FINDING PARAMETERS PRODUCING GAS OUTPUTS FROM CLOSED UNDERGROUND USING MATHEMATIC MODEL

ZJIŠTĚNÍ PARAMETRŮ ZPŮSOBUJÍCÍCH VÝSTUPY PLYNŮ Z UZAVŘENÉHO PODZEMÍ S VYUŽITÍM MATEMATICKÉHO MODELU

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Abstract

For a number of reasons, for example – population safety, but also with reference to potential alternative energy sources we investigate possibility of gas exploitation from free space in abandoned mines. In order to asses the real gas reserves in this surroundings we can use many methods. The solution in this report is focused on the Ostrava-Karvina field (OKR), especially the Jaklovecky Mine locality.

Abstrakt

Z řady důvodů, například ochrany osídlení, ale také s ohledem na potenciál alternativních energetických zdrojů, se zkoumá i možnost využití plynu, který je soustředěn ve volných prostorech uzavřených dolů. K posouzení, jaká je skutečná zásoba plynu v tomto prostředí, mohou být použity různé způsoby. V tomto příspěvku je řešení zaměřeno na ostravsko-karvinský revír (OKR), konkrétně lokalitu Jaklovecký Důl.

Key words: atmospheric pressure, underground storage capacity, residual coal gas capacity, temperature, humidity, geodetic head, top bench permeability

1 INTRODUCTION

In the presented paper a procedure is presented, when for determining parameters of factors taking effect during gas outputs from closed underground a computing model is used. According to up to now experience we know that factors producing gas outputs are as follows: Development of atmospheric pressure, internal pressure, volume of gas storage, centre of internal pressure, residual gas capacity (emission), temperature, medium humidity, geodetic head, top bench permeability, mine-geological situation involving effects of conducting mining works and tectonic division.

2 SITUATION ON THE TERRITORY OF THE JALOVECKY MINE IN SILESIAN OSTRAVA

In 1998 on the territory of the Jalovecky Mine atmogeochemical survey was conducted during which it emerged that methane concentrations reach in soil 1-16% CH_4 approximately on ten spots. Therefore in the year 1999 a degassing system was implemented consisting of 38 methane drainage boreholes. These boreholes denoted as Jd1 to Jd38 were oriented to abandoned workings in seams of the Jalovecky drainage adit so that they were situated as close as possible to outcroppings in individual seams, in order they catch, if possible, abandoned workings of more seams and spots with an increased methane occurrence. The situation is illustrated in Fig. 1.

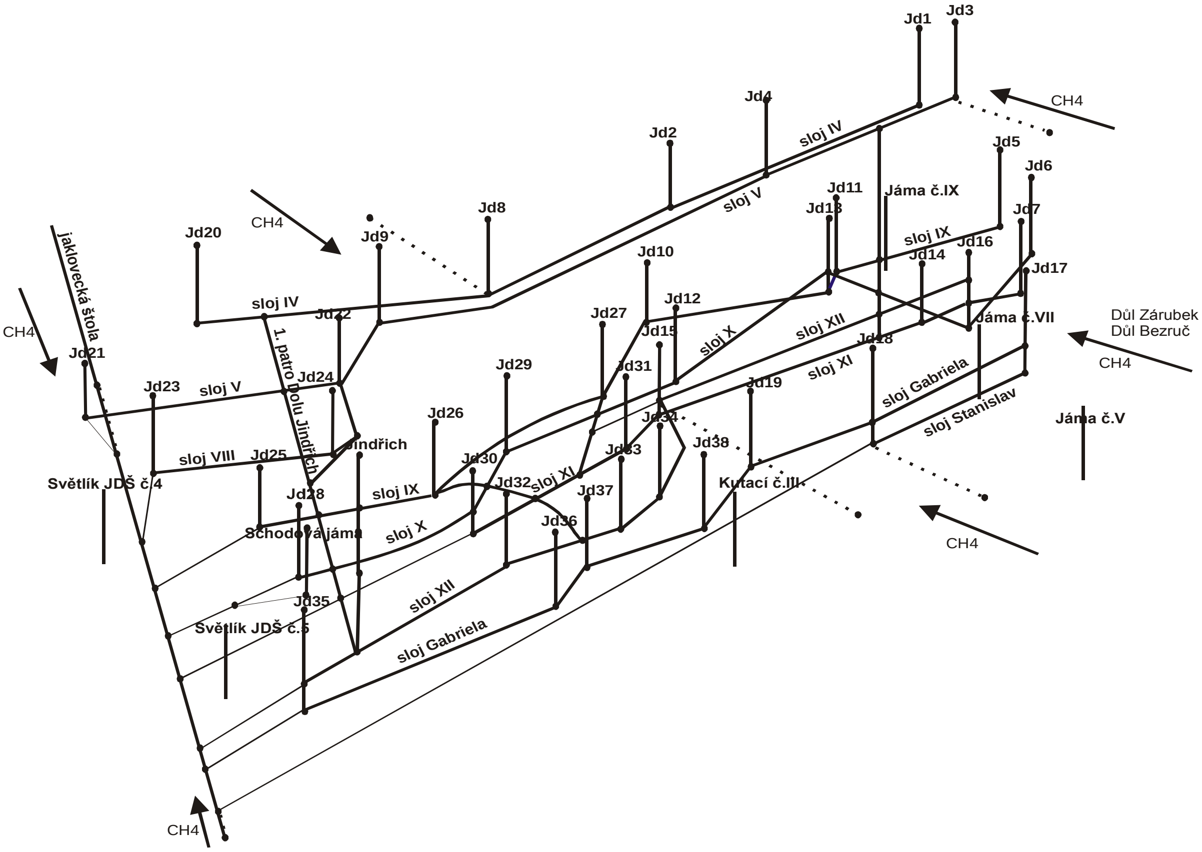


Fig. 1 Situation of the Jd1-Jd38 borehole locations in the Jalovecky Mine

The Jd3 borehole in the entire period of time is characterized by an increased activity as regards volume flow rate, gas pressure and methane concentrations. These values are tracked and one of measurement sets is provided in Table 1, according to [3].

