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MODERN CRITERIA FOR SEISMIC EFFECT ASSESSMENT IN HARD ROCK QUARRIES

ARISTID BOYTE*
IONUȚ PREDOIU**

Abstract: *Following the growing rate of explosives use in blasting operations in opencast mining, and mainly the explosive loads employed in blasts, major implication consequences are induced, concerning the seismic effects on quarries slope stability. The need for understanding the occurrence mechanism of the phenomenon and the prevention measures and techniques of these "mining earthquakes". Blasting operation seismology in hard rock quarries should approach the issues of seismic wave's generation and physical-mathematical modeling of the blasting process. In order to solve the various related theoretical and practical issues, the development of adequate design norms and techniques are required (taking into consideration the blasting process specific parameters) together with of employing the needed explosive amount to provide a minimal knowledge regarding seismic wave propagation.*

1. INTRODUCTION

The continuously increasing industrial and economical growing rate involves, among others, a significant growth in explosive use in mine or quarry blasting operations, in excavation works for civil engineering and infrastructure projects, in tunneling and other kind of workings. As a direct consequence, the industrial blasting operations are representing a basic problem for researchers and professionals in the field, illustrated by a large number of technical and scientific work carried out worldwide.

Following the growing rate of explosives use in blasting operations in opencast mining and mainly the increasing explosive loads are raising major implications basically concerning the seismic effects of blasting on surface facilities and underground workings. In deep mines, blasting operations can have a major role generating rock eruptions. This, in turn, imposes a proper knowledge of the process occurrence mechanism and an adequate development of prediction models and prevention measures.

*Prof. PhD. Eng. – University of Petroşani
** PhD. Student Eng. – University of Petroşani

Besides the above-mentioned, blasting operations are also employed in seismic prospecting, aiming to describe the underground geological structure and to identify new mineral deposits. In our country, such seismic prospecting research was initiated about six decades ago. All these considerations are imposing the appropriate knowledge of seismic effects of blasts to gain experience in controlling them and optimizing their use.

Blasting seismology should deal, first of all, with seismic wave generation employing explosive sources and then to assess the basics of physical, mathematical and computer modeling of blasting process. Solving the various related theoretical and practical issues related to blasting seismic effects on buildings and other facilities, development of anti-seismic statutory requirements and design techniques (considering the specific parameters of the blasting process) and selection of blast effect reduction and control, the potential use of blasting in surface ground structure research are requiring a minimal level of knowledge in the field of seismic wave propagation theory.

Based on recording vibrations generated by explosions and industrial facilities, recordings carried out employing accelerometers the "energy ratio" ER, was defined as a concept by the following relationship:

$$ER = a^2/f^2 \tag{1}$$

or

$$ER = 16\,\pi^4 f^2 u^2 = 4\pi^2 v^2 \tag{2}$$

Where: a - maximal acceleration;
v - maximal velocity;
u - maximal displacement;
f - frequency related to maximal amplitude.

The previous relationships are assuming an imposed simple harmonic rock particle motion, being obtained through moving soil kinetic energy computation assuming that the "energy ratio" is directly linked to the alteration effect.

Empirically, three ranges of ER value can be defined (in m^2/s^2) for buildings:

$ER < 0.27$……………….total safety ranges;

$0.27 \leq ER \leq 0.54$…………caution range for improperly built buildings;

$0.54 \leq ER$……………….hazardous ranges for any building.

An ER value of 0.27 is equivalent to a particle velocity of about 84 mm/s, which is superior that the safe velocity value proposed by the Bureau of Mines, but in fact equals the allowable limit. It can be noticed that displacement levels for certain frequencies are corresponding to about 85 mm/s particle velocity level.

Another seismic effect evaluation criterion is the Zeller factor, defined as it follows:

$$Z = \frac{a^2}{f}, \quad (3)$$

Where: a-maximal acceleration;
f - vibration frequency.

Zeller factor was defined for the frequency rate comprised between 10 to 100 Hz, and a estimation scale was developed, having the name of his author (see table 1):

The vibration intensity, expressed in vibrar: and defined as below:

$$S = 10 \log \frac{Z}{Z_s}, \quad (4)$$

represents another criterion for the alteration degree estimation.

If $Z_s = 0.1$ cm^2/s, is considered as reference value, the relationship becomes:

$$S = 10 \log(10 Z), \quad (5)$$

Based on these relationships a so-called "hazard scale" was given (see Table 2):

Table 1 *The Zeller scale*

Magnitude factor Z (cm^2/s^2)	Seismic effect's brief description
1	Unperceivable
2	Very low
10	Low
50	Measurable (small fractures)
250	Quite strong
1000	Strong (below dangerous level)
5000	Very strong (serious fractures)
20000	Destructive
100000	Devastating
500000	Blighter
2500000	Catastrophic
10000000	Very catastrophic

Table 2. *Hazard scale (vibrar)*

Vibration intensity	Vibration level	Effect on buildings
10-20	Low	No danger
20-30	Medium	No danger
30-40	Strong	Low degradation (wall fracture)
40-50	Severe	Supporting wall fracture
50-60	Very severe	Building crash

The three criteria (ER, Z and S) are not having a sufficient observational basis, while it was not proven that the three factors can be related to any kind of degradation.

Considering the Zeller factor and taking into account the general shape of the degradation criterion it is obtained that:

$$ER = K_D\, A^2\, f^2$$

and

$$Z = K_D\, A^2 f^3 \qquad (6)$$

A remark should be done regarding all the vibration levels (expressed in values of displacement, velocity, acceleration etc), namely: any N non-hazardous or hazardous vibration level represents a probability type level. If the observed value of the employed parameter or factor exceeds N, it exists a high enough probability to exceed the considered degradation level N. The non-hazardous vibration level do not represents a value above which it is sure that the damage will occur. Nevertheless, the damage occurrence probability will increase or decrease according to that vibration level N, considered as dangerous.

Even if the particle's motion acceleration has a major role in natural earthquakes effect generation on buildings, as far as massive blasts are concerned, I that the degradation criterion is described at the best by the particle's velocity. For major civil engineering objectives it is recommended to carry out systematic measurements for-at least- two of the three parameters (velocity, acceleration, displacement) every two years, and the knowledge of oscillations frequency is also compulsory.

Other parameters employed for further description of ground seismic movement induced by blasting operations in quarries are represented by the average value of particles relative pseudo-velocities and particles velocity square value.

The relative pseudo-velocity spectrum, SPVR (T), can be determined with the following relationship:

$$SPVR\,(T) = \max{}_t \left| \int_0^t \exp\left[-\frac{2\pi\left(t - t'\right)}{T} \right] \sin\left[\frac{2\pi\left(t - t'\right)}{T'} \right] a\left(t'\right) dt' \right| \qquad (7)$$

Where: a - ground movement acceleration;

t, t' - time;

T - oscillation period of considered system, without amortization.

$$T' = \frac{T}{\sqrt{1 - n^2}} \qquad (8)$$

Where n is the critical amortization factor (a value n=0.08 is accepted).

The average relative pseudo-velocity spectrum is determined with the expression below:

$$\left(SPVR\right)_m = \frac{1}{T_2 - T_1} \int_{T_1}^{T_2} SPVR(T)\,dT \qquad (9)$$

Where for T_1 and T_2 the values below are recommended:
T_1=0.15s and T_2=0.08s.

$$D = \int_0^{t_{max}} \left[v_x^2(t) + v_y^2(t) + v_z^2(t) \right] dt, \tag{10}$$

Table 3. *Potential damage related to different values of (SPVR) $_m$ and D parameters for blasting operations in quarries*

Magnitude (degrees)	(SPVR) $_m$ (mm/s)	D (m^2/s)	Potential damages
V	50	0.00025	Damage on very low quality buildings
VI	100	0.001	Cracks in coating, damages in low quality buildings
VII	200	0.004	Damages in acceptable status buildings (cracks in coating, fall of coating pieces, cracks in the walls, chimneys)
VIII	400	0.016	Serious building damages (cracks in basic structures and walls, in separating walls, coating and chimney falls)
IX	800	0.064	Buildings are destroyed (large cracks in walls, masonry destruction, wall areas are falling)

The data included in table 3 can be used to assess the potential damages for different seismic effect levels, levels expressed through $(SPVR)_m$ values and correlated with the seismic intensity expressed in degrees.

2. PROCEDURES AND COMPUTATION RELATIONSHIPS FOR THE PARAMETERS DESCRIBING PARTICLES OSCILATIONS IN MASSIVE BLASTING OPERATIONS

The recordings often are giving only one of the three main parameters for particles motion (displacement, u(t); velocity, v(t); acceleration, a(t)), but practical reasons are requiring the knowledge all these parameters. The computation technique of one parameter as a function of the others basically consists in solving the following integrals and derivatives:

$$u(t) = \int v(t)dt \quad or \quad v(t) = du/dt$$

$$v(t) = \int a(t)dt \quad \text{or} \quad a(t) = dv/dt \tag{11}$$

Solving these equations, by integration or derivation, can be performed either mathematically, or by computer. Within this scope it is needed that the recording of the value employed to compute another value should fulfill certain conditions so that the seismogram can be digitized. The technique can also be applied in the frequency range. From recordings the Fourier spectrum is determined, employing the known methods (expeditious Fourier operator, Sado method etc). This spectrum is then integrated (or derived, according to what equation from equations (11) is applied) in the frequency range, and the resulting value represents the Fourier spectrum for the computed parameter. Then, through a Fourier synthesis operation the searched seismogram is obtained. For example, if the recorded acceleration diagram a(t) is available and the velocity diagram v(t) is to be obtained, the Fourier spectrum will be determined stating from the integral:

$$S_a(\omega) = \int_{-\infty}^{+\infty} a(t) e^{-i\omega t} dt \qquad (12)$$

Where: S….- is the acceleration a(t) complex Fourier spectrum.
The integration operation is done in frequency range employing:

$$S_v(\omega) = \frac{1}{i\omega} S_a(\omega) \qquad (13)$$

Through a synthesis operation, expressed by:

$$v(t) = \frac{1}{\pi} \int_0^{\infty} \left[A_v(\omega) \cos \omega * t + B_v(\omega) \sin \omega * t \right] d\omega \qquad (14)$$

where it was considered:

$$S_v(\omega) = A_v(\omega) + iB_v(\omega) \qquad (15)$$

the particles seismogram is obtained, v(t).

Another technique is allowing the assessment of a parameter as a function of another one (recorded) employing the following relationships:

$$u = v / 2\pi f \quad \text{or} \quad v = 2\pi f u$$
$$(16)$$
$$v = a / 2\pi f \quad \text{or} \quad a = 2\pi f v,$$

where: f represents the seismic oscillation frequency in the maximum recorded amplitude area on the seismogram.

Figure 1 depicts a nomogram based on eq. (16), expressing the relationships between frequency (f), acceleration (a), velocity (v) and displacement (u). Employing this diagram, two parameters can be assessed if the other two are known. For example, knowing f=100 Hz and u=0.025 mm it results (see figure 1) v=15 mm/s and a=1g. Equations (16) are valid in the case of simple harmonic motion, which do not correspond to real situation, because seismic movement is rather of impulsive shape.

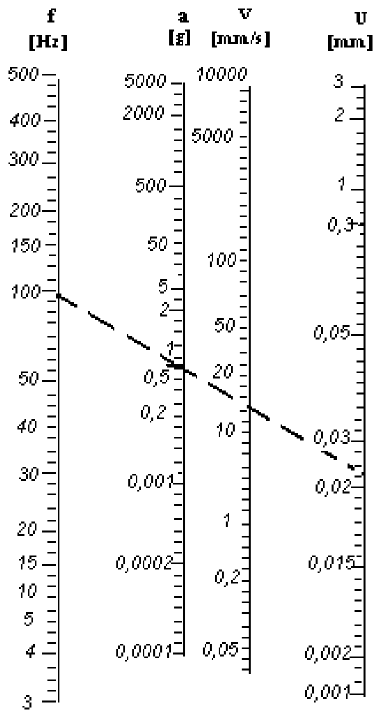

Fig.1. Nomogram for computation of parameters expressed by equations (16)

In order to carry on such a study, the following procedure should be applied. Recordings of particle's velocity will be employed from a series of blasts carried out in various conditions, with different loads. It is recommended that input data will include the radial, cross-sectional and vertical component. On each seismogram are measured the maximal amplitude v of particle's velocity and the related frequency. If the displacement u should be determined, the first equation from (16) is applied. The same v(t) recordings are digitized and fed into computer to obtain the Fourier spectrum. This spectrum is integrated in frequency range in order to obtain the u(t) displacement Fourier spectrum. Using the Fourier synthesis, the u(t) seismograms are issued, allowing to read the maximal amplitudes u, which in turn are compared to those obtained by employing the first equations in (16).

In such a study the results are plotted in figure 2, which contains, in the abscissa the determined displacement by velocity integration and the displacement computed with the first equation in relationships (16). The line having the value 1,0 indicates the area of points resulting if the displacements assessed by the two techniques would be identical. The set of points are located (in figure 1) under the line of 1,0 value, showing that computed displacements, assuming simple harmonic motion, are generally lower than the displacements computed by integrating the v(t) seismogram, which in turn are correct from the physical and mathematical point of view.

In a similar manner should one proceed for the other cases (e.g. velocity v computation using displacement u or acceleration a). The results for velocity v are represented in figure 3. While the majority of points are located under the line of 1.0 value, it comes that velocities v, computed assuming simple harmonic motion are lower than the recorded velocities. It is obvious that a computation of particle's velocity from recorded acceleration data would lead to results comparable to those from figure 3.

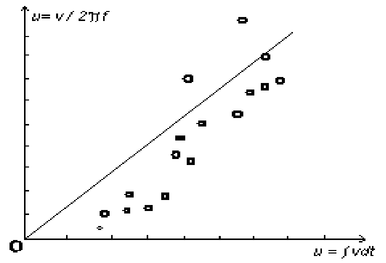

Fig.2. Comparison between computed particle velocity – employing particle velocity recording and assuming simple harmonic motion (first (16) equation – and displacement determined by particle velocity recording integration

So, the particle's velocity, computed either from recorded displacement data, or from recorded displacement data assuming simple harmonic motion will be generally lower than directly recorded particle's velocity. On this topic, *Bollinger* (1980) has a contrary opinion, showing that by computing the velocity v from recorded displacement, assuming the simple harmonic motion, an overestimation of real movement is done.

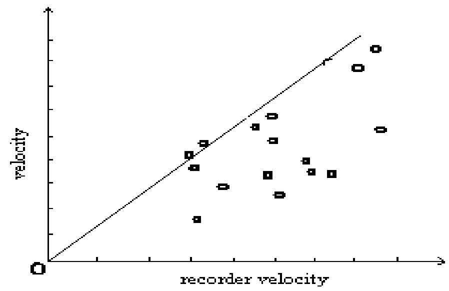

Fig.3. Comparison between computed particle velocity – employing particle displacement recording and assuming simple harmonic motion (first (16) equation – and displacement determined by particle velocity recording integration

In view of computing the significant dynamic parameters of seismic oscillations generated by blasting operations there also have been established, several empirical relationships as a function of the explosive charge, distance to the blasting point, explosion type, environment characteristics etc. The results are dealing with instantaneous blasts (micro-delayed blasts), and u, v and a from formulas below are representing peak values of the parameters. These empirical formulas can serve for vibration level estimation, without any blast generated wave recording.

a) Displacement calculus

Field observations showed that for radial displacement computation, induced by seismic vibrations from blasts, the following relationship (I.C.I., 1972), can be applied:

$$u = \frac{k_a \sqrt{Q}}{r} \tag{17}$$

where: u - radial displacement, mm;
Q - explosive charge, kg;
r - distance to the explosion location, m;
k_a - coefficient depending on blasted rock's nature and nature of rock sustaining the buildings (Table 4):

Table 4. *Location coefficient factor (k_a) values*

Nature of blasted rocks	**Rocks in buildings location**	**k_a**
Hard rocks	Hard rocks	0.57-1.15
Hard rocks	Hard rocks	1.15-2.30

b) Velocity calculus

Because the particle's velocity represents the basic dynamic parameter in studying the seismic effect of blasting on surface facilities and quarry slopes several relationships were proposed foe its calculus. The following one was given for determination of radial particle's velocity:

$$v[\mathrm{cm/s}] = 268\left(\sqrt[3]{Q[\mathrm{kg}]}/r[\mathrm{m}]\right)^{3/2} \tag{18}$$

Based on data gathered during blasting in hard rock quarries, the expressions below were proposed:

$$v[\mathrm{cm/s}] = 408\left(\sqrt[3]{Q[\mathrm{kg}]}/r[\mathrm{m}]\right)^{3/2} \tag{19}$$

$$v = \frac{k}{r} Q^{0,55} e^{4,62} \left(\frac{h}{r} \right)^{0,1}, \quad (20)$$

where: h -explosive charge location depth.

k - coefficient depending on the ground conditions.

A relationship having a similar shape with (18) and (19), but taking into consideration a larger range of blasting conditions, building location conditions, propagation environment etc, is given below:

$$v[cm/s] = k_1 k_2 k_3 k_4 k_5 k_6 \left(\frac{\sqrt[3]{Q[kg]}}{r[m]} \right)^{3/2}, \quad (21)$$

where: k_1- coefficient considering the blasted rock nature, the building's ground nature and the season (see table 5);

k_2 - coefficient considering the way the blast is directed with respect to the protected buildings location. (see table 6);

k_3 - coefficient depending on blasting conditions (see table 7).

Table 5. *Values for k_1 coefficient*

Nature of blasted rocks	Rock type	Summer	Autumn and spring	Winter
Hard rocks, harder than the average	Rocky rocks with a thin layer of deposition	120	120	120
Hard rocks, harder than the average	Clay and sand deposits with 10-15 m thickness	200	300	250
Hard rocks, weaker than the average	Hard and medium strong rocky rocks	90	90	90
Hard rocks, weaker than the average	Clay and sand deposits with higher than 10-15 m thickness	150	230	200

- For humid, non-rocky soil, the k_1 coefficient will be multiplied by 1.5.

Table 6. *Values for k_2 coefficient*

Protected objective's location	$\mathbf{k_2}$
Behind blasted block	1.0
On a side of the blasted block; charges are detonated in opposite direction of protected objective	0.65
On a side of the blasted block; charges are detonated in the direction of protected objective	0.85
In blasting blocks having 4-5 free surfaces	0.85

Table 7. *Values for k_3 coefficient*

Blasting conditions	$\mathbf{k_3}$
Usual face	1.0
One free surface; massive unexcavated rock blasting; for blasting in several stages; blasting in compressed environment etc	2.0
In blasting blocks having 4-5 free surfaces	0.5

Table 8. *Values of quantities k_v, k_u, k_t, k_T şi n*

Rock type		**Wave longitudinal**		**Wave R**	
		$\mathbf{k_v}$	$\mathbf{k_u}$	$\mathbf{k_T}$	**n**
Clay soil		1100	75	0,08	0,11
Saturated sand		700	60	0,15	0,00
Granite		700	15	0,0058	0,44
Hard limestone		700	15	0,035	0,20
Loess with moisture	5%	130	14	0,06	-
	2%	70	7,5	0,06	-

Maximal particle velocity for longitudinal wave is given by eq. (22):

$$v[cm/s] = k_v\left(\sqrt[3]{Q[kg]}/r[m]\right)^{1,7}, \tag{22}$$

where: k_v is a coefficient depending on ground nature: for hard rocks k_v = 360, and for clays k_v = 700.

The oscillation period, for longitudinal wave, can be estimated with the following relationships (valid for $10^3 \le Q \le 10^6$ kg):

$$T[s] = 0,0065\sqrt[6]{Q[kg]}, \tag{23}$$

for hard rocks, and:

$$T[s] = 0,06\sqrt[6]{Q[kg]}^{0,21}, \tag{24}$$

for clays.

The particle's maximal vertical displacement within the surface waves R (Rayleigh waves) is given by the equation below:

$$u_{z[mm]} = 1900\left(r_0 / C_p\right)\varphi\left(Q / r_o\right)f\left(r\right) \tag{25}$$

where: r_0 is the distance from blast at which waves are becoming quasi-elastic, computed as it follows:

$$r_0\left[m\right] = k_0 \sqrt[3]{Q\left[kg\right]}, \tag{26}$$

where: k_0=4.5; 3; 2.5; 6-8 respectively for granite, schist, clay-sandy loess, clay. The function $f\left(\bar{r}\right) = \left(\bar{r}\right)^{-0,5} e^{-1.75(r)^{0,2}}$, is expressing the blasting backfilling effect. The function f(r) has the shape given below:

$$\bar{r} = r / \sqrt[3]{Q}\left[m / kg^{1/3}\right] \tag{27}$$

where: the values of $f_{(\bar{r})}$ function are computed from table 9.

Table 9. *Values for $f_{(\bar{r})}$ function*

$\bar{r}$	**1**	**2**	**5**	**10**	**20**	**50**
$f\left(\bar{r}\right)$	$17,4 \cdot 10^{-2}$	$9,5 \cdot 10^{-2}$	$4 \cdot 10^{-2}$	$2 \cdot 10^{-2}$	$9,3 \cdot 10^{-3}$	$3,8 \cdot 10^{-3}$
$\bar{r}$	**100**	**200**	**500**	**1000**	**2000**	**5000**
$f\left(\bar{r}\right)$	$1,23 \cdot 10^{-3}$	$4,58 \cdot 10^{-4}$	$1,03 \cdot 10^{-4}$	$3 \cdot 10^{-5}$	$7,5 \cdot 10^{-6}$	$3,2 \cdot 10^{-6}$

The maximal horizontal displacement u_H in R waves can be assessed knowing the ratio u_H / u_Z (having values of 0.6-1.1 for granite; 1.0-2.2 for clay; 1.4-1.8 for loess) and the u_Z value assessed as shown above.

Fig. 4. Effect of blasting backfilling depth as a function of Q/r_0 ratio

The oscillation period of R waves can be estimated with the following relationship:

$$T[s] = K_T\left(\sqrt[6]{Q}\right)\left(\frac{r}{\sqrt[3]{Q}}\right)^n, \tag{28}$$

where the constant values K_T and n, for a few types of ground, are presented in table 8.

The maximum vertical particle velocity, for R waves can be written, consequently, as it follows:

$$v_z[mm/s] = \frac{2\pi u_z}{T} = \frac{1{,}19\times 10^4 r_0 \varphi(Q/r_0) f(\bar{r})}{C_p K_T \sqrt[6]{Q}(r)^n} \tag{29}$$

and the maximum horizontal velocity is:

$$v_H[mm/s] = v_z \frac{u_H}{u_Z}, \tag{30}$$

If recording data are lacking for an accurate calculus of averaged value of relative pseudo-velocities spectrum, this value can be estimated using the expression below:

$$(SPVR)_m[m/s] = c\frac{r[m]}{\sqrt[3]{Q[kg]}} \tag{31}$$

where c is determined for each case from the location conditions and blasting conditions.

Excepting the three waves for whom the equations (21)-(25) are given above, obtained from experimental data, any seismogram can comprise several other waves (longitudinal, reflected, refracted etc.). While the pattern is quite complex, I consider that the wave separation on seismograms is rather difficult, not too sure and less useful from the point of view concerning the seismic effect asse4ssment on buildings and surface structures. Furthermore, the formulas related to maximum amplitude (of displacement, velocity or particle acceleration) seem to appear much more useful, independently of which wave is considered. (considering equations (25)-(31)). Anyway, the R waves are having the highest magnitude, being the most dangerous for the buildings and surface structures.

CONCLUSIONS

Assessments of seismic energy released by rock blasting operations indicate that these are comparable with tectonic earthquakes having lower magnitude than 5. Apparently a paradox the rock blasts are, on one hand, a ignition factor for rock bursts and mine strokes and, on the other hand, they can be used, in a well conceived and designed system, in prevention of this kind of mining earthquakes. In our country the research of rock blasts is less developed, mainly because until the date in Romanian mines or quarries this kind of phenomenon did not occurred.

On the other hand, the seismologic research of controlled rock blasts in industry, started more then 20 years ago in Romania, considerably developed in the recent years. Research work was carried out concerning the seismic effect of blasting on surface structures and underground mine workings and studies in which blasting operations performed in quarries are employed in describing geological structure and, even, the upper part of surface ground and slope stability in quarries.

REFERENCES

[1]. Greenhalgh S.A. 1980 - *Bull. Seism*. SOC. AM. 70 p 2037-2050

[2]. Mosineț V.N: Drobiascee - *Î Seismiceskoe deistvia vzrîva v gornîh prodah* . Izd. NEDRA Moscova

[3]. Spottiswoode, S.M; Mcgarr (1975) - *Bull. Seism*. SOC. AM. P 93-115

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PRESENT AND PERSPECTIVE TENDENCIES REGARDING EFFICIENCY OF COAL LONGWALL EXPLOITATION

IOAN DUMITRESCU*
VALERIU PLEŞEA**

Abstract: *In line with the strategy of socio-economic development of the Jiu Valley coal field and at the same time, the targets set by Romania's Energy Strategy, improving technologies for the exploitation of coal is a goal of strict necessity and opportunity. In the paper is a brief evolutionary analysis of current methods used to exploit the mines in the Jiu Valley, with the extension of the presentation layer technology with coal undermined at the level which describes the possibilities for complex mechanization of the main operations of the cycle of mining works.*

Key words: *coal, exploitation, coal face, mechanical complex*

1. INTRODUCTION

The mining in the Jiu Valley is still representing an important source of providing energy to the economy of coal, underground coal extraction continued at seven mining exploitations, namely: Lonea, Petrila, Livezeni, Vulcan, Paroseni, Lupeni and Uricani.

With all efforts supported by teams from the mining National Huile Company Petroşani on improving business and employment company in a state of normal economic and financial results are most satisfactory, the entire structure is marked on the part of market coal and energy prices, materials and equipment that are purchased on the open market, on the other hand, the lack of technologies for exploitation of high productivity and economic efficiency.

The implementation and the method of operation since 1995 with sap behind the front, with the use of individual support columns and beams SVJ 2500 and GSA 1250 beams, whose degree of participation to the total output current pool is approx. 65% was compared with classical methods of operation, a step forward, but limited technical possibilities and technical-economic indicators produced modest (working in production of 7.7-8.0 tones/post and total operating expenses for 1530-1690 lei/1000

* *Prof. PhD. Eng. –t Universiy of Petroşani*
** *Assoc. Prof. PhD. Eng. – Universiy of Petroşani*

goods production and even larger at one of the mining exploitations) continues to be reflected directly in the results below the threshold of profitability provided. In these conditions, for efficient operating of layer 3 of the pool, the complex consisting of mechanization of operations consuming labor and cycle time of the production method of operating the bank undermined.

2. ESTIMATION OF COAL PRODUCTION AND METHODS OF OPERATION

Analyzing the evolution of coal during the period 1995 to 2008, finds important mutations that took place restrictions on the area of application of classical methods of operating history and even replace them for some new stuff, the greater productivity and economic efficiency (ex. method of operating the bank under-mined coal), as follows:

- room mining works and SCRI are not used anymore;
- frontal mining works, in all variants respond best to geo - mining production is realized most of those mining works (77 % in 1990 – 92,1 % in 2008);
- classical fronts front with long mechanized front recorded a decrease (from 31% in 1990 to 19.4% in 2008), it is due but, mainly, lack of sources of funding needed to carry out major investment for the acquisition of complex mechanized latest generation. The technical indicators - economic benefits are below the schedule and far from the average achievements in countries with advanced mining (production daily slaughter of 450 - 550 tons / day from 1500 - 2500 tons / day and production of 9-12 tones / post from 20-25 tonnes / post)
- there is a continuous decrease in the production front with individual support (with long front decline from 21.7% in 1990 to 7.5% in 2008, while those with short front from 25% in 1990 to 2.6% in 2008), this focusing method for the impairment introduced in 1995 and which was expected to obtain technical indicators - high economic;
- - The application of the method in 1995 with the operation of bank undermined thick layers of coal in the Jiu Valley (layer 3) has made progress in achieving upward overall basin production, from 0.9% share of participation in 1995 to 65.2 % in the quarter of 2008 (fig.1).

Depending on the variants of technological exploitation applied, the undermined bed method recorded the end of 2008 share of 28.3% for layers of low slope (up to 25°) and 36.9% for the average slope of layers (25˚- 45°) and high (greater than 45°).

Regarding the main method of operation with coal bank undermined applied to mines in the Jiu Valley, is evaluated using its technology in 3 variants, depending on remote tilting layer exploited to roost.

For all 3 variants of technological exploitation characterized by the use of supporting frameworks of individual, consisting of articulated beams mounted in the network and columns hydraulic circuit open cut coal from the front base of the working class through the process of clipping-shooting and partly through the rocks with hammers working, is making some major deficiencies that negatively affect the overall technical-economic indicators.

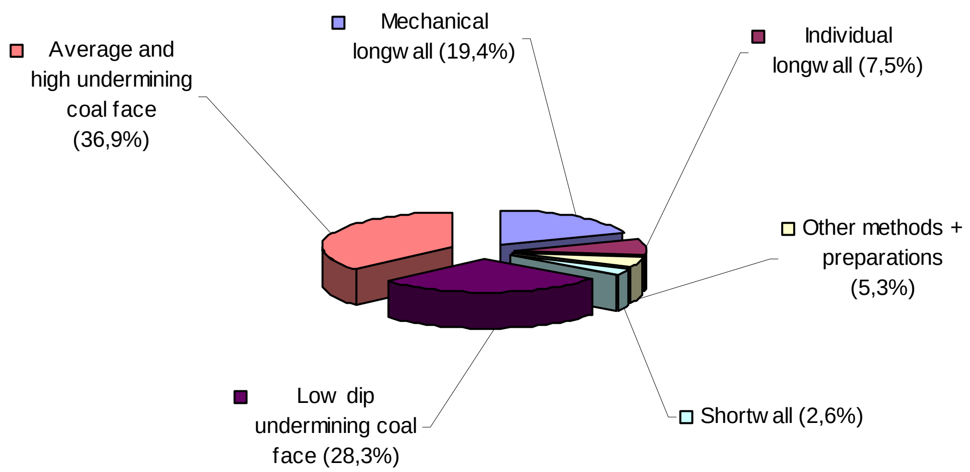

Fig.1. The weight factor of participation of mining exploitation methods to the hole basin coal production (2008)

From the main technology's deficiencies we have:

- Complex operations of the technology, all is done manually, with significant inputs of labor and time;
- Classic method used for cutting coal involves punching and shooting short sections on the front of the front, each with lengths of up to 5 - 6 m, resulting in this way, the total length of 50 - 60 m in front, the need for implementation of 10 -20 cycles shooting. In this way, if the requirement for a front vent for each of cycles performed (15-20 minutes) appears to extend the duration of total cycle working with 150 - 400 minutes, only for reasons of safety and health work;
- The use made of support beams that support articulated mount network implies additional inputs of labor, both at the support strips cut again, and during the management of mining pressure, as a consequence of multiple joints "feather - finger" in order to be accomplished;
- Density of reinforcement is consistent hydraulic columns, which compete in serious difficulties, both in handling them and slow the movement of staff by working. In the method, individual support is the location of 5 poles hydraulic throughout a range of 3 beams in the arrangement String spaced 0.8 m in the transverse plane of hewing;
- Dismantling and winding transporter working in one of the most difficult and unproductive cycle of operations working.

Given the current deficiencies in the method of operation with bank undermined, it becomes necessary to introduce new alternatives, based mainly on the mechanization of the basic operations of the working cycle.

3. SOLUTIONS OF MECHANIZATION OF THE UNDERMINED FRONT BENCH

Method of operation layers thick with mechanized slaughter long front bench and undermined, was designed and could develop into a number of countries with experience in the field (Russia, Slovenia, Germany, France, Spain, England, China, USA, Australia, etc.) only in the adaptation and improvement of the classical mechanized claims used in the case of slices of the normal layers of coal (2,5 – 3 m).

Compared to the existing experience worldwide in the field of mechanization of operations in the method of operating the bank undermined, at CNH Petrosani, are consisting in introduction of similar equipment, in the condition of using combination cutting and loading machines and stepping frame sets.

Through the local level institutes and profile companies was a cantilever stepping type GEROM-GP 250/1200 for support on the basis of the assimilation model KOPEX, including a SALZGITTER model (Germany). The model is designed to serve both in technology to cut the coal at the front is a classic method of clipping-shooting, and when combined with the cutting of hewing (fig.2).

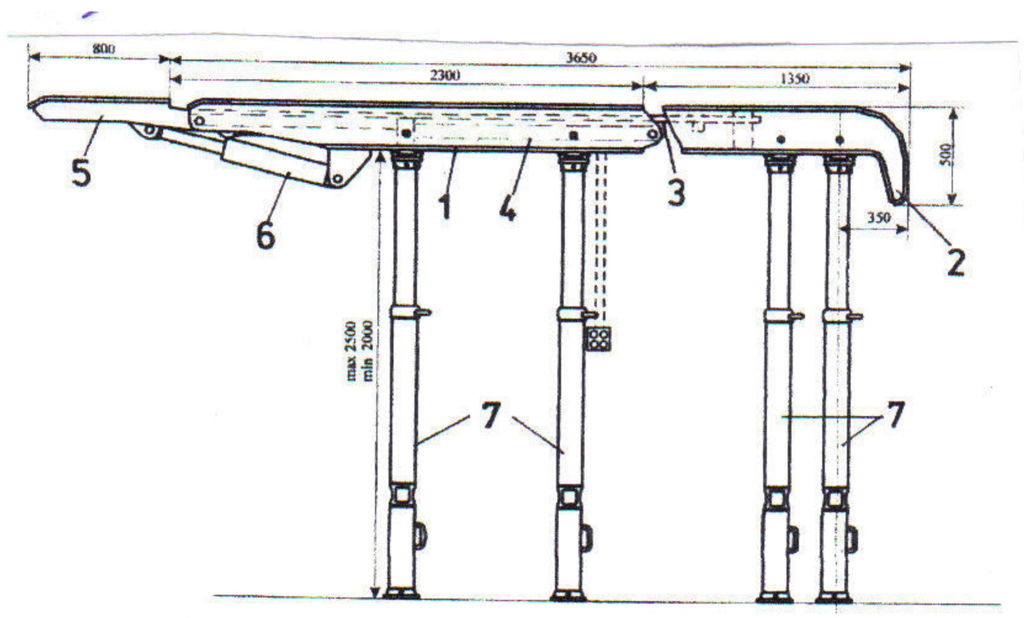

Figure2. Beam gait type GEROM GP 250/1250: 1 – main beam; 2 – secondary beam; 3 – gliding element; 4 – stepping hydraulic cylinder; 5 – front catcher; 6 – front catcher hydraulic cylinder; 7 – hydraulic retaining pillars

By relieving the coal with explosives will be working has the following equipment:

- Light rotating perforators – PR8;
- Stepping frames GEROM-GP 250/1200;
- Scraper conveyor TR3, with role in evacuation of coal from both the front and of the undermined bank.

In the cut with the combine, the complex provides mechanized equipment in the machinery:

- Stepping frames GEROM-GP 250/1200;
- Front combine ESA-150L (Eickhoff), or similar;
- Carrier TR-7A, or similar for coal eviction from the front;
- Carrier TR3 for undermining.

In the organization of work and working techniques of calculation of indicators for the two scheduled technologies operating results are presented in Table1.

Table1. **Average indicators of possible techniques to achieve the technological variants of exploitation (P_C=1,25 m)**

No. crt.	Specification	U.M.	Cutting with explosive and stepping frame variant	Cutting with combine and stepping frame variant	Classic variant (explosive cutting and individual retain)
1	Production - by cycle - by shift - by day - by month	tone	 1085 211 844 17935	 1085 292 1168 24820	 1085 141 564 11985
2	Advancing speed - by day - by month	m	 0,97 14,7	 1,34 20,0	 0,65 10,0
3	Work productivity	tone/post	17,22	23,83	11,5

Analysis of results is found in all cases that the size of the working cycle (P_c = 1,25 m), technical indicators with the operation and use of bank staff undermined gait are superior compared to the classical current, which support the implementation of individual columns and beams SVJ 2500 articulated beams GSA 1250.

Thus, if the operations mechanization level of slaughter is found to increase yields 31.20% and 51.71% when used to support frames gait and coal cutting is done with explosive and with the combined light of hewing. Also, compared with the classical current operating speed of advancement are higher with 31.97% and 50% respectively, while labor productivity increased by 33.22% and 51.74%, which recommended the introduction and widespread operation of the Jiu Valley coal in the method of operating the bank on which undermined the complex operations to be performed in a mechanized mode.

4. CONCLUSIONS

To streamline the operation of layer 3 of the Jiu Valley, with the front bench abatajele coal undermined, correlated with the directions of action set out in the strategy of socio-economic development of the mining industry in the Jiu Valley, in the case of premises achieving the objectives set by strategy Romania's energy, the current concerns of stakeholders (CNH Petrosani, SA ICPM Petrosani University, Petrosani) consisting of the introduction and widespread mechanization technologies based on complex major operations consuming labor and time of the production cycle.

In response to the possibilities of mechanization of the basic operations of the bank undermined work faces, provides for the use of gait for the support and combines cutting type easily, with one arm, in mechanized coal cutting in the front.

Compared to the classical version of the operating bank undermined, technology based on mechanization operations bring a surplus of labor safety hewing generating, also obtain higher net technical indicators.

Bibliography:

[1]. Dumitrescu, I., Pleşea, V., *Presentation regarding the hard coal technological extraction level in Jiu Valley.* Scientific Works of International Symposium „Continuous surface mining", Petroşani, October 2008.

[2]. Pleşea, V., Dumitrescu, I., Radu, S., ş.a., *Present technological stage of undermined bed exploitation in Jiu Valley and mechanization solution of the coal face operations cycle.* First stage of research at project PDT no. 1024 from INOVARE National Program (Modulus 1), January 2009.

[3]. Pleşea, V., Radu, S., Orban, M., *Solutions of competitiveness growth of the mines from Jiu Valley through mechanization of the operations of undermined bed exploitation method.* Revista Minelor, nr. 4, 2008.

[4]. * * * Undermined bed exploitation methods *of the thick coal layers from Jiu Valley.* Documentations of S.C. ICPM – S.A. Petroşani, 2005.

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EXPLORATION AND SELECTIVE EXTRACTION OF STONES AND ROCKS IN OVERBURDENS OF LUSATIAN OPEN-PIT LIGNITE MINES

W. FAHLE*
S. KÖRBER**

Abstract: *This presentation focuses on the exploration and selective extraction of stones and rocks in overburdens of Lusatian open-pit mines. It is divided into six sections: 1 Stones and Rocks Interfering with the Excavation Process, 2 Geology of the Stone and Rock Deposits, 3 Detection Procedures for Geophysical Explorations, 4 Preliminary Extraction of Stones and Rocks with Auxiliary Equipment, 5 Protecting Heavy Equipment from Stones and Rocks, 6 Summary.*

1 STONES AND ROCKS INTERFERING WITH THE EXCAVATION PROCESS

The overburden layers of the quarternary deposits of the Lusatian lignite district contain, in part, very compact stones and rocks. These boulders impede the operation of heavy equipment during mining as follows:

- Downtimes due to stone blockage or damage repairs
- Damage to the excavating equipment and conveyor belts
- Material fatigue during long-term operation
- Using auxiliary equipment to clear the excavator’s operating level

The consequences are a reduction in the effectiveness of our heavy equipment in open-pit mines and increased maintenance and repair efforts and expenditures. All told, these stones and rocks cause 400 to 500 disturbances per year in the four active open-pit mines located in the Lusatian mining district. In 2003, these disturbances resulted in an additional expenditure amounting to € 3.9 million of which € 1.2 million were due to additional maintenance and repair work on the excavating equipment and conveyor belts. Figure 1 shows a detailed cost breakdown.

* *PhD.Eng. - Gesellschaft für Montan- und Bautechnik mbH (GMB), Germany*
** *PhD. Eng. - Vattenfall Europe Mining AG*

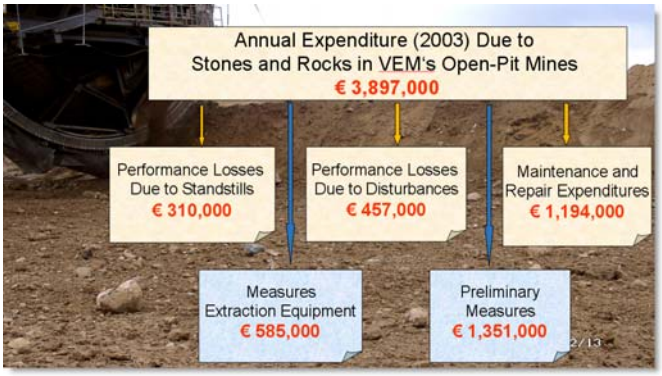

Figure 1: Expenditures due to stones and rocks

2 GEOLOGY OF THE STONE AND ROCK DEPOSITS

The stone and rock deposits are a result of the quarternary orogenesis. The stones and rocks were transported during the Ice Age from Scandinavia to Lusatia and deposited here as a result of deglaciation. Geological surveying has revealed that boulders are deposited primarily in the following geological structures:

- On the surface of dumped moraines,
- In meltwater channels close to the surface,
- At the base of quarternary deposits, and
- In alluvial marly complexes of the Drenthe (early Saale) and Elster Ice Ages.

These deposits are depicted in Figure 2.

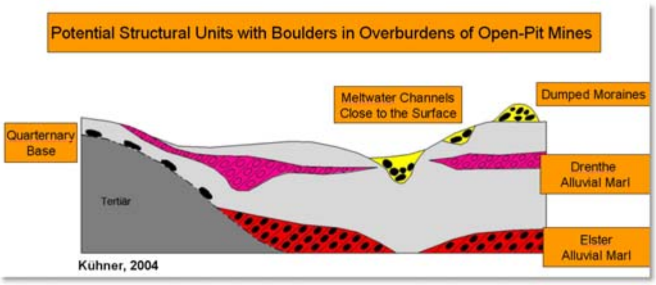

Figure 2: Geology of the stone and rock deposits

Figure 3 shows in an exemplary fashion the frequency of such stone and rock deposits and their diverse sizes at the operating level in the Welzow South open-pit mine. In Figure 4, one can see a rock wedged in the bucket wheel of an SRs 6300.

Figure 3: Stone and rock deposits close to the surface

Figure 4: A rock wedged in the bucket wheel of an SRs 6300

3 DETECTION PROCEDURES FOR GEOPHYSICAL EXPLORATIONS

The stones and rocks are deposited randomly despite their frequency. They cannot be detected through drilling; unless it is by accident.

Geophysical surface procedures can detect geological structures and individual stones and rocks. In the Lusatian lignite district, extensive development work has been carried out to detect stones and rocks through geophysical surface procedures since the end of the 1980s.

- Geoelectric mapping of melt water channels and
- Georadar to detect individual stones and rocks in unfixed material

have proven to be the most successful methods.

3.1 *Geoelectric Detection Procedure*

The geoelectric potential procedure measures the specific electrical resistance of the soil through current and voltage measurements (Figure 5). The distance between the measuring probes determines the actual measuring range. This is the half-space under the probes. The mean value of the entire section cannot indicate individual stones or rocks. The borders and depths of unfixed channel structures can be ascertained quite well with the geoelectric procedure. Typically, they contain stone and rock deposits.

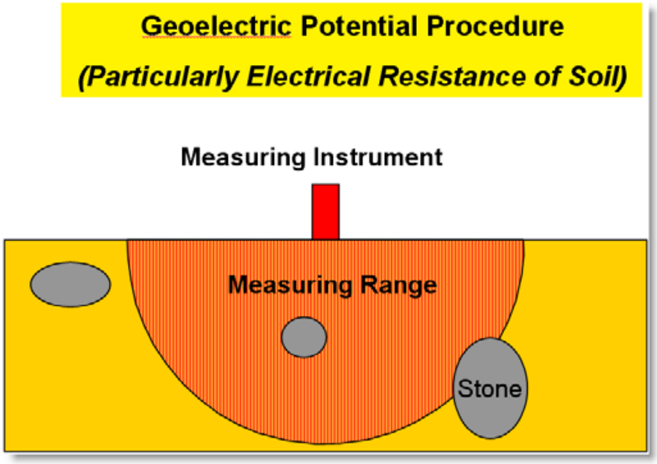

Figure 5: Geoelectric procedure

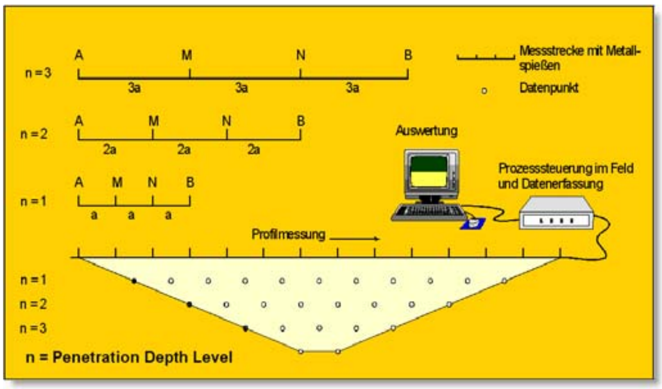

Figure 6: Geoelectric probe mapping procedure

Figure 6 shows the geoelectric probe mapping procedure. It is carried out with multiple electrode measurements. Up to 100 sensing electrodes are set along a profile and connected to the measuring instrument. The resistance coefficients are ascertained for the horizontal and vertical measuring points. The result is a vertical section of the resistance distribution (geoelectric vertical section).

Figure 7 shows an unfixed gravel channel (brown) in a geological, vertical section in the top right corner. By comparing and contrasting it with the geological profile at the open-pit slope, it is easy to recognize the excellent conformity of the stone and rock bearing gravel values with the measured values of the geoelectric procedure.

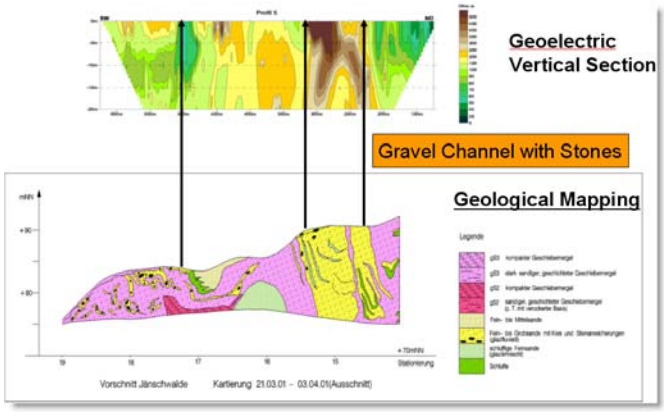

Figure 7: Comparing and contrasting the geoelectric and geological sections

The level course of the gravel channels is ascertained in the surface depiction (horizontal resistance distribution) through several parallel profiles.

3.2 *Georadar Detection Procedure*

With the georadar wave procedure, the time lag of the reflected electromagnetic waves is measured, and the depth is calculated on the basis of the propagation speed. The size of the stones and rocks is estimated from the reflected image – Figure 8.

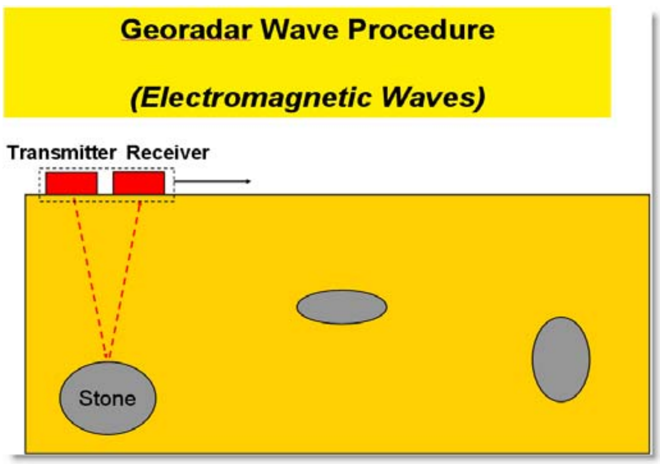

Figure 8: Georadar procedure

The measurement is carried out continuously via a measurement profile in which the transmitting and receiving dipole is moved evenly on the profile.

Figure 9 shows a georadar measurement being carried out at the operating level. A 100 MHz measuring antenna is pulled by a cross-country vehicle. The measuring equipment and power supply are in the vehicle.

Figure 9: Georadar measurement in an open-pit mine

A radargram is created (Figure 10). As an amplitude step-up – as is depicted in red here –, stones and rocks are discernible as a local reflection. In the vertical recording of the profile, the depth can be determined with the precision of a few decimeters.

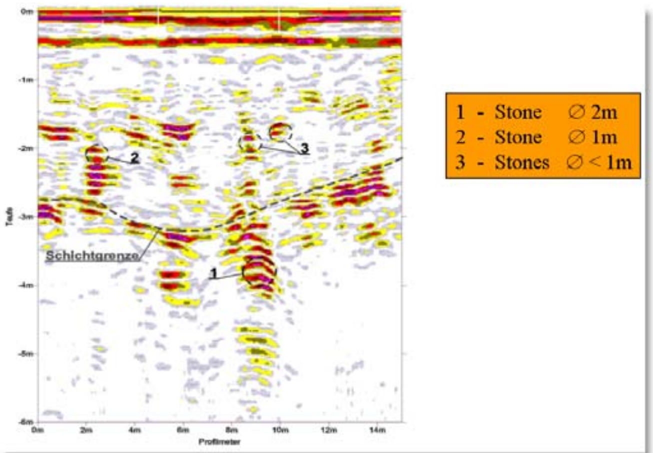

Figure 10: Radargram

The size of the stones and rocks can be estimated according to the width and shape of the reflection. The Lusatian open-pit mines use a scale of 2 m, 1 m, and < 1 m grades.

Stones and rocks can be detected in sandy gravel deposits up to a depth of 15 m. Reliable readings are not possible in clay or silt sections, or only up to a depth of 2 m.

How are these procedures applied in the Lusatian open-pit mines?

Depending on the actual progress made in open-pit mining, regular geophysical profiles are taken in order to map the stone and rock distribution with 15 km to 30 km georadar and at intervals of 10 m to 20 m. Since 2004, georadar has also been used at operating levels of the preliminary section to identify local stone and rock concentrations.

The geoelectric measurements are carried out prior to open-pit mining. The gravel channels are mapped primarily in cohesive loose boulders. The profile intervals are between 40 m and 60 m.

4 PRELIMINARY EXTRACTION OF STONES AND ROCKS WITH AUXILIARY EQUIPMENT

As a result of the geophysical surface mapping and the geological model, sections having large stone and rock concentrations are identified prior to open-pit mining.

The extraction and the blockage of the stones and rocks is carried out in two steps:

1 Using auxiliary equipment prior to heavy open-pit mining equipment. That is the focal point. Up to a depth of 5 m, hydraulic excavators (Figure 11); up to a depth of 15 m, dragline excavators with a long boom (Figure 12).

2 Applying technical measures at the heavy open-pit mining equipment Stones and rocks which had not been detected are blocked at the heavy equipment.

Figure 11: Hydraulic excavator to extract stones and rocks

Figure 12: Dragline excavator to extract stones and rocks

Both types of equipment are used in similar fashion. The stone and rock horizons or individually detected boulders are excavated with the auxiliary equipment, carried away with trucks, and deposited at the edge of the open-pit mine.

In Figure 13, one can see in a graph the proportion of the forecast stones and rocks to the number of boulders actually extracted in the first overburden section of the Welzow-South open-pit mine. The proportion shows that considerably more stones and rocks had been collected than had actually been forecast. Just in 2007 alone, this number amounted to about 60,000 stones and rocks.

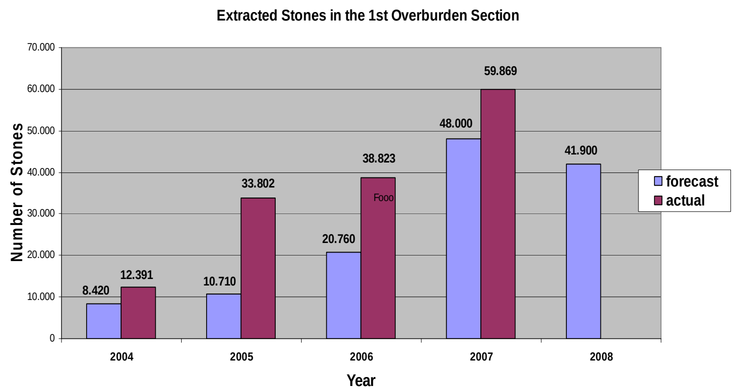

Figure 13: Proportion of forecast and actually extracted stones and rocks

5 PROTECTING HEAVY EQUIPMENT FROM STONES AND ROCKS

In addition to selective extraction, a number of technical adjustments were made on the heavy open-pit mining equipment in order to block stones and rocks which come from individual deposits, depths, or sectors where auxiliary equipment cannot be used. These technical measures include, for example:

- Buckets with cutting edges
- Stone and rock guards on the buckets
- Reversibility of the wheel belt
- Stone and rock catchers on the middle chute of a belt transfer

Figure 14 shows the locations of possible stone and rock blockers on an SRs 6300 bucket wheel excavator. One can see that stones and rocks cannot be transported from the conveyor belt on the loading boom.

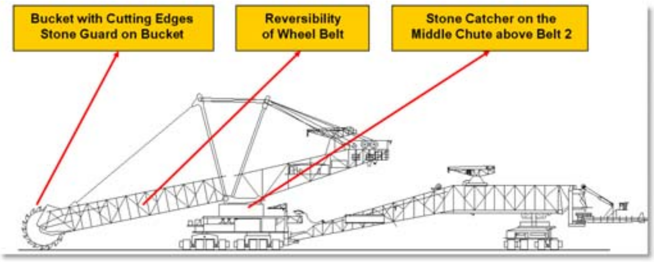

Figure 14: Locations of the stone and rock blockers on the SRs 6300

Another technical option are stone and rock guards (Figure 15) – as depicted on an SRs 2000 at the Jänschwalde open-pit mine. They keep large stones and rocks out of the bucket wheel.

Figure 15: Stone and rock guards on the SRs 2000

6 SUMMARY

In part, the geology of overburdens in some Lusatian open-pit mines exhibits extensive disturbances. Several ice ages have disturbed the bedding. The open-pit mining technology has to be adjusted to these disturbances. They also include the presence of rocks and stones with diameters ranging from a few decimeters to a couple of meters. Geological drilling cannot detect these rocks with any degree of certainty.

That is why geophysical measurement procedures have been used quite successfully in the exploration and detection of the general distribution of stone horizons for several years now.

The georadar wave procedure permits the search for stones and rocks up to a depth of 15 m if sandy and/or gravel soil layers are present. In cohesive or clayish soils, this is only possible up to a maximum depth of 2 m. In these zones, the geoelectric potential procedure is applied. With this procedure, it is not possible to detect individual rocks, but only soil layers containing rock concentrations as well as channel structures.

Zones containing rock concentrations are classified with the complex evaluation of all exploratory data and the mapping of slopes in open-pit mines.

The stones and rocks are selected and extracted prior to the first overburden cut. Depending on the individual depth of the stone horizons, this is done with hydraulic excavators up to depths of 5 m and with dragline excavators up to 15 m. The stones and rocks are then removed separately with trucks.

This procedure has been applied successfully, both technically and economically speaking, in two Lusatian open-pit mines for more than 15 years now.

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COMPUTERIZED WASTE DUMP DESIGN - PETRILA

ADRIAN FLOREA*

Abstract: *Mining waste facilities classification is introduced according to Romanian technical prescription PT-C 39. Preliminary geotechnical studies on the basement rocks and on the waste material are necessary in order to define the maximum height of the dump and the slope angle, which ensure the stability of the dump at this height. The first step supposes modeling the morphology of the area based on available survey information. The decision on the shape and geometry of the dump could be taken according to various geotechnical, technological, legal and economical aspects involved based on analyze done on the digital terrain model.*
A computerized design process allows possibility to analyze several variants in less time and ensure results that are more accurate and useful in the later stage of building and remediation of the area. This process is illustrated on waste dump Petrila.

Key words: *mining waste facilities classification, waste dump design, computerized design process*

1. INTRODUCTION

The mining waste facilities in Romania are design, built and check according to technical prescription PT-C 39. This technical prescription contents several criteria of mining waste facilities classification (table 1, table 2).

Table 1. **Waste facilities classification according to technical prescription PT-C 39**

Classification criteria		Index	Characterization
1. After the nature of deposited rocks	1.1. Content of ore	1.1.1	Waste facilities
		1.1.2	Ore deposits
	1.2. Rock hardness	1.2.1	Soft rock waste facilities
		1.2.2	Hard rock waste facilities
	1.3. Flammability	1.3.1	Nonflammable waste facilities
		1.3.2	Flammable deposits and waste facilities
	1.4. Radioactivity degree	1.4.1	Low radioactivity level waste facilities
		1.4.2	Radioactive waste facilities

* *Assoc. Professor Eng., Ph.D. at the Mining Engineering Faculty, University of Petroşani, E-mail: adflorea@upet.ro*

2. After deposit geometry	2.1. Number of benches	2.1.1	Single bench waste facilities
		2.2.2	Multi bench waste facilities
	2.2. High	2.2.1	Low waste facilities (< 30 m)
		2.2.2	High waste facilities (> 30 m)
		2.2.3	Very high waste facilities (> 100 m)
	2.3. Terrain morphology	2.3.1	Waste facilities on horizontal surfaces
		2.3.2	Waste facilities on inclined surfaces (< 20°)
		2.3.3	Waste facilities on very inclined surfaces (> 20°)
3. After environmental pollution risks	3.1. Influence of airborne dust	3.1.1	Waste facilities without dust generation possibilities
		3.1.2	Waste facilities with dust generation possibilities
	3.2. Water influence	3.2.1	Normal waste facilities, without water presence in base or in direct fundament (basement)
		3.2.2	Normal waste facilities, with pipes in basement for water transport
		3.2.3	Waste facilities placed on springs, swamps or water courses but with drainage systems in basement
		3.2.4	Waste facilities placed on springs, swamps or water courses with drainage systems in placed in base, over the basement
		3.2.5	Waste facilities placed on springs, swamps
		3.2.6	Waste facilities placed on water courses
		3.2.7	Waste facilities with water exfiltrations downstream during the building process
		3.2.8	Waste facilities with water exfiltrations downstream in the conservation stage
		3.2.9	Waste facilities where initial water exfiltrations disappeared during the building process
		3.2.10	Waste facilities where initial water exfiltrations disappeared in the conservation stage
4. Waste facilities building process	4.1. Wet transport	4.1.1	Tailing ponds with fix dispersion point
		4.1.2	Tailing ponds with mobile dispersion point
	4.2. Dry transport	4.2.1	Waste dumps built by truck transport
		4.2.2	Waste dumps built by rail transport
		4.2.3	Waste dumps built by conveyor belts transport
		4.2.4	Waste dumps built by aerial ropeway transport
		4.2.5	Waste dumps built by spreading installation

After the waste facilities classification criteria from table 1, the waste dump Petrila is:

- 1.1.1 – a waste facility,
- 1.2.1 – a soft rock waste facility,
- 1.3.1 – a nonflammable waste facility,
- 2.1.1 – a single bench waste facility,
- 2.2.1 – a low waste facility (< 30 m),
- 2.3.2 – a waste facility on inclined surfaces (< 20°),
- 3.1.2 – a waste facility with dust generation possibilities,
- 3.2.5 – a waste facility placed on springs, swamps,
- 4.2.4 – a waste dumps built by aerial ropeway transport

*Table 2.***Waste facilities classification according to the nature of objectives from influence area and degree of deposit stability**

Nature of objectives from influence area	1. Waste facilities with large volume and active displacements	2. Waste facilities relatively stable which could enter in dangerous displacements because of different factors (terrain morphology, meteorological reasons, upstream water accumulation, seismic influence, explosions, underground mining activities)	3. Waste facilities with displacements which could be limited by technical measures (building small dams, drainage channels, etc.)	4. Stabilized waste facilities without probability of instability phenomena
1. Houses and social building	1.1	1.2	1.3	1.4
2. Industrial buildings and installations, transport axis with intense traffic, big rivers	2.1	2.2	2.3	2.4
3. Transport axis with low traffic and low person circulation	3.1	3.2	3.3	3.4
4. Areas without construction and very rare person circulation	4.1	4.2	4.3	4.4

According to classification criteria from table 2, the waste dump Petrila is a 3.4 category waste: a stabilized waste facility without probability of instability phenomena located in an area with low traffic and low person circulation.

A case study of waste dump Petrila - branch V will illustrate the steps involved in the computerized waste dump design process.

2. WASTE DUMP DESIGN

The waste dump Petrila is located on the eastern part of Jiu Valley, between the towns Petroşani and Petrila (figure 1) and ensures the discarding of waste rock resulted from underground hard coal mine Petrila.

Figure 1. Location of waste dump Petrila

The waste dump has five branches (figure 2), the active one is the branch V where the activity started in 1977. The building system is based on aerial ropeway transport (figure 3) supported by 11 pillars and the total length of the branch is 1582 m, the width varies between 30 m to 137 m, the heights are between 16 m to 25 m and the slope angle vary between 20^{o} to 50^{o}.

Based on the mechanical characteristics of the waste material and of the rocks from fundament, the previous stability studies concluded that this is a stable dump if the total height is maintained below 27 m and the slope angle at this height below 35^{o}.

Figure 2. The five branches structure of waste dump Petrila

Figure 3. The aerial ropeway transport system

The first step made in order to proceed at design of waste dump was to generate de digital terrain model based on available survey information (figure 4).

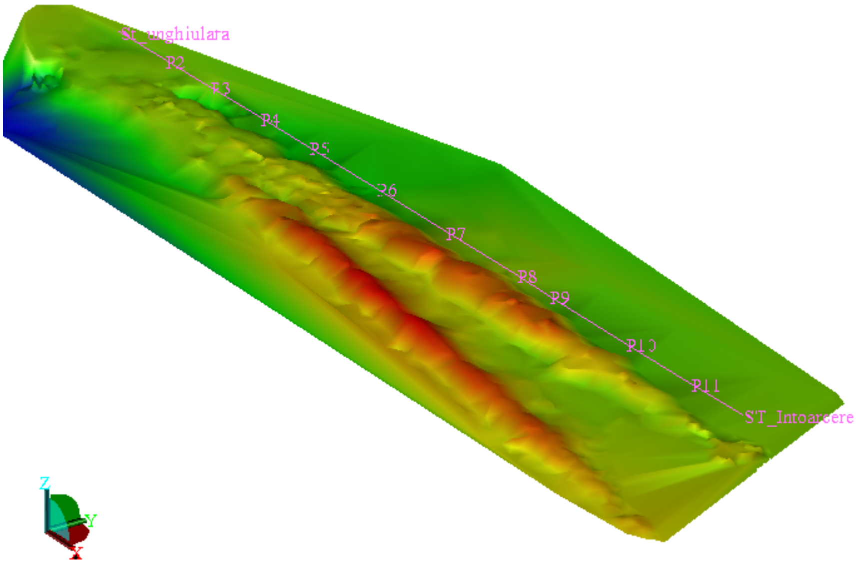

Figure 4. The DTM for actual situation of waste dump and pillars position of ropeway

Analyzing the morphology of area, the lateral extension in the southern part, in direction of branch no. IV, was revealed the solution for increasing the dump capacity.

The first analyzed variant was to fill complete the void between the branch no. V and the branch no. IV (figure 5).

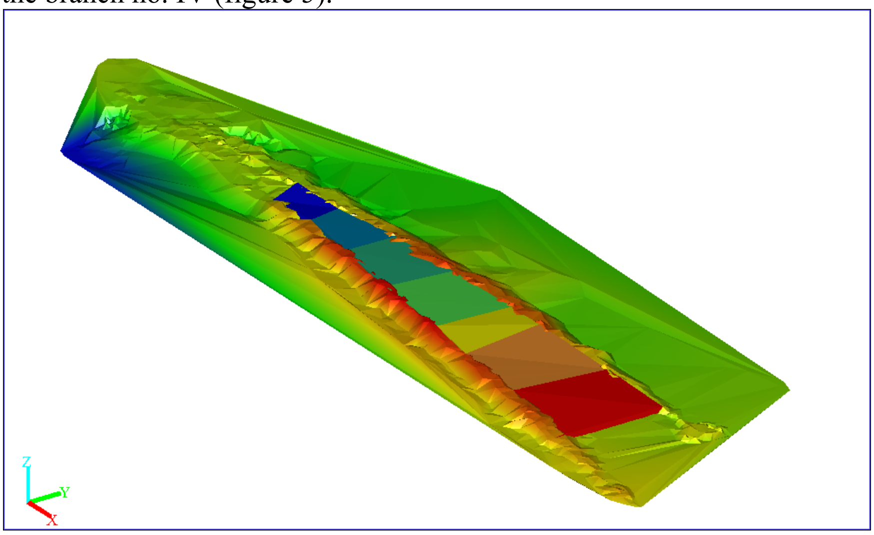

Figure 5. The designed extension of waste dump- variant 1

The second variant was the extension of the waste dump only after the pillar no. 6 and maintaining a small void between the wastes body of branch no. IV and the extension of branch no.V (figure 6).

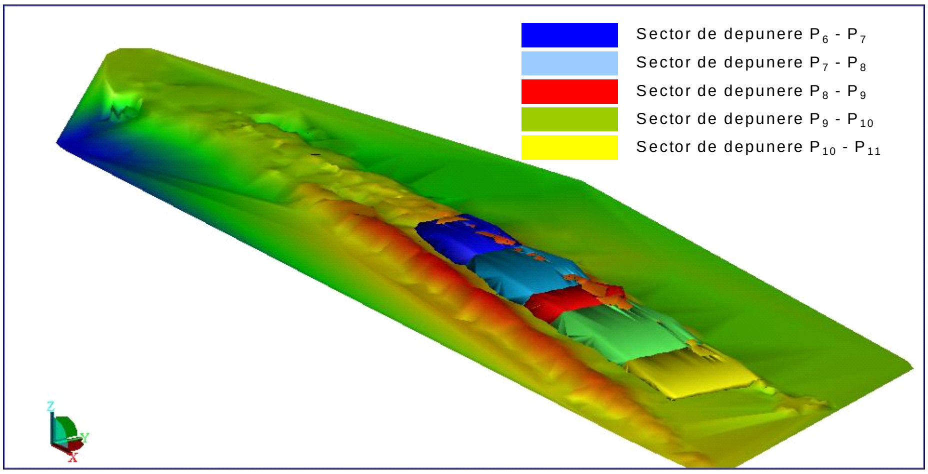

Figure 6. The designed extension of waste dump- variant 2

The geometry in the extension area was design in order to ensure the stability of waste dump (table 3), with a slope angle around 33^o. The capacity of dump increased in both variants (table 4)

Table 3. **Geometry of designed extension of branch V – variant 2**

Pillar	Elevation at rope axis (m)	Waste dump height (m)
P_6	751,00	25,00
P_7	758,00	24,50
P_8	755,00	27,77
P_9	753,50	27,45
P_{10}	743,00	16,00
P_{11}	740,20	9,40

Table 4. **Waste volumes on dumping sectors**

Sector	Volume (m^3)	
	Variant 1	Variant2
P_4-P_5	38.518	-
P_5-P_6	98.090	-
P_6-P_7	214.271	112.644
P_7-P_8	358.939	193.431
P_8-P_9	251.098	100.766
P_9-P_{10}	422.758	255.174
P_{10}-P_{11}	417.034	133.659
TOTAL	1.800.708	795.674

Both variants have advantages and disadvantages. Variant 1 have the advantage of a larger capacity (with over 1 million cubic meters) but suppose a higher operational expenses. Variant 2 suppose lower operational expenses but also have a smaller dump capacity.

The variant proposed was variant 2 which ensure a proper discharging activity for a long enough time and lower operational expenses.

3. CONCLUSION

In order to reach an adequate solution at waste dump design it is necessary to made geotechnical studies on the basement rocks and on the waste material for defining the maximum height of the dump and the slope angle, which ensure the stability of the dump at this height.

The first step for design the dump supposes modeling the morphology of the area and creating the digital terrain model based on available survey information. The decision on the shape and geometry of the dump could be taken according to various geotechnical, technological, legal and economical aspects involved based on analyze done on the model of morphology.

Using a computerized design process allows possibility to analyze several variants in much less time and ensure results that are more accurate. The generated model is very useful in the later stage of building and remediation of the area.

The case study made on waste dump Petrila – branch V show an increased capacity of dump with almost 800.000 m^3 maintaining the actual dumping technology and ensuring minimum costs in safety conditions

REFERENCES

[1]. Bristol, R., Kumar, K., Jackson, P., - *DTM surfaces in Surpac VISION, Surpac Minex GROUP Pty Ltd (a Gemcom Company), Perth, Western Australia, 2007*

[2]. Florea, A., - *Proiectare şi planificare minieră asistată - note de curs, Facultatea de mine, Universitatea din Petroşani, 2007*

[3]. Florea, A., - *Mining Waste Facilities– types, building considerations and solutions, preliminary studies, waste storage options, associated risks, monitoring, safety measures - Training of Representatives of the Environmental Authorities of the EU Member States - Vienna, 17-18 April 2008 – SAFEMANMIN – PC6 project no. 044126/2007, www.safemanmin.eu*

[4]. Florea, A., - *Mining Waste Facilities – classification, risk assessment, risk prevention, case study simulations - Training of Representatives of the Environmental Authorities of the EU Member States - Vienna, 17-18 April 2008 – SAFEMANMIN – PC6 project no. 044126/2007, www.safemanmin.eu*

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STORAGE IN UNDERGROUND SPACE

TUDOR GOLDAN[*]

Abstract: *Underground space has been used for the storage of a wide range of materials ranging from energy products, such as natural gas and oil, to water, chemical products, waste, munitions, paper and computer records, and even works of art. The current interest is in the underground storage of natural gas. However, in the longer term, injection and storage of carbon dioxide underground is also increasingly seen with potential to provide part of the solution to climate change and commitments to reduce greenhouse gas (GHG) emissions from point sources, such as power stations. In addition, with the need to reduce surface landfill, operating and abandoned mines are being considered for waste storage and disposal.*

Keywords: c*arbon dioxide, natural gas, underground cavities.*

1. INTRODUCTION

Today, 22 billion tonnes of CO_2 are emitted each year into the atmosphere from manmade sources. Worldwide, approximately one-third of emissions are from electricity production, one-third from transportation, and the rest are from heating buildings and other industrial uses. Oil, coal and natural gas are the source of these emissions, and these fossil fuels provide for over 85% of the world's energy needs. Over the next hundred years, demand for energy is expected to more than double. Growth will be particularly critical in developing nations where industrialization and improved quality of life will increase demand for energy. Scenarios designed to predict future emissions estimate that, unless action is taken to limit emissions, by 2100, annual emissions of CO_2 from fossil fuels will range from 16 to 110 billion tonnes per year. Most of these scenarios indicate a doubling of CO_2 emissions by the middle of this century.

In operating mines and where cavities are specifically excavated the potential exists for utilising the excavated material. For example, brine produced from creating salt caverns by solution mining may be used as a chemical feedstock where a market exists. Rock produced in constructing caverns could be used as a source of aggregate,

[*] *Assoc. Professor, Ph.D.Eng., University of Petroşani*

building stone or for other mineral products. The potential also exists to design a storage facility or a mine to meet both objectives of providing mineral and storage space as part of an on-going development.

Pore storage uses the porous nature of certain rocks, such as sandstones in depleted reservoirs, for natural gas and CO_2 storage, or in aquifers for groundwater recharge, thermal exchange systems, natural gas and, potentially, CO_2 storage. Injection of CO_2 into oil and gas reservoirs is already used elsewhere in the world in a process referred to as tertiary enhanced oil recovery (EOR).

2. STORAGE IN CAVITIES

Rock salt (NaCl) exhibits unique physical properties and mechanical behaviour that makes it an ideal host for the development of (large) caverns for the storage of materials that do not themselves react with or dissolve salt. Salt-bearing strata are, therefore, an important resource, not only as a source of salt, but also as a host for the construction of salt caverns.

Large underground salt caverns produced by solution mining may be used for the storage of liquids (oil, natural gas liquids, and liquefied petroleum gas), gaseous hydrocarbons and compressed air. Currently there is particular interest in their use for natural gas storage.

Coal mining remains the largest underground mining activity. However, whilst some waste may have been disposed of in old coal workings in the past, the voids created by coal mining are unstable and are unsuitable for storage purposes. Although not strictly ‘storage’, these voids do naturally collect mine gas (methane), which is released into workings during mining operations and continues to accumulate long after the mine is abandoned. The methane is released from the surrounding coal seams and from pore spaces in rocks into which the gas has previously migrated. Methane may be recovered from operating deep mines, or the artificial voids left in abandoned mines.

Limestone, including dolomite and chalk is worked on a large scale for use as aggregate, in cement manufacture, for industrial and agricultural applications and as building stone. Production is almost entirely by surface quarrying but in the past limestone for use as building stone and for industrial applications was locally obtained by underground mining. Underground working of limestone generally takes place at relatively shallow depths accessed by adits or, more commonly in the past, by steep inclines. Stone production uses the room and pillar method of extraction and extensive, interconnecting underground gallery systems can be created.

Chalk is a type of very fine-grained limestone. Although chalk and flints contained within it have been mined on a small scale in the past all production today is from surface quarries.

The mine has storage potential but any requirement would need to take into account the high humidity at all times of the year, but especially during midsummer. This would probably rule out secure document storage. There is now no ventilation or power infrastructure.

3. PORE STORAGE

Sedimentary basins contain porous and permeable rocks that hold and permit the flow of groundwater (aquifers) and hydrocarbons (reservoir rocks). In rocks such as sandstones, porosity and permeability is provided by the natural pore spaces that occur between the constituent grains and which form an interconnecting network of minute channels in the rock. Fracture systems (in e.g. limestones and igneous rocks) may also provide porosity and permeability. Porous and permeable rocks, therefore, offer potential for the storage of liquids and gases, and also heat using fluids to transport that energy.

Pore storage potential occurs in:

- *aquifers* - aquifers are the natural storage reservoirs for groundwater. This storage is naturally recharged and discharge provides baseflow for streams. Storage is exploited in the provision of groundwater supplies but aquifers are also being assessed for their thermal energy and thermal storage potential. Other possibilities include natural gas, hydrogen, compressed air and perhaps CO_2 storage;
- *reservoir rocks* – depleted/depleting oil and gasfields, where the pore spaces that once contained oil or gas are utilised. This is mainly for the injection and storage of natural gas.

To begin a risk assessment of geologic storage of CO_2, we must first understand both the context for evaluating CO_2 exposures and the human health and environmental impacts of exposure to elevated concentrations of CO_2. Fortunately, there is a large amount of information to draw on in this regard. Carbon dioxide was one of the first gases identified, and it remains widely used in industry. Regulations are well developed for using CO_2 in occupational and industrial settings and for storing and transporting it.

Carbon dioxide is ubiquitous in the natural world. It undergoes an endless cycle of exchange among the atmosphere, living systems, soil, rocks, and water. Volcanic eruptions, the breathing of living things from humans to microbes, mineral weathering, and the combustion or decomposition of organic materials all release CO_2 into the atmosphere. Atmospheric CO_2 is then cycled back into plants, the oceans, and minerals through photosynthesis, dissolution, precipitation, and other chemical processes. Biotic and abiotic processes of the carbon cycle on land, in the atmosphere, and in the sea are connected through the atmospheric reservoir of CO_2.

Carbon dioxide is a commodity that is used in a wide variety of industries: from chemical manufacture to beverage carbonation and brewing, from enhanced oil recovery to refrigeration, and from fire suppression to inert-atmosphere food preservation. Because of its extensive use and production, the hazards of CO_2 are well known and routinely managed. Engineering and procedural controls are well established for dealing with the hazards of compressed and cryogenic CO_2.

Ambient atmospheric concentrations of CO_2 are currently about 380 ppm. Humans can tolerate increased concentrations with virtually no physiological effects for exposures that are up to 1% CO_2 (10,000 ppm). For concentrations of up to 3%, physiological adaptation occurs without adverse consequences. A significant effect on respiratory rate and some discomfort occurs at concentrations between 3 and 5%. Above 5%, physical and mental ability is impaired and loss of consciousness can occur. Severe symptoms, including rapid loss of consciousness, possible coma or death, result from prolonged exposure above 10%. Loss of consciousness occurs within several breaths and death is imminent at concentrations above 25 to 30%.

Ecosystem impacts from exposure to elevated concentrations of CO_2 are less well understood. Plants in general are even more tolerant than invertebrates to elevated CO_2, so any small-scale, short-term gas leaks would have minimal impacts. Because CO_2 could accumulate in soils, persistent leaks, in contrast, could suppress respiration in the root zone or result in soil acidification, which would be harmful to plants. While unlikely to occur, catastrophic releases could certainly kill vegetation as well as animals. Moderate increases in CO_2 concentrations stimulate plant growth, while decreasing the loss of water through transpiration.

Carbon dioxide is stored in deep geological formations by injecting it through a well into a porous formation that is sealed on top by a low permeability cap. Essential elements of this technology include site characterization, performance prediction models, injection well drilling and construction, pumping, and monitoring. All of the technologies have been developed over the past century and are widely used for injection of fluids, particularly for oil-field operations, including CO_2-EOR, and natural gas storage. The majority of natural gas storage projects are in depleted oil and gas reservoirs and saline formations, although caverns in salt have also been used extensively.

Naturally occurring accumulations of CO_2 are found in natural gas, oil and CO_2 reservoirs throughout the world. Effective containment of CO_2 occurs in the same types of geologic settings that trap hydrocarbons, mostly in sedimentary rocks overlain by low-permeability strata. There is no evidence that CO_2 is stored underground any less effectively than other gases. Moreover, CO_2 accumulates underground as a gas, mixture of gases, supercritical fluid, and/or solute dissolved in oil or aqueous phase, thus providing confidence that storage will be possible for the range of conditions expected for intentional man-made geologic storage.

Underground gas storage may be defined as the storage in reservoirs of porous rock at various depths beneath the surface of the earth of large quantities of natural gas not native to these reservoirs. Before planning storage-field capacity and deliverability, one must have knowledge of the market requirements. The influence of the weather on sales of gas for space heating of buildings is important. When the annual storage volumes and daily delivery rates are developed for a distribution system, the facilities for storage fields may be designed to meet the need.

All types of natural gas sales, whether domestic, commercial, industrial, or space heating, present variable load factors. Probably the most difficult load for the distributor to meet is the space-heating load. It varies from a minimum of zero in the summertime to a maximum that can occur any time during the cold winter months.
Probably the largest potential market for the natural gas distributor is residential space heating. The problem of the distributor, then, is to find efficient and economical methods of handling the load-factor problem in distribution of space-heating gas.

Table 1

Country	**Annual consumption** (Billion m^3)	**Storage capacity** (Billion m^3)	**Storage capacity relative annual consumption**	**Days storage**
UK	103	4	3-4%	14
Germany	101	19	19%	69
Italy	81	13	16%	59
France	46	11	24%	87
USA	631	114	18	66

Prospective sedimentary basins are now at a mature stage of exploration, but nevertheless, continue to attract interest and large areas remain licensed for exploration. With improving technology modest onshore discoveries continue to be made. However, depleting oil and gasfields also have the potential for underground gas storage.

Risk is the possibility of loss or injury due to an incident in storage operations. Natural gas storage operations have two kinds of risk. The first has to do with the safety of people and property from harm due to explosions or fires resulting from uncontrolled gas losses or movement. The second risk is economic, the possible loss of unretrievable gas underground or into the atmosphere.

Natural gases serving as domestic fuel must be odorized so that leaking gas may be detected by its odor. The requirement is that a gas concentration of 20 percent of the lower combustion limit will indicate its presence by smell, a safety factor of 5. This requirement applies to fuel gas in a gas distribution system, but may not apply to high-pressure transcontinental pipelines or distribution lines.

Odorants are organic compounds containing sulfur, usually mercaptans, disulfides, thioethers, or carbon sulfur ring compounds.

LP gas (propane) is marketed as a liquid, after in cylinders. Here the odorant is placed in the liquid, which in turn gives off a vapor fuel with the proper odorant concentration.

The amount of non-recoverable gas is of interest in storage reservoirs since it has to do with the mechanics of storage reservoirs. For non-water drive reservoirs, it is a matter of economics, well flow capacity, and low a rate can use for the utility. Abandonment pressures vary for such gas fields, with pressures like 50-100 psi often used. The non-recoverable gas content of a field is the gas left at the abandonment pressure.

In water drive gas fields or aquifer storage projects, water will flush a portion of the reservoir while gas is being removed below the original aquifer pressure. Such invading water will trap gas at the prevailing pressure.

In abandoning a field, it is assumed that gas will be produced from the wells following a withdrawal period. Water from the aquifer will enter the reservoir, interfering with well operation. At some point, it will become noneconomical to continue production of the remaining gas and the reservoir will be abandoned. This does not mean that no more gas can be produced-only that it is not economical or it is impractical to use the field to serve the utility market.

In 1950 the use of salt cavities for storing propane and butane underground was introduced. Although there had been a long history of creating salt cavities by solution mining of salt, the creation of a salt cavern for the purpose of LP gas storage was an innovation.

Salt beds occur in two modes within limited areas of the world. These beds may be extensive layers of evaporative or extruded domes of salt.

Salt layers in beds are quite different from salt domes. The nature of the beds can be observed in rock-salt mines. Layers of limestone, dolomite, or anhydrite may occur in the salt beds; these do not dissolve in solution mining, but form ledges that fall in as the dissolution progresses. Generally, the NaCl in salt domes is more homogeneous than that in evaporative beds.

CONCLUSIONS

Conversion into storage facilities may be a sensible use of the voids created by mining but location may not necessarily be ideal in a planning context due to surface impacts not generated by the mining phase. This situation could also arise where the storage operation is undertaken in a worked out part of a currently operational site. In other situations the works involved in storage (structures, infrastructure and scale of activity) may not be significantly different, or require any extra facilities, from that required for the extraction operation. The planning considerations could then be limited to the issue of the proposed change in use.

REFERENCES

[1]. Allen, K., *Eminence Dome-Natural Gas Storage in Salt Comes of Age*, J. Pet. Tech., Nov. 1972.
[2]. Ehgartner, B. e.a., *Gas Releases From Salt,* SMRI Spr. Mtg., 1998.
[3]. Gentry, H.L., *Storage of High Pressure Natural Gas in Underground Storage,* Symp. On Salt, Cleveland, 1963.
[4]. Hellberg, C., Iversen, E.U., *Construction of Natural Gas Stores in Salt Formations with High Insoluble Fractions,* SMRI Fall Mtg., 1994.
[5]. Munson, D. e.a., *Interior Cavern Conditions and Salt Fall Potential,* SMRI Spr. Mtg., 1998.
[6]. Rezunenko, V.I., Smirnov, V.I., *Rock Salt Underground Storage,* SMRI Fall Mtg. 1994.
[7]. Richner, D.R. e.a., *Solution Mining: In situ Techniques,* SME Min. Engr. Handbook, 2nd Ed., V2, 1992.
[8]. Schalge, R., Schwartz, W., *Chilling Natural Gas to Increase Salt Cavern Storage Capacity,* SMRI Fall Mtg., 1998.

