist tours called the Graphite Mine. After the end of mining, the Lazec II adit was partially made inaccessible. The mouth of the adit and the abandoned surface area are currently located on the land of a private owner. In addition, it is located within the Blanský les Protected Landscape Area, established in 1990.

For these reasons, the original surface areas cannot be used for renewed mining. Both localities can be used for emergency exit and ventilation needs.

The assumption of graphite mining recovery envisages the construction of completely new access from the surface. The area on the border of the cadastral territory of Kladná and Kladná-Dobrkovice was selected as a suitable locality. The locality is situated in the Český Krumlov – Vyšný Protected Deposit Area on the edge of the Blanský les Protected Landscape Area and the Vyšenské kopce National Nature Reserve. The railway line Český Krumlov – České Budějovice passes nearby.

The subject of the proposal for the concept of the opening of the deposit is the design of a new surface connection of the site with the existing mine workings of the former graphite mine on the +500 m level and the concept of the opening of the +400 m and +300 m levels in the Městský vrch and Lazec localities. The level opening concept is proposed in two options:

- Option 1 – level opening with vertical working
- Option 2 – level opening with inclined drips

The connection down from the surface is the same for both options.

3.1 Access from the surface

The surface access mine workings consist of a pair of mine workings:

- underground haulage passage
- Dobrkovice adit

The conveyor tunnel is an incline mine working that will be used to transport ore to the surface. It will be equipped with a conveyor belt. The Dobrkovice horizontal adit would be used for transporting material and workers, and possibly the landfill. It would be equipped with a 600 mm gauge rail line.

