MINING OF COAL SEAMS UNDER THE MAIN HAULAGE LEVEL

PODPATROVÉ DOBÝVÁNÍ UHELNÝCH SLOJÍ

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Abstract

The question of mining under the main haulage level as a way by which in some cases coal reserves can be effectively extracted is still discussed. The paper introduces advantages and disadvantages of this method. It presents examples of the bedding of a seam in a limited depth under level, for example 50 m, when the opening by the under level mining method is obviously more advantageous. Special attention is given to risks of ventilation short circuit which are higher in this method compared to classical opening. The paper also gives a brief economical reflection allowing to determine the efficiency of under level mining.

Abstrakt

Otázka podpatrového dobývání, jako způsobu, kterým lze v určitých případech efektivně vytěžit uhelné zásoby, je stále diskutována. V uvedeném příspěvku se uvádějí výhody i nevýhody této metody. Jsou uvedeny příklady uložení slojí do omezené hloubky pod patrem, například 50 m, kdy je příprava sloje podpatrovým dobýváním zřejmě výhodnější. Upozorňuje se také na rizika větrního zkratu, které je u této metody, oproti klasické otvírce, vyšší. V práci je také uvedena stručná ekonomická úvaha, podle které lze určit efektivnost podpatrového dobývání.

Key words: Gas, methane, seam, under the main haulage level, costs of coal mining.

1 INTRODUCTION

The presented work starts from findings, as published in [3], and supplement them by certain facts which were not given in [3] for various reasons, especially the possibility of scope of the article. We draw attention especially to the danger of a ventilation short circuit, which may cause serious complications when working under the main haulage level, and suggest some opportunities for its improvement. We dealt with the comparison, when working under the main haulage level is effective from an economic point of view. We give an example, when it seems preferable to use a typical way by deepening pits for opening a deposit.

2 UNDER LEVEL MINING DEPENDING ON SEAM BEDDING

Figure 1 and 2 show fairly frequent cases of mining a seam under the main haulage level on different conditions of its bedding. These are the situations of individual seams (or a seam), whose typical opening would require a relatively high costs. In the literature [1] this method is described as "occasional, random".

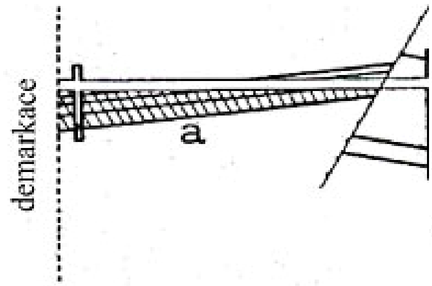


Fig. 1 Possible ways of under level mining depending on seam bedding. (Case "a")

In the case "a" as in Figure 1 it is a group of coal seams, which is directed to the boundary of the mining field. The development of these coal seams would require driving out a long cross-cut plus a staple pit from the bottom at the level of 595 m. Therefore, the under level mining method is more preferable.

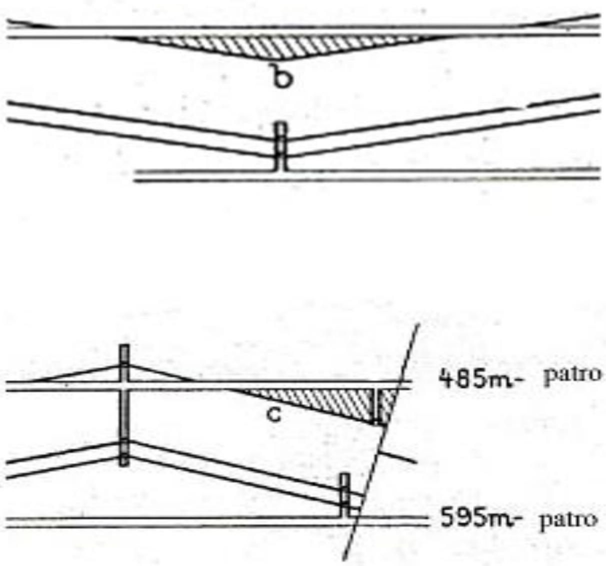


Fig. 2 Possible ways of under level mining depending on seam bedding. (Cases "b, c")

The case "b" in Figure 2 represents a flat syncline, whose greatest depth is close to the upper level at 485 m, thus it is in a long distance from the bottom level of 595 m.