Tab. 1 Values measured on the Jd3 methane drainage borehole.

Jd3 methane drainage borehole									
Date, Time	***dp_2***	***v_1***	***Q_c***	***CH_4***	***φ***	***t***	***CO_2***	***CO***	***p_1***
	[Pa]	***[$m.s^{-1}$]***	***[$m^3.s^{-1}$]***	***[%]***	***[%]***	***[°C]***	***[%]***	***[ppm]***	***[hPa]***
15.9.2004, 9:30	*128*	*2,5*	*0,042553*	*28*	*86*	*19,2*	*0,6*	*3*	*1020*
22.9.2004, 12:30	*269*	*3,7*	*0,07023*	*27*	*66*	*12,9*	*0,6*	*3*	*1010*
28.9.2004, 13:30	*-46*	*1,2*	*-0,01602*		*70*	*17,5*			*1019*
1.10.2004, 10:30	*-198*	*2,3*	*-0,03819*		*73*	*13,5*			*1022*
4.10.2004, 13:00	*-25*	*1,2*	*-0,01602*		*54*	*24,0*			*1020*
6.10.2004, 14:30	*15*	*1,3*	*0,01787*	*2*	*35*	*22,5*			*1019*
8.10.2004, 10:30	*50*	*1,5*	*0,0217*	*2*	*90*	*15,0*	*0,8*	*3*	*1018*
12.10.2004, 14:00	*-378*	*3,1*	*-0,0561*		*53*	*10,2*			*1031*
14.10.2004, 14:30	*145*	*2,6*	*0,04476*	*3*	*60*	*12*			*1018*
15.10.2004, 14:00	*175*	*3,1*	*0,0561*	*8*	*60*	*12,5*			*1008*
19.10.2004, 10:30	*-168**	*-1,8*	*-0,02533*		*65*	*12,5*			*1014*

Jd3 methane drainage borehole									
Date, Time	***dp_2***	***v_1***	***Q_c***	***CH_4***	***φ***	***t***	***CO_2***	***CO***	***p_1***
	[Pa]	***[$m.s^{-1}$]***	***[$m^3.s^{-1}$]***	***[%]***	***[%]***	***[°C]***	***[%]***	***[ppm]***	***[hPa]***
22.10.2004, 14:00	*-234*	*-2,4*	*-0,040361*		*75*	*17,5*			*1022*
25.10.2004, 16:30	*183*	*3,3*	*0,06075*	*7*	*67*	*17*			*1015*
2.11.2004, 15:30	*-161*	*-2,0*	*-0,0318*		*95*	*10,0*			*1023*
5.11.2004, 14:00	*-198*	*-2,3*	*-0,0382*		*75*	*11,0*			*1020*
11.11.2004, 13:00	*-149*	*-2,2*	*-0,03604*		*83*	*7,5*			*1018*
15.11.2004, 15:30	*-226*	*-2,4*	*-0,04036*		*82*	*2,0*			*1022*
18.11.2004, 11:00	*378*	*3,8*	*0,0726*	*9*	*81*	*9,2*	*0,5*	*3*	*1007*
25.11.2004, 11:00	*-357*	*-3,2*	*-0,05841*		*70*	*2,0*			*1031*
2.12.2004, 11:30	*185*	*3,2*	*0,0584*	*8*	*75*	*8,0*	*1,4*		*1010*
18.12.2004, 11:30	*419*	*4,8*	*0,09736*	*18*	*65*	*3,5*	*3,0*	*5*	*997*

dp_2	Pressure measured on borehole valve
v_1	Speed of gas mixture measured by anemometer on borehole chimney
Q_c	Volume flow rate on borehole chimney
CH_4	CH_4 concentration of gas mixture measured on borehole chimney
φ	Relative humidity of outer atmosphere
t	Temperature of outer atmosphere
CO_2	CO_2 concentration of gas mixture measured on borehole chimney
CO	CO concentration of gas mixture measured on borehole chimney
p_1	Atmospheric pressure at the time of measurement

Based on the grounds I proceeded to compilation of a mathematic model that should prove that parameters participating in gas outputs can be mapped using the measurements on an appropriate borehole.

The model requires a series of input data, some from which can be unambiguously defined and some others has to be derived by editing in the model.

For assessment, what development can be expected round the borehole, it is important to find out:

- Value of residual gas capacity, (we denote it as 'emission' in the model)
- Size of free gaps round the borehole (we denote them as 'storage').

Further the model involves data on gas permeability of rocks and especially development of volume flow rate and pressure on borehole depending on changes of barometric pressure, temperature and atmosphere humidity.

3 MODEL COMPILED ACCORDING TO THE JD3 BOREHOLE

To solve the listed assignments the PowerSim computing program was applied, [2]. It is a software, in which dynamics of gas flow outwards from the underground and conversely is displayed in individual steps (iterations). The program assesses all effects participating in dynamics of outputs.

Its basic conception results from a presumption that an unlimited source from theoretical point of view enters into the system. In our case it is a gas emission (residual gas capacity) from an abandoned underground. Simultaneously from the system a gas mixture gets out from the underground and when changing the barometric pressure masses of air enters into it. This complicated process is modelled as a dynamic phenomenon.

The model structure is presented in Fig 2.