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MINE WATER STREAMS IN THE CENTRAL PART OF THE NORTH BOHEMIAN BROWN COAL BASIN

JOSEF HALIR*
HANA LORENCOVA**
LUKAS ZIZKA***

Abstract: *Submitted paper describes the problems of the self-fill aquifer in the central part of the North Bohemian Brown Coal Basin in the Czech Republic. The self-fill aquifer creates in the interest area a very large antropogenic collector. This collector was created in former times by underground mining of the brown coal. Due to the morphology of the seam floor and interference of her progression by the fracture lines, there is forming a partial depression. These depressions are successively flooded and they create the reservoirs of the self-fill water. In the central part of the north bohemian brown coal basin was described seven meaningful reservoirs: from the west there are Albrechtice, Jiretin, Chuderin reservoires, then smaller reservoirs. Centrum and Viktoria, reservoir in the field Venus and wide reservoir Kohinoor – Alexander. The last named is situated in the deepest part of the brown coal basin.*

1. PUMPING STATIONS IN DEEP MINES IN THE CENTRAL PART OF THE BASIN

The central part of the North Bohemian Brown Coal Basin is situated between Chomutov and Duchcov. More than one hundred years of mining of a strong brown coal layer in a number of deep mines from outcrops down to the deepest parts changed the previously almost water proof environment of strata very significantly. Water flew from adjacent water-containing collectors (quaternary, overburden, interdeposit and underlying sand, crystalline complex) into hollowness created in the coal strata by deep mining. In order to ensure safety it was necessary to dewater the stratum for which a number of pumping stations in the deep mines were used.

* *The Brown Coal Research Institute, j.s.c., Budovatelů 2830, 434 37 Most, Czech Republic*
** *Mostecká uhelná j.s.c., V.Řezáče 315, 434 67 Most, Czech Republic*
*** *The Brown Coal Research Institute, j.s.c., Budovatelů 2830, 434 37 Most, Czech Republic*

In order to ensure failure free and safe brown coal mining in the central part of the North Bohemian Brown Coal Basin some pumping stations were in operation. Pumping stations in the mine *Zdenek Nejedly* was situated in southeast part of the central part of the basin and collected water from south periphery of the basin. Operation was terminated in 1981 and an average annual pumping was 860 thousand m^3 of mine water. Pumping station in the mine *M.J.Hus* was situated in the south of the central part of the basin and collected water from south periphery of the basin. Operation was terminated in 1986 and an average annual pumping was 1 200 thousand m^3 of mine water. Pumping station in the mine *Pluto* was situated in the southeast of the central part of the basin and collected water from north stratum outcrops and from east from the former pumping station *Vitezny Unor*. Operation was terminated in 1996 and an average annual pumping was 860 thousand m^3 of mine water. Pumping station in the mine *Alexander* was situated in the deepest section of the central part of the basin (155 m under sea level) at east periphery of the basin and collected water from north stratum outcrops, from flood disturbance and from south from the Bilina region where used to be mining in mines *Emeran, Pokrok II and Gorkij.* Operation was terminated in 1997 and an average annual pumping was 1 500 thousand m^3 of mine water. Pumping station in the mine *Julius III* was situated in the middle of central part and collected inflow from south from former pumping station *M.J.Hus* and *Zdenek Nejedly*. Operation was terminated in 2002 and an average annual pumping was 530 thousand m^3 of mine water.

In present there are in this part of the basin only two pumping stations in operation. The first is in the still active deep mine *Centrum.* The pumping station is situated in the middle of the central part of the basin and collects inflow from west and northwest. Average annual pumping is 990 thousand m^3 of mine water. Second pumping station is in the mine *Kohinoor II.* It is situated between the former pumping stations *Julius III* and *Alexander* and at present it is the deepest pumping station in the basin (90 m under sea level). In order to keep the water level deeper to be able to continue with mining safely, there was left pumping of goaf water in the mine Kohinoor II in operation even after stopping mining. It collects almost all inflow into the central part of the Northbohemian Brown Coal Basin. Average annual pumping is 2 million m^3 of mine water.

2. GOAF WATER RESERVOIRS

Separate phenomenons which cannot be omitted in this part of the North Bohemian Coal Basin from hydrogeological point of view are goaf waters or goaf water horizon. Goaf water horizon contains secondary mine water which flows or accumulates in hollow spaces created in the strata by mining. As significant amount of mine water that had been pumped out for many years in the deep mines in the deepest part of the central depression flows through adjacent hollows, this is predominantly goaf water.

Because in the past there was strata going steeply to outcrops almost along the whole length of central part of the basin adjacent to the mountains and this strata was mined by small deep mines. This resulted in creation of preference routes which route infiltrated water directly to the labyrinth of hollows. Water flows through this labyrinth downwards the coal strata base into central depression. This was proved by communication tests. If, according to the strata morphology, there are partial depressions, there were created permanent reservoirs of goaf water the size of which is regulated by overflow level towards the deepest sections of goaf water horizon. With regard to the sub-soil morphology the strata creates a few main depressions in the whole North Bohemian Brown Coal Basin which match more or less the partial basins. Central part of the basin is almost everywhere deep mined. After termination of deep mining and after stopping pumping mine water in the deep mines, the hollows are filled up with water and so a large goaf water horizon is created. This horizon will subsequently occupy this whole area. At present some parts are completely without water yet. Through others water flows only from infiltration areas at the strata outcrop or other sources to the deeper parts of the basin. As descend of the strata is not even, at places there are partial depressions under the goaf water horizon which predispose reservoirs, where water stagnates up to the level of the overflow to the lower mining fields. Today there are seven goaf water reservoirs in the central part of the basin, predisposed by their morphology and tectonic ruptures of the strata. Going from west they are Albrechtice, Jiretin, Chuderin reservoirs, partial minor reservoirs on high block masses of fractures Centrum and Viktoria, similar reservoirs in the field of Venuse and further the reservoir Kohinoor - Alexander in the deepest part of the basin.

The *Albrechtice reservoir* is situated most to the west in flooded hollows of the former deep mine *Marsal Konev*. It is morphological structure of the strata, basically copying the morphology of the crystalline complex. Formerly it had an oval shape extended in the direction southwest- southeast with the length approx. 2 km and width approx. 1 km. It relative depth, related to the stratum base was 30 m at least. The stratum base is at the deepest place of the depression at the level of +40 m above sea level. Water level in hollows of the former mine *Marsal Konev* was lowered due to progress of the opencast mine *Ceskoslovenske armady* towards this area by pumping in the pit VI. At present water flows out of the depression gravitationally to the mine bottom where it is pumped to the main pumping station. The water level of goaf water in the rest pit of the *Albrechtice* reservoir varies about +62 m above sea level at present. The *Jiretin reservoir* is created by flooded hollow fields of the mine *Centrum* and the former deep mine *Humboldt* in strata depression south of the villages *Cernice* and *Horni Jiretin* predisposed most likely by volcanic explosive structure in subsoil. An overflow of it is most likely around the level of +75 m above sea level partly eastwards to the pumping station of the mine *Centrum*, partly southwards to the drain system under the internal deposit in the rest pit of the former mine *Obranců miru*. Water level has been monitored here since 2005 in the pit XVIII and at present it is approx. +80 m above sea level. The *Chuderin reservoir* is an assumed smaller accumulation of underground water in hollows of surface significantly limited round depression south of the former mine Knize nebes (Rudy sever) in the mining field of the former deep mine *Herkules*. Its outline is highlighted by circular defect again showing an explosive volcanic structure in the strata subsoil. There no specific data available about water horizon of local hollows, it is just concluded based on the morphology of the long wall. An overflow to the central depression is assumed around the level of +20 m above sea level and the volume is assumed at only 0.2 mil. m^3. The reservoir *Viktoria* is situated on a high block mass of *Viktoria* fracture and there are also no specific data about it and its existence is assumed based on the strata morphology between the fractures Centrum and Viktoria in hollows of the former mine *Minerva*. Assumed overflow over the fracture *Viktoria* into the mining fields of Kohinoor II is at the level of +10 m above sea level. The reservoir *Centrum* is situated on an upper block mass of Centrum fracture and until 2002 it was dewatered by the mine *Julius III.* After finishing pumping and subsequent liquidation of the mine it was assumed that water would rise up to +55 m above sea level (overflow to the *Viktoria reservoir*) based on relation between base configuration and permeability of the fraction *Centrum*. In 2006 there was started operation of a monitoring bore-hole into the hollows of this mine and at present water level in this bore hole is at +76 m above sea level. The *reservoir Venuse* consists most likely of two water accumulations near to each other. It is a reservoir on depressed block of the fraction *Viktoria* and a reservoir on the high block of the fraction *Centrum*. Water level in hollows on the depressed block was checked in 1983 by a drill hole LB200. Steady level of goaf water was in depth of 183 m under the terrain, i.e. +92.5 m above sea level. The largest is the reservoir *Kohinoor-Alexander*. Due to stopping pumping mine water in the mine *Kohinoor I* in 1965 there was created reservoir of goaf water *Kohinoor*. For certain time there was the deepest pumping station in operation in the mine *Alexander* which lowered the level of goaf water down to the level -155 m under sea level. In 1997 pumping in the mine Alexander was stopped and so there happened radical change in goaf water streams because the whole deepest part of the basin began to be filled up to the overflow over „dividing line“ between the mines Alexander and *Kohinoor I* around the level -60 m under sea level. This caused creation of a large reservoir of goaf water *Kohinoor-Alexander*. Water line development in this goaf system, which covers the area from the former mine *Pluto* to inundation fraction, was monitored from 1997 to 2002 in the pits IV and V of the former mine *Kohinoor I*. Last measurement (IX/2002) the water line reached the level of -17,9 m under sea level in the pit IV and -10,7 m under sea level in the pit V (III/2002). Due to liquidation of the mine both mines were filled with dirt in 2002. At present there is no place for monitoring water line in this reservoir.

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ASPECTS REGARDING THE MARKETING OF METHANE FROM THE COAL MINES AS AN ALTERNATE POWER GENERATING SOURCE

CONSTANTIN LUPU[*], ION TOTH[**], CRISTIAN TOMESCU[***], EMERIC CHIUZAN[****] , DOREL TAMAŞ[*****]

Abstract: *Considering the national program on power generation for the period 2007 ÷ 2020, the alternative power generating resources can play an important part. one of these resources is the methane come from virgin coal beds (VCBM). This paper deals with possible technologies that can be used in the use of CBM.*

Key words: methane, coal bed, drillings, cbm & vcbm technology

1. INTRODUCTION

Worldwide, due to the high consumption of power generating resources, we face a continuous increase of costs both for oil and for natural gases; this trend affects mainly the less developed countries, among which is Romania. The crisis of natural gases triggered by Russia at the beginning of 2009 has also affected several EU countries which rely on the Russian gases.

Romania can provide only 60% of the internal resources for natural gases, the rest comes from import. The forecasts for the following years show that the external suppliers are preparing a new increase of the price for natural gases.

[*] *Ph. D. Eng. – Senior scientific researcher II – INCD INSEMEX Petroşani*
[**] *Ph. D. Eng. – Senior scientific researcher I – INCD INSEMEX Petroşani*
[***] *Eng. – Senior scientific researcher – INCD INSEMEX Petroşani*
[****] *Eng. – Assistant research - INCD INSEMEX Petroşani*
[*****] *Eng. - Senior scientific researcher III – INCD INSEMEX Petroşani*

Consequently, it is imperiously necessary to find new strategic solutions to get low cost alternate power generating sources, that should meet the measures for environment protection, to observe the energetic objectives proposed by the World

Power Council: accessibility (energy available at acceptable prices), availability (continuity in providing long-time power and high quality services) and acceptability (modern energy together with the traditional energy).

In Romania, coal is the main source for the power production, although Romania is known as a country with a high potential in the field of mineral resources. Coal deposits contain large amounts of methane which is diluted to non-hazardous concentration during mining operations. The problem is that the amount of methane discharged into the air by the mine ventilation stations and by the degassing stations is wasted and, above all, this one represents a strong factor for the environment pollution; it is a greenhouse gas (GHG) 21 times stronger than carbon dioxide.

Considering the above-said aspects, the research team at INSEMEX of Petroşani intends to study the means for the marketing of methane come from active and closed coal mines, come from the closing mines or from the virgin coal strata.

Romania possesses a couple of installations that use methane come from the degassing stations related to the mines in the Jiu Valley for the production of thermal energy. Consequently, it is necessary to show some details regarding the genesis of coal and the factors which influence the methane content of coal.

Considering the importance of new energetic resources, an ad-hoc group was laid foundation inside the UNO that deals with the aspects of methane inside coal mines. This group summarized the notions on the existing forms of methane and for the methane recovery.

It follows a presentation of the notions related to the occurrence of methane in coal mines.

2. DEFINITIONS

AMM - Abandoned Mine Methane - Methane released from the coal bearing strata associated with past coal mining activity.

CAG - Coal Associated Gas - All methane contained within a coal seam and the surrounding strata above and below the seam.

CBM - Coalbed Methane - A generic term (USA) for the methane originating in coal seams that is drained from surface boreholes before mining takes place.

CMG - Coal Mine Gas - Gas associated with opening or abandoned coal mining activities.

CMM - Coal Mine Methane - Methane component of gases captured in a working mine by methane drainage techniques.

Pre mining CMM - Methane extraction prior to the mining process from underground boreholes in the mine (for safety reasons).

Post mining CMM - Methane extraction after completion of the mining process from vertical surface goaf wells, underground inclined or horizontal boreholes, gas drainage galleries or other goaf gas capture techniques, including drainage of sealed areas in the mine (for safety reasons).

CSG - Coal Seam Gas - methane found in coal seams. It is formed during the coalification, the process that transforms plant material into coal. Also known as Coal Seam Methane and Coalbed Methane.

GHG - Greenhouse Gas - Those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation.

VAM - Ventilation Air Methane - Methane mixed with the ventilation air in the mine that is circulated in sufficient quantity to dilute the methane to low concentrations for safety reasons.

VCBM - Virgin CBM - Methane produced from unmined or virgin coal using surface boreholes.

ECBM - Methane produced from unmined or virgin coal seams using surface boreholes, by injecting carbon dioxide (CO_2) and/or nitrogen (N_2).

All these forms said above are represented in the Figure no. 1.

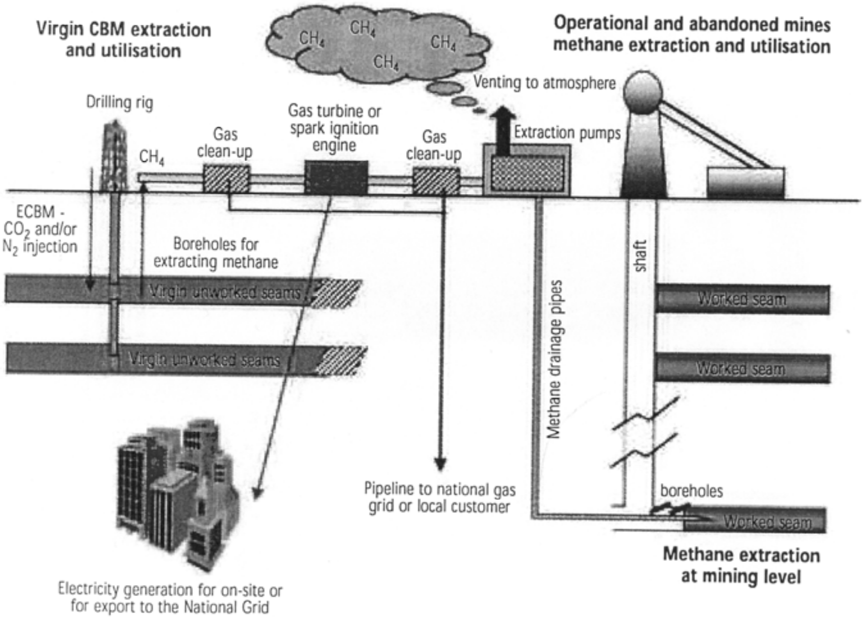

Fig. 1

The Jiu Valley coalfield embeds high amounts of hard coal that can be used both in the production of energy and/or coking; additionally, this area is a large methane deposit related to coal.

Methane that can be used from the Jiu Valley Coalfield derives from the central degassing that has been applied.

Both world and national researches focus on the use of methane from the closed mines, from virgin coal beds and discharged by the ventilation systems.

The paper shows the variants with vertical and horizontal drillholes of CBM technology (methane extraction from virgin coal beds)

3. PRESENTATION OF CBM TECHNOLOGY

3.1 Version with vertical boreholes

CBM represents the methane originating in coal seams that is drained from vertical boreholes. Its releasing is being stimulated by fracturing operations (Figure no. 2.). The methods used to stimulate fracturing in order to increase the methane release output are of three categories (Figure no. 3):

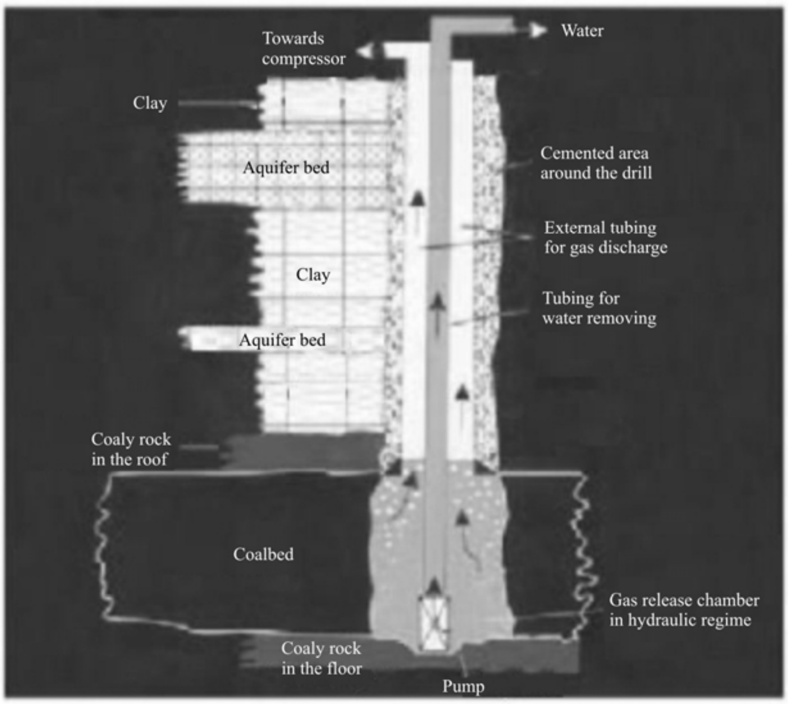

Fig. 2 - Vertical drilling performed in the coal bed

- Hydraulic fracturing - it is a two-way vertical fracturing directed at aprox. 180^0 towards the outside of the hole. As a result of the fault, as well of the possibility for

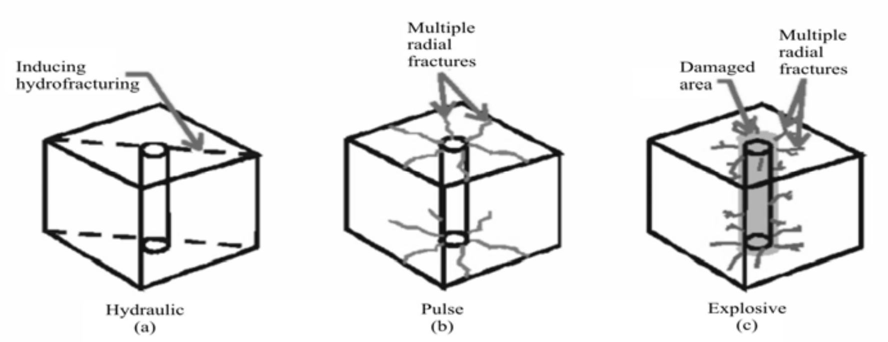

Fig. 3

pumping large volumes of fluid at low speed, the penetration power necessary for fracturing can reach high values, sometimes even tens of meters. This method is most used in CMM / CBM.

• Fracturing by means of explosives involves a rapid stressing of the area inside the massif, thus resulting a high faulting of the area around the borehole, but whose radius doesn't usually exceed 3 - 4 m. As the peak pressures exceed both minimum and maximum horizontal stresses inside the massif, there occurs a radial faulting that gives birth to a good fracturing nearly the drill hole.

• Pulse fracturing is being characterized by leaks of pressure that exceeds both maximum and minimum stresses inside the massif, thus giving birth to radial fracturing. This method gives a strong vertical fracturing, extended radial around the borehole, with a fracturing potential of 3 - 7 m.

The first and the third fracturing methods are widely used in CMM / CBM technology. These two important fracturing methods include five technologies which are widely used: three are hydraulic (with liquid CO_2 and stabilizer; with nitrogen without stabilizer, with spiral tubes and two pulse time methods).

As an alternative to hydro-fracturing method, there has been developed a pressurization-depresurization method of the coal bed by compressed air in order to remove the coal particles and give birth to a hole, but its use is somewhat limited due to the low permeability of coal beds.

3.2 Version with horizontal holes

A newer alternative involves the drilling of several horizontal holes (fig. 4) into the coal bed from one vertical drilling. Increasing the contact surface with the coal shall increase gaseous emissions, thus removing the need to apply hydro-fracturing.

The first stage includes a tube lined drilled hole. For the case of those deposits that haven't been confirmed which are going to produce gas at high pressure through the drilled holes, a simple crossing of the coal bed shall not give a flow of CBM.

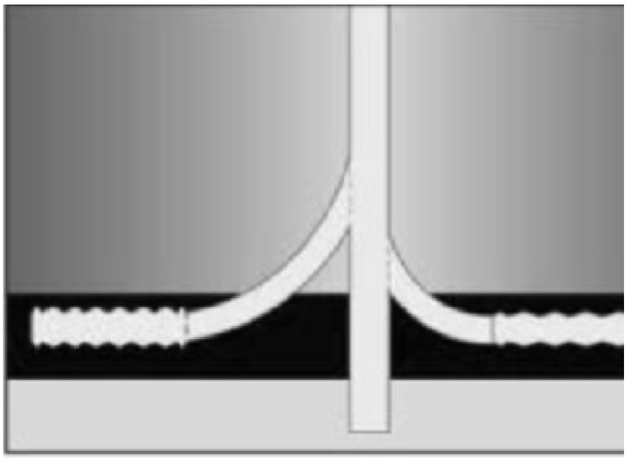

Fig. 4 - Drilling of horizontal holes into the coal bed

Generally, a fluid - sometimes a foam with nitrogen - shall be pumped from the surface through the drill holes up to the coal bed, the process being known under the name of fracturing. The fluid is pushed into the already existing faults for their enlarging. If some material (such as sand) is being added to this foam, these faults shall be kept open; consequently, both water and gas shall flow through these interconnected faults filed with sand.

In order to stimulate the flow of CBM, the natural pressure in the coal bed should be reduced by accessing coal. A pump located at the upper part of the borehole shall remove water which is naturally found into faults. This diminution of pressure due to the void created in a certain coal bed, leads to the absorption of gas from coal, thus allowing its flow through the drill hole. This drainage can last from several months up to several years. After this flow reaches surface, gas is separated from water, this gas being led along a pipe up to the measuring station where the volume extracted from each borehole should be recorded.

CBM is collected from several boreholes; then, it is sent to a compressor station where is compressed in a conveyance pipe.

Water is sent to a discharge and, depending on its quality and quantity, then is either injected into underground or used at surface.

CBM should have a continuous production in order to provide a gas flow at a low constant pressure and to provide a worthwhile operation.

Whether a CBM drilling is stopped for some period, after its restart, the water contained by coal shall be collected from the drill hole.

The drill holes for CBM are being produced by using methods similar to the ones used for regular drills. Whether coal beds are located at shallow depths and display low thickness, there can be used cheaper installations, such as a drilling installations with water, modified.

Gaining initial gas rates is better by performing an horizontal drilling than a vertical drilling (perpendicular or inclined).

The drilling installations used for CBM are made by several companies, such as Atlas Copco, Boart Longzert Gefco (models 150K and 185K), Technicoil, etc.

4. FINAL PURPOSES IN USING METHANE RESULTED FROM CBM TECHNOLOGY

The accessible and/or available options for the use of CBM include:
– electric power generation;
– heating of industrial or urban areas;
– home consumers and industrial consumers (at low pressure in the distribution columns);
– in the national system for gas delivery (at high pressure).

CBM is a natural substitute for natural gas and it can be used for the local generation of electric power; it represents a fuel for the industrial users, gained at low price.

Consequently, gas got by the CBM technology can be used as sole fuel, or together with coal and oil for getting hot water and for the heating of industrial areas (the utilities belonging to the mine or neighboring areas). It can also be used for drying the coal in the coal processing plants, for the heating up of shafts, thus preventing the ice formation. As a consequence this increase both safety level and the comfort of workers.

Other possibilities for the use of CBM include: fuel supply of the boilers burners, the use of CBM in cells for the production of hydrogen, in the chemical industry for the methane production, black powder, formaldehydes and synthetic fuels.

5. CONCLUSIONS

• Fossil fuels shall remain the main source of power generating material.

• The increased price for oil and gas, together with the greenhouse effect due to methane discharged by coal mines require additional researches in the use of mine gas.

• The U.N. ad-hoc group is in charge with the coordination of methane use in coal mines.

• The main forms for drainage and use of methane from coal mines are the following ones: the use of CBM, of VAM, of AMM + CMG.

• At INCD - INSEMEX the activities have also focused on the use of CBM and VAM, beside the researchers on the use of methane by the degassing system.

REFERENCES

[1]. Lupu, C. - *Methane from coal mines*, INSEMEX Publishing House, Petroşani, 2007

[2]. Băbuț, G., Moraru, R., a.s.o. - *Environment engineering and underground ventilation,* Technical Publishing House, Bucharest, 2000

[3]. *** - *Cleaner Coal Technology Programme* – UK Capability : Coalbed Methane and utilization.

[4]. *** - *UNO Ad-hoc group documents*, Geneva

[5]. *** - "*Partnership in priority domains*", Project

[6]. .*** - *Prefeasibility study reports regarding the use of CBM in the Jiu Valley*, INCD INSEMEX Study report, Petroşani, 2007

[7]. *** - *The use of CBM from the areas of pillars at Lupeni Mine*, IMPACT Project - 2007

[8]. *** - *Strategy of the mining industry for the period 2007 - 2020*.

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INCREASING IMPERMEABILITY OF THE SEALING WORKINGS IN THE ROMANIAN MINES

CONSTANTIN LUPU[*], ION TOTH[**], CORNEL GLIGOR[*], DORU CIOCLEA[*], MARIUS MORAR[***], EMERIC CHIUZAN[***]

Abstract: T*his paper reviews the researches carried out in the field of increasing impermeability of the sealing workings in the Romanian mining activity. This paper:*
– settles the technical requirements necessary for the selection of materials used to seal the sealing workings;
– shows the stand that is being used to determine the impermeability of the sealing materials;
– shows the tests performed on different sealing materials; these tests have been made in the laboratory and in underground.

Key words: *goafs, spontaneous combustion, dam, air leakness, sealing*

1. INTRODUCTION

The following types of long-lasting structures are used frequently to seal off the mine workings:

- clay made dams made of mine wood;
- cast concrete dams;
- dams made of keystones.

[*] *Ph. D. Eng. – Senior scientific researcher II – INCD INSEMEX Petroşani*
[**] *Ph. D. Eng. – Senior scientific researcher I – INCD INSEMEX Petroşani*
[***] *Eng. – Senior scientific researcher – INCD INSEMEX Petroşani*
[****] *Eng. – Assistant research - INCD INSEMEX Petroşani*

The sealing dams used nowadays lose their sealing properties as time goes by; this is the very reason why they need additional sealing (clay wash or cement wash).

Clay washing is an operation which is specific for the dams made of pieces of mine wood and clay, structures good for high pressures but which after a short period of time (30 days maximum) lose their sealing characteristics due the clay drying. Accordingly in the first stage of this process clay wash method consists in covering the dam surface with a mixture of clay and NaCl (kitchen salt) in several layers.

Cement washing is an operation specific for the cast concrete dams or for the dams made of keystone walling.

These structures are used when an average and high mine pressure occur. The concrete dams crack when high pressures occurs, accordingly, die sealing properties are lost and an improvement in the sealing is necessary by covering on a regular base the whole surface with a water-cement-sand mixture.

All through the years, several methods have been used to get a better sealing and they have consisted basically in covering the surface with a film (one or several layers) made of materials or mixtures such as: latex; vynil polyacetate (vinarome); mixture of plaster, ashes, vinarom and water.

It is stated that these aren't used on an everyday mine basis.

Establishing the technical requirements for the selection of the materials necessary in the additional sealing of dams

As these sealing materials are to be used in underground, they have to fulfill a set of technical requirements related to the geological and mining conditions and to the microclimate conditions. They should:

– provide a high sealing level,

– adhere on different types of materials (sterile rock, coal, wood, metal mesh, concrete, clay, etc.);

– use simple engineering methods during their layering;

– stand in a humid atmosphere with an environment favorable for the development of microorganisms, in a dusty atmosphere;

– stand the fire and they should not propagate the burning process and they should not be toxic;

– there should be possible to get these materials in sufficient amounts;

– the validity of these materials should be as extended as possible.

Test stand to determine impermeability to air currents of the materials used on the sealing dams

To get a clear picture on the sealing of different types of materials that should be used for the intended purpose, they should tested to impermeability a parameters that indicates the sealing level of dams.

Consequently, there has been designed a test stand that allows the modeling of dams with the use of different sealing materials.

The test stand is made up of the following parts:

a) Two cylindrical vessels A and B, of 1000 mm in diameter;

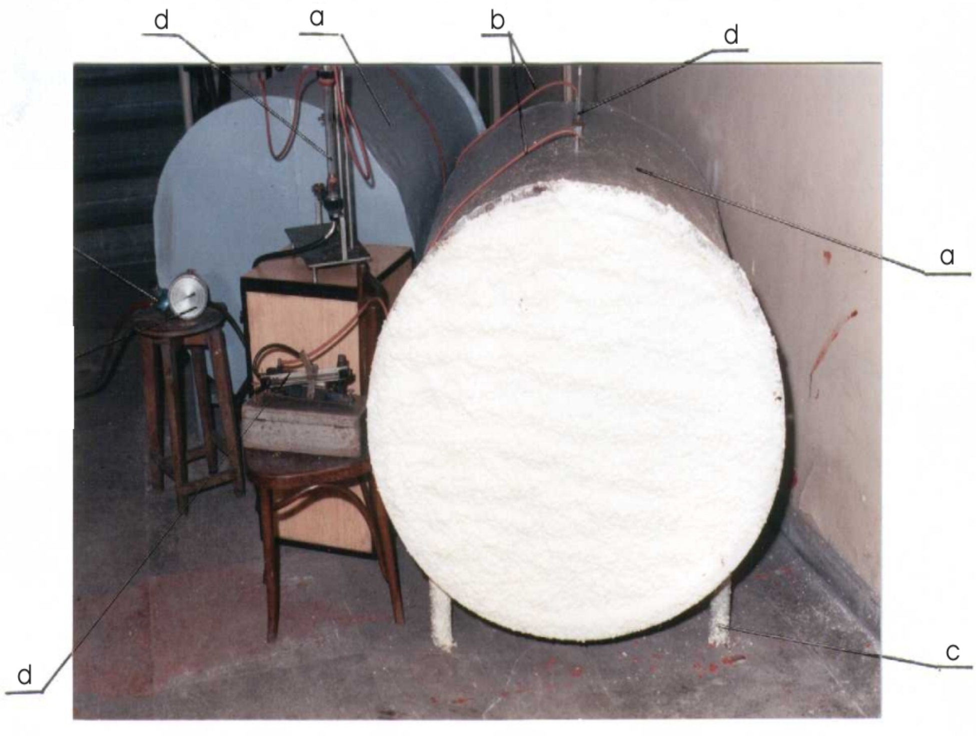
b) Connecting tubes (hoses or pipes);
c) The supporting system;
d) Instrumentation.

Analysis of the Materials that Form the Additional Sealing Solutions

Considering the technical criteria (demands) for those materials used for an additional

sealing of dams, several mixtures were tested and they were grouped into the followings:

a) mixtures based on urelite (urea-formaldehyde resin),
b) mixtures based on cement and inert dust;
c) mixtures based on sodium silicate (soluble glass).



Laboratory tests

Six mixtures (sealing solutions) were tested and applied under the form of a film in 1, 2 or 3 layers.

The measurement started the day after the first film was applied, and went on for several days (10 days max.).

For a comparison of the results and to determine tile best solutions for an additional sealing of dams, the values of the specific air outputs corresponding to a pressure of 1 mm H_2O as well the specific strengths for a square flow state for each tested solution were used.

Considering the results, the additional sealing materials for dams which displayed the highest sealing degree were the ones made of bentonite + sodium silicate and clay + sodium silicate.

Underground tests

Aninoasa Mining Unit was chosen to test in underground the additional sealing materials for the dams selected after lab tests.

Selection of the test places

The following aspects were considered to get as may information as possible about the behavior of the additional sealing materials of underground dams and to select the test places:

- the classical dams made of walling and stone key and of mine wood parts and clay;
- different values of humidity,
- dams with positive, negative or ”zero” pressure;
- current state of the dams surface (clay washed or not, cement washed on not partial concreted forms);
- occurrence of mine gases m different rations behind tire dams (CH_4, CO_2, O_2).

Working method

The sealing materials that were used consisted in:

- sodium silicate + bentonite + water
- sodium silicate + clay.

Bowls with pre-determined volumes were employed to produce the sealing solution.

The component materials of the solution were mixed up to homogeneity.

The solution was brushed in several layers, after the previous one had been dried.

Results

For a surveying of the behavior and the efficiency of the additional sealing solutions used on dams, measurements were carried out before and after their brushing and they consisted in measuring the gas concentration in front of and/or behind dams the temperature, the pressure difference on the dams, the air pressure and the difference humidity.

The following aspects derive from the tests:

1). The specific consumption for each layer of sealing solution made of bentonite 1 sodium silicate is between 1.4 ÷ 1.6 l/m^2, and made of clay + sodium silicate is between 1.3 ÷ 1.6 l/m^2, values which correspond to the first layer. This consumption reduced with 20% and with 30% for the second and third layer compared to the amount of material used for the first layer.

2). The drying period necessary for the sealing layers had wide limits depending on the underground climate (temperature, humidity air speed), on the quality of the dam surfaces smooth or rough surfaces, dams with or without concrete forms, etc.) and the engineering conditions (the ventilation of the area in front of the dam.).

3) A longer survey of how the sealing layers behaved showed that the film, preserved its continuity all through the testing period (5 months), even when it changed the initial glossy appearance (some white spots appeared) the exception is represented by the occurrence of areas with needle type crystals as a result of high concentration of CO_2 and a high air pressure behind the dam where the sealing film damaged after about 2 months.

On the surfaces made of concrete (concrete dams made of keystones walls) as well the ones made of clay (dams made of mine wood parts and clay-washed), the sealing solutions had a good catch, with no tendencies of peeling off or cracking all through the testing period.

Based on the results, it may be concluded that the solutions presented in this paper shall improve the sealing of goafs and they may be used for an additional sealing of the dams made of concrete, keystone walls or of wood parts and clay.

2. CONCLUSIONS

1. An increased impermeability of the sealing workings shall be accomplished with the help of additional sealing materials bushed over them.

2. There have been established the technical requirements for the materials that are going to be used as sealing materials.

3. There has been devised a test stand to determine the impermeability levels of materials. It is used to measure air currents proofness of these dams.

4. The sealing materials (mixtures) with a good behavior on the test bench were made of sodium silicate +- clay and sodium silicate + bentonite. They increase hundreds of times the impermeability compared to the support (dam) which is not additionally sealed.

5. When choosing the sealing solutions for the classical dams, two aspects were considered: the material used to build us the dam and the compatibility of adherence on the surface of the dam.

6. The underground tests of the above-mentioned sealing solutions showed that they improve the sealing of goafs, aspect that shall diminish the risk of occurrence of underground fires and the period of not using the darned coal deposits.

REFERENCES:

[1]. **Matei, I., Toth, I., Cioclea, D., Purcaru, S.I., Vochițoiu, H**. – *Combustia spontabă în minele de cărbune*, editura PRINT-EVEREST, Deva, 2003.

[2]. **Matei, I., Cioclea, D., Toth, I., Gligor, C., Purcaru, S.I., Voinoiu, N**. – *Prevenirea combustiilor spontane la extragerea prin metoda de exploatare cu banc subminat*, editura AGORA, Călăraşi, 2004.

[3]. **Cretien, S**. – *Différentes manières d'étanchement*, Publication Technique des Charbonnages, France, 1 / 1967.

[4]. **Toth, I**. – *Tehnologie de prevenire a combustiilor spontane la extragerea cărbunelui prin metode de exploatare cu banc subminat*, Program MENER, 2002-2004.

[5]. **Toth, I., Gligor, C., ş.a.** – *Îmbunătățirea soluțiilor de etanşare a diferitelor procedee noi in închiderea rapidă a lucrărilor miniere*, Studiu CCSM-Petroşani, 1993

[6]. Cererea de brevet de invenție nr. A 2003 / 01010

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THE GEOTECHNICAL CHARACTERIZATION OF THE EMPLACEMENT CONDITIONS OF MIHOIESTI DAM

MIHAELA TODERAŞ*

Abstract: *Large Dams are a particularly important case of seismic risk assessment. On the one hand, the dams themselves have a high value, having implications for the whole economy, through the production of electricity, water supply systems for irrigation and flood prevention, etc. On the other hand, structural damage of a dam can lead to major disasters, the population exposure to effects caused by sudden floods. The situation in Romania is such a kind that should be given to the future safety of existing dams. The first reason is that these dams were designed and constructed on the basis of technical rules, which the majority are no longer in force, a second reason is the major climate changes in the last period, which have led to the volume of water in increasingly large lakes in the accumulation of them. A third reason logically, is the length of existing dams. Accumulation Mihoiesti dam was to ensure, primarily, the water in the area of mines Apuseni Mountains - Rosia Poieni use fall created to produce electricity and other uses of the river basin Aries.*

Key words: accumulation, dam, importance, geotechnical category, geotechnical risk.

1. THE EMPLACEMENT OF MIHOIESTI DAM

Accumulation Mihoiesti is located at the foot of Bihor Mountains; Mihoiesti is the village in Alba County, downstream from the confluence with Ariesu Mare, approx. 4 km upstream of town Câmpeni. Dam has a height of 29 m and volume accumulation is 6.25 million m3 of water. Planning goal is to adjust the flow of the river Aries throughout the year, so that the pumping station Gârda to achieve an approximately constant flow, Figure 1.

Dam was filled with ballast, weathertight upstream of the facing of the mask with PVC foil of 0.4 mm and 0.5 mm, in equilibrium with reinforced concrete slabs on a total area of 11,000 hectares, Figure 2. Seals in depth were achieved with a veil of injections performed on upstream of dam of the facing concrete. Canopy is circulable, being used as access road to the village Vidra, Figure 2.

* *Assoc. Prof. Ph.D. Eng. - University of Petrosani,*

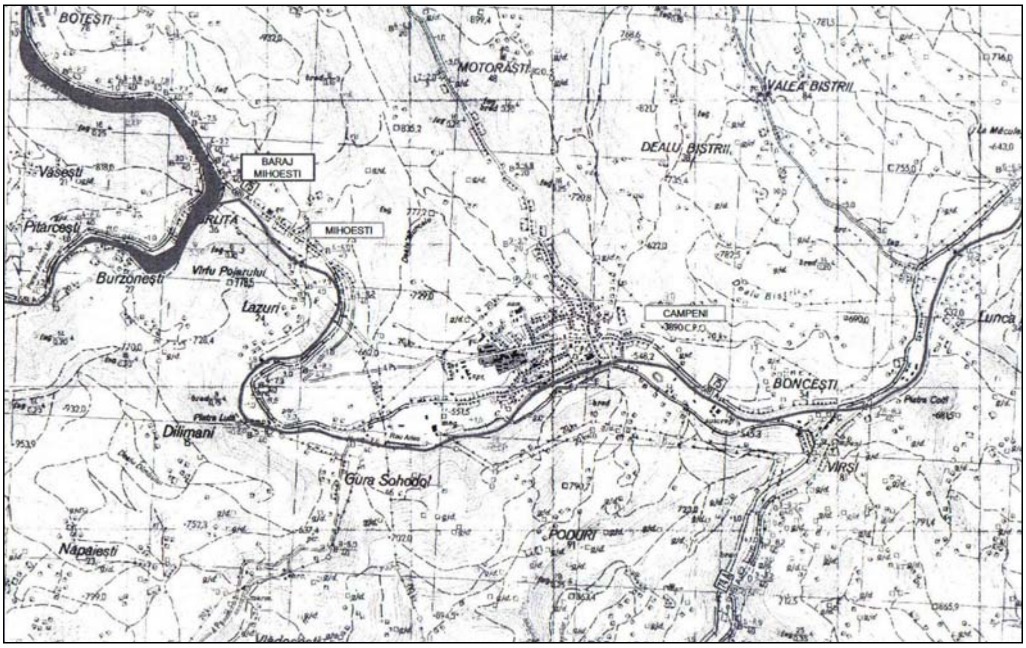

Figure 1- Localization of Mihoiesti Dam.


Figure 2- General view of the Mihoiesti Dam.

2. GEOTECHNICAL AND HYDROLOGICAL DATA

From geological point of view, most of the basin dam, rock base is represented by different varieties quartzite slate sericites chlorites and gneiss feldspathes. In the area of dam site in the left hill in the bottom and the right to appear quartz peaks chlorites sericitoase crossed by quartz veins and in the right gneiss feldspathes.

Quartzite slate, chlorites sericites have texture system are fissure and fissure and a general of 16^o - 18^o and 35^o inclination of - 60^o to downstream and towards the right bank. Gneiss feldspathes have massive texture, are less fissure and fissure, have the broad 17^o - 19^o / 45^o - 60^o, being consistent with quartz peaks chlorites sericitoase. Area altering the basic rocks is an average thickness of 5.00 m on versions of approximately 6.00 m layer. Alluvia major riverbed of the average thickness of 4.00 - 5.00 m, but accidentally reach thicknesses of 8.00 m, are represented primarily by sands with stones and rocks, but sometimes appear discontinuous lenses of clayey sand or sandy clays both the bottom and at the top. Deluvial is composed of a clayey material - sand, with angular fragments of altered rock type peaks and gnaiselor; deluvial dimensions are variable, between 0.05 m - 1.00 m. The thickness deluvial on the left is between 0.50 m - 2.00 m, respectively, 3.00 m - 5.00 m on the right. On the right, there are three levels of terrace, with the average thickness of 2.00 m - 4.00 m. The basin character are virtually impermeable, the base rock consists for the most part, crystalline peaks. In general, alluvia have characters similar to those of dam. The peaks are mostly stable. Groundwater alluvial deposits occur in the meadow, but also to the deposits on deluvial peaks or cracks in the surface area, altered basic rocks. They present desalkalinizing aggression against the concrete. In the area of energy of the outleting gallery, have executed a number of drillings 6, where they found that:

- average thickness of vegetable earth is 0.30 m;
- alluvial deposits have thicknesses between 4.20 m and 4.70 m and are mostly represented by rocks with stones and sands, sometimes with clayey cement dust;
- deluvial deposits consist of fragments of rock of various sizes, attached in a binder clay - dust;
- rock base is represented by gneiss feldspathes weathered.

In the downstream area of the gallery of the outleting of energy alluvial deposits have changed both in terms of their thickness, but also as granulometry, but in a less extent.

Rock base comprises two petrographical types:

- quartzite slate sericitoase chlorites;
- gneiss feldspathes.

Geotechnical parameters for quartzite slate sericitoase chlorites were calculated and assessed according to geotechnical studies, are as follows:

1- Weathered state:

Density bulk, γ	24 – 26 kN/m^3
Internal friction angle, Φ	$26^o – 34^o$
Cohesion, c	1.2 – 3.5 daN/cm^2
Conventional pressure of calculus, p_{conv}	800 – 900 kPa
Coefficient of friction on the plate foundation, μ	0.50

2- Unweathered state:

Density bulk, γ	26 – 27 kN/m^3
Internal friction angle, Φ	$35^o – 42^o$
Cohesion, c	7.5 – 12 daN/cm^2
Conventional pressure of calculus, p_{conv}	1500 – 1600 kPa
Coefficient of friction on the plate foundation, μ	0.60

Gneiss feldspathes from the right peak, of grey colour are tough, have a massive texture and macro granular structure. Area altering these rocks is 4.00 m - 5.00 m. Geotechnical parameters for gneiss feldspathes established in the geological study are as follows:

1- Weathered state:

Density bulk, γ	25 – 26 kN/m^3
Internal friction angle, Φ	28^o – 40^o
Cohesion, c	3.0 – 7.0 daN/cm^2
Conventional pressure of calculus, p_{conv} (base value)	1000 – 1500 kPa
Coefficient of friction on the plate foundation, μ	0.60

2- Unweathered state:

Density bulk, γ	26 – 27 kN/m^3
Internal friction angle, Φ	42^o – 55^o
Cohesion, c	10.0 – 15.0 daN/cm^2
Conventional pressure of calculus, p_{conv}	2000 – 2300 kPa
Coefficient of friction on the plate foundation, μ	0.65

Landfills covers are represented by the deluvial on the peaks and of alluvia on the major riverbed. Deluvial consist of sandy clay material with fragments of altered rock, having a thickness of 3.00 m - 5.00 m on the right. Geotechnical parameters of deluvial appreciated are as follows:

Density bulk, γ	19 – 20 kN/m^3
Internal friction angle, Φ	20^o – 25^o
Cohesion, c	0.10 – 0.20 daN/cm^2
Conventional pressure of calculus, p_{conv} (base value)	250 – 275 kPa
Coefficient of friction on the plate foundation, μ	0.30
Coefficient of permeability, K	0.08 – 0.08 m/day

Alluvia consist of small stones with rocks and sands, sometimes with binder clay - dust, having thickness of 4.00 m - 5.00 m, but may reach and 7.00 m - 8.00 m. Geotechnical parameters of these types of alluvial appreciated are as follows:

Density bulk, γ	21 – 22 kN/m^3
Internal friction angle, Φ	35^o – 38^o
Cohesion, c	0,00 – 0,05 daN/cm^2
Conventional pressure of calculus, p_{conv} (base value)	450 – 500 kPa
Coefficient of friction on the plate foundation, μ	0,50
Coefficient of permeability, K	50 – 100 m/day

In terms of how to behave at picking the types of soil encountered in the studied area, according to "rules for guidance on resource consumption items estimate for works of embankments - Ts, 1994 edition, prepared by ISPCF and I.N.C.E.R.C. Bucharest and approved MLPAT to order 1 / N of 03.04.1992, are classified and presented in Table 1.

According to STAS 11100/1-93, accumulation Mihoiesti fall zone 6 intensity microcosmical. Based on the norm P100/92, the seismic calculation is F and corresponds to a seismic coefficient Ks = 0.08 and a corner period Tc = 0.7 sec. Underground water, all the studies mentioned above and presents the leaching of aggression against concrete.

Table 1- Types of land in the studied area of Mihoiesti depending on the digging behaviour:

Type of earth's name	Cohesive properties	Field category after the behaviour at the digging				Medium weight in situ (in the digging [kg/m^3])	Raising of the digging after excavation, [%]
			Mechanized				
		Manually	Digger	Bulldozer	Moto screper		
Vegetable land surface to 30 cm thick	weak	easy	I	I	I	1200 – 1400	1 4 – 28
Sandy clay with gravel up to 10 %	medium	strong	I	II	I	1800 – 2000	2 6 – 32
Big sand	Non cohesive	easy	I	II	II	1600 – 1700	8 -17
Deluvial the dominant fraction of sands and sandy clays	medium	strong	II	II	II	1500 – 1700	1 4 – 28
Gravel and sand blocks clogged with clay	medium	Very strong	III	III	III	1500 – 1700	8 -17
Blocks up to 200 mm, with fractions greater than 200 mm over 50 %	Not cohesive	Very strong	III	III	III	1700 – 2000	8 -17

3. HYDROLOGICAL DATA CHARACTERISTIC TO THE STUDIED SITE

Hydrological data used are based on hydrological studies developed in recent years by the National Institute of Meteorology and Hydrology (INMH) for geographical basin Aries, supplemented and updated by other studies conducted in subsequent periods. Data characterizing morfometrics Aries river basin and the multiannual average flow in some sections on the main are presented in Table 2. The maximum characteristic of leakage of water in the basin, and maximum values with different probabilities of exceedance, layers and drained volumes waves flood with the probability of exceedance of 1% in the main hydrometric stations are shown in Table 3. The presented flows do not include debts but increase security, the latter for verification flow is shown in Table 4. In the same section characteristics, flood waves Schematic (type) are presented in Table 5.

Table 2- Morfometrice characteristics of river basin Aries and flows in multi-media section on the main course:

River	Section	L, [m]	F, [km^2]	H_m, [mdM]	i_{river}, [m/km]	q, [l/s km^2]	Q_m, [m^3/s]
Arieşul Mare	s.h. Scărişoara	220	200	1126	20	27	5,39
Arieş	Lac Mihoiesti	42	574	1019	12	20	11,5
Arieş	s.h. Câmpeni	48	639	999	12	18,9	12,1
Arieş	s.h. Turda	133	2358	897	6	10,8	25,4

Table 3- Maximum leakage in the pool and the maximum flow in sections of the hydrometric stations:

River	Section	Maximum flows [m^3/s] with probability:					$h_{1\,\%}$, [mm]	$W_{1\,\%}$, [mil m^3]
		0,1 %	0,5 %	1 %	2 %	5 %		
Arieşul Mare	s.h. Scărişoara	517	375	313	258	178	101	20,3
Arieş	Lac Mihoiesti	961	700	594	495	363	101	57,7
Arieş	s.h. Turda	2022	1457	1211	1000	680	64,5	152,6

Table 4- Increase safety for flow verification:

River	Section	Increase safety for Q_p [%]		
		0,1 %	0,5 %	1 %
Arieş	Lac Mihoiesti	14 %	12,6 %	12 %

Table 5- Where flood schematic characteristic studied in sections:

River	Section	T_{tot}, [ore]	$T_{increase}$, [ore]	Form coefficient
Arieşul Mare	s.h. Scărişoara	72	13	0,25
Arieş	Lac Mihoiesti	93	15	0,29
Arieş	s.h. Turda	125	27	0,28

According S.R. 11100/1-1993, accumulation Mihoiesti is framed in terms of seismicity in area 6 of macro seismic intensity, and according to norm P 100 / 92, the seismic calculation is F, corresponding to a coefficient Ks = 0.08 and a corner period Tc = 0.7 sec. Depth of frost, according to STAS 6054-77, more than 110 cm.

4. DAM CLASSIFICATION CLASS AND CATEGORY IMPORTANCE

Given the accumulation Mihoiesti mitigation of flood wave and water classes for hydro importance of work in the scheme of arrangement studied have been established under the provisions in force (STAS 4273/2-83) and the likelihood of insurance verification and calculation of corresponding classes of importance were determined according to STAS 4068/2-87. Mihoiesti accumulation was placed in Class II of the importance which it corresponds to a debit account with the annual probability of exceedance of 1% and the verification flow of 0.1%. The importance of work safety on the accumulation Mihoiesti, according to GD no. 261/1994 and Law no. 10/1995 on quality construction, is B, meaning a category of importance. Mode setting is set out below.

The characteristics of the dam and the conditions of emplacement = **BA**

Partial criteria	Characterization				
0	1	2	3	4	5
Dam's size	Small H < 15 m 0,05 < V < 1 hm^3 **10**	Medium 15 < H < 30 m 1 < V < 50 hm^3 **6**	Big H > 30 m V > 50 hm^3 **2**	-	**6**
0	1	2	3	4	5
Dam's type	Weight or Snap (PG + VA) **20**	Riprap with the mask (CB + Erm) **15**	Riprap with the cor clay (ERrn) **10**	Front of the total or partial retention of the ground (TE) **5**	**5**
Discharger type	Free overflow **25**	Weir with stave **15**	Sluice valves and register with the fund **10**	No surface **5**	**25**
Foundation	Rock **20**	Alluvia **10**	Difficult area **2**	-	**20**
Importance class (STAS 4273-83)	I **15**	II **10**	III ÷ IV **5**	-	**10**
Seismic area (P 100-92)	D ÷ F **10**	C **7**	B **5**	A **3**	**10**

The behaviour of dam and the the structure's state = **CB**

Partial criteria	Characterization				
Survailance	AMC + topo + visual **17**	Topo + visual **7**	Only visual **2**	Without **0**	**3**
Mechanical equipment	Operational + current manevras **17**	Operațional + periodical manevras **7**	Not sure **3**	Affected evacuated capacity **0**	**7**
Maintenance	Very good **10**	Acceptable **5**	Low **0**	-	**5**
Age (years)	T < 10 **10**	20 > T > 10 **7**	50 > T > 20 **3**	T > 50 **0**	**7**
Infiltrations or flows under pressure A. TE + ERn B. PG+VA+ERm	In prognozed limits **17** **7**	Atypical but not dangerous **7** **3**	Evolutionary **3** **1**	Endanger safety **0** **0**	**3**
Deformations A. TE + ERn B. PG+VA+ERm	In prognozed limits **17** **7**	Atypical but not dangerous **3** **7**	Evolutionary **1** **3**	Dangerous **0** **0**	**3**
Warping	Unsignifiant **10**	Clear bottom block **7**	Affected transit capacity **3**	Vat affected **0**	**10**
Dissipated	Very good **6**	Acceptable **3**	F. det./inex. **0**	-	**0**
Seismical calculus	Actual norms **6**	Reactualizated **3**	Uncalculated **0**	Unknown **0**	**0**
TOTAL CB					**38**

The effects of damage = **CA**

Partial criteria	Characterization				
Population density	Big agglomeration **20**	Normally populated **10**	Less populated **5**	Not populated **0**	**5**
Alarm system	No alarm **20**	Local Inf. **10**	Unchecked AC **5**	Verified AC **0**	**10**
Importance reported to third	Uncial source AA **20**	There are alternative sources **10**	Energy + irrigations **5**	Other use **2**	**10**
Economical goals	Industries **10**	Small industry **5**	Family factories **3**	Without industry **0**	**0**
Using the up field	Agricol **10**	Pasture / forest **5**	Unproductive **2**	-	**10**
Environment effects	Ecological disaster **5**	Effected quantifiable **3**	Negligible effects **1**	-	**3**
Position in the dam	Affects breakings **15**	Affects the attenuation of incursion **7**	No secondary effects **2**	-	**7**
TOTAL CA					**45**

Note: if the equipment is locked or infiltrations are dangerous, CB index is multiplied by 0.1. It is considered that the information is sufficient and satisfactory processing; topographic measurements are systematic and interpreted.

SG dam safety:

$$SG = \alpha \times BA + \beta \times CB = 0{,}8 \times 76 + 1 \times 38 = 99$$

$$\mathbf{SG = 99}$$

α = 1 - dam built under existing rules;

α = 0.8 - dam built on the old rules, but verified according to α current standards;

α = 0.4 - no data on design α;

β = 1 - normal behaviour;

β = 0.7 - past incidents or accidents, which required major remedial works

The probability of dam failure PC

$$PC = \frac{1}{SG}$$

$$PC = \frac{1}{99} = 0.0100 \qquad PC = 0.0100$$

Index of risk associated with RB

$$RB = PC \times CA$$

$$RB = 0.0100 \times 45 = 0.45 \qquad \mathbf{RB = 0.45}$$

Importance category according to the index of risk RB:

INDEX OF RISK	**Importance's Category**		**Monitoring of the behaviour**
RB > 1,0	Unacceptable risk, it is necessary to remove from exploitation by bringing in limits of acceptable risk		
1,0 ≥ RB > 0,5	A	Exceptionally importance	Special
0,5 ≥ RB > 0,25	**B**	**Specialy importance**	**Special**
0,25 ≥ RB	C	Normally importance	Currently

REFERENCES:

[1]. Manea S., s.a, *Mecanica pamânturilor*. Editura Conspress Bucuresti, 2003.

[2]. Toderas M., *Geotehnica si fundatii*. Editura Universitas, 2005.

[3]. Toderas M., *Geomecanica. Probleme de mecanica pamânturilor si fundatii*. Editura Universitas, 2005.

[4] *,** *Acumularea Mihoiesti pentru apararea impotriva inundatiilor si alte folosinte*.

[5]. *,** *Documentatie tehnica si geologica – Barajul si acumularea Mihoiesti*.

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GEOTECHNICAL PROPERTIES OF SOILS OF THE PODKRUŠNOHORSKÁ VÝSYPKA DUMP IN SOKOLOV BROWN COAL FIELD AND THEIR LONG TERM TREND

M. MIKOLÁŠ*
F. FRAUS**

Abstract: *Open pit brown coal mining in the Sokolov coal field has been suffering with the lack of a space for overburden rocks dumping from its very beginning. The Podkrušnohorská výsypka dump is situated in a geomorphologically highly broken landscape at the Krušné Hory Mountains foot and northern part of Sokolov Basin divide. The Podkrušnohorská výsypka dump originated by the union of Lipnice, Vintířovká, Pastviny, Týn, and Boučí dumps. Its area is 1957 ha, length 8.3 km, width 2.3 km, maximal elevation 600 m above sea level. The original configuration of the terrain under the dump was 460 – 530 m above sea level. The area of interest belongs to the Krušné Hory Mountains crystalline massif region from the global geologic point of view. The contact of the dump with bedrock is not a continuous aquifer. The dump's subsoil is dewatered by a drainage system. The underlying rock – crystalline is composed of mica schist and phyllites. The surface of the crystalline was weathered by kaolinite to great depth. Tertiary in the dump bedrock is represented by sandstones, quartzes, and agglomerates laid on the crystalline denuded surface. Dump rock consists of tuffaceous clays with minimal specific resistance values QST = 0.5 - 1.0 MPa and cypric clays with minimal specific resistance values QST = 1.0 - 2.0 MPa. Large scale research works took place on the dump in various periods of time. The mining solutions of the methods on the dump were subjects of stability expert's statements. 23 statements were produced sequentially from 1966 which were aimed to both general slopes of whole the dump and partial issues on the dump during its foundation. The dump was the scene of the series of landslides, most important of them were in the years 1986/1987 and 1990. Hydro-geological and geotechnical research was the base for stability reports and it concentrated in the dump bed quality, dump water bearing, bed water bearing, and to obtaining geotechnical parameters dump bed and dump rock fill. Basic physical and descriptive strength, transformation and technological parameters were established by in situ and laboratory tests.*

** VŠB – Technical University of Ostrava, Czech Republic*
*** Geotechnic and Mining Engeenering, Sokolov, Czech Republic*

1. AREA CHARACTERISTICS

Podkrušnohorská Výsypka Dump is situated in a highly geo-morphologically broken landscape at the boundary between the Krušné Hory Mountains foot and northern part of the Sokolov Basin. The area of interest was originally created with forest landscape with varying representation of beech, oak, and significant share of confers, mainly fir and pine. The landscape was originally very broken and the segmentation was kept by mining activity – building of the Podkrušnohorská Výsypka Dump.

The object area can be found north and north east of Sokolov town among Vintířov – Vřesová – Dolní Nivy – Boučí – Lomnice communities. A territory influenced by activities on the Podkrušnohorská Výsypka Dump is on 8 cadastral units in Sokolov District, Karlovarský Region. Total area affected by mining activities is 1957.1 ha. The dump length is 8.3 km west – east and width 2.3 km. Ca 886 000 000 m^3 overburden rock was deposited in the dump.

An original configuration of the terrain under the dump was ca 460 – 480 m above sea level in the south and 460 – 530 m above sea level in the north, the terrain was declined from north to south and south west under a general declination not more than 2 degrees. The Boučský and Hluboký Potok Streams ran a western part of the area in a widely opened valley which got narrow to a deep gorge. The Lomnický Potok Stream ran between the western and eastern part of the dump in a shallow valley and the area had a character of an elevation which made good conditions for precipitation runoff. The Lipnický Potok Stream ran between the central and eastern part of the dump in a N – S oriented valley which created depressions with surface and underground water overflow in its central part. The Vintířovský Potok Stream ran in the eastern part of the area in a NW – SE oriented valley. The eastern part of the original terrain was relatively flat with a plain at 480 m above sea level. The Lipnice quarry was mined out and its mining space cancelled. Former Lipnice pit bottom and W and N parts declines generally in longitudinal N – S direction and in general N - N declination in south and eastern part. The Erika quarry was mined out in the south western part of nowadays dump. The bottom of the pit decreases from north and west to south to the deepest point of 429 m a. s. l., which was in the central part of the pit. Both mined out pits were filled with older dumps. Dumping in all the dump was finished according to valid projects.

The configuration of a new terrain after finishing all dump body is created by a new body with a oblong shape in W – E direction with a 8.3 km total length and 2.3 km average width with two peaks 600 m a. m. s. l. high between which a shallow gap originated in S – N direction. The surface of the dump decreases from the peaks under a general declination 1 : 15 to 1 : 17 to south and south west, under a declination 1 : 13 to 1 : 15 to south east, and under a declination 1 : 7 to 1 : 8 to north. Single dump levels are sloped and shaped to a required body form.

The Podkrušnohorská výsypka dump originated by the union of Lipnice, Vintířovká, Pastviny, Týn, and Boučí dumps, as stated before. Almost all the dump was dumped as an external one on the natural terrain with maximum 600 m a. m. s. l.

with the exception in central part where the former Lipnice mine was situated and a south west part where the former Erika mine was situated with lowest point 429 m a. m. s. l. It can be stated that the dump surface is broken alike an original terrain, and that after reclaiming the area, the dump will be incorporated as a cultural landscape into local natural and living environment.

Total area of dump affected territory is 1957 ha.

Geological characteristics of Podkrušnohorská Výsypka Dump bed layer

This part of the area of interest belongs to southern block of Svatava crystalline complex which is a part of the Krušné Hory Mountains crystalline complex.

Crystalline complex

Crystalline rock massif is created by binary micaceous muscovitic schist, silicificated a lot, locally by phyllitic rock. The crystalline surface was weathered kaolinitically to a remarkable depth. Weathered material was often redeponed by water erosion and it creates positions of coarse sandy micaceous kaolinitic clays to fine grain sands.

Tertiary

Early tertiary is represented by sediments of Staré Sedlo strata lying on denuded crystalline surface. Sandstones, quartzites, and conglomerates of those strata have been preserved only at the relicts near south and south east margin of the area of interest

Quaternary

Quaternary sediments are developed in irregular mostly small depths in the area of the dump. They are slope loams with low content of the chips of quartz, sandstones, and mica schists. There are peat stones and small depth peat in local depressions. An immediate dump bed is created by a small layer of loams, sandy clays with mica schist or quartz chips under which positions of totally or partly decomposed mica schists are. It implies from the analysis of all research works in the territory that base is not an unsuitable geo-mechanical environment with occurrence of unbearable stratigraphic strata.

Hydro-geologic situation in the base and body of the dump

It implies from engineering geological exploration results that the contact of a dump with the base is not aquiferous continuously at all the area of the dump but aquiferous areas are quit large.

Geotechnical exploration works at the dump

Pastviny dump, 1965 - 15 core drills 10 to 20 m deep

Vintířov dump, geo-mechanical exploration, 1988 - 17 drills, incl.: 13 for geo-mechanical tests, 1 hydro-geological pumping, 3 hydro-geological observing

Pastviny – Týn dump, 1990 - standard and bulk laboratory sample tests

Týn dump - vane in situ tests in natural material laboratory shear tests of natural samples taken in various depths of the base

Pastviny dump, 1991 - 14 penetration probes, core drill (P 36)

Vintířov dump, geo-mechanical exploration, 1991 - 40 static penetration probes

- *Erika quarry area, 1992* - 3 core drills, 6 static penetration probes

- Lomnice – Boučí area, engineering geological exploration of the area, 1992 - 13 core drills, 450.9 m, static penetration 1867.6 m, 9338 tests, 1375.6 G-G logging, 13 756 measurements,273 inclinometric measurements.

Exploration profiles

Characteristic profiles where slopes stability was explored were selected to evaluate the stability of dump slopes.

1–1´ X=1007000, Y=865995; X=1008000, Y=865605
4–4´ X=1009500, Y=867185; X=1008000, Y=866680
5–5´ X=1009000, Y=869415; X=1008000, Y=867540
6–6´ X=1008300, Y=869500; X=1007500, Y=867250
7-7´ X=1009500, Y=867765; X=1007000, Y=867470
E–E´ X=1007000, Y=864645; X=1008000, Y=864195
F–F´ X=1007000, Y=863865; X=1008000, Y=863865

The stability of slopes was solved, exploring and surveying works were concentrated, hydro-geological regime of water in the dump, and field observations were carried out in the profiles which go through sensitive parts of the slopes of the Podkrušnohorská Výsypka Dump.

Strength parameters

Strength parameters of dumped rocks

Strength parameters of dumped rocks were found out in more stages.

- Vintířov dump, 1965

Shear strength determined empirically. The values of shear strength were derived from measured slope declination in limit balance status.

Jiří quarry cypris clays:

$c = 15$ kPa, $\varphi = 12.5^{o}$

Lipnice quarry grey yellow and yellow brown clays:

$c = 25$ kPa, $\varphi = 7^{o}$

The shear strengths of rocks were derived empirically from measured slope declination in limit balance status.

- Týn – Boučí dump, 1987

Dump contact with bed :

$\gamma = 21.0$ kN.m^{-3}, $c = 15$ kPa, $\varphi = 17^{o}$

Medard quarry overburden earths:

$\gamma = 18.0$ kN.m^{-3}, $c = 33$ kPa, $\varphi = 7^{o}$

- Vintířov dump, 1989

Space fill of dumped cypris claystones, residual values:

$c = 25$ kPa, $\varphi = 7^{o}$, $w < 35$ %

Dumped cypris claystones, residual values, normal tension > 600 kPa:

At $w = 50$ %, $c = 26$ kPa, $\varphi = 2^{o}$
$w = 40$ %, $c = 59$ kPa, $\varphi = 2^{o}$
$w = 30$ %, $c = 91$ kPa, $\varphi = 2^{o}$

- Vintířov dump, 1990

Cypris clays and claystones, safety coefficient $F > 1.5$, considered values:

$\gamma = 17.2$ kN.m^{-3}, $c = 25 \pm 5$ kPa, $\varphi = 8 \pm 0{,}5^{o}$
- Pastviny – Boučí dump 1990

Dump rocks, for safety coefficient F = 1.5 ensuring minimum shear strength values :

$c_{rez} = 2.5$ kPa, $\varphi_{rez} = 2.5^{o}$
- Vintířov, Pastviny, Týn, Boučí dump areas, 1991

Dump rocks, valuation of input data in previous reports :
$c = 10$ kPa, $\varphi = 12^{o}$, for dump body
$c = 20$ kPa, $\varphi = 7^{o}$, for a contact in a zone where normal tension $\delta > 600$ kPa
$c = 20$ kPa, $\varphi = 2^{o}$, for a contact in a zone where normal tension $\delta < 600$ kPa
- Erika quarry dump, 1992

Contact dump base - dump :
$c = 10$ kPa, $\varphi = 6^{o}$
Dump rocks 10 -14 m above base :
$c = 20$ kPa, $\varphi = 6^{o}$
Dump rocks 18 – 28 m to terrain:
$c = 10$ kPa, $\varphi = 6^{o}$
Planned values of strength parameters in dump project :
$c = 10$ kPa, $\varphi = 12^{o}$
Values of shear strength parameters acquired by back calculation on the dump base – dump contact used in the calculation :
$c = 5$ kPa, $\varphi = 2.6^{o}$
- Lipnice quarry area dump

Disturbed part after instability manifestation in 1986/1987:
$c = 10$ kPa, $\varphi = 3^{o}$
Strength parameters of the dump base
- Pastviny dump, 1965, the values are expressed in total parameters

Quaternary loams
$\gamma = 21.0$ kN.m^{-3}, $w_n = 18.0$ %, $c = 10$ kPa, $\varphi = 3^{o}$
Light brown and grey clays
$\gamma = 19 – 21.0$ kN.m^{-3}, wn = 22.3 %, $c = 49$ kPa, $\varphi = 15^{o}$
Destructed tuffaceous clays
$\gamma = 20.6$ kN.m^{-3}, wn = 20.0 %, $c = 130$ kPa, $\varphi = 10.5^{o}$
Kaolinitically decomposed mica schists
$\gamma = 19.5 – 24.3$ kN.m^{-3}, wn = 6.5 – 20.8 %, $c = 20 – 82$ kPa, $\varphi = 14 - 38^{o}$
- Týn – Boučí dump 1987

Redeposited mica schist eluvium:
$\gamma = 18.6$ kN.m^{-3}, $c = 12$ kPa, $\varphi = 17^{o}$
Mica schist eluvium (kaolinitic clays with markable pattern of original rock :
$\gamma = 21.0$ kN.m^{-3}, $c = 15$ kPa, $\varphi = 17^{o}$
Hard kaolinitically weathered mica schists, very quartzificated:
$\gamma = 22.4$ kN.m^{-3}, $c = 30$ kPa, $\varphi = 25^{o}$
- Pastviny – Týn dump 1990

Geotechnical laboratory tests of dump base. Values of geotechnical properties were found out by standard geotechnical tests.

Quaternary, diluvial sediment, sandy loam, solid consistency :

$\gamma = 20.49$ kN.m^{-3}, $c_{ef} = 0.0$ kPa, $\varphi_{ef} = 27.9^o$, $c_t = 34$ kPa, $\varphi_t = 25.2^o$

simple pressure strength $\sigma_{pd} = 212$ kPa

lateral tension strength σ_{ptp} = not found

compressibility modulus $E_0 = 14.9$ MPa

Tertiary, red brown tuffaceous with high plasticity, solid consistency

$\gamma = 20.98$ kN.m^{-3}, $c_{ef} = 37$ kPa, $\varphi_{ef} = 16.3^o$, $c_t = 83$ kPa, $\varphi_t = 13.3^o$

simple pressure strength $\sigma_{pd} = 663$ kPa

lateral tension strength $\sigma_{ptp} = 146$ kPa

compressibility modulus $E_0 = 34.2$ MPa

Tertiary, red brown tuffaceous with high plasticity, solid consistency

$\gamma = 20.51$ kN.m^{-3}, $c_{ef} = 30$ kPa, $\varphi_{ef} = 13.3^o$, $c_t = 105$ kPa, $\varphi_t = 7.5^o$

simple pressure strength $\sigma_{pd} = 371$ kPa

lateral tension strength $\sigma_{ptp} = 86$ kPa

compressibility modulus $E_0 = 20.1$ MPa

- Smolnice – Týn dump,1990

Soil-mechanical field and laboratory tests. Exploration of earth strength through vane tests in situ in natural material and laboratory shear tests of natural samples taken from various depth levels.

Vane tests – marginal conditions:

- Vane rotation speed $\omega = 0.3$ ^{o}/s,
- 1st depth level – 0.8 m below surface, insertion step below 1st depth level always 1 m,
- Test ended after reached deformation $\vartheta > 90^o$
- Relation of shear strength to the depth bellow surface (found out at vane tests): $\tau = 483.23 + 13.91 * T$ / kN/m^2 /, (T – depth /m)

Laboratory shear tests:

- Carried out in circular torsion sensor KR 50. The samples were cut by a steel string, sample area A = 50 cm^2, height h = 1.6 cm.
- Samples pre-consolidated with unified tension $\sigma_k = 400$ kN/m^2, consolidation time five days,
- Shear tests ran in normal tensions set $\sigma = 100$, 200, 300, 600, 900 and 1200 kN/m^2
- Shear speed v = 0,003 mm/min (until reaching top strength)
- Shear speed v = 3 mm/min (after reaching top strength), shear test carried out until reliable reaching residual strength.

- Týn dump rocks shear strength parameters:

Sampling shear strength of rock samples

depth		**top**		**residual**
	φ	c	φ´	c´
(m)	**(^{o})**	**(kN/m^2)**	**(^{o})**	**(kN/m^2)**
4.9	13.7	32.5	10.8	20.1
3.6	15.9	21.3	14.2	13.6
2.3	21.0	34.0	17.6	12.1

Strength parameters of rocks used in final review of dump slopes stability (For the plan of opening, preparation, and mining)

Calculation parameters of shear strengths were determined from the analyses of previous development of stability in the dump.

a) Shear strength of mushy earths from lower parts of filled Erika pit. It is lower than a measured minimum. The mushy earths were not able to undergo shear tests owing to their odd consistency:

c = 5 kPa, φ = 2.6^o

b) Shears strengths of earth which are in the area of lowest measured residual strengths. They characterise shear strength of the contact of a dump and a base with various aquiferosity and disturbance:

c = 5 kPa, φ = 2.6^o

c = 6 kPa, φ = 2.9^o, enlarged by 20 %

c = 7.5 kPa, φ = 3.9^o, enlarged by 50 %

Strength which is a calculation value for current dump levels in Erika quarry area. The strength is approximately in the middle of the residual values range:

c = 10 kPa, φ = 6^o

Strengths which characterise shear strength of new dump. i.e. planned levels. They are approximately in the middle of top values range:

c = 10 kPa, φ = 12^o, lower value is applied at calculation of Erika quarry area

c = 20 kPa, φ = 14^o

Safety of final dump shape in all the dump space is explored at eight characteristic profiles. The found out stability coefficient ks $\geq$ 1,5 suits mining regulations.

Stability solution

Three independent methodologies were used for dump stability solution:

(MON) octaedric tension methodology

(MRS) force balance methodology

(MS) S. K. Sarma methodology

Each of the methodologies evaluates the dump slope stability in its specific way (safety against various ways of dump body fault is valuated). Obtained stability coefficients are usually different. The relatively lowest stability coefficient of all three methodologies solution results for each researched case (profile) is a criterion for dump examination.

The octaedric tension method uses resistance values measured on the pin of a penetration probe to define limit state of soil disturbance. The determined global stability degree is practically a balance of limit states of slopes partial blocks disturbances at examined (supposed) shear area.

The force balance method is a combination of single bad method with a wedge method. The outcrop of a hear area is substituted by a resultant of horizontal ground pressure. A safety level on the contact area between a dump and a base which usually continues down to foot of the dump on the base of equation of sums of balance in horizontal direction.

The methodology of S. K. Karma evaluates an dump stability with regard to possibility of originating deep shear areas going to less bearable positions. The algorithm for shear area shape optimisation enables searching a shear area with lowest stability.

Hydrologic situation

A large body of Podkrušnohorská Výsypka Dump with its 1957,1 ha area is a significant hydrologic element in the landscape, too. There are more water outflows in the foot of the dump. All the outflows are long term monitored.

As the outflow monitoring shows, the Podkrušnohorská Výsypka Dump is a rich permanent water source. All watercourses which were in the area of future dump (streams from the Krušné Hory Mountains, Boučský Potok Stream) were relocated outside the dump area before starting the dump. Most original watercourse channels were used as suitable places for drainage building. Right there and at some of the places waters flowing out of the dump are measured.

Monitoring of dump hydrologic situation

Monitoring of out flowing water was changed step by step according to dumping continuation. Basic changes were carried out when single part of the dump (Týn, Boučí, Smolnice, Vintířov dumps) unified to one complex unit – the Podkrušnohorská Výsypka Dump. The monitoring measures all out flowing waters from the Podkrušnohorská Výsypka Dump only after 2000.

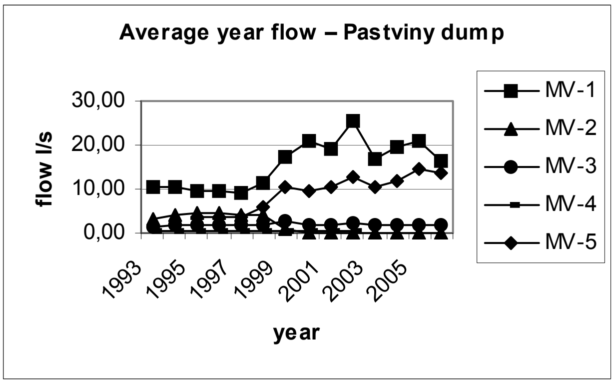

Fig. 1 Average year flow –Pastviny dump

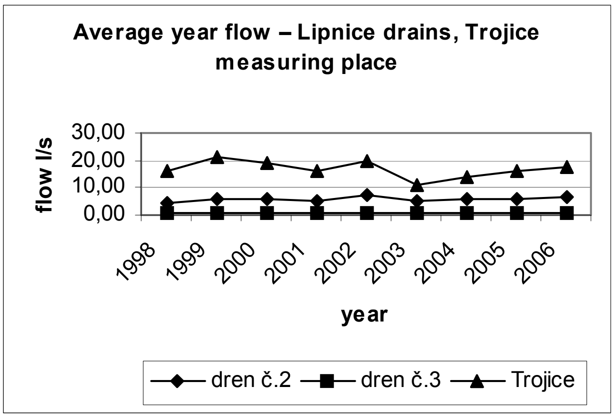

Fig. 2 Average year flow –Lipnice drains, Trojice measuring place

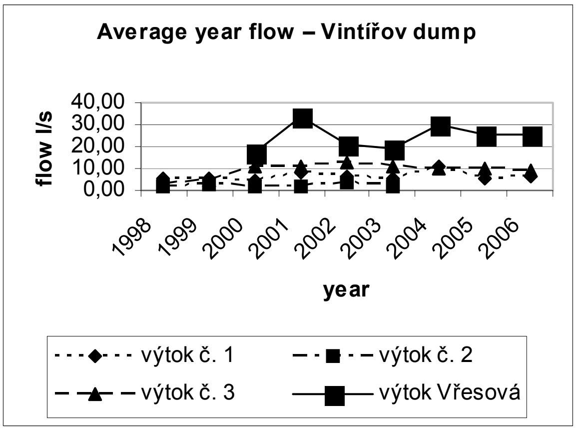

Fig. 3 Average year flow –Vintířov dump

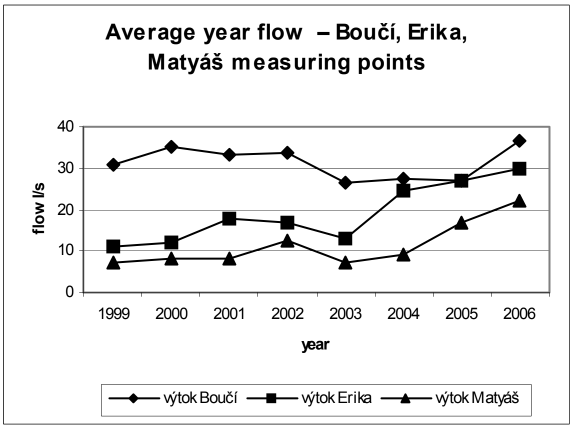

Fig. 4 Average year flow –Boučí, Erika, Matyáš measuring points

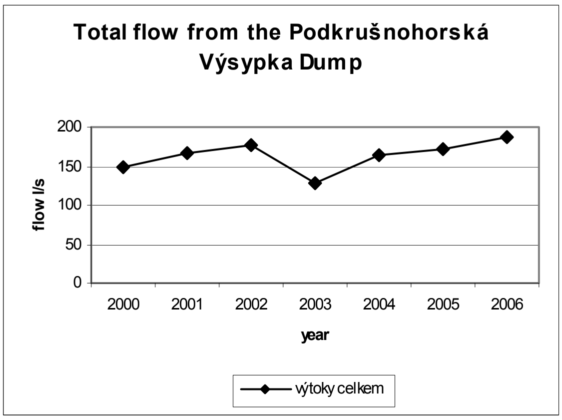

Fig. 5 Total flow from the Podkrušnohorská Výsypka Dump

2.RESULTS EVALUATION OF BP 46 AND BP 47 PENETRATION PROBES MEASUREMENT DEFINITION OF SHEAR STRENGTH PROPERTIES OF EXAMINED ROCKS IN AN EFFECTIVE AND TOTAL VALUE SET

The strength evaluation of a set of 9 penetration probes which were realised on two identical places of the dump is the object of interest. The probes were carried out on the Boučí external dump which is a part of a large Podkrušnohorská Výsypka Dump (with Vintířov, Pastviny, Týn, and Boučí called dump areas). Clays from deposited mined claystones of cypris upper strata complex of the Antonín seam were dumped at the places of BP 46 and BP 47 probes.

Both probes are located at the report 5-5´profile. Repeated examination of Boučí dump stability in this profile line was the reason why penetration measurements were repeatedly realised at the BP 46 and BP 47 probe place from 1992 to 1998. Results of the measurement were used as input data to stability calculations.

1.1 *Comparison of dump body changes 1992 - 1997*

Tens tables with hundreds shear strength values were obtained by measurement. Such data amount is hard to interpret. It is a need to process the data in "some acceptable" way and get final values of the shear strength which can characterise changes which took place in the dump body in 1992 – 1997. Tables "Total parameters of the probe for evaluating by a weighted average" were used to compare the changes. Values for dump body were obtained by the means of a weighted average where depths of single dump layers were the weight (see tables). It is an overall strength average of dump body in a given place and an observation time, except the contact dump base area which was evaluated separately.

The separation of a dump to dump body and contact area with base implies from long term experience in dump observation. A contact of a dump with a base is usually created at the bottom of a dump where some decrease of strength parameter occurs. The existence of the contact can be put in direct context with a water horizon at dump base. This horizon at the base of a dump is practically under all body of the dump, depending on the morphology of original terrain. Its yield is depending on the amount of water input to the dump body and an efficiency of drainage system. It is practically a single water horizon hydrological continuity of which can be proved by a large area observation.

A visualisation of the comparison of 1992 – 2007 measurements results was carried out by the means of the Excel graphs with regard to higher transparency.

Obtained values of strength parameters of dump rocks and determined dependencies of resistance on depth (trend lines) were plotted to the graph by the means of lines. With allowed simplification it can be stated that a declination of the trend line corresponds with an angle of inner friction and a length from the origin of coordinate system corresponds with consistency. At this interpretation, the parallelism of trend lines proves equality of inner friction angle, equal distance from horizontal (axis with a level above sea) or equal intersection point on the Penetration resistance axis prove equal consistence value. Improvement of the strength parameters of dump caused by the primary consolidation enlarges the declination of a trend line (Not typical for a dump) or the distance from the origin of coordinate system. Or by both, but improvement of the two strength parameters at once is not typical for dump rocks. Fill of a dump has a high piece rate and behaves as false gravel after its dumping i. e. high angle of inner friction and low consistency. Values of the angle of inner friction should decrease by time which should be compensate by increase of consistency i.e. the trend lines should decrease their declination and increase their distance from the origin of the coordinate system. Such a time depended run of changes in strength parameters distribution correspond theoretical presumptions on dump body behaviour. Measurements results of BP 47 (1992) and BP 471 (1998) probes correspond exactly to the presumptions and prove that dump rocks have a tendency change the distribution of strength parameters – see fig. 7.