The case "c" represents the throwing of the seam (thrust fault), also in a small depth below the top level at 485 meters.

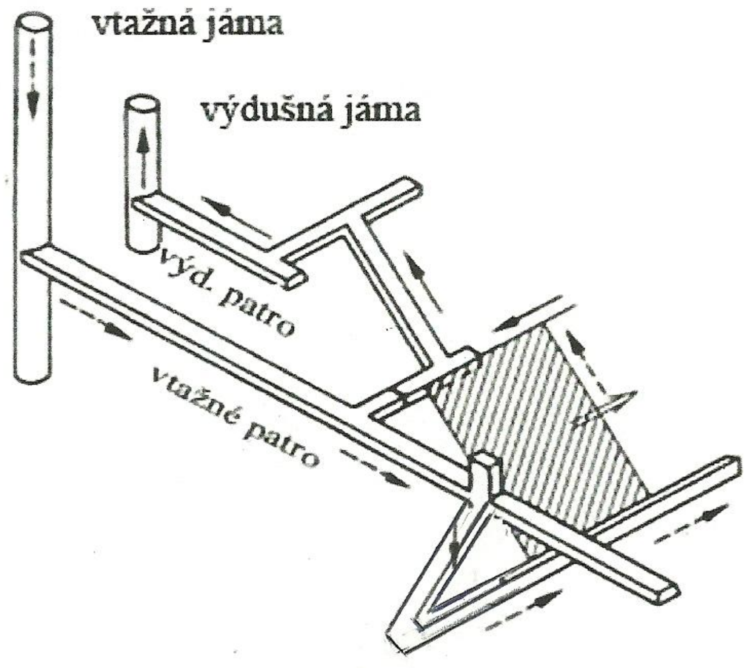
In all these cases it is so-called "outstanding" (incomplete) mining under the main haulage level. It is characterized by the fact that fresh air is fed from a higher (mining) level (the level at 485 m in Figure 1 and Figure 2).

In contrast, in so-called solved (full) mining under the main haulage level the intake air is fed from the bottom level (the level at 595 m in Figure 1 and Figure 2).

The fresh intake in the cases shown in Figures 1, 2 is fed from the main mining level through a staple pit, or dip working to the lowest point, the location of the seam, and from here then it progresses up through appropriate mine workings. The exhaust air returns to the main mining level and must be diverted to the return level through the shortest path. However, in this way the risk of a ventilation short circuit occurs. This must be prevented by air doors, or other appropriate means.

3 INCOMPLETE UNDER LEVEL MINING

Figure 3 shows according to [2] a simple air diagram of the method of incomplete under level mining. Since this is primarily the representation of ventilation, it is rather simplified. For instance, there is no pass-by in the outline, which should be built for the filling point at the intake level. (This is shown in Figure 9).



Intake shaft

Upcast shaft

Upcast level

Intake level

Fig. 3 Isometric diagram of incomplete under level mining

From Figure 3 we can deduce how the air from the intake level is drained through an incline to the bottom road under the coal face. Thereout then it proceeds across the face through the upraise to the upcast level. So as the air flows at the intake level through the incline under the face, an explosion control object must be installed behind the incline - see Fig. 4.

And just the possibility of its opening represents the risk of volume flow rate depletion for the active face. Another sensitive point is also a permanent stopping between the return airway of the face and the upcast level.