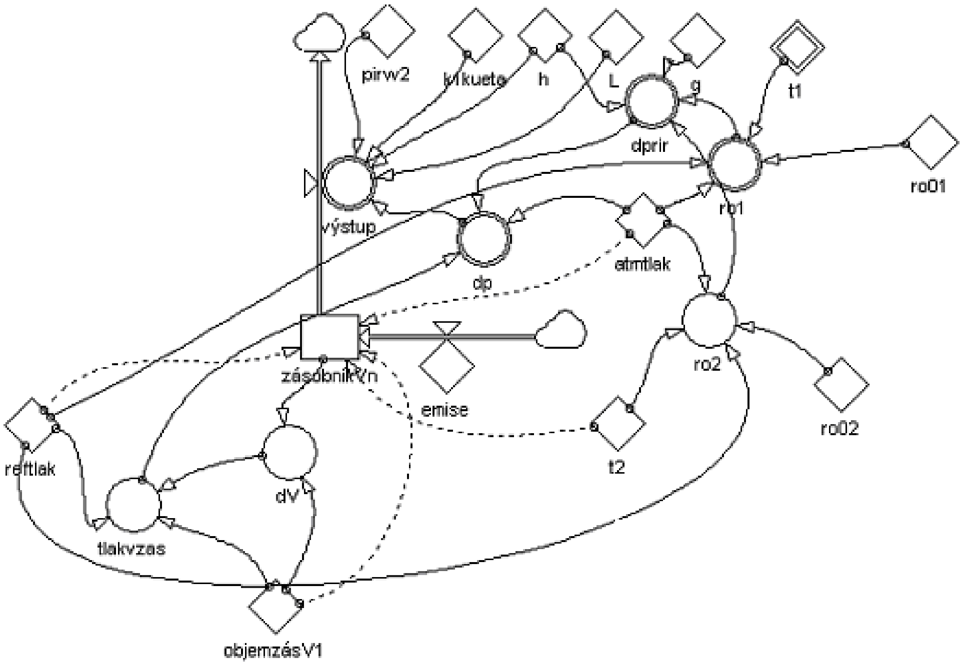


Fig.2 The model structure for calculation of parameters participating in gas outputs according to data of the Jd3 borehole. PRREP3 1A Model.

We will compile the model according to Fig. 2 and proceed from specific knowledge of needful parameters.

The input values of here presented model were selected with respect to experience so that they conform to usual real situation. We used hereto a large set of measurements on boreholes in different localities of OKR, according to [2, 5, 6].

The input parameters of the model for the Jd3 borehole using data according to [6] are as follows:

rw	Radius of methane drainage borehole (0,05 m)
o	Circumference of methane drainage borehole for currently performed boreholes in OKR as well for the Jd3 borehole (0,314 m)
h	Depth of borehole (40 m)
L	Distances of borehole from centre of pressure, (50 m)
k1	Top bench permeability for borehole. (7.10-9 m2)
η	Dynamic viscosity for CH4 (1.0.10-5 Pa.s)
V1	Predicted volume of storage, i.e. volume of free gaps incurred by performance of mining works and their subsequent consolidation during period of time (3.2 mil.m3)

Predicted gas emission (residual gas capacity) (0.008 m3.s-1), for more details see [7]

p0	Pressure for normal condition of masses of air (100 000 Pa), in the model denoted as reference pressure

In the mentioned model also changes of temperatures on surface and underground were respected

t	Temperature on surface (20, or 5°C)
t1	Underground temperature (8°C)
ρ1	Density of masses of air on surface (1.267 kg.m-3)

ρ2	Density of gas mixture underground (1.01 kg.m-3)
dp_0	Natural depression, which occurs owing to the presented differences of temperatures and specific density.

A very important magnitude in the model is in Figure 2 denoted as “dp”. Hereto it is necessary to present a more detailed explanation. The model works so that in individual iterations it determines changes of storage volume that occur underground. A value of pressure in the gas storage results thereof and the difference between it and barometric the pressure decides on meaning and size of volume flow rate. However, the difference between pressure in gas storage and barometric pressure is not the same as the difference of pressure on the foot and mouth of borehole, where we measure it. It relates to permeability of the environment. Between gas storage and borehole foot a pressure loss arises that has to be expressed. The way proved its worth, when after determining pressure in gas storage and measured values of pressure differences between foot and mouth of the borehole under different state of barometric pressure we determine a so-called coefficient “x”, which expresses the loss.

The definition of gas reservoir in the abandoned underground - For identification of underground free gaps the expression “storage” started to be used. For specification I give a more detailed definition of the term.

A gas (methane) storage is a closed space destabilized by elder mining works and its free gaps are enriched with methane and other gases.

It often concerns a bulk deposit whose gross volume can reach several tens to millions cubic metres. A useful volume corresponds to volume of cavities and gaps incurred by shifts and porosity of remaining coal, just like residual volume of roads, adits and underground workings.

The volume does not represent any supply of mine gas, because methane is simultaneously stored in a free form in pores and cavities of coal and rock matrices and in an absorbed form on the surface of coal, inside its microscopic structure.

In the storage pressure fluctuates with exhaust (sucked) quantity of gas and total volume inflow, owing to desorption of methane and air inflow [4].

A change of gas volume is expressed by the known equation (1).

$$V_n = \frac{V_1}{1+\gamma \cdot t_1} \cdot \frac{p_1}{p_0} \tag{1}$$

Where:	V_n	Reduced gas volume [m^3]
	V_1	Volume (physical) [m^3]
	γ	1/273.15 K^{-1} = 0.003
	p_1	Barometric pressure [Pa]
	p_0	Normal pressure (10^5 Pa)
	t_1	Temperature in storage

Further the following relation will be used

$$dV = V_1 - V_n \tag{2}$$

Where: dV Difference of storage volumes [m^3]

In the equation (2) dV assumes values from positive to negative ones. In order to apply the reversal of flow in the further procedure the equation (3) will be used for calculation of pressure in the storage “p_2“. (In models of the PowerSim program this relation is solved via the signum function).

$$p_2 = \frac{V_1 + dV}{V_1} \cdot p_1 \tag{3}$$

Where: p_2 Pressure in storage [Pa]

$$dp_1 = p_2 - p_1 \tag{4}$$

Where: dp_1 Pressure-difference between pressure in storage and barometric pressure on the surface (it is not the pressure-difference on borehole).