A course of strength changes of the dump body in the place of probes from the BP 46-462 measurement set can be seen in fig. 6. It must be stated in the very beginning that measurement results from 1995 (BP430) are not in an accord with a characteristic behaviour of the dump (it is interesting that the same is with BP 440 probe in the place of BP 47 probes) and it is why the BP 430 and 440 probes were put out of the penetration measurement interpretation.

Note. - Had the BP 430 measurement been realised as first it would have suited into the frame of typical behaviour of dumped material – see so called “false gravel” short after dumping – high φ, low c, i.e. a steep trend line intersecting the “Penetration resistance” axis near the origin.

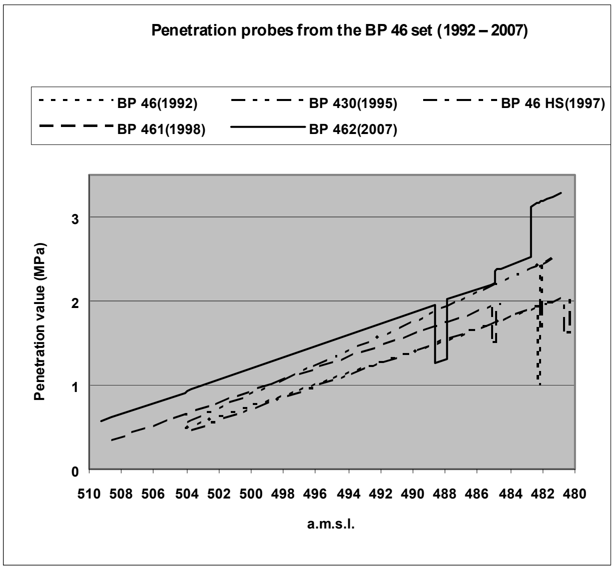

Fig. 6 Penetration probes from the BP 46 set (1992 – 2007)

It can be seen in the fig. 6 that the 1992 and 1997 measurement results (see BP 46 and BP 46 HS probes) do not differ very much, only the resistance in the contact of the dump with a base increased much (it means improvement of strength parameters). The dump body itself did not practically change. The BP 46 HS was drawn dashed as both trend lines overlaid in some interval

After increasing the height of the dump in the BP 46 probe place by 4.9 m, the strength parameters improved in primary consolidation process in 1998 see the BP 461 probe in the fig. 6. Values of inner friction angle did not change (there were no apparent reasons of their increase) but the values of consistency increased significantly – see the translation from the origin of the coordinate system. Remarkable improvement took place in the failure body itself and there were no changes in the contact area of the dump with the base, respective it increased slightly.

The 2007 measurement results (BP 462) show further improvement of strength situation that is consistency values increase in both the dump body and the base contact area. The rocks with higher strength values were even measured in the area of contact with a base than the strength of the dump body itself. The highest resistance values were even measured at the immediate area with the contact with bed see newly separated area at the at the base of the dump. This improvement was measured by BP 462 probe but it must be said that such a remarkable improvement is not typical for dump bodies – it an exception of strength situation improvement.

An exceptional layer in the depth of h = 20.6 – 21.4 m (488.7 – 487.9 m a. m. s. l.) with $\varphi=5.9^{o}$, c= 11.3 kPa parameters was marked at the BP 462 probe on fig. 6. The occurrence of the layer shows that though the overall situation improved (both dump body and base contact) places can occur in the dump body where local situation deteriorates.

The measurement results on probes from a BP 47-440-471-472 set show similar behaviour character as the BP 46-430-46HS-461-462 probe results. It can be stated that generally they are “better” than the BP 46 results. The range of occurrence of a contact with a bed does not vary in some depth interval for its area as it is with BP 46 set probes, besides the decrease of inner friction angle values compensated by the increase of a consistency values at BP 47 and 471 probes. The measurement results overlay for the area of a dump bed contact at BP 47 set probes so that this area of the dump was measured in a stabile constant depth. It must be further stated that the measurement results for the contact area dump – bed are much more standard at the BP 472 probe (2007) than it was at BP 462 probe (2007) because even if the strength situation improved at the base of a dump at the contact area with bed at the BP 472 probe this part of a dump keeps being its weakest link which corresponds with acquired long term knowledge of the dump behaviour

The 1995 measurement results (BP 440) are not in accord with a typical dump behaviour ant they are hard to interpret see so called “false gravel” short after dumping (high φ, low c) which does not correspond with a reality when at first measurement the dumped body did not show such a character of distribution of strength parameters.

The 1998 results (BP 471) or the trend line for a dump body shows a slight decrease of an inner friction angle which is compensated by an increase of consistency values which exactly corresponds with a typical process of a change in the dump strength parameters distribution. An improvement not only for a dump body but for the contact area with a bed was measured in comparison with 1992 (even if moderate), see fig. 7. The same is valid for the 2007 measurement (BP 472) when the consistency values for both the dump body and the contact area with a bed where an increase of the consistency values, or penetration resistance was measured.

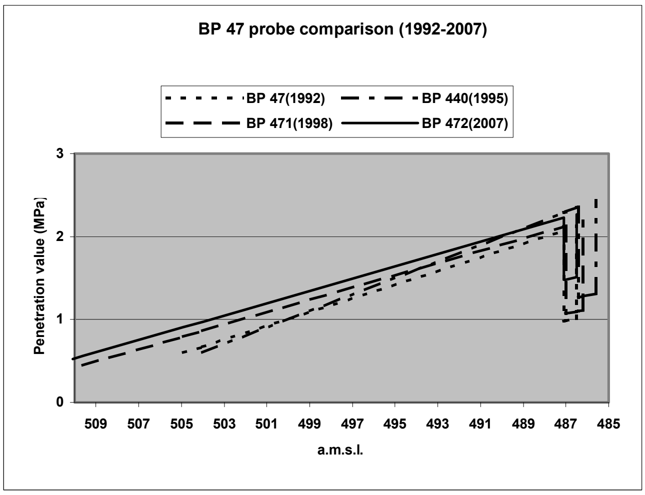

Fig. 7 BP 47 probe comparison (1992-2007)

The increase of consistency for the dump body is a little smaller at the BP 471 and BP 472 probe places than at BP 461 and BP 462 probe places. A fact that the BP 472 probe is located in a great distance from the other probes could have a negative effect and the same place was not so exact in the case of this probe.

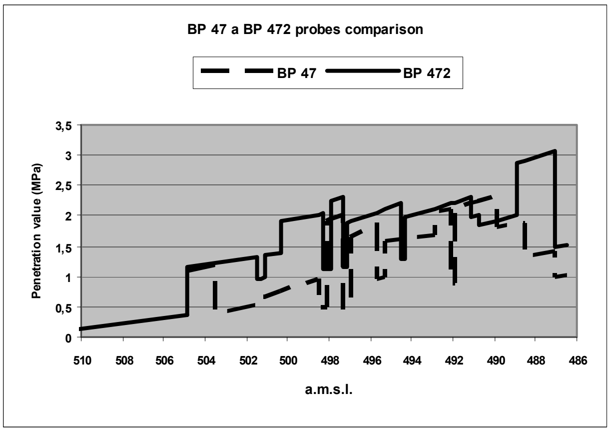

Fig. 8 BP 47 a BP 472 probes comparison

Trend lines of all geotechnical layers in which the dump was divided at BP 47 (1992) and BP 472 (2007) probes are drawn in fig. 8. It can be seen that even if strength situation improved generally (see increases of most penetration values at BP 472 probe) places occur locally in a dump body where the situation locally deteriorated in the 1992 – 2007 interval – see fig. 8 – position in depth h = 15.6 – 15.8 m (494.5 – 494.3 m a. m. s. l.) and h = 19.0 – 20.2 m (491.1 – 489.9 m a. m. s. l.). Water streaming could be disabled and it could accumulate locally after increasing the height of the dump (pores could be clamped). These positions of local value decrease (as a layer in the depth h = 20.6 – 21.4 in fig. 6) proved that even if the situation improved in average (both in a dump body and in a bed contact area) places can occur in the dump body where the situation deteriorates permanently

At the end of analysis acquired shear strength parameters from 1992 – 2007 are summarised to two tables below for an easy comparison of the measurement results.

Year Probe		Shear strength parameters		
1992 BP 46	*Dump body*	**8.1°**	**17.1 kPa**	**16.9 kN.m^{-3}**
	Contact with bed	*4.6°*	*5.8 kPa*	*16.9 kN.m^{-3}*
1995 BP 430	*Dump body*	**10.2°**	**19.1 kPa**	**17.7 kN.m^{-3}**
	Contact with bed	*6.3°*	*17.4 kPa*	*17.6 kN.m^{-3}*
1997 BP 46 HS	*Dump body*	**8.2°**	**16.4 kPa**	**17.5 kN.m^{-3}**
	Contact with bed	*6.1°*	*15.5 kPa*	*17.5 kN.m^{-3}*
1998 BP 461	*Dump body*	**8.0°**	**24.5 kPa**	**17.5 kN.m^{-3}**
	Contact with bed	*6.1°*	*19.8 kPa*	*17.5 kN.m^{-3}*
2007 BP 462	*Dump body*	**7.5°**	**35.4 kPa**	**18.6 kN.m^{-3}**
	Contact with bed	*8.4°*	*34.8 kPa*	*18.6 kN.m^{-3}*

Fig. 9 Measurement results

Year probe		Shear strength parameters		
1992	*Dump body*	**10.4°**	**20.5 kPa**	**16.9 kN.m^{-3}**
BP 47	*Contact with bed*	*5.8°*	*4.2 kPa*	*17.0 kN.m^{-3}*
1995	*Dump body*	**12.7°**	**19.5 kPa**	**16.8 kN.m^{-3}**
BP 440	*Contact with bed*	*6.5°*	*10.7 kPa*	*17.0 kN.m^{-3}*
1998	*Dump body*	**9.0°**	**28.5 kPa**	**17.3 kN.m^{-3}**
BP 471	*Contact with bed*	*4.7°*	*14.3 kPa*	*17.3 kN.m^{-3}*
2007	*Dump body*	**8.8°**	**32.5 kPa**	**17.5 kN.m^{-3}**
BP 472	*Contact with bed*	*6.3°*	*19.8 kPa*	*17.5 kN.m^{-3}*

Fig. 10 Measurement results

REFERENCE

[1]. *This article is component of research project Czech Science Foundation 105/07/1483.*

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PREVENTING THE OCCURENCE OF SPONTANEOUS COMBUSTIONS IN HARD COAL MINES BY THE HELP OF ZINC CHLORIDE SPRAYED PARTICLES

ION TOTH[*],
CONSTANTIN LUPU[**],
DORU CIOCLEA[**],
EMERIC CHIUZAN[***],
MARIUS MORAR[****],
CRISTIAN TOMESCU[****]

Abstract: *Spontaneous combustion represents a major risk during coal mining. It can trigger fires, with adverse effects both from a material point of view and with human losses. The study of coal deposits composition, of the mechanism that triggers spontaneous combustion and the mining method has led to the occurrence of this combustion. It relies on the conveyance of zinc chloride sprayed particles into goals and into fissures in the coal back. These particles diminish coal tendency to self-ignition with more then 90%, thus diminishing the possible occurrence of spontaneous combustions. The tests have passed the laboratory stage and now are process of implementation in industry at mines.*

Key words: *spontaneous combustion, prevention technology, inorganic inhibitor*

1. SPONTANEOUS COMBUSTION

Self-ignition is a complex physical and chemical process of coal oxidation. It includes three successive or simultaneous stages of development. They influence one another and are the following ones: self-heating, moisture evaporation and self-ignition.

Figure no. 1 shows the successive stages regarding the development of spontaneous combustion.

* *Ph. D. Eng. – Senior scientific researcher I – INCD INSEMEX Petroşani*
** *Ph. D. Eng. – Senior scientific researcher II – INCD INSEMEX Petroşani*
*** *Eng. – Assistant research - INCD INSEMEX Petroşani*
**** *Eng. – Senior scientific researcher – INCD INSEMEX Petroşani*

The first stage comprises an intensive heat accumulation and it is the thermal trigger of self-ignition.

The amount of heat resulted after oxidation can exceed the heat loss by convection and conductivity and, within 3/4 days, coal temperature can reach 40 - 60^0C. Consequently, this stage of self-ignition comprises a local increase of coal temperature above the temperature of surrounding rocks and diminishes gas emissions. This stage is called the ”self-heating stage”.

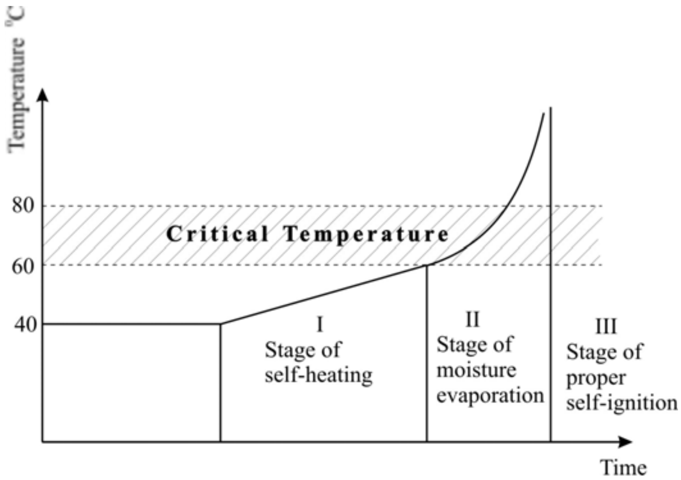


Fig. 1

The 2^{nd} stage comprises moisture evaporation and lasts longer (around 60 - 70% of the period necessary for self-ignition) and it also includes a continuous temperature increase, together with a strong moisture evaporation. The chemical process inside coal can diminish during this stage due to moisture evaporation that lowers coal oxidation or it can stay at constant level with CO and CO_2 emissions and strong perspiration on the walls of coal massif and fogging.

The occurrence of condensation and of fog may represent specific signs of this stage of self-ignition. When temperature reaches 60 - 80^0C, then oxidation shall speed up and the composition of mine air shall change at the beginning nearby the potential fire centre and as this process speeds up the composition shall change in the farthest areas. These changes involve a diminution of oxygen content, an increase of air temperature above 25^0C, hydrogen and saturated hydrocarbons above the basic content of these gases. the first two stages of self-ignition form the ”induction period”.

When moisture evaporation comes to an end, oxidation shall accelerate and temperature shall increase.

When temperature reaches 60 - 80^0C (also called critical temperature), there starts the third stage of self-ignition. It is characterized by the following specific features: a sudden increase of temperature, an intense heat accumulation, a rapid absorption of oxygen and large emissions of hydrogen, CO and CO_2. At the end of this stage, there also occur unsaturated hydrocarbons, together with an important diminution in oxygen content and relative air humidity. The process shall reach self-ignition within the interval 0.1 m^3/min and m^2 of cross-section and 0.9 m^3/min and m^2 of cross-section and when the amount of accumulated heat exceeds 70% of the heat amount emitted during oxidation. Smoke and open flame occur during this stage.

The length of this stage depends on the air addition and on its oxygen content. When the oxygen content is between 18 - 20% vol., this stage shall last a couple of days; afterwards, the burning products occur.

Worldwide, there are several theories on spontaneous combustion. There follows a presentation of the hypothesis that involves the participation of microelements as catalysts during the initiation stage.

For triggering oxidation reactions during the first stage at low temperatures, it is necessary an impulse that provides the energy necessary for the formation of the activated complex. The researches tend to assign the decisive factor to the free valence from the organic substance of coal or of some redox potential sources.

Literature comprises qualitative observations on the parts played by certain elements inside the mineral substance of coal, such as Fe, Na and K oxides that accelerate oxidation or Al, Ca and Mg oxides that show down all these processes, but without including the participation of these elements in any of the triggering mechanisms.

There has been discovered recently the special importance of the property displayed by certain complex combinations of transition metals to fix reversibly the molecular oxygen, i.e. to work as oxygen conveyors. The power of the molecular oxygen to bind as ligant in complex combinations has determined the development of the researches in activating of this molecule.

The complex combinations oxygen conveyors can be models in the study of the mechanism for reversible oxygenation of natural conveyors (for ex. in biology) and for the study of certain catalytical oxidations in different industries.

Consequently there follows some examples of complex combinations, oxygen conveyors for Co^{2+} şi Ni^{2+}:

$[\{Co(NH_3)_5\}_2(O_2)](SO_4)(HSO_4)_3$

$[\{Co(NH_3)_5\}_2(O_2)](NO_3)_5$

$[\{Co(NH_3)_4\}_2(O_2)(NH_2)](NO_3)_4$

$[\{Co(NH_3)_5\}_2(O_2)](SO_4)_2 . 4H_2O$

or: $[Ni(PPh_3)_2(O_2)]$, (PPh_3) - triphenylphosphine.

If one considers the fact that humite is the main component part of vitrite and literature says that it is a component part of coal with the highest tendency to self-ignition, then the hypothesis on the catalytical part played by certain microelements as active centers by forming complex combinations of oxygen conveyors can constitute the triggering point of coal self-ignition.

2. INHIBITING CHEMICAL SUBSTANCES

These substances are used to mitigate self-oxidizing tendency of coal. The tests relied on the ides regarding the catalytic part played by the microparticles in coal.

There have been tested 8 substances from the class of chlorides in the presence of the anion PO_4^{3-}. The coal test items have been sampled from Petrila Mine, bed no. 3, block 0, face no. 137.

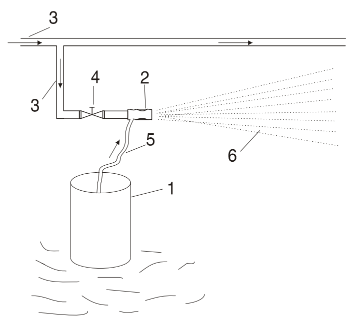
Working method: oxidation in an atmosphere of gaseous oxygen.

Table 1 shows the substances that have been tested, their concentrations in relation to the coal mass, as well the efficiency to the items subjected to testing procedures.

The highest inhibiting efficiency have been registered for the aluminum chloride, manganese chloride, magnesium chloride, cadmium chloride, with a maximum of 89.47% in case of manganese chloride, at a concentration of 1%.

No.	Type of inhibiting substance	Nature of treatment with inhibiting substance	Inhibiting efficiency η (%)
1.	Potassium chloride KCl	0,5 gr KCl 1% + 0,5 ml H_3PO_4	34,21
2.	Aluminum chloride $AlCl_3$	0,5 gr $AlCl_3$ 1% + 0,5 ml H_3PO_4	82,63
3.	Strontium chloride $SrCl_2$	0,5 gr $SrCl_2$ 1% + 0,5 ml H_3PO_4	34,21
4.	Manganese chloride $MnCl_2$	0,5 gr $MnCl_2$ 1% + 0,5 ml H_3PO_4	89,47
5.	Magnesium chloride $MgCl_2$	0,5 gr $MgCl_2$ 1% + 0,5 ml H_3PO_4	88,95
6.	Cadmium chloride $CdCl_2$	0,5 gr $CdCl_2$ 1% + 0,5 ml H_3PO_4	85,79
7.	Barium chloride $BaCl_2$	0,5 gr $BaCl_2$ 1% + 0,5 ml H_3PO_4	82,63
8.	Zinc chloride $ZnCl_2$	0,5 gr $ZnCl_2$ 1% + 0,5 ml H_3PO_4	85,05
9.	Aluminum chloride $AlCl_3$	0,25 gr $AlCl_3$ 0,5% + 0,5 ml H_3PO_4	49,47
10.	Manganese chloride $MnCl_2$	0,25 gr $MnCl_2$ 0,5% + 0,5 ml H_3PO_4	57,37
11.	Magnesium chloride $MgCl_2$	0,25 gr $MgCl_2$ 0,5% + 0,5 ml H_3PO_4	64,74
12.	Cadmium chloride $CdCl_2$	0,25 gr $CdCl_2$ 0,5% + 0,5 ml H_3PO_4	38,95
13.	Manganese chloride $MnCl_2$	1 gr $MnCl_2$ 2% + 0,5 ml H_3PO_4	43,16

Table no. 1



SPRAYING DEVICE
LEGEND:

1 - mixing tank
2 - ejector
3 - compressed air pipe
4 - valve
5 - connection hose
6 - sprayed particles

Fig. 2

3. METHOD FOR TREATMENT OF GOOFS WITH SPRAYED PARTICLES

Preventing self-oxidizing during coal undermining relies the circulation of very fine (micron – sized particles) derived from the inhibiting solution spread all through the goaf and at the working face, depending on the location of the installation and in compliance with the air flow.

Description of installation

The installation used to produce sprayed particles (fig. 2) is made of a 200 ml tank (1), an air-water spraying device (2) and the connection hoses (5) to the compressed air mains at the working place and to the tank with the inhibiting substance (1).

The special spraying device has been designed with the view to reaching a high level of selectivity for the sizes and amount of sprayed particles.

The spraying device for spraying the inhibiting substance has got the following parameters:

- the working pressure: 0,3 – 0,6 MPa;
- consumption of compressed air: 0,8 – 1,05 m^3/min;
- consumption of inhibiting solution: 0,8 – 1 l/min;
- sprayed solution ratio: 90 – 100 %.

This type of spraying devices can be successfully used for spreading of sodium bicarbonate under the form of powders towards goafs. To this end, it is necessary to change and interchangeable item. This device has already been used for dispersing luminous powders necessary for a qualitative evaluation of air leakages through goafs.

Mounting and commissioning of the installation

The inhibiting solution is put into the tank (1), then it is filled with water. The inhibiting final product shall be manual stirred in the tank.

Afterwards, a supply hose attached to the spraying is connected both to the compressed air mains and to the tank. The spraying device is placed in the cross drift or in front of goafs with high concentration of CO.

The spraying device is equipped with a regulating means; accordingly one may regulate the size of the sprayed particles in such a manner that the very fine particles should be ≈ 90 % of the inhibiting solution.

The amount of inhibiting solution in the tank ensures an autonomy of operation of around one hour.

4. CONCLUSIONS

- Spontaneous combustion (the underground fire) is a major risk during coal mining.
- Self-ignition is a complex physical and chemical process of coal oxidation that develops in three stages.

- The factors that boost the underground fires can be objective (the physical and chemical nature of coal, petrography and geology of the underground) and subjective (in relation to the mining method).
- After studying the chemical composition of coal, the initiation of self-ignition, there has been developed a method to prevent the occurrence of spontaneous combustion with inhibiting substances of zinc chloride type.
- The preventive method relies on transformation of the watery solution of zinc chloride into sprayed particles.
- The device that transforms the watery solution into sprayed particles is called ”two stage ejector”.
- The sprayed particles are conveyed by the air flows into goafs and fissures in coal massif, thus inhibiting the active centers on coal.
- The efficiency for diminishing coal tendency to self-ignition with the help of zinc chloride reaches 85%.
- The in-situ testing of the new method was at Lonea mine, in the front working with undermined coal bed no. 74, bed 3, block VII.
- The results have confirmed the high efficiency in preventing spontaneous combustion with the help of the new method.

REFERENCES

[1] Bardocz, V. - *Nouă ipoteză în ce priveşte rolul catalitic al microelementelor în procesul de autoaprindere al cărbunilor,* A 21-a Conferinţă Internaţională a Institutelor de Cercetări în domeniul securităţii miniere - Sydnei - Australia, octombrie 1985

[2] Cioclea, D., Toth, I., Gligor, C. - *Măsuri de securitate la metoda de exploatare cu surparea cărbunilor şi a rocilor înconjurătoare în vederea reducerii riscului de apariţie a combustiilor spontane,* Simpozion jubiliar - U. Petroşani, 1998

[3] Matei, I., Toth, I., Cioclea, D., Purcaru, S.,I., Vovhiţoiu, H. - *Combustiile spontane la minele de cărbuni,* Editura Print Everest, Deva - 2003

[4] Nicolaescu, E., Toth, I. - *Măsuri de securitate privind metodele de exploatare în felii cu canale de aeraj în scopul reducerii riscului de producere a focurilor endogene*, Studiu ISM - Petroşani, 1992

[5] Toth, I., Cioclea, D. - *Studiul inhibitorilor chimici pentru reducerea capacităţii de autooxidare a cărbunelui,* Studiu INSEMEX - Petroşani, 1995

[6] Toth, I., Gligor, C., Cioclea, D., Jurca, L. - *Noi cercetări în diminuarea fenomenului de autoîncălzire în Valea Jiului, utilizând inhibitori anorganici,* A 27-a Conferinţă Internaţională a Institutelor de Cercetare şi Securitate Minieră - New Delhi - India - 1996

[7] Toth, I., Cioclea, D. - *Studiul inhibitorilor chimici pentru reducerea capacităţii de autooxidare a cărbunilor*, Studiu INSEMEX - Petroşani, 1997

[8] Toth, I. - *Perfecţionarea metodelor de prevenire / combatere a combustiilor spontane / focuri endogene în vederea creşterii gradului de securitate a muncii şi a zăcământului de la minele de huilă din Valea Jiului*, Studiu INCD INSEMEX Petroşani, 2007 - 2009

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CONSTRUCTIVE AND FUNCTIONING IMPROVEMENT SOLUTION OF THE SLIDING STEEL TIMBERING FOR UNDERGROUND EXCAVATIONS STABILITY

VALERIU PLEŞEA*

Abstract. *According to the emplacement conditions, the steel timbering are subject of many loadings, asymmetric located on the underground mining excavations contour, exposing symmetric steel elements of the timbering to high force, having effects on the elastic drive sliding and functioning of entire construction. Within the paper it is analyzed and presented the stage of residual stress exercised upon timbering joints, and according to them are proposed constructive improvement solutions of the used rolled sections, with presentation of new types, more resistant and efficient from economical point of view in comparison with present SG rolled section.*

1. INTRODUCTION

For the execution of steel timbering elements (beam and two piles), in our country, respective Jiu Valley mines it is being used an imported rolled section, similar to SG.23 made in our country not long ago.

As in case of SG.18 and SG.23 rolled section made in the country, once with the taking-over of the timbering force and buckling, at the base of the section take place tangential stress concentrations, whose effect it is the forming and exercising of extremely high cross forces, generating the weakening of the material and coalescence of the rolled sections, through compression of the superior section (beam) and cleavage of the inferior one (pile). In these situations, frequently meet in Jiu Valley mining practice, the timbering elements are seized up and entire construction it's hardened, after that, once with the growth in intensity of the forces there is produced the braking of material and longitudinal fracture of the sections, practically the hole inferior rolled section.

According to rolled section geometry, the execution parameters of an underground excavation and mining stress, there can be determined the efforts produced at the base of the sections, with benefic effect on evaluation and appreciation of the residual stress and taking constructive improvement actions that are imposing for a better functionality of the timbering.

* *PhD. eng. - The Mining Research and Design Institute Petrosani*

Within the paper there are presented new types of rolled sections for the execution of elastic steel timbering, on which the contact it is made in the done hallows at shoulders level and which have superior resistant characteristics.

2. THE ANALYZE OF RESIDUAL STRESS EXERCISED UPON TIMBERING FLEXIBLE JOINTS

The geometric shape of the general rolled sections used for joints generates an initial contact between flanks, resulting spaces between flanges (shoulders).

For the analyze, there are considered SG.18 and SG.23 rolled sections used in Jiu Valley mining practice, whose geometric and supporting characteristics are similar to the present imported rolled section (table 1).

Tab.1.*Statical and supporting characteristics of the SG (18, 23) rolled sections*

Type of rolled section	Bearing coefficient, daN/kg	Parameters size			
		Linear mass, Kg/m	Resistance moment, cm^3		Bending moment, daN · m
			W_x	W_y	
SG.18	108,5	18,2	47	50,6	1974
SG.23	119,5	23,55	67	71,3	2814

In this case, according to forces moment that it's exercised upon timbering elastic joints can be determined the normal maximum effects from the base of the sectors (fig.1).

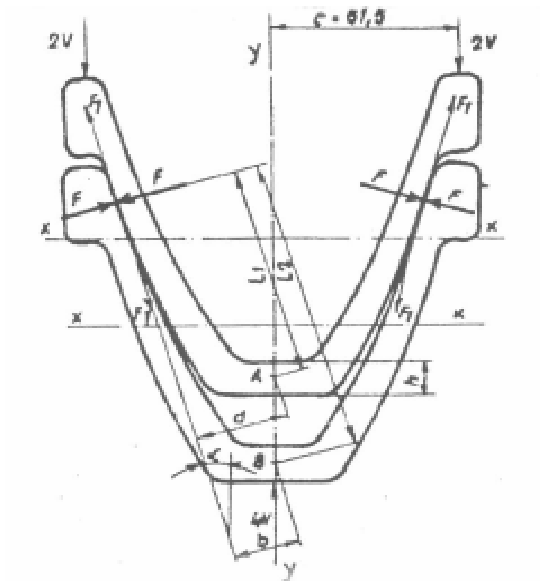

Fig.1. Joining of the usual rolled sections

From the balance condition of vertical projected forces, the efforts produced in section A and B from the base of rolled sections can be determined according to relations:

$$\sigma_A = 2\frac{V}{d \cdot h}\left|\left(\frac{l_1 + \mu \cdot a}{\sin\alpha + \mu\cos\alpha} - e\right)\frac{6}{h} + \frac{\mu\sin\alpha - \cos\alpha}{\sin\alpha + \mu\cos\alpha}\right| \qquad (1)$$

$$\sigma_B = \frac{2v}{d \cdot h}\left(\frac{l_2 + \mu \cdot b}{\sin\alpha + \mu\cos\alpha} \cdot \frac{6}{h} + \frac{\mu\sin\alpha - \cos\alpha}{\sin\alpha + \mu\cos\alpha}\right)$$

Replacing in relation 1 and 2 the values of the parameters get directly by measuring (l_1, I_2, a, b, e, α, h, d) and expressing V reaction according to the gallery radius (R), bracing bay (L) and mining pressure (P), there are getting:

- SG.18 rolled section

$$\sigma_A = 61{,}3\frac{P \cdot L \cdot R}{d}; \quad \sigma_B = 154{,}3\frac{P \cdot L \cdot R}{d} \qquad (2)$$

- SG.23 rolled section

$$\sigma_A = 35{,}3\frac{P \cdot L \cdot R}{d}; \quad \sigma_B = 101{,}6\frac{P \cdot L \cdot R}{d} \qquad (3)$$

For exemplification there is considered the execution of a gallery at GDM 12 (R=2,15m) rolled section, in conditions of a mining pressure equal in size to timbering frames bearing, respective P=120 kN/ m^2 in case of SG.18 and SG.23 rolled sections.

Replacing the data and making the calculus, for friction coefficient between sections μ=0,4, the distance between timbering L=0,5m and admitting three superposition distances of the joints (d=0,4m, d=0,45m, d=0,5m) there are getting the values of the lateral stress form table 2.

Tab.2.The values of lateral stress form the base of rolled section x10^3 kN/ m^2

Distance Rolled / section type	***d*=0,4m**		***d*=0,45m**		***d*=0,5m**	
	σ_A	σ_B	σ_A	σ_B	σ_A	σ_B
SG.18	1977	4976	1757	4423	1582	3981
SG.23	1139	3277	1012	2913	911	2621

It is estimating that once with the rolled section growth of the weight on linear meter, the stresses are reducing ca. 42% in case of SG.23 rolled section – σ_A case, respective ca. 34% - σ_B case in comparison with SG.18, for all 3 joints considered sizes.

Also, there is estimated that along the superposing of the elements on higher distances, in case of both rolled sections, the base stresses are reducing with (10 – 26)%, what proves the positive influence of the superior contact between the flanges.

In comparison with execution material resistance, it turn out that, in case of both sections type, the registered efforts from their base overtake the minimum allowable value, which size it's:

$$\sigma_a = (0{,}7 - 0{,}8) \cdot R_m \qquad (4)$$

where:

R_m = 6200 daN/cm^2, represents OPM steel braking strain used for rolled sections.

3. NEW ROLLED SECTIONS FOR MINE REINFORCEMENTS CONSTRUCTION

On the basis of the present resulted deficiencies at galleries steel timbering joints, ICPM – SA Petrosani has designed, as a response to present and future conditions, two new types of rolled sections, named SG.94/28 and SG.94/34.

In comparison with the geometry of the sections in use, new shape of section consist of bottom narrowing and thickening, on the basis of growth and height of the contact in the shoulders hollows (fig.2 and 3)

At resistance checking in the main areas of the new sections, admitting the way of distribution of the forces (fig.4) and replacing in relation 5 the characteristic geometric parameters size, for efforts calculation there are getting the relation 6 and 7.

$$\sigma_A = \sigma_B = \frac{6V \cdot e}{d \cdot h^2} \qquad (5)$$

- SG. 94/28 rolled section

$$\sigma_A = \sigma_B = 9{,}2\frac{V}{d} \qquad (6)$$

- SG. 94/34 rolled section

$$\sigma_A = \sigma_B = 8{,}9\frac{V}{d} \qquad (7)$$

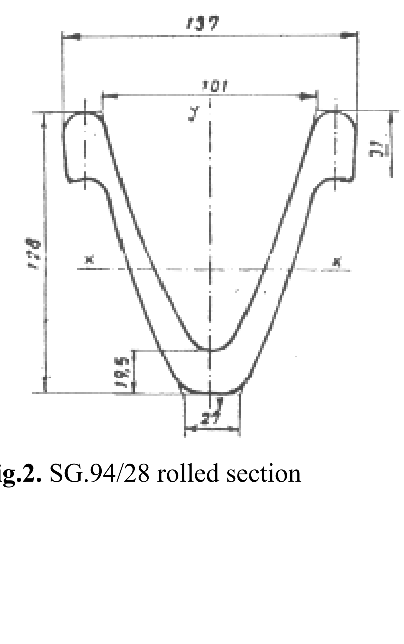

Fig.2. SG.94/28 rolled section

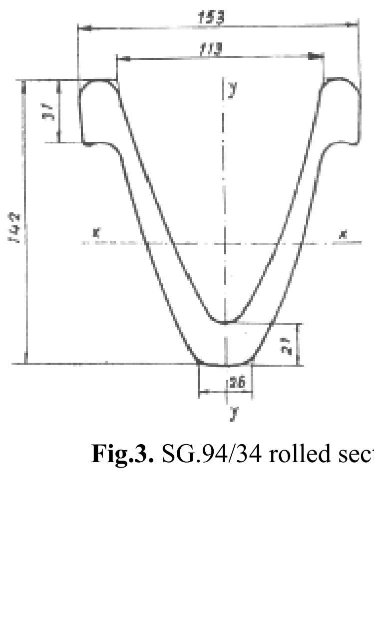

Fig.3. SG.94/34 rolled section

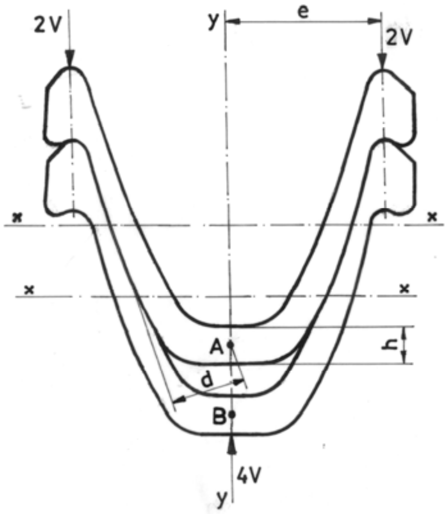

Fig.4. New rolled section joints

In the relations 6 and 7, expressing the *V* reaction in accordance with the same conditions of gallery execution (*R*=215 cm, *L*=50cm), and considering the size of mining pressure equal to timbering frames bearer, respective *P*=160kN/m^2, there are getting the values from table 3.

Tab.3. *Normal stress fat the base of* σ_A, σ_B *x* $10^3 kN/m^2$

Rolled sections superposition distance, m	SG.94/28	SG.94/34
0,40	397	303
0,45	352	340
0,50	317	306

Towards the present results it turns out that efforts reduction up to 64% in case of SG.94/28 rolled section and up to 72% in case of SG.94/34rolled section in comparison to the rolled sections in use.

There can be estimated as well the fitting of new rolled sections in the optimum resistance field, pointing out for both types, the situation of efforts size below maximum allowable resistance limit of the execution material (σ_A=4340daN/cm^2), even when, for SG.94/28 processing, the metal consumption per linear meter it's the same as for SG.23.

CONCLUSIONS

1. The form and construction of present in use rolled sections for steel timbering execution generates at joints the effect of de-calibration, resulting piles cleavage and beam compression. Under the circumstances, in the main areas takes place longitudinal material braking and rolled section fissuring.

2. For deficiencies elimination in case of present sections joints, there is proposed for assimilation other two new types of sections, SG.94/28 and SG.94/34, which construction consist of bottom narrowing and thickening, on the basis of growth and height of the contact in the shoulders hollows. In comparison with sections in use, the proposed types are characterized by a superior resistance, giving optimum functioning conditions of timbering system.

3. Beside higher resistance, new types of sections beneficiate by a series of economical advantages, pointed out through metal consumption, work force and expanses economy.

BIBLIOGRAPHY

[1]. Pleşea, V. – *Proiectarea si construcţia susţinerii lucrărilor miniere din sectorul carbonifer.* Ed. Universitas Petrosani, 2004, ISBN 973-8260-68-X.

[2]. Pleşea, V., ş.a. – *Eficientizarea susţinerii lucrărilor orizontale la minele din Valea Jiului*. Ed. Polidava Deva, 2001, ISBN 973-99458-7-2.

[3]. Pleşea, V. – *Cercetări privind îmbunătăţirea parametrilor susţinerilor metalice pentru lucrările miniere orizontale din Valea Jiului.* Teză de doctorat, Petroşani, 1998.

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OBSERVATIONS AND CONSIDERATIONS ON THE HYDROSTATIC LEVEL OF GROUNDWATER IN THE STERILE DUMPS OF THE ROŞIUTA OPEN PIT -E. M. C. MOTRU

I.ROTUNJANU*
M.LAZĂR*

***Abstract**: The paper work presents the results of research carried out on groundwater infiltrated in the sterile dumps of the Rosiuta lignite quarry part of Motru mining basin. They reveal the dependence of the groundwaters on the structure and nature of the dumped rock, rainfall and water infiltration possibilities in the dump. Tracking of the hydrostatic level in dumps is necessary for an efficient dumping process and in order to avoid dump deformations.*

1. Introduction

The opening and commissioning of Rosiuta quarry, in the Motru mining basin, necessitated positioning and construction of external dumps for the storage of sterile rocks. Because the quarry area is hilly, the dumps had to be positioned in valleys adjacent to the perimeter, Rogoazelor, Stiucani and Bujorascu Mic valleys being chosen for this purpose, all of them situated in the northern part of the quarry.

From the lithological point of view the rocks in the top layer of the quarry are mostly clays, dusty and sandy clays, where the weight is approx. 80% argillaceous material and 20% dusty and sandy material.

According to technological flows and the stratigraphic intervals excavated, the three dumps contain the same rock types, with some minor lithological differences.

Over time the three sterile dumps have been affected by numerous instability phenomena, caused mostly by geotechnical terrain conditions, the nature and characteristics of the bedrock, the dumping technology, the partial execution of hydotechnical and water-drainage works, executed on the hill slopes and valleys, and last but not least by the presence of water in the structure of the dumped material.

Field research has pointed out that the main sources of water in the sterile dump bodies are precipitation and infiltrations from and within the slopes.

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* *Prof. Ph.D. Eng. –University of Petrosani*

2. Water hydrogeological regime inside the sterile rock dumps

Water infiltration was and is favored by particle size structure, looseness and weak consolidation of the dumped rocks, the existence of water stagnation zones and the fact that even drainage slopes are not assured.

Aquiferic proprieties for the dumped rocks are appreciated through infiltration coefficient and filtering coefficient, also named coefficient of permeability Darcy.

The infiltration coefficient refers to the downward circulation of water following surface infiltration. Water infiltrations is realized through spaces between mineral particles of the dumped rock to the extent that it meets the water detention capacity by unsaturated rocks, until it meets the hydrostatic level, after which the infiltrated water contributes to rising the hydrostatic level.

Infiltration is influenced by gravity, rock porosity, temperature, viscosity and dissolved salts content, its value being dependent on the existence or lack of a hydraulic link with other possible aquifers areas that can influence its character.

Due to water infiltration, as a result of precipitation or underground aquifer currents caused by infiltration from slopes, every external sterile dump of the Roşiuta quarry manifests the presence of groundwater that saturates the rocks sometimes at depths of approx. 1- 8 m or even less. Increased fluctuations of the hydrostatic level are common depending on the input of water or the possibilities of draining it.

The filtering coefficient, which defines movement of groundwater under the action of a unitary hydraulic gradient, through a porous medium saturated with water, depends on both the characteristics of the mineral skeleton of the rock as well as the characteristics of the water circulating through its pores.

The main factors influencing the filtering coefficient are: porosity and the geometrical characteristics of pores, the mineral nature of the soil (rock), the specific weight of water; magnitude of the hydraulic gradient, dynamic viscosity of water and eventually rock stratification.

For rock permeability characterization, the filtering coefficient is determined with the help of mathematical relations or by field and laboratory research.

Determination of the filtering coefficient has been done, in the laboratory with the help of the variable gradient permeability meter, given the nature of the dumped rock. The obtained values were between $2.4 \cdot 10^{-5}$ and $1.045 \cdot 10^{-2}$ cm/s for rocks in the Rogoazelor Valley dump and $4.18 \cdot 10^{-6}$ and $3.25 \cdot 10^{-4}$ cm/s for the ones in the Ştiucani dump [1]

Because the presence of groundwater in dumps is influenced by the storage/disposal capacity by the dumped rock, these characteristics have also been studied and the laboratory analyses results are presented in table 1.

For sandy rocks the storage capacity coefficient is about 53÷69 %, and for the argillaceous ones 55÷78 %.

The share of disposed water for sandy rock is about 24÷32% and for argillaceous rocks about 17÷20% of the total volume of stored water. There are some uncertainties on the mentioned values for laboratory determinations due to the compacting degree of the rock in the dump.

Table 1 Hydro characteristic of dumped rocks

Type of dumped rock	Sterile dump	Total porosity n [%]	Pore index ε	Natural humidity W [%]	Water quantity absorbed k_w [%]	Water quantity released k_c [%]
Dusty Clay	Rogoazelor	43,14÷45,70	0,75÷0,84	26,4÷27,7	62,65÷76,70	17,6÷18,75
Argillaceous dust	Rogoazelor	42÷44,65	0,68÷0,80	25,8÷27,64	70,2÷78,30	18,60÷21,35
Dusty clay	Ştiucani	44,8÷47,38	0,72÷0,89	28,5÷32,8	55,5÷63,20	17,80÷20,05
Sandy clay	Ştiucani	48,20÷50,23	0,8÷0,94	32,3÷38,9	54,34÷57,20	22,4÷26,00
Argillaceous Sand	Ştiucani	44,80÷53,25	0,81÷0,96	30,16÷41,28	53,90÷69,32	24,28÷32,30

The obtained values confirm that the mixture of rocks from the external dumps of Roşiuța quarry, dispose of water in a reduced quantity. Therefore it is considered that gravitational drainage for the stored water through drillings will be inefficient, due to the long time it takes for depletion, small area of influence and extremely reduced flow capacity. Reduced flow capacity has been confirmed through experimental pumping done after the execution of drill holes (0.7÷1.4 m^3/day and drilling).

3. The evolution of the hydrostatic level (NH) in dumps based on field observations

For the purpose of tracking the hydrostatic level of groundwater in the external dumps of Roşiuța quarry, between 2002 and 2007 there has been several tubed and filtered hydro observation drill holes executed, namely: 16 drillings in Rogoazelor Valley, 10 drillings in Ştiucani and 14 drillings in Bujorăscu Mic rock dump. With time, some of these have been destroyed due to landslides or have been covered by further dumping by not extending their filtering columns

Table no 2 presents the hydrostatic level values determined in some drill holes in the three dumps

Analyzing the data from the measurements, the next aspects detach:

➢ The groundwater level is variable in the three dumps, highest in Ştiucani dump and lowest in Bujorăscu Mic dump, presuming that the rocks in Ştiucani have a more argillaceous character and a higher water detention capacity.

This assessment relates to the geotechnical research results on dumped rock.

➢ The same dump manifests variations of the hydrostatic level not only for drill holes situated on different levels but also for the ones on the same level, which points out different permeability and water detention capacities. They are dependent on the scratchy character of the dumped rocks, scratchy character that manifests itself vertically and on the surface of the dump tiers. They are also dependent on the quantity of water accumulated in the depositing period.

The rocks scratchy character has been pointed out during the execution of geotechnical and hydro observation drill holes.

The hydrostatic level changes based on rainfall occurrence. During the periods with precipitation (November 2007 and early March 2008) there is an increase in the hydrostatic level up to approx 5 m – drill hole HO.9 and HO.10- Rogoazelor Valley dump and even to 10 m- drill hole HO.3- Bujorăscu Mic dump, according to local conditions, which has an unfavorable influence on stability by increasing water pressure in the pores, worsening the resistance characteristics of rocks, modifications in the consistency status and reduction of the carrying capacity of rocks.

➢ The presence of water in some drill holes at terrain height level or near it - drill holes: HO.4; HO.6 and HO.7 of Ştiucani, HO.12- Bujorăscu Mic and even above terrain drill holes HO.1, HO.3 Ştiucani and HO.14; HO.15 of Rogoazelor Valley, indicates the presence of some areas with ascension waters, a result of local hydrological and morphological conditions, and under no circumstances because of the existence of aquifer currents in the dumps.

A particular case is presented by the HO.5 and HO.7 drill holes of Bujorăscu Mic dump, in which a raise of piezometric level during April 03÷10 2008 occurred under the influence of overburdens created by dumping rocks over the 340-355 m tier.

The increase in external pressure leads to an additional pressure on water in pores, which on one hand conditions water circulation phenomena in rocks, and on the other hand actually influences efforts which act on the structure of the rocks, therefore on their deformations.

The manifestation of this phenomenon induces the hypothesis that also in other upward level drill holes cases it's possible that lithological burdens could be the cause of the rise in water level.

➢ The existence of swampy areas on the Ştiucani and Rogoazelor Valley dumps is tied to the existence of the unleveled zones which accumulate water during rainfall, by the presence of a high piezometric level and the low permeability of rocks which do not allow drainage/movement of groundwater.

➢ The low permeability of rocks and lack of underground currents is reflected by the level differences of groundwater between neighboring drill holes. The drill holes HO.14, HO.15 and HO.9 of Rogoazelor Valley dump, which registered shares in N.H. of approx. 21-22 m for distances of 350÷400 m (I=0.055÷0.06) drill holes HO.7 and HO.5, respective HO.13 and HO.5, from Bujorăscu Mic dump, with differences in N.H. of 24 and 25 m for distances of 165 m and 150 m and hydraulic gradients I=0.145÷0.166 or the drilling holes from Ştiucani HO.4 or HO.3 and drill hole HO.6 where there are differences in levels of 12÷12, 5 m for intervals of 365 and 225 m, with hydraulic gradients of 0.03 and 0.053, without the water to appear on the terrain surface in the form of exfiltrations.

➢ All findings outlined lead to the conclusion that one cannot speak of a certain groundwater regime in the sterile dump, and for a better appreciation of the hydrogeological regime in the dump body a continuation of the research is required through new hydro observation drillings which should be positioned according to a certain geometry, based on the results and conclusions obtained from them.

➢ The necessity of hydro-observation drillings is assessed also by knowledge of the hydrostatic level evolution in the dump, for dumping works orientation in areas with reduced level, because simultaneous with the reduction of the hydrostatic level water pressure in pores is also reduced, and the external pressure exerted by the dumped material is taken by the mineral skeleton through the contact surfaces of mineral particles or rock fragments. This way the microstructure of the system changes over time, water in pores will gradually dissipate, and link-forces between the granules will be sufficient to balance the shearing components due to external charge, which is the same as rock consolidation.

4. CONCLUSIONS

Based on observations on hydro observation drillings and researches made, the following are to be mentioned:

- The presence of groundwater is signaled in every sterile dump of the Roşiuța quarry, the hydrostatic levels in Ştiucani being higher.
- The water repartition is uneven, areas with higher and lowers hydrostatic level having been observed. The existence of these areas is tied to the structure and nature of the dumped material and the dumping conditions (precipitations, water accumulations in unleveled areas).
- Variation in the hydrostatic level is dependent on precipitation, observing drops in light precipitation periods and rises in heavy precipitation periods, which is normal and undoubtedly.
- The rise in hydrostatic level is due to overburdening caused by deposits. Under their influence water pressure in pores increases and rock compression also increases, which leads to a rise in hydrostatic level and water migration to an area more favorable for filtration.
- Knowledge of the hydrostatic level in dumps is absolutely necessary for mastering of phenomena and orientation of the dumping. This way, hydro observation drills are necessary on the dump tires that should be elongated simultaneous with their rise. Referring to the positioning of the drillings, it is considered that a 200m x 100 m network is adequate given the current knowledge of the groundwater regime.
- Combating water infiltration in dumps is possible only through leveling and rock compacting works and through a proper management of surface waters (collecting and regulating drains). Leveling and compacting the rocks will reduce water infiltration in the dump and most of all the presence of free water, which leads to forming of hydrogeological structures in the area and the manifestation of water pressure in pores.
- For proper appreciation of the hydrogeological regime in the dump bodies, research continuity is required through new hydro observation drillings and eventually 1-2 drainage drillings which should be carefully monitored through several seasons with the aim of providing flow and drain effects data.

BIBLIOGRAPHY

[1]. Lazăr, M., Rotunjanu I. ş.a. - *Sistem complex de urmărire a nivelului hidrostatic în corpul haldelor de steril* – SNLO Tg. Jiu 2008.

[2]. Rotunjanu I - *Asecarea şi stabilitatea lucrărilor miniere în cariere*, Litografia IMP, anul 1984.

Table 2 Situation of piezometric level in hydro-observation drillings

Location (Dump)		**Rogoazelor**			**Bujorăscu Mic**				**Ştiucani**			
Drilling number		HO.9	HO.13	HO.15*	HO.3	HO.5	HO.7	HO.13	HO.3*	HO.4	HO.6	HO.7
Drill hole depth (m)		69,5		56,0	45,0	68,0	67,0	61,0	60,50	58,80	58,00	64,00
Drill hole level (terrain)		311,28	348,85	3312,26	297,00	320,00	337,00	335,3	321,0	322,00	310,00	319,00
Aerial column length (m)		1,0	1,0	0,80	0,70	0,80	0,70	1,30	0,80	1,20	0,90	0,90
Hydrostatic level	28.06.2007	7,60/304,68	20,20/329,65	0,40/331,66	18,50/279,20	-	-	-	0,0/321,80	2,00/321,20	2,16/308,75	3,00/316,90
	23.07.2007	7,90/304,38	20,60/329,25	0,45/331,71	17,80/279,90	11,75/309,05	5,60/332,10	1,95/334,65	0,0/321,80	1,85/321,35	2,30/308,60	3,70/316,20
	22.08.2007	7,70/304,58	20,50/329,35	0,30/331,56	17,65/280,05	11,60/309,20	5,50/332,20	1,85/334,75	0,0/321,80	1,60/321,60	2,20/308,70	3,50/316,40
	07.11.2007	2,90/309,38	-	-	7,40/290,30	11,61/309,19	5,70/332,0	-	-	-	-	-
	03.03.2008	2,50/309,78	15,20/334,65	0,65/331,91	12,10/285,60	12,34/308,46	-	14,08/321,92	0,16/321,64	1,20/322,00**	1,15/309,75	0,90/318,97
	03.04.2008	2,69/309,59	16,05/333,80	0,68/331,38	12,25/285,45	9,10/311,70	2,07/335,63	-	0,14/321,66	1,20/322,00**	1,41/309,49	1,20/318,70

* drill holes with water level above terrain elevation;
** water level at terrain elevation.

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THE SAFETY OF VALEA SĂLIŞTEI TAILING DAM

SIMONA TODERAŞ*

Abstract: *The Valea Săliştei tailing dam was built within the scope of providing the mechanical cleaning of pulp waste water issuing from the Gura Roşiei processing plant, having as goal the replacement of the old tailing dams, which presently are in preservation state. This tailing dam is a hollow type dam, initially designed to be developed through the hydro-cycloning technology. Due to several inconveniences encountered in the hydro-transportation system, the lack of hydro-cyclones and other practical drawbacks, the dam could not operate using the envisaged technology and, consequently, the standard exploitation was applied, based on upward progression and downward compartment filling, the last one being scheduled for the roughage sterile fraction, issued as a by-product of the hydro-cyclones' operation. The intensive use of this compartment, related both to the waterproof character of the dam's sink and tp inadequate development of sewage drains, lead to increased hydrostatic levels within the deposit, outcroping in the upward ramp, above the tailing dam's initiation dam. The stability calculus outlines that the Valea Săliştei tailing dam from Roşia Montană is having a low value geo-mechanical stability degree. It appears a certain hazard level that, if several dynamic elements are induced, the dam's body to diminish his shearing strength and, finally to totally loss his stability, leading to a both human and ecological disaster.*

Key words: tailing dam, stability, safety, ecological disaster,

1. THE VALEA SĂLIŞTEI TAILING DAM'S CHARACTERISTICS

The Valea Săliştei tailing dam (see figure 1), developed in order to provide the mechanical cleaning of the pulp waste water issuing from the Gura Roşiei processing plant, having as goal the replacement of the old tailing dams no. 1, 2 and 3, which presently are in preservation state, is a hollow type dam, initially designed to be developed through the hydro-cycloning technology, being located on the valley having the same name – Valea Săliştei.

* *Eng .Ec. at RMGC Rosia Montana ONG ProRosia,*

Due to several inconveniences encountered in the hydro-transportation system, the lack of hydro-cyclones and other practical drawbacks, the dam could not operate using the envisaged technology and, consequently, the standard exploitation was applied, based on upward progression and downward compartment filling, the last one being scheduled for the roughage sterile fraction, issued as a by-product of the hydro-cyclones' operation. The intensive use of this compartment, related both to the waterproof character of the dam's sink and to improper development of sewage drains, lead to increased hydrostatic levels within the deposit, the outcrop reaching in the upward ramp, above the tailing dam's initiation dam.

Figure 1- General view on Valea Săliştei tailing dam.

In order to control the weeping effect, the dam's downward ramp slope was decreased, the pulp water overflow time lapse was diminished and a rock mass ballast, having filtering purpose, was disposed at the dam's bottom, aiming to block the hydro - dynamic entrainment generated by exfiltrations.

After only a few tears of operation, the two compartments have jointed, resulting a slope angle of 16°, providing a higher stability level for the whole dam. The physical and chemical characteristics of the hydraulic mass and chemical and physical properties of the gangue filling material disposed in the dam's body are given in table 1.

Table 1- Physical and chemical characteristics of the hydraulic mass filling material composition

Characteristic		*U.M.*	*Value*
0	1	2	3
Physical and chemical characteristics of the hydraulic mass disposed in the tailing dam	Solid-liquid ratio	-	1 : 5.5
	Specific density	t/m^3	1.12
	pH	-	6 – 7.5
	Iron	mg/l	0.02
	Calcium	mg/l	0.01
	Sodium	mg/l	0.01
Physical and chemical composition of the gangue filling material disposed in the tailing dam	Sulphur	%	0.27
	Sulphur dioxide	%	72.35
	Aluminium tri-oxide	%	11.97
	Iron	%	0.97
	Iron oxide	%	0.09
	Magnesium oxide	%	0.25

Physical and chemical composition of the gangue filling material disposed in the tailing dam	Calcium oxide	%	0.94
	Manganese	%	0.10
	Arsenic	%	0.09
	Sodium oxide	%	0.45
	Potassium oxide	%	9.80
	P_2O_5	%	0.01
	Vanadium	%	0.0012
	Titanium dioxide	%	0.45
	PC	%	2.0
	Gold	%	0.5 – 0.6
	Silver	%	6.3 – 8.8

The Roşia Montana tailing dams no. 1, 2 and 3 are presently, as mentioned before, in preservation and practically they are connected each to another. These three dams are flank dams combined with plain ones; the ramp slopes varies between 1:1,4 and 1:2. The granulometrical structure of the disposed material consists in: 79 % sands, from which 32 % rough sand, 14 % dust and 7 % clay. When material is disposed in the tailing dams, it occurs a separation between the several centimeters thick sand layers and the several millimeters thick dust and clay layers, which actually are heavily permeable layers; in a general manner, as studies have proven, water is maintained on the side face. The dam's general stability is adequate, no landslides being registered until the present day. The coverage degree with natural vegetation on the slopes and ramps of no. 1 tailing dam is of about 30 %. On the adjacent dams, namely dams no. 2 and 3, the spontaneous installed vegetation appears rather seldom, so the site has a pronounced moon - like perspective, mainly duet o the erosion generated by rainfall streams.

2. STABILITY ANALYSIS FOR THE VALEA SĂLIŞTEI TAILING DAM

The last reliability and stability assessment of the Valea Săliştei tailing dam from Roşia Montană, was done in April 2002, following the document entitled *Methodology concerning the operational safety state assessment of dams and ramparts which are developing industrial waste deposits.* The assessment was directed to characterize and check by engineering methods the tailing dam's and operational conditions.

2.1. Characterization of the technical and safety conditions of the dam

The Valea Săliştei tailing dam, property of RoşiaMin S.A. Roşia Montană Branch, according to STAS 4273-83 is framed in 2-nd class as importance and B importance category, as being of major importance, according to NTLH-021. The tailing dam is ranked, in accordance with the methodology regarding the determination of significance category for industrial waste deposits, as having assigned a risk index RD = 0.73.

At the time when the Valea Săliştei dam and his dam were conceived and designed, the legal design statutory requirements were significantly different from those applied presently. So, if before the tailing dams were conceived with deflector dams or waterproof dams, the subsequent regulations have stipulated the need of developing these works by employing permeable mineral aggregates, able, by their specific drainage capacity, to reduce the depression curve and, in this manner, to provide stability of the deposit during its operation lifetime.

Despite the fact that the project envisaged the hydro – cycloning technology in order to dispose the rough fraction waste downward, the development was done with the height upwards, on both dams,, finally resulting a staggered slope of about 2,5 m with wastes taken over from the foreshore, this material fullfiling, at least in the upper talus side, the conditions required for development (see figure 2).

Figure 2- Valea Săliştei tailing dam –elevation talus, upper benches.

At the lower section (see figure 3), the talus includes more heterogeneous material, having a higher fine material content, issued through the lack of enough decantation length, in the time period when the dam was operated between the two dams. The waste decantation in the dam takes place by gravity, the bigger particles settling the first time near the dam, and the fine fraction settles along the dam towards the outlet system. The solid waste disposal level is 653.4 mdM on the final's bench elevation dam and 651.6 mdM on the foreshore.

The resulting limpid water from wastewater settlement, as well as the average flows of Sălişte rivulet upstream from the tailing dam, are taken over by the evacuation system with reversed well and directed beneath the dam, until they reach the outlet flank spillway. For high level discharge of the hydrographic basin related to the dam, the water level, within the hydraulic, screen increases, exceeding the discharge capacity of the evacuation system with reverse wells, the overspill being undertaken by the outlet flank spillway.

Figure 3- Valea Sălişte tailing dam –lower benches, with leveling and ballasting operations.

The nominal discharge of this one is of 29 m^3/s, and the discharge downward the dam is provided by the intermediate of a hydro-technical gallery to whom the drain is connected. Basically, the tailing dam's stability and reliability is provided by the geo-mechanical characteristics of the rough fraction cover, existing outside the dam, the so-called elevation talus. These characteristics are much more advantageous to stability, if the solid waste material's diameter is higher and the water level in the slope is lower, for a given optimum slope angle.

The major problems confronting Valea Sălişte tailing dam, are having as basic generating cause the solid waste deposition between the two dams, cause which already have induced a series of negative effects, such as:

- the development of a less waterproof talus, while the solid waste did not settled correctly in the talus area, both the rough and the fine fractions being deposed;
- the plugging of the initial drainage system existing between the two dams, system dimensioned to be covered only by rough material, issued from the pulp wastewater hydro-cycloning process;
- the occurrence of the entrainment of a certain quantity of fine fraction of solid waste material, from that disposed in the talus proximity, leading to the need of bench reconstruction with ballast.

The stability studies, carried out on regular basis, have emphasized a progressive decrease with time for the stability safety coefficient, according to a corresdaming decrease in piezometric level in the talus.

This trend is fastened in the last time period. If, in 1997, the safety coefficient value was 1.55, in May 2002, the value was only 1.112.

2.2. Hydro-geo-technical study

The hydro-geotechnical stability study of the tailing dam represents a tool having as goal to check-up the safety state, from the stability point of view, imposed through technical specific statutory requirements and standards for this kind of hydro-technical developments.

In order to achieve a detailed analysis of the technical state in which the tailing dam was during the research period, the following activities were carried out:

- surface, visual observations aimed to ascertain the general shape and state of the tailing dam, the elevation talus slope, the exfiltration area, the dam's offshore and the adjacent lands general state, together with the identification of possible physical and geological phenomena having damaging potential with respect to the dam's stability;
- hydro-geotechnical drillings, having as goal the installation of piezometry tubes and agitated and non-agitated samples collection, required for laboratory test analysis of constitutive material characteristics;
- research drills at the talus bottom, in areas assessed previously, by geo-electrical studies, as having serious hazard potential related to structural heterogeneity;
- laboratory tests performed on the samples collected from drill-holes;
- stability computations.

The physical and mechanical characteristics of sterile material samples available were determined in the geo-technical laboratory and have consisted in assessing the following parameters: specific weight, porosity, pores index, moisture content, internal friction angle, cohesion, compressibility modulus, specific settlement rate and permeability.

These waste material properties were than employed in order to assess the safety coefficient of the tailing dam, at the given moment admitting the hypothesis that a ballast drainage prism would be built at the tailing dam's lower section. The current activity of safety evaluation consisted in continuous monitoring of water level in piezometers.

The natural ground on which the tailing dam is located is represented by the Salişte Valley sides. The right side of the valley, with slopes of 15° - 20°, covered mainly with grass lands, poorly wooded, is stable. In the openings developed within the road talus there can be observed the deposits within the ground, consisting in sandstone schist, having a direction parallel to the valley's direction and slopes concordant with the versant, deposits covered with dusty clays. Before this dam's construction, on the right side there were several flank rivulets, some of them with permanent flow, which nowadays are covered by the tailing dam's deposits; it is anyway possible that they are feeding now the talus of the dam. The underground water analyses have emphasized an identical water composition to the water from the dam's backside proving that the water from the dam's hydraulic screen is feeding the ground water in the versant, leaking on schistuosity joints. The left side is more strongly inclined, 25^o – 35^o, with frequent outcrops of the rocky base, having a reverse incline with respect to the versant slope, fact that induces a better stability; most of it is strongly wooded. The dam's talus is supported on a leg dam, built-up from local materials, such as dusty clays and base rock fragments, having a poorly permeable character. Above this material, due to exfiltrations occurred when the dam elevation increased, a limestone cover was disposed, covering the dam's top beam and the first elevation benches. Over the deflector dam, the dam has been elevated through successive benches, built with settled material. After level 634 m was reached, by exceeding the main dam's highest level, the dam surface have increased, achieving a normal decantation and developing an alluviums sandy foreshore, having widths of about 200 – 300 m, simultaneously with a hydraulic screen retreat towards the dam's backside.

The elevation benches are placed above fine material existing in the dam's foreshore. The waterproof character of the leg dam, and the high permeability degree of deposits on which the elevation dams are built, have lead with time to exfiltrations occurrence. At the beginning, these exfiltrations occurred above the deflector dam, afterwards the raised on the slope, being associated with solid material entrainment from the inner side, giving birth to cavities in the talus, reaching 2 m width and depth. In order of their appearance, the cavities were filled with easily perishable materials, which in time were fixed with clays, contributing themselves to a further reduction of talus permeability. Once the talus level exceeded the 617.7 m bench level, the exfiltration level raised to 628.5 m level. In order to mitigate the expansion phenomenon, the inferior elevation benches were covered with a ballast layer, until 628.5 m bench level. Even if strong exfiltrations do exist, drenching the lower talus benches, the expansion process is presently stopped, the upper side being dry, only with week moisture marks at bench level 640 m. The foreshore level is located under the top beam, the foreshore width being of about 200 m.

The 4 hydro-geotechnical drill-holes were equipped with piezometers, in completion of existing profiles, being done in order of assessing the physical and mechanical parameters of the materials disposed in that area and determination of hydro-geological conditions. On the lower side of the talus, two more drillings were carried out, in locations where geo-physical research have emphasized electrometrical disturbances; these drillings have had as purpose to identify some cavities existing in the rock mass, as a consequence of the expansion process. Based on laboratory tests with materials sampled from drillings, the following conclusions have resulted:

- regarding the granulometry, the material sampled from drillings, is characterized as an average and smooth sand with sandy clay intrusions, where the percentage of sandy and clay fractions increases with depth; the sandy fraction is 100% at the deposit's surface, in the first 3-4 m, but at 10 m depth it reaches to 46%.

- the physical and mechanical parameters of material sampled in the upper side indicates a dry material on the first 3-4 m depth, with an average consolidation degree: volumetric weight 1.37 – 1.73 t/m3; porosity 44.7 – 53.9; moisture content 7.1 – 17.0; cohesion 0.17 – 0.34 kg/cm^2; compressibility modulus 71.4 – 100 kg/cm^2; specific settlement degree 21 – 38 mm/m and permeability 3.27x10^{-5} – 1.58x10^{-4}.

The above-presented data indicates that at surface, where the moisture content id lower, the material can be considered as dry and his characteristics are weaker, growing in depth before intercepting the NH; then, the characteristics are altering, the material being practically saturated. The intercepted NH was located between 1 - 4.8 m in the lower third of the talus and between 1.7 - 6.0 m in the upper side, with outcrop on 628 m level bench.

3. STABILITY CALCULUS OF THE TAILING DAM

Taking into consideration the critical conditions in which the Valea Săliştei tailing dam find himself during the stability evaluation study, as a consequence of the very high hydrostatic level within his body, the stability computations and calculus were carried out for the existing geometrical and hydro-geological conditions at that moment, namely: maximum bench level 653.5 m; general slope angle16^o; NH existing in the most adverse central profile. The method employed was the Bishop method, commonly used for tailing dams stability assessment in the mining industry, because its easier approach and adequate computation accuracy; the software applied was STB2002, whose author is professor Arnold Verruijt, from Delft University-Holland.

Within the method, it is assumed that the potential sliding surface is circular; in contrast to Fellenius method, the forces between the sections in which the dam/dam is divided are considered. The piezometric surface is defined through coordinates x and y, being known from monthly measurements on steady alignments; this value can be modified in any moment of the analysis, in order to allow the safety factor evolution. The physical and mechanical properties were defined for each prism; as parameters required for analysis, we retain the following ones: W_d – dry-state volumetric weight, kN/m^3; W_s– saturated-state volumetric weight, kN/m^3; K_0 –neutral horizontal stress coefficient; C- cohesion, kN/m^2; φ - internal friction angle, degrees; P / F – selector to input the piezometric level (P-ground water level higher than the pressure in pores, given by the hydrostatic level location; F- fixed water level, higher than the pressure in the pores, given by a fixed hydrostatic level, inside the same layer); P- pressure value in the pores; C_{ap} –capillarity area thickness over the hydrostatic level (negative pressure in pores), m.

The tailing dam's body was divided into 3 different lithological areas and 100 slashes, the analysis being carried out for two cases:

(1) Statistic analysis of stability, without external influences;

(2) pseudo-dynamic stability analysis considering, as an horizontal component which increases the active prism gradient, instead the passive one, the seismic strain.

Further, there will be briefly outlined the obtained results after performing this stability analysis, considering the analyzed section as passing through the central axis of the dam and being normal on the maximum slope line. For the dam without ballast prism, the safety factor is critical in the static hypothesis F = 1.112, being under the specific limit for these conditions (F > 1,40); in the case of pseudo-dynamic analysis, the seismic factor leads to a total dam stability loss, F=0.789. The critical surfaces are outlined diagrammatically in figures 4 and 5.

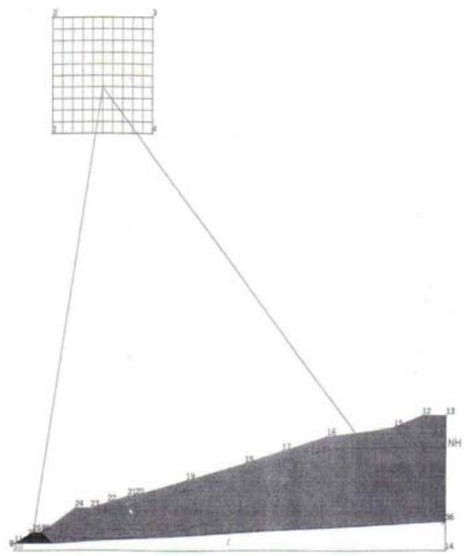

Figure 4- Representation of the critical sliding surface in the static hypothesis.

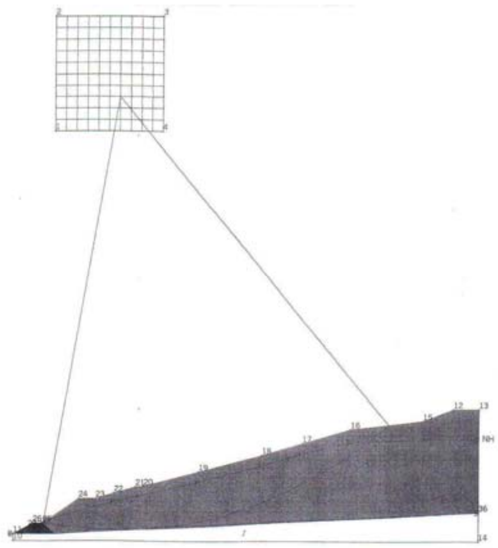

Figure 5- Representation of the critical sliding surface , considering the seismic effect contributionin safety coefficient’s calculus.

Embracing the ballast prism solution (counter-rampart from rocks) and computing the safety factor in this hypothesis, it comes an increase in his value to acceptable limits for this kind of hydro-technical structure, F= 1.527; the pseudo-dynamic analysis issued a unit value safety factor (F = 1.004), which allows the adoption of adequate emergency measures. The critical sliding surfaces are represented in figures 6 and 7.

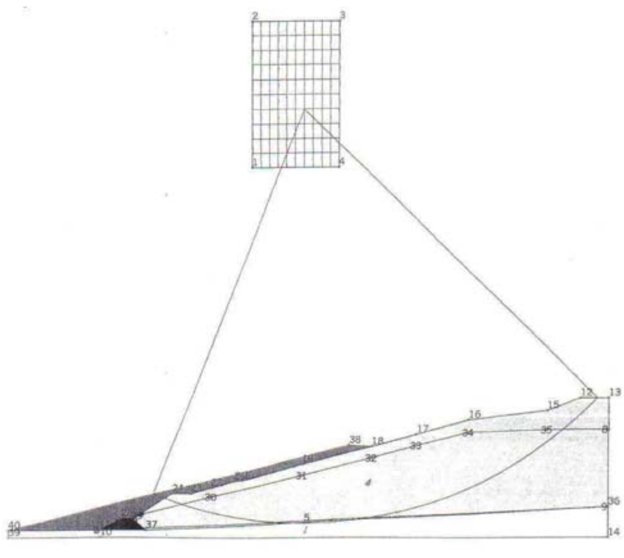

Fig.6- Representation of the critical sliding surface in the static hypothesis-talus with ballasting prysm.

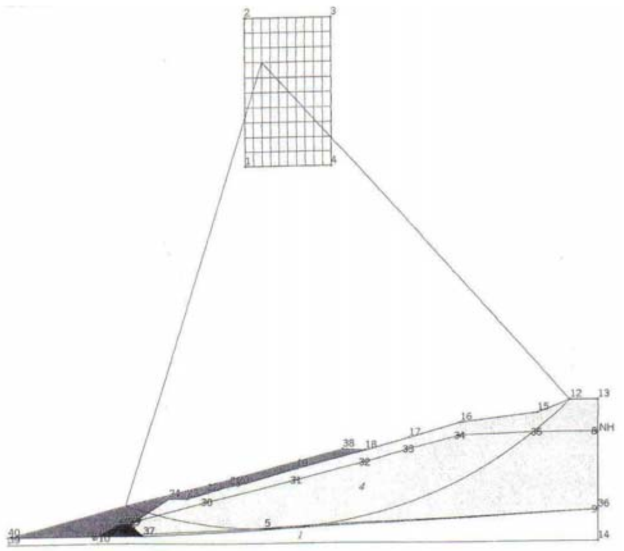

Fig.7- Representation of the critical sliding surface, considering the seismic effect contribution in safety coefficient's calculus- talus with ballasting prysm

4. CONCLUSIONS REGARDING THE VALEA SĂLIŞTEI TAILING DAM'S STABILITY

Conclusively, after the stability computations, it results that the Valea Sălişteı tailing dam from Roşia Montană is characterized by a low geo-mechanical stability degree. The hazard exists that, in case of dynamic components are induced (such as vibrations generated by large-scale blasting operations) the dam's body to diminish his shearing strength and, finally, to loss completely stability, which consequently could generate a both human and ecological disaster. In order to reduce this risk, by increasing the dam's stability and reliability, it is required to take into consideration the technical solution involving a ballasting prism and/or the decrease of the hydrostatic level under the top beam, resorting to auxiliary drainage workings.

The research study and his results revealed a safety coefficient having the value of 1.112 in static regime and 0.789 in dynamic regime, coefficient computed for the present moment; by applying a ballasting prism, the safety coefficient became 1.527 in static regime and, respectively, 1.004 in dynamic regime.

To provide a continuous operation of the tailing dam, namely to increase his height, a 3 m higher level was modelled above the existing one, resulting, if we allow the ballasting prism hypothesis, a stability coefficient of 1.456 in static regime and at the lower limit, in dynamic regime. These values are not exceeding the norm for the safety coefficient, having a value of 1.40 for the importance class were Valea Sălişteı tailing dam is classified, according to the national standard STAS 4273.

REFERENCES

[1]. Toderaş, S. – *Posibilităţi de reabilitare a zonei Roşia Montană afectată de activitatea minieră.* Referat de doctorat. Universitatea din Petroşani, 2007.

[2]. *** - *Instrucţiuni tehnice privind proiectarea, executarea, întreţinerea şi exploatarea iazurilor de decantare în industria minieră*. MMPG, 1974.

[3]. *** - *Report 2001*. Knight Piesold. 2001.

[4]. *** - *Evaluarea stării de siguranţă a iazului de decantare Valea Săliştei.* SC IPROMIN SA. Bucureşti, Iulie, 2002.

[5]. *** - *SNC Lavalin Consultants Roşia Montană Project Geotechnical Investigation*. 2003.

[6]. *** - *Passive Treatment Options at Closure*. MWH. 2004.

[7]. *** - *Roşia Montană Project – Dam Geotechnical Design Parameters*. MWH 2004.

[8]. *** - *Tailings Management Facility – Geochemistry and Water Quality Report*. MWH 2005.

[9]. *** - *Documentaţie geologică şi tehnică RoşiaMin*.

Annals of the University of Petroşani, Mining Engineering, 10 (2009)

POWER ELECTRONIC STARTER FOR SLIPRING ROTOR MOTORS

D. SIMKE*

Abstract: *Drives with slipring motors for mining units and belt conveyors are broadly used in open pit mining enterprises among the more and more common use of variable frequency controlled drives. This paper describes the construction and operation of a starting unit based on power electronic components.*

1 DRIVES WITH SLIPRING ROTORS

ABB Automation GmbH Cottbus and the predecessor companies VEM Starkstromanlagenbau Cottbus and VEM Automatisierungsanlagenbau Cottbus alone have installed more than 2000 slipring rotor drives on conveyor bridges, bucket-wheel excavators, bucket-chain excavators, spreaders, stockpile machines and belt drive stations.

Meanwhile converter drives have established themselves for all drives requiring good closed-loop control behaviour.

Nevertheless the slipring rotor still provides a cost-efficient alternative to the converter drive, in particular for drives of a higher performance that are operated at constant speed.

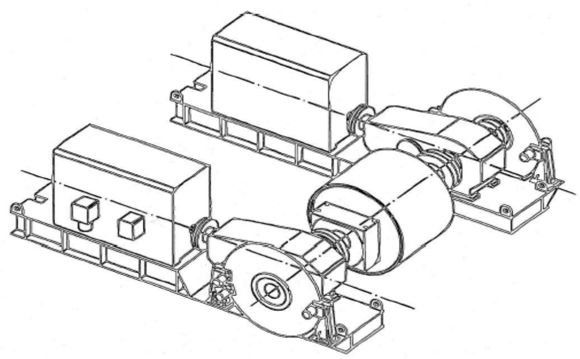

Figure 1 Principle construction of a belt drive

* *Eng. - ABB Automation GmbH Cottbus, Dep. Open Pit Mining, Germany*

2 OPERATING MODE AND STARTING TECHNOLOGIES

A circuitry connected in the open rotor circuit can be used to optimize the operating behavior of the motor. This is usually carried out by resistors that change the inclination of the speed/torque characteristic without changing the maximum torque (breakdown torque) (Fig. 2).

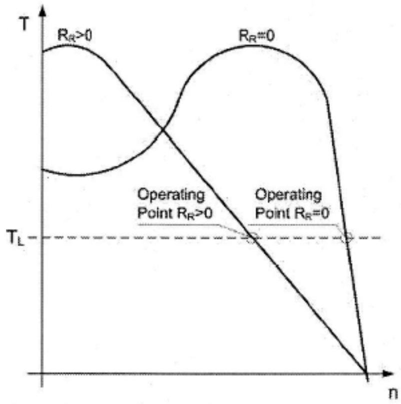

Figure 2. Influence of the rotor resistance on the torque

The most important drive technologies used at present are:

- The liquid starter, in which the resistor takes the form of a soda bath. The resistance is changed by changing the distance of the electrodes in the liquid.
- The resistor starter, in which the resistors are made from cast iron or steel plates. Individual parts of the resistor are shorted out by contactors or switches so that the effective resistance may be changed gradually.

By using, for instance, binary combinations of the partial resistors or contactors, the number of steps can be increased at a given number of partial resistors and contactors. Figures 3-4 show a typical speed/torque characteristic and the rotor circuit of a binary stepped resistor starter.

Resistor starters are usually controlled by a timer or by monitoring a current.

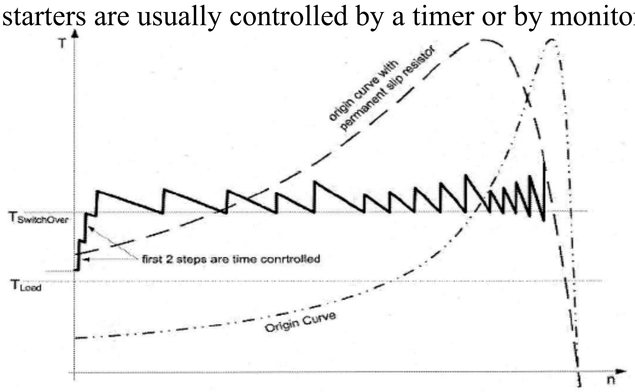

Figure 3. Typical torque characteristic of a binary stepped starter

The objective of the time control is to keep a specified nrn-up time. Stepping is carried out in accordance with a previously calculated time regime.

The objective of monitoring the current is to keep an average run-up torque. Stepping is carried out when the stator current falls below a specified value. Owing to the high resistance value in the rotor circuit the stator current provides an exact enough reference for the torque.

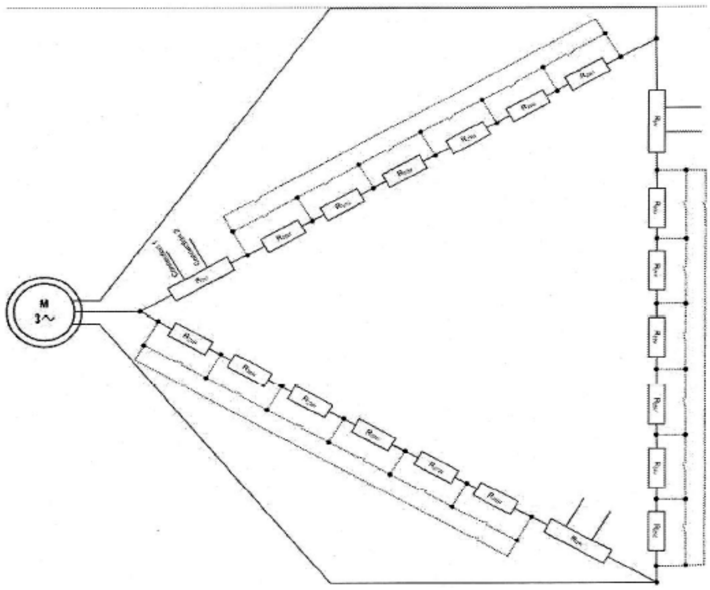

Figure 4. Rotor circuit of a binary stepped starter

The necessary steps of the resistance limit the possibilities for control and open-loop control. In addition to that the sudden changes of the torque during the change-over from step to step have to be taken into consideration for the dimensioning of the drive components.

3 POWER-ELECTRONIC STARTING DEVICE

Aimed at achieving improvements of the quality of the slipring motor systems, which are still in operation or have been newly constructed, by innovative approaches, ABB Automation GmbH Cottbus has taken up the not really new idea to use power-electronic components for controlling the starting process of slipring rotors.

This idea was, for example, proposed by the Professors Schönfelder and Habiger from Dresden in 1981 (Schönfelder & Habiger 1981). Dr Meyer from the Karlsruhe University discussed this principle in more detail in Meyer (1985). Figure 5 shows the principle of the circuit.

The resistance acting towards the rotor of the motor is changed by the gate control of the IGBT-406. The current commutates from the IGBT branch with its very low resistance to the resistor branch. As the IGBT gate control is carried out in accordance with the proportional pulse principle, the average time of the effective resistance results from the ratio of dead time and switching time. The designed basic frequency of 500 Hz and 1000 Hz was selected so that both a safe distance to the mains frequency is kept and the switching losses via the IGBT are kept at a minimum.

The ECOSS electronic compact starter has the following advantages over the stepped starter:

- Maintenance is not necessary because there are no step contactors.
- As the starting resistor -R12 is a completely current-carrying resistor; it can be designed of the same elements by which the number of spare parts is reduced.
- As the starting resistor -R12 is a completely current-carrying resistor; the temperature of the resistor can be recorded by only one measuring point. This in turn allows a better utilization of the resistor, so that a more specific prediction whether another starting process can be allowed or not is possible.
- The cabling of the rotor circuit is clearly minimized.
- This principle enables - within the limits defined by the resistor and the motor - a continuous closed-loop control of the drive during the start, which allows closed-loop controls of speed or torque but also a combination of the two.