4 PLANNED UNDER LEVEL MINING

Planned mining under the main haulage level lies in that the entire coal reserves under the mining level will be mined out on this level upwardly. Usually, the interval for mining the bottom seam managed to increase and thus the development of the seam could start later. But due to certain disadvantages of under level mining and in the meantime achieved progress for mining out between seams, the planned under level mining is generally not recommended. Especially chutes and drag conveyors from the new means have proved themselves in mining out between seams.

Fig. 4 The ventilation control object in a coal mine

5 ADVANTAGES AND DISADVANTAGES OF UNDER LEVEL MINING

The major advantage of mining under the main haulage level lies in savings of costs on development work, but at least in saving of time to carry out extensive development work. Therefore, possible under level mining, as an alternative, cannot be completely excluded for instance when transiting to a deeper level. When even the development of the bottom level is in default and there are enough reserves for mining under the main haulage level at the mining level, the planned under level mining is very desirable.

On the other hand, however, the under level mining have many disadvantages that cannot be neglected. In addition to complex ventilation management, it is necessary to pay special attention to water regime. The costs of capturing and pumping water is the larger, the more water is contained in the mountain range. Also the remaining water in the abandoned mining area of the initial under level mining after completing the extraction must be taken into account.

The affecting of the main mining level by undermining by the coal seam (seams) being mined is however also very unpleasant. Especially the sites of filling stations, whose shifters and chain tracks are very sensitive to dip changes, are quite critical. Also the transport by means of mining large-volume cars is getting difficult.

6 VERTICAL AND DIP WORKINGS IN UNDER LEVEL MINING

For developing a seam (or a group of seams) either vertical or dip workings are used.

For dip workings the method of transport and excavation, which will take place on them, must always be considered. Figure 5 shows several possibilities.

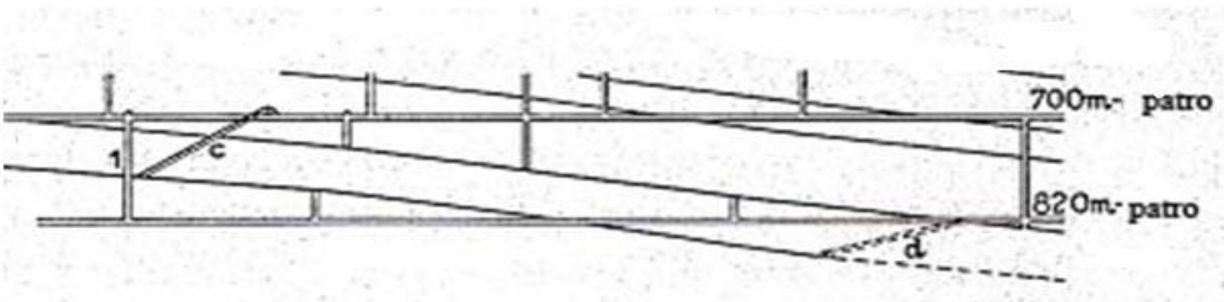


Fig. 5 Vertical and dip workings in under level mining. (The cases „c, d“)

In the case "c" it concerns the development of seams under the main haulage level by a dip working (incline) with a dip of 30°. Selecting a higher inclination means shortening the working, but it also requires a

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more intensive means of transport for the extraction. In this case, a special conveyor should be chosen. For details, see [2].

When developing according to "d" when the incline has the dip of 13° to 15° a conveyor belt could be used.