Pressure on borehole foot consists of barometric pressure recalculated to borehole depth and certain portion of emitting gas pressure. According to [5]

$$p_3 = p_1 + 13{,}3 \cdot h + x \cdot p_4 \tag{5}$$

Where: p_1 Barometric pressure at geodetic borehole head [Pa]

p_3 Barometric pressure recalculated to borehole depth [Pa]

h Borehole depth [m]

For borehole of depth of 40 m 13.3.h is equal 532 Pa.

x Coefficient using which we determine pressure loss between storage and borehole foot

p_4 Emitting gas pressure is a value being highly discussed.

From number of works as the most reliable according to [4] the finding is, when by long-term survey in various localities determination of the value $p_4 = 1{,}88\ m^3.24h^{-1}.Pa^{-1}$ *was successful. It results from recalculation that the gas pressure 367.6 Pa corresponds to the emission (internal pressure) equal* $0{,}008m^{3}\cdot s^{-1}$ *.*

In the Powersim program the finding p_4 facilitates application of the parameter “emission” (residual gas capacity) that depending on storage size, barometric pressure and further dependences inherent in the model, will express the effect of pressure of emitting gas and resistance.

The pressure loss “x” is produced by resistance between storage space and borehole foot. (Partially the relation can be explained according to Figure 4). A borehole will intervene to a large storage space in limited area only, where the pressure p_2 will not manifest itself fully.

There is a substantial difference between the value of pressure in storage found according to the equation (3) and the value of pressure measured on borehole p_3 according to (5).

The following relation is true:

$$p_2 \rangle p_3 \tag{6}$$

However, we have to introduce the experience to the model.

In actual solutions [2, 5, 6] a possibility was proved to proceed in the following way:

According to equations (1 to 6) a particular calculation is performed in Excel first for determining pressure in storage p_2.

The following input values were entered:

$V_1 = 3200000\ m^3$,

$t_1 = 5^{\circ}C - 8^{\circ}C$, (underground temperature)

p_1 changes from 99000 to 103000 Pa,

$p_5 = p_3 + p_4$

$p_0 = 100000$ Pa

$\gamma = 0{,}003$

The appropriate calculation in an abbreviated form, see Tab. 2

Tab. 2 Calculation of difference between internal and barometric pressures (p_2-p_1).

p_2	V1+dV	(V1+dV)/V 1	dV	V1	Vn	p_5	p_1	p_2-p_1
[Pa]	[m^3]	[m^3]	[m^3]	[m^3]	[m^3]	[Pa]	[Pa]	[Pa]
101947,8	3277670	1,024272	77669,9	3200000	3122330	99899	99000	2415,8
101996,1	3246602	1,014563	46601,94	3200000	3153398	100899	100000	1464,0
102796,6	3215534	1,004854	15533,98	3200000	3184466	101899	101000	492,8
102034,3	3184466	0,995146	-15534	3200000	3215534	102899	102000	-497,7
102024,3	3153398	0,985437	-46601,9	3200000	3246602	103899	103000	-1507,7

Simultaneously I derived by the calculation according to the file of pressure and volume flow rate measurements now for the particular Jd3 borehole in the area of Jalovecky Mine the value of pressure in the borehole (dp_2) for different values of barometric pressure. If we divide the value of difference between the pressure in storage and barometric pressure by the value of the pressure on borehole we obtain the coefficient "x", which determines the pressure loss between the storage and borehole. The calculation is in Tab. 3.

Tab. 3 Calculation of coefficient "x" for recalculation of pressure-difference "dp" underground and in borehole.

p_1	p_2-p_1	dp_2	*Coeff. „x"*
[Pa]	*[Pa])*	*[Pa]*	*[-]*
99000	*2415,8*	*368,4*	*6,556*
100000	*1464,0*	*220,0*	*6,652*
101000	*492,8*	*95,0*	*5,187*
102000	*-497,7*	*-69,13*	*7,139*
103000	*-1513,0*	*-297,4*	*5,086*

p_2-p_1 is adopted from Tab. 2.

According to data in Tab. 3 the diagram in Fig. 3 was compiled.

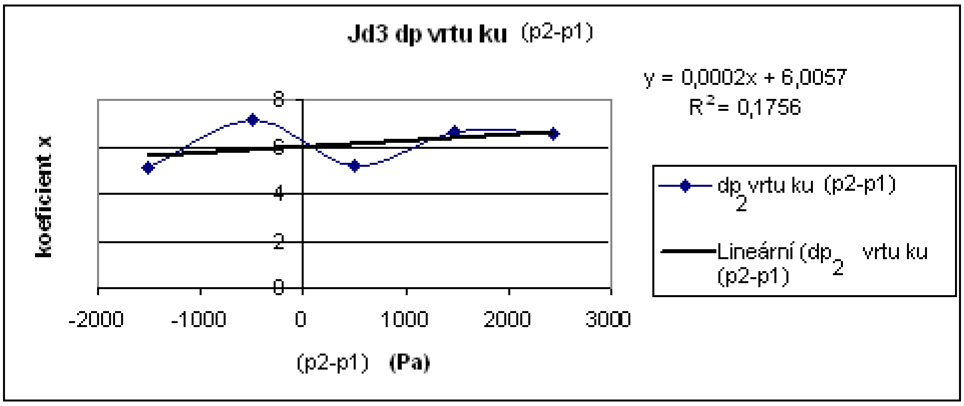


Fig. 3 Diagram of determining coefficient "x" for recalculation of pressure-difference dp underground and on borehole.

As we could expect the finding of pressure change between rock environment (storage) and borehole is complicated and in each situation a number of factors take effect that can be defined with difficulty. It is demonstrated in Figure 3 by a relatively low value of reliability R2 = 0.1756.

Rock environment (storage) is a very complicated structure. This situation can be get closer by Figure 4, where free gaps in the abandoned underground can be seen.