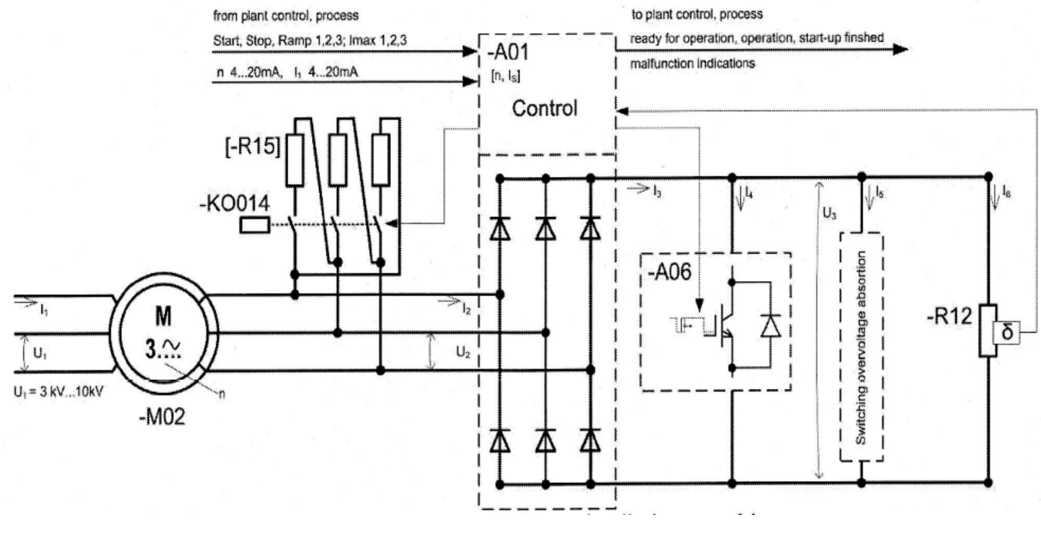

Figure 5. Principle circuit of a ECOSS electronic compact starter for slipring rotor

When the drive is equipped with a DC braking, the braking effect can be optimized by a shift of the characteristic, as shown in Figure 6.

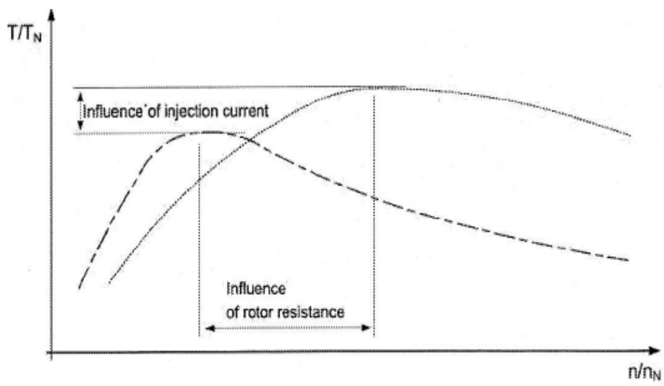

Figure 6. DC braking - influence of the rotor resistance

3.1 Dimensioning and closed-loop control

To confirm the calculations regarding the dimensioning of the power-electronics components and to investigate the closed-loop control behaviour, a test station using a 4 kW slipring motor was built in the Brandenburg University of Technology.

Within the framework of a diploma thesis assigned by ABB dimensioning guidelines and closed-loop control principles were investigated.

During these investigations a change was made from the classical process of reducing the overvoltage's caused by the fast switching operations of the IGBT by the so-called snobber onto an active circuitry. This keeps the overvoltages within a precalculated range and increases the safety during the dimensioning of the IGBT.

With regard to the closed-loop control, signal flow charts were developed for speed control and torque control that are based on the measurement of the stator current. Figure 7 shows that the change of the torque generation at a given change of the rotor resistance depends on the presently effective rotor resistance and the load state. Therefore it is indispensable to adapt the closed-loop control parameters accordingly. Figure 8 shows the speed-controlled run-up of the test machine using closed-loop control parameters, which secure that the drive responds moderately to load changes without deviating seriously from the speed set point (30 sec. ramp).

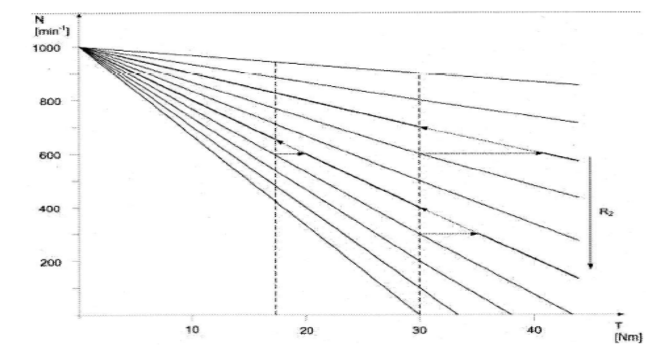

Figure 7. Effect of a resistance change of the test machine

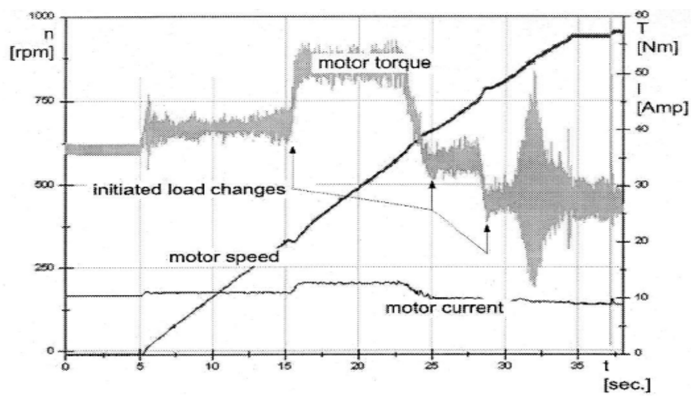

Figure 8. Speed control of test machine

3.2 Configuration and use

It is planned to cover the performance range up to 2000 kW with a standard configuration consisting of three design types.

The configuration of a switch cubicle for the power electronics rotor starter (Fig. 9) is based on Rittal standard switch cubicles with a depth of 600 mm. Depending on the motor size and the installation conditions it can be designed with a depth of 1000 mm or 1200 mm.

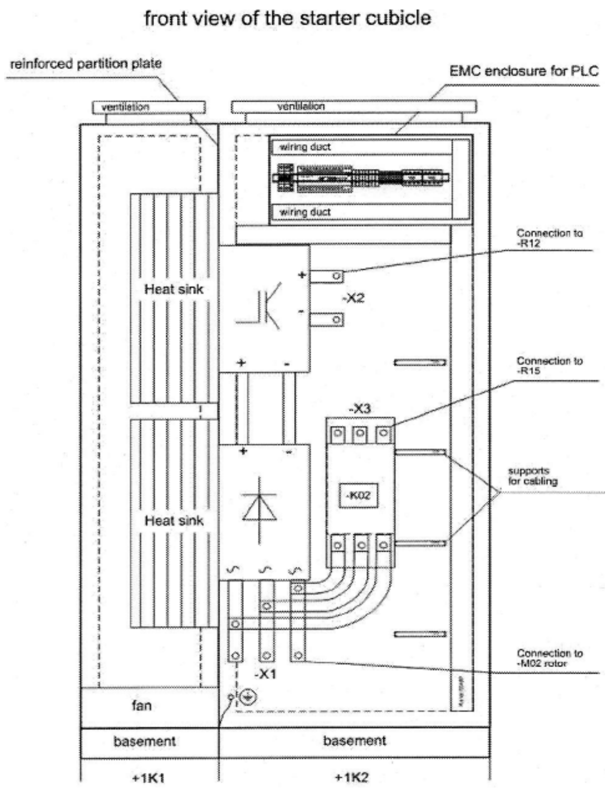

Figure 9. Principle configuration of starter cubicle

For the ABB compact starter (DUK 1-4, Figure 10), which was developed for conveyor bridges and drives which are relatively far away from a switch house, an IP54 version of a 1200 mm wide switch cubicle was developed.

The power electronics starter can be used for both the retrofitting of already existing starters and for new plants. In already existing plants the starter is connected to the PLC system by parallel inputs and outputs of the respective signals whereas a PROFIBUS interface is available for new plants.

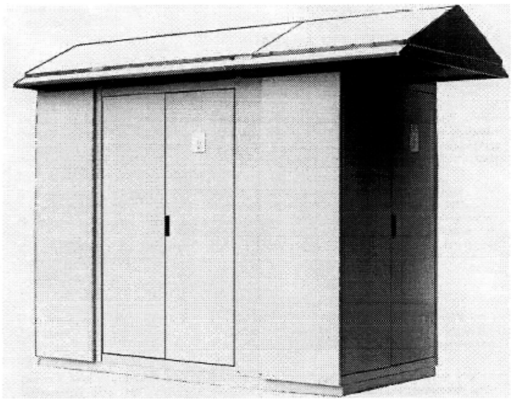

Figure 10. AIIB compact starter DUK 3

4 PROSPECTS

After finishing the tests at the test station in 2008, a starter is being developed for a 900 kW belt drive in the Nochten opencast mine of Vattenfall Europe Mining AG.

Provided that this starter works steadily, the drives of the F60 overburden conveyor bridge in the Reichwalde open cast mine that operate in the power range between 400 kW and 1500 kW will be equipped with ECOSS starters.

5 REFERENCES

[1]. Schönfeld, Rolf; & Habiger, Ernst 1981. *Automatisierte Elektroantriebe*. Berlin: VEB Verlag Technik
[2]. Meyer, Manfred. 1985. *Elektrische Antriebtechnik*: Band l. Berlin, Heidelberg, New York, Tokyo: Springer
[3]. Brömme, Sören. 2008. *Untersuchung des Betriebsverhaltens eines leistungselektronischen Anlassers für Mittelspannungsschleifringläufermotoren und daraus resultierende Folgerungen für Steuerprinzipien und BauteilausIegung (Investigatin of the operating behaviour of a power electronics drive for medium-voltage slipring motors and the resulting consequences for controlprinciples and components).* Coltbus: Brandenburg University of Technology, ABB Automation GmbH.

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PREVENTIVE METHODS AGAINST SPONTANEOUS COMBUSTIONS BASED ON PHOSPHATE-TYPE INORGANIC INHIBITORS USED IN COAL MINES WHICH EMPLOY BED UNDERMINING

ION TOTH*
CLEMENT IONESCU**
LORAND TOTH***
CLEMENTINA MOLDOVAN****

Abstract: *Coal mining shall lead to the occurrence of certain phenomena characterized by high risk factors produced by spontaneous combustions. The non-prevented spontaneous combustion can give birth to fires with adverse effects in every plan. After studying the chemical structure of coal, the theories of self ignition and of the oxidation reaction of the organic compounds, two new technologies for fire prevention based were developed on the inhibition of coal oxidation. The first technology consists in spraying water drops mixed with inhibiting substances into grafs; the second one consists in the infusion of a mixture made of several chemical compounds. The tests performed in situ showed a high efficiency of the new technologies even at those long walls with coal with a high reactivity from the point of view of their self-ignition.*

Key-words: *spontaneous combustions, new technologies for prevention*

1. INTRODUCTION

Coal has been and shall always be the primary source of power. It has been included in the strategies specially developed and implemented for the purpose of building a sustainable power sector both within the EEC area, and all through the entire world.

** degree Scientific researcher PhD eng. – INCD-INSEMEX Petrosani*
*** Assoc. Prof. PhD. Eng. - University of Petrosani*
**** Scientific researcher PhD eng. – INCD-INSEMEX Petrosani*
***** Assist. Prof. PhD Chem. – University of Petrosani*

The”power coal” sector in Romania must operate in an efficient manner with a reduction of the production costs. Consequently, the mining activity has been reorganized and modernized. There have been introduced highly efficient mining methods, such as mining of coal by undermined bed in the worth paying mines.

But this method amplifies certain risk factors, such as the spontaneous combustion.

As the subventions for mining have diminished, it is urgent to increase profitability of the mining units. One way to accomplish is to prevent the spontaneous combustions in coal mines; accordingly, the time-out of the coal deposits is reduced, the mining activity is going on without break periods, the number of accidents is being diminished, the mining equipment is used in very good conditions and at last, but not in the least, the expenses related to an active, passive or mixed control.

Beside the classical methods used for prevention (mud filling, treatment with antipyretic substances, treatment with chemical and sealing substances), there have been developed and tested in laboratory, pilot and in situ new technologies that use homogenous inhibitors.

2. SCIENTIFIC EXPLANATION OF COAL SELF-OXIDATION. INHIBITING THE SELF-OXIDATION PROCESS

2.1 Coal chemical structure

According to the researches carried out in the field of coals chemical structure, they are considered macromolecule compounds made of compressed aromatic nuclei with side hydrocarbons chains included, which show an increased reactivity with respect to the compressed aromatic nuclei, in compliance with the structures shown in figures 1, 2 and 3.

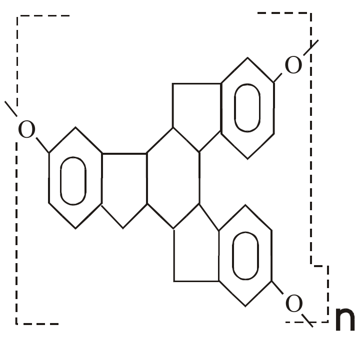

Fig.1

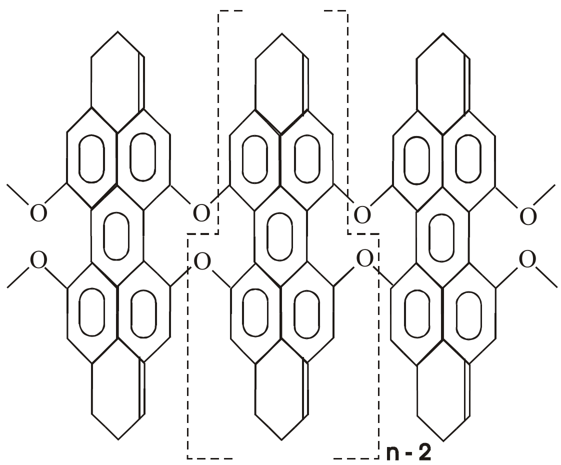

Fig. 2

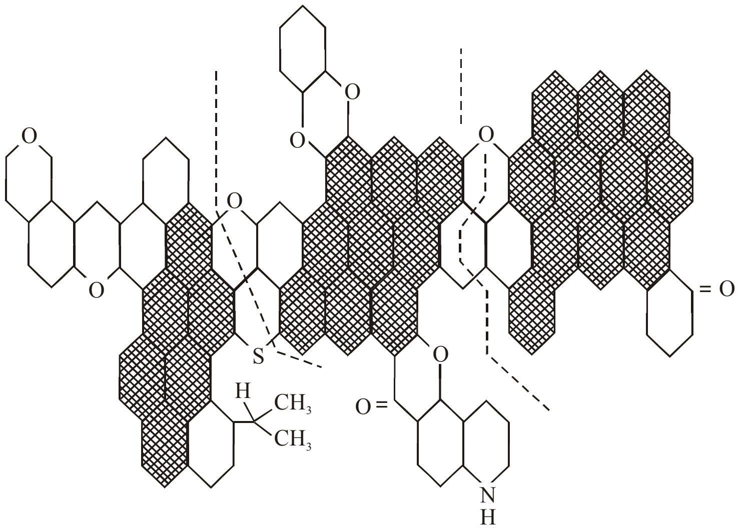

Fig. 3

An increased metamorphism increases the content of aromatic nuclei, to the prejudice of side chains; as a result, there is developed a more arranged structure that comes near the crystalline network of graphite.

2.2 Self-oxidation of organic compounds

Considering coal chemical structure, one can say that coal is a complex organic compound that observes the same rules valid for all the organic substances, so including the one of self-oxidation.

Self-oxidation is a reaction between the organic compounds with the molecular oxygen, in relatively mild conditions of temperature and pressure.

Generally, the reaction is triggered by dimmers or ions of the transient metals and this proves the radically character of the process.

2.3 Inhibiting the self-oxidation process

Self-oxidation of hydrocarbons polymers and of other organic compounds is a chained process. For inhibiting this process, one can take the suitable measures either during the stage of chain formation, or during the chain spreading and branching.

The inhibitors that are used during the chain formation may be compounds of screened phenols or sulphurs type.

According to literature [1], [2], [3], the theory of the ”pyretic-oxidation” and the theory related to the role played by the microelements that are component part of coal corroborated with the theory of oxidation have led to the conclusion that the substances that are part of the ”phosphate” group may have inhibiting effects over the coal self-oxidation.

Several authors [2], [3] consider that the use of the phosphate has led to:

a) The decreasing of the temperature of the treated sample, compared to the untreated sample, during the determination of the coal tendency to self-ignition by the method of thermal oxidation with gaseous oxygen.

b) The decreasing of the temperature gradient with a 20 minutes period from the start of the oxidation, at the end of the self-oxidation, as well all through the oxidation process, compared to the untreated sample. It is important the decreasing of the temperature gradient that occurs at the beginning of the process when heat accumulation occurs and may trigger later the self-ignition.

For all the above-mentioned situations, the output is expressed by the following equations:

$$\eta_1 = 100 - \frac{\Delta\, T_f \text{ treated sample}}{\Delta\, T_f \text{ untreated sample}} \cdot 100 \qquad (1)$$

$$\eta_2 = 100 - \frac{\Delta T / 20 \text{ minutes heating of the untreated sample}}{\Delta T/20 \text{ minutes heating of the treated sample}} \cdot 100 \qquad (2)$$

These measurements have led to the conclusion that the inhibitor that is part of the phosphate group shall diminish coal tendency to self-ignition with around 80%.

3. NEW METHODS FOR PREVENTING SPONTANEOUS COMBUSTIONS WHEN USING COAL MINING WITH UNDERMINED BED

After a thorough study of the self-ignition theories and of the coal chemical structure, there have been developed new methods of preventions that use the phosphate type inorganic inhibitor as a base substance.

The researches that have been carried out in the laboratory, in the field and the pilot researches have produced two new preventing technologies:

– the prevention method with inhibiting sprayed particles;

– the prevention method of spontaneous combustion with chemical foam and inhibitor spread locally with the help of a pump.

According to literature [4], [5], the methods which have been developed and tested are the following ones:

3.1 Methods of prevention with inhibiting sprayed particles

3.1.1 Description of the installation used to produce the inhibiting sprayed substance and of the working method

The prevention of endogenous fires when using the mining with undermined bed is accomplished mainly with the help of very fine (micron – sized particles) derived from the inhibiting solution spread all through the goaf and at the working face, depending on the location of the installation and in compliance with the air flow.

The installation used to produce sprayed particles (fig. 4) is made of a 200 ml tank (1), an air-water spraying device – CCSM (2) and the connection hoses (3) to the compressed air mains at the working place and to the tank with the inhibiting substance. A tap (4) is mounted on the compressed air hose of the spraying device.

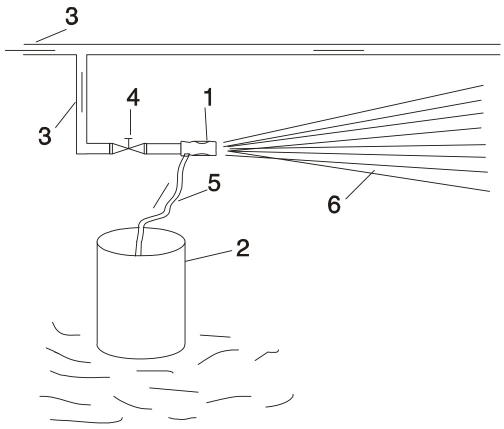

Fig. 4

The spraying device for spraying the inhibiting substance has got the following parameters:

- the working pressure : 0,3 – 0,6 MPa;
- consumption of compressed air: 0,8 – 1,05 m^3/min;
- consumption of inhibiting solution: 0,8 – 1 l/min;
- sprayed solution ratio: 90 – 100 %.

3.1.2 Mounting and commissioning of the installation

The inhibiting solution of 0,5 % phosphate is put into the tank (1). Due to the phosphate high solubility, we can get an inhibiting final product in approx. 5 min after a manual stirring in the tank.

Afterwards, a supply hose attached to the spraying is connected both to the compressed air mains and to the tank. The spraying device is placed in the cross drift or in front of goafs with high concentration of CO.

The spraying device is equipped with a regulating means; accordingly one may regulate the size of the sprayed particles in such a manner that the very fine particles should be ≈ 90 % of the inhibiting solution.

The amount of inhibiting solution in the tank ensures an autonomy of operation of around one hour.

3.1.3 Treatment method with sprayed particles of inhibiting substance

Due to the inhibiting characteristics displayed by the phosphate during the coal oxidation and self-ignition process, coal oxidation and self-ignition process, a suitable treatment with sprayed particles from the „phosphate" group shall diminish the risk of spontaneous combustions.

To treat adequately a goaf, this spraying device shall be located in the cross drift of the blasted pre-crushing raise. The sprayed device shall also be mounted in front of the holes in goafs where high concentrations of CO were previously detected (over 0,1 % vol).

The spraying device shall be placed at a height of 1 -1,5 m from the mine floor, being orientated towards the area that is to be treated with the help of sprayed particles and shall operate in every point for approximately one hour.

3.2 Method for the prevention of spontaneous combustion with chemical foam and inhibiting substances, locally applied with the help of a pump

3.2.1 Description of the installation used for the treatment of the goaf

The installation shown in fig. 5 is made of the following component parts:

– connection to the supply main for industrial or drinking water;

– line mixer;

– a 100 l vessel for mixing the solution;

– foam delivery pipe;

– apparatus for producing the ASC-3 chemical foam, made of an electric motor of 15 kW, an air-driven motor and a SADU-type centrifugal pump.

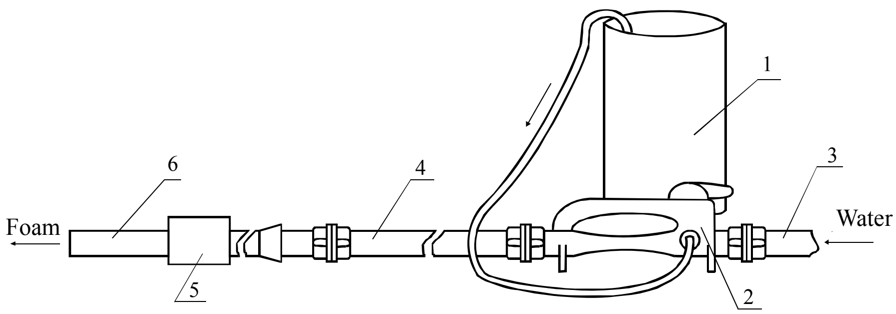

Fig. 5

3.2.2 Operation of installation

Before commissioning, it is necessary that the mounting scheme shown in fig. 5 should be produced and then the whole installation be connected to the water main of the mine or to the mudding plant.

For being able to interconnect all the sub-assemblies, B and C connectors should be used (used also by firemen), as well C-type hoses with a 50 mm diameter.

After opening the supply valve, the incoming water reaches the line mixer and afterwards, it crosses a convergent–divergent ejecting nozzle; as a result, it sucks the mixture formed beforehand in the 100 l vessel in the suitable ratio between water and the mixture of chemical substance and foaming agent. Then, this mixture under pressure crosses the foam delivery pipe and here we can get a foam with an expansion rate of 10 by supplementing a great amount of air. Due to the fact that this mixture displays a low pressure when coming out of the foam delivery pipe, it can be thrown away over a distance of only 6-8 m away. Accordingly, an ASC-3 apparatus is necessary to be mounted in the goaf for the foam transportation along metallic pipe; this apparatus sucks in a powerful manner the foam from the delivery pipe and throws it with high pressure along the pipe located in the goaf.

3.2.3 Component stages of the method used for the treatment of goaf with antipyretic chemical substances

The treatment of goaf with antipyretic chemical substances includes the following component stages:

a) The producing of the mounting shown in fig. 5;

b) Connecting the line mixer to the drinking or industrial water main;

c) Connecting the foam delivery pipe to the line mixer;

d) Preparing the mixture of antipyretic foaming substance in the 100 l vessel:

– 0.5 kg of inhibiting substance;

– 10 - 20 l foaming agent;

– water up to 100 l.

e) The opening of the water supply valve and the introduction of the supply hose of the line mixer in the 100 l vessel; previously, there has to be checked whether absorbtion occurs;

f) Driving the foam jet towards the goaf by 50 mm diameter pipes. The foam shall be introduced into the caved rock with ASC-3 apparatus. The operation goes on until all the preset amount of foam is delivered or until the drill hole doesn't accept more foam.

Observation:

– Treatment can be performed in several stages.

– Treatment shall be performed right away after the discharge operation.

– After the treatment is brought to an end, both the installation and the hoses shall be washed up for 1-2 min.; after that they shall be gathered at the very place where the mixture is made so as to be readily available for a new commissioning in the following cycle.

4. RESULTS

4.1 The effects of the sprayed solution

The effects of the sprayed solution have materialized for the following directions:

– the sprayed solution moved towards the goaf and covered the coal which remained within the goaf as a result, coal tendency to self oxidation diminished;

– the airborne coal dust in the cross gallery attached to the sprayed particles; as a result, the atmosphere at the working place cleared within minutes from the moment when the solution has been sprayed;

– whether this solution is sprayed during the blasting operation or right away after the end of this operation, the toxic gases attach within minutes. Accordingly, the ventilation period after the blasting operation diminishes;

– the sprayed particles cooled the area, leading to a dissipation of the heat produced during the spontaneous combustion.

4.2 The effects that result after the treatment of the goaf with chemical substances

The chemical substances - the foaming agent together with the inhibiting substance injected towards the goaf allow a suitable mining of the sublevel with no occurrence of endogenous fire through reactivation. The mining of the coal slice shall create the basis for a continuous mining of the lower sublevel by longwall working with undermined bed.

The effects of the chemical substances sprayed inside the goaf were the following ones:

- a cooling down of the influence area covered by the mixture of chemical substances;
- a diminution of the tendency to oxidation for the coal left inside the goaf; in this manner the development of a new spontaneous combustion is prevented;
- a diminution of the concentration in carbon oxide inside the goaf resulted from a previous spontaneous combustion.

5. CONCLUSIONS

- Coal is and shall remain an important energy source.
- A reconversion to the market economy includes reorganization and a modernization of the coal mining field in Romania, too.
- Coal mining with undermined bed has introduced new risk factors, among which an important place is hold by spontaneous combustion.
- Prevention of spontaneous combustion during the implementation of the new mining method can be reached by new ones that use inhibiting substances.
- Two methods have been devised and tested with good results, i.e:

- one that uses sprayed particles with inhibiting substances;
- one that involved the local treatment of the goof with a mixture made of a chemical foam and inhibiting substances

REFERENCES

[1]. Matei, I, Toth, I, Cioclea, D, Purcaru, S I, Vochitoiu, H, *Spontaneous combustion în coal mines,* Print Everest Publishing House, Deva, Romania, 2003

[2]. Matei, I, Cioclea, D, Toth, I, Gligor, C, Voinoiu, N Vochitoiu, H, *The prevention of spontaneous combustions during coal mining by undermined bed,* Agora Publishing House, Calarasi, Romania, 2004

[3]. Toth, I , Nicolaescu, E, *Safety measures on the slicing method of working with ventilation ducts for a diminution of the hazards of occurrence of endogenous fires,* Study of National Institute for Mine Safety and Explosion-proof Protection Petrosani, Romania, 1992

[4]. Toth, I, Cioclea, D, *Program for underground testing at the working face SCRI no.39 from Lonea Mining Unit 2003 of the technology with inhibiting sprayed particles and mixtures of chemical substances,* Study of National Institute for Mine Safety and Explosion-proof Protection Petrosani, Romania, 2003

[5]. Toth, I, Cioclea, D, *Study on the chemical inhibiting substances for diminishing the coal self – oxidation,* Study of National Institute for Mine Safety and Explosion-proof Protection Petrosani, Romania, 1996

[6]. x ^{x} x., *Specific norms for labor protection in coal, shale's and bituminous sands mines*, Published in 1997.

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ASPECTS CONCERNING THE STABILITY OF THE STERILE HEAPS FROM JIU VALLEY

**VIOREL VOIN*
ILIE ROTUNJANU*
MARIA LAZĂR***

Abstract: *This paper presents the situation of the active sterile heaps in the Jiu Valley followed by the analysis of the stability for natural humidity and saturation.*

1. INTRODUCTION

The Jiu Valley mining basin has currently a number of 10 active heaps, belonging to 8 mining units, as follows: Lonea M.E with Lonea 1 and Jiet heaps; Petrila M.E. with the U.P. Petrila V Branch heap; Livezeni M.E. with the P.A. no.2-3 Maleia precincts and U.O. Livezeni heaps; Vulcan M.E., Arsului Valley heap; Paroseni M.E. Wolf Valley heap; Lupeni M.E., U.P. Branch 3 heap, Uricani M.E., New Funicular heap and E.P.C.V.J. with U.P. Coroiesti Branch 2 heap. Overall, the heaps occupy a surface of 55.9 ha and have a total volume of about 14 mil m^3.

2. THE SITUATION OF THE ACTIVE HEAPS FROM JIU VALLEY

The main characteristics of the heaps are presented in Table no. 1.

The majority of the heaps are situated on hilly slopes. The exceptions are the sterile heaps from Lonea 1 and Jiet, U.P. Livezeni and Arsului Valley Vulcan, situated on flat areas with low slope angles, which have less significant influence on the stability of the heap.

The volume of the sterile heaps varies between 50800 m^3, as in the case of the Jiet heap, to 2,827 mil. m^3, for R IV-V Branch from Petrila M.E. and 2,325 for R2 Branch from E.P. Coroiesti.

* *Professor, PhD.Eng. at the University of Petrosani*

Table no. 1. The characteristics of the analyzed sterile heaps

Mining unit	Heap	CHARACTERISTICS OF THE HEAPS								
		Location	Volume (mil. m^3)	Surface (ha)	No. of treads	Geometry		Technical status	general classification	Construction method
						α (degrees)	h (m)			
Lonea M.E.	Lonea 1	Old precinct	0.35	2.10	1	30-40	5-30	Stable	3.2	Conveyor transportation
	Jiet-Defor	On the coal expedition platform	0.056	0.78	1	11-36	3-12	Stable	3.4	Conveyor transportation
Petrila M.E.	RV Branch	Platform comprised between the East Jiu and Maleia	2.827	19.59	1	25-50	15-25	Stable	3.4	Funicular transportation
Livezeni M.E.	P.A. no.2-3 Maleia	On versants through lateral extension	0.31	2.30	1	20-45	3-12	Stable	2.3	Conveyor transportation
	Livezeni Prep.	Old Livezeni Prep's area	0.42	2.38	1	25-38	9-20	Stable	4.4	Conveyor transportation
E.P. Coroiesti	R2 Branch	Priboi Valley and Plesnitoarea	2.35	11.20	1	21-48	10-47	Relatively stable	4.2	Funicular transportation
Vulcan M.E.	Arsului Valley	On Arsului Valley	0.61	1.32	1	16-24	6-8.7	Relatively stable	3.3	Automotive transportation
Paroseni M.E.	Wolf Valley	Wolf Valley	0.729	3.8	2	20-35	10-15	Stable	4.2	Funicular transportation
Lupeni M.E.	R3 Branch	Hilly area with water flows (Ferejele + Bonci)	8.5	6.3	1	25-35	5-30	Partially stable	3.3	Funicular transportation
Uricani M.E.	New Funicular	Hilly area on the right side of the West Jiu	0.47	2.90	1	30-35	10-25	Relatively stable	4.2	Funicular transportation

The surface occupied by the heaps varies between 0.78 ha at the Jiet heap and 19.9 ha at the R IV-V Branch from Petrila M.E.

Structurally, the heaps present heights varying from 3-12 m, at heaps Jiet-Defor and P.A. 2-3 Maleia to 25-30 m at the heap R3 from Lupeni M.E.

The slope angle of the heap tread talus is generally of 20-35^{o}, consistent with the natural talus angle of the heaped rocks.

3. CURRENT TECHNICAL STATUS AND INSTABILITY PHENOMENA

Field observations showed that the sterile heaps from Lonea M.E., Livezeni M.E., Petrila M.E., Vulcan M.E. and Paroseni M.E. are stable and do not pose any stability concerns. The remaining heaps present a relative stability, mostly due to the lack of geotechnical reinforcements at the base of the heap. The stability is also affected by the surface run-off and groundwater flow. As a result, instability has occurred, manifested through sliding, plastic leaks and erosion.

The instability phenomena were documented especially at Lonea 1, P.A. 2-3 Maleia – Livezeni M.E., Arsului Valley – Vulcan M.E., Branch 3 from Lupeni M.E., New Funicular – Uricani M.E.

4. CLASSIFICATION OF HEAPS

Based on the “Technical prescriptions concerning the designing, accomplishment and preservation of the heaps” the analyzed sterile heaps are framed in different categories (Table no. 1), according to stability degree and nature of sensitive receptors in the area of influence.

Examination of Table 1 shows that most of the heaps do not have sensitive receptors in the area of influence. The exception is the P.A. 2-3 Maleia, where wood processing installations and DN 7A are located in the vicinity of the heap. Several factors, such as natural features and accumulation of surface run-off upstream pose a significant risk factor upon the stability of the slopes at Branch 3 Lupeni, Branch 2 – E.P. Coroiesti, Lonea 1., Arsului Valley – Vulcan, and New Funicular – Uricani.

5. NATURE OF HEAPED ROCKS AND EVALUATION OF GEOTECHNICAL CHARACTERISTICS

The sterile from the analyzed heaps is represented by a heterogenic mixture of rocks, with different granulometry and lithology. The analyzed granulometric fractions are consistent with the gravel (φ=2-20 mm) and stones (φ>20 mm) classification. The lithology consists of a mixture of rocks from the productive horizon, formed of clays, marls, grit stones, bituminous schist’s, with varying granulometry and alteration degree.

Geotechnical mapping and field data collection offered a comprehensive base used for further lab analysis. Various locations on the heaps were used as collection points, from surface to fundament. The results of the analysis are presented in Table no. 2.

Table no. 2. Geotechnical characteristics of the rocks

Type of rock	Classification of rock	Geotechnical characteristics							
		γ_a [kN/m^3]	W [%]	n [%]	S	E_c [kN/m^2]	e_p [m^2/kN]	C [kN/m^2]	φ [grade]
Rock from the direct fundament	Vegetal soil (dusty clay)	16,8-18,0	14-24	32-48	0,49-0,75	4500-8000	315-1100	12-30	12-24
Material from the heap	Psefitosamitic heterogenic mixture	16,0-18,7	11-20	29-46	0,34-0,67	5200-13300	390-7900	10-45	14-26

The analysis of the physical-mechanic characteristics of the heaped rocks and the fundament showed the following:

- the granulometry of the heaped material is different, depending on the nature and provenience of the heaped rocks. The high granulation fragments prevail as a consequence of the sterile origin from the underground mining works and the cabling operations;
- the material from the fundament of the heaps is represented by the vegetal soil, specific to the argyle-sandy-dusty and argyle soils, where the presence of fine granulometric fractions favor water retention and alter the mechanical resistance;

- the volumetric weight of the heaped material varies within a wide range due to the non-homogeneity of the rocks mixture and different compaction of the heaped material;
- the natural humidity of the heaped rocks is about 20% lower than the natural humidity of soil, due to the higher water retaining capacity of the vegetal soil;
- based on the compressibility values, the heaped material and the vegetal soil present moderate to high compaction, favoring deformation through non-uniform compaction;
- the shear resistance is variable, depending on the humidity of the rock.

The cohesion of the heaped rocks varies between 10 kN/m^2 and 45 kN/m^2 while for the vegetal soil varies between 12 kN/m^2 and 30 kN/m^2. The internal friction angle varies from 26^o to 14^o for the heaped material, and from $24\text{-}12^o$ for the vegetal soil, depending on the humidity reaching the saturation level.

6. STABILITY ANALYSIS AND RESULTS

The stability analysis for the analyzed sterile heaps was performed based on the most recent topographical rises executed by I.C.P.M. SA Petrosani. Based on these measurements, situation plans of the heaps were drawn. The plans consisted of longitudinal and transversal sections through the areas of sensitive geometry of the talus or where the instability phenomena occurred.

The stability analysis has been conducted based on 3 hypotheses regarding the sliding of the heaps:

a. sliding through heaps’ body (curve surfaces);
b. sliding on the contact between the heap and the direct fundament (polygonal surfaces);
c. sliding through the direct fundament represented by vegetal soil (polygonal surfaces);

The stability analysis was performed using dedicated geotechnical software. The application calculates automatically the stability factors for curved surfaces (the Fellenius, Jambu, Bishop method) and for polygonal sliding surfaces, taking into consideration a multitude of variants related to the position of the sliding surface and the geotechnical characteristics of the rocks.

Following the data input for each analyzed section, stability factor values were calculated for each case. According to literature references [2]; [4] “The technical prescriptions concerning the designing, accomplishment and preservation of the heaps”, a stability factor of $Fs \geq 1.3$ is recommended to provide stability of the heap. .

This condition is fulfilled for the majority of the heaps, excepting the ones presented in Table 3. Examination of Table 3 shows a factor below 1.3 which requires special measures in order to provide stability of the heaps.

Essentially, the stability issues can be addressed by redesigning the geometry of the heap. Several analyses were performed regarding the size of the talus. Analytical and graph-analytical procedures established the geometric elements of the talus, within the real field constrains (technical and technological logistics).

Table no. 3 The values of the stability factors for the instable heaps

Mining unit	Heap	Section	h (m)	α (degrees)	Natural humidity			Saturation humidity		
					Fellenius	Jambu	Bishop	Fellenius	Jambu	Bishop
Petrila M.E.	R5 Heap	T1-T1	16.5	33	-	-	-	1.02	1.06	1.05
		T4-T4 (south)	17	30	-	-	-	1	1.05	1.08
		T4-T4 (north)	25	33	-	-	-	0.82	0.86	0.86
E.P.C.V.J. Vulcan	U.P. Coroiesti	T3-T3	27	34	-	-	-	0.63	0.66	0.66
		T4-T4	14	41	-	-	-	0.74	0.78	0.76
		T4-T4 (west)	25	44	1.16	1.22	1.22	0.53	0.56	0.55
		T5-T5 (west)	21	48	1.18	1.25	1.22	0.54	0.57	0.56
		T5-T5 (system)	39	33	-	-	-	0.56	0.59	0.61
Lupeni M.E.	R3 Heap	L1-L1	53	36	1.12	1.17	1.16	0.92	0.95	0.95
Uricani M.E.	New Funicular	Heap body 3	54	47	1.07	1.10	1.08	0.78	0.80	0.78

The results of the sizing calculations for the heaps that presented stability issues are presented in Table no. 4.

Table no.4 The results of the sizing calculus of the instable heaps

Mining unit	Heap	Height of the talus h (m)	Talus angle (degrees)	
			Natural humidity	Saturation humidity
Vulcan M.E.	Arsului Valley	10	56	24
Lupeni M.E.	R3 Heap	20	46	38
		25	42	33
Uricani M.E.	New Funicular	20	56	39
		25	52	37

Results of the sizing calculations showed that, starting from a required stability factor of Fs≥1.3, resizing is required to determine the talus angle for different heights of the talus. The geometry that satisfies the stability requirements given the most conservative scenario of high humidity consists of the following, according to each particular case:

- in Arsului Valley, Vulcan M.E., the talus must have heights of 10 m, for an angle blow 24-25^o. Thus, the heap will have 2 treads of 10 m and a gap of 15 m, at a general talus angle of 18^o;
- in R3 Heap – Lupeni M.E., the heap trades will have heights of 20-25 m at talus angle of 33-38^o.
- in New Funicular – Uricani M.E., it is necessary to reduce the height of the trades at h=25 m, for which the talus angle at rocks' saturation limit will be of 37-39^o.

7. CONCLUSIONS

Complex field research, laboratory analysis, topographical rises and stability studies of the heaps have lead to the following conclusions:

- The heap material consists of a heterogenic mixture of hard rocks, resulted from the underground technological processes and from the preparation and sorting of coal.
- The direct fundament of the heap is formed of vegetal soil, with resistance characteristics affected by the presence of water.
- The physical-mechanical characteristics of the heaped rocks and the vegetal soil have been determined on peat samples. Cohesion and the interior friction angle measurements were performed. .Results shown that heaps consist of a rocks mixture with lower granulometry
- The resistance of the heaped rocks and the vegetal soil decrease with the increase of water content, situation which demands water management measures in order to avoid water infiltration into the heaps.
- Fled geotechnical mapping showed that most of the active heaps in Jiu Valley are stable, although some geotechnical phenomena and deformation are observed. Generally, the stability issues are related to erosion phenomena and exfiltration due to poor management of surface run-off.
- Calculations giving a recommended stability factor value of $Fs \geq 1.3$ showed that stability requirements are met at most of the analyzed heaps, excepting the ones mentioned in Table no. 3. For stability factors below 1.3 redesign of the geometry has to be taken into consideration (Table no. 4).
- SE appreciates that these heaps have a good stability given the current conditions; however, when continuing or restarting the heaping activity, redesign of the tread geometry measures is required, consistent with the local morphology and constrained by available geotechnical solutions.

BIBLIOGRAPHY

[1] Rotunjanu, I., Voin, V., Lazar, M., Boyte, A., Florea, A., *Stability studies for the active heaps from the mining subunits of CNH Petrosani,* Research contract no. 69ASL/2005.

[2] Bancila, I., *Engineering Geology, volume I and II,* Technical Publishing, Bucharest, 1980.

[3] Florea, M.N., *Land Slidings,* Technical Publishing, Bucharest 1979.

[4] Rotunjanu, I., *Talus and Versant's Stability*, Infomin Publishing, Deva, 2005

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MODERN METHODS FOR PROCESSING THE COAL SLURRY FORM COROESTI SETTLE POUNDS

ALINA (CHIȚAC) LORINȚ *
ROMULUS SÂRBU **

Abstract: *Whereas the settle ponds from Coroesti are now to the full storage capacity, are necessary aggradations works for dams. Because the perspectives for Coroesti settle ponds will be empting and valorize the existent coal slurry it is necessary to study the processing methods. This paper establishes a flux for coal slurry processing.*

For establish the optimum methods for processing coal slurry it must be determined their preparability. Coal slurry's bearing in concentration process can be appreciated by densimetric curves. In Henry Reinhard curves case, the appreciation is made by the curve shape. (y = f (v)).

We analyzed the slurry coal from 1A settle pound and the results are presented in table 1 and the curves HR in figure 1

Table 1. *Densimetric composition established on the average of the slurry coal sample from 1 A settle pounds*

Densimetric fraction	Weight extraction v_i %	Ash content y_i %	$\sum v_i$ %	$\sum v_{1-1} + \frac{v_i}{2}$	$c_i = \frac{\sum v_i \cdot y_i}{\sum v_i}$	$\frac{100a - \sum v_i y_i}{100 - \sum v_i}$
	0	3,65	0	0	3,65	51.24
-1.3	6.39	3.69	6.39	3.19	3.69	54.48
1.3-1.4	8.69	7.00	15.08	10.73	5,60	59.36
1.4-1.5	3.49	11.55	18.57	16.82	6,72	61.24
1,5.-1.7	4	18.32	22.57	20.57	8,77	63.46
1.7-1.9	2.39	39.27	24.96	23.76	11,69	64.06
+1.9	75,04	64.06	100	62.48	51,24	86
TOTAL	100	86	-	100		

* *PhD. Student eng. - National Hard Coal Company - Laboratory for monitoring environmental factors*
** *Prof. Ph.D. eng. - – University of Petrosani Faculty of Mining*

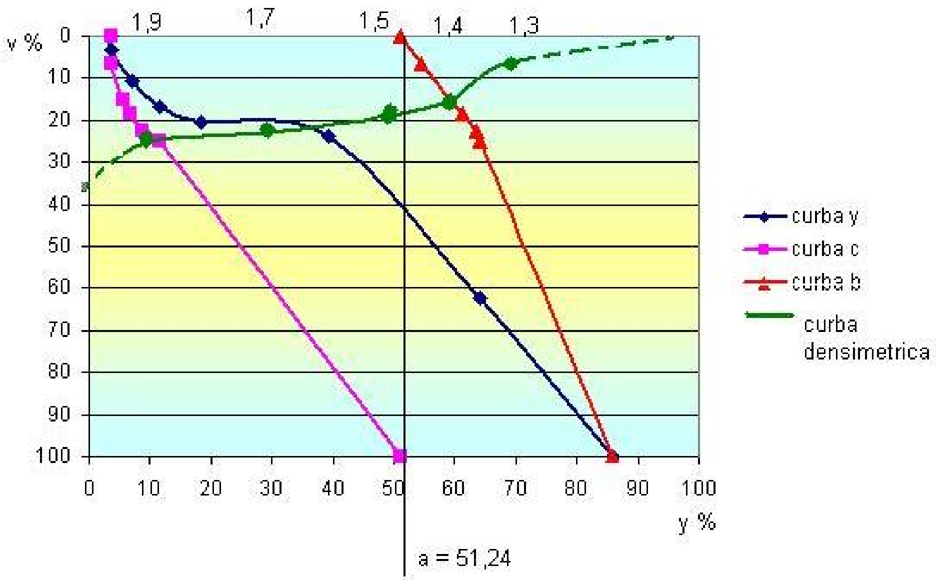

Figure 1 Densimetric curve HR for coal slurry from 1 A settle pound

The abscissa of the superior point for "y " 's curve is given by the most clean fraction ash, respectively by the inseparable ash of the clean coal "p" and the abscissa of the inferior point of "y curve" correspond to the ash content of clean sterile "q".

For the coal slurry from 1A settle pound: p = 3, 65 % and q = 86 %

The statistic index for concentration proposed by Preigerson, for the coal slurry from 1 A settle pound is:

$y = 100 \cdot \frac{\sigma}{a}$, where a = 51, 24

$$\sigma = \sqrt{\frac{\sum (c_i - a)^2 \cdot v_i}{100}} = 22,41 \quad \Rightarrow \quad y = 100 \cdot \frac{22.41}{51.24} \Rightarrow \mathbf{y = 43,73}$$

Looking at this index and also to the HR curves we can conclude that the coal slurry from 1 A settle pound has a very difficult preparability.

For 1B settle pound the results are presented in table 2 and the curves HR in figure 2.

Table 2. *Densimetric composition established on the average of the slurry coal sample from 1 B settles pounds*

Densimetric fraction	**Weight extraction v_i %**	**Ash content y_i %**	$\sum v_i$ %	$\sum v_{i-1} + \frac{v_i}{2}$	$c_i = \frac{\sum v_i \cdot y_i}{\sum v_i}$	$\frac{100a - \sum v_i y_i}{100 - \sum v_i}$
	0	2,7	0	0	2,7	38,28
-1.3	6,39	2,73	6,39	3,20	2,73	40,71
1.3-1.4	8,69	5,18	15,08	10,74	4,14	44,34
1.4-1.5	3,49	9,51	18,57	16,83	5,15	45,84
1.5-1.7	4,00	13,56	22,57	20,57	6,64	47,50
1.7-1.9	2,39	29,00	24,96	23,77	8,78	48,09
+1.9	75,04	48,09	100,00	62,48	38,28	62,48
TOTAL	100	62,48	-	100,00	-	-
					a = 38,28	

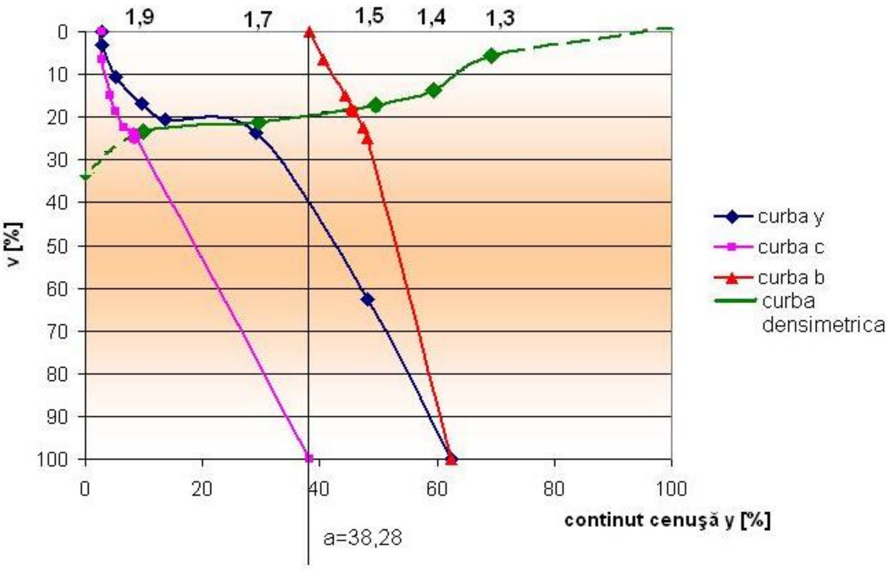

Figure 2. Densimetric curve HR for coal slurry from 1 B settle pound

For the coal slurry from 1B settle pound: p = 2,7 % and q = 62,48 %. The statistic index for concentration proposed by Preigerson, for the coal slurry from 1 B settle pound is:

$$y = 100 \cdot \frac{\sigma}{a} \quad \text{Where} \quad a = 38,28$$

$$\sigma = \sqrt{\frac{\sum (c_i - a)^2 \cdot v_i}{100}} = 16,76 \Rightarrow y = 43,80$$

Looking at this index and also to the HR curves we can conclude that the coal slurry from 1 B settle pound has a very difficult preparability.

For the second (2) settle pound the results are presented in table 3 and the curves HR in figure 3

Table 3. *Densimetric composition established on the average of the slurry coal sample from second (2) settles pounds*

Densimetric fraction	Weight extraction v_i %	Ash content y_i %	$\sum v_i$ %	$\sum v_{1-1} + \frac{v_i}{2}$	$c_i = \frac{\sum v_i \cdot y_i}{\sum v_i}$	$\frac{100a - \sum v_i y_i}{100 - \sum v_i}$
	0	5,2	0	0	5,2	73,82
-1.3	6,38	5,32	6,38	3,19	10,10	78,16
1.3-1.4	8,69	10,10	15,07	10,73	17,09	83,89
1.4-1.5	3,46	22,22	18,53	16,80	19,39	86,20
1.5.-1.7	4,04	29,41	22,57	20,55	25,96	87,77
1.7-1.9	2,38	56,10	24,95	23,76	32,21	91,5
+1.9	75,05	91,52	100,00	62,48	73,82	98,00
TOTAL	100	98	-	100	-	-
					a = 73,82	

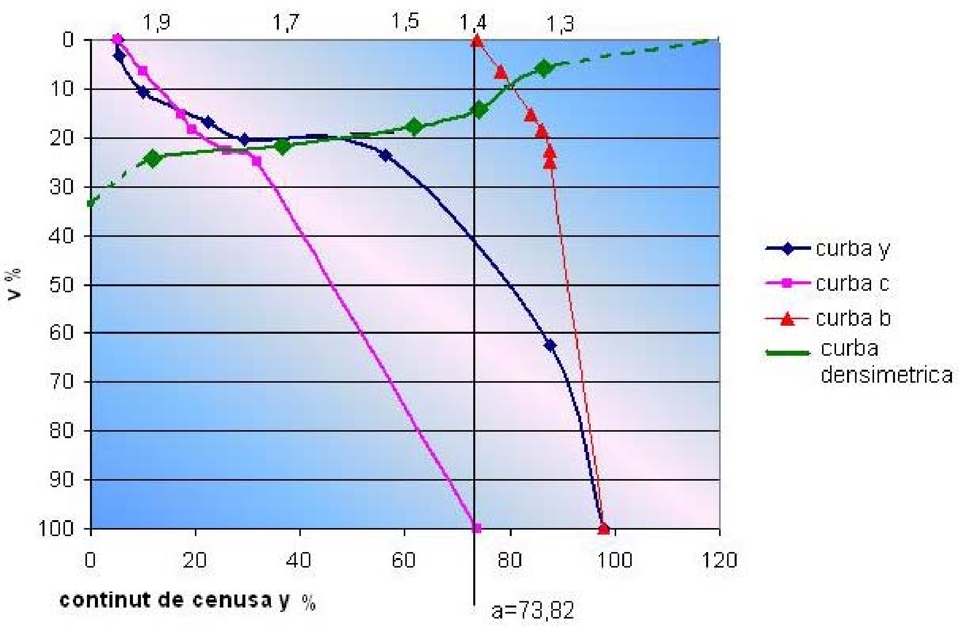

Figure 3. Densimetric curve HR for coal slurry from second (2) settle pound

The statistic index for concentration proposed by Preigerson, for the coal slurry from second (2) settle pound is

$$y = 100 \cdot \frac{\sigma}{a} \quad \text{Where} \quad a = 73,82$$

$$\sigma = \sqrt{\frac{\sum (c_i - a)^2 \cdot v_i}{100}} = 27,92 \Rightarrow y = 37,82$$

Looking at this index and also to the HR curves we can conclude that the coal slurry from 1 B settle pound has a very difficult preparability.

Choosing the best method for coal slurry from Coroesti settle pounds is a problem that depends by many factors and the most important are:

- Coal slurry characteristic
- The association between coal fraction and sterile
- Concentrate utilization
- Water supply

Coal slurry from 1 A settle pound, with ash average content of 51, 24 it is situated in beneficiary request limits (under 53%) and it can be valorize as it is.

If from the coal slurry from 1 B settle pound is separated 0,040-0 mm class, and from the second (2) settle pound is separated 0,125-0 mm class, which has a high quantity of ash we can obtain a weighted average ash without class 0,040-0 mm (a') for 1B settle pound and a weighted average ash without class 0,125-0 mm (a'') for the second settle pound (table 4). The ash value after this process is much lower than the initial one. So it can be made a separation process of class under 0.040mm for 1B settle pound and under 0.125 for the second (2) settle pound. And the rest of coal slurry can be processed in flux for a hydro cyclone preparation and sold (because it has a lower ash quantity).

Table 4. *Comparison between weighted average initial ash and weighted average ash without 0,040 - 0 mm and 0,125-0 mm classes*

Granulometry class [mm]	**Ash average content %**		
	1A settle pound	**1B settle pound**	**2 settle pound**
weighted average initial ash (a) %	51,24	38,28	73.82
weighted average ash without 0,040 - 0 mm (a') %	27,89	15.58	62,99
weighted average ash without 0,125-0 mm (a'') %	-	-	58.15

Flux diagram using hydro cyclone method for coal slurry preparation is presented in figure 4.

Coal slurry form Coroesti settles pound is temporary kept in a tank (1) from where with some screw feed (2) gets is an attrition mill (3). Here it is produced a 0.5 dilution and the attrition process. From the mill the material gets in hydro cyclones (4) and then coal fraction gets in a vibrant screen (6) and in a centrifugal with vertical pivot (7) for drying. The resulted product (which will have humidity lower than 12.5 %) will represent the final product and will be transported in a silo with some belt travelling (8). The water resulted from the process together with very fine suspension particles which could not be separated are collected in an equaliser basin (9), and sent for cleaning. Clean water is re circulated and solid fraction is sent to press filters.

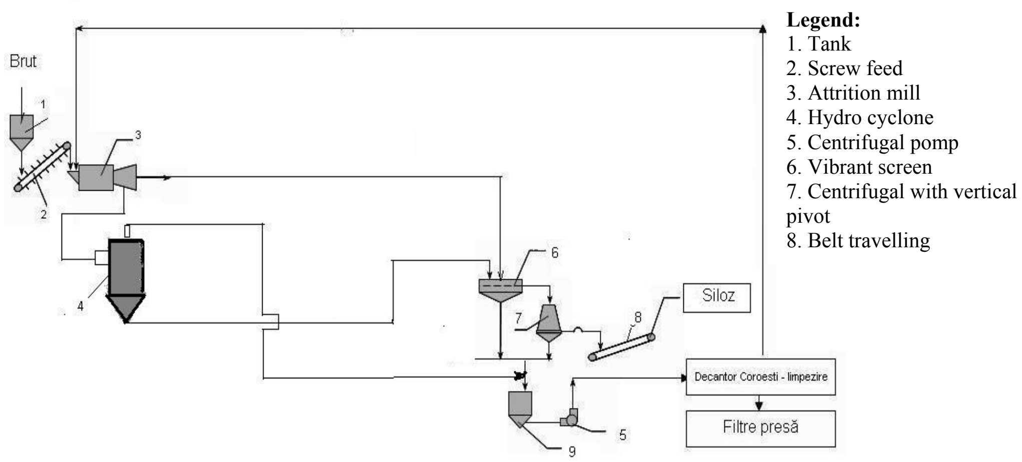

Figure 4. Flux diagram using hydro cyclones for coal slurry from Coroesti

CONCLUSIONS

Because the perspectives for Coroesti settle ponds will be empting and valorize the existent coal slurry it is necessary to study the processing methods.

The study establishes a flux for processing coal slurry from Coroesti settle pounds using hydro cyclone method.

BIBLIOGRAPHY

[1]. Ionel Crăescu, Sanda Krausz, Romulus Sârbu, Dumitru Constantin, Nicolae Haneş – *Utile mineral substances processing*, Bucharest, 1982
[2]. Luigi Dobrescu – *Utile mineral substances preparability* – Bucharest 1978
[3]. Luigi Dobrescu – *Coal preparation*, Bucharest, 1963
[4]. Sârbu Romulus Iosif –*Gravitational preparation* –First part, Petroşani 1993
[5]. Sârbu Romulus Iosif –*Gravitational preparation* –Second part, Petroşani 1993
[6]. x ^{x} x - Petroşani University – *Study: „Research for establish the chemical composition of coal's ash from Jiu Valley*" , 1995
[7]. Cristea N, ş.a. – *Valorizing the quartziferous sand from Husnicioara mine*, 2008
[8]. Sârbu R, Sârbu R jr., Sârbu N – *Hydro cyclone with additional water current*, Invention Brevet OSIM nr. 119930/30.08.2006

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RESEARCHES REGARDING THE INERTIZATION OF THE CHEMICAL MUDS WHICH HAVE A CONTENT OF HEAVY METALS

CAMELIA BĂDULESCU*
EUGEN TRAISTA*

Abstract: *The paper present the inertization solutions used at a world-wide and national level and the researches regarding the inertisation of the chemical muds resulted from purifying the mine water.*

Key words:*inertization, chemical muds, cement, sodium silicate, electric conductibilities.*

The statistics and the observations from the national level indicate the water and soil pollution as one of the most visible effects of the mining activities. Near the mines, the waste dumps, near the decantation ponds and near the processing plants of the ores, the surface and the underground waters are polluted with heavy metals (Pb, Cu, Zn, Cd, Cr etc), species which are dangerous for the aquatic biocenosis and for the man, and with a high bioaccumulation potential. The main vector of the pollution with heavy metals represent the mining waters, with a variable pH, acid in general and with a high content of salts.

The reorganization of the mining sector in Romania implicated the stopping of the activity of hundred of mines, nowadays assuring the protection measures of the environment being of a big importance.

Assuring an adequate framework for the promotion of an environment management to an European level is imposed by the Romania's adhere to UE, the execution of all the assumed commitments in the field of the environment's protection regarding the mining activity being necessary.

* *Assoc. Prof. Eng. Ph.D. -University of Petroşani*

1.The main legislative aspects concearning the treating/depositing of the waste

In the year 2006, at the European's Union level the ***Directives 2006/21/CE*** was adopted, regarding the management of the waste resulted from the extractive industries of the member countries, which had as a term day for transposing it into the national legislations, the date of 1st of May 2008. The directives regulates the management of the waste resulted from the extractive industries.The national legislation transposes through HG856/2008 this directives, regulating the management of the waste resulted from the extractive industries, originating from activities developed on dry land, respectively of the waste resulted from prospecting and extracting activities, including the phase of development anterior to the putting in production, the treating and the storage of the mineral resources, and that of the materials resulted from the extraction in the pit. The directives introduces community rules for preventing the water and soil pollution as a result of long time depositing in decantation ponds or in the waste dumps.The purifying of the mining waters leads to the forming of muds which need to be managed according to the national legislation regarding the waste depositing (HG 349/2005) and the management of the waste resulted from extractive activities (HG856/2008).

1.1. Criterions for the accepting of the waste to depositing

According to HG 349/2005 regardind the waste depositing, the deposits are classified depending on the nature of the deposited waste, as follows:

- Deposits for actionless waste;
- Deposits for waste which are not dangerous;
- Deposits for dangerous waste.

  According to HG 349/2005 regardind the waste depositing, the criterions for collecting and treating the leaching, the collecting and evacuation systems of the deposit gas;
- Assuring the normal development of the processes of stabilization of the waste in the deposit;
- The protection of the human health;

And the accepting of the waste to a certain depositing class is based on:

- The lists of accepted waste, defined after nature and origin;
- The characteristics of the waste determined through standardized analysis methods, an exception being the domestic waste.

  The criterions of accepting the waste in a depositing class, based on the characteristics of the waste, refers to:
  - The physical-chemical composition;
  - The content of organic substance;
  - The capacity of biodegradation of the organic compounds from the waste;

- The concentration of the compounds potentially dangerous/toxic in relation to the criterions mentioned above;
- The presumed or tested leaching capacity of the potentially dangerous/toxic compounds in relation to the criterions mentioned above;
- The ecotoxicologic properties of the waste and of the resulted leaching.

2. Inertization solutions used at a world-wide and national level

2.1. On world-wide level

In the European Community the priorities and the directions from this field are focused on the development of the recicling solutions and of the limitation of the volume of unrecicable waste. Problematical are the modalities through which the quantity of unrecicable waste will be anihilated that so the impact on the environment to be minimum and controled or to be eliminated. In this regard we present the following cknown objects and the stage existing at the world-wide level: the Institute of Chemical Technology from **Prague- Cech** Republic proposes the acid leaching of the dangerous sludges followed by the selective precipitation in more stages, and that is: the trivalent metal's precipitation, Cu, Cd, Ca, Mg and Si; the oxidative precipitation of the manganese and finally, the precipitation of the zinc as a carbonate.

The method proposed by the University from **Nis- Serbie** implies the inclusion of the heavy metals from the sludges (Cu, Cr, Cd, Ni, Pb, Zn) in ceramic bottles very resistent from a chemically point of view to the action of the substances with an acid and alkaline character.

In the United States of America it's applied a method licensed 6962562 which implies the calcination of the toxic waste, their treating with phosphoric acid and the achievement of a product

In **Turkey** was proposed the mixture of the dangerous waste with portland cement, this way resulting an actionless mass. Another **American method** licensed 6843617 implies the fixing of the toxic metals in the water from the waste's pores, by controling the physical- chemical parameters wich influence the leaching: pH and redox potential. In Portugal is prepared a inertisation technology of the toxic metals from the sludges by fixing them in ceramics based on clay.

2.2. On National level

Depending on the methods applied, the inertisation technologies can be grouped as it follows:

- Chemical processes based on the addition of reagents
  - Based on cement;
  - Based on Pozzolan (vulcanic ash);
  - Based on chalk;
  - Based on phosphate;

  - Based on special additives;
  - Mixed.
- Physical processes:
  - The macroincapsulization/ conteinerisation;
  - The microincapsulization without addition of chemical reagents.
- Thermical processes:
  - The incapsulization with the help of thermoplastic polymers;
  - The vitrification.

Nowadays it doesn't exist a specific technology, efficiently 100% for a certain waste or a class of waste. The selection of the adequate one is made using the characterization data of the waste and based on thelaboratory experiments meant to establish the optimum parameters of operation.

The verification of the proposed technologies eficiency is made on laboratory level on the bases of the standardized leaching tests correlated with the legislation regarditnd the depositing on depositing classes of the waste produced by the industrial and domestic activities.

The leaching tests have in view the degree of solubility in time of the inorganic and organic components based on some calculating formulas which lead to the determination of the concentration limits of the pollutings rendered soluble in the leach that so the tested waste to be accepted in a certain depositing location, especially arranged.

1. **Technologies based on the usage of the Portland cement**

   The technology of stabilization/solidification based on the Portland cement was applied for the first time in 1950 in the field of the nuclear waste. Nowadays is the most used inertisation system of the waste from many activity fields including the ones with a content of heavy metals.

During the reactions of stabilization, the water from the structure of the waste reacts with the cement forming hydrated silicates and aluminium/aluminous compounds and the other constituents form an aggregate „concrete" type whose hardness depends on the composition and on the initially quantity of water.

The calculation formula of the mixture's composition for stabilization is determined through laboratory studies depending on the type of waste and on the properties which needs to have the final product for depositing. The content of heavy metals plays an important role for the degree of hardness of the final product.

2. **Technologies based on cement/soluble silicate**

   The technology is based on the reactions between the soluble silicates and the Portland cement in order to obtain a controled matrix. There were defined three classes of reactions:

   - Fast reactions between the soluble silicates and the majority of the polivalent metalic ions resulting metalic silicates with a reduced solubility;

- Slow reactions between the soluble silicates and the constituents of the Portland cement which allow the control of the final product's structure from which the mechanical resistance is extremly important;
- Reactions between the waste, the Water and the Portland cement.

The elements which influence the obtaining of a final product with a low degree of leachingness of the heavy metals are as it follows:

- The dose of silicates added that so the leach won't contain big quantities of metalic complexes with silicon;
- The dosage speed of the soluble silicates on which depends the quality of the gel formed and the degree of permeability of the final product;
- The manner in which the components are mixed;
- The temperature.

Nowadays exist more similar technologies which are based on the addition of ash, clay and furnace powder or other ingredients which contain insoluble calcium and aluminium silicates.

3. Technologies Pozzolan Type

➢ **The system cement/ash**

The usage of the mixtures of Portland cement and „flying" ash in the processes of stabilization- inertisation- solidification is known from several decades leading to the improving of the costs by replacing up to 35% of the cement, expensive material. The ash represents an efficient additive for increasing the viscousity and for preventing the separation of the phases, but its utilisation has the disadvantage of increasing the volume of the final product. In general the proportion of the masses between the quantity of ash and the one of cement is 2:4.

➢ **The system lime/ash**

In the field of the technics S/S, the lime is another term which defines the fast lime, the hydrated lime and the hydraulic lime. Its combination with ash leads to the forming of a material cement type. The initially reaction product is a uncrystalline gel which becomes hydrated calcium silicate, compound which exists in the composition of the hydrated Portland cements. The reactions are in general more slow and don't lead exactly to products similar to the ones obtained through the Portland method. The ash used in this technology is the ash resulted through the burning of the coal in power stations.

The system destabilization- inertisation- solidification with lime and ash can be applied to the treatment of the waste with complex matrixes which can contain more than 20% organic matter. From the point of view of the stabilization of the metalic constituents, the method is less efficient than the systems based on cement.

➢ **The system furnace powder**

The powder from the burning furnace and the one from the furnace which product the cement is intensivly used in The United States, being very efficient in the case of the acid waste.

It presents the advantages of a fast solidification which continues in time and its unmonolithic final products, which are many times prefered to be deposited, in comparison to the monolith blocks, which don't settle in time and therefore don't produce free space for depositing.

The main disadvantage is given by the big quantity of additive 50-200%, in comparison to the mass of the waste which needs to be stabilizated.

4. Technologies based on the addition of phosphate

The technology stabilization- inertisation of the waste by adding phosphates is more recent and was borrowed from the field of treating the used waters, having into view the reduction of the solubility of some constituents by precipitation as phosphates.

By adding only phosphates in the composition of the waste it won't obtain a depositable solid preoduct, but contributes to the improving of the quality of the final product resulted by adding cement. Sometimes the method is considerated as a variant of the stabilization systems based on cement or the ash in which the phosphate is an additive.

The addition of phosphate contributes to the diminuation of the leachingness of the compounds with lead especially due to the reduced solubility of the final products in a large field of pH.

5. Other unclassified technologies

On the market of the S/S technologies exists a big number of methods which can't be included in the classes previously presented, but which can be applied in certain specific fields:

- Processes based on the addition of **gypsum**: the utilisation of the semi-hydrated calcium sulphate is used only in the sector of the nuclear waste;
- Processes based on the addition of **furnace slag**: can be considerated as variants of the cement and Pozzolan type methods; it isn't a commercial technology and exist a few informations on this subject in the special literature;
- Processes based on the addition of **emulsified asphalt**;
- Processes based on **absorbtion phenomenons** (active coal, organic clay, rubber) and on the addition of surfactants.

6. Technologies based on thermic and physical processes

This class of stabilization- inertisation- solidification technologies was studied a lot in the last years but didn't know an extinded commercial development, with the exception of the sector of the nuclear waste.

- The **vitrification-** thermic method which transforms the waste into glass and/or chrystalline materials.

Usually, the vitrification takes place at temperatures ≥1200° C (electric heating in the fusion, external heating through convection, conduction and radiation, heating through induction and heating with plasma). To these temperatures, the metals form oxides in the glass mass and others (lead, chromium) integrate in its structure.

The technology leads to the obtaining of a final product with a low degree of leaching of the heavy metals and has the advantage of reducing the volume which usually is of 10-30% but which may get even to 80% for certain types of waste.

In our country too were realized studies for the inertisation of the metalic compounds (oxides) through vitrification.

- **Processes which use thermoplastic polymers**
- **The incapsulization in the absence of high temperatures**
  - the microincapsulization (with organic polymers)
  - the macroincapsulization (conteiners)

The selection of the optimum stabilization- inertizare- solidification technology for waste with a high content of heavy metals (including galvanic muds or ores from the extraction/processing industry) depends on several factors: the composition of the waste, the conduct of the primary waste to leaching, the laboratory results regarding the degree of recuperation of the useful constituents, optimum treating technologies, S/S technologies available on the local market, preoportion costs/ efficiency, the existing depositing capacities.

3.Researches regarding the inertisation of the chemical muds resulted from purifying the mine water

The purification of the used waters, in oreder to evacuate it in the natural receivers or of its recyclation, leads to the retaining and to the forming of some important quantities of muds which contain both the impurities contained by the raw waters and the ones formed in the purification process.

From a physical point of view, the muds are consdered complex colloidal systems, with a heterogeneous composition, containing colloidal particles, dispersed particles, aggregates, materials in suspension etc, having a gelatinous aspect and containing a lot of water. Defined from a technologically point of view, the muds are considered as the final phase of the water's purification, which contains products of the metabolic activities and/or primary matters, intermediar products and final products of the industrial activity.

The quantities of mud which are retained in different purification stages are variable from one source to another, depending on the physical-chemical characteristics of the raw water, on the method and on the degree of purification imposed.

In order to characterize the muds, general indicators are used,as:

-humidity;
-density;
-pH;
-the mineral-volatile proportion;
-calorific power etc.

And other specific indicators like:

-fertilizing substances;
-surfactants;
-metals;

-oil and grease etc.

Based on the determinations performed from the muds resulted from the purification of the mine waters (muds from the purifying stations), resulted the following variation fields of their composition:

Table 1. The content of metals from the chemical muds

Variation fields of the content of metals in muds resulted from the treating of the mine waters	
Element	**Variation field g /kg s.u.**
Zn	0.75 – 61
Mn	0.8 – 70
Fe	56 – 406
Al	4 – 67
Cu	0.05- 76
Pb	< 0.02 -0.3
Cd	0.015- 0.20
Ni	<0.08- 0.43

3.1. Laboratory researches regarding the inertisation of the muds with cement and sodium silicate

The attempts of inertisation of the muds were performed using cement in different percents and sodium silicate.

By using the method of optimising the gradient was established the optimum inertisation recipe, taking as variables the consume of cement and sodium silicate and as a response function the electric conductibility of the eluat.

Tabel no.2. presents the consume of composite materials and the electric conductibilities obtained for the 6 inertisation recipes tested for the mud from the experiments.

Tabel 2. The electric conductibility of the inertisated mud determined to different consumes of composite materials

Materials / **No.test**	***Cement***		***Sodium silicate***		***Electric conductibility***
	g	%	g	%	[S/m]
1	20.0	15.38	10.0	7.69	0.0732
2	15	12.24	7.5	6.12	0.1050
3	25.0	18.86	7.5	5.66	0.0510
4	15.0	11.76	12.5	9.8	0.0908
5	**25.0**	**18.18**	**12.5**	**9.09**	**0.0477**
6	19.88	15.3	9.99	7.69	0.0805

After the inertisation experiments, according to the programming matrix for the two variables, were determined the following optimum consumes of materials:

-basin mud 1-73%;

-cement 18%;

-sodium silicate 9%.

The technology tested for the inertisation of the muds in the variant cement+ sodium silicate, applied for the muds originating from the purifying stations of the mine waters, is represented in the figure no.1:

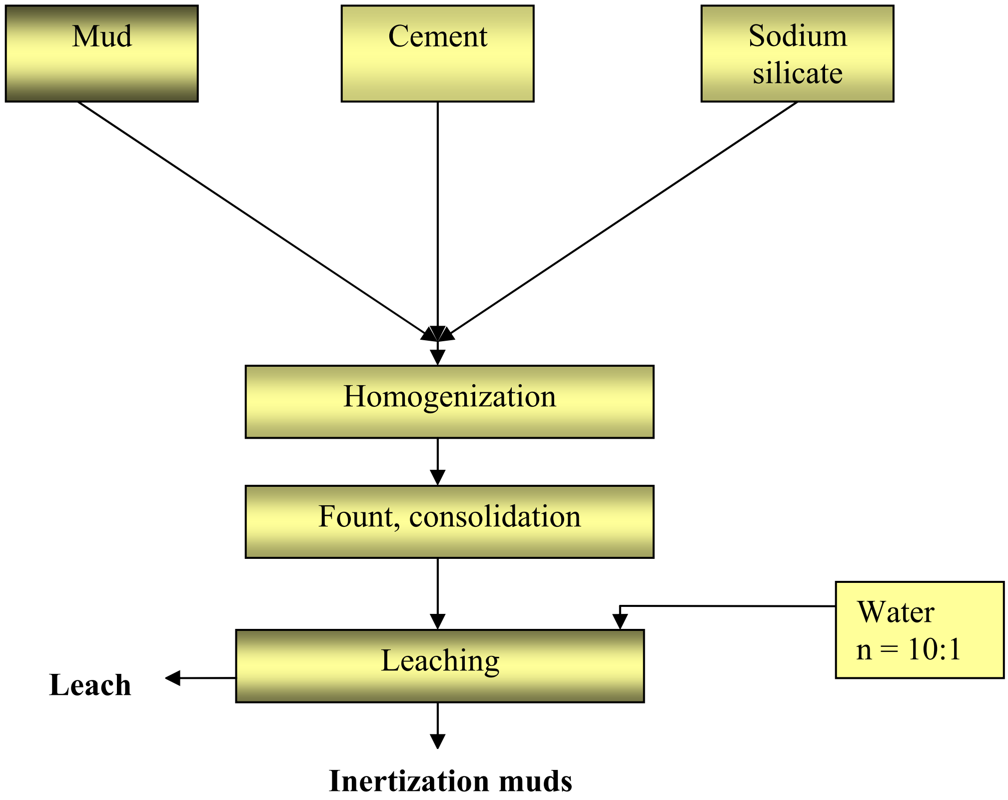

Fig.1. The technologic scheme of mud inertisation

3.2. The testing from the chemically point of view of the material inertisation through the technique cement+sodium silicate

After 7 days (the time it takes to the material to harden), were performed the leaching tests in the following conditions:

-the hardened material breaks into pieces, diluate with water (whose electric resistivity was previously determined);

-the work dilution is of 10:1;

-the electric conductibility of the water used for dillution was determined;

-after 24 hours the electric conductibility of the leach is determined, parameter which represents the response function;

-the pH of the leach integrates in NTPA001/2005 regarding the evacuation in the emissary. The electric conductibilities of the leach and their pH are presented in table no.3.

Table 3. The electric conductibility and the pH of the leach

Sample	pH	Electric conductibility
Chemical mud	7.65	0.0477

The conductibility of the water used for dillution was 85.7 (µS ⁄ cm).

In table no.4 are presented the results of the chemical analyses performed on the leach sample (**L/S = 10 l/kg).**

Table 4. Inertisated chemical mud

Analyzed indicator	**UM**	**Value**	**Inertisated waste**	**Not dangerous waste**
			mg/kg dry substance	mg/kg dry substance
pH	mg/kg	**7.65**		
As^{2+}	mg/kg	**0.00**	0.5	2
Ba^{2+}	mg/kg	**0.08**	20	100
Cd^{2+}	mg/kg	**0.00**	0.04	1
Cu^{2+}	mg/kg	**0.14**	0.5	10
Cr^{3+}total	mg/kg	**0.03**	2	50
Hg^{2+}	mg/kg	**sld**	0.01	0.2
Mo^{2+}	mg/kg	**sld**	0.5	10
Ni^{2+}	mg/kg	**0.01**	0.4	10
Pb^{2+}	mg/kg	**0.02**	0.5	10
Sb^{2+}	mg/kg	**sld**	0.06	0.7
Se^{2+}	mg/kg	**sld**	0.1	0.5
Zn^{2+}	mg/kg	**0.87**	4	50
Cl^{-}	mg/kg	**sld**	800	15000
Fluoruri	mg/kg	**sld**	10	150
SO_4^{2-}	mg/kg	**208**	1000 (*)	20000
Indice de fenol	mg/kg	**sld**	1	
DOC	mg/kg	**sld**	500	800
TDS	mg/kg	**530**	4000	60000

The results of the chemical analyses show the fact that the leach obtained after the inertisation of the muds is characterized through a reduced content of impurifications, especially of heavy metals.

3.3. The influence of the cement content over the electric conductibility

The experimental attempts performed in order to establish the influence of the content of cement over the electric conductibility of the leach performed in the followinf work conditions:

-the content of sodium silicate considered as optimum (9,09%) from the experiments presented above was kept;

-was kept constant the quantity of mud submited to the inertisation;

-the content of cement was variated, starting from 0% up to 30%;

-the time necessary for the material submited to the inertisation to harden was of 7 days;

- the leachingness of the inertisated material was performed in the same conditions as the ones presented previously;

-the parameter studied was the electric conductibility of the leach.

The results obtained showed the fact that to an increase of the content of cement over a certain limit, this one doesn't have with what to react, increasing the electric conductibility of the leach.

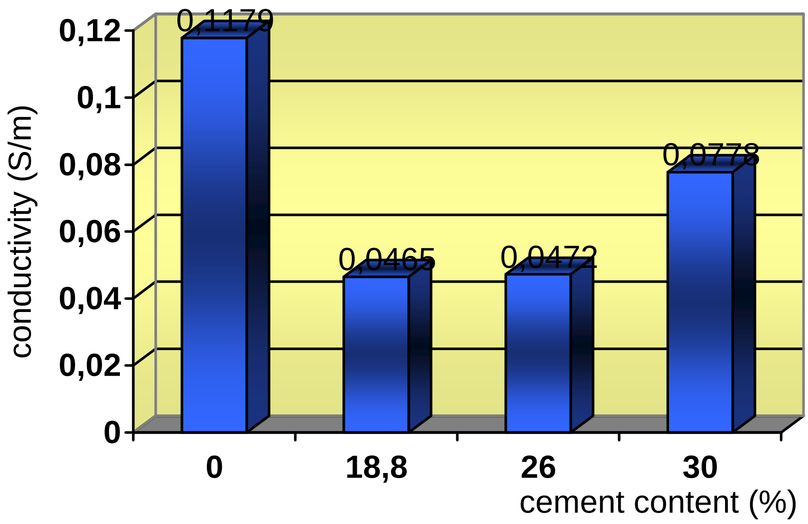

Fig. 2. The variation of the electric conductibility of the leach with the content of cement

CONCLUSIONS

- the muds resulted from the mine waters of the mining exploitations of polimetalic ores belong to the category of dangerous waste whose depositing has to be strictly controled;
- under the action of the environmental factors (water, air) and especially of the microorganisms, these industrial waste suffer transformations with forming of chemical and acid compounds(especially sulphuric acid) which lead to the impurification of the surface and underground waters;
- the materials used for the inertisation of the chemical waste were the sodium silicate and the cement. The purpose of the utilisation of these composite materials was of forming silicate through the reaction, in liquid environment, between the silicon dioxide and the oxides of the heavy metals- in this case. The role of the cement was that of fixing the silicate on the heavy metal and of increasing the resistence to compression;
-the experimental trials performed on the mud samples collected from the mining field Baia Mare, focused on their inertisation, using as composite materials the cement and the sodium silicate;
- the deteremination of the optimum consumes of inertisation materials was established using the method of optimising the gradient, the response function being the electric conductibility of the leach;
- to a consume of 18.8% cement, 9.1% sodium silicate the electric conductibility of the leach for the sample experimental mud was of 0.0477s/m.
- the chemical analyses performed on the leach show the fact that the contents of heavy metals are located under the limit values admitted, corresponding for not dangerous waste even under the values admitted for actionless waste. The stabilization of the muds inertisation through the utilisation of sodium silicates needs to be studied on a long term;

REFERENCES

[1]. Anghelescu-Dogaru A. G., Popescu I., Chitanu G. C., *Maleic polyelectrolytes as ecologically favorable additives in chrome tanning process*, Journal of Environmental Protection and Ecology (JEPE), 5, 00-00, 2004.

[2]. Azzam R. A. I., *Agricultural polymers. Polyacrylamide preparation, application and prospects in soil conditioning*, Commun. Soil Sci. Plant Analyses, 1-8, 767-834, 1980.

[3]. I.Dumitrescu, E.Traistă , C.Badulescu – *Reducerea impactului deseurilor solide periculoase asupra mediului prin tehnologii de inertizare în conformitate cu aquisul de mediu al U.E.* , contract CEEX 304/2006;

[4]. De Boodt M. F., *Synthetic polymers as soil conditioners: 35 years of experimentation. In: Water saving techniques for plant growth*. (Ed. H. J. W. Verplancke et al.), Kluwer Academic Publishers, Netherlands, 137-161, 1992.

[5]. Lăcătuşu R., *Metodă pentru evaluarea nivelului de încărcare şi de poluare a solurilor cu metale grele,* Ştiinţa solului, vol. XXIX, 2, S.N.R.S.S., Bucureşti, 1995.

[6]. www.ecologie.rec.ro – ordinul nr.95/2005 privind stabilirea criteriilor de acceptare a deşeurilor la depozitare;

[7]. A.Simionescu – *Optimizarea proceselor de preparare a substanţelor minerale utile,* Ed.Tehnică, Buc., 1978.