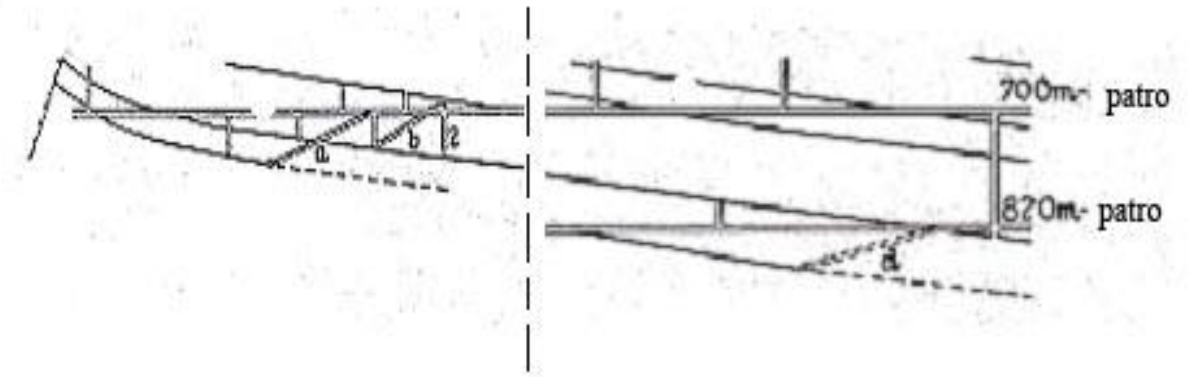


Fig. 6 Vertical and dip workings in under level mining. (Case „a, b“)

As a transport means on inclines (Fig. 6) according to "a" or "b" with a dip of 19° to 21° a plate conveyor should be used.

The inclines "b" (Fig. 6), or "c" are led out over the mining level - 700 m and leads into the bin over the filling station.

For the "complete" under level mining, fresh intake is led between blind pits from the bottom level at 820 m. The upper level at 700 m is also intake one, namely up to the ventilation gate at the cross-cut, through which the under level mining is open under this level at 700 m.

A relatively large distance of about 400 m between the filling point and a blind air pit creates a space large enough for empty cars, which come from one side, and on the other side of the blind pit a ventilation gate can be installed, where long trains can be placed just as well.

7 DANGER OF VENTILATION SHORT CIRCUIT

One of the serious risks in under level mining is a possible short circuit when opening the ventilation door. Today, most of doors, especially those through which traffic is intense, or due to which unclosing a dangerous short circuit can occur, have implemented a function of automatic opening and closing.

Most often the automatic opening function is provided by a pneumatic or hydraulic cylinder - see figure 7, which is activated by motion of a lever mechanism hung in front of the door. The lever mechanism and opening cylinders are connected by pulleys and a cable. Closing the door is controlled by signalisation that informs on closing at the control room.

