The problems of sudden outbursts of rock and gas in The Czech Republic and abroad

Petr Urban[1]

Problém náhleho výbuchu plynu v horniane v Čechách a v cudzine

Sudden outbursts of rock and gas present some of the most complicated problems in the deep underground mining.

This paper deals with a solution of these problems in different countries around the world. It is searching for methods of prediction and prognosis that can be most useful for the control of these phenomena. The records of relatively successful solving of this question in the Czech Republic are present. The authors of the project won the government award in 1984.

Key words: *Mining, outbursts of rock and gas, forecasting and preventing the danger of sudden outbursts, methods of prevention.*

Introduction

The danger of rush of rock and gas interrelates among others with actual mining activities in single regions and countries. In the sixties of past century a gradual inhibition of extractions in world's coal mining occurred. The restraint started in the Western Europe and quite logically was cutting-off the mines, where the sudden outbursts could occur. It coheres with series of causes. Especially it was the fact that though substantial funds were invested to combat the danger of outbursts, the required effect was not achieved. Above all, in terms of securing the needed safety and in no small measure, the mines with this danger could not achieve a required productivity of work.

The trend to inhibit extractions later penetrated into East European countries as well as into Japan and Canada. Thus a somewhat diverse map of locations and countries, in which combating the danger of outbursts has an actual sense, can be seen.

At a brief balance of this development the Czech Republic in the period when the problem of outbursts has been solved by specialists from many countries, presented an indispensable share. In the renowned German technical periodical Glückauf, pieces of knowledge about a complex method of mining in dangerous seams with sudden outbursts at the Paskov colliery in the Ostrava-Karvina region were published. After in the inhibition of extractions in the Czech Republic, especially in the Ostrava-Karvina Mining District, the problems of outbursts exist only at the Paskov mine plant Staric.

At presence the problem of danger of sudden outbursts focuses only on the following regions and countries: the Donbass District in Ukraine, the region Kemerovo in Russia, further in Poland where outbursts occurred recently in the Uper-Silezia district. A high account of this question of danger is in China, whose quick development of extractions originate many new cases. A considerable attention is applied to the rush also in Australia. Our aim is to establish and keep contacts with these regions and contribute to solving this serious problem.

Studying the foreign findings, we were attracted by the contemporary trend when the methane drainage is used for the moderation of hazards of outbursts. To the optimize of drainage as a component of the combat danger of rush, we follow a theoretical and practical experience from one disposal and would like to apply them in those conjunctions.

Forecasting and preventing the danger of sudden outbursts

The question of danger of rush is at present very actual in the above mentioned countries.

The applied methods of forecast have mostly a common basis and they are confronted with series of events. For example, according to [1], in Donbass (Ukraine) in the years 1951 to 2001, altogether **5 866** cases of outbursts occurred. This set is large enough to enable us to derive an order of regularities. The desorption of gas from the coal mass mostly forms the basis for forecasting. For example, according to [2] the following limits for conditions of mine Zasjadko were determined:

- -safe zone $q_0 \leq 0{,}2 – 0.5$ m^3/(min.t)
- -zone dangerous with outbursts $q_0 \geq 0{,}85 – 0{,}9$ m^3/(min.t)

[1] *Ing. Petr Urban, Ph.D.,* Czech Republic, VŠB-Technical University of Ostrava, Faculty of Mining and Geology, Institute of Mining Engineering and Safety, 17.Listopadu 15, 708 33, Ostrava-Poruba, petr.urban@vsb.cz
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"q_0" is the value of desorption determined by an analogical progress as it is known in the Czech Republic and in other countries in Europe and Australia.

Apart from the value "q_0" shown in [2], the quantity x_e which matches the content of gas in the coal mass in ($m^3.t^{-1}$) can be used, too.

In [2] a practical example of the measured values of "q_0" and "x_e" are presented. (See Tab. 1.)

Tab. 1. Values of the desorption and the content of gas in the coal mass on single workplaces of the mine Zasjadko in different depths of the prognostic borehole. ("l" is the depth at which the prognostic boreholes exceed the burden).

Workplace, index of coal seam	l=1,5 m		l=2,5 m	
	q_0 [m^3/(min.t)]	**x_e** [m^3/t]	**q_0** [m^3/(min.t)]	**x_e** [m^3/t]
10-east. l_1	0,02 - 0,17	1,1 ± 0,1	0,02 - 0,18	1,7 ± 0,1
15-west road m_3	0,2 - 0,49	4,5 ± 0,7	0,15 - 0,37	4,6 ± 0,4
9-east l_1			0,16 - 0,58	5,4 ± 0,4
Slant road k_8	0,04 - 0,42	4,3 ± 1,4	0,05 - 0,37	4,6 ± 1,0
Road before GDJa	0,32	3,3	2,18	20,1

GDJa means the geomechanical event (when the possibility of outburst is very high).