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LIMONITE CONCENTRATION FROM MUD

NADEŽDA ĆALIĆ[*]
MIROSLAV GLUŠAC[**]
MIROSLAV IGNJATOVIĆ[***]

Abstract: *Morphological and structural characteristic of limonite ore from some beds or mineral bodies, already at excavation, cause getting of large quantity of mud of size class below 30 µm. Each further procedure increase share of these classes, from which it is not possible to derive concentrate of satisfactory quality utilizing ordinary mineral processing procedures, and therefore it often represent waste not convenient for disposal. Known procedures of limonite concentration from mud are analyzed in this paper, which technological results depend very much on mineral content, and which include selective flocculation of limonite. Particularly, results of laboratory testing of limonite concentration are presented, utilizing high gradient magnetic concentration, together with foregoing treatment of mud by surface active compound, which acts as dispersant, and simultaneously decreases medium resistance to particle move.*

1 INTRODUCTION

Limonite contains relatively high percentage of crystalline water, so that, without preliminary magnetizing roasting, it is not possible to get concentrate with over 55% of Fe by the mineral processing methods.

The procedure of limonite ore concentration at the first place depends on limonite content. The most often used are washing and desliming, gravity concentration and magnetic concentration in the high intensity field, and for fine classes, also in the high gradient field. Limonite belongs to the group of weakly magnetic minerals. Specific magnetic susceptibility of limonite amounts 250-760 m^3/kg (Svoboda, 1987, 22).

In the process of limonite ores grinding, as a rule, big quantities of fine classes are produced, which often contain high percentage of limonite, and due to that, however concentration method may be successful, recovery of Fe in respect to ore is low, regarding that already in the processes of grinding, washing and desliming of ore, great part goes to waste mud, which is, according to its basic characteristics, between

**prof.PhD. Eng. - Faculty of Mining and Geology, Belgrade Serbia*
*** Ph.D.Eng. - Water supply, Prijedor, Bosnia and Herzegovina*
****Ph.D.Eng. - Serbian Chamber of Commerce, Belgrade, Serbia*

colloidal solution, in which the particles are below 1 μm, and suspension of particles of few hundreds of μm.

The basic problem, which appears at the separation of different mineral components from mud is the fact that the mud is pseudo colloid state, when the activity of physical forces, characteristic for concentration by the mineral processing methods, such as gravitation, magnetic or electric forces, practically do not influence on solid particles according to laws of physics, than more expressed are the Brown move forces, intermolecular forces, electrostatic forces of attraction and retraction, Van der Waals forces of attraction, viscosity, due to which the resistance to particle move forces of the medium grow enormously.

System destabilization can be in theory achieved in two ways:

1. By flocculation, that is by aggregation of more, sometimes more tenths, of particles in flocculi by the use of chemical reagents,
2. By magnetization of weakly magnetic minerals as it is limonite, and
3. By decrease of the resistance of the medium to particle move.

2. FLOCCULATION

In mineral processing muds, in which the chemical composition of solid particls is saisfactory, may be interestig, for instance, mud from limonite ore containes over 50% of Fe with the satisfactory participation of other usefull or adverse components, and muds which represent potential raw material from which it is necesary to separate two or more different solid phases, that is different mineral components.

In that case flocculation may be applied for efficient separation of liquid phase by the increase of separation kinetics, that is, by the increase of water squeezing in the process of precipitation or move of floccules under the action of differences in pressures. Much more demanding procedure is selective flocculation of certain mineral sorts from mud of complex mineral structure. Selective flocculation of little particles can be realized by the activity of attraction magnetic forces or by the addition of chemical reagents – flocculants Georgios N. Anastassakis, 2002,.

The whole procedure in which selective flocculation is applied, take place in three steps. The first step is dispersing of fine particles, the second step is producing of selective flocculi of certain mineral sort, and the third step is separation of flocculated part, which in mineral processing may represent concentrate or tailings, or two concentrates. Separation of flocculated particles from non flocculated residue may be effectuated by precipitation and desliming, by flocculation or magnetic concentration.

In literature there are more data about successful selective limonite flocculation by the use of starch and poly-acrylic acid. Selective flocculation of iron oxide mixed with kaolin, is realized by the use of modified polyacrylamide which contained hydroxanthic functional groups. After selective hydrophobic flocculation using sodium oleate and kerosene, formed flocculi of very small particles of limonite are successfully separated as a magnetic product of mud which contained 30.5% of Fe. Obtained concentrate contained 54% of Fe, with the recovery of 82%. Moreover, the good results are obtained by magnetic concentration of limonite after flocculation of hydrolyzed and caustic flocculants which are applied for flocculation of very small particles of iron minerals.

A theoretical model of magnetic flocculation of weakly magnetic minerals was shown by J. Svoboda (1982 and 1987). A threshold magnetic field, at which magnetic flocculation begins, was derived, and the dependence of particle size, magnetic susceptibility, and other factors characterizing the mineral suspension were examined. Stability ratios and flocculation rates computed from the model indicate that magnetic flocculation commences provided the total energy of interaction of particles is zero, and simultaneously the flocculation time is reasonably short. The latter condition increases the threshold magnetic field, particularly for large particles. However, for all studied mineral systems (hematite, siderite, goethite) the flocculation magnetic induction is in the range of industrially feasible magnetic fields (0.1-3 T), being higher for larger and less magnetic particles, and lower for fine and more magnetic minerals. Likewise, magnetic flocculation is possible, if magnetic field of adequate intensity is provided. The industrial application of magnetic flocculation in beneficiation of iron ores was outlined.

3. MAGNETIZATION OF WEAKLY MAGNETIC MINERALS

There are two types of magnetization:

a. reduction-roasting, and

b. surface-magnetization.

The former is a common way to enhance mineral's volume-magnetism by roasting-reduction, and is feasible technically, but it is energy-intensive and therefore more costly, and also brings about environmental problems. The latter, surface-magnetization, as a way to enhance surface magnetism, therefore has attracted some attention in recent years, and it mainly includes: alkali-leaching magnetization, electro chemical magnetization, hydrophobic magnetization and magnetic seeding magnetization. Relatively speaking, the last one, magnetic seeding magnetization, is dominant among these surface magnetization methods.

In mineral processing field, the method of magnetic seeding magnetization was also used to recover fine iron mineral particles and tiny magnesite (S. Prakash et al., 1998; G. Anastassakis, 2002). As a special method to separate minerals, magnetic seeding magnetization is restricted by some factors as the magnetic seeds (crude mineral magnetite) must be very fine and have very high purity.

Synthetic magnetic particles adsorb on limonite which has a low specific-susceptibility and magnetize it. Magnetized limonite can be recovered in a quite low magnetic field. The essential of this technology is that magnetic particles are synthesized in slurry by adding metal ion salt and adsorb on limonite surface selectively, and effectively enhance the magnetism. Compared with the previous surface-magnetization techniques, this method doesn't need particular steps for preparing magnetic seeds before magnetization process.

How to make magnetic particles adsorbing selectively on limonite rather than on gangue, namely, selective magnetization, is the most important thing in surface magnetization. The surfactant sodium oleate had a positive role to promote the selectivity between minerals limonite and quartz. The biggest recovery gap between limonite and quartz was when sodium oleate dosage is at $3.3x10^{-4}$mo1/L near of Critical Micelle Concentration.

The introduction of the surfactant into slurry magnetization system could result in competitive adsorption among magnetic seeds, minerals and surfactant ions. As well known, oleic acid is a common flotation collector for iron oxide ores, and oleate ion is prone to adsorb on mineral limonite and magnetic seeds while without a cationic ions as an activator, oleate ions don't adsorb on gangue quartz. These adsorption differences of oleic ion result in the selective magnetization with the aid of sodium oleate. When oleate ion concentration exceeds Half Micelle Concentration, long hydrocarbon chains of oleate ion adsorbed respectively on limonite and magnetic particles would have an association action, consequently strengthening the magnetization of limonite. There are quite a few ways to magnetize weakly magnetic mineral surface, but magnetization occurring in slurry can cut down needless steps. According to the test results above, two conclusions can be drawn:

1. Magnetization of weakly magnetic mineral particles with iron salts was realized directly in slurry, and magnetized mineral particulates tend to aggregate,

2. Magnetization with the aid of the surfactant sodium oleate, synthetic magnetic particles were able to selectively magnetize limonite from quartz in slurry. The principle of this selective magnetization may lie in that oleate ions adsorb competitively between magnetic seeds and minerals limonite or quartz, and that long hydrocarbon chain of oleate ions adsorbed on limonite and magnetic seeds could have a mutual association.

4 DECREASE OF MEDIUM RESISTANCE TO PARTICLE MOVE

In all examinations of small diameter particles move in fluid we start from the very well known Stokes model for medium resistance to particle moves, according to which resistance depends on medium viscosity, and particle diameter and move velocity. Apparent viscosity can be reduced and rheological attributes can be changed by adding a dispersing agent or by lowering the pH value. Both of these actions increase the particle's electrostatic repulsion and dispersion. (Subramanian, S. and Natarajan, KA, 1987, Weissenborn P.K., Warren L.J., Dunn J.G., 1995.) We can say that medium resistance depends also on surface tension at the particle-fluid border (Ignjatovic at all, 1995; Ignjatovic, 1997). That can easily be proved by the dependence of particle move velocity and electro-kinetic potential. Separation (secession) of particle from fluid, under the action of any force which causes its move, occurs on skid plane which is characterized by particle surface electro-kinetic potential. We have shown, on different mineral combinations, that the very fine particle move under the action of an attraction magnetic force may be realized by the decrease of medium resistance to particle move, by the decrease of surface tension at the particle-fluid border, by the addition of surface active reagent with the solidophilic group over which the surface active compound may be adsorbed at the mineral-fluid surface. This reagent, as well as oleate acid, is a common flotation collector for iron oxide ores, and dodecilbenzosulphonate is prone to adsorb on mineral limonite, while without a cationic ions as an activator, oleate ions don't adsorb on gangue.

In this paper only research concerning laboratory examinations relating to the possibilities of limonite magnetic concentration from hydrocyclone overflow of fineness of 45% -0.005 mm is presented, which according to current process flow sheet represents tailings. Results of magnetic concentration without and with the application of dodecilbenzosulphonate, with the aim to decrease the surface tension at the mineral particle-solution contact, are presented. Comparing these results, it was shown that medium resistance to particle move was decreased by this procedure and attrition magnetic force in separator magnetic field prevailed.

5. EXPERIMENTAL

5.1 Sample for examination

In the laboratory examination, sample of mud is taken at the hydrocyclone overflow. According to chemical analyses, a sample contained 44.83% of Fe, 39.62% of MgO, 6.44% of CaO and 11.31% of SiO_2. A hydrocyclone overflow sample of fineness about 95% -30 μm contained 30% of class -9 μm.

Particle size analysis is shown in table 1.

Table 1. Particle size analysis

Size μm	Weight %	Weight %↓	Weight %↑
Sample (feed)	100		100
-0.074+0.038	4.51	4.51	95.49
0.038+0.018	39.21	43.72	56.28
0.018+0.009	26.28	70.00	30.00
0.009+0.000	39.00	100	

5.2 Reagents

For the decrease of medium resistance to particle move, sodium dodecilbenzosulphonate, surface active compound, which is also contains solidophilic group, was used, so that it can also be successively adsorbed at the surfaces of solid phase, with the purpose of selective or non-selective flocculation prevention.

5.3. Procedure of examination

Zeta potential in function of pH was determined by measuring of electrophoretic mobility of particles in horizontal tube of Riddiks Zeta meter. The pH value was adapted by means of HCl, p.a. and NaOH and sodium dodecilbenzosulphonate as surface active agents.

Magnetic concentration laboratory examinations, which results we show, were performed on a hydrocyclone overflow sample, taken during industrial examinations.

Before magnetic concentration in the laboratory high gradient and high induction separator of type SALA at the induction of 1,6 and 1,9 Tesla..

The sample was conditioned 5 minutes with the addition of sodium dodecilbenzosulphonate in amounts of 10, 20 and 30 g/t of solid phase in overflow.

6 RESULTS AND DISCUSSION

The electro kinetic measurements of limonite were performed against pH in the presence of HCl or NaOH as regulators of pH value and sodium dodecilbenzosulphonate as surface active agents collectors, and the results are shown in Figure 1.

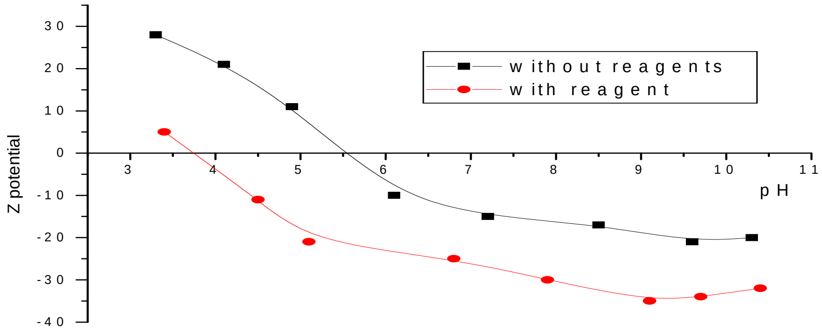

Figure 1. The zeta potential of limonite as a function of pH without and with 50 g/l sodium dodecilbenzosulphonate

According to these results, the iso-electric point of limonite was found to occur around pH 5.5. As we can expect, the presence of dodecil-benzosulphonate change the pH value of iso-electric points. However, in the presence of this agent, the surface of limonite changes, and becomes less positive or more negative. These results indicate that dodecilbenzosulphonate specifically adsorbs into the surface of limonite what provoke decrease of free surface tension and decrease the difference in the polarity between two phases: mineral - fluid. This influence on the resistance of particle motion.

In the magnetic concentration laboratory experiments the hydrocyclone overflow sample, as feed, without the addition of surface active reagent, was used. Concentrates are obtained with the content of Fe which mainly correspond with the content of Fe at the feed of magnetic concentration, that is, correspond with the content of Fe in the hydrocyclone overflow. These results, as not interesting, are not presented in this paper. Namely, obtained concentrate, as a magnetic fraction, contained 45.83% of Fe, and tailings, as a non- magnetic fraction, contained 44.82% of Fe, at the magnetic induction of 1.6 T, and somewhat better results, but still below the requirements, were achieved at the magnetic induction of 1.6 T, that is, concentrate, as a magnetic fraction, contained 47.68% of Fe, and tailings, as a non-magnetic fraction, contained 42.92 of Fe.

The results of magnetic concentration experiments obtained in the presence of surface active compound, which was added to decrease the medium resistance to particle move in the direction of magnetic or gravitation force, are shown in Tables 2 and 3.

Table 2. Metal balance with 10, 20, and 30 g/t Na-dodecilbenzolsulphonate and induction of 1.6T

Product	**Weight %**			**Fe %**			**Recovery of Fe %**		
Feed	100.0	100.0	100.0	41.87	42.31	43.27	100.0	100.0	100.0
C/Fe	58.1	49.0	48.1	50.18	51.11	51.12	65.4	65.2	60.0
Middlings	26.9	25.4	25.7	24.14	25.90	18.90	18.9	21.2	19.8
Tailings	15.0	25.6	26.2	21.21	14.11	28.14	15.7	14.6	20.2

Table 3. Metal balance with 10, 20, and 30 g/t Na-dodecilbenzolsulphonate and induction of 1.9T

Product	Weight %			Fe %			Recovery of Fe %		
Feed	100.0	100.0	100.0	39.99	40.11	41.12	100.00	100.0	100.0
C/Fe	64.2	54.4	52.2	52.11	53.13	52.12	76.00	78.4	64.3
Middlings	13.6	11.8	8.4	26.44	24.12	25.18	8.12	6.45	28.9
Tailings	22.2	33.8	39.4	24.08	25.15	17.16	15.88	15.15	8.8

On the base of the results shown in these tables it is obvious that, with the introduction of surface active compounds, it is possible to create high induction magnetic field condition for the production of limonite concentrate from very fine classes applying magnetic concentration with high gradient and The results obtained do not show significant dependence from the reagents consumption, but it is evident that the concentrate with higher content and higher recovery of Fe is obtained, as far as higher is the magnetic induction of the field in separator zone.

7 CONCLUSIONS

In this paper some results from literature, which indicate to the possibility of limonite concentration from fine classes (-50 μm) utilizing the common concentration procedures after selective flocculation, are shortly presented. We have experimentally proved that limonite concentration from fine classes (-50 μm) can be realized by the decrease of surface tension on the particle-solution border, by which the medium resistance to particle move is decreased.

Experimental examinations of the possibilities of limonite magnetic concentration from hydrocyclon overflow of fineness of 95.49% -38μm in Omarska, which, according to current process flow sheet, represents tailings, are presented.

The electro kinetic measurements of limonite which were performed against pH in the presence of HCl or NaOH as regulators of pH value, and sodium dodecilbenyosulphonate indicated that sodium dodecilbenzosulphonate was specifically adsorbed into the surface of limonite what provoked decrease of free surface tension and decrease the difference in the polarity between two phases: mineral - fluid. This influenced on the resistance of particle motion.

The results of the magnetic concentration experiments (Tables 2 and 3) show that this adsorption brings to the recovery of limonite.

The results of magnetic concentration with and without the application of dodecil-benzosulphonate, which at certain concentration conditions and pH value brings to the decrease of surface tension at the mineral particle – solution contact, are presented. Comparing these results, it is shown that, by the application of dodecilbenzosulphonate, the resistance to particle move was decreased and the attraction magnetic force in the separator field prevailed, what enabled to obtain mach better and in technological sense satisfactory results of concentration in a magnetic separator of relevant induction.

REFERENCES:

[1]. Ćalić N., 1997, *Ispitivanja u oblasti visoko gradijentne magnetske separacije u cilju izbora parametara procesa i uređaja,* Monografija: Magnetska separacija, Editor M. Ignjatović, ITNMS, pp 41-61, Beograd.

[2]. Georgios N. Anastassakis, 2002, *Separation of Fine Mineral Particles by Selective Magnetic Coating*, Journal of Colloid and Interface Science 256: 114-120.

[3]. Gregory J., 1992.101, *Flocculation of Fine Particles in Innovation in Flotation Technology,* Academic Publishers, Netherlands.

[4]. Glušac M., Ćalić N. 2008, *Possibility of Concentration of Limonite-Baryte Ores*, Proc. of the XXI International Mineral Processing Congres, Antalya, Turkey.

[5]. Ignjatović M, Ćalić N, Marković Z, Ignjatović R., 1995, *Development of a combined gravity-magnetic separation process for magnesite ore using HGMS*, Magnetic and Electrical Separation, Vol.6, pp.161-170, Gordon and Breach Science Publishers SA, Amsterdam,

[6]. Ignjatović M., Doctoral thesis, 1997, RGF, Beograd.

[7]. Luo Li-Qun , Zhang Jing-sheng and Yu Yong-fu, December 2005, *Recovering limonite from Australia iron ores by flocculation-high intensity magnetic separation*, Central South University of Technology, ISSN1005-9784, Volume 12, Number 6.

[8]. Song A., Lub S., Lopez-Valdiviesoa A., June 2002, Minerals Engineering, Volume 15, pp. 415-422.

[9]. Svoboda J., 1987, *Magnetic Methods for the Treatment of Minerals,* Elsevier, pp. 516-530.

[10]. Svoboda J., 1982, *Magnetic flocculation and treatment of weakly magnetic minerals*, Magnetics, IEEE Transactions, Vol.18, pp. 796-801.

[11]. Subramanian S., Natarajan KA., 1987, *Selective flocculation studies on iron ore minerals*, Transactions of the Indian Institute of Metals 40(6): pp. 489-496.

[12]. Weissenborn P.K., Warren L.J., Dunn J.G., 10 June 1995, *Selective flocculation of ultra fine iron ore, 2. Mechanism of selective flocculation,* Colloids and Surfaces A., Volume 99, Number 1 and 2, pp. 29-43 and11-27, Publisher: Elsevier.

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KINETIC STUDY OF FINE COAL FLOTATION USING DIFFERENT REAGENT SYSTEMS

NICOLAE CRISTEA*
GEORGETA CRISTEA**

Abstract: *Froth flotation is a major process for producing clean coal. Although flotation is a rate process, flotation kinetic data are rarely collected or analyzed for commercial application. The analysis of flotation kinetics is useful in providing engineering design criteria, process scale-up information and a process control strategy. Understanding fine coal flotation kinetics may prove important for improving flotation process and understanding important flotation parameters.*

Keywords: *coal flotation, kinetics of flotation, flotation model, flotation rate constant*

1. INTRODUCTION

Flotation, as any technological process in which the results are determined by many random factors, is a process occurring in time. In order to form a permanent attachment between a particle and a bubble there must be, first of all, a collision between a particle with a bubble and the kinetic energy must be contained in certain range of values, on the one hand large enough to overcome the barrier of the potential of the particle – bubble interaction and, on the other, little enough to make this connection stable, in other words, not to detach the particle from the bubble. Both the particle – bubble collision and the value of particle kinetic energy are of random character. In fact, the permanent particle – bubble connection is determined by a set of random events whose probabilities affect the velocity of the process course. The higher probability, the faster is the flotation process.

Kinetics, i.e. the course of the process in time, results not only from the statistical character of phenomena occurring on the phase boundaries but also from the successive inflow of free surface into the flotation system, in the form of air bubbles, on which the adhesion of coal particles occurs and which, among others, limits the velocity of the process course.

* *assoc.prof.PhD.Eng. – University of Petrosani*
** *assist.prof. PhD.Eng. – University of Petrosani*

In order to make a particle float, i.e., adhere to bubbles and be removed by froth flotation, it has to be made hydrophobic. This is accomplished by selective adsorption of a chemical agent on particle surfaces.

Flotation kinetics study is important owing to their experimental data that permit to achieve an increase the coal flotation efficiency. The different coals record different float abilities and also different flotation kinetics. Flotation rate, representing the combustible matter recovery variation in time, can be determined as a result of flotation tests with concentrate fractionate collecting in time, in laboratory.

2. THEORETICAL CONSIDERATIONS

In a way, there is an analogy between the mechanism of chemical reaction (collision theory of molecules) and the mineralization of the air bubble in flotation process. Therefore, the flotation kinetics is well described by the equation analogical to the equation of kinetics of chemical reaction. Majority of the researchers have proposed flotation kinetics to follow a first – order reaction.

The rate of flotation recovery can be obtained using the following equation:

$$w = \frac{dm}{dt} = \psi k \varphi N e^{-k\int_0^t \varphi N dt} \qquad [1]$$

where:

- w – the flotation rate;
- k – the flotation rate constant;
- m – the combustible matter recovery;
- ψ – the degree of liberation between valuable and sterile components;
- φ – a frequency function of efficient collision number;
- N – bubble number in the volume unit of slime pulp [Krausz S., Ilie P., 2001]

When flotation conditions permit to maintain constant values for some influence parameters (an advanced liberation degree between coal and mineral matter, so that $\psi \approx 1$, constant air flow, constant pulp volume, etc.), it is possible to consider a simplified equation for flotation rate:

$$w = \frac{dm}{dt} = k(1-m) \qquad [2]$$

Also, the combustible matter recovery in concentrate and the flotation rate constant can be obtained using the following equations:

$$m = 1 - e^{-kt} \qquad [3]$$

$$k = \frac{1}{t}\ln\frac{1}{1-m} \qquad [4]$$

3. METHODS AND MATERIALS

Flotation experiments for coal were performed at room temperature in the Denver laboratory machine of 1,2 dm^3 capacity with the constant rotor speed 1350 rpm and the fixed air flow rate. The content of solids was the same in all experiments and was 80 g/dm^3. Such conditions ensured the constant amount and size of air bubbles in the chamber with limited turbulence of flotation pulp caused by the rotor. Low concentration of flotation pulp was used for practical reasons because at low pulp density it is possible to obtain favorable results of coal flotation (Sablik, 1998).

For the experimental study, three coal samples were used: two samples from Jiu Valley basin and the third from Oltenia basin. The particle size of each sample was under 0,125 mm, able to assure an advanced liberation between combustible and mineral matter in coal samples and to avoid the size particle influence carried to hydrophobization influence in flotation kinetics. Some sample characteristics are presented in table 1:

Table 1 ***Coal sample characteristics***

Parameter	Lupeni sample	Lonea sample	Lignite sample
Ash content, %	9,41	9,33	42,3
Volatile matter, %	42,5	45,5	51,16
Carbon content, daf, %	83,2	78,5	65,5
Oxygen content, daf, %	8,9	13,68	27,1
Average value for contact angle, degree	75	68	63
Mean critical wetting surface tension, mN/m	41,8	47,8	52,3

The concentrates were collected from 20 to 240 seconds. After each test, the froths were dried, weighed, analyzed and cumulative combustible recoveries calculated. In order to determine the constants in kinetic equations, the first order model was used.

4. RESULTS AND DISCUSSION

4.1 Lupeni coal flotation kinetics

The Lupeni coal is characterized by a higher natural hydrophoby, the average surface energy being proximate of 41,8 mN/m and the average contact angle value of 75^0. For flotation tests, four reagent systems were tested:

- 1.25 kg/t dodecane and 0.5 kg/t MIBC
- 0,75 kg/t dodecane and 1,0 kg/t PEG 400
- 0,5 kg/t dodecane, 0,5 kg/t Triton X100 and 0,1 kg/t MIBC
- 0,5 kg/t dodecane, 0,75 kg/t Brij 35 and 0,2 kg/t MIBC

The test results permitted to calculate the medium values for flotation rate constants. They are presented in table 2.

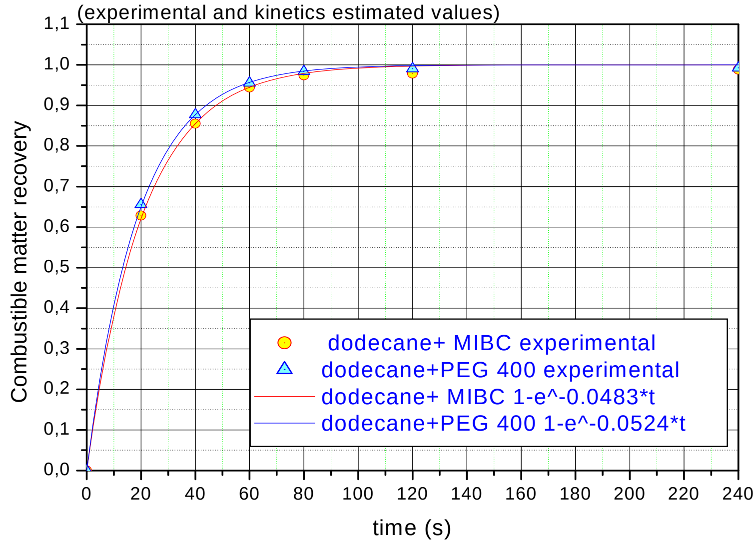
Table 2 ***Lupeni coal flotation results***

Time, s	Dodecane + MIBC		Dodecane + PEG 400		Dodecane + Triton X 100 + MIBC		Dodecane + Brij 35 + MIBC	
	m, %	k, s^{-1}	m, %	k, s^{-1}	m, %	k, s^{-1}	m, %	k, s^{-1}
20	62.86	0.0495	65,58	0.0533	42.12	0.0273	40.84	0.0262
40	85.5	0.0483	87.72	0.0524	65.68	0.0267	64.12	0.0256
60	94.4	0.0480	95.54	0.0518	80.04	0.0269	78.42	0.0256
80	97.2	0.0456	98.36	0.0514	90.74	0.0264	89.84	0.0254
120	97.84	0.0320	99.07	0.0390	95.84	0.0265	95.21	0.0253
240	98.84	0.0186	99.25	0.0204	98.65	0.0179	98.44	0.0173

When dodecane and PEG 400 reagents are used, the higher rate constant value is obtained of 0,052 s-1 and above 95% from coal is floated, with an ash content of 7,16%. The following performance from point of view of flotation rate was the reagent system with dodecane and MIBC. The flotation rate constant was of 0,048 s-1, but the floated grade was higher, ash content being of 6,85% after 1 minute for flotation time.

In figure 1 are plotted the experimental values for combustible matter recovery obtained for these two reagent systems and those which are estimated from first order flotation model, resulting a good correlation between experimental and theoretical values.

Figure 1 Combustible matter recovery variation in time for Lupeni coal flotation with dodecane and MIBC and dodecane and PEG 400 (experimental and kinetics estimated values)



Lower results were obtained with more complex reagent systems, including apolar and heteropolar reagents, showing that for this type of coal, the complex reagent systems are not recommended.

4.2 Lonea coal flotation kinetics

Flotation tests for this coal, characterized by a reduced natural hydrophobicity, with an average surface energy of 47,8 mN/m and a contact angle value of 68^0, were achieved with the following reagents systems:

- 1,5 kg/t dodecane and 0,75 kg/t MIBC
- 1,0 kg/t dodecane and 1,0 kg/t PEG 400
- 0,75 kg/t dodecane, 0,75 kg/t Triton X100 and 0,2 kg/t MIBC
- 0,5 kg/t dodecane, 0,75 kg/t Triton X100 and 0,2 kg/t MIBC
- 0,75 kg/t dodecane, 1,25 kg/t Brij 35 and 0,4 kg/t MIBC
- 0,5 kg/t dodecane, 1,25 kg/t Brij 35 and 0,4 kg/t MIBC

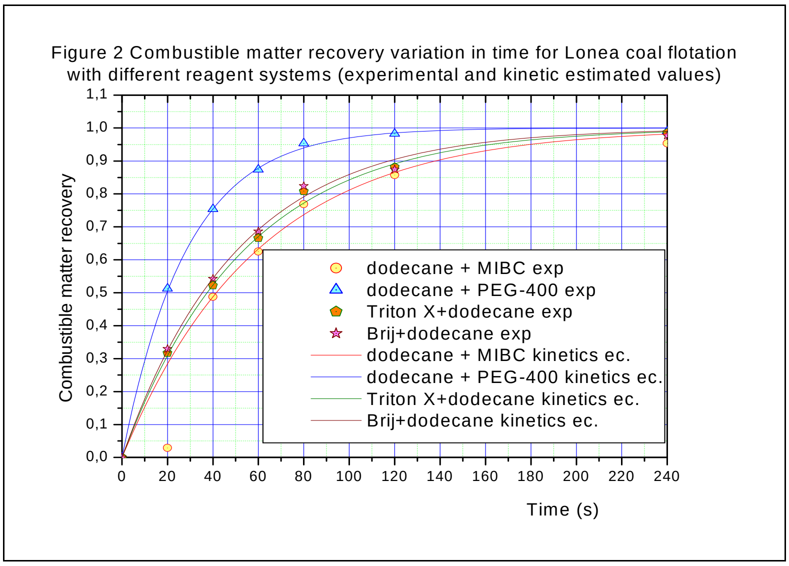
The results of these testes are presented in table 3.

Table 3 ***Lonea coal flotation results***

Time, s	**Dodecane + MIBC**		**Dodecane + PEG 400**		**Dodecane + Triton X100 + MIBC**		**Triton X100 + Dodecane + MIBC**		**Dodecane + Brij 35 + MIBC**		**Brij 35 + Dodecane + MIBC**	
	m, %	k, s^{-1}	m, %	k, s^{-1}	m, %	k, s^{-1}	m, %	k, s^{-1}	m, %	k, s^{-1}	m, %	k, s^{-1}
20	29.08	0.0172	51.23	0.0359	27.12	0.0158	31.72	0.0191	24.48	0.0140	32.95	0.0200
40	48.78	0.0167	75.43	0.0351	45.94	0.0154	52.22	0.0185	43.74	0.0144	54.27	0.0196
60	62.54	0.0164	87.41	0.0345	60.12	0.0153	66.62	0.0183	57.36	0.0142	68.67	0.0193
90	76.87	0.0163	95.37	0.0341	75.03	0.0154	80.84	0.0184	72.11	0.0142	82.4	0.0193
120	85.76	0.0162	98.25	0.0337	83.56	0.0150	88.22	0.0178	83.81	0.0152	87.43	0.0173
240	95.36	0.0128	99.04	0.0193	96.24	0.0137	98.64	0.0179	96.76	0.0143	97.73	0.0158

Flotation rate constants, calculated from combustible matter recovery results show that the complex reagent systems including heteropolar and apolar reagents are suited for this coal type. When only one single type of collector reagent is used, the flotation results are poorly. The reagent system with dodecane and PEG 400 allowed obtaining the higher values for flotation rate, the k values being placed around of 0,035 s^{-1}, but separation selectivity was lower. The highest final combustible matter recovery was achieved but with a lower selectivity. For reagent systems including dodecane and Triton X100 and dodecane and Brij 35, the obtained flotation rate constants were around 0,0155 s^{-1}, respectively 0,014 s^{-1}. When the heteropolar reagent was dosed before dodecane the flotation rate constants were of 0,019 s^{-1}, respectively of 0,02 s^{-1}. These values were easily higher given the case when only apolar collector was applied. In these situations, higher combustible matter recoveries are achieved. In these flotation tests, heteropolar reagent has higher efficiency, both in coal surface hydrophobization and in higher dodecane dispersion. Such, coal flotation conditions allowed a decrease in dodecane dose because its hydrophobization action was improved. Therefore, the surfactants act as an activator on the coal surface to which the oily collector will more readily adhere. Also, its emulsifier action resulted in a higher number of dodecane drops able to achieve a higher number of efficient collisions with coal particles and results in a intensified hydrophobization. In order to achieve the desired effect in the most economical manner, the surfactant and the oil should be dispersed and conditioned into the slurry separately, since the oil will otherwise tend to adsorb or absorb the surfactant.

In figure 2 are plotted the experimental values for combustible matter recovery obtained for these two reagent systems and those which are estimated from first order flotation model, resulting a good correlation between experimental and theoretical values.



Also, appears clearly the superiority of dodecane and PEG 400 system from the point of view of flotation rate, the combustible matter recoveries being higher on the whole flotation progress, more evidently in the first period. When only dodecane was used like collecting reagent, was the most inappropriate reagent system. Comparing with Lupeni coal flotation, this coal type floats with lower rate and poly ethylene glycolic reagent contributes also to increase the flotation rate.

4.3 Lignite flotation kinetics

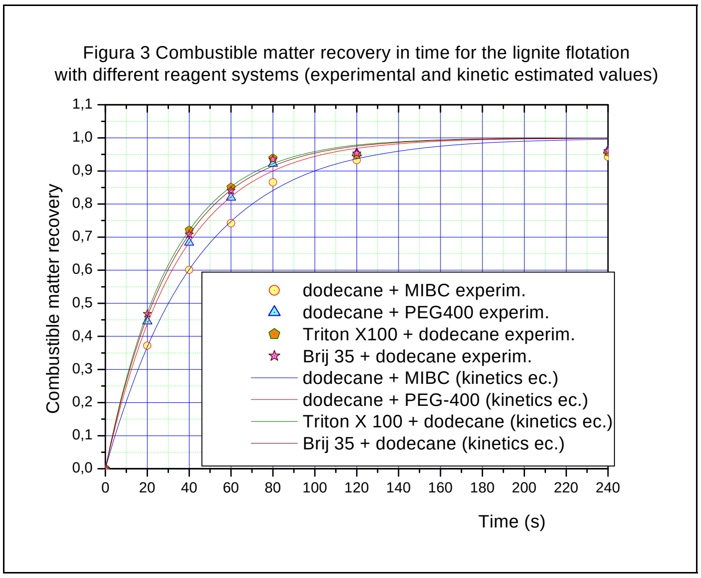
For flotation tests, the following reagent systems were chosen:

- 3,0 kg/t dodecane and 1,0 kg/t MIBC
- 2,0 kg/t dodecane and 1,5 kg/t PEG 400
- 2,5 kg/t PEG 400
- 1,15 kg/t dodecane, 1,5 kg/t Triton X100 and 0,2 kg/t MIBC
- 0,8 kg/t dodecane, 1,5 kg/t Triton X100 and 0,2 kg/t MIBC
- 1,4 kg/t Triton X100 and 0,2 kg/t MIBC
- 1,15 kg/t dodecane, 2,0 kg/t Brij 35 and 0,4 kg/t MIBC
- 0,8 kg/t dodecane, 2,0 kg/t Brij 35 and 0,4 kg/t MIBC
- 2 kg/t Brij 35 and 0,4 kg/t MIBC.

Lignite has unfavorable surface characteristics for flotation, its surface energy being about 52,3 mN/m, as a result of its chemical composition, having a higher oxygen content, higher of 27 % and contributes to the more polar surface character.

When applying the regime with apolar collector the flotation rate was slower, the rate constant being 0,023 s^{-1} and the combustible matter recovery was lower. When applying the regime with heteropolar collector the results obtained are even worse, the flotation rates dropping more ten time and also, the reached combustible matter recoveries being worsened. This reagent type was unable to hydrophobize coal surface for flotation. When PEG 400 was used with apolar reagent, the flotation kinetics was intensified comparatively with the situation when MIBC was used, but there is not a net detaching. Reagent systems containing both reagent type, apolar and heteropolar, allowed increase performances. When dodecane and Triton X 100 were used, the flotation rate constant was of 0,028 s^{-1} and was recorded an increase to a reverse order in dosage to 0,032 s^{-1}. Dodecane and Brij 35, permet to achieve a flotation rate constant of 0,027 s^{-1}, and when the inverse order in dosage was used, the flotation rate constant was of 0,030 s^{-1}. Both reagent systems permit obtaining higher results when heteropolar reagent was dosed before the apolar reagent, situation when hydrophobization process with apolar reagent was intensified. The surfactants act as an activator on the coal surface to which the oily collector will more readily adhere. Also, its emulsifier action resulted in a higher number of dodecane drops able to achieve a higher number of efficient collisions with coal particles and results in a intensified hydrophobization.

In figure 3 are plotted the combustible matter recovery variation in time for the two situation, when dodecane and two frothing reagents, MIBC and PEG 400 are used and also, when the more complex reagent systems were used. The experimental data verify well the first order kinetic model those representation are also presented.



The superiority of complex reagent systems is recorded even given the situation when PEG 400 reagent was used. When only apolar collector is used, even in higher dose, the flotation results were decreased, its efficiency being lower, indifferently of the frothing reagent.

5. CONCLUSIONS

The kinetic study showed the following remarks:

- The reagent system containing dodecane and MIBC permits to obtain a efficient flotation for coals with a high natural floatability ($k = 0{,}049\ s^{-1}$) and when a frothing reagent with collecting capacity was used, the flotation kinetics increased ($k = 0{,}053\ s^{-1}$) but to the prejudice of flotation selectivity.
- The complex reagent systems including apolar and heteropolar reagents were suited for the flotation of coals with lower floatability. The synergy in their action of coal surface hydrophobization and the heteropolar reagent multiple action at different interfaces in flotation systems permit to obtain k values of $0{,}018 – 0{,}019\ s^{-1}$, for Lonea and of $0{,}031 – 0{,}032\ s^{-1}$, for lignite, but when the doses were increased.
- The frother action must take account of their possibility to act at liquid – gas interface but also to other interfaces, when together with collecting reagents can enhance flotation results.
- The heteropolar reagent use represents a possible way the increase the flotation efficiency owing to their possibility of multiple actions, the reagent structure being also, of importance.
- For coal flotation efficiency, both the coal surface characteristics and the reagent structure, dictating their possibility in action, are of importance.

6. REFERENCES

[1] Cristea G., *Research on evaluation of relationship between the reagent system and coal physico – chemical characteristics for the flotation efficiency increasing*, *Ph.D.Thesis*, University of Petroşani, 2008

[2] Krausz S., Ilie P., *Teoria si tehnologia flotatiei*, Editura Matrix, 2001

[3] Huber-Panu, et al., *Mathematical models of bath and continuous flotation*, Gaudin Flotation Symposium, 1976

[4] Polat M., Chander S., *First order kinetics medels and methods for estimation of the true distribution of flotation rate constants*, Int. J. Miner. Process. No.58, 2000

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THE AURIFEROUS PIRITES ROASTING IN THE MICROWAVES FIELD ON THE CIANYDATION RESULTS

SANDA KRAUSZ[*]
NICOLAE TOMUŞ[**]
LILIANA CIOBANU[**]
EUGEN CRĂCIUN[***]
ŞTEFAN CRĂCIUN[***]

Abstract: *Using the microwaves energy was extended in the last times its applications being numerous and in various domains like extractive metallurgy. It is also known that it was recorded a wide change in the different materials behavior under the microwaves action. Based on this fact it have been studied the possibility of the coarse ores and concentrates pretreatment with microwaves before applying the hydro or pirometallurgical processes and also before applying some processing methods on the different wastes of different compositions. In that context it's registered our research that wants to establish the roasting effect on the auriferous pyrites in the microwaves field, by comparing the obtained results on the cyanidation of the roasted and unroasted pyrites.*

1 INTRODUCTION

The sulphide concentrates roasting is a pirometallurgical operation frequently applied having as goal the removal of the sulphur excess but also to realize some material transformations by heating the material under the melting temperatures. Except the roasting operation applied for the material drying, that don't produce any structural or chemical changes, all other roasting processes have as results a chemical transformation (decomposition, redox operations, etc.) of the material that is prepared in this manner for the metal extraction phase. It is also assured by this way the thermal breakup of the sulphides, and the elimination of the gaseous compounds like: S_2, O_2, As_2O_3, SO_2, followed by the apparition of some pores, microchanells and cracks that insures a good penetration of the attack solution (Kheil, Golcea, Krausz, 2006).

* *prof.PhD.Eng. - University of Petrosani*
** *PhD.Eng. - Research and development National Institute for Metals and Radioactive Resources*
*** *PhD.Eng.- S.C INTEC SA*

The precious metals recovery from the pyrites that contains such metals can be improved by a preliminary roasting.

As it is known, the pyrite breakdowns at 740°C and the sulphur is liberated as it is shown in the following reaction:

$$FeS_2 = FeS + ½ S_2 \quad \Delta G^o_{743} = 14110 \text{ cal/mol} \quad (1)$$

The iron sulphides oxidation leads mainly to form oxides as Fe_2O_3 and Fe_3O_4, but it is possible to form a thin layer of ferrous sulphate that interfere with the residual FeS in a very fast reaction, that can be resume in the following reactions establish by Pinkovski (apud Frenay,1994):

$$FeS + 2O_2 = FeSO_4 \quad (2)$$
$$FeS + 3FeSO_4 + O_2 = 2Fe_2O_3 + 4SO_2 \quad (3)$$
$$2FeSO_4 + SO_2 + O_2 = Fe_2(SO_4)_3 \quad (4)$$

The FeS obtaining is realized by the FeS_2 breakdown at 1000°C in argon atmosphere. Then, the FeS roasting begin at 320°C, with the ferrous sulphate formation which is discomposing partially in the reaction with the residual FeS that suffer a thermal decomposition at 850°C and the SO_2 liberated initiates the ferric sulphate formation. Vary researches shown that is excluded the primary formation of the ferric sulphate, this one is formed with no doubt in the reaction (4) (Bolgiu, Dumitrescu and Thornhill, Pidgeon, apud Frenay, 2004).

For some compounds that appear during the pyrites roasting we know the exact values of the thermodynamic functions. The pyrites roasting occur in an oxidizing atmosphere and that fact shows the type of the stable compounds that forms the roasting gases: O_2, N_2, SO_2, H_2O and CO_2. Between all these gases appear only one interaction rended by the following reaction:

$$SO_2 + 1/2\ O_2 = SO_3 \quad (5)$$

Due to its avidity, SO_2 can be cached, by gases leading, in a buffer bowl containing $Ca(OH)_2$, at pH = 12; in this case it’s obtained the sulphurous acid:

$$SO_2 + H_2O = H_2SO_3 \quad (6)$$

After its interaction with the $Ca(OH)_2$ the solution pH decrease at 3,5 and take place the following reaction:

$$Ca(OH)_2 + H_2SO_3 = CaSO_3\downarrow + 2H_2O \quad (7)$$

The actual knowledge regarding the cyanidation process show that only a small part of gold is leached after the Elsner reaction, the mainly part is leached in the second phase (Adamson, 1972), in conformity with the reaction bellow:

$$4Au + 8CN^- + O_2 + 2H_2O = 4Au(CN^-)_2 + 4OH^- \quad (8)$$
$$2Au + 4CN^- + O_2 + 2H_2O = 2Au(CN^-)_2 + H_2O_2 + 2OH^- \quad (9)$$

The gold solubilization – as any other – depend on the cyanide solution concentration, on the solution alkalinity, pH and on the temperature. Our investigation has as target the overlap of the thermochemical effect expressed by the reactions from above with the influence of the microwaves action, to the auriferous pyrite preparation for the precious metals extraction.

2 MATERIALS AND INSTALLATIONS USED

2.1 The characteristics of the sample material

The experimental research has been realized on a sample taken from the auriferous pyrite concentrate deposit of the Central Flotation Plant – Baia Mare; the chemical composition of this pyrite (the main components) is presented in table 1.

Table 1 Chemical composition of the auriferous pyrite sample (main compounds).

Substance	Content %	Substance	Content %
SiO_2	9,38	Pb	0,57
TiO_2	0,80	CaO	0,80
Al_2O_3	0,06	MgO	0,06
Fe	39,16	K_2O	0,45
P_2O_5	1,70	Au	8,4*
S	42,30	Ag	59*

* în g/t

The difractometric analyze show the presence of the following minerals: pyrite, chalcosine, native gold, aurostibil, stromeyerit, pyrostilpnit and subordinated quartzite, quartz, feldspar, galena, blende, antimonite, magnetite, heavy minerals. It has been establish their balance on the granulometric classes.

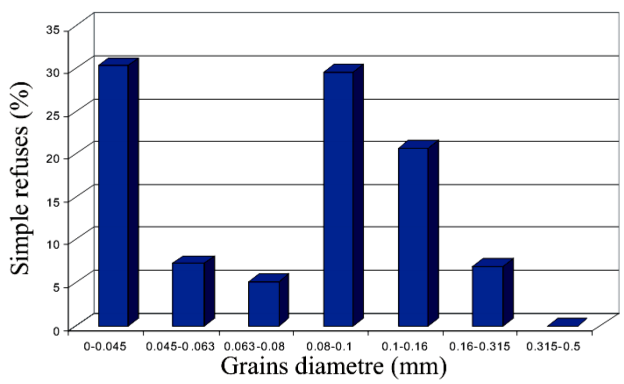

Figure 1 The percentage balance of the granulometric fractions.

The results of the granulometric analyze are presented in figure 1 by percent balance of the granulometric classes and this show a relative irregular granulation of the material, the predominant classes being those under 0,045 mm, 0,063 – 0,08 mm şi 0,8 – 0,16 mm.

To remark the pyrite roasting effect in different conditions, from the pyrite concentrate have been separated 3 samples with identical characteristics; one of the sample is called “raw pyrite” and the others two have been submitted to a roasting process in the microwave field at 400°C and 700°C.

2.2 The experimental installation

Because the auriferous pyrite concentrate has a very good electromagnetic coupling with the microwave radiation, it have been design and realized a roasting installation in fluidized bed that contain: the microwave generator, the transmission line of wave guide type, the microwave applier – the process reactor in fluidized bed, the fluidized agent source, the gas-powder separator as cyclone and the neutralization reactor for the products issue from the reaction (figure 2).

The temperature variation inside the microwave applier during the roasting process is presented on figure 3. This variation must be known because it influence in an appreciable manner the dissolution speed of the gold due to the activation energy needed in the process and due to diminishing of the oxygen solubility with the temperature increasing.

To remark the roasting effect on the samples, each of them have been chemically and on the electronic plunger analyzed before and after processing.

Figure 2- The microwave heating installation in fluidized bed.

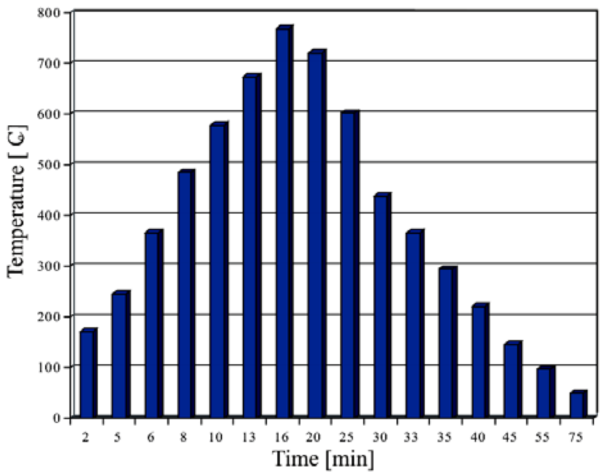

Figure. 3 Temperature variations inside the microwave applier during the pyrite roasting.

3EXPERIMENTAL RESEARCHES

The experimental investigation passes through three steps: the first consist in the raw pyrite cyanidation, in the second the pyrite is roasted at 700°C and in the third the pyrite is roasted at 400°C.

3.1 The raw pyrite cyanidation

It has been realized by the "rolling bottle" method in the following work conditions:

To the pyrite sample (0,5 kg) have been added 750 ml NaCN solution containing 400 ppm CN^- ions (1,5 g NaCN for 2000 ml water). The pH value was initially 10,3 and after 5 minutes of agitation drop to 1,44. As a consequence, it was added a lime solution; the addition of 55 g of lime (corresponding to a specific consumption of 100kg/t) ensure a Ph of 12,1. The solution temperature has been maintained at 24,7°C.

All along the solubilization process it has been followed the concentration of the CN^- free ions (by titration with a $AgNO_3$ solution) and the gold concentration passed in the solution after 2, 24 48 and 72 hours.

The CN^- content in the initial leaching is high (400 ppm) but after two hours of stirring its drop at 100 ppm, and for that reason it have been added a new quantity of NaCN to restore the initial concentration of the CN^- to 400 ppm.

After 24 hours of stirring, the CN^- concentration drops again to 6,24 ppm, went it have been added again 1,4 g of NaCN; the CN^- concentration rise to 340 ppm and rested nearly constant after 72 hours of stirring.

The gold content increasing from 0 to the maximal value of 2.72 mg/l (figure 3) is realized in time with two different values; so, in the first two hours the increasing is from 0 to 0,68 mg/l, with an average of 0,34 mg/l, and in the 22 hours that follows to 2,05 mg/l, with an average of 0,06 mg/l; its take place a normal and predictable diminution of the dissolution speed relayed to the diminution content of the free CN^-. Between 24 and 48 hours the gold concentration increasing is much more slow, from 2,05 to 2,18 mg/l, with an average of only 0,005 mg/l,h, even if there is an increasing of the CN content by adding NaCN. In the last period of time, the dissolution speed increase to 0,023 mg/l,h, at the same time with the significant increasing of the CN concentration, that the effect is diminished (and then maintained constant) due to the existing and available gold from the pyrite surface that pass in the solution (figure 4).

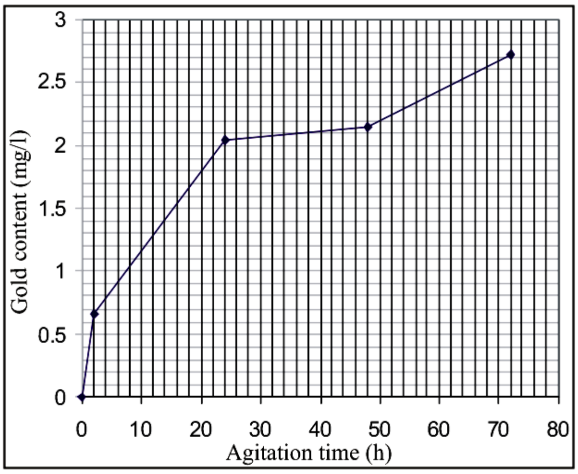

Figure 4. The variation in time of the gold content from the solution, at the raw pyrite cianidation.

The total NaCN consumption for the raw pyrite leaching has been of 2,8 kg/t.

The leaching efficiency has been calculated taking into account the initial gold content from the 8,4 t of pyrite; from the quantity of 0,004 g of gold that can be find in the 500 g of pyrite sample submitted to the cyanidation process, it have been dissolved, after 72 hours only 2,72 mg/l x 0,75 l/1000 = 0,002 g; it result an efficiency of 50%.

3.2 The pyrite cyanidation after roasting in the microwave field, at 700^{o}C

A pyrite sample has been roasted at 700^{o}C, in the previous installation. After roasting, the pyrite aspect was different from the raw pyrite, as it can be seen in figure 5.

a)

b)

Figure. 5 The raw pyrite aspect (a) and the roasted (at 700^{o}C) pyrite aspect (b)

The pyrite leaching was realized in identical conditions, with the same quantity of material.

The solution pH diminution after 5 minutes of contact with the sample occurred from 10,3 to only 6,72; its correction to the value of 12,4 was realized with a smaller quantity of lime, of only 10 kg/t.

It have been followed the same parameters, at the same periods of time and the CN^- concentration maintenance was realized by adding new quantities of NaCN from time to time. The totally adding of NaCN was about 0,853 g that represent a specific consumption of 1,706 kg/t.

With an eye on the dissolution process dynamic (represented in the figure 6), it can be observed that in the first period of time of 2 hours, it occurred the same pronounced increasing content of gold in the solution from 0 to 1,63 mg/l (0,815 mg/l,h) and the diminishing of the CN^- to 108 ppm. It have been added NaCN (0,37g) and realized a concentration increasing to 139 ppm. In 24 hours. During the same period, the gold content that dissolve in the solution increase to 3,28 mg/l realizing an average dissolution speed of 0,075 mg/l,h. adding a new quantity of NaCN (0,33 g) ensure, after 48 hours of stirring, a CN^- concentration of 280 ppm but the gold dissolution run slower until 3,49 mg/l, with an average speed of 0,008 mg/l,h. Adding a new NaCN quantity (0,153 g) it has realized an increasing of the gold content in the solution about 4,32 mg/l with an average og 0,035 mg/l,h.

As it can be determined, the evolution in time of the dissolution process is similar but the content of the dissolved gold is considerable higher, recording an extraction efficiency increasing from 50 % to 81 %, with 31 % higher than in the case of the raw pyrite. It can be added to that the advantage of a considerable reducing of the specific consumption of alkalinization reagents and NaCN.

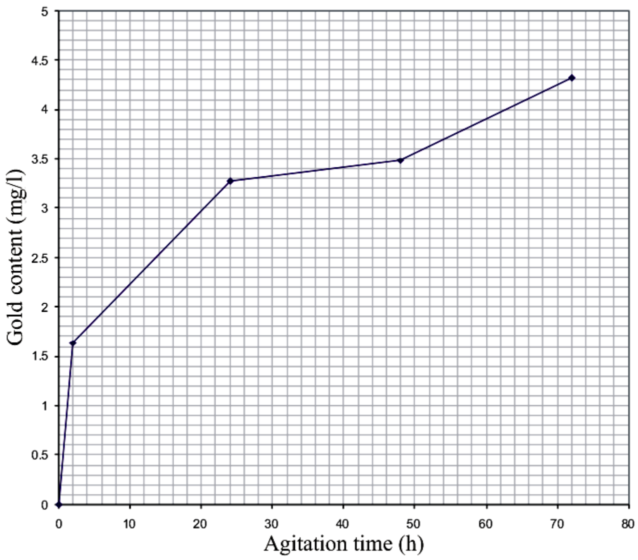

Figure 6. The variation in time of the gold content from the solution, at the cyanidation of the roasted pyrite at 700°C.

3.3 The pyrite cyanidation after roasting in the microwave field, at 400°C

The aspect of the roasted pyrite at only 400°C can be seen in figure 7. It defers essentially from the roasted pyrite at 700°C and that can suggest a different behavior during the dissolution.

Figure 7 The aspect of the roasted pyrite at 400^oC

The cyanidation has been realized in the same conditions. The pH value drop, in the first 5 minutes of stirring from 10,3 to 2,52; to ensure an alkalinity of 12 it was used a quantity of 45 g of lime, meaning 90 kg/t. By the same modality it was followed the free CN^- and the gold content dissolved in the solution. The NaCN added, step by step, was this time of about 2.796 kg/t.

It have been remarked (figure 8) that, after 2 hours of cyanidation, the gold content was about 1,55 mg/l, so, the dissolution have been realized with an average of 0,775 mg/l,h. After 24 hours of stirring the gold content increased to 2,06 mg/l, with an average of 0,023 mg/l,h, after 48 hours to 2,15 mg/l (0,0035 mg/l,h) and finally, after 72 hours to 2,88 mg/l 0,03 mg/l,h). The gold extraction efficiency was about 54 % in the conditions of a small reduction of the specific consumptions of lime and NaCN than these needed for the raw pyrite.

The comparing results obtained can be seen in table 2 and their show the important effect of the pyrite roasting in the microwave field, with the condition that the pyrite is roasted at 700^oC.

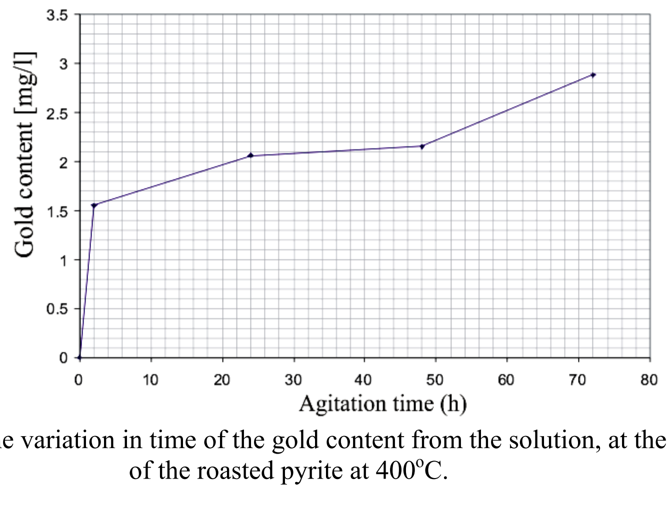

Figure 8 The variation in time of the gold content from the solution, at the cyanidation of the roasted pyrite at 400^oC.

Table 2 The parameters of the cyanidation process and the comparative results.

Parameters, indices	Raw pyrite	Roasted pyrite 700°C	Roasted pyrite 400°C
Sulphur content, %	42,3	15	25
Final gold content , mg/l	2,72	4,32	2,88
Dissolution average speed, mg/l,h	0,038	0,06	0,04
Gold extraction efficiency, %	50	81	54
Specific lime consumption, kg/t	110	10	90
Specific NaCN consumption, kg/t	2,8	1,7	2,796

4. CONCLUSIONS

This research presents the first essays to establish the possibility of using the roasting in the microwaves field, to the auriferous pyrites roasting with low content of precious metals, in view to improve the metal extraction at the cyanidation. As we can see, it has been confirmed the assumption of a benefic effect of that processing on the gold extraction efficiency.

The roasting of that type of pyrites concentrates in these conditions is possible due to the fact that these materials are microwave absorbents.

The research results shown in table 2 remark that is important to roast the material at 700°C because in that case the material has a reduce content of sulphur (from 42,3 to 15 %) and this ensure a faster reduction of the pH and automatically a lower consumption of the alkaline reagent. On the other side, the pyrite roasting at that temperature ensure the formation of cracks, microchannels and pores, that offer a contact surface much bigger with the NaCN solution and reduce the specific consumption of NaCN and increase the gold extraction.

The encouraging results obtained recommend the pursuit of these researches in view to optimize the working parameters to increase the gold extraction

REFERENCES

[1]. Adamson, R. J., *1972: Gold Metallurgy in South Africa.* Chamber of Mines of South Africa, Johannesburg, South Africa.

[2]. Frenay J., *1994, Le grillage des sulfures de cuivre, plomb, zinc et fer.* Faculté des Sciences Appliquées de l' Université de Liège.

[3]. Kheil O., Golcea N., Krausz S., *2006: Precious metals.* Monography, Pb.H. MatrixRom Bucharest

[4]. N.Patraik; R.B. Rao, *2004: Microwave Energy in Mineral Processing* - A review; I E (I) Journal - MN vol 84, feb, pg. 56- 61

[5]. S.W.Kingman, *1998: Microwave Treatment of Minerals - a Review,* R.A. Rowson, Mineral Engineering vol 11, pg. 1081- 1087.

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THE COAGULATION OF ARGILLACEOUS SUSPENSIONS FROM WASTEWATER IN ELECTRIC FIELD FROM COAL WASHING PROCESS

ROMULUS SÂRBU*
ADRIAN CORUI**

Abstract: *Water resulted from mining industry and coal processes are characterized by a high concentration in colloidal solid suspension, argillaceous, which doesn't deposit free not even in weeks. To increase the sedimentary speed for waste water are used different cleaning – coagulated – flocculated reactive which must realize a solid faze concentration in the cleaning water corresponding to the evacuation in the emissary or to be re circulated in washing equipment. This study proposed and did to replaced Zetag reactive – with coagulation role, used in present time at Coroesti processing plant with electro coagulation in continue electric field with consumable anode.*

1. STABILITY AND THE DESTRUCTION OF COLLOIDAL SYSTEMS

The stability of colloidal systems is provided by two factors who independently or synergic act for impeding or delaying the union of particles from disperse faze:

- electrostatic factor
- steric factor

Assuring the stability with electrostatic factor is realized because it is forming the double electric layer on colloidal particles and in this way the particles are rejected.

Intervention of steric factor is the results of the absorption of some amfifile molecules or some polymeric substances on colloidal particles surface which act like a mechanical charge for particle collision.

Destroying the disperse systems through particles agglomeration, resulting lowing the dispersion grade and the separation of the aggregates by sedimentation, can be produce by 2 methods: the coagulation and flocculation, which have in essence the same results.

* *Prof. PhD. Eng. – University of Petrosani*
** *PhD. Eng. - University of Petrosani*

The coagulation is the process who unite the disperse particles destroyed by electrolytes or by modifying other influence factors who produce the destruction of the elements and facilitate the attractive force between particles. The agents who produce the coagulation are coagulants.

Destroying the disperse systems with a flocculants agent, a macromolecular compound is made by creating some connections between particles without some substantial modification of the elements that stabilize the system.

Destroying the disperse systems by coagulation involve approaching the particles of disperse faze to some distance where the attraction forces can manifest and lead to the union of the particles and the forming of some big aggregates capable to sedimentation on gravity action. Approaching the particles of disperse faze it is realized because of Brownian moving or mechanical agitation of the system. When the particles of disperse faze approach, electrostatic rejecting forces appears because the diffuse double layer interpenetrate and Van der Waals physical attraction forces.

Specialized literature recommends many substances with the role of flocculants agents. The coagulants are generally salts of some polyvalent metals Fe^{3+}, Al^{3+}, $Ca^{2+,}$ etc, which by hydrolysis or by dissociation liberates metallic ions which cancel the negative electric charge of colloidal particles from water, specially argillaceous particles and it is produce the coagulation of disperse faze and the its rapidly sedimentation in the cleaning process.

Aluminum ions for example, metal use in the experimental analysis, forms with water aluminum hydroxides, liberate hydrogen ions.

Waste water from U.P.Coroesti washing technological process have a lot of argillaceous colloidal substances and are recalcitrant in cleaning.

Because the dispersion grade is high $1/d_m = 7{,}14$, where d_m is medium diameter for solid particles, these particles have a big specific surface and in this way can be explained the high value of surface energy and their high capacity for absorption the ions from water. Because they will have the same electrical sign they will also have a high gravitational stability of the suspension.

So the flocculation process is a complex one, by electrical, chemical and mechanical nature where the cations tied by anionic group of flocculants challenge the inversion of the solid particles charge from stabiles waste water and in this way they lose the water layer adherent at their surface.

The most efficient process is **electrical discharge of the particles**.

The coagulation can be provoked by:

- addition of ion salts (Zetag)
- addition of macromoleculars organic salts (Magnafloc)
- the action of electric field or galvano chemical process

Some research shows that between electrodes happened similar phenomena with water electrolyze, liberating H^+ ions:

$$H_2O + e^- \rightarrow H^+_{ads} + OH$$

which are absorbed at hydrated part of micelle, changing its sign, or liberating Al^{3+} ions from consumables electrodes, who in their way to cathode meeting some minerals particles negative charged , they partially neutralized this particles and provoked their coagulation by decreasing the electro kinetic potential Zeta (Z_p).

The galvanic chemical process for cleaning permits to reach the cleaning level necessary, based on the utilization of elements galvanic elements formed by electrodes pairs, placed in the solution that must be cleaned, by applying a current from an exterior source, without utilize chemical coagulants reactive.

Galvanic chemical oxidation speed of the galvanic pair components depends of some factors like:

- electric power parameters
- environment temperature
- galvanic pair shape and characteristic
- potential of galvanic pair components
- galvanic pair components dimension
- interaction with waste water
- solubility of formed metallic hydroxides
- system ohm resistance
- distribution of electric power density
- other technological parameters

The electric power density cause the speed process of galvanic chemical dissolved for galvanic pair components.

The constant value for the speed of coagulation process is determined by:

$$K = -\frac{1}{t \lg \frac{c}{c_0}} \qquad (1.1)$$

Where K is the constant value for the process; t is processing time (s); c_0 is initial wastewater concentration (g/l); c is final concentration for waste waster

In this way for $c_0 = 52$ g/l, c = 0,65 g/l, t = 25 s, we obtain K = - 0,021 s^{-1}.

For understanding the process is necessary a description of metal solubility (aluminum).

Aluminum, choose for manufacture electrodes, is in the third group of periodic system, has 13 atomic number and 26,9815 atomic mass .

Aluminum atoms have in the exterior electric layer 3 electrons and the maximum oxidation position in +3.

General reaction for anodic dissolved of aluminum and forming the hydrated ions is:

$[Me] + H_2O = Me_{aq}^{z+} + ze^-$

The process speed for this kind of electrode V_m can be determined with:

$$V_m = \frac{d\Delta_m}{dt} \qquad (1.2)$$

where Δ_m is substance quantity and dt is time for passing the substance in solution

Corresponding to the first law of Faraday $\Delta_m = k_e \cdot Q$ where Q is electricity quantity equal with intensity of electric power I multiplied with time t, and k_e is a proportionality coefficient called *electro chemic equivalent.*

Ascribe the law to an gram equivalent E, the quantity of electric power is Q = I t = 1F and the result will be:

$$E = k_e F \qquad (1.3)$$

Respective,

$$k_e = \frac{E}{F} \qquad (1.4)$$

E for aluminum is E = 26,9815/3 = 8,993

In this way

$$\frac{EIt}{F} = \frac{8{,}993 \times 0{,}17 \times 25}{96494} = 3{,}93 \times 10^{-4} \qquad (1.5)$$

Conforming with the second law of Faraday, he is proportionally with chemical equivalent A/z, where A is element atomic mass.

Modifying the electrode mass in the electro chemical dissolve process can be determined: if (a) is ion's mass and N in ion's number, we will have $\Delta_m = a \cdot N$. Ion's mass is equal with element atomic mass A divided with Avogadro number N_a; ion's number N which pass in solution is equal with he ratio of total electric charge Q which pass through system and ion's electric charge:

$$N = \frac{Q}{z_e} \qquad (1.6)$$

Results:

$$\Delta_m = \frac{Q}{z_e} \times \frac{A}{N_a} = \frac{QA}{F} \qquad (1.7)$$

Where F is Faraday number F = N; z_e = 96486.7 C/moli.

The equation which tie both Faraday shows that specific speed for electric chemical dissolve of the substance is proportionally with it's mass and with electricity quantity who pass from the system.

Because between the metal quantities dissolved in anode and electricity exist a direct proportionality, based on the above relation it can be written:

$$\frac{d\Delta_m}{dt} = \frac{dK_e \times Q}{dt} = k_e I \qquad (1.8)$$

In this way the speed of electrical chemical reaction in proportional with current intensity I; it can be express substance equivalent gram if current intensity is ascribed to Faraday unity, respectively I/F, or gram /ion unities, taking account of particles charge, respectively I/zF

The speed depends of the dimension of separation surface between electrode's faze – electrolyte and there for the speed has to be divided to the surface and due to a electric charge density:

$$I_s = \frac{I}{S} \quad [A/m^2] \qquad (1.9)$$

In laboratory instrument condition the surface of one aluminum plate is S = 0,055 m^2. For 14 anode plates S = 0,77 m^2. For current intensity corresponding to the recommended value I = 0,17 A, the current density is I_s = 0,18 A/m^2.

The electricity quantity necessary for obtain an equivalent gram from a substance, it is determined from F value and the electric energy consumption is F·E.

For evaluating the electricity quantity which participates to electrode reactions were considered:

At cathode

$2H_2O + O_2 + 4e = 4\ OH^-$

By passing 4 electrons mol through galvanic pair , will be formed 4 hydroxyl ions; 1 electron mol is 1 faraday and 1 hydroxyl ion is a gram atom, respectively 17 g. In this way electricity quantity necessary is 96486 C. Because 1C =1 Ampere · Second results that through galvanic pair pass 96486 C, if for example current intensity in 10 A and passing time will be 9649 s.

At anode

$Al = Al^{3+} + 3e^-$

3 faradays dissolve 26,9815 Al gram atoms.

At anode is also possible the reaction:

$2H_2O = O_2 + 4H^+ + 4e^-$

Results that passing 4 electricity unities it is emitted 32 O grams.

In one month functioning 24 hours/ day and 30 days in a month

$$\Delta_m = \frac{EIt}{F} = \frac{8{,}993 \times 0{,}17 \times (30 \times 24 \times 3600)}{96494} = 41[g]Al \qquad (1.10)$$

We must say that changing electrodes polarity it can be realized a rational Al consume. Unfortunately experimental checking for the extraction at metals galvanic chemical dissolving, in cleaning waste water, in hard enough to realize.

Next it is studied the replacing possibility for Zetag 7195 reactive use like coagulant with the electro coagulation, use for this purpose an electrizor (sketch 1), where is an electrodes pair (plate shape 58 x 95 x 0,5 mm) made by aluminum and connected to a continue electric power by low tension.

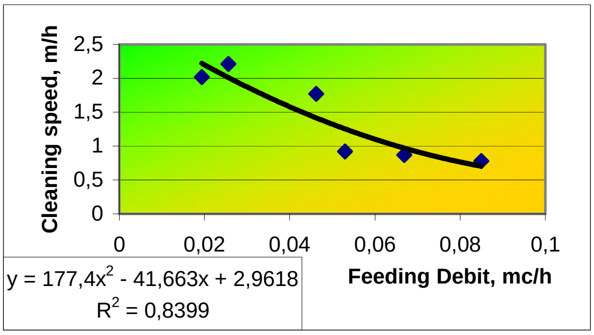
The 4 mm space between electrodes and the connection of this to continue electric power assures electrolyze. In this way Al ions pass in solution by dissolving the anode and migrates to cathode and in their way discharge electric negative mineral particles and coagulate them.

Cloudiness feeding it is made by up to down and in this way the space between electrodes in always full.

Technologic parameters very influence in the cleaning process is feeding debit, parameter hard enough to control in practice, and because of that are accepted variations in stabilized limits. The debit puts in good condition action time for the electric power on cloudiness or in other words passing time for cloudiness through electrizor. Correlation between feeding debit and cleaning speed, calculated on the registered influence parameters and experimental results from the table data, is presented in figure 1 and described with a good estimation.

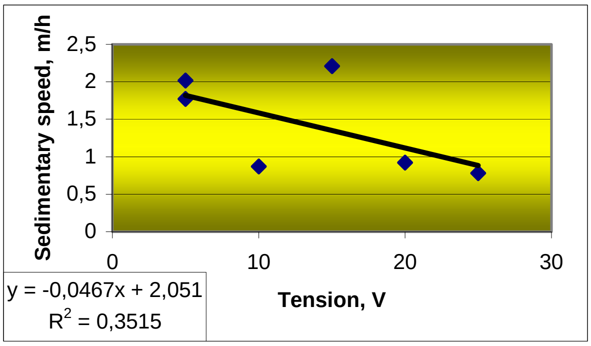
As we expected growing the debit determines lowing sedimentation speed, showing the role of stationed time for cloudiness in electrizor.

Fig. 1. Correlation between feeding debit and sedimentation speed



Regarding the correlation between work tension a sedimentation speed, this has a low intensity (correlation coefficient R=0.59), described by a decreasing first grade equation. This means that lower tensions are better in the process.

Fig. 2 Correlation between tension and sedimentary speed



An important parameter which makes the connection between other process parameters is consumed energy, W.

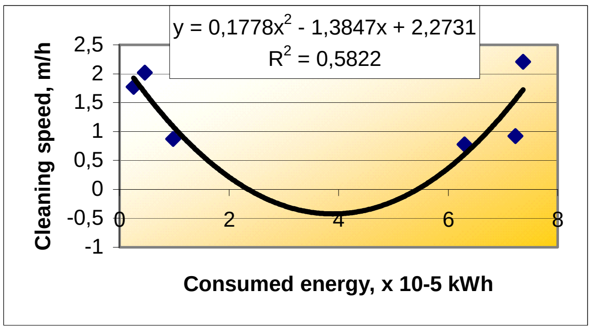
$$W = P.t = U.I.t = U.I\ .V / Q \ \ [kWh], \qquad (1.11)$$

Where

- P is power in W;
- U – tension, V;
- I – intensity , A;
- T – passing time of cloudiness through instrument, h;
- V – utile volume for electrizor m^3;
- Q – Cloudiness feeding debit, m^3.

Correlation between electric power consumed and sedimentary speed who was choused by purpose, is presented in fig. 3 and described by a second grade equation and the connecting law is of medium intensity R = 0,75.

Fig. 3. Correlation between electric power consumed and sedimentary speed

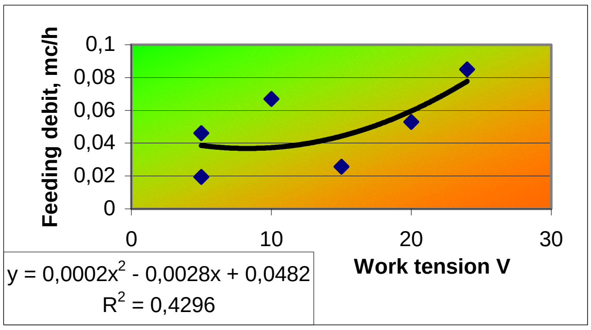


Overlap the diagrams v = f(Q); v = f(U) and v = f(W), where v is sedimentary speed, we obtain 2 variation domains where the results are acceptable.

W Є (0 ÷ 1.10^{-5}) kWh where Q debit and the tension have small values and
W Є (6 ÷ 8.10^{-7}) kWh where Q debit and the tension have high values.

This thing shows the connection between feeding debit and work tension, who is described by a growing second grade law and medium intensity, R=0.65 (fig.4)

Fig. 4. Correlation between feeding debit and work tension



On this reasons next experiments set was realized on the same solid phase concentration, the same Magnafloc flocculent consume and the 24 V tension considered un dangerous. Were made 4 analyses for big tension values who determine high intensity and decreasing the interior resistance of the instrument a high quantity of aluminum is dissolved. On the obtained data it was recalculate the correlation between the consumed energy and the cleaning speed, presented in fig. 5.

It can be observed that the energy value is over 4 $x10^{-5}$ kWh, which means high power much stationing time in detriment of processing debit.

In these conditions for putting the experimental results on industrial scale we purpose the next work plan:

-Work tension 24 V
- Consumed power 4, 08 x 10^{-3} kW
- Electric power specific consume 0,047 kWh/m^3, treated cloudiness
- Electric power density in electrode 0, 18 A/m^2
- Aluminum specific consume at anode, 41g/month
- Cleaning speed 1.67 m/h
- Solid phase concentration in clean water 0,65 g/l

The final conclusion is that treating method in continuous electric field with consumable anode it is proper for wastewater from Coroiesti and the processing cost are more reasonable (smaller) comparing with Zetag reactive.

Fig. 5. Correlation between consumed energy and the cleaning speed at over 24 V tensions

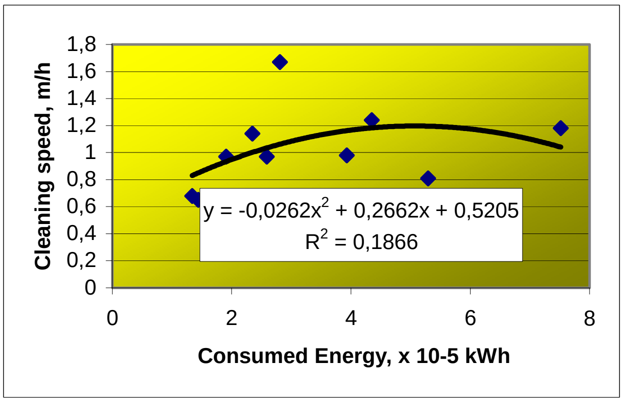
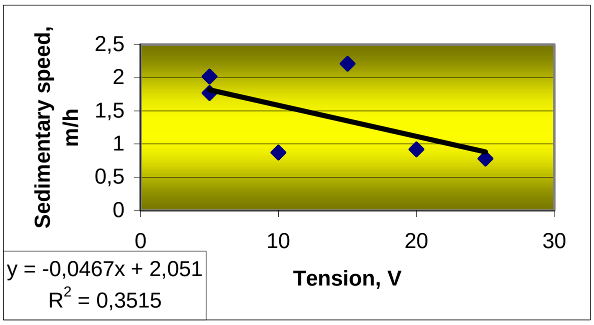


Fig.6 Correlation between electric power tension and sedimentary speed



The method can be implemented in the process and the battery can be put on the actual flux without important outlays.

CONCLUSIONS

By treating the wastewater contaminated with argillaceous mineral suspensions in electric field and by obtaining the dissolution of the aluminum anode and the transfer of Al^{3+} ions in solution, the coagulation process can be achieved without using coagulant reactives, such as polielectolites, which are very expensive

REFERENCES

[1]. Valentin A., Solojenkin P. Krausz S. - *Theoretical ads practice base for galvanic chemical waste water cleaning,* Ed. Universitas Petroşani 2004

[2]. Beral E., Zapan M. - *Inorganic chemistry Ed. Tehnică Bucureşti 1968*

[3]. Sârbu R. ,Bekesi C. - *Waste water treatment in electric field ROPET 2001 scientific symposium, Petroşani*

[4]. Sârbu R. Bădulescu C., Traistă E. - *Treating waste water procedures and equipment Univ. of Petroşani litography, 1998*

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SYNTHESIS OF THE MODIFIED REAGENTS AND THEIR USE FOR THE FLOTATION OF ORES FROM VARIOUS DEPOSITS

P. M. SOLOZHENKIN*
A. GORNOSTAL**
A. M. MICHNEA***
P. ILIE***

Abstract: *The flotation properties of acetic acids modified by xanthic and dithiocarbamic fragment in regards to copper and ferrous minerals and their noble metal containing ores have been investigated. The effectiveness of the co-using of these reagents with xanthates and dithiocarbamates has been shown, ie using of proposed reagent regimes for the flotation of Au-containing ores increases gold recovery by 4.2 -4.7 percent, and in the case of flotation of copper Re-containing ores copper recovery increases by 3.3 percent, rhenium recovery - by 15.5 percent. The mechanism of the action of these reagents has been explained by the data of UV and ESR- investigations of their sorption on mineral surface. The information on structure and properties of co-ordination compounds of some metals with (Diethyldithiocarbamato) acetic acid were used also for the explanation of flotation mechanism.*

1 INTRODUCTION

Due to the processing of poor and hard to dress ores and increasing requirements for the quality of the commodity, output of the non-ferrous metallurgy sets essential problem of the search of new effective reagent regimes. Thus, oxidized ores are hard to dress and in the case of their flotation the use of xanthate even in high consumptions does not provide required dressing indices. On the other hand, the oxidized ores flotation by fatty acids is not selective and requires high consumptions of reagents, which are obtained from food raw materials. Therefore the problem of searching for new effective collectors is of essential scientific and practical interest.

**Prof .PhD. Eng. - Institute of problems of complex development of bowels of the Russian Academy of Science (IPCON the R A Sc)*
*** Moscow State University of Technology and Management, Rostov Branch*
**** North University of Baia Mare*

The main type of the flotation reagents-collectors used for the ore dressing are the collectors of the election donor type - sulfhydrylic and oxyhydrylic reagents and non-ionic derivatives of sulfhydrylic reagents. Sulfhydrylic reagents (xanthates, dithiocarbamates, dithiophosphates) and their derivatives (S-alkyl ethers and thionocarbamates) are used for the sulfide ores flotation. Among the oxyhydrylic reagents the higher carboxylic acids are the most known. They are mainly used for the flotation of salt and oxidized mineral types and corresponding ores. The mechanism of the action of electron donor type collectors is explained most successively by the co-ordination theory of flotation. According to this theory, the chemosorptional fixation of collector on mineral surface resulting to its hydrophobization is because of the formation of the coordination compounds between surface metal ions and collector containing electron donor groups.

It has been shown in the technical literature that thiol collectors (xanthates, dithiocarbamates, dithiphosphates) modified with acetic acid fragments are very efficient collectors for the flotation of oxidized copper minerals and for precious metals too, resulting in higher metal recoveries and grade (Solozhenkin, 1990, Gornostal et al. 1993; Michnea et al.1998). It was stated that, during the flotation process, the acetic fragment is preferentially attached to the oxidized minerals or the secondary copper sulphides; hence the total amount of collected minerals rises by floating minerals that usually are going into the tailings. The chemical synthesis of the tested co-reagents was carried out by the carboxylation of the xanthates. The manufacturing procedure for the modified xanthates is very simple and easy to perform on- site in the flotation plant (Michnea et al.2003).

The manufacturing of the acetic acid derivatives modified by xanthate fragment was carried out by the xanthates carboxylation and the neutralization of the resulted acid, as represented by the following equations:

$$ROC(S)SNa + ClCH_2COOH \rightarrow ROC(S)SCH_2COOH + NaCl \quad (1)$$

$$ROC(S)SCH_2COOH + NaOH \rightarrow ROC(S)SCH_2COONa + H_2O \quad (2)$$

where R is an alkyl C_2–C_5 radical.

The following modified acetic acids with xanthate and N,N-dialkyldithiocarbamato fragments were prepared within this research work:

$C_2H_5OC(S)SCH_2COONa$ (3)
sodium (O-ethylxanthate)acetate (EXa)

$C_4H_9OC(S)SCH_2COONa$ (4)
sodium (O-isobuthylxanthate)acetate (iBXa)

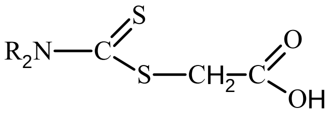
$C_4H_9OC(S)SCH_2COONa$ (5)
sodium (O-buthylxanthate)acetate (BXa)

$(C_2H_5)_2NC(S)SCH_2COONa$ (6)
sodium (N,N-diethyldithiocarbamato)acetate (DEXDtcaNa)

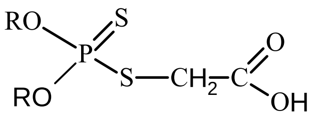
The new reagents-collectors such as carboxylic acids modified by fragments as:

O-alkyldithiocarbonic or N,N-dialkyldithiocarbamic or O,O-dialkyldithiophosphoric acids

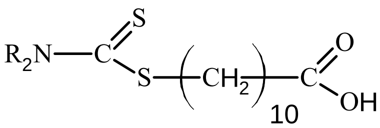
have the following formulas:



(N,N-dialkyldithiocarbamato)acetic acids (7)



(O,O-dialkyldithiophosphato)acetic acids (8)



(N,N-dialkyldithiocarbamato) undecanoic acids (9)

By using the molecular orbital approach (Solozhenkin et al.1983) it is possible to suppose that reagents of this group must bond well with oxidized sulphide minerals surface due to the simultaneous affinity of carboxyl oxygen to oxygen-containing anions of mineral surface and sulphur atoms of dithio fragment to the metal cations and the sulfide anions. This effect is to be essentially increased in the case of “soft” metal ion in the mineral surface such as Cu (II), Hg (II), Ag (I).