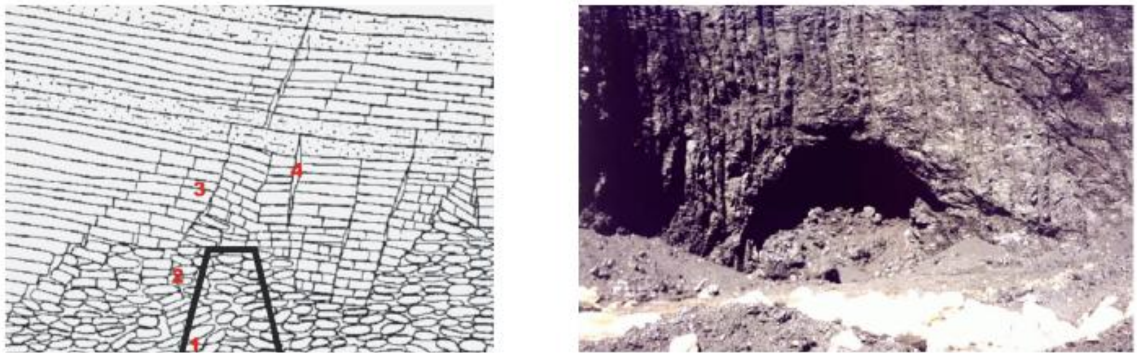


Fig. 4 Display of a possible situation of rock opening after completing mining activities and photography of partially caved working

From the photography of partially caved working it is possible to derive, how storage volume is formed in fact. (Relatively greater free space of original mine working and at the same time very cramped free gaps in fissures of rock).

However, it is possible from Figure 3 and there presented equation of regression model to derive that dp_2 in borehole is for our case

$$dp_2 = \frac{(p_2 - p_1)}{0{,}0002 * (p_2 - p_1) + 6{,}0057}$$

For more precise determination of the dependence it is necessary to perform measurement on borehole namely best methodically in longer time sequence at different development of barometric pressure. Such methodical measurement requires a special registration technique, which was not available. However, also values found out by the presented procedure can reliably answer the required specification.

After introducing the input data some of which were selected as a presumption, the calculation took place depending on development of barometric pressure. For the presented example its behaviour was applied as it was registered in the interval every 5 minutes for the period of 1 million seconds, i.e. 11.57 days. (It concerns a period from October 2007).

By the calculation a behaviour of important parameters was mapped and especially we tracked how magnitudes “output” and “pressure-difference on borehole” developed.

“Output” represents volume flow rate through borehole in $m^3.s^{-1}$ that can be positive (gas exhales from the underground) or negative at higher barometric pressure (masses of air flow to abandoned mine). For the “output” magnitude we also use denotation Q_c.

It is calculated in the model according to (7)

$$Q_c = \frac{o * h * (dp_2 - dp_0) * k_1}{\eta * L} \qquad (7)$$

The symbols in the equation (7) have already been defined in preceding equations.

By determining Q_c a dp_2 through the model we verify how their value corresponds to the measured values in borehole and thereby the parameters correctness is acknowledged we would like to find out and that we introduced in some cases as a presumption to the model.

Based on the presented procedure it is then possible after inserting input data at a given behaviour of barometric pressure and at present relatively great findings on top bench permeability and further parameters to determine a series of magnitudes.

In this work among others a storage volume (free gaps) was found out in the closed underground that together with the ***value of residual gas capacity*** *shows a possible way of arranged drainage of gas and its contingent economic utilization.*

Graphic printout of model results

Model results can be displayed either as a numerical or graphic listing.

In Figure 5 a graphic printout of some parameters is illustrated.