From table 1 follows that lowest values of q_0 and x_e are in the 10-east l seam with no influence of other mine works. The highest values of q_0 and x_e were located on the instant before the GDJa when x_e achieved 20,1 m^3/t, which was allied to the natural gas bearing value of seam, i.e. 22-24m^3/t. The values q_0 and x_e measured before the GDJa many times surpass the indices in the development of drift-ways in situations with no outburst observed. At the place of interference of the 9 eastern seam by incline drifts in the underlying stratum, enhanced values of q_0 and x_e were found. This demonstrates the mutual influence of additional pressures in the foreland of works when the total distance between the seams was 40 m.

In Poland, according to [3], the relation for the complex index exposure is used for the forecast:

$$Z = 0{,}6.\frac{P.V}{f.l} \tag{1}$$

Z the indicator of exposure by the outburst,
P gas pressure in the borehole (N/cm^2 or kg/cm^2),
V production of gas from the borehole (l/min),
F strength of coal according to Protodjakonov (-),
l depth of the measurement (cm).

If the indicator Z = 1, a certain degree of danger exists. If the indicator Z < 1, the workplace is not endangered.

The above mentioned criteria are not in conflict with the values stated by contemporary regulations [4], which – in conditions of salt deposits – are based on the values of the gas production from boreholes and for coal seams from the intensity of desorption, gas pressure and the fastness of rock (coal). The index "l" is based on the depth of advance on the working face.

Fundamental characteristics according to [4] go in for the jeoparded (exposed) strata:

- intensity of desorption D = 1
- gas pressure in the prognosis borehole (for methane) P = 80 kPa
- strength of coal f = 0,3
- length of burden (according to § 415 part. 1 and [4]), l = 200 cm

The indicator of the exposure for methane amounts:

$$Z' = 0{,}625\frac{P.D}{f.l} \tag{2a}$$

for CO_2

$$Z' = 1{,}6666\frac{P.D}{f.l} \tag{2b}$$

From Australia, a remarkable information came about the recognition of a zone of disturbance that is, along with higher values of desorption, mostly characteristic for the occurrence of outburst. That is, why the important aspect of forecast is the determination of a tectonic disturbance and its character. It is possible to reach by boring. The author of the study [5] has no doubt that the sensor for the scan of speed and impact on the boring implements can disclose the disturbances. For fruitfulness hereof, an inquiry is indeed needed in order to find out the character of the faulty zone, especially the characteristics of material with which the zone is formed. (Whether a fine share or coarse particles.) As far as they are coarse particles, the probability of rush is negligible. This means that the sensors of speed and stroke can make a detection of the filler of faulty zone.

In China, the method of quantity of boring gravel from the pilot borehole and the initial emission velocity of gas in this borehole are presently used as an index of danger of outburst. The experts designated by the Ministry of coal-mining industry established rules of forecast (prognoses) and the prevention of outbursts of coal and gas. The values of critical index (indicators of danger) are shown in Tables 2 and 3.

Tab. 2. Critical values of initial velocity of gas in borehole for forecast of outburst.

Assumption, outburst does not originates [%]	5 - 15	15 - 20	23-30	>30
q [l/min]	5,0	4,5	4,0	3,5

"l" volume of emitted gas in dm^3

Tab. 3. Critical dangerous index of the volume of boring crushed rubble for predicting (forecast) the danger of outburst in gates. [6].

Pressure of gas [Pa]	Maximum produce of gravel		Danger
	[kg/m]	S [L/m]	
≥ 200	≥ 6	≥ 5,4	Danger
< 200	< 6	<5,4	Without danger

"L" volume of rubble in dm^3

While using these rated criteria, the outburst occurred in some cases, in spite of the fact that the index did not overreach the critical value. In other words, the outburst phenomenon occurred at a lower index of prognosis (forecast). It happened, for example, in the Pingdishan Coal Co. Ltd. colliery Mine office Songazao Mine Bureau.

The methods of prevention

The following manners of prevention of outburst are largely applied:

- Extraction of a protective seam.
- Preventative exhaustion of gas (drainage) from the mined strata.
- The lightening shot firing.
- Boring of lightening bore holes and their dispersion by means of a high water pressure.

The way of exhaustion gas (drainage) from the mined seam has a special meaning. An upper-most technical level in this direction was achieved evidently in Australia. The exhaustion of gas as a protection against outburst is at the same time used from the economic and ecological standpoints. In the districts Bowen and Sydney, according to [7], for an enhancement of the effect of drainage, several vertical boreholes were hydraulically fissured and the interference part was extracted subsequently. The originated scratches were charted and a feedback of their orientation and lengths was applied. In some cases, the pressure alterations in coal around scratches were directly measured.

By sinking of water concentrated by sands and by monitoring the borehole in the coal stratum and its surroundings, meaningful creation failure areas were verified. The zone of interference in a 5 m - thick seam (the altitudinal extent from 287 to 302 m) achieved 135 m from the centre prop. It is a remarkable result. The permeability of the coal seam was influenced to such a degree that the total degasification of coal and a high yield of gas in the degasification borehole were achieved.