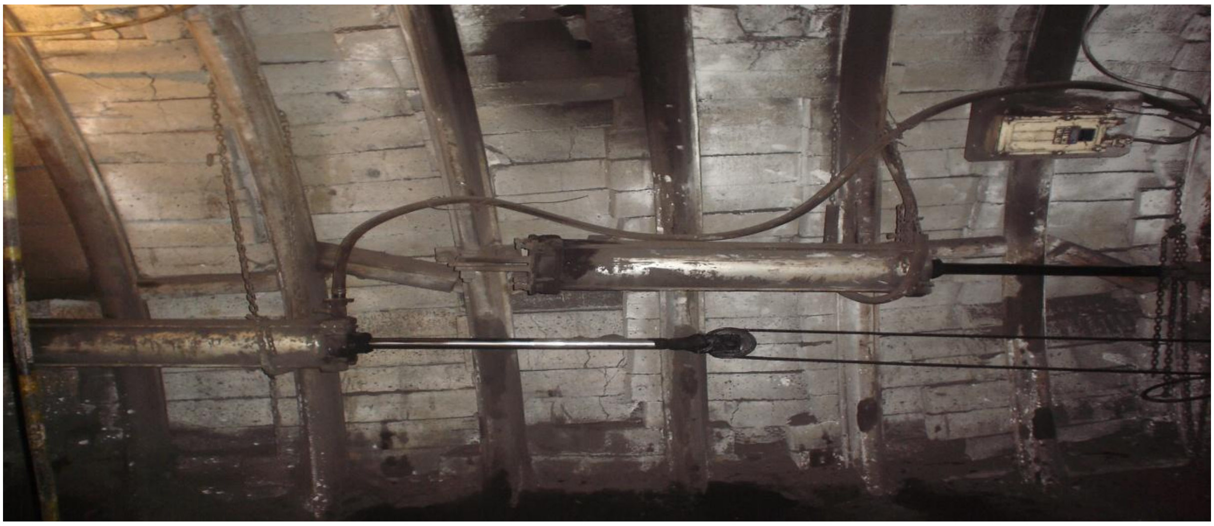


Fig.7 Control of ventilation and dam doors

The risk of a ventilation short circuit often threatens on air bases of coalfaces, where the intake and upcast are separated by a wooden door. The ventilation door is still without mechanized closing. They are inclined to close themselves after release. Today, only sensors indicating opening the door are implemented. The signals are led out to the mine control room. But also this way of signalling represents a clear increase in security. The dispatcher may warn the nearest staff or technical supervision on the signal of opening by a loud intercom.

8 DOOR DESIGN ACCORDING TO FOREIGN SOURCES

Due to the importance of ventilation doors in case of a possible short circuit in ventilation network, we were also interested in possibilities occurring in the door design over the world.

According to [4] there are several companies in the USA specializing in the manufacture of doors for mining operations.

For example, the U.S. company American Mine Door, [5] offers 2 types of doors: High-and low-pressure ones. Figure 8 shows an example of the low-pressure doors design.

Fig. 8 The mine doors design of the company American Mine Door

The low-pressure doors, i.e. apparently a similar type that is in our mines used to control the air at less frequented workings, are made of lighter materials, narrower wings and a smaller frame. Therefore, they are lighter and cheaper.

The doors, during their opening, use opposing wings and thus cancel the effect of static pressure. Also at higher pressure in surroundings they are relatively easy to open, because the pressure against one wing is abolished by the wing on the opposite side.

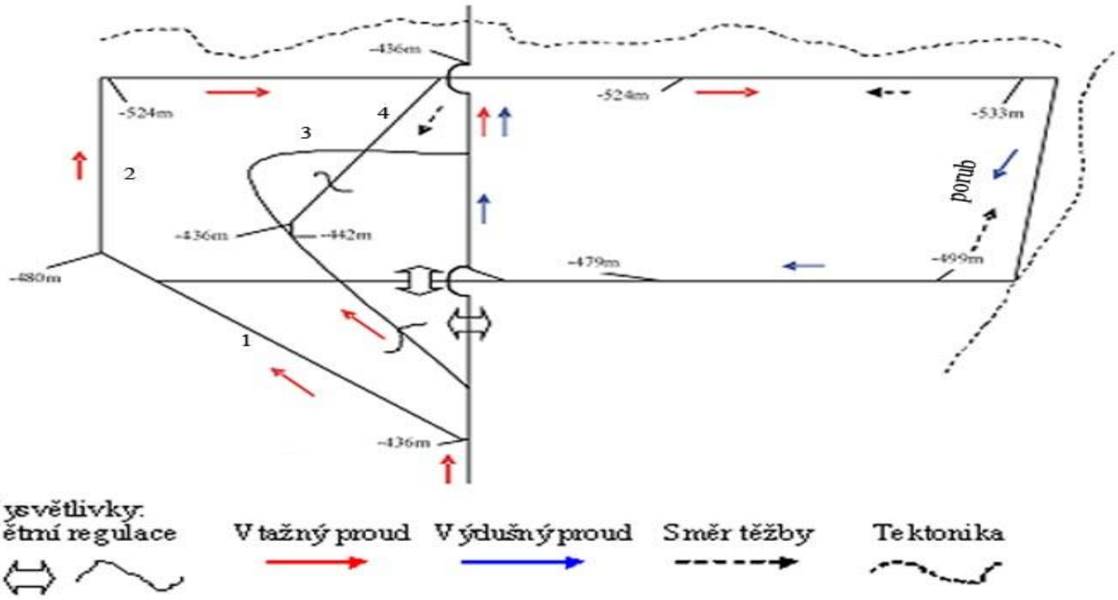
The same pressure helping in opening the doors helps also in their closing. The pressure created by the ventilation system is evenly distributed. This feature is particularly preferable in building the doors in dip workings. The doors can be used several times. If they lose their importance in the original working, they can be disassembled and relocated.