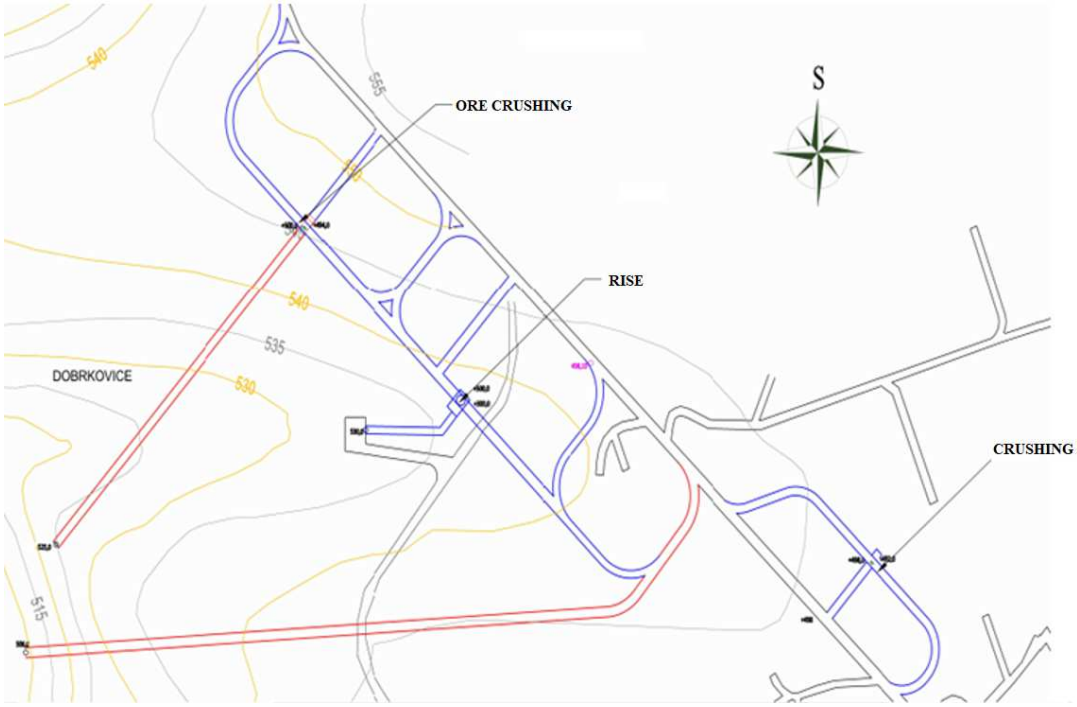

Fig. 5 Situation of mine access works from the surface

3.2 Level opening with vertical mine working – Option 1

Due to the location of the surface plant on the edge of the Blanský les Protected Landscape Area and close to the town of Český Krumlov, the principle of placing as much of the operation underground as possible was respected in the design of the mine opening concept. The location and design of the vertical opening mine working are based on this principle. In this option, we propose to open the lower levels with a rise – a 4.5 m diameter blind shaft. The rise will not open to the surface. The haulage engine room will also be located underground. (Fig. 5)

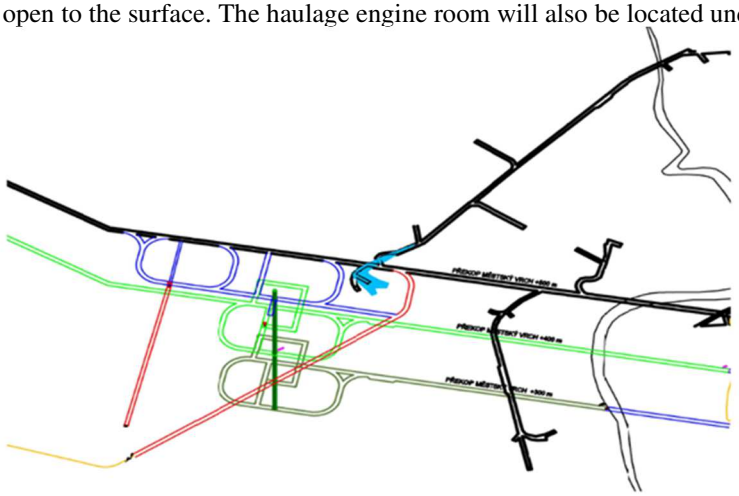

Fig 6. Diagram of Option 1

The levels +500 m, +400 m and +300 m will be made accessible by the rise (blind shaft) (Figure 6). First, mining will start from the +400 m level at the Městský vrch locality. Therefore, it is proposed to locate the rise closer to this locality in relation to the connection of the +500 m level from the surface. As the life of the +400m level of the Městský vrch locality is assumed to be 28 years, the rise will not be excavated at its full length. The +400 m level will be excavated in the first phase, including the sump (bottom of the +380 m blind shaft). Over time, it will be extended to the +300 m floor (bottom of the rise +280 m) for a smooth transition of mining to the lower level.

On both levels, there will be walkways for transport accessibility, a pumping station and a substation. Crosscuts will be dug horizontally from the bypasses to the Městský vrch and Lazec localities. The opening workings will be followed by preparatory mine workings in each locality.

At the +500 m level, an ore-crushing plant will be built at the base of the underground haulage passage. The mined material will be crushed here into a fraction for entry into the treatment plant. Similarly, the tailings crushing plant will be located on the +500 m level. Here, the tailings from the opening and preparation workings will be crushed to a fraction that can be used as a backfill for the excavated spaces in the mine.

3.3 Level opening with inclined drifts – Option

In this option, the newly designed levels will be made accessible by means of inclined drifts. The inclination of the inclined drifts is max. 15° in terms of transport possibilities. With a level height of 100 m for the newly proposed levels, the length of the inclined drift is approximately 400 m. The +400 m level at each mine locality will be accessed from the +500 m level by a separate inclined drift located as close as possible to the deposit at each level (see Figures 7, 8). In the sufficient time before the +400 m level reserves are mined, the inclined drifts will be driven to the +300 m level.

At the head and foot of each inclined drift, bypasses will be built for transport accessibility. A pumping station and substation will also be located on the bypasses. Short shafts will be driven horizontally from the bypasses at the foot of the inclined shafts to the Městský vrch and Lazec localities. Preparatory mine workings will follow opening works in each locality. In this case, the extraction and transport of the material is possible by means of wheeled transport. Traffic sizing can be done by calculations or modelling (Sanderova, 2020).