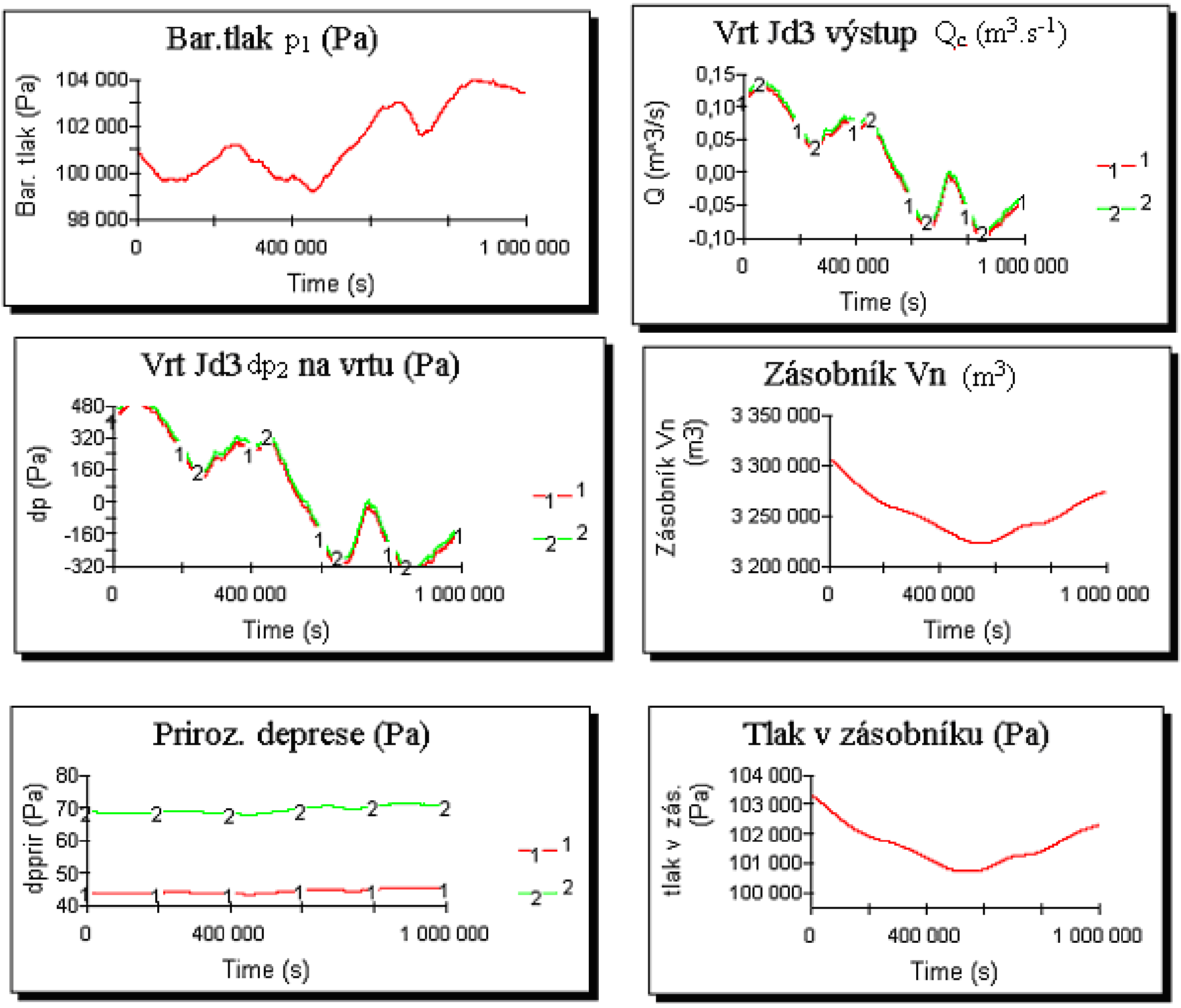


Fig. 5 Graphic printout of the PRREP3 1A model results for the Jd3 borehole

From Figure 5 it can be derived that barometric pressure had till the period of simulation of ca 400,000 s. relatively low values (below 101 240 Pa) and then started to increase nearly systematically. Behaviour of volume flow rate Q_c and pressure on borehole dp_2 corresponds to such development. As mentioned above it was impossible to acquire measured data on the Jd3 borehole in a continuous time sequence.

I had to manage with the data according to Table 1 containing irregular measurements in the period from September 15, 2004 till December 18, 2004, when also especially the temperature on the surface was being changed. I introduced the change to the model so that I solve values of output and pressure in borehole for the temperature on the surface of 20 °C or 5 °C. Therefore there are in printouts in the diagrams “output” and “dp_2“ two curves (1 and 2) projecting the difference. As it is obvious the difference is all in all insignificant. Its detailed numerical value is included in the numerical printout. This one I did not involve to these conclusions for simplification. However, I add for information that for instance at the time of 850 000 s simulation, when a significant change of barometric pressure takes place, the calculated values dp_2 a Q_c for temperatures on the surface of 20 °C or 5 °C are as follows, (Table 4).

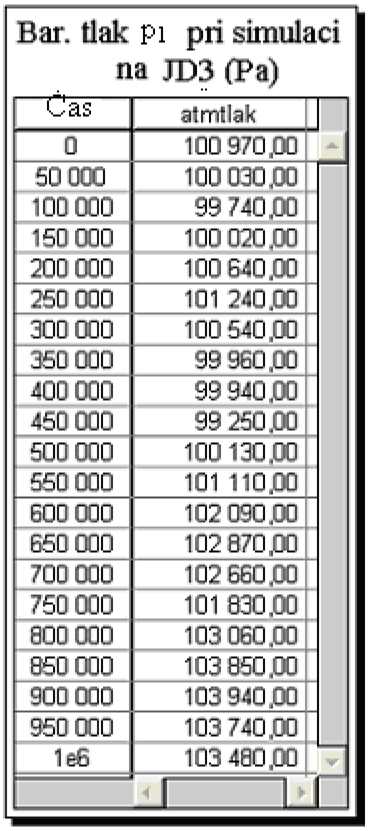
Tab. 2 dp_2 and Q_c on the Jd3 borehole for different temperatures on the surface

Temperature [°C]	dp_2 [Pa]	Q_c [$m^3.s^{-1}$]
20	-338,8	-0,00894
5	-313,3	-0,00826

Further it is apparent from Figure 5 that natural depression is higher for the curve “2” illustrating behaviour under the temperature on the surface of 5 °C. The natural depression in both cases is positive, it means that supports the gas output from the underground. It is possible to derive also changes in storage volume and pressure in this environment depending on development of barometric pressure.

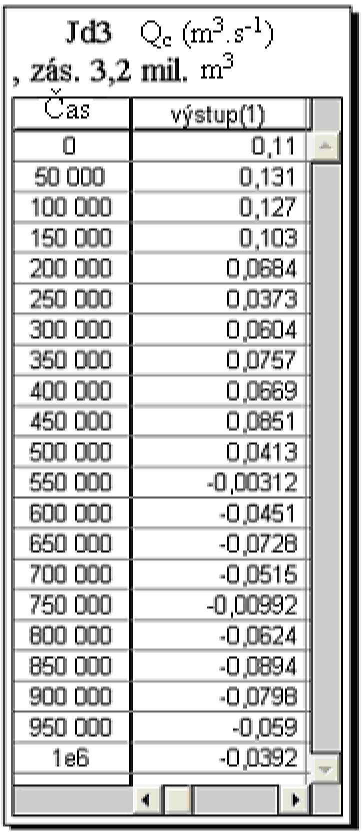
Numerical printout of measurement results

Tab. 3 Printout of the PRREP3 1A model results for the Jd3 borehole. Given behaviour of barometric pressure every 50 000 s, i.e. 13.8 hours and values dp_2 a Q_c in borehole in identical time intervals.