Complex working method in seams with a danger of outburst, developed in the Czech Republic

The above-mentioned pieces of knowledge have a considerable meaning also in our conditions. The deeper analysis unfortunately shows that even though the most sophisticated methods of forecast are applied, the unexpected outburst can occur. For example, when the position and character of the tectonically disturbed zone or changes in the character of strata, especially a decreased fastness, are not detected in time. A redistribution of tension around the working can cause an unforeseen disillusion too.

The elaboration of a complex method for driving and mining was based on the necessary operations of technological cycle that has to be executed even in seams without the danger of outburst. Among other things we are talking about the decrease of gas volume (methane) by means of drainage; the irrigation of the seam in order to decrease the dustiness; the interference of the strength properties of overburden strata for a regular development of caving; the inevitable geological prospecting of the neighborhood of the seam.

These operations were timed and organized in such a way that it does not hinder the cycle of driving or mining. A scheme was derived, whose pattern is shown in Fig. 1.

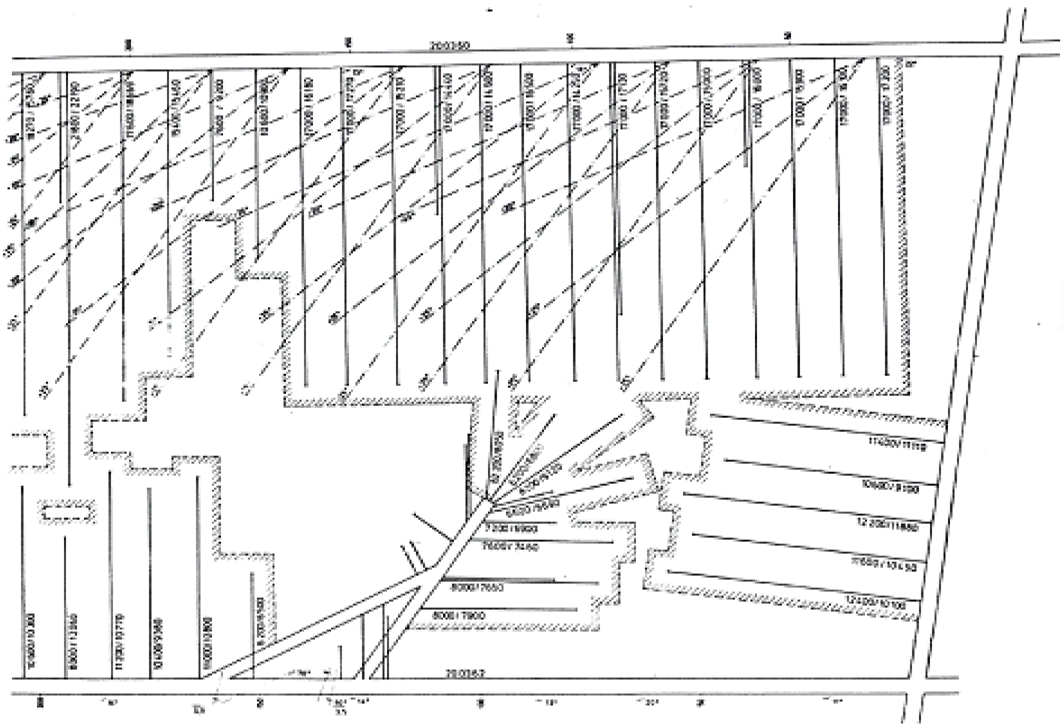

Fig. 1. Pattern for the longwall face in complicated geological conditions in the seam with a danger of outburst.

Before extraction, the irrigation boreholes in the seam have been bored from the intake and return airway (full line). At each of them, the planned and actual quantity of water that was grouted by a high-pressure multiplier, are indicated in Figure 1. The borders of effective reach of irrigation are shown as well (----- line). The boreholes at the same time checked the deposition of the coal seam. In a given example, the boreholes demonstrated that the zone of tectonic irregularities is situated at the distance 160m from the hauling/bottom road. For its dispatch and the passage of face, auxiliary headings were driven.

During the irrigation of long boreholes, the drainage system in the seam was already functional, with drainage boreholes leading away the gas already in the phase before beginning of mining. (The drainage boreholes are shown in Fig. 1 as -.-.-.- lines). A detailed description of the whole process can be seen in [8] or in [11]. This complex way of protection during mining a seam dangerous by a sudden outburst brought remarkable results. They are summarized in the Table 4.

Tab. 4. The data of classical and complex way of prevention in coalfaces.

	Average values in faces with classical prevention	**Average values in faces with complex way of prevention**
Pressure of gas in prognosis borehole [kPa]	160	80
Desorption in prognosis borehole $\mathbf{v_1}$ [$cm^3.(10g)^{-1}.min^{-1}$]	6,4	0
Relative dustiness [$mg.m^{-3}$]	5,06	2,5
Emission CH_4 into return flow [$m^3.t^{-1}$]	37,3	17,8
Productivity in coalface [%]	100	125

We utilize the complex way of prevention to possible avert of danger of outbursts, as shown in [8].

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