The mining doors are mechanically controlled and their position is indicated by light and sound signals. They have an internal lock, which ensures the door not to open when another door is open too. They have an open-door sensor that secures any object not to be ajar; remote opening and closing, sound sensors.

9 INTERIM BALANCE TO ASSESS THE EFFECTIVENESS OF UNDER LEVEL MINING

In order to assess, whether it is economically advantageous to choose the method of under level mining or proceed to the typical development, it is possible to use an interim economic balance. As an example of its implementation we used the following procedure.

In [3] there is given a rough overview of the investment costs of opening out workings required for the development of the block for under level mining. That block is schematically depicted in Figure 9. The amount of investment costs on opening out workings required for obtaining reserves under the level - 436 m is listed in Table 1.



Legend:

Air control Intake air current Upcast air current Direction of mining Tectonics

Fig. 9 Schematic outline for assessing the balance of under level mining

1., 2. dip working for making the reserves under the level accessible

3. pass-by from cross-cut at the level of 436 m

4. upraise for leading the mining output into the bin

Tab. 1 Costs of developing the coal seam for under level mining.

Name of working	Number	Profile	Length	Costs of erection (CZK)
Pass-by from cross-cut at -436m	"3"	K14-P28-0,5 m 1 m=81 735,-CZK	300m	24 520 500
Upcast crosscut	"4"	K 14-P28-0,5 m 1 m=81,735,-CZK	110m	8 990 850
Vertical binbetween upcast cross-cut 2436/3 and pass-by at -436 m	"4"	1 m about CZK 180,000	10m	1 800 000
Incline	"1"	K12-P20-0,7 m 1 m=CZK 36,816,-	175m	6 442 800
Incline	"2"	K12-P20-0,7 m 1 m=CZK 36,816,-	90m	3 313 440
Total costs on developing the workings for under level mining				45 613 893

From the face 44,974 tons were extracted. From the bottom block under the face further 48,610 tons were extracted (i.e. 93,684 tons in total), so the work required for developing the seam for under level mining in the given area would burden a ton of coal by the sum **487,- CZK/t.**

For our own consideration on the profitability of applying the method of under level mining, we chose the solution of using the typical way for opening out and preparing a certain quantity of reserves. This means deepening pits and driving out the cross-cut at a lower level. In order the consideration to be based on the same level heights for obtaining reserves, as those showed in Fig. 9, we assume therefore deepening pits by 45 m.

If the investment costs of deepening a pit by 1 m are CZK 500,000, then the required total investment for both the pits will reach CZK 45 million. We also assumed that for making the reserves accessible up to the development stage (when only the workings in the seam will be open out), it will be necessary to open a 200m cross-cut. When the costs per 1 m of the cross-cut are CZK 85,000,-, it would be CZK 17 million in total.

Thus the development phase, in case we theoretically make the reserves accessible by deepening the pits, will require the costs of deepening the pits and opening out the workings **CZK 62 million**.

From this very simple consideration the costs of opening out by the method of under level mining (which amount to CZK 45.6 million, see Table 1) are more preferable.

However, if in opening out using the method of deepening the pits and crosscutting also the reserves at the deepened level are made available, which is very likely, then the consideration of economic efficiency would be changed. In order the way of developing by deepening the pits to achieve the same amount of costs per 1 ton of reserves, as in opening by the under level mining method, it should achieve according to the equation (1) at least