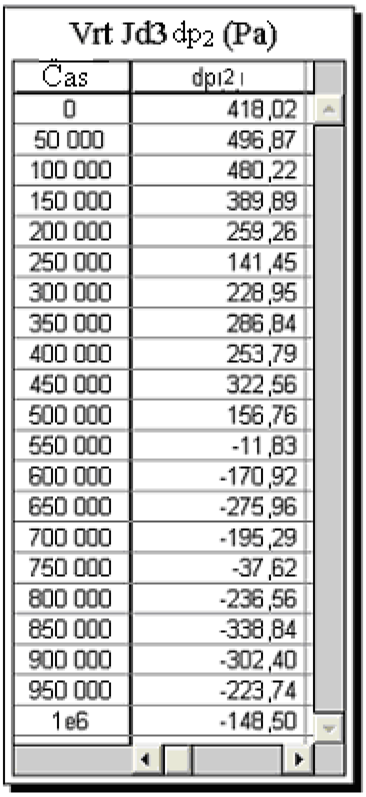
Bar. tlak p_1 pri simulaci na JD3 (Pa)

Čas	atmtlak
0	100 970,00
50 000	100 030,00
100 000	99 740,00
150 000	100 020,00
200 000	100 640,00
250 000	101 240,00
300 000	100 540,00
350 000	99 960,00
400 000	99 940,00
450 000	99 250,00
500 000	100 130,00
550 000	101 110,00
600 000	102 090,00
650 000	102 870,00
700 000	102 660,00
750 000	101 830,00
800 000	103 060,00
850 000	103 850,00
900 000	103 940,00
950 000	103 740,00
1e6	103 480,00



Jd3 Q_c ($m^3.s^{-1}$) , zás. 3,2 mil. m^3

Čas	výstup(1)
0	0,11
50 000	0,131
100 000	0,127
150 000	0,103
200 000	0,0684
250 000	0,0373
300 000	0,0604
350 000	0,0757
400 000	0,0669
450 000	0,0851
500 000	0,0413
550 000	-0,00312
600 000	-0,0451
650 000	-0,0728
700 000	-0,0515
750 000	-0,00992
800 000	-0,0624
850 000	-0,0894
900 000	-0,0798
950 000	-0,059
1e6	-0,0392



Vrt Jd3 dp_2 (Pa)

Čas	dp2
0	418,02
50 000	496,87
100 000	480,22
150 000	389,89
200 000	259,26
250 000	141,45
300 000	228,95
350 000	286,84
400 000	253,79
450 000	322,56
500 000	156,76
550 000	-11,83
600 000	-170,92
650 000	-275,96
700 000	-195,29
750 000	-37,62
800 000	-236,56
850 000	-338,84
900 000	-302,40
950 000	-223,74
1e6	-148,50

4 COMPARISON OF MEASURED AND MODEL-CALCULATED VALUES

In order to prove the possibility of use of the presented computing program for finding out important parameters affecting a gas output from a closed underground I plotted the measured values of gas pressure and volume flow rate on the Jd3 borehole according to Table 1 and at the same time the identical model-calculated values according to Table 5 for equal value of barometric pressure.

The result is illustrated in Figures 6 and 7.