2 SYNTHESIS AND PHYSICO-CHEMICAL PROPERTIES

2.1 Synthesis and physico-chemical properties of the modified carboxylic acids and their co-ordination compounds with metals

Synthesis of reagents was carried out by carboxyalkylation of alkali salts of dithioacids, as shown in Figure 1.This reaction proceeds at room temperature with high yields. Therefore the convenient synthesis of these reagents has been elaborated, which can be used in conditions of dressing plants.

The structure and properties of these reagents have been characterized by the data of UV, NMR and mass-spectroscopy.

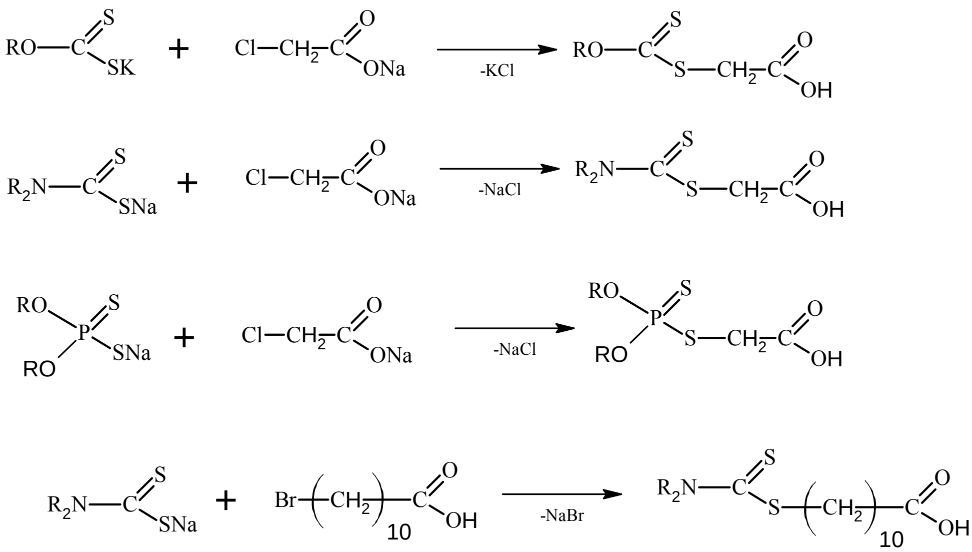
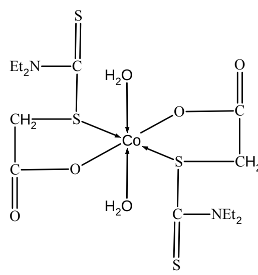


Figure 1. Synthesis of reagents

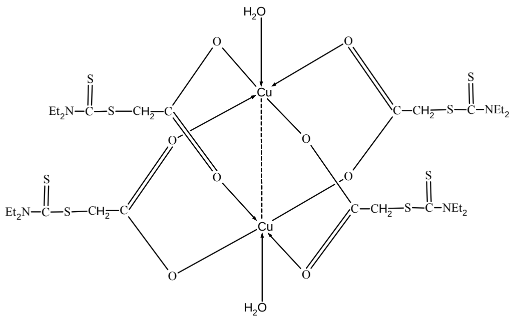
For the interpretation of the mechanism of interaction of studied reagents with surface of sulfide and oxidized minerals the coordination compounds of (diethyldithiocarbamato)acetic acid with Co(II), Ni(II), Cu(II), Zn, Cd, Pb(II) have been synthesized and investigated by the methods of IR, electronic, proton and carbon NMR and ESR spectroscopy (Solozhenkin et al.1990,b). The formation of chelate ring including carboxyl oxygen and dithiocarbamate sulfur has been established in the synthesized complexes. Co(II) and Ni(II) complexes are the monomers with weak octahedral crystal field and MO_4S_2 chromophore (formula 10).

The correlations between the IR and UV spectroscopic parameters reflecting the strength of metal-sulfur bond and the “softness” of metal ion have been discovered. The strength of metal-sulfur bonding has been established to decrease in the range Cu>Ni>Pb>Co>Cd>Zn.



(10)

In the case of considerable “softness” of metal ion the conversion of its complex with C—S bond rupture becomes possible. Thus, Copper(II) (diethyldithiocarbamato)acetate has dimeric structure with four bridge carboxyls:



(11)

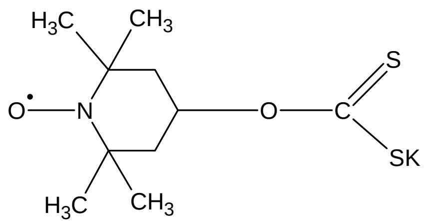
This complex (11) in organic solvents turns through the series of intermediate monomer forms with CuS_2O_2 and CuS_3O chromophores to the complex with CuS_4 chromophore and free carboxyl groups.

(Diethyldithiocarbamato)undecanoic acid can not react as O,S-chelating ligand due to long distance between carboxyl and dithiofragment. Therefore the complexes of Ca, Sr, Ba, Co(II), Ni(II), Zn, Cd, Pb(II) with this compound have the oxygen environment of metal ion owing to low affinity of these metal ion to sulfur atoms. They are the compounds of soap-like character not soluble in water. The possibility of formation of coordination compounds with CuO_4, CuO_2S_2, CuO_3S and CuS_4 chromophores has been established in the case of “soft” Cu(II) cation and (diethyldithiocarbamato)undecanate anion. In this case it acts as ambidentate O,O- or S,S-chelating ligand (Solozhenkin et al 1990, c).

Of course, it is not worth extrapolating these facts directly to the mineral surface, but it indicates the tendencies in the interaction of investigated compounds with “soft” ions of non-ferrous metals, and it may be possible for the cations of mineral surface. Modified acetic acids must have collector properties for oxidized sulfide minerals alone of in synergistic mixtures with xanthates (Solozhenkin et al 1988; Solozhenkin et al 1990). Due to long hydrocarbon chain and the presence of hydrophobic dithiofragment (dialkyldithiocarbamato)undecanoic acids may act as analogs of fatty acids but more selective (Solozhenkin et al.2008).

2.2 The use of spin labeled reagents for the ESR investigation of the sorption of modified carboxylic acids

I. The effect of (butylxanthato)acetate on the sorption of spin-labelled potassium iminoxylxanthate (RKxK) (Solozhenkin et al. 1983; Solozhenkin et al. 1986) has been investigated by the method of ESR. The relative quantity of sorbed RKxK was defined as peak to peak intensity J_o of its ESR signal on mineral surface (in mm). Upon combined supply of BxaNa and RKxK the sorption of latter on surface of chalcocite-bornite mixture has been established to be maximal at BxaNa concentrations being in limits (3.26-9.78) x 10^{-4}mol/l (Figure 1).



(12)

The decrease of the sorption of RKxK at further increasing of BxaNa concentration can be explained by their competition for the active sites of the surface. In the case of the treatment of pyrite and chalcocite-bornite mixture by iminoxylxanthate doped in BxK in combination with BxaNa the sorption of RKxK has been established to increase with the increasing of BxaNa concentration, and the nature of sorption layer is altered. Such ESR parameters as label rotation rate *v* and distance between paramagnetic centers R were calculated.

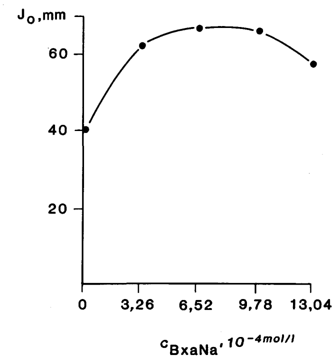
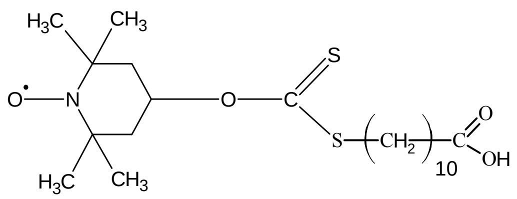


Figure 2. Effect of BxaNa on intensity J_o in ESR spectrum of adsorbed RKxK on chalcocile-bornite mixture

II. In order to study the interaction of modified oxyhydrylic collectors with non-sulfide minerals spin-marked fatty acid of formula



(13)

has been used for the first time (Solozhenkin et al, 1983). This compound has high flotation characteristics due to the formation of the complexes with calcium and barium cations on the surface of non-sulfide minerals.

Data from the infrared spectrophotometric study indicate the coordination of alkaline earth metal atoms only by carbmechanism of action of fatty acid collectors.

Upon increasing the concentration of spin-labeled acid the intensity of ESR-signal increases. Recovery of mineral also increases. The study of the nature to sorption layer of this acid on the barium sulphate (barite) treated by the mixture of spin-labeled fatty acid and sodium oleate has been presented weakly resolved triplets. Upon increasing the temoxyl.

The introduction of spin label into the molecule makes it possible to use this compound as model for studying a perature in the interval of 30 and 85°C the rotational mobility of spin-labeled fatty acid was increased and is observed dully resolved triplet. Spectra were recorded with standard of manganese, HFS of which 87 oersted.

The sorption of radicals on mineral surface brings about reducing of radical rotation nearly on 2 orders in contrast with rotating of a label in toluene solution. When concentration of sodium oleate was increased to 200 mg/l the reduction of local concentrations of label occurred and weak resolution of a triplet was observed. Increasing of temperature to 50°C promoted resolution of triplet and increased a rotating frequency to $1.7 \bullet 10^9$ s^{-1}. The floatability of barite in this case was enhanced and hydrofobity of the surface was increased to the account both of sodium oleate and spin-labeled fatty acid.

3 ORE FLOTATION TESTS

3.1 Au-containing ores from deposits of North Tajikistan

Sinter burden composed from Au-Ag-containing ores of various deposits of North Tajikistan was the subject of flotation. These ores contain 0.3-0.5% of sulfur. The extent of oxidation (the ratio of oxidized iron to its sulfide form) in burden fluctuated in the range 50-70%. Gold in these ores occurs in native form and in association with quartz, goethite, hydrogoethite and sulfides. Au content in pyrite yields 53 g/t according to data from chemical analysis. Silver occurred in form of cerargirite and in association with gold (Solozhenkin et al.2007).

Flotation experiments have been carried out in continuous process with 4 ore samples. The scheme included rougher (9 minutes) and scavenger (12 minutes) flotation and one cleaning flotation (3 minutes). The initial ore was ground to 50% –0.074 mm and tailings of rougher flotation were reground to 90 % –0.074mm. In grinding stage 150 g/t Na_2CO_3, in rougher flotation 40 g/t NaCl, 60 g/t T-80 and 40 g/t collector and in scavenger flotation 30 g/t T-80 and 220 g/t collector were supplied. BxK was used as main collector and BxaNa, DtcaNa and sodium (N,N-dimethyldithio-carbamato)acetate(DmdtcaNa) were supplied in addition. Gold recovery increases by 4.2-4.7% upon using of additional reagents.

Based on the positive results reached in laboratory tests the reagent regime including BxaNa in addition to xanthate has been tested in one of gold-treating plants of Middle Asia because of the possibility of synthesis of BxaNa immediately in the dressing plant.

Reagents were supplied in BxK: BxaNa ratio 4:1 according to existing technological scheme. Highly oxidized and mixed ores are treated in this plant (these ores were the subject of the investigation in laboratory tests previously described). Plant regime included the following reagents: BxK - 170-230 g/t, Na_2CO_3 - 150-250 g/t, T-80 - 40-110 g/t, NaCl - 100-150 g/t. During the tests, the xanthate was changed by the mixture of BxK and BxaNa with the same total consumption. The use of reagent regime with BxaNa allowed an increase in gold recovery with 8.9 %, silver recovery with 1.0% in comparison with the plant regime (Table 1).

Table 1 Results of industrial tests with BxaNa

Content in ore g/t		Content in concentrate g/t		Recovery per cent	
Au	Ag	Au	Ag	Au	Ag
PLANT REGIME (BxK - 200 g/t)					
1.16	40.66	76.7	1567.7	68.4	79.5
TEST REGIME (BxK - 160 g/t, BxaNa - 40 g/t)					
1.26	21.77	75.1	1148.3	77.3	80.5

3.2. Au-containing ores from deposits of Siberia

Under the technical rules, the firm "Beraton" has organized the manufacture of sodium (N,N-dimethyldithicarbamato)acetate (trade mark Beraflot -30D-1 and Beraflot -30 D-2) and potassium (O-alkylxanthato)acetate-BxaK (Beraflot -30D-3, Beraflot -30D-4, Beraton -30D-5) (Algebraistova et al. 2005). The mixture of butyl xanthates and Beraflot 30 D-2 allows increasing the overall extraction of the gold.

3.3. Copper Re-containing ores of Geskazgan (Kazakhstan)

Copper ores of Geskazgan deposit are of the type of copper sandstones. The main ore minerals are bornite (20-24%), chalcocite (50-60%), and chalcopyrite (5-9%). The oxidized copper minerals such as malachite and azurite occur also. Rhenium (up to 4 g/t) reposting to concentrate is contained in such ores (Solozhenkin et al.2007).

The flotation scheme includes the separate flotation of sands and slimes. Reagent regime of flotation was the following: 20 g/t of mixture of butyl and isopropyl (5:1) xanthates in combination with 30 g/t of DtcaNa were used as collector in test. In comparative experiment 70 g/t of xanthates mixture were used alone. Cu and Re recovery in test regime has been increased by 3.3 and 15.5%, respectively. Simultaneously xanthate consumption has been reduced significantly.

3.4. Sasar gold ore (Baia Mare, Romania)

The gold-bearing ore sample assayed Au=1.15 g/t, Ag=15.8 g/t and 1.6% S (total). It is an oxidized ore with high content of clayed slime (Michnea et al.1999; Michnea et al.2003; Michnea et al.2007).

The ore sample was ground to 75%-0.074 mm. The flotation scheme included rougher (5 minutes) and scavenger (3 minutes) flotation. The reagents consumption in the rougher flotation circuit amounted to: collector – 350 g/t and AGF200 (frother) – 40 g/t. The scavenger flotation tests were conducted in the presence of Na_2SiO_3 – 200 g/t. The following collector regime was tested:

Table 2 Collector regime for Sasar ore tests

Test	Collector
1	sodium ethylxanthate
2	sodium ethylxanthate:sodium (ethylxanthato)acetate = 4 : 1
3	sodium isobuthylxanthate
4	sodium isobuthylxanthate : sodium (isobuthylxanthato)acetate = 4 : 1

The flotation results are shown in figure 2 (for gold) and figure 3 (for silver).

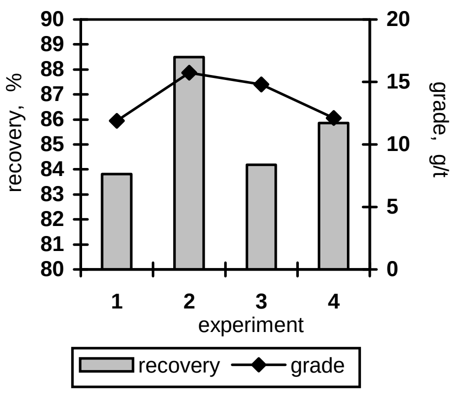


Figure 3. Gold recovery and grade in Sasar ore flotation tests

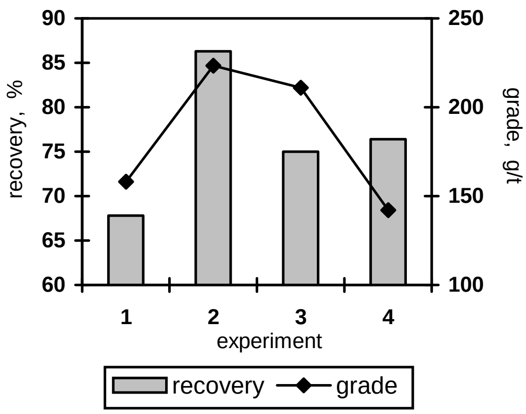


Figure 4. Silver recovery and grade

As it can be seen in Figure 3 and 4, the precious metal recovery is larger when it has been collected by the tested mixtures, compared with the use of xanthates individually, especially in the case of ethyl xanthate with the appropriate modified acetic acid.

The results reveal the synergistic action of the xanthate and the appropriate modified acetic acid mixtures. Recovery as well as grade of gold and silver has been increased in the case of collecting with mixtures of ethyl xanthate and (ethylxanthato) acetate. It can be assumed that the presence of modified acetate raises the collecting power towards all the occurring forms of precious metals. The affinity of modified acetate structures to the oxidized minerals enhances the recoveries of the valuable metals, but in the same time it induces the decrease of the grades.

It is very significant to notice according to data of chemical analysis that an increase of the amount of coated gold with oxides and hydroxides occurred in experiment 2, compared to experiment 1. The amount of coated gold with oxides and hydroxides increased from 2.9% in the concentrate of experiment 1 to 16.2% in the concentrate in experiment 2. The larger gold recoveries might be explained by the extension of the collecting abilities of the collector mixtures on oxidized minerals too, that might induce the extraction of supplementary amounts of gold. In experiment 2, gold recovery was improved by approximately 5 points, from 83.8 to 88.7%.

3.5. Baita Bihor copper ore (Romania)

The mineralogical observations for the copper-bearing ore sample have shown the presence of bornite, covellite, chalcocite and chalcopyrite. Chemical analysis assayed 0.92% Cu and 3.27% S.

The ore sample was ground to 73%-0.074 mm, with lime, in order to get the pH level of 8-8.5. The flotation tests were run for collecting the copper concentrate. The flotation stage was carried out for 4 minutes in the presence of 25 g/t collector and 30 g/t AGF250 as frother. Collectors for the flotation experiments were as following:

Table 3 Collector regime for Baita Bihor ore tests

Test	Collector
1	iBX
2	iBX:iBXa = 1:1
3	iBX:iBXa = 2:1
4	iBX:iBXa = 4:1

The results from Baita- Bihor ore flotation tests with the new synergistic mixtures of collectors are plotted in Figure 5.

It can be noticed that the use of synergetic collector mixtures resulted in higher copper recoveries, compared with the use of individual xanthates. It might be suggested that the supplementary extraction of copper oxidized minerals is responsible for increasing the metal recovery, despite of the lower grade of the concentrate obtained in the tests with mixture of collectors.

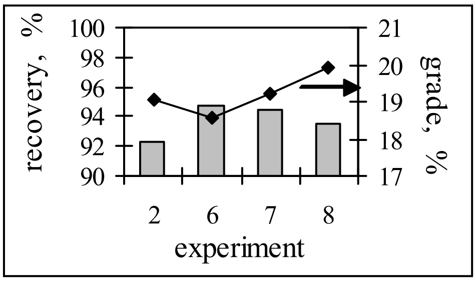


Figure 5. Cu grades and recoveries for the Baita Bihor ore flotation tests

Hence, the grade decreased in experiment 2, but in the following up tests the amount of acetic derivative was proportionally decreased, resulting in smaller recoveries and higher grades. In experiment 2 (iBX:iBXa=1:1), Cu recovery was improved by 2.5 points, from 92.27 to 94.77%.

3.6 Turt Mine ore (Satu Mare, Romania)

The ore sample assayed Pb=1.7%, Cu=0.21% and Zn=1.66%. The mineralogical observations highlighted the presence of metal sulphides as well as the oxidized minerals such as oxides, carbonates or secondary sulfides; chalcopyrite, galena, sphalerite, wurtzite, tetrahedrite are the main minerals that were found. The ore sample was ground to 75 % –0.074 mm with lime, in order to reach the pH of 8-8.5. The flotation tests for the collection of the copper-lead concentrate were run with the new reagent regime as presented in Table 4. The flotation stage was carried out for 4 minutes in the presence of 20 g/t collector.

Data in Table 5 highlight that Cu recovery increases with 0.3 to 13.6% and Pb recovery increases with 3 to10.5 % by using the tested non-conventional synergistic mixtures.

It is very interesting to remark that selectivity indices increase with raising the mass ratio Ac/A in the synergistic mixture (where Ac - amyl xanthate acetate and A - amyl xanthate). It seems that zinc minerals are not floated by the acetic xanthate derivative and decreasing the amount of amyl xanthate, zinc sulphides will not pass into the Cu-Pb concentrate; hence, the recovered amount of Zn in the collective Cu-Pb concentrate remains constant and even decreases and consequently the selectivity for Cu and Pb is improved. It is very well remarked the synergistic effect of the tested mixture of collectors and it is rather clear that the effect is due to the supplementary collecting ability of the co-reagent on the oxidized minerals of the valuable metals.

Table 4 Collector regime for Turt ore tests

Test	Collectors
1	NaEX:KAX = 2 : 1
2	NaEX:KAX:KAXAc = 2 : 0.2 : 0.8
3	NaEX:KAX:KAXAc = 2 : 0.33 : 0.67
4	NaEX:KAX:KAXAc = 2 : 0.66 : 0.33
5	NaEX:KAX:KAXAc = 2 : 0.8 : 0.2

The flotation tests were conducted in order to obtain the copper-lead concentrate, using collectors as proposed. Cu grade is improved with 0.51% and Pb grade with 1.53%, respectively.

Table 5 Experimental results in Turt ore tests

		Grades,%			**Recoveries, %**		
		Cu	**Pb**	**Zn**	**Cu**	**Pb**	**Zn**
1	Cu-Pb conc.	3.62	40.59	2.23	53.8	74.5	4.2
	Zn-rich tailing	0.1	0.44	1.62	46.2	25.5	95.8
2	Cu-Pb conc.	3.69	40.3	2.28	54.1	73.0	4.2
	Zn-rich tailing	0.98	0.47	1.63	45.9	27.0	95.8
3	Cu-Pb conc.	3.81	41.05	2.08	58.2	77.5	4.0
	Zn-rich tailing	0.09	0.39	1.64	41.8	22.5	96.0
4	Cu-Pb conc.	4.05	41.32	2.0	65.2	82.2	4.1
	Zn-rich tailing	0.07	0.31	1.65	34.8	17.8	95.9
5	Cu-Pb conc.	4.13	42.12	1.97	67.4	85.0	4.1
	Zn-rich tailing	0.06	0.22	1.97	32.5	15.0	95.9

3.7. Flotation of the CaF_2 ore

Earlier we offered a number of ω - (N, N - N,N-dialkyldithiocarbamato) undecanoic sodium as collectors of non-sulphide minerals (Solozhenkin et al. 1989; Solozhenkin et al. 1990,a; Solozhenkin et al. 1990,b):

$(C_2H_5)_2NC(S)SNa+ClCH_2(CH_2)_9COONa=$
$(C_2H_5)_2NC(S)S(CH_2)_{10}COONa+NaCl$ (13)

$(C_4H_9)_2NC(S)SNa+ClCH_2(CH_2)_9COONa=$
$(C_4H_9)_2NC(S)S(CH_2)_{10}COONa+NaCl$ (14)

Reach reagents has the common formula: $R_2N\text{-}C(S)\text{-}S\text{-}(CH_2)_{10}\text{-}COONa$ (15)

The collector properties of (N,N-diethyl dithiocarbamato)undecanoic acids because of their longer hydrocarbon chain have been investigated in non-sulfide flotation (Solozhenkin 2008).

Sodium ω-(N,N-diethildithiocarbamato) undecanoic (DExDtcaNaU) (#1) and sodium ω-(N,N-buthyldithiocarbamato) undecanoic (DBtcaNaU) (#2) were tested.

Flotation experiences were carried out on calcite, barite, celestite, fluorite and quartz size –0.2 +0.063 mm in laboratory flotation apparatus with volume of the chamber 20 ml on a mineral in weight of 1g.

The maximal extraction of fluorite is achieved at concentration DExDtcaNaU and DBtcaNaU 6 mg/L while at this concentration accompanying minerals flotation is insignificant, and quartz practically not flotation. In the flotation of the mentioned minerals, sodium oleate in concentration of 5 mg/L makes the extraction of fluorite at 95.1%, calcite-31.9% and barite-97.7%. Minerals flotation occurs in a wide range of hydrogen ions concentration.

Researched reagents were tested at flotation of various fluorite ores. Experiences were carried out under the circuit including crushing up to 64% of the class of –0.074 mm, the basic and control flotation, and also six cleaning stages. In crushing stage the following reagents moved: CBL (a concentrate bards liquid) (800 g/t), $NH_4F\text{-}HF$ (150 g/t), $A1_2(SO_4)_3$ (200 g/t), NaHS (500 g/t). In basic flotation were used: Na_2CO_3 (2000 g/t), collector (200g/t) and in control stage - collector (50 g/t). The concentrate of the third cleaning stage was roasted for 10 minutes at 80°C in the presence of reagents CBL (700 g/t) and $NH_4F\text{-}HF$ (75 g/t). The use of $NH_4F\text{-}HF$ allows to connect calcium cations in calcium fluorite and flotation it. Residual concentration of fluorine ions in a pulp does not exceed maximum concentration limit. Experiment carried out in a continuous cycle with six probes with oleic acid and DBtcaNaU shows that DBtcaNaU, the acid and DExDtcaNaU has the greater collective ability, than the oleic acid. However better quality of a concentrate is achieved at application of DExDtcaNaU. For optimization of flotation of fluorite ore, combinations of reagent DExDtcaNaU (#1) and oleic acid were also tested. Application of combination DExDtcaNaU with oleic acid has allowed increasing extraction of fluorite in comparison with the extraction obtained at their separate use. Quality of the concentrate in this case was also improved. At the application of the combination DExDtcaNaU with DBtcaNaU, extraction of fluorite has a little bit increased, however quality of the concentrate became worse than at separate use of the specified reagents.

Thus, chemosorption plays a prepotent role in selective flotation of fluorite, and also in display of collective force of reagents DExDtcaNaU and DBtcaNaU.

Application of a combination of oleic acid / and sodium ω-(N,N-diethildithiocarbamato) undecanoic in the ratio 1:1 at the flotation of fluorite ore with contents of CaF_2 – 23.4 % allows obtaining a fluorite concentrate with 96.3% CaF_2 and fluorite extraction of 85.4 %. At application of a combination of reagents it is obviously observed the synergistic effect.

4 CONCLUSIONS

1. Short-chain carboxylic acids modified by dithio fragments in combination with sulphydrylic reagents promote best sorption of the latter on copper and ferrous minerals and increase their recovery upon flotation by these combinations.
2. Chemical features determining flotation activity of acetic acids modified by dithio fragments have been established: chelating ability and occurrence of two co-ordination sites with significantly different “softness” – carboxyl and dithio fragment.
3. The use of modified acetic acids in addition to xanthate promotes the increase of technological indices of Au-Ag and Cu-Re-ores flotation.
4. Application of a combination of oleic acids and sodium ω-(N,N-diethildithio-carbamato) undecanoic in the ratio 1:1 at the flotation of fluorite ore with contents of 23.4 % CaF_2 allows to obtain a fluorite concentrate with 96.3% CaF_2 at the extraction of fluorite of 85.4%.

RERERENCES

[1]. Algebraistova, N.K., Rakhmanova, Z.A., Alekseeva, E.A., Batalova, E.S., Taranushchenko, Yu.V., (2005). New Reagents for Flotation of Gold–bearing Ores. *Tzvetnii Metalli* 5, pp. 18-20

[2]. Gornostal, A., Solozhenkin, P.M., Avrakhov, A., Abdurazakov, A., (1993). Carboxylic acids modified by dithio fragments as reagents for gold and copper containing ores flotation, *Proceedings, XVIII International Mineral Processing Congress, Sydney, May 23-28,* pp. 549-555

[3]. Michnea, A.M., Ilie, P., Filip, G., Sasaran, N., (1998). The study of parameters in the mineral-collector system, *Proceedings, 7-th International Mineral Processing Symposium Innovation in Mineral and Coal Processing, Istanbul, Turkey, September 15-17,* pp. 189-194

[4]. Michnea, A.M., Ilie, P., Filip, G., (1999). Processing of nonferrous sulphide minerals using collector mixtures with synergistic action, *Proceedings, Conference New Trends in Mineral Processing III, Ostrava, Czech Republic, June 24-26,* pp. 545-550

[5]. Michnea, A.M., Ilie, P., Filip, G., Podariu, M., (2003). Synergistic collector’s mixtures for the non-ferrous sulphide minerals flotation from NW Romania, *Proceedings, X Balkan Mineral Processing Congress, Varna, Bulgaria, June 15-20,* pp. 212-215

[6]. Michnea, A.M., Oprea, G., (2007). The synergistic effect of mixtures of xanthates and their derivatives, *Proceedings, XII Balkan Mineral Processing Congress, Delphi, Greece, June 10-14,* pp. 285-290

[7]. Solozhenkin, P.M., (1983). Investigation of interaction of reagents with minerals by the methods of magnetic radiospectroscopy, *Physicochemical Bases of Flotation Theory"* (Ed: B N Laskorin), Moscow: Nauka, pp 98-101

[8]. Solozhenkin, P.M., Kopitsya, N.I., Zinchenko, Z.A., Shvengler, F.A., Aknazarova, T.N., Krylova, I.D., Ivanova, N.K. (1986). Spin-labelled reagents and their using for the investigation of mechanism of interaction of flotation reagents combinations, *Flotation Reagents* (Eds: A. M. Golman and I. L. Dmitrieva), Moscow: Nauka, pp 24-29

[9]. Solozhenkin, P.M., (2007). Designing Sulphidrilic Reagents of Double Action Effective at Flotation of Gold-and-Rhenium Containing Ores, *Proceedings, Conference New Trends in Mineral Processing III, Ostrava, Czech Republic, June 24-26*, pp. 545-550

[10]. Solozhenkin, P.M., Ivanova, N.K. Avrakhov, A.A., (1989). Flotation of non-sulphide minerals by Undecanoic acid Derivatives, *Second World Congress on Non-metal Minerals, (Beijing),* 3, pp 1002-1006

[11]. Solozhenkin, P.M, Avrakhov, A.A., Gornostal, A.A., (1990 a). Flotation properties of carboxylic acids modified by sulphydrylic reagents, *Obogatshenie rud, No. 2*, pp 18-21

[12]. Solozhenkin, P.M., Gornostal, A.A., Ivanov, A.V., Grigina, I.N., (1990 b). The Interaction of Copper (II) with Ambidentate Ligand - (Diethyldithiocarbamato) undecanoic acid, *Doklady Akademii Nauk SSSR, 314, 1,* pp 209-213

[13]. Solozhenkin, P.M., Gornostal A.A., Ivanov, A.V. (1990c), Synthesis and properties of bis-[(diethyldithiocarbamato)acetate]copper, *Doklady Akademii Nauk SSSR, 310, 3,* pp 649-652

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PRACTICAL GUIDANCE PRINCIPLES IN OCCUPATIONAL RISK ASSESSMENT PROCESSES

ROLAND MORARU*
GABRIEL BĂBUȚ*

Abstract: *Risk assessments are conducted primarily to support the decision-making process regarding the occupational health and safety. Decisions on the adequacy of a design usually occur during a design review. Integrating risk assessment in an organization is a process that generally follows a sequence of phases. To be effective, the company culture must be willing to embrace the risk assessment process, and cultural acceptance stems from management leadership. A very broad cross section of methods documents the current state of the art and wealth of activity in the risk assessment process. Risk assessment methods are being deployed in many industries, and that the momentum will likely continue. Although the level of sophistication in risk assessment processes varies from industry to industry and within industries, the general risk assessment process applies across all industries and applications. Emphasizing some of the major benchmarks in occupational risk assessment approaches, the paper summarizes and outlines several basic principles directed towards practical risk assessment process improvement.*

Key words: *risk, assessment, occupational, guidance principles*

1. INTRODUCTION

There are many forces pushing safety through design including: costs, competition, quality, international influences, legal requirements, the desire to capture knowledge and the costs of retraining engineers. In general, there is considerable support that safety needs to be addressed during the design process rather than as a retrofit activity, and risk assessment pushes safety into the design process. However, an engineer's ability to integrate safety into the design process is limited by the training and education he or she has received.

The goal of risk assessment is to reduce risks to an acceptable (or tolerable) level [2, 7, 13]. A zero risk level is not attainable. Efforts to distinguish terms such as

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* *Assoc.Prof.PhD.Eng. at the University of Petroşani*

"acceptable" or „tolerable" risk can lead to inadvertent errors, even by organizations that wish to promote a difference in the terms. Risk reduction efforts to achieve acceptable risk must work within the real world constraints of feasibility, practicality and cost. Resources are always limited. Cost is an important factor in obtaining acceptable risk. A practical solution to achieving acceptable risk is a good faith application of the hierarchy of controls within the risk assessment process.

This approach, coupled with the As Low As Reasonably Practical (ALARP) framework [6, 11] are useful guides in reducing risks to an acceptable level. Any organization discussing risk and risk assessment needs a common understanding of the applicable terms. Terms used in the risk assessment process are defined in literature [2, 6, 7, 8] but many terms have more than one meaning. A basic rule is to be certain that the risk assessment team is working with a common definition.

Risk assessments are conducted primarily to support the decision-making process regarding the occupational health and safety. Decisions on the adequacy of a design usually occur during a design review. Risk assessment supports the design review process by providing the underlying analysis on which safety decisions can be made. Risk assessments take time to conduct effectively, typically more time than can occur within a design review session. In most cases the assessment should occur separately from the design review.

Corrective actions that may be taken to introduce or improve safety through design efforts include formalizing existing but informal design processes that include elements of risk assessment, acquiring tools and training to conduct risk assessments, and advocating training on safety through design.

2. RISK ASSESSMENT PROCESS IMPROVEMENT

When all is said and done, someone needs to get his or her hands dirty and actually do the risk assessment. This section focuses on the practical application of the risk assessment process, representing a resource for getting up to speed quickly on the different options available and the means to introduce and implement risk assessments.

The step by step basics of the risk assessment process comprise the same basic stages. Although many companies and industries use different risk assessment methods, the fundamentals of the risk assessment process are common:

- identify hazards;
- assess risk;
- reduce risk;
- document the results.

A general risk assessment process describes the basic steps in completing a risk assessment. One step in particular, identifying hazards, is critical because if major hazards are omitted the associated risks will remain unknown.

Several practical, real world applications of risk assessment demonstrate the risk assessment process and the results drawing on the author's experiences in conducting risk assessments in industry. The examples include work process designs, product designs, and interactions with government authorities in different industries.

Integrating risk assessment in an organization is a process that generally follows a sequence of phases. To be effective, the company culture must be willing to embrace the risk assessment process, and cultural acceptance stems from management leadership. Engineering design needs to change to include the risk assessment process to more effectively move safety into design. Only by changing the design process will risk assessment efforts succeed. Issues such as changing the design process to include risk assessment are critical to address for the risk assessment effort to be successful in a company. As with any new process or substantive change, people may resist. Guidance is shared on how to change the design process to include risk assessment, and what resistance may be encountered in doing so.

A team of interested persons should conduct the risk assessment. The team members can be drawn from several areas such as engineering, operations, safety, users and others. They may include different participants as the assessment evolves. To integrate risk assessment into the design process engineers will likely need education and training on risk assessment in some form.

Unfortunately, most engineering design efforts do not currently include formal risk assessments. Engineering design must include the risk assessment process to more effectively move safety into design. Introducing the risk assessment process will explicitly change the design process, allowing hazards to be identified and risk reduction methods to be incorporated early in the design process. If the design process does not change, long term efforts to improve worker and product user safety will fail even if risk assessments are deployed.

Risk assessment does have limitations. Several limitations should be considered and discussed in order to minimize unrealistic expectations. Successfully integrating the risk assessment process into an organization requires time and effort.

In consumer product and component product applications, the manufacturer is responsible for conducting the risk assessment, if applicable. Product users typically have no risk assessment responsibilities beyond using the product in conformance with the product information. In industrial product or process applications, both equipment suppliers and users should perform risk assessments and be involved in the risk assessment process.

Tips and guidance on how to most effectively introduce the risk assessment process to an organization, and how to conduct them thereafter can be extracted from different sources, but the most valuable information source remains the practical experience gained by effectively performing the risk assessment.. Practical guidance should be provided for companies get started and make progress in the risk assessment process. Topics addressed include: the time to complete an assessment, forming a team, what to expect, when to stop a risk assessment, what to do in cross industry situations, when to revise an existing risk assessment, making changes to the protocol, results of risk assessment, and others.

„Risk ranking matrix" is the term that describes how risks are assessed, employing a method-specific tool. There are many variables, factors and combinations that must be considered in selecting a risk ranking matrix. Since there are many different systems used to arrive at risk levels, as a combination of probability and consequences, the different variables that are used to rate risk are requiring a proper understanding. The three most common types of risk ranking systems are qualitative, semi-quantitative and quantitative.

Given the subjective nature of rating risk, risk scoring systems will likely continue to emerge and proliferate as users refine and improve their risk assessment process. This divergence of methods should be considered healthy. In time, convergence to one or a few risk scoring systems may occur as efforts to harmonize and standardize risk assessment methods occur. This process will require some time.

A very broad cross section of methods documents the current state of the art and wealth of activity in the risk assessment process. Risk assessment methods are being deployed in many industries, and that the momentum will likely continue. Performance-based standards have been a key driver in the growth of risk assessments because they are the primary means to demonstrate that risks have been reduced to an acceptable level. Although the level of sophistication varies from industry to industry and within industries, the general risk assessment process applies across all industries and applications.

A heated debate often occurs when discussing the issue of documenting risk assessments. There remains considerable resistance to creating risk assessment documents from the legal community primarily due to product liability concerns. However, good engineering practice, continuous improvement and risk assessment requirements all push for documenting risk assessments. Documenting the risk assessment process is required or recommended by even guideline, standard or technical description of risk assessment.

There are many variations in risk ranking systems because different risk ranking systems work well in different applications. There are many risk ranking systems in use, each offering its strengths and weaknesses. This variation reflects the great diversity of opinion on risk assessment. Some of the most significant differences between risk assessment methods used today involve how risk is assessed. There is a continuum of risk ranking systems from qualitative to quantitative that effectively address a variety of risk assessment applications. Very few benchmarks use quantitative risk ranking systems. However, there is no indication that any particular risk ranking system is better than another for all applications.

One of the most critical considerations in selecting an approach to risk assessment is logistics. In many instances logistics can be the overriding criteria due to implementation challenges that arise. The costs and logistics of performing quantitative risk assessments are prohibitive in many industries. In these applications new methods, approaches, or software tools may be needed rather than those developed for the sophisticated situations. With the level of activity occurring today in risk assessment, there remains plenty to learn.

In many instances an individual or organization starts with an existing risk assessment method and finds it to be lacking in one or more respects. Thus begins a search for a better method. The search can take one of two paths - look for other methods and adopt all or part of them, or modify the existing approach to create a method better suited for the application. There are several reasons for and against harmonizing the various risk assessment methods. Although both viewpoints have merit, some basic steps toward harmonization appear achievable. However, complete harmonization is not likely to occur soon.

If a harmonized risk assessment process is to be developed, flexibility will he a critical factor to its success. Although most standards specifically seek to avoid flexibility, a harmonization effort will likely fail unless a standard framework can be provided that permits flexible application of the details.

There appears to be very little value in attempting to compare the results of risk assessments from vastly different applications to one another. Such comparisons provide no useful information to achieving acceptable risk. Since the goal of the risk assessment process is achieving acceptable risk, the risk assessment method one uses to attain this goal is less important than achieving the goal.

3. PRACTICAL GUIDANCE PRINCIPLES IN RISK ASSESSMENT

Based on the above-mentioned benchmarks, the following eight principles directed towards practical risk assessment process improvement can be stated:

1. Minimize the use of labels

The use of labels to describe portions of the risk assessment process need to be minimized. The terms used in assessing risk can be very confusing. There exists confusion or at least no common understanding as to the meanings of the following terms:

- risk assessment;
- risk analysis;
- risk estimation;
- risk evaluation.

The term „risk assessment” can mean the specific steps related to calculating a risk level, an overall term for the entire process, or to refer to any method that assesses risks. Efforts at harmonizing, standardizing or even communicating are severely hampered by the current confusion and different uses of the term „risk assessment” and others.

The practitioner trying to conduct a risk assessment does not care about terms or labels. He just wants to know what he need to do to complete and effective the risk assessment. Extra terms detract from this objective. Unnecessary terms that add no value should be removed from the risk assessment process. Labels that provide no value only add confusion.

2. Simplify the risk assessment process

Use Active Verbs

The steps of the risk assessment process should be written using active verbs rather than labels or titles.

Simplify the Steps

The steps of the risk assessment process need to be simple and straightforward, and provide the reader very clear direction on what he or she needs to do. There are many instances where clear direction is lacking or the steps are unnecessarily confusing or ambiguous. Simplifying the risk assessment process by using active verbs and clear and simple steps will assist those engaged in conducting risk assessments.

3. Adopt „risk assessment process" as overall term

The term „risk assessment process" should be adopted to describe the overall process of identifying hazards, assessing risk and reducing risk.

The terms „risk analysis", „risk assessment", „risk management" and others have different definitions depending on the industry using them. The two most frequently used terms to describe the overall risk assessment effort are „risk assessment" and „risk management". Although arguments can he made for either term, the use of „the risk assessment process" seems the best for referring to the overall process of identifying hazards, assessing risks, and reducing risks.

4. The risk assessment process includes risk reduction

There is no point in assessing the risks of a system, design, process or product unless one plans to perform risk reduction. The risk reduction effort is always completed even though not every residual risk requires further risk reduction (the risk may already be acceptable). This implies that risk reduction is a necessary part of, and should be included in, the overall risk assessment process regardless of the term used to describe that overall process.

5. Adopt the risk assessment process flow chart

Figure 1 presents a typical risk assessment process incorporating principles 1 to 4. This figure should be adapted because it simplifies the process and reflects how risk assessment is conducted in industrial practice.

6. Subjective judgment needs to be accepted

Subjectivity is a necessary part of risk assessment. Even in quantitative risk assessments subjective judgment occurs. However, the subjectivity does not diminish the value or credibility of the risk assessment process. Safety is not an absolute state, but a relative one. Engineers, safety practitioners and decision makers need to become comfortable with subjectivity, and recognize that the subjective risk assessments do offer value.

7. Accept uncertainty

Uncertainty enters risk assessment as assumptions, estimates and subjective judgments. Even in quantitative assessments there often remains substantial uncertainty. Risk is uncertain. Performing a risk assessment does not create the uncertainty. Uncertainty is, and should be accepted as, an integral part of the risk assessment process.

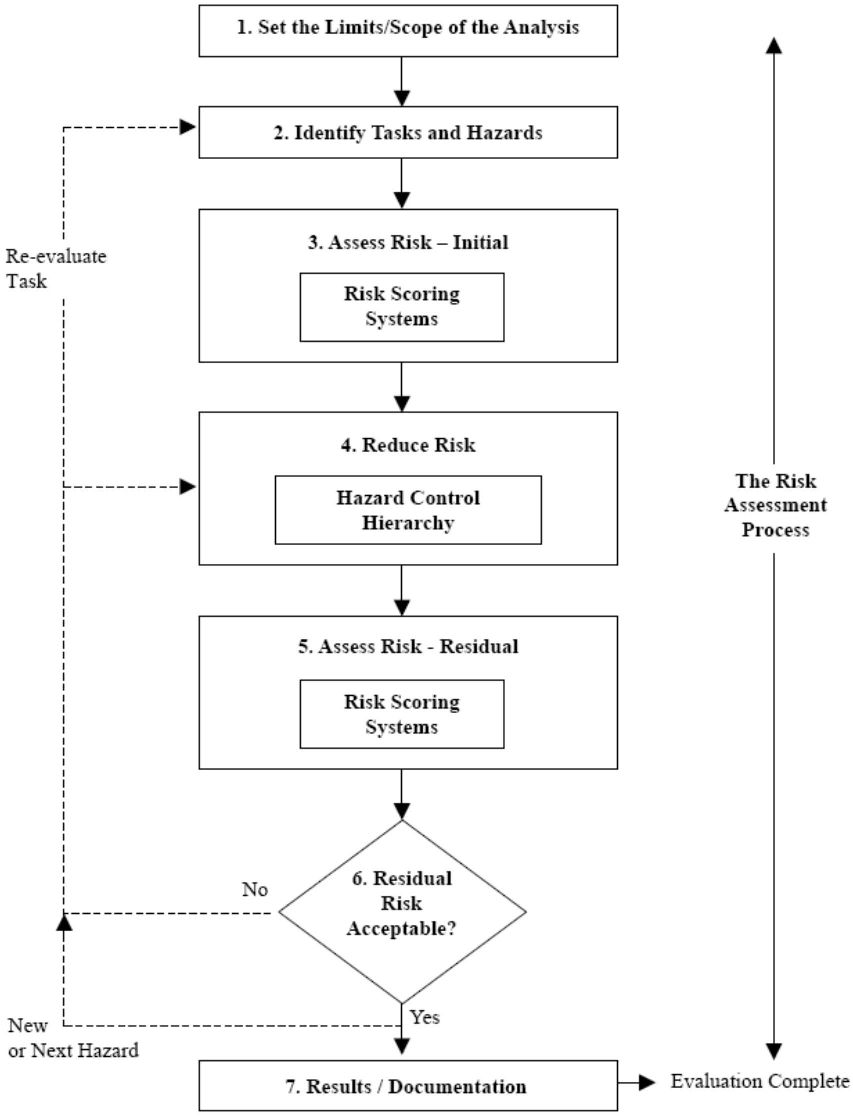

Figure 1. The Risk Assessment Process

8. Define „risk assessment"

Very different definitions of the term „risk assessment" exist. The two primary differences tend to be whether the term is used as a verb to mean any method used to assess risk (such as FMEA, What if, HAZOP, Fault Tree Analysis, Job Safety Analysis, Event Tree, MADS-MOSAR and others), or used as a noun to refer to a specific type of analysis. No current consensus exists in this regard. It could be very difficult for those seeking to harmonize the various risk assessment methods to make significant progress until some agreement is reached on the definition of the term.

4. CONCLUSIONS

Health and safety arrangements always depended upon risk assessments although these have generally been based on experience and intuition. Structured procedures are aiming to manage risks by measuring them against agreed standard and introducing further controls if that standard is not achieved. In order to achieve health and safety policy objectives with reasonable resources and demonstrate compliance, risk assessments should be comprehensive, structured, focused, cumulative and accessible. However, general assessments of larger units will usually prompt more detailed examination of priority areas identified. The current state of the art is such that most companies are not performing normal risk assessments, but this is changing.

The leaders in risk assessment tend to be the companies actually performing them rather than any particular industry, country or standard. The preceding principles focus on simplifying the risk assessment process, improving it to reflect current practices in industry, and advancing deployment of the risk assessment process. The team conducting the risk assessment needs to quickly come to a common understanding of the terms it uses, its goals and objectives, and the process to attain them. Competent persons should be consulted as appropriate when undertaking risk assessments.

BIBLIOGRAPHY

[1]. Băbuț, G., Moraru, R., Matei, I., Băncilă-Afrim, N., *Sisteme de management al securității şi sănătății în muncă. Principii directoare*, Editura Focus, Petroşani, 2002.
[2]. Darabont, A., Pece, Şt., Dăscălescu A., *Managementul securității şi sănătății în muncă* (vol. I, II), Editura Agir, Bucureşti, 2002.
[3]. Less, F.P., *Loss Prevention in Process Industries* (vol. I, II), Butterworths, London, U.K., 1980.
[4]. Moraru, R., Băbuț, G., Matei, I., *Ghid pentru evaluarea riscurilor profesionale*, Editura Focus, Petroşani, 2002.
[5]. Moraru, R., Băbuț, G., *Analiză de risc*, Editura Universitas, Petroşani, 2000.
[6]. * * *, *Guidance on risk assessment at work*, European Commission, Luxembourg, Office for Official Publications of the European Communities, 1996.

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RISK INTERPRETATION AND DECISION MAKING IN OCCUPATIONAL RISK MANAGEMENT

ROLAND MORARU*
GABRIEL BĂBUŢ*
LUCIAN-IONEL CIOCA**

Abstract: *The holistic approach of occupational risk management provides managers and other decision-makers a tool to recognize, evaluate, eliminate and control all the diverse threats and risks to occupational safety and health. This paper discusses the two of the most important steps within the risk management process, as a routine and required part of planning, preparing, and executing everyday tasks. This framework allows decision-makers to operate with maximum initiative, flexibility, and adaptability, to make informed, conscious decisions to accept risk involving safety and occupational health factors, design and construction of equipment and other situational factors. Managing occupational risks related to such operations requires educated judgment, situational knowledge, demonstrated experience, and professional competence. It is also outlined that, except in extremely technical evaluation, the probabilities should be considered as falling within a range.*

Keywords: *risk, hazard, assessment, management, occupational, decision making*,

1. INTRODUCTION

Due to the holistic nature of occupational risk management [1,8], the process requires the multidisciplinary participation using a range of diverse tools to provide the employer with the knowledge to make informed risk decisions about all the identified losses and their risk. A major threat to combat readiness is losses caused by hazard-based accidents [3]. Therefore, one of the major components of occupational risk management is the decision-making process, as explained in this paper. Practitioners use the risk management process to identify, evaluate, and manage risks to tasks, personnel, equipment, and the environment during working processes due to safety and occupational health factors, design and construction of equipment, and other mishap factors.

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* *Assoc.Prof.PhD.Eng. at the University of Petroşani*
***Prof.Ph.D.Eng.at the "Lucian Blaga" University of Sibiu*

The accident risk management is the process of providing recommendations on whether to accept or resolve potential consequences of hazards associated with a given activity. It is neither a "science" in the sense that it provides leadership with a precise prediction of the future events, nor just "common sense" or "something good managers have always done." It uses systematic procedures and specific techniques to analyze safety and occupational health factors, design and construction of equipment, and other situational hazards, following a structure shown below in figure 1.

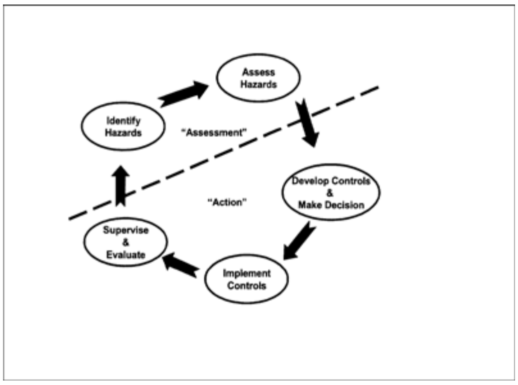

Figure 1. Five-step cycle of Accident Risk Management Process [7]

The risk assessment consists of the first two steps of the risk management process provides for enhanced situational awareness. This awareness builds confidence and allows organizations to implement timely, efficient, and effective preventive and protective control measures. Finally, leaders and individuals evaluate the effectiveness of controls and provide lessons learned so that others may benefit from the experience.

2. HAZARD SCENARIO AND RISK INTERPRETATION

An approach to identifying a hazard is to consider it a sequence of specific events or an accident (loss scenario). The accident-loss scenario consists of three elements (source, mechanism, and outcome) that describe the hazard. The outcome, or undesired event, is the result of the mechanism occurring due to the source being present. Some examples of outcomes, mechanisms and sources are listed below in table 1.

Table 1. Examples of outcomes, mechanisms and sources

Outcome or undesired effect	**Mechanism or effect**	**Sources or causes**
Auto crash	Hydroplaning	Rain-slick roadway
Asphyxia	Leaking pipe joint	Inert gas
Fall from elevation	Inattentive walking	Open-sided platform
Electrocution	Unprotected hand contact	Exposed electrical wire
Detonation or explosion	Exposure to heat	Stored blasting materials
Cut	Hand contact	Unprotected sharp edges
Sprained ankle	Inattentive walking	Rocky terrain

Over the years, evaluators have developed many investigative tools to aid in identifying hazards [6]. One set of these tools, called hazard analyses, provides a systematic method of identifying hazards. All hazard analyses evaluate a given activity to identify hazards; however, each type of analysis does so in a different manner, and therefore, each has its strengths and weaknesses. With experience, the evaluator learns which analysis tool is best for investigating which type of activity. The qualities of a good hazard analysis are:

- clear, concise, and a well-defined method that a reviewer or reader can readily understand.
- Orderly and consistent in systematically reviewing the activity or system for risk.
- a closed loop where the assessor reviews each hazard control for its impact on the other hazards and their controls.
- objective in that reviewers and users can understand and verify each step of analysis.

Towards the hazard scenario development, the evaluator uses the hazard matrix to associate potential failures with the generic hazards from the hazard list. The potential failure area represents those areas where if the hazard occurred, it would most likely have an effect on the activity, such as structural failures, power systems failures, pressure failures, leakage, spills, mechanical failures, personnel failures, or procedural failures. These investigated areas may be tailored to fit the operation or systems being evaluated.

After hazard scenario development, the next step is risk assessment [2], which involves evaluating each hazard and assigning a level of risk based on the estimated probability and severity for the likelihood and impact of the hazard on the system. Risk always deals with uncertainty or events that cannot be predicted with certainty. If the events could be predicted with surety, there would be no risk. Risk involves estimating future losses, where neither the likelihood nor magnitude is known with certainty. Risk is defined [5] as the measure of the expected loss from a given hazard or group of hazards, usually estimated as the combination of the likelihood (probability) and consequences (severity) of the loss. Probability has no dimension but must be attached to an interval of exposure (for example, one operating year, a million vehicle miles, 1,000 landings, and so on). Severity is an approximation of the amount of potential harm, damage, or injury associated with a given hazard scenario or accident.

Probability helps us figure out the likelihood of something happening. The likelihood of an event can range between 0 and 1.0. Zero represents an event that cannot possibly occur. A probability of 1.0 indicates an event that always occurs. For a probability to be meaningful, an exposure interval must be associated with it. The exposure interval can be a unit of time, an activity (such as, kilometers driven, aircraft landings, operations, machine cycles, units produced) or the life cycle of the facility, equipment, or process. The following examples demonstrate associating an exposure interval with a probability.

- during the year “X”, 220 workers died on the job. This results in a probability of 0.0000007 per year of a worker dying on the job. However, the probability of being injured at work during that same year, resulted in a probability of 0.005 injured employees per year, based on 150,560 reported injuries. Again, the exposure interval is “per year.”
- if we change the exposure interval to a working life time (from 18 years to 65 years), the probability of being killed increases to 0.000035 during a working life and the probability for being injured increases to 0.25 during a working life. The exposure interval is now “working life” which was stated as 50 years.
- the exposure interval does not always have to be expressed in time interval; other units can be used. In year “Y”, aircraft model A experienced 47 events in which one passenger died due solely to the operation of an aircraft. During that same period, aircraft model B had one such event. However, the probability of being killed on aircraft model A is 0.000000005 (5x10–9) per passenger-mile flown, while on aircraft model B, the probability is 0.00000012 (1.2 x 10–7) per passenger-mile flown. In this example, the exposure interval is “per passenger-mile flown.” The longer the trip or the more miles a passenger flies in a year, the greater the probability of death. This increasing probability per passenger-mile is shown in the table 2.

Table 2. Increasing probability versus passenger mile

Miles flown per year by passenger	Probability of passenger dying Aircraft Model A	Probability of passenger dying Aircraft Model B
1,000	0.00001	0.00012
5,000	0.00003	0.00060
25,000	0.00013	0.00300
75,000	0.00038	0.00900
375,000	0.00188	0.04500
1,000,000	0.00500	0.12000
1,500,000	0.00750	0.18000

This demonstrates another important concept when dealing with probabilities. *Probabilities are estimations and only estimations.* The better the knowledge of the situation, the more factual and historical information used, and the greater the experience of the evaluator, the more accurate the estimation will be. Except in extremely technical evaluation, the probabilities should be considered as falling within a range.

In the real world, it is often very hard to determine objective or numerical probability values. The information necessary to derive these values is often missing, or more often than not, there is just not enough time to make the necessary studies. When the information and time is available, an effort should be made to use the numerical probability values. However, in the other situations, it becomes necessary to make subjective decisions in estimating the probability. To aid evaluators, probability ranges have been established using keywords and phrases to help estimate the likelihoods for the occurrence of a accident […].

3. DEVELOPMENT OF CONTROLS AND DECISION MAKING

After assessing each hazard, the assessor develops one or more controls that either eliminate the hazard or reduce the risk (probability or severity) of a hazardous incident [4]. When developing controls, the assessor considers the reason for the hazard not just the hazard itself. A key element of the risk decision is determining if the residual risk is justified. The appropriate decision maker based upon the level of risk associated with the mission must compare and balance the risk against mission expectations. The decision maker alone decides if controls are sufficient and acceptable and whether to accept the resulting residual risk. If the decision maker determines the risk level is too high, the decision maker can direct the development of additional controls or alternate controls, or the decision maker can modify, change, or reject the course of action.

When developing controls, it is important to try to implement controls based on the mitigation order of precedence. The mitigation order of precedence is a prioritized ranking of methods for instituting countermeasures and controls ranked by effectiveness in reducing the risk associated with an identified hazard. The mitigation order of precedence is discussed below.

a. Design to eliminate hazards: the most effective method of controlling a hazard is to eliminate it from the mission, process, system, or equipment by making fundamental changes in the design, process, system, equipment, or task. An example is situations or operations where an explosive environment is likely, such as paint booths, solvent cleaning areas, or storage and processing areas for ammunition and explosives. The presence of electricity increases the probability of an explosion occurring, therefore by substituting pneumatic or hydraulic powered tools for the electrically powered tools reduces the probability of an explosion. Each situation must be viewed considering not only the hazard being addressed but also the total situation. An excellent control used in another situation might seem appropriate, yet when viewed, holistically in the context of the current task it not only does not work but also introduces new hazards.

b. Incorporate safety devices: when the hazards cannot be designed out or eliminated from the process, system or equipment, then safety devices need to be incorporated. The following are examples of safety devices:

- for traffic situations, a safety device would be installing stop signs on every corner to slow traffic moving through congested areas. These signs cause the vehicle to slow down due to stopping often.
- for systems, processes and equipment, safety devices include such devices as guards and lock-devices at the point-of-operation to protect Soldiers and operators. An example is the dead-man-switch on lawn mowers. If the operator

trips or falls and releases the switch, the lawn mower's engine automatically stops.

- employing release devices that open automatically when certain conditions are reached. Electrical fuses are examples; they fail open to break the electrical circuit and protect electrical equipment from being overcharged. Another example is the release pressure valve on hot water heaters. When the pressure in the water tank becomes too great, they open, relieving the pressure before the tank explodes.

All of the above are active controls and do not rely on the Soldier or operator to react to a given situation. However, safety devices can be circumvented, such as the dead-man-switch being tied down. Therefore, leaders and supervisors need to constantly check safety devices to make sure they are in working order and not being bypassed.

c. Provide warning devices: warning devices are passive. While they provide notification that a hazardous situation exists, they require the operator to react to a given situation. Warning devices consist of bells, whistles, announcements, lights, and other such devices. The following are examples of warning devices:

- flashing yellow lights are an example of a warning device. They are normally associated with a situation requiring extra caution, such as warning of high pedestrian traffic. Since they are passive, they depend upon the operator-heightened level of caution for protection.
- flashing red lights are another warning device that is often used to restrict or prohibit entry into areas where dangerous equipment is being used.
- even when using devices such as gauges to inform the operator of conditions, it is best to have hazardous areas indicated on the gauge.

d. Develop procedures and provide training: procedures rely upon the operator executing them. This requires initial training as well as periodic training to ensure that the operator understands the "why" and the "how" of the procedures. They should be trained in what the hazards are, how to recognize the hazards and what the control procedures are. If they do not understand the consequences, they are less likely to follow them. When implementing procedures the following factors need to be considered prior to their development.

- *targeted community*: what are the demographics of the audience? What is the at-risk group and how large is the group.
- *intervention*: are the reasons for application clearly defined, are the results repeatable.
- *outcome measurement*: how do we measure the effectiveness? Have measurable goals and objectives been established?
- *implementation process*: what are the implementation issues and are there unresolved issues and questions?
- *developing training*: first, it establishes what factors to address in the training and then how to address those factors. For instance, does the employee need new knowledge to do the procedure? If so, then what is that new knowledge?

- *leadership*: in addition to the training, leadership must supervise their operators to enforce the standard operating procedures. If leadership does not place value and importance on them, their operators will not value them or implement them.

e. Selection, development and evaluation of controls: a good understanding of the risk mechanisms facilitates effective development, selection, and prioritization of risk countermeasures and controls. Once the hazard is understood, various controls and countermeasures should be developed. The idea is to brainstorm as many controls and countermeasures as possible. Once a list of possible controls or countermeasures has been developed for each hazard, the next step is to evaluate them. The selection should be made based on how well it mitigates the risk, its cost, feasibility and management controls required.

f. Decision-making: this involves deciding which countermeasures to use, and in some special situations, requirements may dictate that the hazard and the risk be accepted due to constraints placed on the mission, process, system, or equipment. However, when the hazard is not eliminated or controlled to tolerable limits, the organization's top management needs to decide about the acceptability of the risk based upon mission requirements. Accepting risk is a serious matter; therefore, the appropriate level of leadership must weigh the increased danger to the mission, personnel, equipment, public, property and environment against the operational requirement that necessitated acceptance of a significant level of risk. Supervision is a form of control measure. It ensures subordinates understand how, when, and where controls are implemented. It also ensures that controls are implemented, monitored, and remain in place. It ensures that complacency, deviation from standards, or violations of policies and risk controls are not allowed to threaten success. Supervision also provides management with the awareness necessary to anticipate, identify, and assess any new hazards and to develop or modify controls as circumstances unfold. It takes an extraordinary degree of discipline to avoid complacency from boredom and overconfidence when personnel are performing repetitive tasks. The most important aspect of implementing controls is clearly communicating how the controls will be put into effect, who will implement them, how they will fit into the overall operation, and how the decision-maker expects them to be enforced.

4. CONCLUSIONS

Of the six groupings of hazard remedies described briefly in the paper, the first two (the design to eliminate hazards and incorporation of safety devices) are the most positive and do not require the operator to respond. Therefore, the first two groupings give any organization's management the greatest control over the risk. However, they take the longest to incorporate and are usually the most expensive. The third is more passive and depends upon the operator to react to a given situation. The last two are totally dependent upon the operator to execute. Since the last two depend on the operator, their use depends upon supervising the operator to ensure they are being followed. If standard operating procedures are not enforced, the hazards and their associated risk will be present waiting to disrupt the mission or process and cause the system or equipment to fail.

Hazards will be eliminated on a worst-first basis. Often a simple substitution will eliminate a hazard. The first step in devising hazard countermeasures and controls is understanding the hazard, its source, mechanism, and effect. By understanding how the hazard occurs and what allows it to happen, controls and countermeasures can be developed. The level of authority accepting the consequences of a given hazard is determined by the level of risk associated with that hazard. The greater the risk, the higher that decision must be elevated.

An important factor in risk acceptance is ownership of the resources necessary to control, eliminate, or correct the hazard in an appropriate time frame.

BIBLIOGRAPHY

[1]. Băbuţ, G., Moraru, R., Matei, I., Băncilă-Afrim, N., *Sisteme de management al securităţii şi sănătăţii în muncă. Principii directoare*, Editura Focus, Petroşani, 2002.

[2]. Băbuţ, G., Moraru., *Cadrul general al managementului riscului de mediu,* Buletinul Agir nr. 3/2006, iulie/septembrie,pp. 103-107.

[3]. Less, F.P., *Loss Prevention in Process Industries* (vol. I, II), Butterworths, London, U.K., 1980.

[4]. Moraru, R., Băbuţ, G., Matei, I., *Ghid pentru evaluarea riscurilor profesionale*, Editura Focus, Petroşani, 2002.

[5]. Moraru, R., Băbuţ, G., *Analiză de risc*, Editura Universitas, Petroşani, 2000.

[6]. Pece, Şt., Dăscălescu, A. ş.a., *Securitate şi sănătate în muncă - Dicţionar explicativ*, Editura Genicod, Bucureşti, 2001.

[7]. * DA-PAM 385-30,** *Safety Mishap Risk Management*, Headquarters Department of Army, Washington D.C., (Unclassified),10 October 2007 (www.army.mil/usapa/epubs/pdf/p385).

. **[8].** *** AS/NZS 4360:2001 – Risk management. Standards Australia/ Standards New Zeeland, Sydney/Wellington, 2001

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ANALYSIS OF PRESCRIPTIONS AND OF EXISTING NORMS FROM OUR COUNTRY AND FROM ABROAD THAT ARE REGULATING THE ACTIVITY OF IDENTIFICATION, ASSESSMENT AND CONTROL OF THE FIRE RISKS INSIDE THE STORAGE AREAS FOR TANKS OF COMBUSTIBLE LIQUIDS

SORESCU FLORIN - MARIN*

Abstract: *Explosions and fires produced in our country and abroad, in the last period are confirming the necessity of knowing the causes that are determining the risks of fires and explosions of this category, working places and possibilities to reduce these risks. In the last period these events made the specialists in this field to call them "the beast still-hunting". The establishing of detailed safety measures is imposed even more when the object of activity does not imply intrinsic risks, risks corresponding to processes raw materials respective the risk of fire and explosion. These risks cannot be entirely eliminated, just controlled by adequate measures.*

The remarkable technical progress of the last years was accompanied, especially in the developed countries, by a continuous evolution of increasing the health and safety activity of improving and perfecting organizational and legislative systems that are specific to this field.

At the present in the world, research and prognosis of alternatives of occurring, on the platforms of petrochemical technological installations or in the storage areas of liquid fuels tanks, for the events of type explosion or fire represent problems with high level of difficulty and complexity, that have to be approached and that are examined or solved starting from the accepted level of technical risk fro the point of view of technical, human and social safety, sometimes using the fundaments of risk theory or the theory of catastrophes.

The contemporary societies can be considered as societies of risks, risks that can be considered to be natural phenomenon but also some other human dangerous activities, if they are getting off of control or disastrous or if they are deliberated acts.

* *PhD. Eng. – University of Petrosani*

This is a conclusion of the fact that human is developing its activity (life) in the risk areas, but that are ensuring the most accessible resources that are necessary for development. The risk of fire and explosion became lately, realities that have to be taken into consideration when establishing the safety measures, and even ore when these risks have occurred before and caused important human and material losses.

Also, the strategies of safety in the case of storage areas for combustible fuel tanks have to comprise all the enterprise activities and all employees, no matter their position on the hierarchical scale.

The issuing of plans and hypothesis for intervention represents a laborious and complex activity, which needs a vast multidisciplinary documentation, together with a series of personal qualities as: imagination, organizational spirit, meticulous, patients and self control. All this activity can have in practice notable results if the analytical capacity of the ones that are elaborating these documents is able to cover and to solve a lot of multidisciplinary problems and to adapt them to some existing objective situations.

Unfortunately, in this field that approaches the damages as an evolution phenomenon not “pre-damage” and not “post-damage”, but “during ...", documentary materials are rare and poor. Besides the treating of strictly technical problems as solving solutions that are focusing on installation that are in the damage status, the interventions are approached, for the operating personnel, as simple technical or technological operations for remediation, and for the intervention personnel as actions with specifically equipment, not being treated in the extremely complex environment.

But, in the environment of new issued legislation, according to the existing legislation in the European Community (see Directives SEVESCO) the elaboration of intervention plan have to give a solution to this kind of problems, and the present paper work is giving new paths in the field, the principles elaborated on the basis of structural analysis of interventions, being a useful guide.

At the moment, in our country exists a covering legislation in the field of preventing major industrial accidents caused by the presence inside the activities of dangerous substances (H.G. no.95/2003 modified and brought up to date by H.G no. 804/2007) [24].

Starting from this founding, in the present paper work, it is trying the "covering” of this filed by the issuing of a set of instruments that are necessary to any economical unit that is interested in implementing of a management system for preventing the major industrial accidents. With this occasion it is mentioned also the facts that during time were identified three major categories for analysis models of work accidents: sequentional, epidemiological and systemically. The first two are based on the idea of a clear connection “cause-effect”. Despite the difference between them, in systemically vision, the accidents are took into consideration as emergent phenomenon, generated by a complex of conditions, that cannot be predicted as surely as in for the other models.

The last affirmation can be formulated as follows: in every work process it exists for its execution person, or can occur on him a risk of accident and professional disease.

But, how can the risk be reduced and what does it mean the maximum possible?

The answers to these questions are marking the second vital moment in theory and practice of health and safety in work, respective definition of risk of accident and professional disease, which allowed its assessment and the establishing of its limits of action.

Neither under this aspect there is no general consensus. A first cause is represented by the differences in approaching the phenomenon of accident and professional disease. To these is added the fact that, in the current language from every country, terms as “risk”, “danger”, “hazard” are usually used as synonyms. The confusion is amplified by the difficulties generated by the translations from a language to another. Nevertheless, he specialists made efforts to get to a common language, to be practical and accessible to everyone.

The first direction of research that lead finally to the issuing of a general definition, relatively similar for risk and collateral notions, had the purpose to obtain the safety of machine, for protecting the operator.The results concretized in issuing of specific instruments [45], but also in normative documents.

The first European norm in this field was EN 292-1:1996 “Security of machines”. Basic concepts, general principal’s for engineering.” Part 1: Basic terminology, methodology” [15]. This one together with the adjacent EN 292-2:1998 [44] were replaced by EN ISO 12100-1:2003: “Security of machines- Fundamental notions, general principles of conception - Part 1: Basic terminology, methodology” [14] and EN ISO 12100-2 “Security of machines – Fundamental notions, general principles of conception – Part 2: Technical principles (ISO 12100-2:2003)” [15].

At the origin of reviewing process were more problems [9]: terminology, producers responsibilities, risk reduction, requirements for protection etc. The first one, terminology is the one that we are interested for our field. In the filed of terminology it had to be obtained a general agreement between CEN and ISO, in order to ensure the coherence of definitions from regulation EN 292 and ISO/CEN 51 – “Guiding principles to be included in the norms the aspects regarding the safety”.

The both organisms were admitting the existence of essential differences between the two documents, because ISO/CEN is considering the safety at all levels, and EN 292 was referring strictly to the safety of machines the conception stage.

A similar situation we can find in the case of standard EN 414, “Safety of machines – rules for elaboration and presentation of safety norms”.

Part 1: Basic terminological methodology” [4], “Part 2: Technical principles and specifications” [4]. The reviews are reflecting the evolutions that took place in the theory and practice of systems safety. This is the second main research direction that allowed the risk definition and it was powerfully influenced by the evolution of industry that is the generator of higher and higher risks, on multiple plans: human, environmental. A similar effect had also the industrial catastrophes and the development of industrial centers [17]. The fundamental document resulted from these researches is the Guide ISO/CEI 51:1999 [35].

A synthesis of the definitions for the significant terms for the risk, that is offering a clear image over the existing differences between diverse international documents, made on the basis of norms and regulations ISO/CEI 51 [19], ISO/CEI 73 [20], CEI 61508 – 4 [17], Directive no.96/82 of the Council from 9th of December 1996 [13] is presented below.

Work accident - violent injury of human body and also acute intoxication, which take place during work process or during the accomplishment of work duties and that, can cause temporary work incapacity of at least three days.

Major accident – any event occurred as an emission of a dangerous substance, a fire or an explosion that result from uncontrolled evolution during the exploitation of any objective.

Danger

An intrinsic propriety of a substance, a technical system, of a disposition, of an organism etc., which has the nature to cause damage to a “vulnerable element” (it is associated to the notion of “danger” the notions of inflammable or explosively, of toxicity, of available energy, of infectious character etc.).

The probability that an accidental phenomenon to produce in a certain point effects of a certain potential gravity or intensity, during a determined period of time.

In conclusion, the danger is, for a specified type of accident, the expression between the couple probability of occurring - potential gravity of effects. It can be placed in space and can be put on a map.

By a danger caring element or by “potential source of danger” we understand: a system (natural or created by human) or a decision adopted that is supposing one or more then one danger. “Danger” becomes a reality through the “danger carrying element”. During the notion of “danger” is an “abstract” notion, the notion of “danger carrying element” is “real”.

Risk

1. Combination between the probability of an event and its consequences.

Combination between the probability of a damage and its gravity.

2. Possibility of occurring a damage that results from exposure to a dangerous phenomenon. In the context of “industrial risk”, the risk is, for a given scenery, the combination between the probabilities of accruing of a violent event/ final considered (incident or accident) ant the gravity of its consequences over the vulnerable elements.

3. Probability that a specific effect to be produced in a given period or in certain circumstances.

4. The mathematical hope of losing human lives, injuries, damages or goods and the affecting of an economical activity during a reference period and in a certain region, for a particular danger. Risk is the product of danger with vulnerability.

The risk represents a “potentiality”. It is achieved only through an “accidental event”, meaning that only as following the gathering and achievement of a number of conditions and existence of a number of circumstances that lead at first to the occurring of an initiating event or more of them, that will allow the development and propagation of phenomenon that allow "danger" to express, producing at first the effects and then affecting one or more vulnerable elements. The risk can be decomposed depending upon different combinations of this three components, respective intensity, vulnerability and probability:

- intensity – vulnerability = consequences;
- intensity – probability = danger;
- risk = intensity – probability – vulnerability = danger - vulnerability = consequences – probability

In the risk analyses and in the danger studies, the risk is qualified, usually by couple consciences – probability.

Risk situations: situation that results from the coexistence, of a permanent or temporary "danger carrying element" and "vulnerable element".

Dangerous situation: situation when persons, goods or environment are exposed to one or more dangerous phenomenon.

Tolerated risk: "Tolerability" of risk results form the comparison of advantages and inconveniences (where the risk is coming from) related to a situation, that will be verified with regularity with the purpose to identify, during time and each time when will be possible, the means that will allow the risk reduction.

The norm CEI 61508-5 and Annex A (§A2) [1] are indicating the fact that "determining of tolerable risk for a dangerous event has the purpose to establish of what is considered as relatively reasonable at frequency (or probability) of dangerous event and its specific consequences. Safety systems are conceived for reducing the frequency (or probability) of a dangerous event and/or of the dangerous event consequences.

Dangerous event: releaser due to which it is going from dangerous situation to damage.

Damage: physical injury of affection of person health or affecting of goods or environment.

Gravity: potential gravity or intensity of a dangerous phenomenon; gravity of effects or consequences of affecting a target with a given vulnerability.

Exposure (or risk): results from the combination of a hazard (event) that is affecting a given target with the vulnerability of that target.

Residual risk: risk that remains after the treating of risk; risk that subsists after the applying of preventing measures.

Storage: presence of a quantity of dangerous substance with the purpose of storage or keeping in safety conditions.

Constructions

- ➢ buildings of any kind;
- ➢ roads, road platforms and sidewalks, rail roads and subway, bridges, tunnels and other masterpiece works, flight strip;
- ➢ hydro technical constructions, harbor facilities;
- ➢ towers, funnels, tanks, silos;
- ➢ technical-urbanites works, underground and above ground, water supply, water treatment stations, water cleaning stations, transportation and distribution net works;

- net works for the transportation of technological fluids, petrol and gas;
- constructions for sustaining the power transportation and distribution net works and telecommunications;
- household facilities;
- constructions with temporary character;

Fire – self supplied burning that takes place without control in time and space, that produces human losses and/or material damages and which needs an organized intervention for the interruption of burning process [27, 31].

Cause of the fire – sum of the factors that contributed to the fire initiation, that usually are represented by the lightning source, the mean that produced the lightning, the first material that took fire, and also the favorable circumstances that let to the fire burning [27].

Protection against fire – represents the integrated ensemble of specific activities, organizational, technical, operative measures and tasks with humanitarian character and for public information, that are planned, organized and achieved with the purpose to prevent and to reduce the risk of fire, for the evacuation, saving and protection of endangered persons, protection of goods and environment against the effects of emergency situations determined by fires [27].

Safety against fire – Constructions have to be designed and executed in that manner that in case of fire to ensure:

- stability of sustaining elements of the construction to be estimated for a certain period of time;
- occurring and propagation of fire and smoke inside the construction to be limited;
- the operators to be able to leave the construction and to be saved by other means;
- to be taken into consideration the safety of intervention teams [26].

Fixed tanks – are recipients for storage, that according to their type of construction are designated to keep their placement in time [30].

Risk of fire – produce between the probability of initiation of a fire in a technological process or in a technical situation and the estimated importance of damages or consequences at the fire occurring [31].

Accepted risk of fire – maximum level limit of fire risk considered acceptable from the point of view of the consequences gravity of fire, together with the initiation probability of respective event [31].

Consequences – result/results of events, negatively or positively expressed, quantitatively or qualitatively [31].

Source of lightning/initiation of fire – source of energy that produces a burning, that can be a physical phenomenon, chemical or other nature, which generates a quantity of energy able to initiate the burning of a material or a combustible environment [31].

Probability of producing fires – measure in which an event of fire type is probable to be produced; it is expressed by a number of events produced in a time unit.

Frequency – Degree of repeatability of an event in a period of time [31].

Reaction to fire – Behavior of a material which by its own decomposer is supplying a fire to which is exposed, in specific conditions [32].

Resistance at fire - capacity of a product to keep on a specified period of time, its stability at fire, tightness at fire, imposed thermical insulation and/or any other imposed function, specified in a standardized test for fire resistance [32].

Electrostatic discharge – process of establishing a conductor channel between two bodies at different potentials towards earth; depending upon the average value of electric field between the two bodies, the discharge can be incomplete (corona) or complete (piercing) [12].

Dispersion – phenomenon of spreading, distribution, dispersing; in the sense of present dispositions, the definition is referring to dust, powder, gas, fogs, that can be lighted; for example the dust is a disperse form of solid substances, and fog is a disperse form of combustible liquids [12].

Static electricity - energy of electrical nature that appears due to electro-chemical phenomenon, frictions, heating and deforming of bodies, their placing in an electric field, and also as following of other physical action that presume the relative changing of contact surfaces; the accumulated energy remains practically constant or presents very slow variations; the accumulated energy, if it is dissipated in an electrical discharging is able to initiate the explosion of flammable mixtures, if it is higher then the minimum energy for their lightning [12].

Electrostatic charging – physical process that, on solids, liquids of vapors appear electrical charges due to mechanical actions (frictions, collision, vibrations) thermical, chemical etc. [12].

Electrostatic sparkle – sudden discharging of electricity, in an interval between two bodies [12].

Decant – operation of passing of a fluid (liquid, gas etc.) or a pulverulent material from a recipient to another by gravitational flow, pumping, etc. [12].

Installation – technical unit inside a placement where are produced, used, handled and/or stored dangerous substances.

The installation comprises all the equipments, structures, pipe system, tools, devices, internal rail roads, docks, embankments for discharging that are used by the installation, unloading docks, storehouses or similar structures, floating or of a different nature that are necessary for the exploiting of installation [18].

Dangerous substance – a substance, a mixture or a preparation, that are presented as raw materials, products, secondary products, residual or intermediary, including those substances about it is presumed that can be generated in case of accident [24].

Hazard/danger – intrinsic propriety of a dangerous substance or of a physical situation, with potential to induce negative effects over the health of population and/or environment [24].

Liquid – it is any substance that is not defined as a gas and that in not in the solid state at a temperature of 20^{o}C, and at standard pressure of 101,3 kPa [24].

CONCLUSIONS

From the facts presented in the paper work, we can find that it is not reached to a common agreement, till at the present, not even regarding the genesis of accidents and professional diseases.

However the majority of specialists accept at the present the following assertions:

- for an accident or professional disease to take place, it has to take place the meeting, "collision" of the victim with an agent, material or immaterial, that should have the capacity to injury the anatomic functional integrity or to alter its health;
- usually, the meeting is the culminant point of a chain of causes, from the inside and/or outside the work system where the event takes place;
- in the case it exists this kind of causal chain, for avoiding the accident or professional disease it can be made actions in any point of the chain; as they intervene sooner in the chain they can eliminate more surely and more efficiently the possibility of meeting between the victim and the agent that causes the injury;
- in any work process exist or can occur generating sources of accidents or professional diseases.

BIBLIOGRAPHY

[1] Bessis, J – *La probabilité et l'evaluation des risques, Masson*, 1984;

[2]*** *DGPSI 004: OMI 108/2001 pentru aprobarea Dispoziţiilor Generale privind reducerea riscului de incendiu generate de încărcările electrostatice*

[3] Golovanea, N., Popescu, G., Dumitranu, T., Coatu, S. / *Evaluarea riscurilor generate de descărcările electrice*, Editura tehnică Bucureşti 2000.

[4] *** Guide ISO/CEI 51 – 1999 „*Aspects lieus a la securité*" – *Principes directeurs pour les inclure dans les normes.*

[5] *** Guide ISO/CEI 73:2002: *Management du risque – Vocabulaire – Principes directeurs pour l'utilisation dans les normes.*

[6] *** *Hotărârea nr.804/25.07.2007 privind controlul asupra pericolelor de accident major în care sunt implicate substanţe periculoase*.

[7] *** *Legea 10/1995- 12.05.2007 privind calitatea în construcţii, Monitorul Oficial partea I 09.05.2007.*

[8] *** *Legea 307/2006 privind apărarea împotriva incendilor publicată în Monitorul Oficial Partea I, Nr.633 din 21.07.2006.*

[9] *** *Normativ tehnic pentru lichide combustibile Tr.bF 20 al Germaniei 2001.*

[10] ****O.M.I.R.A. 210/2007 pentru aprobarea metodologiei privind identificarea, evaluarea şi controlul riscului de incendiu.*

[11] ****Ordin pentru aprobarea Regulamentului privind clasificarea şi încadrarea produselor pentru construcţii pe baza performanţelor de comportare la foc aprobat, publicat în monitorul Oficial al României Partea I nr.90/27.01.2005.*

[12] Pece Şt – *Evaluarea riscurilor în sistemul om – maşină*, Editura Atlas Press, Bucureşti 2003.

[13] *** *SR EN 292–2+A1:1998: Securitatea maşinilor. Concepte de bază, principii generale de proiectare. Partea 2: Principii şi condiţii tehnice*, ASRO, Bucureşti 1998.

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EXPLOSIONS LEADING TO FIRE GENERATION

SORESCU FLORIN – MARIN*

Abstract: *A fire is a destructive phenomenon, a complex process characterized by an indefinite evolution of burning, having major social and economic implications. It is a random phenomenon, a sum of physical and chemical processes, which increases and becomes more and more complex in its evolution and it can not be described by simple schemes. This phenomenon, unwanted by anyone, should be fought everywhere, and everyone, from the responsible persons in private or state companies, institutions and municipalities to the cuss, also at work and in own place or home.*

1. INTRODUCTION

Fire as a destructive phenomenon

Fire is one of the complex and phenomena destructive for material values, materials, sometimes incalculable. There are not rare cases when people, goods, construction and unique works of art fall prey to flames, anyone of these can not be restored. Many fires turn into disasters, bringing great trouble and suffering to the people.

People's manifested negligence, rising from their regard lessness mainly that from their ignorance on the phenomena, in certain circumstances people largely contribute to the outbreak of fire.