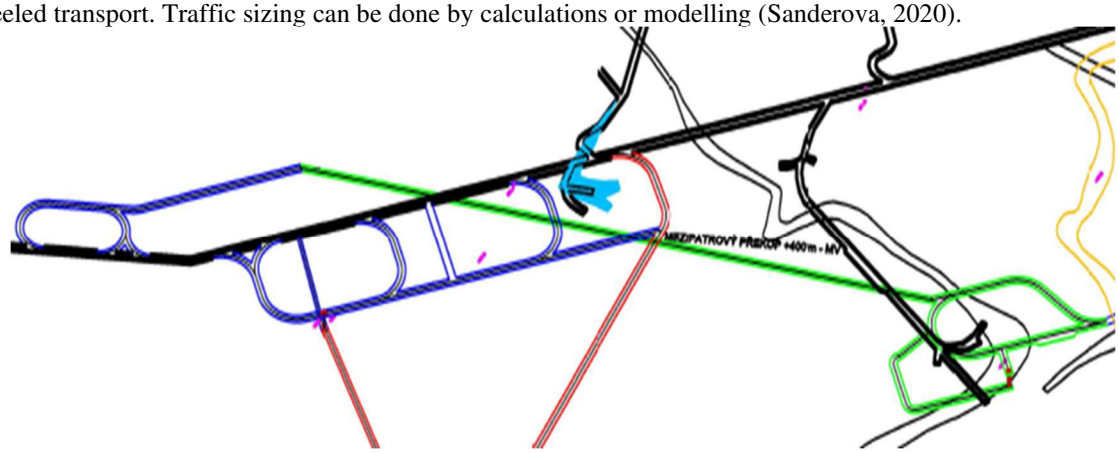

Fig 7. Schematic of Option 2 (access to the Městský vrch locality +400 m)

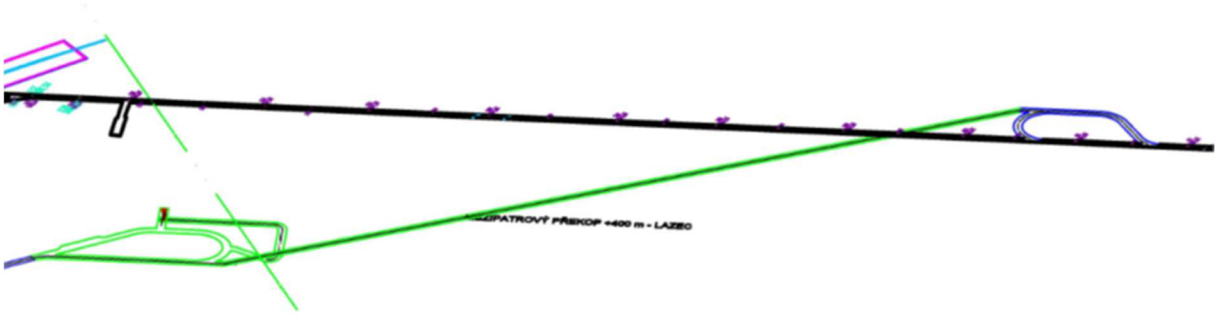

Fig 8. Diagram of Option 2 (access to the Lazec locality +400 m)

Conclusion

The article was focused on the proposal for the restoration of graphite mining in Český Krumlov. Suitable mining methods were proposed for the concerned localities, taking into account the positioning conditions of the deposits and the maximum use of the existing opening and preparatory mine workings while minimising the environmental impact.

There are sufficient potentially recoverable graphite reserves in the concerned locality, which are largely accessible by opening mine workings, and some blocks of reserves are even ready for mining. This is mainly the Lazec locality. The Bíca locality, whose graphite reserves would be made available again after the unconsolidated backfilling of the K 27 raise has been removed, also appears to be potentially very advantageous. The backfill material from the K 27 raise could be used in the future as backfill material in our proposed mining method.