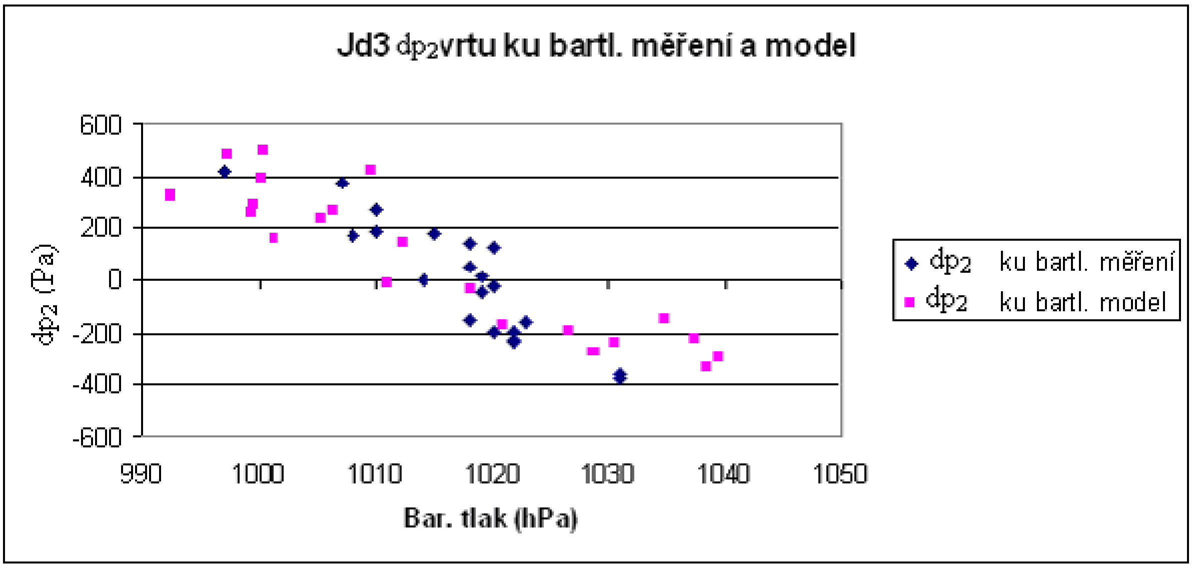


Fig. 6 Measured and calculated values dp_2 on the Jd3 borehole

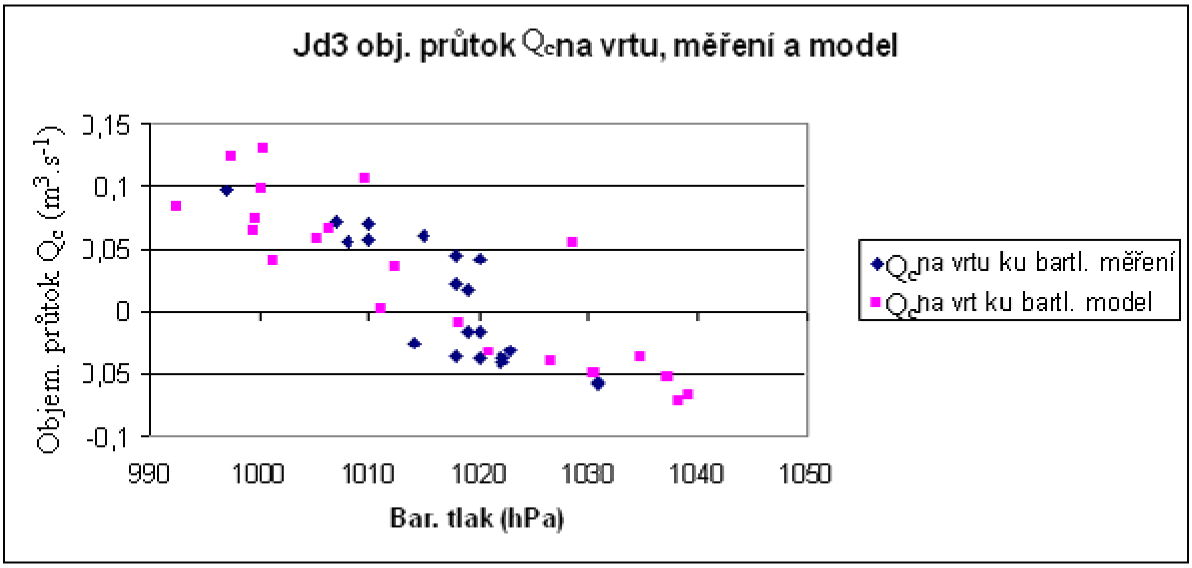


Fig.7 Measured and calculated values Q_c on the Jd3 borehole

Although there is a certain difference between the measured and calculated values it can be noted that the difference is in acceptable limits of errors and can be used for practical needs.

In particular I would like to underline that the measured and model-calculated values are identical nearly absolutely in sense of flow. The model thus can contribute to explanation of the important factor, at what development of barometric pressure and temperature conditions a dangerous state of gas output from underground can be expected.

According to Figures 6 and 7 it is necessary to expect gas outputs under barometric pressure below 102000 Pa.

5 EXAMPLE OF PRACTICAL MODEL APPLICATION

The model results imply that in surroundings of the Jd3 borehole the following takes effect:

- Gas emission, *it means residual gas capacity* in the amount of 0.008 $m^3.s^{-1}$
- Here the storage volume of 3.2 mil. m^3 is formed.

From Table 1 it is obvious that the highest methane concentration can reach up to 28 %. It is surely still a dangerous state and so a question intrudes, how long the mentioned situation can last.

From Table 5 we can derive that for instance in the period of 600 000 to 1 000 000 simulation, air will flow to underground. The air will dilute the methane concentration in the storage. For such development I use a well-known equation (8)

$$x : y = \left(c - c_y\right) : (c_x - c) \qquad (8)$$

Where: x x mixture portions with concentration c_x

y y mixture portions with concentration c_y

c Concentration after mixing

If for the period of 400 000 s air flew to the underground in an average volume flow rate of 0.07 $m^3.s^{-1}$, 28 000 m^3 of air without a methane content flew into the storage.

If the methane concentration in the storage is the same as at output to the surface, i.e. 28 %, then the output is

$$\frac{28000}{3200000} = \frac{(c - 28)}{(0 - c)}$$

c = 27,75 % CH_4.

When barometric pressure decreases the methane inflow is being renewed for the period of the decrease, obviously with concentration 28 % to the storage and the concentration can be rebalanced.

It can be then expected that the CH_4 concentration decrease on the Jd3 borehole will be a matter of a longer time period.

6 CONCLUSIONS

From the series of possibilities offered by the presented procedure of modelling gas outputs I would like to call attention to some in my view important aspects.

Let us assume such situation we have established in a certain locality methane drainage boreholes that should drain gas and so protect population. As it is known the situation in boreholes develops and in term of safety it is necessary to acquire a prediction which contingencies can occur in connection with barometric and temperature changes. The model can specify it and so we are able at a certain development to react promptly to the dangerous situation.

Further then by verifying the free space volume around an appropriate borehole using the model, we can determine concentration progress of gas mixture output. Provided that as in the presented example air flows for a certain period to underground dilution of methane concentration occurs. It is an analogy of a natural ventilation. Provided that we know free space volume, gas emission and initial methane concentration in outgoing mixture, we can calculate the dilution according to periods of higher barometric pressure. Thereby we could determine in which period the borehole decreases the concentration to a safety limit.

For a more detailed explanation of the term “free gaps (free space)”, for which also expression “storage” is , it is necessary to add that it concerns gaps communicating with an objective borehole. In our case with the Jd3 borehole. It is not an entire space of a locality as presented in Figure 1.

Gas emission itself also changes during a period of time. In most cases it gradually decreases very slightly, although localities are known where its value is high for a long time. For instance the situation presented in the work [4], or in our country the Paskov Mine of the Paskov Plant. Provided that changes of values Q_c a dp_2 take place on an appropriate borehole under identical conditions of barometric pressure and temperature, we can express using the model emission changes and so determine its development tendency.

While investigating problems of gas output from underground a question is often discussed of possible economic use of gas as an energy source [1].

It relates closely to emission value (residual gas capacity), tendency of its development and storage size. It is possible to document the answer to the given question more demonstrably using the model.

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RESUMÉ

From factors affecting gas outputs from underground especially the following ones are significant:

- Residual gas capacity, we denote it as “emission”
- Size of free gaps underground (we denote as “storage”).

It is advisable to determine residual gas capacity by the procedure stated in [7]. However, if we did not manage to find out it prior to closing the mine, which is the case of already most of formerly damped operations in OKR, then we can determine it just using the presented model.

By analogy it is possible to display also further factors participating in gas outputs using the model.

In the presented solution it was proved that by the procedure it is possible to find out the searched parameters relatively reliably.