The fire means a maintained burning, without control in time and space running, causing loss of life and/or damage to property and that requires an organized process for the purpose to disrupt the combustion [3.4].

A fire statistical study in 1999, notes: "In the last 50 years there have been 25 large fires and ammonium nitrate explosions, resulting more than 5000 dead people". On two explosions generating fires in the past, were treated with wealth of details in literature, we try to talk below. Ammonium nitrate decomposition can occur as an endothermic reaction (a process which occurs with absorption of heat from the outside); this event can take place only after the primary explosive initiation as shown in the following presentation of a disaster.

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* *PhD. Eng. – University of Petrosani*

A strong explosion of ammonium nitrate happened in 1921 year, in a chemical fertilizers factory in Oppau city (Germany). That explosion was considered the strongest triggered explosion in the world up to atomic bomb creation. The fertilizer produced in Oppau factory was ammonium nitrate. Were 4500 tons of this fertilizer in the warehouse, which is as concretioned as was necessary to be dislocated using a shovel or pickax. It was decided to make dislocation with small explosions of big grained black powder, introduced in drilled holes in the mass of fertilizer. At one of the explosions, the entire mass of fertilizer exploded, causing major damage. The factory - not a vestige remained, and in the city has been destroyed over 2000 buildings. Over 1000 people died and others 2000 were injured. The force of the explosion was as strong as formed in the area a hole having 1.85 m depth, 96 m width and 165 m length. The total destruction area was 1.5 km radius.

One of the biggest ammonium nitrate explosions was produced on 16th February 1947 in Port of Texas City (USA) on the 10,000 tons ship "Grandcane". The transport destinations of ammonium nitrate were Bordeaux city, in France.

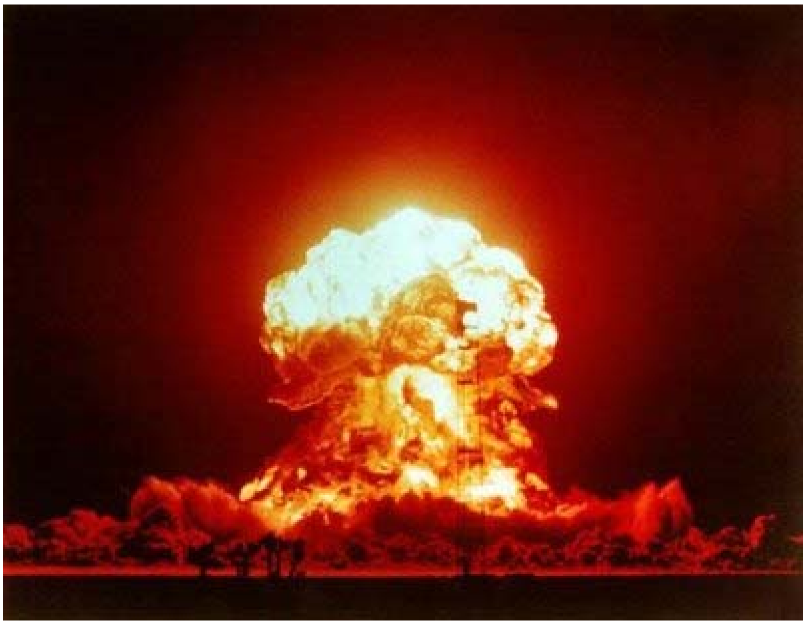
Loaded about 2,300 tones of ammonium nitrate when, in the fourth stowage of the ship started to leave a thick white smoke. After the stowage doors were thrown into the air and blaze orange languages flames raised to the sky, so a huge explosion followed as entire ship splitted in pieces, and a large quantity of water dislocated. Waves force produced serious damage to oil tanks and port facilities in the area.

The second ship, a barge full anchored behind the destroyed ship was thrown to 70 m distance, falling in the end in a parking, over some parked cars. Incandescent metal parts of the destroyed boats have been thrown by the explosion force and fell within a radius of 3300 m in the city and the golf, resulting multiple fire outbreaks.

Gasoline and oil tanks were lit, and the oil from pipeline continuously leaked. Fire covered a large area of the port district, have ignited and burned houses, cars, warehouses, whole streets. Explosion effects - expanded at a great distance, both on the land and in the air. Within a radius of about 41 km all the buildings' windows were broken. Two planes that fly over the city were affected by the shock wave and had collapsed in gulf waters. Four fire intervention trucks involved in extinction actions have been thrown over keys. The black smoke column, mushroom-shaped has raised up to 1.5 kilometers altitude. The extinguishment operations lasted 4 days. This catastrophe produced 1000 deaths, port and 1/3 of the city destruction, 15,000 people homeless and the complete. Material damage being estimated at about 100 million dollars.

2. A SPONTANEOUS IGNITION OF FERTILIZER (AMMONIUM NITRATE) NH_4NO_3

Most fires have a technical cause and in most cases they appear and act as a result of human negligence. The human negligence, mainly the easiness in dealing with problems, rather than ignorance of these phenomena largely contributes in some cases, at fire outbreaks. Without knowledge on the causes of fires and explosions, on the scope and mode of action, it is not possible to take the most appropriate prevention measures to remove the fire danger.



Chemical fertilizers or artificial fertilizers can be initiating fire sources by their spontaneous ignition in the case of improper handling or storage. Among most commonly used artificial fertilizers (nitrogen, phosphorus, potassium, etc.), Ammonium nitrate presents an increased fire danger. Ammonium nitrate is hygroscopic, easily absorbs water from the atmosphere, after which is becoming a monolithic, hard solidificated mass. It is a substance soluble in water, ethanol and methanol and used in agriculture, forestry and other fields in the form of granules. Is included in the list of dangerous substances, according to Decision no. 804 of 25.07.2007 on the control of major accident hazards substances.

It is unstable in heat conditions, having a fusion temperature 169^{o}C, and at 200^{o}C – 210^{o}C it starts the decomposition with energy liberation. Storage of ammonium nitrate do not presents fire danger. However, as a result of the fact that it is hygroscopic when it is stored together with lime, with other substances with impurities (coal dust, wood fibers imbued fat, etc.) it creates fire dangerous hazards. Wood or paper having ammonium nitrate traces, are immediately burn when they come into contact with an open flame.

In practice, the temperature of 240^{o}C is dangerous for fires and explosions. At a strong warming, over 400^{o}C, ammonium nitrate suddenly disintegrates, exploding, with nitrogen and carbon dioxide evolution. Decomposition phenomena also occur when slough formed is crashed by mechanical shocks (sparks resulting). Unextinguished lime mixed with ammonium nitrate or ammonium sulphate, under certain conditions of humidity, produces calorification. In the presence of inorganic (ground limestone, calcium nitrate) ammonium nitrate do not present any danger. To remove the explosion and fire danger, research studies performed using a mixture of 50% ammonium nitrate, 15% calcium carbonate and other substances that make ammonium nitrate inert. Ammonium nitrate is a powerful oxidizing substance, and it has a chemical self-ignition tendency.

Possible causes of the explosion are following: heating in a limited space that allows the creation of high pressure, contact (impurification) with slightly oxidizing substances, fine divided metals, oil, coal, and other combustible substances in particular (organic) may lead to acceleration of decomposition and the whole mass explosion.

On this latter characteristic - *addition of organic substances in an acceleration of decomposition* - manufacture of explosives consists: Amonits and Amonals.

Ammonium nitrate can also explode at strong shocks and by initiation from a primary explosive. As a extinguishing method, water is used in large quantities (flooding). In 1971, the ship Vranchos under Greek flag in Galati port, loaded with 2.500 tons of ammonium nitrate was about to explode (near the ship, there were two other ships loaded with ammonium nitrate). The explosion would have produced much destruction in the city Galati.

According to a fire statistic study in 1999, in the last 50 years took place in the world 25 large fires and explosions of ammonium nitrate, with more than 5000 victims. Sure we can not exploit this space to show everything is known about ammonium nitrate, but no one can say that some things are unknown, or researches does not exists, or some learns from the cases which took place in the country and abroad. Is it not appropriate that all those who are using – in a way or another - to give the necessary attention to this issue?

One thing must be clear to all people coming in contact with ammonium nitrate: the presence of chemicals and foreign bodies (aluminum powder, coal, oil, pieces of iron, glass, nitric acid, potassium bicarbonate, fat, etc.) accelerates the decomposition and also radically change its properties, becoming an explosive material.

3. THE EXPLOSION - A SUBJECT TRIGGERING THE FIRE

Explosion, as a distinct technical phenomenon, should be treated as a trigger fire fact and not as an ignition source. Like any combustion, explosion in some situations may create a fire, and in other situations – it can not generate one. Basically, an explosion can generate a fire either by explosive mixture flame propagated and meeting other combustible materials, or by sparks resulting from mechanical shocks. In both presented above examples, summarized from the explosions of ammonium nitrate in the port of Texas City in the U.S. on the ship "Grancane of 10,000 tones, and the fertilizer factory in the town Oppau (Germany), we presented characteristics of ammonium nitrate.

Literature in art notes that were explosions that generating gas and butane - propane fires, also at a warehouse of a flour mill or at a synthetic rubber plant. Explosions of gas and butane - propane fires that have started in the last period have greater frequency.

Methane is a fuel gas, lighter than air with a high calorific value (about 37.800 kj/m^3N) which can easily ignite from a spark or an open fire. To be identified if escape of gas occurs, methane is odorized with strong smelling substances (etilmercaptan in vapor form). If gas pressure drops a lot, especially during cold, flame tends to extinguish, and the valve remained open, back pressure, unburned gas is leaving in the premises in question (during sleep or absence of the residents).

Because gleaming exterior pipeline networks cracks, corroded by chemical agents or electromagnetic pollution etc, in buildings' basements can appear methane gas accumulation. Sources of ignition may be: mechanical sparks, electric sparks [electric switch on the television, refrigerator, lighting bodies, etc., open flame (candle, lighting cigarette match), etc.) [2].

Butane- propane liquefied petroleum gas (stove) with a calorific value of about 47,000 kJ/m^3N having almost double heavy that air, accumulates from the floor and ignite from sources like outlets, stoves, refrigerators, etc.

For example we mention some cases:

Much time ago there was a methane gas explosion at a design institute. Methane gas leaked (through cracks) of two transmission and distribution buried pipelines and infiltrated the in the subsoil building through underground telephone cable channel.

In the basement - has formed an explosive mixture. Source of initiating the explosion was - an electrical spark and the flame produced using an electric switch.

In the basement were stored combustible materials (paper, folders and shelving) that the flames attacked fast. Following the explosion, the building and institute neighborhood constructions have degradation up to the fifth floor. All the windows were completely destroyed. A wall thickness of 40 cm at the distance of 5 meters outside the front door was heavily distorted by the blast.

On 10th of December 1998, four people were injured and 20 apartments were destroyed in a gas explosion and the fire that occurred in the city of Craiova in Dolj County. The explosion was caused by an inmate trying to decant gas from a cylinder to another.

An explosion took place in Bucharest in the morning of 3 December 1998 on Dacia Bulevard. A six storey building has been transformed into a wreck and had 2 deaths.

On 3rd of January 1999, an explosion followed by fire occurred in the city of Resita, Caras Severin because accumulation of methane gas in the basement of the block, from the outside pipelines - was a victim and four seriously injured persons. And this kind of examples may continue. But to see why at a synthetic rubber plant where the explosion took place in the production of phenol section, because of overcoming the technological parameters (temperature and pressure). Note that the facility was equipped with an automatic device, which at a temperature of 114^{o}C has to indicate optical and acoustic in AMC room, but for unjustified reasons, this was removed from service.

The temperature during the operation should not exceed 110 ^oC, and at 125 ^oC start s to decompose the hydroperoxid of izopropilbenzen, with the danger of explosion.

When the temperature reached 155 ^oC caused the explosion. It was felt at 20 - 35 km. Following damage to the column which - caused the explosion, the liquid leaked, creating conditions for the propagation of fire. Liquidation of fire - done in difficult conditions (winter, air temperature was - 20 ^oC).

At a warehouse of flour in a mill, produced in steps, the explosion of flour dust - air on the open source explosion lit a cigarette. Initially held ignition with an explosive burst, which initiated a second explosion, more powerful, followed by dynamic effects.

Due to the explosion in the flour mixture to room, floor, second floor and roof deposit of flour were disposed off, the windows - were broken and the carrying wall between the second floor and the third was curved to the outside.

CONCLUSIONS

Each year, worldwide, fires cause thousands of lost lives, hundreds of thousands of injured and huge material losses. Every 7 minutes, somewhere in the world, up bursts a fire, yearly records - there are over 75,000 fires.

This scourge causes more loss of lives and material goods than all natural disasters. Therefore, protection and fire fighting have a role of particular importance.

If, for various reasons and in different circumstances the mass of ammonium nitrate includes chemicals and foreign bodies (pieces of iron, glass, copper powder, aluminum, coal dust, nitric acid, potassium bicarbonate, fats, petroleum products etc.) it/they accelerate the decomposition and it radically changes the properties of ammonium nitrate to become a powerful explosive material.

BIBLIOGRAPHY

[1] *** *Decision no. 804 of 25.07.2007 on the control of major accident hazards involving dangerous substances*

[2] Ionel Crăciun, Sorin Calotă, Victor Lencu – *Determining the causes and fire prevention* 1999;

[3] *** *Law 307/2006 on protection against fire published in the Official Gazette, Part I, no. 633 of 21.07.2006;*

[4] *** *O.M.I.R.A. no. 210/2007 approving the methodology for the risk of fire identification, evaluation and control.*

[5] Pompiliu Bălulescu –*Technical causes of fires and their prevention*, Editura Tehnică Bucureşti, 1971.

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WORKPLACE HEALTH AND ENVIRONMENTAL RISK ASSESSMENT OF NANOMATERIALS - PRESENT STATE AND CHALLENGES

GABRIEL BĂBUŢ *
ROLAND MORARU*
LUCIAN-IONEL CIOCA**

Abstract: *As an important future technology, nanotechnology presents an opportunity for positively influencing economic development in the long term through intensive research and the effective translation of the research results into innovative products. Hence, there is a need to monitor the development of the new technology, to weigh up the opportunities and risks in a transparent process and compare them with established technologies. The paper emphasizes that, since exposure of humans and the environment as well as toxicological risks cannot yet be evaluated, the need to conduct further investigations and close gaps in knowledge by means of research and assessment activities is compulsory. There are summarized the statutory and legal requirements at European and international level and highlighted the international research activities in the field. Specific consideration is given to the risk assessment strategic aims concerning nanoparticles.*

Keywords: *nanotechnology, nanomaterial, risk, assessment, research, strategic.*

1. INTRODUCTION

As an important future technology, nanotechnology presents an opportunity for positively influencing economic development in the long term through intensive research and the effective translation of the research results into innovative products. Nanotechnology describes the production, investigation and application of structures, molecular materials and inner boundary surfaces having at least one critical dimension below 100 nm. The following strategic aims should be considered in order to achieve coordinated, targeted and effective risk assessment [1]

* *Assoc.Prof.PhD.Eng. at the University of Petroşani*
***Prof.Ph.D.Eng.at the "Lucian Blaga" University of Sibiu*

- Risk-oriented approach [14,15];
- Comprehensive risk characterizations and risk assessments;
- Integration into the statutory and sub-statutory regulatory framework;
- Research that is application-oriented and relevant from the regulatory viewpoint.
- Sustainability and the precautionary principle;
- Transparency and public discourse.

There is an obvious need to examine the extent to which nano-specific aspects and particularities [12 have to be considered in the various areas of chemicals assessment and management. For the purpose of high-level structuring, the research and work areas can be assigned to various topics:

- Identification of nanomaterials and characterization of the physico-chemical properties, determination of the chemical reactivity;
- Exposure of workers and consumers (oral, dermal, inhalative), development of measurement methods;
- Exposure of environment (development of measurement methods for the use of nanomaterials in the environment, life-cycle analyses, exposure scenarios;
- Toxicological assessment (test methods: in vitro, in vivo, epidemiology/occupational medicine,);
- Toxicological test strategies and risk-assessment procedures;
- Ecotoxicological test strategies and risk-assessment procedures;
- Risk management;
- Information and communication (handling aids, safety data sheets, training);

An EU experts survey in 2005 [17] rated "nanoparticles and ultrafine particles" as the most important emerging risk in the area of occupational safety. It is particularly important to launch coordinated and effective research aimed at creating a sound and comprehensive knowledge base for toxicological and ecotoxicological risk assessments, which have to satisfy the demands imposed by the regulatory framework [3,9], and the resultant recommendations (e.g. classifications, limit values, recommendations for handling). The following research projects and support initiatives are considered to be particularly urgent for the common needs of occupational health, consumer protection and environmental protection, whereby they in part follow on from each other:

- Identification of relevant nanomaterials;
- Assessment of nanomaterials within the existing statutory framework;
- Minimum requirements for publications;
- In vivo studies for assessment of the risks of nanomaterials;
- Assessment and validation of the in vitro methods.

From the point of *occupational health* [13], research is needed in the following areas:

O1: Development of measurement methodology and measurement strategies for the determination of exposures to nanomaterials by inhalation;

O 2: Provisional handling aids for certain frequently occurring activities involving nanomaterials in the workplace.

From the point of view of *consumer protection*, research is urgently needed in the following areas:
C 1: Investigations into absorption, systemic availability, accumulation and elimination of nanomaterials after oral exposure (foodstuffs and food packaging materials)
C 2: Assessment of the toxicity of nanomaterials after oral exposure.
From the point of view of *environmental protection*, research is urgently needed in the following areas [10]:
E 1: Identification of relevant parameters for behaviour and fate in the environment;
E 2: Exposure, persistence and accumulation of nanomaterials in the compartments water, soil and sediment;
E 3: Development of uniform standards for the testing of nanomaterials.

The currently foreseeable research topics and requisite activities in fundamental areas will require specific support in the next 5 to 10 years. In particular, this also applies to conceptual aspects relating to the procedures and strategies. It will be possible to change to a more routine form of investigation and assessment of nanomaterials (individual substances and substance classes) which will continue for as long as new nanomaterials with relevant exposure of humans and the environment are developed.

2. STATUTORY BACKGROUND

The coverage of nanotechnology by the legal instruments is discussed by various authors [6, 9, 16]. A number of legal instruments have the task of protecting workers, consumers and the environment without specifically dealing with nanotechnology [7], e.g.:

- Regulation (EC) No 1907/2006 of the European parliament and of the council of 18 December 2006 concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH); Regulation (EC) No. 1907/2006 (some of the following rules and regulations have been repealed by the REACH Regulation);
- Existing Substances Regulation; Regulation (EEC) No. 793/93;
- Assessment of risks to humans and the environment of existing substances (EC) No. 1488/94;
- Classification, packaging and labeling of dangerous substances, Directive 67/548/EEC;
- Preparations Directive; Directive 1999/45/EC;
- Biocide Directive; Directive 98/8/EC;
- Directive concerning the placing of plant protection products on the market, 91/414/EEC;
- Occupational safety directives; 89/391/EEC, 98/24/EC;
- Directive on the safety of toys; Directive 88/378/EEC;
- Directive on general product safety; Directive 2001/95/EC;
- Cosmetics Directive; Directive 76/768/EEC;

- Directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment; Directive 2002/95/EC;
- Consumer goods; Regulation 2004/1935/EC;
- Waste Incineration Directive 2007/76/EC;
- Water Framework Directive 2000/60/EC;

In the area of occupational safety, the fundamental statutory rules hold the employer responsible for protecting the health of workers (European: Framework Directive on health and safety 89/391/EC, protection of the health and safety of workers from the risks related to chemical agents at work 98/24/EC). Special rules and regulations relating to nanomaterials are not currently available. Up to now there has been no substance-specific statutory duty to perform studies specially for nanomaterials. Also, with regard to the areas foodstuffs, consumer goods and cosmetic products, there is currently no special regulation of nanomaterial. Nanomaterials may be added to products and articles in order to achieve a biocidal effect (e.g. silver). A notification duty exists in the case of biocides (Biocide Notification Ordinance, Biocide Directive). However, the particle size is not recorded here. The Federal Environmental Agency (UBA) has already produced an expert report [19] which analysed the statutory areas with regard to the current state of technology. Stock was taken here of the existing national and European environmental legislation. Gaps in regulation that exist at European and national level in connection with "nanotechnologies" were identified and possible regulatory approaches indicated. Recommendations for the further regulatory approach were additionally formulated. The analysis of the individual statutory areas has made clear that, with regard to the specific properties of nanomaterials, gaps exist at many points in the sectorial environmental legislation.

3. EUROPEAN AND INTERNATIONAL ACTIVITIES IN THE FIELD

Since the exposure of humans and the environment as well as the toxicological and ecotoxicological properties and risks, in particular in connection with newer nanomaterials, cannot yet be assessed, there is general recognition of the need to perform further investigations and close gaps in knowledge through research and assessment activities. For example, the European Commission published an action plan which provides for contributions towards the investigation of the associated health risks. The reports that appeared at an early stage in the United Kingdom [5], describe in an exemplary manner an approach in the areas risk research, participation of the Competent Authorities and the public at large in a transparent discourse. Fair and early communication about the opportunities and risks of nanotechnology will be crucial for the way society deals with this technology. In Germany, the discourse is accompanied by various official events and activities. In turn, the basis for risk communication and social discourse is provided by the availability of the most well-founded knowledge possible on the exposure and toxicity of nanomaterials, including the analysis required for the generation of knowledge. Various authors have discussed the topic of a research strategy for nanomaterials [2] (An overview of the ongoing and planned research in the

United Kingdom and the international research activities was also produced by the UK Ministry of the Environment [6]. In Germany, an investigation into the health effects is to be found, , in projects undertaken by the Federal Institute for Occupational Safety and Health (BAuA), the Federal Institute for Risk Assessment (BfR) and the Federal Environmental Agency (UBA) as well as in the projects Nanocare, INOS and Tracer [17].

At international level the Higher Federal Authorities participate in the work performed by the Organization for Economic Cooperation and Development [18] (OECD). A "Working Party on Safety of Manufactured Nanomaterials" (WPMN) that was established in 2006 focuses in its work programme on safety aspects relating to human health and the environment due to synthetic nanomaterials and the assessment of them. The topics that are required for a risk assessment are elaborated in 8 projects:

- Project 1: Development of an OECD database on EHS research
- Project 2: EHS Research strategies on manufactured nanomaterials
- Project 3: Safety testing of a representative set of manufactured nanomaterials
- Project 4: Manufactured nanomaterials and test guidelines
- Project 5: Co-operation on voluntary schemes and regulatory programmes
- Project 6: Co-operation on risk assessment
- Project 7: The role of alternative methods in nanotoxicology
- Project 8: Co-operation on exposure measurement and exposure mitigation.

4. RISK ASSESSMENT STRATEGIC GOALS

The following aspects are of fundamental significance and should be considered generally during the conception of nanomaterials risk assessment:

a. Risk oriented approach: when determining the orientation of research, special importance should attach to the assumed risk. Both the individual risk, which describes the level of the individual risk, and the population risk, which considers the number of affected persons, are relevant quantities which should crucially influence the process of determining the focus of interest of research [4].

b. Comprehensive risk characterizations and risk assessments: the current uncertainties surrounding the risks posed by nanomaterials necessitate comprehensive risk characterization and assessment. This shall include all of the possible toxicological properties and end points as well as cover all of the various exposure situations throughout the life of a nanomaterial. The life-cycle analysis therefore forms part of the comprehensive risk characterization and assessment.

c. Integration into the statutory regulatory framework: a statutory body of rules is available for the appropriate limitation of the risks. Since the options for action taken to limit the risks are oriented towards the body of rules and are derived from it, orientation and adaptation of the research activities to the demands of the statutory framing conditions are essential in order to be able to translate the results of the research into specific measures for the protection of humans and the environment should the need arise. At present, integration into the existing statutory framework is envisaged and no attempts are being made to draw up a specific nano-law.

d. Research that is application-oriented and relevant from the regulatory viewpoint: research activities with regard to the assessment of the risks are sensible if the research results may have an indirect or direct influence on the limitation of the risks. It is therefore necessary, as a matter of principle, for the toxicological and ecotoxicological studies to be performed in such a way that they can be used in regulatory toxicology.

e. Assessment of the novelty of nanomaterials: a large number of new nanomaterials is expected in future. In comparison with the established industrial chemicals, an increased need for information on the risks of the nanomaterials as a result of the new properties is justified from various quarters. It is necessary to examine the extent to which a particularly critical approach, one differing from other new or well-known chemicals, is justified in the case of the new nanomaterials.

f. International cooperation and coordination: coordination of the research activities among the various nations and institutions should be targeted in order to enable a division of labor and to avoid duplication. In an increasingly globalized world, it is necessary to act at a supranational level while still taking due account of regional particularities.

g. Sustainability and the precautionary principle: the need to consider aspects of sustainability when accompanying a new technology is of general importance and not specific to the assessment of the risks to health and the environment posed by nanomaterials. Long-term consequences with a harmful effect that only becomes apparent decades or generations later must be avoided [14]. This is ensured by acting according to the demand for minimization. The same applies to the consideration of the precautionary principle which, as a fundamental principle, urges caution in the case of knowledge gaps and is taken into account in test strategies as soon as the first grounds for suspicion become apparent.

h. More efficient structures for targeted promotion of research: without comparable financial means, the responsibility for the assessment within the current statutory framework lies with the Federal Ministry for Labor and Social Affairs (BMAS), the Federal Environment Ministry (BMU) and the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) in U.S.A and the corresponding institutions at European level. Bodies which prepare and support the assessment of the risks within the current statutory framework have not yet been established and supported financially.

i. Transparency and public discourse: the consideration of social problems is a crucial factor in any attempt to do justice to a sustainable technological development.

5. CONCLUSIONS

Nanotechnology is considered to be an important area of development by all industrial nations. Consequently, there is a recognized need for research at European and international level in order to be better able to assess the risks of the nanomaterials.

The OECD working party therefore creates a very important platform for bringing together and agreeing at international level the diverse tasks and activities relating to the assessment of nanomaterials.

The level of the exposure is essentially influenced by the on-site processes and protective measures. Production of the nanomaterials systems that are, as far as possible, closed as well as the use of further protective measures (e.g. air filtering in exhaust ventilation systems and filter masks, gloves) can essentially influence the exposure.

In various systems relating to the assessment of risks and hazards, the level of exposure can be estimated quantitatively using model calculations. Before such models can be developed for nanomaterials, it is first necessary to develop the corresponding measurement methods and have available sufficient measurement data in order to identify the parameters that crucially determine the level of exposure from among the exposure conditions associated with the measurement data. Once the causal connections are demonstrated with sufficient certainty on the basis of various measurements, it is then possible to develop a model that permits the estimation of the approximate level of exposure even without the need for further measurements.

Like exposure of workers and consumers, the exposure of the environment is currently largely unclear due to the absence of essential information on the type, distribution and use of nanomaterials. Likewise, little is known about the direct use of nanomaterials in the environment (e.g. treatment of waste water, restoration of soils or pest control). However, consideration should also be given to the fact that nanoscale particles are not entirely new. Natural and unintentionally produced particles of this size have long been entering the environment and resulting in the exposure of humans and the environment.

Research activities are required to clarify the release of nanomaterials to the environment during production, further processing, use and disposal. Furthermore, nanomaterials intentionally released to the environment should be identified and their fate clarified.

BIBLIOGRAPHY

[1]. Balshaw et al. (2006), *Research strategies for safety evaluation of nanomaterials. part III. nanoscale technologies for assessing risk and improving public health,* Toxicological Sciences, 88, 298-306

[2]. Borm et al. (2006) Research strategies for safety evaluation of nanomaterials. part V. role of dissolution in biological fate and effects of nanocale particles Toxicological Sciences, 90, 23-32

[3]. Băbuț, G., Moraru. (2006), *Cadrul general al managementului riscului de mediu,* Buletinul Agir nr. 3/2006, iulie/septembrie,pp. 103-107.

[4]. Davies (2006) Managing the effects of nanotechnology www.nanotechproject.org/file_download/files/PEN2_MngEffects.pdf

[5]. Defra (2005), *Characterizing the risks posed by engineered nanoparticles: a first UK Government research report,* www.defra.gov.uk/environment/nanotech/research/reports/index.htm

[6]. Defra (2007), *Characterizing the potential risks posed by engineered nanoparticles: a second UK Government research report,* www.defra.gov.uk/environment/nanotech/research/reports/index.htm

[7]. Dekkers et al. (2007), *Nanomaterials in consumer products, Availability on the European market and adequacy of the regulatory framework, RIVM/SIR Advisory report 11014 (IP/A/ENVI/IC/2006-193),* www.europarl.europa.eu/comparl/envi/externalexpertise/environment_en.htm

[8]. Franco (2007), *Limits and prospects of the „Incremental Approach“ and the European legislation on the management of risks related to nanomaterials,* Reg Tox Pharm, in press'.

[9]. Frater et al. (2007), *An overview of the framework of current regulation affecting the development and marketing of nanomaterials,* www.berr.gov.uk/files/file36167.pdf

[10]. Hund-Rinke und Herrchen (2007*),* *Technisches Vorgehen bei der Testung von Nanopartikeln, Forschungsvorhaben Umweltbundesamt*, FKZ 206 61 203/03

[11]. Krug (2005), *Auswirkungen nanotechnologischer Entwicklungen auf die Umwelt* www.scientificjournals.com/sj/uwsf/abstract/ArtikelId/7641

[12]. Maynard and Kuempel (2005), *Airborne nanostructured particles and occupational health Journal of nanoparticle research,* 7, 587-614 www.springerlink.com/content/700q5022523342j4/

[13]. Moraru, R., Băbuț, G., Matei, I. (2002), *Ghid pentru evaluarea riscurilor profesionale*, Editura Focus, Petroşani, 2002.

[14]. Moraru, R., Băbuț, G. (2000), *Analiză de risc*, Editura Universitas, Petroşani, 2000.

[15]. * AS/NZS 4360:2001 –** Risk management. Standards Australia/ Standards New Zeeland, Sydney/Wellington, 2001

[16]. Thomas et al. (2005), *Research strategies for safety evaluation of nanomaterials. part I. evaluating the human health implications of exposure to nanoscaled materials,* Toxicological Sciences, 87, 316-321

[17]. BMBF (2007), *EuroNanoForum 2007,* www.euronanoforum2007.eu/

[18]. OECD (2007), *OECD Guidelines for the Testing of Chemicals* http://oberon.sourceoecd.org/vl=3019884/cl=17/nw=1/rpsv/periodical/p15_about.htm?jnlissn=1607310x

[19]. UBA (2006), *Nanotechnik: Chancen und Risiken für Mensch und Umwelt,*www.umweltbundesamt.de/uba-info-presse/hintergrund/nanotechnik.pdf

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MONITORING AND FORECASTING THE PARTICULATE MATTER POLLUTION CAUSED BY SURFACE MINES

R. BÖHNER*
C. NIEMANN-DELIUS*

Abstract: *In the vicinity of lignite surface mines increased particulate matter concentrations keep arising. Therefore, action plans have been drawn up and implemented for the Hambach and Garzweiler I surface mines in the Rhenish Lignite District. The measures mainly comprise technical means and focus on the very point of origin of the particulate matter. A prerequisite for this is the prior identification of the emission sources in the surface mine and a possibly accurate forecast of their effective range. Next to selective measurements, numeric dispersion models constitute an important monitoring and forecast procedure. They allow the calculation of dust concentrations of any number of emitters and the simulation of their effective range. The result is an exact dust register of the area examined. Through processes and due to its spatial extent surface mining operations may cause increased dust concentrations. Emissions here arise from various sources: besides diffuse dust discharge there are mobile as well as point and continuous sources caused by excavation, transport and refining processes in surface mining. Using dispersion calculations it becomes possible to forecast the particulate matter situation for any period of time and to include dust reducing action in planning or to check planned measures for the expected effects.*

1. AIR POLLUTANT PARTICULATE MATTER

1.1 *Limit values for particulate matter in the European Union*

Since the 1st January 2005 strict limit values for particulate matter in the outside air apply for the member states of the European Union. Particulate matter consists of airborne particles whose aerodynamic diameter is under 10 µm; so the international term is particulate matter 10 or short PM_{10}. Particles of this size are able to deeply penetrate the lungs and are therefore able to cause serious health damages. The European Commission has for this reason set limit values and also issued rules and regulations regarding the monitoring of air quality. At the moment, a yearly limit value for the particle size of PM_{10} of 40 µg/m³ applies as well as a daily limit value of 50

* *RWTH-Aachen University, Germany*

µg/m³, which must not be exceeded more than 35 times a year. Presumably in 2010 these limit values will be further put up to a yearly average value of 20 µg/m³; the daily limit value of 50 µg/m³ will be retained but may only occur on 7 days a year. In addition to that, a limit value for the particle size $PM_{2,5}$ will be introduced, which is supposed to be legally binding from the year 2015.

1.2 *Average concentrations of particulate matter for different types of areas*

Dust is a natural part of air and thus is present everywhere. Based on comprehensive measurements and studies, certain average dust concentrations can be assumed for different types of areas. In areas influenced by industry the average annual value for particulate matter is 30-40 µg/m³ and so lies below the presently permissible limit value. By the way, it is exceeded by areas close to traffic; there the average annual value is as high as 30-40 µg/m³. However, the average number of days on which the daily limit value of 50 µg/m³ is exceeded is 50-90 days and therefore shows that this limit value cannot as a rule be adhered to without dust reducing measures.

2 DUST EMISSIONS IN OPEN PITS

2.1 *Various sources*

The material mining industry operating open pits contributes to particulate matter concentrations on account of the spatial extent of its operations and the related processes. Lignite surface mines have a higher erosion and emission potential due to their spatial extent and the mostly missing vegetation. Here, emissions result from various sources. The dust discharge partly is diffuse from the open mining surfaces by erosion and by the process-related mechanical load from defined single sources. To be mentioned here are stationary operational processes such as the mining or dumping of lignite or waste, especially at conveyor belt transfer points or at places where a spreader dumps material increased dust emissions arise. All vehicles moving around the surface mine constitute mobile sources with the dust emissions discharged by them being especially high when the material is being transported on open loading areas. Roads and belt facilities within the surface mine are also significant dust sources, which are continuous.

Table 1. Typical average particulate matter concentrations for different types of areas in Germany

Station category*	1	2	3	4
Yearly average concentration [µg/m³]	10-18	20-30	30-45	30-40
Quantity of days >50 µg/m³	0-5	5-20	15-100	50-90
Highest daily concentration [µg/m³]	50-70	60-100	70-150	100-200

*1 rural areas
2 urban areas
3 traffic areas
4 industrial areas

The material lying on roads or the one conveyed on belts is exposed to wind erosion. The material on roads is additionally subject to strong mechanical load by the use of unpaved roads.

2.2 *Dust reduction*

To what extent surface mines contribute to particulate matter problems in the environment and which operational processes are significantly responsible for this, however, cannot be finally judged. According to EU law every particulate matter polluter is obliged to reduce its emissions and to start measures to reduce dust if necessary. The measures mainly comprise technical means such as the use of sprinkling, spraying or purification facilities or the intermediate greening up of open areas and start at the point of origin of the dust. Mainly devised for the avoidance of coarse particles the effect of the use of such measures to avoid particulate matter is not yet secured.

The prerequisite for the development of useful dust reduction measures is the prior identification of dust sources in surface mines and a possibly exact forecast about their effective range. In order to monitor the particulate matter pollution 400 measuring points of the Office for the Environment have been set up in Germany. Additionally, some companies run their own measuring devices

Figure 1. Dust emissions caused by mining in an open pit

3 FORECASTING THE PARTICULATE MATTER POLLUTION

3.1 *Numerical dispersion calculations*

In order to examine the particulate matter formation in quantity and quality numeric dispersion calculations are being used next to measurements. They are an important instrument for calculating the effective range of one or more dust sources and can simulate an area-wide forecast of the dust concentration in an area of any size and for a time period of any length. They so represent an important monitoring and forecast method.

Unlike in the past when emissions were defined as annual values on judgment areas of as a rule 1000 x 1000 m, which means they were area related, the dispersion calculations nowadays have to be point related according to the particle model of

Lagrange. Another important change is that next to annual average values daily or hourly average values have to be taken.

The Lagrange particle model is a numeric model which allows simulating the dispersion of indicators in the atmosphere and calculating their concentration. Simulated are the trajectories of a great number of particles representing an indicator, which are removed in a turbulent air stream independently of one-another. So, the particles are followed on their way across the atmosphere. The result of the calculation is the concentration field for particulate matter and the distribution of the deposition of the overall dust. It can be used in connection with the current diagnostic or planning or forecast related issues. Typical areas of use are e.g. dispersion calculations for facilities that require authorisation or environmental risk assessment.

An important input parameter is the knowledge about the source strength of individual emitters. It can be calculated or be ascertained by a measuring campaign in the surface mine. For their calculation the German law provides calculation methods which allow the calculation of source strengths for the dropping as well as for the taking of bulk goods. Another required parameter is a representative meteorological time series, which contains hourly measurements of wind and turbulence data. In order to take into account topographic and hence modifications of the particles dispersion and distribution that are due to micro-climates a digital terrain model of the area can be allowed for. The simulation program independently generates a three-dimensional wind and turbulence model with the help of the terrain model and the meteorological data. Dispersion calculations can be used for areas with an extension of 20 metres to up to 100 kilometres and for problem times of 10 minutes and up to several years. This only depends on what spatial and timely scale the meteorological data is provided. The result is an exact dust register of the examined area.

3.2 *Example of use*

In 2005 such dispersion calculations were made as part of a master thesis. The object of examination was the expected dust exposure of a German lignite surface mine. These were projected into the future for three determined years. The calculations were to reveal whether the working area would lead to increased particulate matter concentrations in its vicinity. The three selected reference years were critical years in this respect as the mining operations would move close to adjacent villages due to the further development of the mine.

Since there were no emission values of individual operation sizes the source strengths of individual emitters had to be ascertained by calculation. To this end, it was firstly necessary to conduct a grain size analysis of the waste and the lignite. The planned excavation quantity and the development of the mine including the use of the equipment were known. On the basis of these and other data the source strength of selected point sources in the surface mine was calculated dependent on time according to the VDI (Association of German Engineers) guidelines. The source strengths were entered into the simulation program. Also, the calculations were based on the digital terrain models of the three excavation years as well as a meteorological time series of the site. The results were hourly values of the emission situation for particulate matter as well as for coarse particles for a whole year. As the effective range of individual sources could be calculated this way the minimum distance to be respected become known in order to avoid increased particulate matter concentrations in the vicinity of the work field. The simulation program already yielded the daily average values in elaborated form. This means that for each grid point of the calculated area the 36th highest value was put out. Since the daily limit value of 50 µg/m³ may occur only 35 times a year the calculation result show in what distance from the dust source the limit value can be adhered to.

On top of that the influence of individual emitters could be selectively quantified and thus yield an important contribution to the planning of reduction methods. Using the results it was also possible to create wind direction analyses based on harmful substance wind roses. So, it was possible to make statements on which wind conditions have an adverse effect regarding the dust situation and when increased particulate matter concentrations could be expected. So, the results could be included into the planning of dust reducing measures.

Dispersion calculations can thus provide a forecast on whether or not and to what extent particulate matter concentrations can be expected in the vicinity of surface mines. Inaccuracies, however, result from the fact that the calculations are exclusively based on wind and turbulence data. So, weather phenomena that have a dust reducing effect such as rain falls or the ones that support dust such as longer dry periods cannot be taken into account. What is very well traceable are the results of stationary high pressure weather situations. Characteristic for these are stable air layers that almost prevent a mixing and thus concentration dilution of air pollutions. During such weather situations generally require enhanced dust reducing measures.

3.3 *Particulate matter is not just a regional problem*

Of special interest is the analysis of polluter rates. There is virtually no area that is not more or less pre-polluted by particulate matter. This is as already mentioned due to the fact that dust is a natural part of air and is present for example in the form of pollen or spores. What is more, particles of this size are to a significant extent subject to remote transport. The Sahara sand events are an example for this. In addition to this, particulate matter also forms in a secondary way, i.e. they result from chemical conversion processes in the atmosphere. Since these secondary aerosols are characteristic chemical substances this proportion can be quantified by chemical analysis. This is more difficult with substances that occur almost everywhere or have an extensive area of circulation.

Time analyses of particulate matter measuring stations normally display a daily or weekly circle. A direct inference on only one polluter or a decisive originator involves some difficulty. Operating hours as a rule correspond with times of increased traffic. When considering the particulate matter pollution over the year it is generally higher in winter than in summer. One reason is that low wind high pressure situations and inversions occur more frequently in winter and reduce the air exchange. Generally, a higher initial level of pollution shows at measuring stations far from industry which is all the more reinforced that additionally emitted particulate matter cannot be removed by wind.

4 CONCLUSIONS

4.1 *Companies have to take action*

Surface mines have been in the public focus since the new air purification policy of the European Union became effective. In the Rhenish Lignite District the German Office of Environment operates several measuring stations. In addition, RWE operates its own measuring devices in and around its work fields. As early as 2005 an action plan was drawn up for the Hambach surface mine, another action plan followed for the Garzweiler surface mine in 2006. To this end, the company has had causer analyses made in cooperation with the environmental authority of the Land in order to identify the relevant particulate matter sources. The 36th excess of the daily limit value entails the necessity of drawing up an action plan to determine measures that help reduce the danger of exceeding the limit value or the time period of the excess. On top of that air pollution plans are decided on for both surface mines. Whereas one plan is aimed at a short-term alleviation an air pollution scheme comprises measures to constantly adhere to the particulate matter limit value.

4.2 *Research to avoid particulate matter pollution*

Today it is already evident that the current particulate matter limit values are not always and not in any place observed. The development of adequate measures to avoid particulate matter emissions is a central task for companies and public authorities as well. An important part in this is the knowledge of the processes that entail particulate matter concentrations. The Institute of Mining Engineering III at the RWTH Aachen has been dealing with this for a considerable period of time. The aim is to be able to make more precise statements as to whether and to what extent surface mines lead to increased particulate matter concentrations in their vicinity and what processes are responsible for this. Methodically, this is implemented by mobile particulate matter measuring devices in combination with dispersion calculations. The results are continuously compared with the measured particulate matter concentrations of measuring stations in the surrounding area that are not influenced by surface mines. As a rule, these stations are located in rural areas. The results and experiences of these examinations are to deliver a clear picture of the emission situation caused by surface mines and to provide important contributions to the execution of the current and future air pollution policies.

5 REFERENCES

[1], Bezirksregierung Düsseldorf (2006): Aktionsplan Grevenbroich. Düsseldorf.

[2]. Bezirksregierung Köln (2005): Aktionsplan in der Umgebung des Tagebaus Hambach. 29. September 2005. Köln.

[3]. Janicke, U. (2004): Austal2000. Programmbeschreibung zu Version 2.0. Dunum.

[4]. Böhner, R. (unpubl.) (2005): Prognose der Staubbelastung durch das Abbaufeld Schwerzau anhand ausgewählter Abbauständе und Entwicklung möglicher Minderungsmaßnahmen. Magisterarbeit an der RWTH-Aachen.

[5]. Richtlinie 2000/69/EG des Europäischen Parlaments vom 16. November 2000.

[6]. Richtlinie 1999/30/EG des Europäischen Parlaments vom 22.04.1999.

[7]. Richtlinie 1996/62/EG des Rates vom 23. September 1996.

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ECOLOGICAL REHABILITATION IN THE MINING BASINS OF OLTENIA

M. LAZĂR*

Abstract: *In Romania, the biggest brown coal reserve is being exploited in Oltenia, in the South of the middle Carpathians Mountains. The reserve is being exploited in five mining basins, in the present there are fourteen quarries with the ability to process between 1,5 – 4 mil. tones/year. As a result of the mining activities from the quarry, there are occupied and degraded areas of stretch-land estimated close to 19000 ha. The major negative impact from brown coal mining in Oltenia is bound to affect the land, the vegetation, the fauna and the landscape, same as inclusively breaking up the trophic chains. The ecological rehabilitation problem of the lands, degraded by mining is settled by mining and environment laws, witch impose rebuilding them after the mining activities cessation. Although, there are concerns and realizations about bringing back in the economic circuit of the degraded lands, in the Oltenia zone, these don't unfold on a global project according to the fundamental principles of ecology. In this paper are exposed the arguments how back up the necessity of am global approach of the concept of ecological rehabilitation and towards practical solutions for the Romanian coal mining zones.*

1. BROWN COAL EXPLOITATION IN OLTENIA

In Romania, the brown coal produces 35-38% of the electrical power and 20% of the thermal energy of the country. In the region of Oltenia, brown coal is extracted in five basins with more quarries (figure 1).

Extraction of brown coal in Oltenia began in the 60s of the past century, and since then closed to 850 millions tones of brown coal and 5000 millions m^3 of sterile have been extracted. In the long run, the contribution of brown coal in the energetically balance of Romania will be constant, that means that the production from the Oltenia quarries will have about the same level as in the during 2005 – 2006.

The 18 quarries use on a large scale (about 92%) the continuous technological flow, consisting of rotor excavators combined with high capacity belt conveyors and waste storing machines (figure 2).

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* *prof.PhD.Eng. - University of Petroşani, Romania*

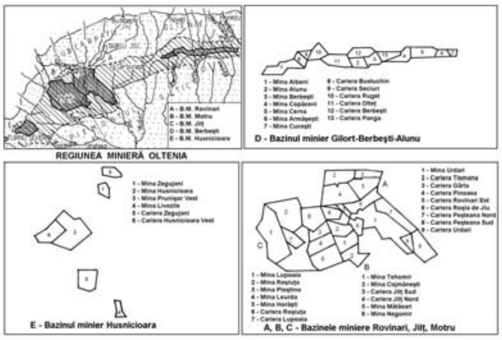

Figure 1 Oltenia coal mining region

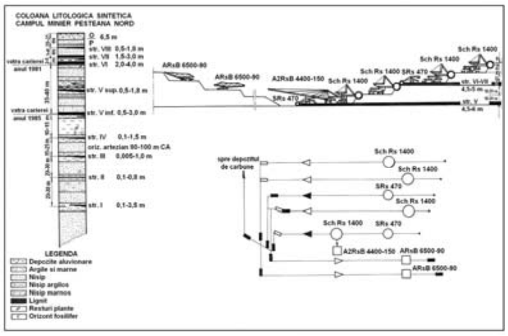

Figure 2 Brown coal extracting technology in the Oltenia open pits

2. THE IMPACT OF THE EXTRACTION OF BROWN COAL ON THE SOIL

Environmental factor that has most suffered from the mining operation is the soil and the entire ecosystem of the area. The most important destructive effects on the soil are produced by activity in open pit, caused by excavations and dumps. The underground mining affects land, soil and subsoil, due to the surface buildings and the phenomena of subsidence. Mining, through specific activities, may generate impacts on air and water, but also on human factor, both at individual and community level.

Estimations are that the areas affected by the mining industry will be about 1% of the national agricultural surface. There is a special situation in the basins of Rovinari, Motru şi Jilț from Gorj country where the affected surface is over 18000 ha, 18% of the agricultural surface.

Although, there are no real statistics about the surfaces taken by mining in the world and in Romania, we can say that the surfaces taken out of the economic use are greater and greater, due to the extension of the open pit exploitation, and yet small as compared with the surfaced needed for industrial installations or transportation systems. As extraction begins, plains are disappearing and the waste dumps represent, for the beginning, a total change of the landscape. Another bad influence on the land is that great surfaces are taken by waste dumps and sorting installations a short or a long period of time. The main bad influences of the waste dumps on the environment are:

- bad visual impact; destroying and occupying large surfaces; pollution of the surface and underground waters with chemicals or small particles taken from the waste dumps by rain or infiltrations;
- air pollution with gas from the minerals in the waste dumps or produced by oxidation or burning them;
- waste of lives and materials due to the lack of stability, etc.

The waste dumps also changed the landscape, as heights of 15 – 20 m up to 90 – 100 m appeared in flat areas.

As a result of mining, large surfaces, partly or completely affected, are out of the agricultural, forest or natural use.

According to the Romanian laws, the mines must rehabilitate ecologically the areas used by them and thus, in time, a part of them were cultivated again. In the Oltenia area, form the 17000 ha of occupied land, about 2000 ha have already been reintroduced in the agricultural or forest use, and the rest are to be rehabilitated and reintroduced in the economy soon. Out of the affected areas, 80% are agricultural and 20% were forests. The present use of land in the Oltenia basin is 31 ha for 1 million tones extracted brown coal.

Out of the total, 25% were pastures and feedlots, which gave low and instable productions and 5%, were orchards and vineyards with great variety but low productivity.

Most of those surfaces are in the Rovinari basin (tables 1 and 2).

As it can see, there are surfaces affected by the mining industry in other mining areas in Romania, but they represent max. 5% of the affected areas in Oltenia.

Table 1 Agricultural and forest surfaces affected by mining

Mine	Affected areas				
	Total	Structure			
		Agra	%	Forest	%
Rovinari	9923	8050	81,0	1873	19,0
Jilț	2211	1777	80,0	434	20,0
Motru	3693	2582	70,0	1111	30,0
Berbeşti	2209	1695	77,0	514	23,0
Mehedinți	586	337	58,0	249	42,0
Total	18622	14441	77,5	4181	22,5

Tabels 2 Agricultural and forest surfaces recultivated after the mining activities cessation

Mine	Recultivated areas				
	Total	Structure			
		Agra	%	Forest	%
Rovinari	1347	664	49,3	683	50,7
Jilț	146	89	61,0	57	39,0
Motru	512	413	80,7	99	19,3
Berbeşti	328	279	85,0	49	15,0
Mehedinți	39	-	0,0	39	100
Total	2372	1445	61,0	927	49,0

3. EXPERIENCE FOR LAND RECULTIVATION

Recultivation has been done on stages, as surfaces were freed by technological tasks, with no plans or projects for rehabilitation.

Due to the climate, average temperature of 10,3°C, average rain 753 mm per year, winds, influenced by the mountains and slopes in the nearby, by the deforestation, change of the river flows, creation of artificial lakes and temporary or permanent puddles which produced changes in micro-climate, more plantations have been experienced, as follows:

- orchards (66 ha) using: apple tree, plum tree, cherry tree, sour cherry tree, nut tree, mirabelle tree, hazelnut tree, etc.

The apple tree and the plum tree gave good results;

- vineyards (40 ha) using: Royal Fetească, Muscat Otonel, Italian Riesling, Merlot and Cabernet Sauvignon.

Best results were obtained by and Royal Fetească product;

- forests (1.037 ha) using: acacia, oak, poplar, pine tree, cherry tree, nut tree and chestnut tree.

Best results were obtained by acacia tree, poplar, oak and esculent chestnut tree with double use, for fruits and for wood;

- cereals and technical plants (1,140 ha): rye, wheat, sun flower, corn, potatoes and peas;

- feedlots and pastures (757 ha).

Best results were obtained by trefoil and clover.

4. GLOBAL APPROACH OF THE ECOLOGICAL REHABILITATION

The decisions about developing a mining area after stopping the production is a challenge for all the responsible, regarding the planning of the use of the surfaces, planning the landscape or ecological planning, which involves a great responsibility. Such a decision must take into account a lot of elements, regarding the ecological characteristics of the area on one side and on the other side the social and cultural structure and needs of the population.

Some of the reasons for re-modelling the land affected by the human activity are:

- to eliminate the risk for land slide from positive land forms resulted from the industry (waste dumps, ash dumps, industrial or domestic dumps);
- to eliminate the negative visual impact of the areas having a moonscape aspect (specific to quarries);
- the need for reintegration of the affected areas in the economic and/or ecologic exploitation of the areas where they are located, leading to their economic regeneration;
- improving the environmental quality;
- reducing the slopes and thus reducing the erosion and stimulating the apparition of the vegetation.

For all the cases of re-modelling of the affected areas we must start from the economic activity that generated the degradation and take into account the future use. There is a fundamental relation between the shape and the morphology of the land and the type of re-use that can be crucial for choosing the new utilization. If a specific use is not foreseen, than re-modelling must be done in order to offer multiple options. Best is to take a specific utilization into account from the very beginning.

The main objectives of such works are:

- to identify the possibilities to re-use the materials and installations;
- making the land flat with or without materials from other locations;

- filling the remaining holes with waste or water;
- decontamination of the lands;
- creation of storage areas for waste from other regions.

Any landscape is unique and irreproducible, the result of superposing in time of components of different origin (natural and cultural) producing always original situations. For such regions, planning and use of the land must take into account a unique design, capable to take into account the inside of the landscape with all its components. One of the causes of wrong planning of the landscape is taking the landscape on pieces or leaving out parts of it.

5. SOLUTIONS FOR ECOLOGICAL REHABILITATION OF THE ROVINARI MINING BASIN

We chose the Rovinari mining basin because it is the most affected by the open pit mining, as here there are eight quarries (figure 3).

Figure 3 Satellite photo of the mining basin Rovinari

As a result of the analysis of the natural characteristic conditions and the climate factors of the area, we consider three possibilities for new utilization of the surfaces affected by mining, Table 3.

Table 3 Possibilities for ecological rehabilitation of the mining basin Rovinari

Possibility of the land re-use / Quarry	Possibility 1	Possibility 2	Possibility 3
Rovinari Est	Dendrological park	Recreational area	Mining museum
Tismana I	Agricultural recultivation	Preparation for motor-sports	Forest recultivation and preparation for fishing
Tismana II	Agricultural recultivation	Nautical and recreational base	
Pinoasa	Filling the remaining hole with water	Domestic waste storage	Forest recultivation

Roşia de Jiu	Agricultural recultivation	Forest recultivation	Filling the remaining hole with water
Peşteana Nord	Filling the remaining hole with water	External waste dump for the Roşia quarry	Forest recultivation
Peşteana Sud	Agriculture and forestry	Storage for fertile soil, recovered from the quarries Peşteana Nord and Roşia	Orchyard and vineyard recultivation

The following ideas were taken into account for determining the final destination post-utilization of the surfaces:

- the necessity for integration of the new surfaces in the surrounding landscape;
- physical needs of the population concerning the land property;
- the morphology of the land and the exposure of the gradients of the quarries and waste dumps;
- pedological characteristics of the soils;
- available water resources and the need for rehabilitation of the level of the underground water;
- costs of the necessary works;

6. CONCLUSIONS

The concept of ecological reconstruction of the mining affected areas in the Rovinari basin meets the following objectives of the national strategy for reconstruction of the mining areas, using the idea of sustainability:

- economical re-using of as big as possible surfaces;
- morphological and landscape reconstruction of the surfaces;
- creating lakes in the remaining holes;
- developing activities for the community in order to use the remaining actives from the closed mining units;
- involving the community members for rehabilitation and reconstruction of the environment;
- paying all the compensations in connection with the use of land.

As a result, we can say that the propositions presented in this paper lead to a decrease of the danger for pollution of the environment in the analyzed area as well as to a rehabilitation of the environmental factors to a state as close as possible to the situation previous to the mining, all in the context of the sustainable development

REFERENCES

[1]. Lazăr, M. (2001). *Ecological rehabilitation,* Ed. Universitas, Petroşani, 2001.

[2]. Lazăr, M., Dumitrescu I. (2006). *Environmental impact of antropic activities.* Ed. Universitas, Petroşani, 2006.

[3]. Lazăr, M., Hojda, D. (2006). Ecological rehabilitation and modelling the final configuration for the Rovinari mining basin, in the context of the sustainable development, Revista Minelor, no. 2.

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THE EFFECTS THE ATMOSPHERIC SULFATE PARTICLES AND FINE PARTICLES – $PM_{2,5}$ HAVE ON HEALTH

CIOLEA DANIELA IONELA *
DUNCA EMILIA **
CRISTEA NICOLAE ***

Abstract: *The diameter of the particles is their most important characteristic. From the qualitative point of view, the individual particles are classified in rough and fine, depending on their diameter, if it's larger or smaller than 2.5 μm. It must be mentioned for comparison that, in order to cover the surface of a small coin, about 100 million particles with a diameter of 2.5 μm. are needed. The main evidence that connects the deterioration of human health and the particles in the atmosphere comes from the statistical studies, which correlate the death rates from different cities with their air's particles pollution level. One can see that the global mortality rates are significantly correlated to the concentration of the sulfate particles, which are carried by the air, as well as the $PM_{2,5}$ (fine particles) levels, as is illustrated in the current paper.*

Key words: *particles, sulfates, pollution, atmosphere, effects, health*

1. GENERALITIES – POLLUTANT PARTICLES

The particles are those tiny solid or liquid dusts, which are suspended in the air and which, usually, are individually invisible to the naked eye. Still, collectively, the small particles often form a mist which limits the visibility. Truly, in many summer days, the sky above cities has a white, milky color, instead of blue, due to the light's spread by the particles in the air.

The particles which are suspended in a given air weight aren't all of the same size or shape, nor have they the same chemical composition. The smallest suspended particles have a size of approximately 0.002 μm (that is 2 nm). When the small water drops from the atmosphere combine in bigger particles than this value, they correspond

* *assist Prof. PhD.Eng. – University of Petrosani*
** *lecturer PhD.Eng. - University of Petrosani*
*** *assoc.Prof. PhD.Eng. - University of Petrosani*

to the rain drops and fall from the air so quickly that they aren't considered "suspended".

There are many usual names for the atmospheric particles: "dust" and "smut" refer to solids, "mist" and "fog" refer to liquid, the latter designating a high water drops concentration.

According to Stoke's law, the velocity at which the particles fall raises with the square of their diameter. In other words, a particle which has half of other's diameter will fall four times slower. The small particles fall so slowly that they are suspended in the air almost indeterminately, if they don't stick to an item they meet.

Thus, the small particles remain usually in the air for days or even weeks, meanwhile the rough deposit pretty fast. Along with this sedimentation process, the particles can be removed from the air through their absorption in the falling rain drops.

2. ATMOSPHERIC PARTICLES' SOURCES

The rough particles begin their existence as solid substance, because, mainly, they originate from the disintegration process of larger matter "pieces". The mineral pollutants represent the rough particles' source in the air.

Many of the large particles in the atmospheric dust, especially from the rural areas, originate as soil or rock and, as a consequence, their elementary composition resembles to the one of the earth's crust, having higher concentrations of Al, Ca, Si and O, as aluminum silicates, from which some contain the calcium ion also.

Around and above oceans, the solid NaCl concentration is very high, due to the fact that the sea foam releases the sodium chloride particles in the air, when the water is evaporated. The pollen released by the plants is formed of rough particles from the $10 \div 100\ \mu m$ also. Most of the volcanic ashes particles have a rough size. The sources of bigger rough particles are natural, such as the volcanic eruptions and the human activities, for example: field's cultivation and rock's crushing in the quarry, which lead to humus and rock particles to be carried by the wind. The typical measures for the airborne atmospheric particles are found in figure 1.

The rough particles from many areas are alkalescent, due to the presence of calcium carbonate and other minerals resembling from the soils. The rough particles originate from the crushing of bigger one, when the fine ones are formed, mainly, through chemical reactions and through the coagulation of some smaller species, including the vaporous molecules. The medium organic content of the fine particles is, generally, bigger than the one of the rough particles.

For example, the incomplete combustion of the carbon originated fuels, such as coal, fuel oil, gas and diesel fuels produce many smut particles, which, mainly, are carbon crystalloids. As a consequence, one of the main sources of atmospheric particles originated from carbon, fine as well as rough, is the fossil fuel's combustion process. A big part of the emissions' organic content is formed of elementary carbon, and this can be easily observed as black smoke, emanated from these installations.

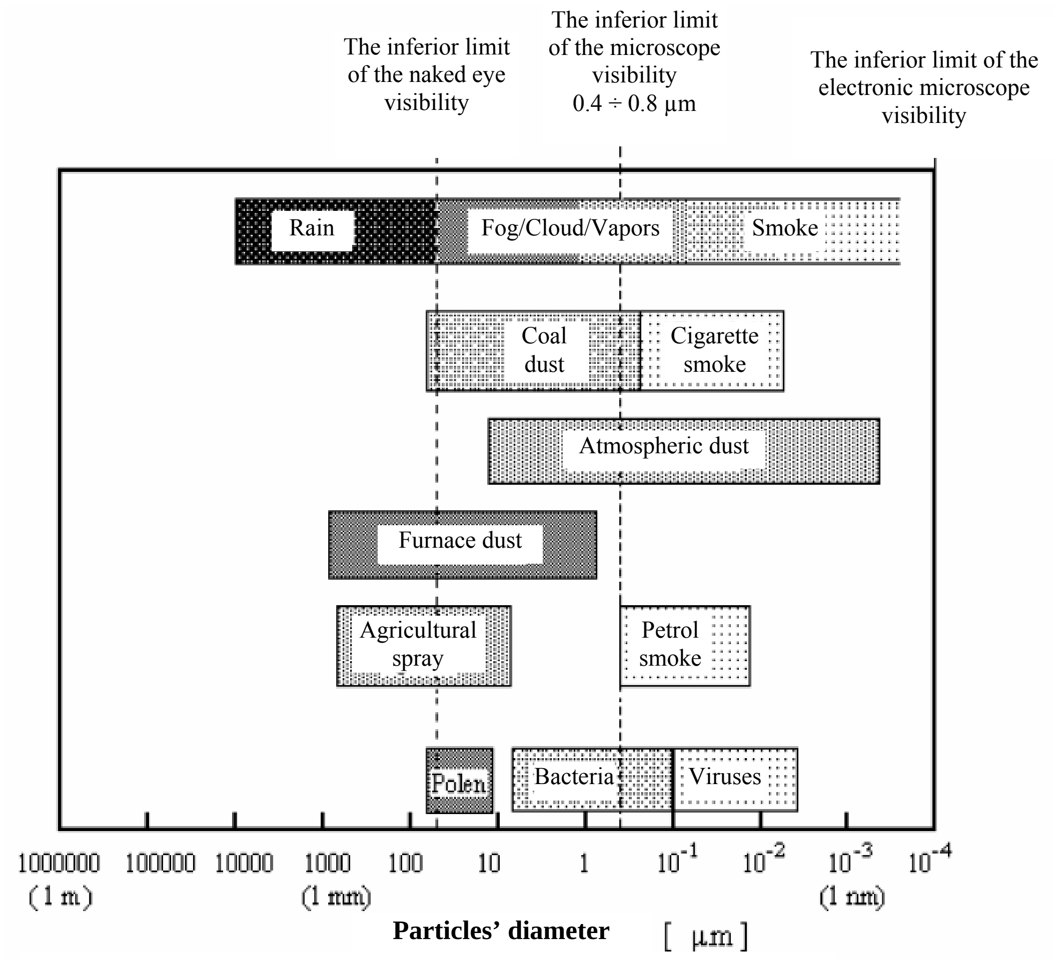

Figure.1. The typical sizes for the airborne atmospheric particles [3]

Fine particles which are suspended in the atmosphere are mainly composed of inorganic compounds of sulfur and nitrogen. The sulfur categories originate in the sulfur dioxide gas, SO_2, produced by natural sources (for example: volcanoes) as well as by industrial pollution sources (electric plants mainly and other combustion installations) and these oxidize in hours or days until sulfuric acid and air sulfates.

The sulfuric acid itself, H_2SO_4, travels in the air, not as gas, but as aerosol with fine drops, because it has a great affinity for water molecules. The fine particles from many areas are acid, due to their sulfuric acid and nitric acid content. The nitric acid is the final product of nitrogen atmospheric gases' such as NH_3, NO and NO_2 oxidation.

The nitric acid, HNO_3, with a much greater vapor pressure than the sulfuric acid, H_2SO_4, will lead to a smaller condensation of the nitric acid on the pre-existent particles than H_2SO_4. If a substantial quantity of gaseous ammoniac is found in the air, the nitric acid will react with it in order to form the ammonium nitrate salt, in the pulverous state.

The sulfuric acid, as well as the nitric one, from the air, often meets eventually the ammoniac gas, released due to the biological decomposition process, which takes place in the soil. The acids go through an acid-alkali reaction with the ammoniac and transform in the ammonium sulfate salts or ammonium nitrate, where the sulfuric acid, H_2SO_4, and the ammonium sulfate $(NH_4)_2\ SO_4$, are in the liquid stage (aqueous particles) and the ammoniac, NH_3, in the gaseous stage.

Part of the aerosols come from the evaporated water which was cooled in the cooling towers and even in lakes, ponds and rivers in which the warm water from the condenser is returned.

This phenomenon is due, mainly, to the thermal gradient between the warm fluid evacuated from the condenser and air or cooling water.

The ashes that's been evacuated on the plant's chimney or flown by the air currents from the coal dust deposit or the ashes deposit constitute an important particles pollution source for rough as well as fine particles.

Shortly, the rough particles are in nature, usually smug, when the fine ones are smug or sulfate or nitrate aerosols. The fine particles are usually acid, due to the acids' presence, when the rough ones are alkaline. A recent study conducted in Great Britain, [2], has reached the conclusion that most of the fine particles in wintertime were originating as smug from car's exhaust and the industrial pollution and in summertime they were originating from sulfur and nitrogen oxides' oxidation.

3. THE PM INDEX

In the latest years, the governmental agencies from many countries have been monitoring PM_{10}, which is the total concentration of every particle with the diameter smaller than 10 μm, which suits to every field of fine particles, plus the smaller classes from the rough particles, all being called particles that can be inhaled. A PM_{10} typical value from an urban settlement is 30 $\mu g/m^3$.

The $PM_{2.5}$, indices is used more and more nowadays. It contains every fine particle below 2.5 μm in diameter, also called breathable particles.

The new superfine term is applied to particles with extremely small diameters, usually smaller than 0.05 μm (50 nm), though various scientists use different values.

In the past, instead of the PM indices were reported the total suspended particles (TSP), representing the concentration of every substance presented as air particle.

The particles which diameter is equal to the value of the light's visible wave length, that is, 0.4÷0.8 μm, can interfere with the light's transmission in the air, reducing the visual clarity, the high distance visibility and the light quantity that reaches the soil.

For example, a high concentration of particles with diameters between 0.1 μm and 1 μm., in the air, produces the mist. Truly, a classical technique for the measurement of an air weight's pollution by the particles, constitute in the determination of its haziness. The mist is due to the sulfate aerosols, which came from the coal's combustion. [3]

The accentuated haziness during the summer is due mainly to the sulfate aerosols, which came from the industrialized areas.

The particles suspended in the atmosphere have different origin and compositions and have been formed during some time periods in random ways, so that there is a wide distribution of the particles' sizes existent in any air weight.

The substances in particles presented as smoke, from the coal's combustion, have constituted an air's pollution problems for hundreds of years.

The air's pollution parameter, which is the most powerfully correlated with the increases of the sickening or the mortality rate from the majority of these regions, is the breathable particles' concentration.

It seems that the atmospheric pollution based on dust has a greater effect on the human health than the one produced by the pollutant gases directly. [1]

4. PROBLEMS FOR THE HUMAN HEALTH

There are some general motives for which the big particles don't present as many problems for the human health as the small ones, respectively:

- considering that the rough particles lay fast, the human's exposure to these, through inhalation, is low;
- when they are inhaled, the rough particles are filtrated efficiently by our nose neck and generally they don't reach the lungs;
- the inhaled fine particles usually reach the lungs (that's why they are called "breathable") and they can be adsorbed on cells' surface, affecting health;
- the area of the unitary surface's weight, at large particles, is smaller than the one of smaller ones and so, for each gram, their capacity of transporting gas-adsorbed molecules, to any side of the respiratory system and of the catalysis of chemical and biochemical reactions, is accordingly smaller;
- the devices, as well as the electrostatic filters and sack type filters (from fine canvas through which air's passing is forced), which are used for particles' removal from the air, are efficient only for rough particles. [1]

Thus, although a device can eliminate 95% from the total weight of particle substance, the reduction of the surface and breathable particles' area is made in a much lower proportion.

The main evidence that connects the deterioration of human health and the particles in the atmosphere comes from the statistical studies, [2], which correlate the death rate from different cities with their air's particle pollution level.

In these studies, the death rates, even if we talk about the total rates or the rates on diseases, like pulmonary cancer, are given graphically depending on the medium concentration of the substances in particles, in order to establish if they are connected one to another.

It has been determined that the global mortality rates are significantly correlated to the airborne sulfate particles' concentration, as *figure 2a)* shows, as well as with the PM $_{2,5}$ (fine particles) levels, as is illustrated in *figure 2b)*. [3]

On specific mortality categories, the particles levels have correlated with the mortality caused by the pulmonary cancer and the cardio-pulmonary problems.

Based on a number of similar studies, the conclusion is that there is an increase of approximately 4% of the mortality rate, at each increase with 50 μ g/m^3 of the PM$_{10}$ index. [3]

It must be mentioned that the risk associated to smoke surpasses greatly the risk due to air's pollution in all categories.

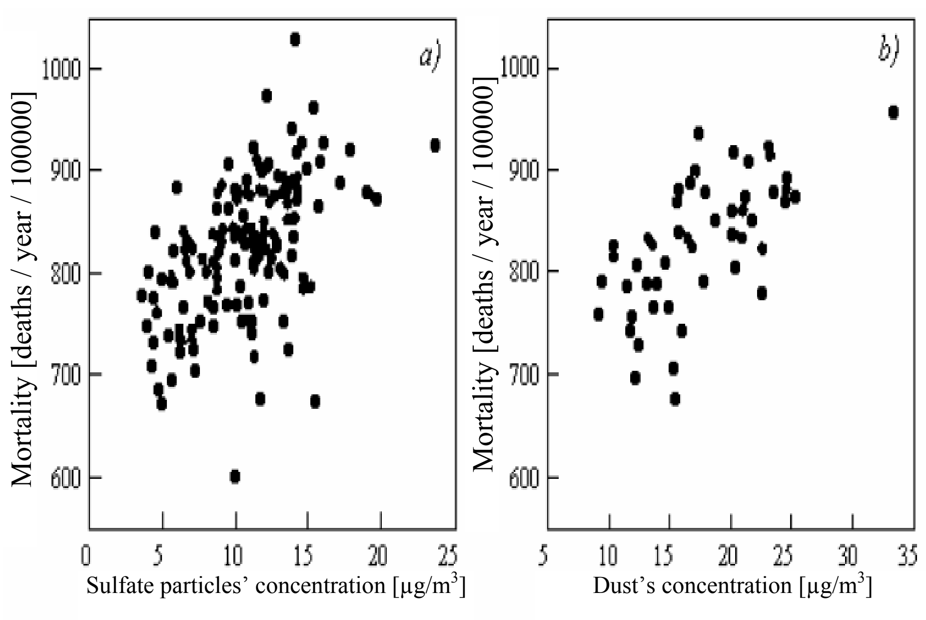

Figure 2. The mortality rate depending on the particles' concentration [3]: a) the sulfate particles' concentration; b) the fine particles' concentration (dust).

In spite of "the circumstance evidences" of the above correlations and from many other studies, it isn't certain the causal connection between air's pollution through dust and human mortality.

Still, the human's majority spends most of their time inside and, as a consequence, the exposure to particles isn't tightly connected to the exterior pollution levels. Besides, it wasn't established yet that a biological mechanism is responsible for the particles' effect on health.

The current standards for air's quality demand a maximal level in 24 hours for the PM_{10} of 50 μ g/m^3, which cannot be outran in more than four days a year. [1]

Lately, the $PM_{2,5}$ emissions have been limited also, to a medium lower than 15 μ g/m^3 per year and of 65 μ g/m^3 per day.

In the correlations that have been obtained until now, there is no limit under which the fine particles don't have an unfavorable effect on health.

CONCLUSIONS

In the days with a lot of dust and pollutant particles in the air, a higher number of old people present to the doctor with heart conditions. In the same conditions one can notice an increased number of old patients that complain of respiratory problems also.

The fine particles from the air are 100 times smaller than the width of a human hair. The smaller particles from the air, which are found in the smoke that comes from the cars or other sources, can "travel" further than the bigger particles, and, when they are inhaled, they can penetrate deeper into the lungs. If they remain in the organism, they can increase the risk of some diseases like lung cancer or heart diseases.

The bigger particles instead, have the tendency of remaining on the superior side of the respiratory machine when they are inhaled and they are easier to eliminate.

The exposure to the substances from the exhaust gases can increase the forming risk of the blood clots that are potentially lethal.

Previous studies have suggested that the exposure to the substances that are formed due to fuel combustions – impurities in air suspension – can increase the risk for cardiac maladies and stroke.

It has been discovered that these substances provoke the forming of the deep venous thrombosis also – blood clots in legs' veins.

The pollution provokes the blood's thicken and predisposes to clot's shaping. The blood clots are formed in the legs and they can reach the lungs, where they stop and can cause pulmonary embolism, potentially lethal.

At an increase of 10 μ g/m^3 of impurities in suspension in the air, the risk of developing the venous thrombosis increases with 70%. The regulations concerning the breathed air's quality stipulates that the small quantities of impurities in suspension in the air must not be higher than 50 μ g/m^3.

The final conclusion that comes off this paper is: the standards concerning the quality of the breathed air should increase and that the efforts for the decrease of the pollution's impact on human health should intensify.

BIBLIOGRAPHY

[1]. Ciolea Daniela Ionela – *The study for the reduction of the atmospheric noxes which are released through solid fuel's combustion in electro thermal plants, applied at C.E.T. Paroseni,* PhD Thesis, University of Petrosani, 2007

[2]. Danielson J.A. - *The engineering control of air pollution*, Academic Pres, New York, 1994.

[3]. Lazaroiu Gh. s.a. - *The CTE impact on the environment,* POLITEHNICA Press Publishing, 2005.

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THE SOCIO-ECONOMIC COSTS OF CLIMATE CHANGE

VASILE GRAMA*
TUDOR GOLDAN**

Abstract: *Most physical phenomena are extremely complicated to describe analytically, due to the presence of complex relations between a large numbers of factors. As a result predicting their behaviour is not generally feasible. This is true especially for climatic systems, which rank among the most complicated of them all natural systems.*

Keywords: *climate change, costs, emissions, scenarios.*

1. MODELLING OF CLIMATE CHANGE IMPACT

To deal with climate change, we need to predict how the climate will change over the future. This is essential as to educate public opinion and generate political will to make the required changes. This is where the modelling of climate change comes in. Modelling is essentially an abstraction of reality, where we decide which are the most critical parameters in a system, and explore them while neglecting the other factors. Models of climate change are then applied as tools to understand what changes must be made in the involved factors, to bring about a targeted change in the response (output) of the model. In the cases described in this paper, the response will generally be a certain concentration of greenhouse gases in the atmosphere (expressed as concentration of carbon dioxide in ppm). The steps of building up a model of climate change and its impacts are illustrated in Figure 1.

All models are subject to uncertainty, and it is important to know the bounds within which the response can vary. This is very challenging for models of climatic change impacts, as the factors involved are coupled at a number of levels. Still with each model, we must state the assumptions we have made, which implicitly involve disregarding some factors.

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* *Assoc.Prof. Ph.D.Eng. - Technical University of Chisinau, Moldova*
** *Assoc.Prof. Ph.D.Eng, - University of Petrosani*

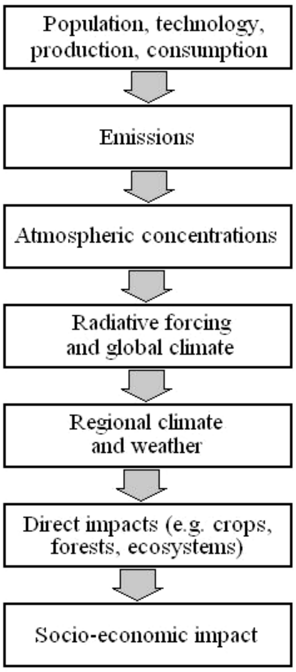

Figure 1.

We will consider models built up by the IPCC (Intergovernmental Panel on Climate Change), which is an international body, entrusted with the task of studying all facets of climate change: its sources, models, implications and possible solutions. A summarized in the tabulation given below, the IPCC models use as their basis four types of assumptions known as families. All together, using different combinations of assumptions, leads to 40 different considered assumptions.

They range from 'Business as usual' scenarios, which extrapolate economic, and population growth from current trends, to scenarios with slower and faster economic and population growth. However none of the built up scenarios assume deliberate change in national or international policy to mitigate climate change impact.

It will be the effort of this report [5] to consider these scenarios as well, and recommend policy changes which reduce emissions leading to stabilization at levels of greenhouse gas concentrations, which prevent catastrophic changes in the earth's climatic system.

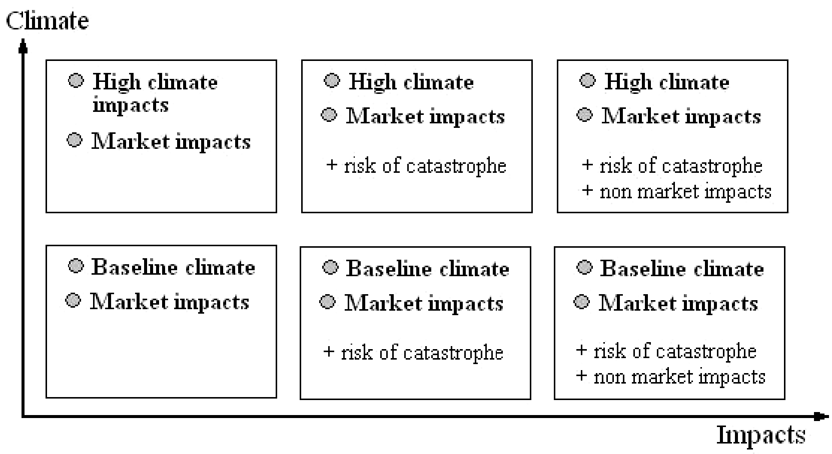

Figure 2. A 3×3 matrix of scenarios [5].

The IPCC Special Report on Emissions Scenarios (SRES) for 2000 groups "alternative futures" into four "families", A1, A2, B1 and B2. Within these families there are variations in assumptions about the underlying driving forces, especially technological change, so that, in all, there are 40 scenarios. While they are given different names the basic differentiating features are:

- *A1 has rapid economic growth and rapid technological change, with population peaking in mid-21st century and declining thereafter. There is a strong convergence of per capita incomes between rich and poor countries.*
- *A2 has slower economic growth and technological change.*
- *B1 has the same population assumptions as A1, strong convergence, and strong reductions in energy and materials intensity.*
- *B2 has rising population growth, "intermediate economic growth, and slower technological change than A1 and B1.*

The scenarios are associated with a range of temperature changes, each sub-scenario within the A1 scenarios, for example, has a range of temperature changes, and the range across the sub-scenario tends to be quite wide, specially for A1 scenarios.

None of the scenarios includes explicit policies directed at controlling climate change. Summary statistics for the scenarios are given in Table 1.

Table 1 [4].

Scenario	**Population** (billion)		**World GDP** (Trillion $ 1990)		**Convergence rich/poor** 2100 (1990=16.1)	**GDP Growth rate 1990-2100** (% p.a.)	**Cumulative Emissions** 1990-2100 (GtC)
	2050	**2100**	**2050**	**2100**			
A1	8.7	7.0-7.1	164/187	525/550	1.5-1.6	3.0	1068-2189
A2	11.3	15.1	82	243	4.2	2.2	1862
B1	8.7	7.0	136	328	1.8	2.5	983
B2	9.3	10.4	110	235	3.0	2.2	1164

The range of temperature increases corresponding to these scenarios is 2.1 to 6.1°C for A1 by 2100, 3.0 to 5.2°C for A2, 1.7 to 3.0°C for B1 and 2.1 to 3.1°C for B2.

Table 2 [3].

	Average annual growth in CO2 emissions (excluding land-use change) % p.a.		**Average annual growth in CO2 emission per capita, % p.a.**	**Average annual growth**
1960-2000	2.3		+0.2	-1.3
1970-2000	1.6		-0.1	-1.5
1980-2000	1.3		-0.3	-1.6
1990-200	1.2		-0.2	-1.4
IPCC projections 1990-2020	A1F1	2.1		
	AIB	2.4		
	A1T	1.7		
	A2	2.0		
	B1	1.7		
	B2	1.4		

Note: The final row refers to the different scenarios produced by the IPCC.

2. MITIGATION AND ADAPTATION

Using data from the IPCC report Stern review has calculated the costs (as percentage of world GDP – Gross Domestic Product) of stabilization at realistic levels of GHG's. The report was novel in trying to factor in the costs of abrupt climatic changes – it's very hard to put a number on these effects.

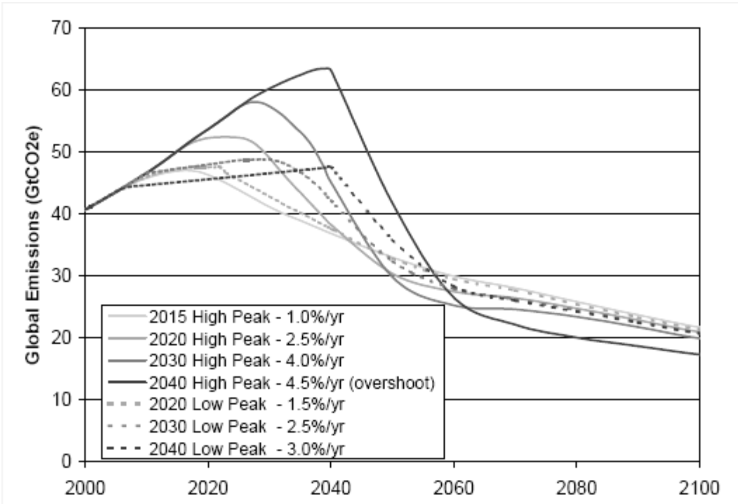

Figure 3 [5].

The conclusion of the Stern review is clear. Climate mitigation makes economic sense. The costs associated with unmitigated climate change are enormous when compared to the costs of stabilization. Stabilization of GHG's means a level where the amount emitted equals the amount the earth-atmosphere system can absorb. Due to the existence of positive feedbacks the higher and later the emissions peak, the lower level of emissions we have to settle to in order to stabilize GHG levels in the atmosphere. This is illustrated by the figure 3.

The following figures illustrate the magnitude of the challenge involved in stabilization. They give different perspectives on a critical are for stabilization efforts – the energy sector.

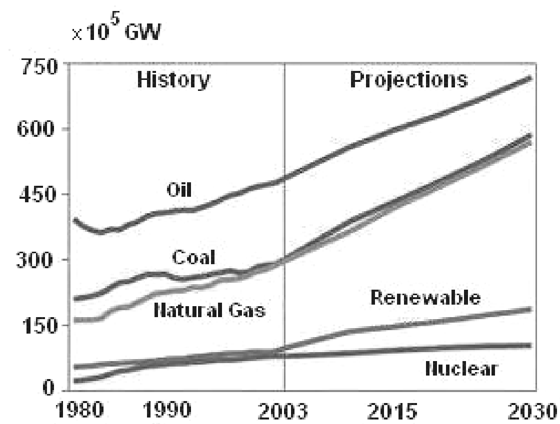

Figure 4. World marketed energy market use by energy type, 1980-2030 [1].