Significant quantities of reserves are also found below the current mine horizon. In order to access these reserves, new opening mine workings will have to be driven or excavated. In the presented article, two options for possible access to these reserves are presented. The construction of a processing line directly underground is also

worth considering. The material from excavating the chamber for the processing line and from the opening and preparation workings could be reused as backfill material using the cut and fill stoping mining method.

References

COLLECTIVE OF AUTHORS: partial report of the CEEMIR project, Stage VIII: VŠB-TUO, Ostrava, 2017.

TICHÝ L.: Final report Český Krumlov - Městský vrch, MS Geofond, Prague, 1984.

KADOUNOVÁ, Z.: Petrologický, petrochemický a strukturní výzkum ložiska grafitu Městský vrch a jeho vztah k horninám krumlovské pestré skupiny. Faculty of Science, Charles University in Prague, 1987.

GEOINDUSTRIA, N. P. Final report Lazec: graphite. Jílové, 1965.

RUDNÉ DOLY, n. p.: Compendium of quarrying methods. Příbram, 1985.

DARLING, P:. SME Mining Engineering Handbook, Third Edition. SME, 2011, ISBN 0873352645.

BOSHKOV, S.H., and WRIGHT, F.D. 1973. Underground mining systems and equipment. In SME Mining Engineering Handbook. Edited by A.B. Cummins and I.A. Given. New York: SME-AIME

MORRISON, R.G.K. A Philosophy of Ground Control: A Bridge Between Theory and Practice, rev. ed. Montreal, QC: McGill University, Department of Mineralogy, Metallurgy, and Engineering. Montreal 1976.

NICHOLAS, D.E. 1981. Method selection—A numerical approach. In Design and Operation of Caving and Sublevel Stoping Mines. Edited by D. Stewart. New York: SME-AIME.

HARTMAN, H.L. Introductory Mining Engineering. New York: Wiley 1987

L MILLER-TAIT, R. PAKALNIS & R. POUL: UBC mining method selection. 4th INTERNATIONAL SYMPOSIUM ON MINE PLANNING AND EQUIPMENT SELECTION/CALGARY/CANADA 1995 Mining Method Selection. Edumine - Professional Development and Training for Mining [online] [cit. 2021-01-04]. Availableat: http://www.edumine.com/xtoolkit/xmethod/miningmethodgraphic.htm.

ATAEI, M.; JAMSHIDI, M.; SERESHKI, F. and JALALI, S.M.E.. Mining method selection by AHP approach. J. S. Afr. Inst. Min. Metall. 2008, vol.108, n.12, pp.741-749. ISSN 2411-9717.

BOGDANOVIC, D., NIKOLIC, D., ILIC, I. Mining method selection by integrated AHP and PROMETHEE method, Anais da Academia Brasileira de Ciências (Annals of the Brazilian Academy of Sciences), 2012, pp. 219-233.

BIENIAWSKI, Z.T. (1976) Rock Mass Classification in Rock Engineering. In: Bieniawski, Z.T., Ed., Symposium Proceedings of Exploration for Rock Engineering, 1, 97-106.

SANDEROVA, J.; ROSOVA, A.; KACMARY, P.; SOFRANKO, M.; BINDZAR, P.; MALKUS, T. Modelling as a Tool for the Planning of the Transport System Performance in the Conditions of a Raw Material Mining. Sustainability 2020, 12, 8051. doi: 10.3390/su12198051.

VILLAESCUSA, E., KUGANATHAN, K.: Backfill for bench stoping operations. Brisbane, Australia, 6th Symposium with Backfill, AusIMM, 1998.

VILLAESCUSA, E., L.B. NEINDORF, and J. CUNNINGHAM: Bench stoping of lead/zinc orebodies at Mount Isa Mines Limited. Proceedings of the MMIJ/AusIMM Joint Symposium, New Horizons in Resource Handling and Geo-Engineering, Yamaguchi University, Ube Japan, 351-359, 1994.