$$\frac{I_n}{T} = 487 \qquad (1)$$

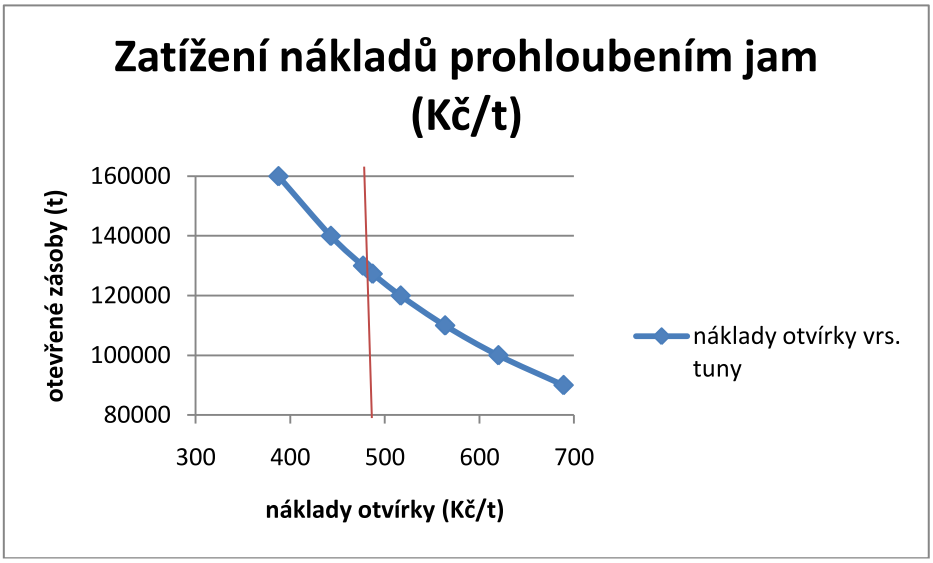
I_n investment costs of deepening the pits and crosscutting (CZK)

T weight of open reserves (t),

which results in **T = 127,310 t.**

This very simplified consideration implies that if the manner of developing resting on deepening the pits opens the reserves, whose weight exceeds 127,310 tons, this way would be more preferable compared to under level opening.

The consideration, though simplified, as neglects e.g. the costs required for mining equipment (plate conveyors, etc.), may be very appropriate for an indicative decision. For the given hypothetical example a graph can be compiled that would express how the costs of opening by deepening the pits burdens the costs per 1 ton of open reserves. (Fig. 10).



Burdening costs by deepening pits
(CZK/t)
Open reserves (t)
Costs of development vs. tons
Costs of development (Czk/t)

Fig. 10. The dependence of the total costs per 1 t of open reserves in the given situation according to Fig. 9 on the costs per one ton of the reserves opened by deepening pits and crosscutting

For the situation according to Figure 9 and Table 1, on the curve left from the red line there is the weight of reserves when opened by deepening the pits, the typical development would burden the costs per one ton of the open reserves less than the system of under level opening.

10 CONCLUSION

The presented article shows the possibilities of mining coal reserves by means of mining under the main haulage level. From extensive problems associated with this method of opening reserves only basic systems of development have been selected.

Furthermore, we pointed out the danger of an air short circuit, which is in under level mining specially significant, and indicated opportunities to improve its handling. The brief economic balance should indicate the procedure allowing evaluating the way of under level mining in comparison with the typical development by deepening pits.

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RESUMÉ

Současné poznatky a vědomosti o podpatrovém dobývání se jeví pro uhelné hornictví ne- zcela dostačující.

Vznikají nesrovnalosti v definování podpatrového dobývání uhlí a v odborné hornické veřejnosti bývá tento termín vykládán s mírnými odlišnostmi.

Část báňských odborníků považuje za podpatrové dobývání pouze hornickou činnost dobývání pod posledním patrem z přístupněným vtažnou jámou, jiná část pak i dobývání pod jakýmkoliv patrem, pokud se porub dostane pod výškovou úroveň těžního patra.

Z porovnání výhod a nevýhod podpatrového a nadpatrového dobývání vyplývá kromě jiného zřejmá nevýhoda a nebezpečnost podpatrového dobývání.Představuje problém především v oblasti větrání a havarijních stavů, zejména protipožární prevenci.

Na tyto problematiky je z části zaměřen presentovaný článek "Podpatrové dobývání uhelných slojí".