As can be seen in the figure below, if we extrapolate current trends (Business-as-Usual scenario), the energy consumption are projected to grow rapidly. At the same time the share of renewable energies grows at a much slower rate.

The following figure shows a break-up of energy consumption by sectors for two years. This sort of breakup is important as it identifies the areas which should be targeted.

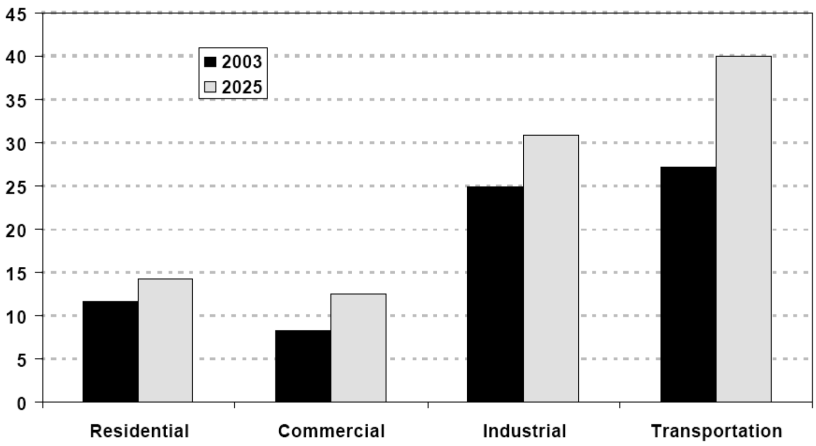

Figure 5. Energy consumption by section [2].

3. MECHANISM FOR SUPPORTING SUSTAINABLE DEVELOPMENT

The development of industrial, urban and transport infrastructure is strongly coupled to rise in global emissions of greenhouse gases. Indeed the presently observed temperature increase has been mostly caused by the emissions of the industrialized countries as they developed, since the industrial revolution. To sever this connection, efforts must be made towards sustainable development. Sustainable development means development using technologies and processes which minimize emissions and other detrimental effects on the environment. This will lead to a decoupling of economic growth from greenhouse gas emissions.

Most critical among the developing countries are nations whose economic growth has accelerated in recent years, and which have a significant share of the world population. Such nations have been exempted from mandatory emission cuts in the Kyoto protocol, but for any future climate change mitigation plan to be effective, their economies will have to target emission cuts with the application of cleaner technology. Such nations need to be drawn into a partnership with the developed countries, which should provide funding and technical expertise at an affordable cost, while the developing nations should accept progressively more stringent emission targets. Any enforced emission targets have to recognize the difference between these nations and the currently developed ones. The developing countries cannot target to reduce their greenhouse gas emissions at the moment, as their per capita income and emissions are still a fraction of those of the industrialized countries and will increase for the foreseeable future.

The emission reduction targets of developed countries have to take into account this fact. For plans of stabilization at a certain level of carbon dioxide concentration (550 ppm) in the atmosphere to work, the developed countries will need to reduce emissions to compensate for emission increase from the developing nations.

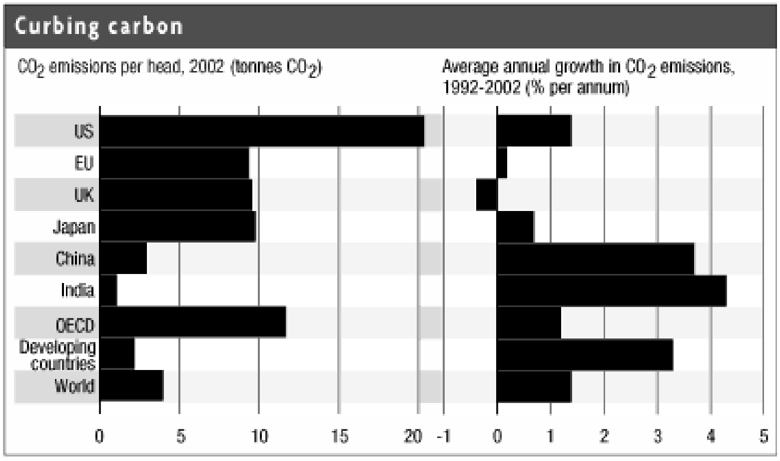

Figure 6.

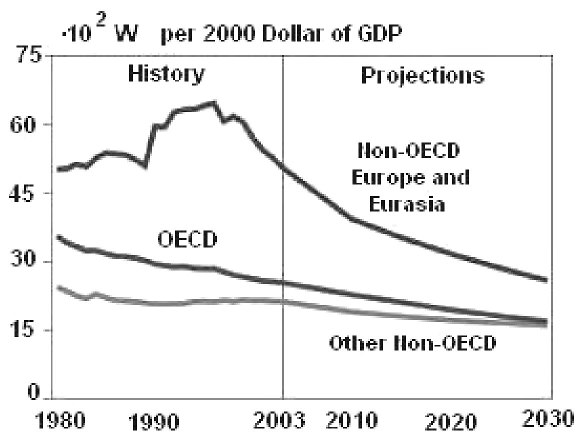

Figure 7. World marketed energy consumption by region

So in a way, aiding and supporting sustainable development in the major developing economies will only lessen the burden on the industrialized economies to cut emissions. Another factor to consider is the global nature of economies today. Stringent emission standards for industry in one part of the world, will not be effective as the industrial production in question will just be shifted to regions of the world were the standards are more relaxed.

In particular two key issues have to be resolved for any international mechanism towards climate change mitigation to be effective:

- How can short-term targets and policies of different countries be coordinated so that long term global targets of stabilization at a certain GGH level are met? The short term targets are by nature flexible –

governments change, corporate policies depend largely upon short term performance targets.

- How can fairness be ensured in an international mechanism? No nation would accept targets which put its industry and economy at a disadvantage.

The first issue is relevant because only national governments in general have the right to enforce binding targets on their industry. Coordination of such targets is essential so that on the global scale we move on a stabilization trajectory. So it is necessary in the post Kyoto scenario for all 'relevant' actors to agree on a stabilization level of GHG. The Stern review for example suggests a target of 450-550 carbon dioxide equivalents (ppm). In addition it would be highly desirable to agree on a trajectory to achieve this goal, starting from the current emission levels.

The next step would be to break up this global target a trajectory to national ones – here lies the tricky part encompassing both the issues above. How to calculate emission targets for different countries over a 50 year timeframe? The two key factors here have to be the GDP per capita and GHG emissions per capita. There are some constraints on these quantities – the developed countries cannot accept targets which lead to a reduction of their GDP per capita while the rapidly developing nations will not accept targets which lead to capping of their GDP's. Historically these two quantities have been tightly coupled, but uncoupling them is the key to climate change mitigation. This can be brought about by investing in massive induction of renewable technologies in industry, and specifically the use of renewable energies for power production. Indeed this decoupling is already in evidence in the economies of some developed countries. Industries in these countries have the financing to invest in green technologies. The challenge lies in making their application wide-spread among developing countries.

The cooperative development mechanism (part of the Kyoto protocol) already provides incentives for companies based in developed countries to participate with investment in developing countries. A company can have emission reductions from an infrastructure investment counted towards it carbon credits for trading.

A similar mechanism could be implemented more aggressively to aid the rapidly developing economies. A number of infrastructure projects are in the pipeline in these countries, leading to massive opportunities for multinational firms. Developing countries should accept an obligation to choose cleaner technologies. The problem here is the higher costs associated with these technologies. A step towards solving this would be to assign a percentage of bilateral and developmental assistance to make up for this difference.

This difference between costs of technologies will reduce with time, given investment in research and development. And this solution may turn out to be a win-win situation (or as close as we can get to it anyway!). It works like this – developing countries are obliged (by treaty) to choose renewable technologies over conventional ones. This can be factored into a tendering process by the tenders for an industrial plant not only quoting a certain price for the project, but also an estimated emission level. Then the choice would be based not only on the lowest price offer, but also on a 'reasonably' low emission level. The difference could be adjusted as mentioned above.

So the developing country gains by getting cleaner infrastructure at about the same cost as that of conventional infrastructure. But the developed countries gain as well! Due to their current levels of R&D, companies from the industrialized countries are the best placed to offer clean efficient technologies at reasonable price levels. So they will most probably win the tender.

CONCLUSIONS

Efforts to reduce the relationship between development and emissions are already underway in many developing countries, driven not by binding emission reduction targets, but due to economic development, poverty reduction and concern for the local environment. The mechanism proposed above will encourage this move not by more regulation but by using market forces to aid in the development of efficient technologies and in making them cost effective.

The special provision for the rapidly developing economies can be revised as these countries reach the position (measured by GDP per capita for example) when they can pay the difference without hampering their development rate. However this will not take long. Industrial ingenuity will ensure that the cost of efficient technologies falls at least to that of the conventional ones for most sectors of industry. More and more developing economies can be brought into the fold of this mechanism as there growth rates (of GDP and emissions) exceed a certain level. And then companies both from the developed countries and India, China and Brazil can compete for projects there. This will be a sort of trickledown effect.

REFERENCES

[1]. Energy Information Administration (EIA), *International Energy Annual 2002.* Washington DC, 2002.

[2]. EIA, *International Energy Outlook 2004.* Washington DC, 2004.

[3]. IPCC, *Climate Change 2001: Impacts, Adaptation and Vulnerability*. Intergovernmental Panel on Climate Change, 2001.

[4]. Nakicenovik, N. et al., *Emissions Scenarios.* Cambridge University Press, 2000.

Stern Review Report on the Economics of Climate Change. HM Treasury (UK), 2006.

[5]. Weyant, J.P., *An introduction to the Economics of Climate Change Policy.* Centre of Climate Change, 2000.

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THE APPROACHES OF RISK IN CLIMATE CHANGE

TUDOR GOLDAN[*]
CIPRIAN DANCIU[**]

Abstract: *The concepts of current, future, actual and potential risk are elaborated as a basis for the quantification of vulnerability and adaptive capacity where this is desirable, for example in integrated assessment models. Finally the relationship between adaptive capacity and actual adaptation is addressed, and concerns about the potential misuse of the concept of adaptive capacity are presented. The concept of adaptation likelihood is tentatively suggested as a means of countering any attempt to use "capacity building" as a political lever to divert attention away from the large-scale structural factors that often cause or exacerbate the vulnerability of groups who have no control over such factors.*

Keywords: *approaches, climate change, risk, impacts.*

1. INTRODUCTION

Climate change is not a new topic in biology. The study of biological impacts of climate change has a rich history in the scientific literature, since long before there were political ramifications. Grinnell [2] first elucidated the role of climatic thresholds in constraining the geographic boundaries of many species, followed by major works by Andrewartha & Birch [1] and MacArthur [3]. Observations of range shifts in parallel with climate change have been particularly rich in northern European countries, where observational records for many species.

The history of biological research is rich in both mechanistic and observational studies of the impacts of extreme weather and climate change on wild species: Research encompasses impacts of single extreme weather events; experimental studies of physiological tolerances; snapshot correlations between climatic variables and species' distributions; and correlations through time between climatic trends and changes in distributions, phenologies, genetics, and behaviors of wild plants and animals.

[*] *Assoc. Professor, Ph.D. Eng. - University of Petroşani*
[**] *Assis. Prof. student Ph.D. Eng, - University of Petrosani*

The study of the vulnerability of human and natural systems to climate change and variability, and of their ability to adapt to changes in climate hazards, is a relatively new field of research that brings together experts from a wide range of fields, including climate science, development studies, disaster management, health, social science, policy development and economics, to name but a few areas. Researchers from these fields bring their own conceptual models to the study of vulnerability and adaptation, models which often address similar problems and processes using different language. Somehow researchers from all these different backgrounds must develop a common language so that vulnerability and adaptation research can move forward in a way that integrates these different traditions in a coherent yet flexible fashion, allowing researchers to assess vulnerability and the potential for adaptation in a wide variety of different contexts, and in a manner that is transparent to their colleagues.

2. GLOBAL WARMING AND SMARTER POLICIES

I would argue that our best information comes from the UN Climate Panel, the so-called IPCC (the Intergovernmental Panel on Climate Change). In Figure 1, we have a simple, standard prediction for the coming hundred years from the medium scenario of the 2007 IPCC report. Here we are told that that over the century global mean temperatures will increase about 2.6°C with a span of 1.8-4.0ºC (and a span of this from 1.1-6.4°C) [4].

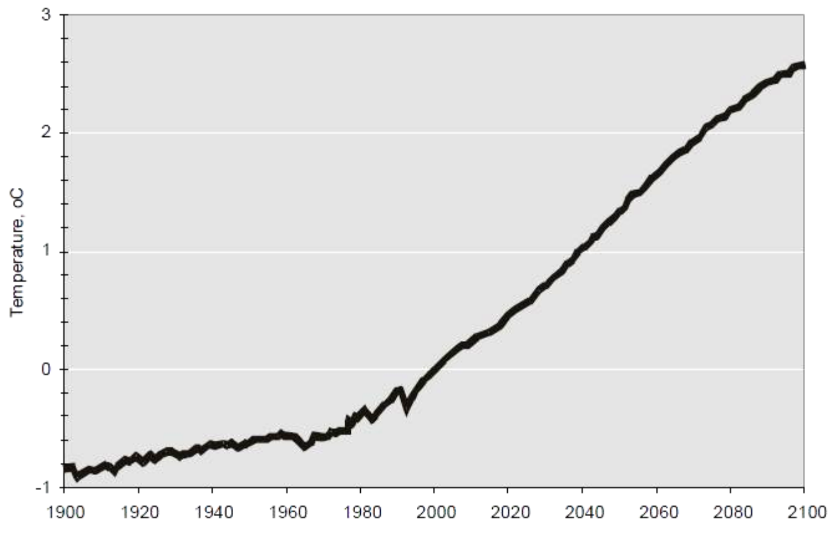

Figure 1. Expected temperature increase from 2000-2100
in the business-as-usual scenario.

The total cost of global warming is anything but trivial, about \$15 trillion [5]. Yet it is only about 0.5% of the total net worth of the 21st century, about \$3,000 trillion [6].

The current raft of policies that are either enacted or suggested are costly but have virtually no effect.

Take the Kyoto Protocol, which even if it had been successfully adopted by all signatories (including the US and Australia) and even if it had been adhered to throughout the century, would have postponed warming by just 5 years in 2100 at a cost of \$180 billion annually, see Figure 2 [7].

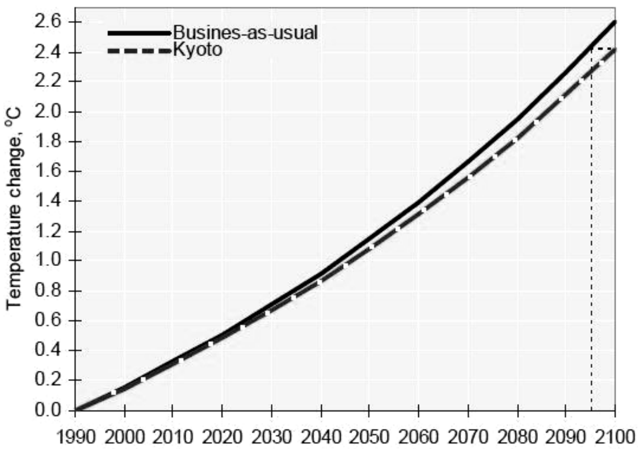

Figure 2. The expected increase in temperature with business-as-usual and with the Kyoto restrictions extended forever.

In the first real commitment since Kyoto in 1997, the EU announced in March 2007 that they would unilaterally cut emissions to 20% below 1990-levels by 2020. This would mean a 25% cut of emissions from what they would otherwise have been in 2020 [8]. Yet the effect on temperature would be smaller than Kyoto, as shown in

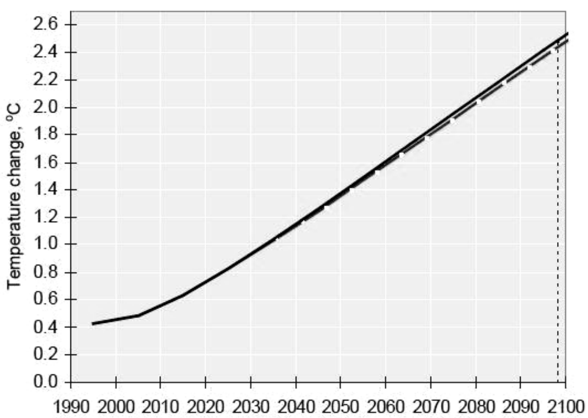

Figure 3. The expected increase in temperature with business-as-usual and with EU minus-20% restrictions extended forever.

Figure 3, postponing warming by the end of the century by about two years. The cost would be about $90 billion per year in 2020 [5]. Thus, we see the same pattern from both the well-established Kyoto protocol and the new EU minus-20% decision – that they have fairly small impact at fairly high cost.

Even if global warming exacerbates some or more of these problems, it is important to point out that the total magnitude of the problems is likely to far exceed the contribution from climate change. Thus, polices to reduce the total problems will have much more leverage than policies that only try to address the global warming part of the issues [9]. Again, we have to ask if there are better ways to help than by cutting CO_2.

3. APPROACHES OF RISK

Definitions of vulnerability in the climate change related literature tend to fall into two categories, viewing vulnerability either (i) in terms of the amount of (potential) damage caused to a system by a particular climate-related event or hazard [10], or (ii) as a state that exists within a system before it encounters a hazard event [11]. The former view has arisen from an approach based on assessments of hazards and their impacts, in which the role of human systems in mediating the outcomes of hazard events is downplayed or neglected. Climate change impacts studies have typically examined factors such as increases in the number of people at risk of flooding based on projections of sea level rise, and have thus focused on human *exposure* to hazard rather than on the ability of people to cope with hazards once they occur. The hazards and impacts approach typically views the vulnerability of a human system as determined by the nature of the physical hazard(s) to which it is exposed, the likelihood or frequency of occurrence of the hazard(s), the extent of human exposure to hazard, and the system's *sensitivity* to the impacts of the hazard(s).

Biophysical vulnerability, as implicitly described in IPCC Def. 1, has much in common with the concept of risk as elaborated in the natural hazards literature. Where vulnerability is included in the definition of risk, it is viewed as distinct from hazard: it is therefore social vulnerability that is being referred to. Risk defined as a function of hazard and social vulnerability is compatible with risk defined as probability x consequence, and also with risk defined in terms of outcome. The probability of an outcome will depend on the probability of occurrence of a hazard and on the social vulnerability of the exposed system, which will determine the consequence of the hazard.

The ambiguity as to whether it is the probability of occurrence of a hazard, or the probability of a particular outcome that is being referred to is addressed by Sarewitz et al. [12]. They define *event risk* as the "risk of occurrence of any particular hazard or extreme event" and *outcome risk* as "the risk of a particular outcome". They state that outcome risk "integrates both the characteristics of a system and the chance of the occurrence of an event that jointly results in losses." Sarewitz et al. [12] are referring to social or inherent vulnerability when they "use the word 'vulnerability' to describe inherent characteristics of a system that create the potential for harm but are independent of the probabilistic *risk of occurrence* ("event risk") of any particular hazard or extreme event."

The principal difference between the natural hazards risk-based approach and the IPCC biophysical vulnerability approach is that risk is generally described in terms of probability, whereas the IPCC and the climate change community in general tend to describe (biophysical) vulnerability simply as a function of certain variables. Nonetheless, the determinants of both biophysical vulnerability and risk are essentially the same - hazard and social vulnerability.

The natural hazards community, which emphasizes risk, and the climate change community, which emphasizes vulnerability, are essentially examining the same processes. However, this has not always been immediately apparent, due to differences in terminology. Both are ultimately interested in the physical hazards that threaten human systems, and in the outcomes of such hazards as mediated by the properties of those systems, described variously in terms of vulnerability, sensitivity, resilience, coping ability and so on. The separation of vulnerability into social and biophysical vulnerability enables us to appreciate the compatibility of the risk-based and vulnerability-based approaches.

CONCLUSIONS

By distinguishing between social and biophysical vulnerability we can resolve the apparent conflict between different formulations of vulnerability in the climate change literature. By acknowledging the broad equivalence between biophysical vulnerability and the natural hazards concept of risk, we can place the study of social vulnerability within a risk management framework. Within this framework, the risk posed to a human system by a particular type of hazard will be a function of the severity and probability of occurrence of the hazard and the way in which its consequences are likely to be mediated by the social vulnerability of the human system in question. Risk may be quantified in terms of outcome, for example in terms human mortality and morbidity and/or economic losses. This may be *post hoc* for a particular event or set of events, or in terms of likely or anticipated outcome. Alternatively, risk may be assessed probabilistically as the likelihood of a particular outcome. Social vulnerability, on the other hand, is more likely to be measured in terms of predictive variables representing factors such as economic well being, health and education status, preparedness and coping ability with respect to particular hazards and so on..

REFERENCES

[1]. Andrewartha, H.G., Birch, L.C., *The distribution and abundance of animals.* Chicago, IL: Univ. Chicago Press., 1954.
[2]. Grinnell, J., *Field tests of theories concerning distributionalcontrol.* Am. Nat., 51, 1917.
[3]. MacArthur, R.M., *Geographical Ecology.* New York: Harper&Row, 1972.
[4]. IPCC, *Climate Change 2007: WGI: Summary for Policymakers*. Retrieved 13-2-07, from http://www.ipcc.ch/SPM2feb07.pdf.

[5]. Nordhaus, W.D., RICE model Retrieved 27-11-06, from http://www.econ.yale.edu/~nordhaus/homepage/dice_section_vi.html.
[6]. Nakicenovic, N., IPCC WG III, *Special report on emissions scenarios : a special report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge ; New York: Cambridge University Press, 2000.
[7]. Weyant, J. P., Hill, J. N., *Introduction and overview. The Costs of the Kyoto Protocol: A Multi-Model Evaluation.* Energy Journal, Kyoto Special Issue, vii–xliv, 1999.
[8]. IEA, *World Energy Outlook 2006.* IEA Publications, 2006.
[9]. Goklany, I. M., *The improving state of the world : why we're living longer, healthier, more comfortable lives on a cleaner planet*. Washington, D.C.: Cato Institute: Distributed to the trade by National Book Network, 2006.
[10]. Jones, R., Boer, R., *Assessing current climate risks Adaptation Policy Framework: A Guide for Policies to Facilitate Adaptation to Climate Change.* UNDP, 2003.
[11]. Allen, K., *Vulnerability reduction and the community-based approach, in Pelling* (ed.), Natural Disasters and Development in a Globalising World, 2003.
[12]. Sarewitz, D., Pielke, R. and Keykhah, M., *Vulnerability and risk: some thoughts from a political and policy perspective, submitted to Risk Analysis.* 2003.

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SUSTAINABLE DEVELOPMENT IN JIU VALLEY

RAREŞ MUNTEANU*

Abstract: *The sustainable developmentie although not a new idea, is more and more actual. The development of any area must be based on the principles of the sustainability in order to be successful.*

Key words: *rehabilitation, development, landsca*pe

1. INTRODUCTION

The rehabilitation of the Jiu Valley area is meant to ensure the development in a sustainable manner for a valuable living and landscape area with multiple options for use.

Redevelopment efforts should be geared towards eliminating hazard potentials to permanently ensure public safety, to develop a post-mining landscape with multiple options for use and an acceptable design which requires no secondary treatment. The rehabilitation area should be developed into a self-sufficient landscape of trans-regional significance for tourism. Simultaneously, issues of flood protection, leisure and recreation, nature, landscape and additional forest area should be resolved in a compatible manner and based on a clear-cut functional division between areas intensively used and areas sensitive to noise. Rehabilitation measures relating to water should focus on the re-creation of a stable and mostly self-regulating regional water balance.

* *lecturer PhD Eng. - University of Petroşani*

2. REQUIREMENTS FOR THE DEVELOPMENT OF THE JIU VALLEY AREA

The facilities for sports, leisure and recreation must be maintained, extended and developed to upgrade this recreational area of trans-regional significance.

Through the formation of a tourist water *association,* water-bound options for recreation at the Campu lui Neag lake can be combined synergetically with the mountain tourism in the western part of the Jiu Valley.

Prerequisites are to be created for a large coherent, richly structured forest area, to systematically increase the percentage of forest and provide protection for the current forest area.
An effective protection of landscape, nature and species shall be guaranteed in the mountain zones (Parang and Retezat), including their spatial and functional integration into landscape elements in the rehabilitation area and in the remaining unexploited environment.

Traffic access and internal development of the rehabilitation area shall be improved essentially and in a target-oriented manner by providing large-area traffic connections, demand-driven traffic development of recreational areas, re-building of devastated or interrupted historical traffic routes and the creation of a multi-use biking and hiking trail network including its integration into the trans-regional and regional traffic and trails network.

Moreover, the general rehabilitation plan must contain stipulations and goals on the following items:

- the geographic position (including boundaries) of the rehabilitation area,
- soil protection and material disposition,
- slope remediation and landscaping,
- areas of potential contamination, contaminated sites and waste dumps,
- regional water balance,
- preventive flood protection,
- noise and dust protection,
- fishing,
- recreation,
- agriculture,
- increase in forest area and forest protection,
- nature and landscape and
- traffic infrastructure and local public transport.

The plan must describe the goals and provides reasons for goal setting while detailed rehabilitation measures and methods are to be laid down in the final operating plans of the Jiu Valley mining area. In addition, the general rehabilitation plan must contain so-called priority areas[6] which cannot be changed by the rehabilitation company or the relevant addressee. A good general rehabilitation plan comprises priority areas for:

- increased forest area
- forest protection
- nature and landscape (succession areas)
- nature and landscape (forest areas)
- nature and landscape (water areas)
- recreation.

In contrast to priority areas whose use has been ultimately defined, the plan also comprises so-called reserve areas, where a particular type of use should be given special weight compared to other options. The reserved areas in the general rehabilitation plan comprise areas for:

- increased forest area
- agriculture
- nature and landscape
- nature and landscape (lakes)
- recreation

After the general rehabilitation plan of the Jiu Valley area becomes legally effective, the in the final operating plan the environmental needs must be harmonized with the economic needs of the society. The harmonization of all these requirements must be done using a regional development concept.

A development concept for the Jiu Valley can be expressed as follows:" The Jiu Valley is to be taken into consideration as a single administrative unit, the social, economic and environmental rehabilitation process will be unitary implemented and under these circumstances the tradition and the novelty, with new ideas, interpenetrate for a sustainable development".

3. CONCLUSIONS

Although the mining industry in the Jiu Valley, Romania, is on the wane and, as a result, the economic situation is very difficult, there are enough possibilities for the local community to continue the development "at home". New activities must be developed. The core issues are the ecologization and making clear the legal status of the land, in order to attract new investments. The position of Jiu Valley at the crossing of important national routes is an advantage that must be carefully put in use in order to ensure the sustainability of the region.

4. REFERENCES

[1]. * * *, *Regional Planning Association: Brown Coal Plan as a General Rehabilitation Plan – updated version of 8 June 2006*

[2]. Munteanu, R. – *Analiza posibilităților de dezvoltare a unor activități economice alternative în condițiile restructurării mineritului din Valea Jiului*, PhD Thesis, 2007

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ASPECTS REGARDING THE ENVIRONMENT POLLUTION SOURCES IN ROŞIA MONTANA

SIMONA TODERAŞ*

Abstract: *Mining activity carried out in the operation area of Rosia Montana, has an impact on water quality in two river basins Corna valley and Rosia valley, the soil and air. This impact could be considered positive if it had been taken to improve water quality by eliminating sources of pollution and purifying water, reducing air pollutants generated by mining and by observing a continuous process of reconstruction, redevelopment and remediation areas for storage of sterile rocks. Negative impact has been generated by use of chemical substances or processes related to the exploitation and processing plant preparation. In this paper, I present the sources of environmental pollution due to work done by former RoşiaMin operation.*

Key words: *pollution, impact, reconstruction, redevelopment, remediation area, underground mining works, mine water, heavy metal, residual cyanide, tailings.*

1. WATER POLLUTION SOURCES

Downloads of pollutants in water are associated with several aspects of mining and ore processing, as shown in Table 1. These discharges could be managed by collection and recirculation or purification.

Leakage area of old mining works at Rosia Montana, including the current mine galleries and mine waters from existing career, characterized by a low pH and a concentration above the permissible limits of heavy metals (copper, iron, nickel and zinc) and the ion sulphate. These categories of pollutants of surface water and groundwater are still in the construction and operation of the mine ore (acidic water from old mining works and assets, household waste water from construction site located in the mining, chemicals from the preparation plant, effluent processing type residual cyanide found in processing of the steriles), but now in the closing phase of the operation RoşiaMin (acidic water from old works, cyanide waste, soil erosion at the site of mining, the latter being a type of pollutant that has shown the negative environmental impact from the exploration phase and the ore continues even in the closing stage of the mine).

* *Eng .Ec. at RMGC Rosia Montana ONG ProRosia*

Table 1- Descharge sources in water:

Type of activity	Specific activities / Development place	Impact upon water
Mining activities	Shooting - excavation	Downloads of water from rainfall in operational areas; downloads acidic water retained in the old mining works, download the drainage mining systems and drainage
	Material transport	Leakage surface sedimentary material in suspension or salts on the transport of mining; infiltrations into groundwater aquifers
	Stack ore	Water leak acid; infiltrations into groundwater aquifers
	Vegetal soil stack	Leakage of water containing suspended solids
Ore's processing	Crushers and grinding	Downloads technological fluids
	Gold recovery	Downloads accidental reactive in the environment
	Transport and storage of reagents	Downloads accidental reactive in the environment
Evacuation through the system of the dam	Pipelines transport Sterile Processing	Accidental downloads or breaks of pipes
	Embankment area	Downloads abnormal / accidental of fluid in the environment; infiltrations into groundwater aquifers
Transport and storage for the sterile rocks		Leakage exfiltrations at the surface of the rocks in the waste damp during wet periods, leakage of surface transport on roads mining
Mining construction, factory and administrative		Breaking pipe sewage waste, possible leakage of chemicals / fuel and oils
People transport		Leakage of fuel and oils
Water alimentation		Leaks in pipelines carrying water from the river, which may contribute to the formation of leaky surface which lead to material in suspension.

Current water discharges include exhilarations of acid from the waste damps current and downloads of 714 gallery and other galleries minor. Average flow rate of the flow in this gallery has been estimated at approximately 10-18 l / s. Leakage flow of small galleries is much lower. It is estimated that an additional volume of acidic water could be generated from the following sources: stack of lean ore; the waste damp, walls careers; sterile processing. Many of the current sources of acid water, including rocks and the existing sterile and most areas of underground mining works, contain ore residue. One of the risks to be considered, is the magnitude of the phenomenon of generating acid water from areas with old mining works and the damps associated to sterile, which may exceed the capacity for activities of mining and excavation of water. Typically, mine water comes from groundwater waters encountered during operation in quarries and pluvial waters infiltrate layers of barren and ore. Draining water from Cetate career is influenced by the following factors: career abode is located under listing land environment, promoting the collection of rain water, there is an extensive network of underground mining works, expanding horizons until the large horizontal and multiple vertical links between them, providing water to drain horizon main transport rate 714 m. It was found, after tests performed that surface waters are heavily contaminated and polluted by heavy metals, which in some places exceed legal limits by more than 70 times, which can be observed from the graph shown in Figure 1.

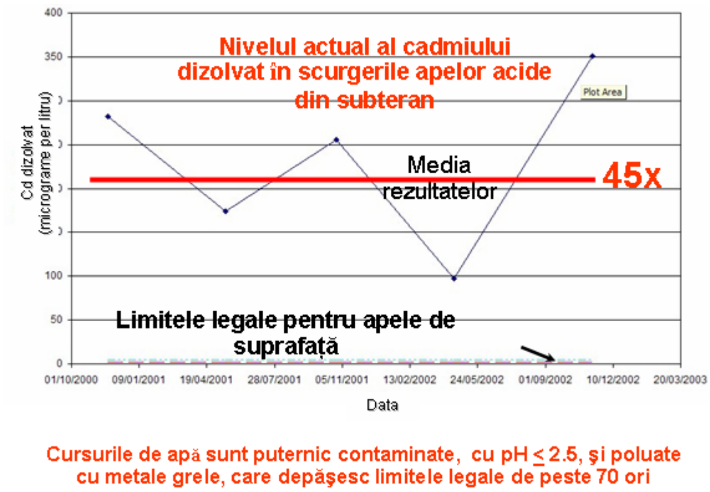

Figure 1- The level of pollution with cadmium in water.

In Figure 1, blue points, together with a blue line represents the level of cadmium dissolved in water and dotted lines at the bottom of the graph represents the legal limits for the discharge of cadmium in surface waters, meaning 5mg/l, observed that the media is 45 times higher than the legal limit. It appears that at present, brooks of Rosia Montana are dying from the biological point of view. On vertical, water circulates uncontrolled through the mining works. Mine waters are discharged in the galleries Rakoşi (quota 820 m) and St. Cross (horizon 714), Iuliana (873 m), Coast (843 m), Aurora (797 m), Măneşti (797 m) Verkeş (853 m). Water discharged by this gallery goes to Rosia Valley.at about 200 m from the point of taking water from the mine. Basically, it can be affirmed that the water discharged in this gallery are discharging into the brook Red Valley, and the water flow is maximum a few tens of m3/day. On the horizon 714, the water is routed through channels inside Gura Minei, where sewage is managed by the Red brook valley, the water flow at the exit from the Gura Minei can reach up to 29 l/s, depending on the season and the amount of precipitation that fell. Waters of the mine galleries Iuliana, Aurora Coast are joined together in the enclosure Sector I, forming a tributary of the stream valley Red maximum flow is the order of tens m3/day. Waters from the work covered by the old mining damp Hop and discharge holes are in Green Valley, a tributary of the right

Corna Valley and waters from Măneşti gallery with a debit order tens of m^3/s are delivered to Valley Nanului. Waters from the gallery Verkeş with debit order tens of m3 /s discharge in the right tributary stream of Red Valley, which runs at the damp Verkeş. Characteristics of samples of mine water were compared with the limit values imposed by The Water Management nr.2/1999, and the limit values imposed by NTPA 001/2002 – Normative, establishing limits on the pollutant load of industrial wastewater and municipal discharges into the natural receptors, taking into account that all the mine waters are or have been discharged into emissary. Comparing these results with the limits imposed under the Order nr.1146/2002 for the norm of the reference for the classification of surface water is presented in Table 2.

Table 2- The comparison of the results of measurements with the limits imposed by norms:

Analyzed indicator	UM	The clean water evacuated from Saliste Valley	Limits according to AGA nr.2/1999	Limits according to NTPA 001/2002
pH		3,30	6,5 – 8,5	6,5 – 8,5
Fixed residue	mg/l	606,8	-	-
Materials in suspension	mg/l	67,7	80,0	35
Clorures	mg/l	10,6	-	500
Calcium	mg/l	68	-	300
Magnezium	mg/l	14,5	-	100
Copper	mg/l	0,03	0,1	0,1
Lead	mg/l	0,04	-	0,2
Zinc	mg/l	0,51	0,5	0,5
Cadmium	mg/l	0,03	-	0,2
Nickel	mg/l	0,09	-	0,5
Mercury	mg/l	SLD	-	0,05
Chromium	mg/l	marks	-	0,1
Manganese	mg/l	18,5	0,1	1,0
Iron	mg/l	6,8	5,0	5,0
Sufates	mg/l	347,3	-	600
CCO-Mn	mg/l	6,42	-	40
Amonium	mg/l	1,81	-	2
Azotates	mg/l	1,26	-	OCT 01
Azotites	mg/l	SLD	-	1,0
Sulfures	mg/l	SLD	-	1,0

From the data presented it is shown the following conclusion: the values of the determined pH were strongly acid in both upstream and downstream of the mine discharge water from the main gallery horizon Gura Minei, is a growth of values determined by the most indicators analyzed in the upstream and downstream, significant increases are recorded for fixed residue indicators, Zn, Mg, Mn, Fe, sulphates, CCOMn; indicators pH values, fixed and residual metals Cu, Pb, Zn, Cd, Mn, Fe under Order nr.1146/2002 fall brook Valley Red both upstream and downstream of the mine discharge water from the main gallery horizon Gura Minei in your class quality downstream brook change their class as for the sulphate from class I to class V and Ni from the class IV of the class will quality. Therefore, water discharged by the mine galleries coast not covered, in general, limits and present danger of excessive pollution, calling for treatment to be included in the SGA - Alba.

In addition to the mine water there are waters discharged from technological clarification decantation ponds. Cloudiness sterile from the ore processing plant in the Gura Rosiei preparation was evacuated to decantation pond Săliştea Valley, which is also the only pond in operation, others are in conservation. Under Authorization Water Management nr.2/1999, maximum flow of water discharged from the clarification pond was 9642 m3/zi. Through the leadership of the process of filing dams in pond water clarification was pushed to the "pound's tail'', where it was captured by the samples and reverse evacuated through a metal conduit underground gallery connected to the exhaust water from rainfall. As it is known practically water clarification is basically polluted water from the pond cloudiness transported, but has a variable water content of rain fell directly on the surface of the pound or drained from the adjacent hills. Referring to the exhaust system of water clarification, there should be: the existence of a single inverse active samples to which access is extremely difficult, even in favourable weather periods, the sample is not protected against possible blockages with floating; underground metal pipe through which download the probe is in an acid environment for a long period of time and is very likely that it will be in an advanced state of degradation, its removal from service being impossible. These details show the vulnerability of the current system of water from the clarification pond decantation and therefore any removal operation of this system could endanger the safety of the pound, especially in adverse weather conditions, coincidence with abundant rainfall. Since 2000 and until 2003, corresponding to the perimeter of the mining operation RoşiaMin was investigated the quality of surface water, which are presented the analytical results and their comparison to values imposed by the Order nr.1146/2002:

1- Red Valley brook upstream and downstream of the operation: the classification of the stream upstream in classes I to IV, based on indicators produced, increasing the downstream for most indicators to analyze the upstream, leading to modification of the classes downstream, the class IV and V. Thus, it finds the pollution brought by the mine water discharged through the main gallery horyzon and drip water from the quarries and waste damps, it should be noted the low pH and high contents of Cu, Zn, Cd, Fe and Mn;

2- valley brook Saliste - evacuation of tailing dam: the indicators ASD, CdD, FET, NiD and ZnD shows employment in the category of water quality will, according to Order nr.1146/2002;

3- Abrud stream - upstream of the lake and valley Sălăştea downstream of the lake Gura Rosiei and confluence with the Red Valley:

a) growth indicators AST, CdT, FET, EDF, and NiD NIT, PBT, ZnT, ZnD, CRT and downstream property of ponds sample in Gura Rosiei and Salistei Valley harvested upstream;

b) change the class quality Abrud brook downstream from upstream, as in category II to category III for the ZnT; of category III to category IV indicators for AST and CdT; the third category of the category indicators will ZnD and NiD. It is noted the contribution made by water pollution from pond clarification decantation Săliştea Valley and possibly influence Gura Rosiei tailing dam;
c) analysis of the indicators determined in the sample taken from the brook downstream of the discharge Abrud brook Gura Rosiei, reveals an increase from their determined values (eg, AST, ASD, CUT, FET, NIT, ZnD, CRT and MNT), which induces a degradation of quality passages from the IV category to the V category for AST, the category III of the class to V category and ZnT from category II to category III for Mn.

In conclusion, after the analysis of all available data until now, it appears that activity within the perimeter of Rosia Montana mining has affected the quality of surface water by discharge of mine water and water discharged from the clarification of the tailing dam Saliste Valley.

2. AIR POLLUTION SOURCES

Pollutants that were emitted into the atmosphere, include particulate matter from different areas of activity and those generated by wind erosion of sterile (such as rocks stored in waste damp sterile processing stored in the lake of decanting that could be subject to erosion wind). Dust is one of the two main types of air pollutants associated with mining activities. Dust resulting from activities such as drilling, shooting, handling, processing and transport of soil and rocks, and as a result of wind action on the areas disturbed. There are two essential features concerning the nature of dust: particle size and chemical composition. Dust generated by mining activities contains particles with diameters between 1 and 100 microm. Dust composition reflects that of the source material, the dust samples studied were not identified concentration of dangerous particles such as silica or asbestos fibbers. Sources generating air pollutants are presented in Table 3.

Table 3- Sources generating air pollutants:

Miner operations as polluter		Emissions in air
0		1
Shooting, cutting, loading		Explosive gas and dust emitted by the explosion, dust issued drills for the shooting holes; dust generated by the excavators and other mobile equipment, wind erosion of areas devoid of vegetation; exhaust gases from vehicles and mobile machinery
Ore procession	Ore stock	Ore dust generated while lifting stack, stack of wind erosion, exhaust gases from vehicles and mobile machinery.
	Crushers	Ore dust generated alligator handling and crush ore
	Grinding	Ore dust generated alligator handling and crush ore.

	Gold recovery	Wet process, possible emission of dust at the point of lime addition, any incidental emissions of HCN; gas from melting furnace gold.
	Reactive storage	Dust chemical reagents in the preparation and vapours.
	Installation for remove the noxiousness	SO_2 emissions.
Procession sterile storage		Dust generated by wind erosion in dry areas of tailings processing
0		1
Sterile rocks storage		Dust generated by transporting ore and rock, the mobile equipment and unloading trucks, wind erosion of areas devoid of vegetation; exhaust gases from vehicles and machinery.
Areas of extraction, processing plant and offices		Exhaust gases from vehicles and equipment, wind erosion of the portion of land devoid of vegetation or unpaved.
Ore and people transport		Emissions from vehicles, dust from the road surface.

Sources of particles emissions related to the activities during the phases of operation and closing operation RoşiaMin are the following three main categories:

- sources represented by disturbed areas (quarry, the waste damps rocks, the ground vegetation of the waste damps, areas devoid of vegetation);
- local small sources, including punctual ones (piles ore poor, stack ore crushers, trash disposal from the processing plant, etc.).
- linear sources (road transport technology and other access roads).

3. SOIL POLLUTION SOURCES

Regarding soil erosion in the Rosia Montana mining perimeter, the following clarification is being made: the current area of mining works massive Citadel gave rise to large areas covered with deposits of sterile and non-sterile rocks, Fig.2, many of them bording upper massif dominating Rosia Valley. These deposits are at a natural angle of slope and not enjoying the delineation of engineering works, consolidation or control the leakage area. During high rainfall in the area of these deposits is affected by erosion, a phenomenon accompanied by sediment transport in the Rosia Valley and Corna Valley. It is believed that soil erosion on the location of mining as a result of operating activities, is primarily related to erosion processes that occur in storage areas of rocks and soil sterile plant, which is in a continuous process planning, restoration, and remediation profiling, throughout the operational phase of a mining operation. In addition, erosion can develop and along access roads and drainage channels. However, mining extraction activities carried out mainly in the perimeter careers should not generate strong erosion outside.

Figure 2- Rosia Valley Massif.

A major land use is mining that extends Rosia Valley and environs, which consists of the current work (and career paths of transport) and from a large area of old mining works. A large portion of land that was old work is considered half abandonee without a well-established destination. The main area is occupied by the village of Rosia Montana. Human settlements of fewer enlargements are found in scattered along the valleys or on hills. The two main limitations of land use in the studied area are generated by steep slopes and small thickness of the layer of topsoil.

On the classification system practiced of the reliability land in Romania, most of the land area is grouped into class V, with limitations due to steep slopes. Some areas are characterized, by limitations, due to small thickness of the layer of soil, present here is thin layer of soil placed directly over natural rock base or disturbed areas with thin layers of soil formed by the alteration of basic rocks exposed. The bassets bedrock in turn covers a part of the landscape, either as a natural occurrence or as traces left by old mines. These areas are grouped into class VI, only compatible with the production of hay and wood, but wrong about another form of agricultural production.

By disturbing the soil, generates sediment sources are likely to be caused by rainfall and surface leakage. Water leaking from the area for the entire mining site is of major importance for the management of mining polluted water and the diversion channel, so that you can maintain a normal flow of unpolluted water in Rosia and Corna valleys. Construction activities undertaken within a mining operation, entails the removal of considerable volumes of soil and rocks plant, planning for the retention of structures and water, some access roads, a processing plant and carry out works preparation for mining extraction, Tables 4 - 6.

Tabel 4- Pollutant of soil – activities with impact in the construction phase:

Pollutant / activity	Location / Characteristics
Temporary and permanent loss of soil as a result of the development operation.	Areas including: careers; damps of barren, the lake of decanting; processing plant; stacks soil plant, ancillary facilities.
The degradation of farmland and forestry following the deposit of particulate matter resulting from construction activities and wind erosion.	The area around the operation, impact on vegetation.

Tabel 5- Pollutant of soil – activities with impact in the exploitation phase:

Pollutant / activity	Location / Characteristics
Temporary and permanent loss of soil as a result of the development operation.	Areas including: careers; damps of barren, the lake of decanting; processing plant; piles soil plant, ancillary facilities.
The degradation of farmland and forestry following the deposit of particulate matter resulting from construction activities and wind erosion.	The area around the operation, impact on vegetation.

Table 6- Pollutant of soil – activities with impact in the close phase:

Pollutant activity	Location Characteristics
Restoration and land use after the closing stage and rehabilitation.	The lake of decanting, processing plant, structures and water management of the waste damps rocks.
Replacement of soil and restoration of land affected.	Restoration of soil and vegetation in affected areas of the occupied area of operation. affected areas of the occupied area of operation.

The current forms of land use in this area are present mining works including old mining and damps outcrop of rocks around their forest plantations consist of conifers in particular, inhabited areas and near-urban, the latter including land agricultural small, used as pasture and meadow. Due to reduced thickness of the layer of soil and steep slopes, the potential use of land is low (class VI land quality). The soil associated with former mining areas are largely exhausted, given that most of the ground vegetation was lost during the operation, remaining either bedrock outcrop or thin layer of soil formed by the gross in situ alteration of rocks base. Land use in Rosia and Corna valleys is mainly agricultural, with a number of peasant households placed along the valley yarn. Agricultural activities include cattle and sheep grazing, cultivation and exploitation the vegetable gardens in the area reduced. In general, these valleys have limited capacity to use for agricultural purposes (Class V quality land). Another source of pollution of soil and ponds is decantation Săliştea Valley (active) and, for ponds 1, 2 and 3 in conservation. In decantation pond was actively discharged from the plant sterile preparation Gura Rosiei. Sterile was transported through the pipeline and hydro transport made pond in the process of filing underwater.

4. OTHER ENVIRONMENT POLLUTION SOURCES

A summary of sources of solid wastes and residues, including methods of disposal, are presented in Table 7 [180]. Solid waste generated in the processing plant site, including ancillary buildings, consisting mainly of household waste digestible and non-hazardous industrial waste. Solid waste including waste from construction (wood, metal), waste from operating (empty barrels, packaging or other packaging waste), waste oils, used tires, spent batteries and accumulators; digestible household waste from offices, cafeteria and ancillary buildings (paper, food scraps). The main sources of vibrations that have propagated beyond the mining site were represented by bursts of rocks and the movement of heavy vehicles which ensured supply equipment and materials. Sources of vibration during operation may be associated with the jail and continue movements of heavy vehicles that have ensured the supply of materials. In addition to the seismic waves generated by operations and shooting propagated in soil, produce and atmospheric disturbances. Baric disturbances with frequencies above 20 Hz are perceived as noise, while those with frequencies below 20 Hz, where the air shock. Often these disturbances interact with different parts of the structures built, producing the transfer of energy that leads to the occurrence of resonance phenomenon.

Table 7- Solid waste and residuum:

Activity		Solid waste
Miner activities		Sterile rock, soil and uncover vegetable deposits generated mining activities. The uncover waste and dam construction the dam's decantation and other structures; sterile rock excess and / or uncover to damp designated and arranged as engineering criteria. Vegetable soil removed from all affected areas to be used during the closure.
Ore processing	Crushers and grinding	Dust recycled in technology, waste steel to be iron deposits outside the old site, recycled / reused in the site.
	Gold recovery	Sterile Processing of CIL circuit to the tailing dam of Corna valley.
	Regeneration coal and melting	Fine particles of coal to third parties for recovery. Mercury retort recovered and collected in sealed containers.
	Use of reactives	Packaging waste, discarded or returned to suppliers in a manner approved.
Acids waters evacuation		Mud from the water purification station to industrial tailing dam. To purify water or red Corna valleys that flow salubrious or recirculation in the technological process.

Miner installation and preparation factory	Waste organizing site, such as scrap metals, wood, the inert waste landfill. Denials of filters undusting, recycled, solid waste from laboratories, recycled technological process or to landfills outside the site. Sewage waste station to water waste. Mud from the station of waste water used in agriculture or rehabilitation site.
Others	Sometimes could generate small amounts of hazardous materials and hazardous. Example, spent reagents and solvents used in analytical laboratories and stored in an approved facility, outside the site, according to regulations.

Noise measured the perimeter of the quarry RoşiaMin fall below the maximum of 50 dB, determined by STAS no. 10009/1988. Values noticeably higher than the maximum permissible limit has been made to the compressor station, and breaking the crunch and factory buildings in preparation comprising hall mills, pumps, etc..; Here were reached maximum values between 70 -- 80 dB.

5. CONCLUSION

Measurements and data from studies performed until now in the area of Rosia Montana mining perimeter, and around it, some results are presented fairly brief, it may be noted that the operation of mining related to the ore from Rosia Montana has quite an impact on pregnant all environmental factors. As a general conclusion, and emerged from the results of investigations conducted within the perimeter of Rosia Montana, it may be inferred that the two social and economic - are unbalanced. Aquatic Pollution and landscape in the valley of Rosia Montana is significant, a result of past mining without appropriate addressing of the environment. Waters from the perimeter of this area are brooks Rosia Montana and Corna, which flows into the River Abrud, then pours it in Aries, from Aries in Mures, from Mures in the Tisa and from Tisa in the Danube.

The polluted water is the surface one and the freatic from the neighbourhood of the surface waters, not the one in depth. Pollution of groundwater can be removed only after removing the source and in a very long time. The main strategy for improving the impact on soils and their use is to establish a closure plan to maximize the recovery of appropriate uses for soils affected by soil conservation area.

REFERENCES:

[1]. Botz, M.M. - *Overview of Cyanide Treatment Methods, Mining Environmental Management*, Mining Journal Ltd., London, UK, pp. 28-30, May 2001.

[2]. *Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.*

[3]. *European Commission (2003): Integrated Pollution Prevention and Control (IPPC) - Reference Document on the General principles of Monitoring*, July 2003.

[4]. *MWH 2005 Geotechnical design parameters*.

[**5**]. *MWH 2005 ERR – Annex A4*.

[6]. *SC IPROMIN SA. Bucureşti - Evaluarea stării de siguranţă a iazului de decantare Valea Sălişţei*. Iulie, 2002.

[7]. *** *The Best Available Techniques for Management of Tailings and Waste – Rock in Mining Activities – Draft* March 2004.

[8]. *HGR nr.638/1999 privind aprobarea Regulamentului de apărare împotriva inundaţiilor, fenomenelor meteorologice periculoase şi accidentelor la construcţiile hidrotehnice şi a Normativului de dotare cu materiale şi mijloace de apărare operativă împotriva inundaţiilor şi gheţurilor*.

[9]. *SNC-Lavalin, 2003; Roşia Montană Open Pit Stability Design Report; Report No. 334318-0000-4GRA-0012*; SNC-Lavalin Engineers & Constructors Inc., Toronto, Ontario, Canada.

[10]. * -** *Proiectul Roşia Montană, S.C. Roşia montană* Gold Corporation S.A., 2002.

[**11**]. ***** - *Reabilitarea Minieră pentru Protecţia Mediului şi Sănătate.* Manual de Studiu. Traducere din limba engleză.

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CRITIC OF THE MARGINAL PEOPLE PHENOMENON THAT FOLLOWS MINES REORGANIZATION IN ROMANIA

CRISTIAN-MARCEL FELEA*

Abstract: *„No chance people", the less-fortunate, marginal, are the nightmare of any civilised society, but they actually exist. Mining industry, for the last decades, was a large scale factory of marginal people, at the edge of society. Merely, those people guilt is they find in the wrong place, at the wrong time, working in mines or horizontal industry, usually in a mono-industrial area. We have to admit, at this stage that is a problem concerning the entire society; above all, concerning the decision level in mining industry – those who already decided for less-fortunate people life. In fact, what is the point for restructuring mining industry, if we passed to the periphery of civilisation 2, or maybe 3 percent, of active population? Mining is not only a question of resources, techniques, money, management, but also a question of humanity and responsibility.*

Key words: *marginal people; mining industry strategy*

1. THE MARGINAL PEOPLE

Reorganization of the mining industry was followed by the engender of an important mass of marginal, that could be concretely defined, without depleting the list in any way: workers reduced in force as a consequence of mining branch restraining politics; workers that have never managed to express their whole professional and volatile skills, being obligated to abide by any post that has been offered to them, owners of small supplier firms for public companies from mining branch, adjourned to their payment until their insolvency; IMM workers dashed by the financial indiscipline, by the recession and the precarious public politics have alike marked the economy of mining areas in Romania. The marginal phenomenon could be described as a fatality, whose limitation bases in modern societies on their governments, on institutions, on the citizens trust in the capability of these institutions and the high officers paid to supervise their efficiently and responsibly administration.

* *Ph.D.Eng. - University of Petroşani*

In “Political man”, Plato imagined a “political life weaver”, where the other members are caught irreflexive. The weaver designs a humanism where the power eternally comes to “those who know” and who always control others reflexivity. So in the politic system that Plato refers to, an elite of those who “think” weaves a positive, paternalist political system, where there are finally caught all the marginal that “don’t think” or who are “not necessary to think” or “must not think anymore”.

Alexander Baumgarden isolates in modern Romanian society a “Reflexivity burglar”, character which “is always ready for the amiably processing assuming of the reflexivity from the unbroken shoulders” and which always gives you the sensation that “it includes you, there is no matter in thinking, because he already did it better”, instead of you and for your own good. The reflexivity burglar “always relies on a tempting, complicated, neologism armed language”, which “obfuscates you”, invades you and possibly offers you the trusting tender to buy you.

This appeal to the notions universe uses to describing what has been known since the antiquity about the mechanism that generates marginal people that are offered by the elite society the “thinking in the exchange of bread”. And for a marginal, it is really agreeable at the beginning to “entrust his reflexivity to others because it makes him forget about his own limitation given by it”.

In Romania today this sort of messages mostly come by media; a advertising slogan in vogue in 90’s in Romania is to be remembered here “*…sleep calm*, (someone) *watches for you!*”, that had a significant impact, but proved to be extremely delusive.

A baggy proportion of the marginal from the mining industry have alimented the migration to the West Europe, North America, Australia etc. economies where they have sold the manpower, the only “wearer” good. So a migration wave previously described by a diversion into the universal history of the notions, has formed and has a phenomenon proportion, succeeding in mining industry reorganization.

2. TOOLS USED TO COMBAT THE “MARGINALISM” AMONG MINERS

It isn’t necessary to appeal at ideologies to combat the marginal phenomenon but to a good public work administration. For the mining branch, good sector administration combined with the other adjacent public politics (social, environmental, educational, and interested local community administrations), is the needful setting. Or else said, can’t be less.

Mining industry strategy in Romania for the 2008 – 2020 periods is wished to be a setting document of planning designed from a more advanced bureaucracy view, according to European committee, with 6 declared objects:

- Onset of the activities in the mining industry based on free market principles;
- The reducing of the government direct implication by gradual attraction of the private branch investment;
- Mining activities deployment in safety environmental conditions;

- Mining activities deployment in healthy and security conditions;
- The attenuation of the social problems determined by uneconomical quarries closing and socio-economical regeneration of the affected mining areas;
- The continuation of the process of closing and purifying the quarries and watching the mining perimeters evolution in time.

The 6 objectives aren't fully proportioned, and the assertions that itemize the first two of them seem to contradict, affirming on one hand mining product capitalization in free market ifs, competing with any intern or external provider, and on the other hand the interest for the backing given to mining operators by public assistance (subventions, capital allowances). Or, public assistance is, by definition, a measure that distorts free competition on market.

The second objective is the one that enunciates also the actions taken into account by the state central administration for counteracting marginal generation phenomenon. It is detailed in 8 measures (contained in the following table) that are also confused, as they are exposed in the observations column.

The measure	The main stipulation	Observations
Measure1: individual and collective dialogue facilitation for the workers informing them about the unity views and situation	Individual and collective dialogue facilitation for the workers informing them about the unity views and situation. Mining operators must choose a person to be responsible to the planning, programming and organization of individual and collective references. The workers shall be consulted about "the reform schedule proposed". Community about closing the quarry will be notified by mass media and posted in public places.	*"The person to dialogue" must poses the capacity of solving the problems that he/she is asked for, so that the references won't be perceived as a "lost of time" by the beneficiary.*
Measure 2: professional training for the reduced in force personal, and also for the hired one in mining industry, for bigger chance on working market	The mining operator with state capital must solicit AJOFM so, on the basis of individual and collective references, different forms of professional training to be organized.	*The personal option for the person's training must be correlated with the evolution of the work market.*
Measure 3: social protection indemnity for reduced in force persons from mining activity	Social protection measures will be taken, in the purpose of assuring the basic resources on a specified period of time, enough to permit finding a new work place and adapting to the new existential conditions.	*"The given period of time" must be correlated with the area specificity and certain classes of particularities.*

Measure 4: sustaining a working program, having as purpose temporary occupancy of reduced in force persons, in view of keeping them in a form of activity that facilitates their access on the work market	Keeping the persons reduced in force in a form of activity by temporary employing them in structures administrated by the union organizations.	*The preference for certain structures, even those "administrated by the unions" is restrictive and can undermine the success in reaching to the purpose.*
Measure 5: social protection for reduced in force persons, with minimum chances of finding a work place because of their age, lack of training or physical condition	The identifying of the persons in this category before the closing of the quarry or in the period of offering "complement income". Creating this institutional frame (NGO) for informing, consulting and coaching the persons who hardly find a work place in the purpose of reaching their legal rights.	*This role can be assumed by the ANDZM, especially because the measure must be applied in the first phase and can't wait "the forming of institutional frame".*
Measure 6: social protection for reduced in force persons families, without chances of finding a workplace, in view of preventing their exclusion, especially the children from teaching and education	The direct implication of ANDZM for periodic identifying of families/persons in this situation. Finding the programs that these persons could benefit of.	*This measure can be easily implemented with the direct implication of the local administrations.*
Measure 7: creation of viable alternatives to assure development conditions of the personalities of those who remain in the area	The implication of the education minister (the youth minister) for identifying the programs for youth and bringing them to the awareness of the persons interested in this matter. The supporting of children from families with reduced material possibilities for continuing their studies after graduating the first 8 grades.	*Cooperation with profile foundations could be much more helpful. Also informing and assistance by local administrations could be more helpful.*
Measure 8: monitoring of the effects of implementation the social protection on the persons affected of the reducing in force politics	The effectuating of periodic soundings, about the impact generated of the implementing of the strategy. The construing of the results and the publishing of the monitoring rapports.	*If the measure doesn't propose itself a clear feedback procedure, the only publishing of some references is not useful.*

The observations from last column start from two tips of realities, as that there are persons that need reliance and institutionalized assistance, because they push themselves on the edge of the society (*chronic marginal*), but there are also persons good enough trained an determined that can pass over the shock of loosing their work, but they need to find in the middle of their communities conditions of manifestation. These ones don't need "reflexivity burglars" but a concrete action. If they don't find the necessary conditions in the middle of their communities, they will search for them in other place, and if they don't find help at the Government, they will migrate to the West of Europe, where they can find a work place but they can also became victims, so *unwilling marginal*.

3. CONCLUSIONS

By changing the perspective about the consequences of mining industry reorganization, from "big objectives" to human drama, the marginal problem doesn't appear anymore as an exotic idea but shows its phenomenon proportions, with a negative connotation that hides in subsidiary a series of chronic aspects, that could be solved with several plans and strategies, because it implies empathy, public efficient politics, resources, volition and determination.

From this point of view I've considered useful this short projection on the strategy of mining industry in Romania, that cannot (and must not) take into account the consequences among the communities remaining without their basic economical activity, in a larger frame, but also the personal dramas, that it will create at human individual scale. Furthermore it is shown in the strategy text that, until 2008, 155 towns from mining zones depended at the moment of ceasing the extractive activity, more than 50%, on the incomes from this tip of industrial activity. Ceasing of the extractive activities has directly affected, during the time, 32,000 persons, and indirectly about 150,000, while for about 50,000 young, their future has been affected because of the reduction of their familiar income and ruining of their own communities.

By the mining industry strategy, the **central administration** of the state proposes to administrate hereinafter, until 2020, activities like:

- continuing the reorganization of the production capacities and economical–financial of the mining operators;
- accomplishing the historical obligations of the environment protection;
- assuring the necessary resources to start the processes of closing and cleaning of the mining zones where the activity has ceased; but leaves in the responsibility of the **local communities** the matter of administering the programs of socio–economical reconstruction of the affected areas.

This last option is slightly unclear, as long as local communities – especially as it is admitted in the strategy text, those from the mining areas – don't dispose of enough resources to do it. If decentralization of the administrative decision will become effective in the nearby future, the local communities would end up searching for financial support further to the County Council, which doesn't simplify the problem of financial resources, but it complicates it.

Until local communities, supported more of less by the county communities (because the specific resource isn't to be taken into account), will find financial solutions for the social–economic reconstruction, a hardly to be estimated number of personal dramas would have been consumed. It is a fact that, for example, accessing European money presumes co loans, up keeping of a bureaucracy specialized in producing European financing dossiers (whose remuneration level is higher than a normal city hall functionary) and possibilities of contracting specialized consultants. For a mining locality of under 15,000-20,000 inhabitants, possibly left without the contribution of the main local industry, the minimal list of conditions from above is inaccessible.

If we have mechanism that originates marginal in the mining areas and we admit that this problem exists, why can't we suggest viable solutions (with the afferent resources) for its counteraction? For a country that is part of the European Union, resolving the marginal problem only on paper is undesirable. At the actual stage of development, Romania's economy has its obvious advantages, because it needs to be made investments in numerous infrastructure projects, environmental or of touring development that can also absorb great work force with medium or under medium qualification.

Mining industry has inclusive stabilization prospects at a certain level, or even new projects stabilization, but the branch strategy is not very precisely and doesn't exclusively insist upon these positive perspectives. This is also the reason why we can ask the question if, quickly opting for pulling off the mining business by privatizing, the state wouldn't offer to the branch a much better perspective, or if this wouldn't be the better and easier strategy for the mining industry.

REFERENCES:

[1] Baumgarten, Alexander – „Bună dimineța, filozofie!" – Editura Bastion, Timişoara, 2008;

[2] Balcerowicz, Leszek – „Libertate şi dezvoltare. Economia pieței Libere" – Editura Compania, Bucureşti, 2001;

[3] Chagnolaud, Dominique – „Dicționar al vieții politice şi sociale" – Editura ALL, Bucureşti, 1999;

[4] Felea, Cristian-Marcel – „Managementul minier românesc şi piața liberă. Nevoia de leadership", Revista Minelor, numerele 4, 5 şi 6 din 2006;

[5] Felea, Cristian-Marcel – Închiderea afacerii minere în Bazinul Văii Jiului şi economia de piață liberă, Revista Minelor, numărul 8 din 2006;

[6] Sloterdijik, Peter – „Reguli pentru parcul uman – un răspuns la scrisoarea lui Heidegger despre umanism"; Editura Humenitas, Bucureşti, 2003;

[7] http://www.minind.ro/strateg_miniera/ - Strategia industriei miniere din România 2008 – 2020.

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L'ETUDE STATIONNEL SUR LES DEPOTS DES STERILES DU PETRILA, ROUMANIE

EMILIA DUNCA*
DANIELA-IONELA CIOLEA**

Abstract*:* *A la suite de l'exploitation des gisements de charbon de la région de Valea Jiului on obtient des quantités importantes de stérile. Celui-ci est entamé dans des dépôts de stérile, qui sont localisés près de la région urbaine. L'objet de ce travail est d'identifier et d'étudier les phénomènes négatifs qui ont un impact important sur l'environnement et d'évaluer les effets produits, en vue de la récultivation biologique et de l'adaptation au paysage naturel.*

1. ETUDE DES PHENOMENES NEGATIFS SUR LE DEPOT

Dans le cadre du périmètre à étudier on a identifié les suivants éléments négatifs: les surfaces confrontées a des problèmes de marécage, couvertes par l'eau, des surfaces couvertes de bourbier, des surfaces caractérisées par l'érosion de profondeur mise en évidence par des ravènes; et des surfaces ou l'on peut remarquer une érosion superficielle très accentuée.

Pour identifier les phénomènes négatifs et pour évaluer les effets produits, on a planimètre les surfaces du dépôt. A la suite de ces actions, on a identifié une surface totale de 27,71 hectares. Les ravènes se sont formées à cause des écoulements des eaux provenus de la pluie ou des neiges, à cause de l'inclination excessive du terrain, qui a provoqué l'entrain des particles du sol et la progression rapide de l'érosion de profondeur. Ces ravènes occupent une surface de 1,37% de la surface totale.

Les ravènes se sont formées à cause des écoulements des eaux provenus de la pluie ou des neiges, à cause de l'inclination excessive du terrain, qui a provoqué l'entrain des particles du sol et la progression rapide de l'érosion de profondeur. Ces ravènes occupent une surface de 1,37% de la surface totale.

Dans cette zone, il y a un type de sol dans lequel on peut découvrir seulement le 4ème horizon (les roches de type mère).

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* *lecturer PhD. Eng. – University of Petrosani*
** *Assist. Prof. PhD. Eng. – University of Petrosani*

La transition vers le marécage, est un processus par lequel le terrain est excessivement humecté, à cause d'un écoulement d'eau qui s'accumule dans le sol ou sur le sol et dégrade les propriétés physiques, chimiques et biologiques en déterminant la réduction et, progressivement la disparition de la capacité productive.

La surface occupée par les marécages représente 5,34% de la surface totale du périmètre. Dans cette zone on a réalisé un type de sol ou l'on rencontre les horizons A, A2 et G.

Les écoulements plastiques et boueux, consistent du déplacement des matériaux désagrégés de la surface du sol sous la forme d'une pate ou de boue à la suite des pluies torrentielles. On n'a pas remarqué des phénomènes de solifluxion, car il n'y a pas de solification.

La surface occupée par la zone des écoulements plastiques et boueux représente 5,55% de la surface totale du périmètre. Dans le sol réalisé on a identifié l'horizon D (roche marneuse, stérile de mine).

A la suite d'études de terrain, on a identifié une surface de 7,008 hectares de terrain caractérisé par une érosion superficielle accélérée, cette érosion étant produite par l'écoulement non-uniforme sur les versants, des eaux de pluie ou résulté de la neige. L'effet de l'érosion accélérée est la réduction graduelle de la couche de sol.

Cette surface excessivement affectée représente 25,29% de la surface totale du périmètre.

Dans le sol réalisé, on a identifié l'horizon D.

Par la présentation du premier type de sol réalisé dans la ravenne, représenté par l'horizon D (marne), on peut dire qu'il y a une érosion excessive et progressive.

Par la présentation du deuxième type de sol, réalisé dans la zone de végétation, ayant une consistance 0,6, on a mis en évidence les horizons A0 – A1 – B1 – B/D – D. On peut remarquer que cette zone ne subit pas des effets négatifs.

Par la présentation du troisième type de sol, réalisé dans la zone de végétation, ayant une consistance 0,3 on a mis en évidence les horizons A0 – A1 - B/D – D. On peut remarquer que cette zone ne subit pas des effets négatifs.

Par la présentation du quatrième type de sol, réalisé dans la zone enherbée, on a mis en évidence les horizons A1 – A1 – B – S. Cette zone ne présente pas des phénomènes de dégradation, cela résulte de la description des types de sol avec les horizons respectifs.

Par la présentation du cinquième type de sol, réalisé dans la zone couverte de marécage, on a mis en évidence les horizons A2 – G – D. On peut dire que le marécage peut progresser si on n'entreprend rien pour éviter cela.

Par la présentation du sixième type de sol, réalisé dans la zone des écoulements de boue, on a mis en évidence l'horizon D (marne). On peut dire qu'il y a une érosion successive qui peut se développer si on n'entreprend rien pour éviter cela.

Par la présentation du septième type de sol, réalisé dans la zone ou le sol est très érodé on a mis en évidence l'horizon D (marne). Il y a une érosion superficielle accentuée, qui va se développer.

De la description des types de sol, on peut remarquer la concordance entre ceux-ci et les phénomènes négatifs qui apparaissent sur le terrain.

Les surfaces identifiées sur le terrain coïncident avec les surfaces du dépôt.

2. DES ETUDES ET DES RECHERCHES STATIONNELS

La carte des stations de terrains dégradés est réalisée selon les dénivellations dans le plan, les études stationnels de terrain, le travail avec les dates et les analyses dans le laboratoire.

Sur la carte on peut distinguer chaque station ou complexe de stations, représentés avec des couleurs ou des signes distinctifs.

A la suite des études et des observations sur le terrain, sur le plan de situation à l’échelle 1:1000, on a identifié les suivants types de stations de terrains dégradés, présentés dans le tableau suivant:

Nr. crt.	**Type du terrain dégradé**	**Symbol**	**Surface (ha)**
1.	Terrain dégradé, avec des phénomènes d’écroulement et des ravènes	Sr	0,381
2.	Terrain dégradé, avec la végétation de consistance 0,6	SV1	3,47
3.	Terrain dégradé, avec la végétation de consistance 0,3	SV2	9,513
4.	Terrain dégradé, avec des phénomènes de marécage	Sinm	1,48
5.	Terrain dégradé, avec des phénomènes d’écoulements de boue	Sc.n	1,54
6.	Terrain dégradé, avec la surface très érodée	Se.e.	7,008
7.	Terrain dégradé, avec la surface couverte d’herbes	Si	4,513
8.	Terrain dégradé, avec la surface couverte d’eau	Ssub	6,21
TOTAL			33,92

Pour calculer la surface de chaque station de terrain dégradé, on a planimètre les surfaces sur le plan de situation des dépôts.

Pour cela, on a utilisé un planimètre ROBOTRON REISS. Pour chaque surface, on a fait deux actions de ce type et on a constaté que la différence entre les deux ne dépasse pas 5% (l’erreur du planimètre, on a considéré comme valide la moyenne des deux surfaces). A la suite de ces actions, on a identifié une surface totale de 27,71 hectares, une surface plus étendue que celle obtenue dans la documentation de la Préparation Petrila.

Le résultat de ces études topographiques a été le plan de situation avec les phénomènes de dégradation identifiés, ce qui constitue la base pour l’évaluation de tous les travaux qui vont être exécutés.

2.1. Des études pédologiques

A la suite des études de terrain effectués, on a identifié sur le terrain les points qui présentent des phénomènes de solification spécifiques pour les surfaces couvertes de végétation ayant une consistance 0,6, pour les surfaces couvertes de végétation ayant une consistance 0,3, les surfaces couvertes d'herbes, les surfaces avec des ravenes, des marécages, des écoulements de boue, des érosions accentuées ou les surfaces couvertes d'eau.

Dans chaque zone identifiée, on a localisé et crée un type de sol, en réalisant la description détaillée de chaque type.

Pour l'analyse physico-chimique de chaque type de sol on a utilisé des méthodes expéditives spécifiques.

Après l'identification de chaque type de sol, on a ensuite réalisé un sondage qui consistait de types de sol qu'on crée généralement à des profondeurs de 50-70 cm, dans notre cas, le sol étant en cours de formation, on a choisi une profondeur de seulement 10 cm.

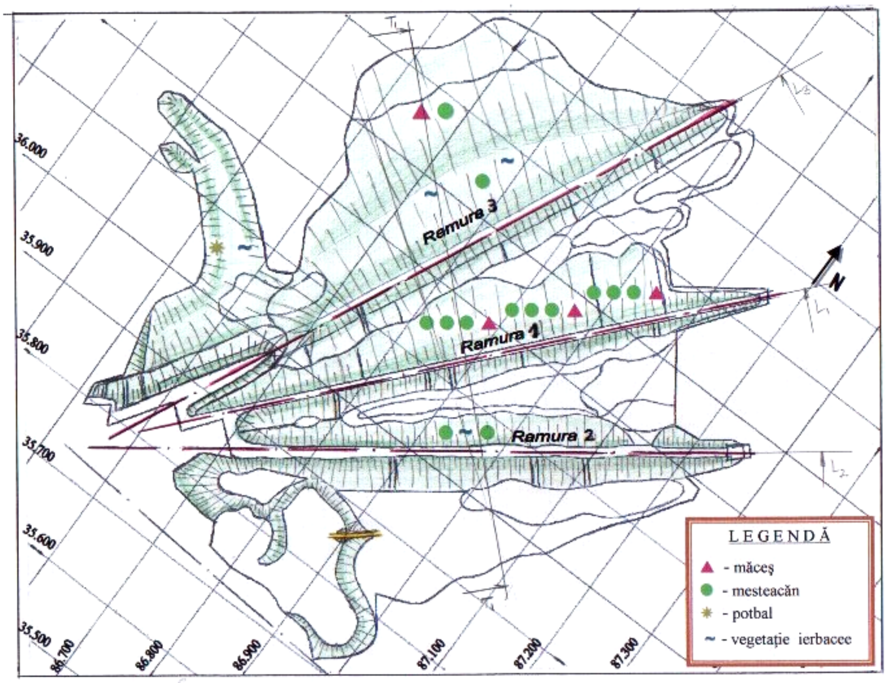

Figure 1 Le plan avec les type des stations identifie sur le depot de Petrila

Le premier type de sol a été réalisé dans une ravene:

- l'épaisseur totale de la couche de sol – 0 cm, forme sur des graviers
- les horizons de différence des types de sol – D (roche marne)
- la couleur – gris
- le niveau d'effervescence avec HC1 – absent
- l'intensité de l'effervescence et le contenu carbonique – absent
- la nature de l'humus à la surface du sol–pas le cas
- le contenu en humus du sol – absent
- la nature du humus – pas le cas
- la consistance granulométrique – cailloux, gravier, sable, poussière, argile

- la structure – non-structure
- la consistance – sable et argile
- la porosité – réduite
- le degré de cohésion – réduite, très friable
- la perméabilité – modérée
- l'humidité – sec
- l'épaisseur physiologique du sol – 0
- le diagnostique de l'état général – du sol très érodé, peu fertile

2.2. L'étude microclimatique

Pour interpréter le plus correctement possible les différences des climats locaux par rapport au climat districtuel, à cause du relief et de l'ambiance locale, il est nécessaire de connaitre, en général, le spécifique des différentes formes de relief.

Les plateaux qui se trouvent sur le dépôt on les traits spécifiques suivants: insolation spécifique aux surfaces planes, des oscillations thermiques relativement signifiantes du jour à la nuit, humidité relativement réduite, des vents puissants et irréguliers.

Les versants des dépôts peuvent présenter des aspects variés du point de vue climatique, à la suite des superpositions entre l'exposition, le synclinal, le profile de la pente et l'altitude.

Notre zone est encadrée dans une sous – région, une partie, avec un climat de versants exposés aux vents de Sud – Ouest et ceux de l'Est et du Sud, dans une sous – région avec un climat de versants abrités. La région avec le climat collinaire, au Sud et Nord – Est, a comme spécifique le climat continental, et, à l'Ouest, Nord – Ouest, un climat continental modéré. Ayant comme fondement ces traits spécifiques du climat, les formes de relief créent une mosaïque de climats locaux.

Le versant du Nord, se caractérise par un degré réduit de lumière et chaleur, et beaucoup d'humidité. La fréquence des vents se manifeste dans la direction Nord. Il y a une uniformité relative des conditions thermiques sur le profile de la pente, à cause de la diminution graduelle des températures.

Les versants de Sud sont plus exposés à la lumière, à la chaleur, l'humidité est réduite et la zone est à l'abri contre les vents froids. Le synclinal détermine le degré de lumière et chaleur dans la période froide de l'année, à cause de la position du soleil et de l'angle d'incidence des rayons.

On peut remarquer le fait que, dans les zones ensoleillées, il y a un microclimat indépendant de celui de l'environnement local, à cause du degré accentué de chaleur sur la surface sous-jacente, tandis que, dans les zones qui se trouvent à l'ombre, le sol est influencé par la température générale de l'air. Par rapport à l'altitude, les conditions du climat varient, premièrement à cause des différences signifiantes de température entre les parties du versant. La partie supérieure est plus chaude au printemps et en automne, étant illuminée par le soleil plus longtemps que la partie inférieure.

La partie inférieure du versant est plus chaleureuse en été, surtout pendant le jour, quand l'air semble immobile, et moins chaude en hiver et pendant la nuit, quand l'air froid s'y déplace.

Sur les versants ensoleillés, les formes de relief font possible un mosaïque de microclimats ayant des caractères intermédiaires.

L'association entre les éléments de relief exposition – synclinal, détermine les conditions locales d'insolation. L'énergie radiante, que reçoit une certaine surface d'une forme de relief, dépend de la dimension de l'angle d'incidence des rayons du soleil avec le plan de la surface en question. Plus la valeur de l'angle est près de 90°, plus la quantité d'énergie radiante reçue par le sol et par l'atmosphère plus proche est grande. Le régime de variation de cet angle est, pour la même latitude, déterminé par la commination de l'exposition et de la pente du terrain. Généralement, on parle de ces éléments de relief séparément, pas de leur élément associatif, essentiel pour la mesure dont la surface est capable de réceptionner l'énergie radiante, donc pour la mesure de l'insolation potentielle.

Par rapport à l'importance de l'insolation pour le régime thermique, pour la climatologie et l'écologie, sa variabilité dépendant des conditions combinées d'exposition – synclinal est devenue le sujet des travaux de récultivation biologique.

2.3. L'étude de la végétation locale

La région de Valea Jiului étant située dans la zonalité bioclimatique sous-alpine (FSa), alpine de mélèze (FM3), alpine de hêtres et résineux (FM2) et alpine – préalpine de hêtres (FM1+FD4), la végétation de ces étages est, elle aussi diversifiée.

Dans la dépression de Petrosani, les mélèzes se présentent sous la forme de quelques bandes qui s'élargissent sur les versants du Nord et du Nord – Ouest.

Les combinations entre les hêtres et les résineux sont également répandues sur les pentes du Sud et du Nord.

De la même façon, les hêtres sont répandus uniformément sur les pentes du Nord, en y occupant des surfaces plus réduites, tandis que, sur les pentes du Sud et de l'Ouest, ils arrivent à 600 – 1300 (1400) m.

Toutes les espèces présentées ci – dessus (mélèze, hêtre) sont des espèces ayant une valeur locale.

Des espèces locales précieuses on peut aussi mentionner le sapin, le charme, le frêne, le sycomore, le pin, le cerisier etc., espèces qui ne constituent pas des massifs forestiers purs mais en combination avec le hêtre. Seuls les mélèzes et les hêtres forment des massifs purs. A cause des exploitations exagérées des forets, le mélèze s'est étendu en dehors de son domaine, en formant des combinaisons de hêtre et mélèze.

Dans la région de Valea Jiului il y a aussi des espèces exotiques qui se sont adaptées à la région, comme: le douglas, le pin, le peuplier noir, l'acacia etc., ces espèces se trouvent occasionnellement. De ce point de vue, en étudiant la zone du périmètre d'amélioration, on a identifié le bouleau et l'églantier, qui constituent de massifs forestiers de bouleaux, sur les trois branches des dépôts étudiés.

Toujours ici, dans cette zone, on trouve des acacias insulaires, une espèce qui a trouvé des conditions propices pour se développer. Ayant en vue son aspect vigoureux, on peut dire que cette espèce s'est bien adapté à la région.

On peut aussi remarquer des arbustes comme: le noisetier, des arbustes de myrtille etc. La floraison, l'apparition des feuilles et le murissement des graines forestières dépendent de nombreux facteurs comme: l'altitude, le degré d'exposition, la pente, la température, la lumière, le vent, le sol, l'aspect lithologique et les exigences des espèces. Du point de vue de l'altitude, les forets de Valea Jiului se déploient de 400 à 1700 m, ce qui conduit au prolongement des périodes de floraison et d'apparition du feuillage, avec 2-3 jours pour chaque 400 m d'altitude.

Pour les espèces locales la provenance est toujours préféré pour mieux valorisiez le potentiel productif de la région.

2.4. Le diagnostique stationnel

La différence et les considérations ont été faites en considérant la station comme une unité physico-géographique et écologique. On a étudié profondément aussi les facteurs physico-géographiques que ceux écologiques. Ces analyses qui portent sur le potentiel de la station seront comparées avec les études écologiques, notamment les exigences des espèces, processus qui sera la base de la sélection des espèces à étudier.

Les facteurs écologiques et les facteurs condition ont été étudiés dans les pages antérieures. On a fait une analogie entre les classes des mesures, les facteurs écologiques et les facteurs condition étudiés.

Pour pouvoir établir les classes de mesures des facteurs écologiques, on a conçu le tableau suivant, contenant le projet de l'encadrement des facteurs mentionnés ci-dessus dans des classes de mesures. Si, du point de vue naturalistique, l'étude sur le type de station et aussi sur la surface stationnelle est le plus détaillé, les types de stations étant trop détaillés il ne faut pas énoncer tant de sollutions et de techniques de cultivation pour tous les types de stations. Dans ce cas on peut mettre plusieurs types de stations dans une seule unité de culture.

Dans les régions avec de la végétation et des arbres on a pris en considération l'état actuel du type de humus.

On a pu distinguer les suivants types de stations:

1 - station où la roche marne se trouve à la surface, ce qui implique un régime d'humidité et d'aération tout spécial S1

2 – station ou il y a un début de solification, avec une couche de humus entre 0,7 – 4 cm, avec des conditions acceptables pour la végétation S2

3 – station excessivement humide (marécages) ou station couverte d'eau S3

4 – station avec des écoulements de boue S4

Pour l'étude des types de stations dans ce travail, la description physico – géographique y compris la description pédologique étant donnée, on présente la fiche écologique pour chaque type de station.

Pour une expression concise des caractéristiques physico-géographiques, écologiques et silvoproductives des types de stations, on utilise la formule stationnelle.

Ainsi, pour le premier type de station, nous avons la formule suivante:
- oligotrophique, oligohidrique, estival sec-humide-sec : $FM_3<P_i-T_I-H_I-Ue_{1-0}$

Fiche écologique pour le type de station S1

FACTEURS	Classes de mesures des facteurs écologiques							
	0…m	I	II	III	IV	V	E1	E2
La température m.a.			+					
Les précipitations a					+			
Les précipitations de chargement du sol					+			
Les précipitations estivales juillet-aout					+			
Les vents				+…	+			
L'humidité relative de l'atmosphère en juillet							+	
L'acidité		+						
La consistance estivale		+						
Le volume édaphique	+							
La durée de la période bioactive			+					

Pour le deuxième type de station, nous avons la formule suivante: - oligomezotrophique, mezohidrique, estival humide : $FM_3-P_m-T_{II}-H_{III}-Ue_r$

La fiche écologique du type de station S2

FACTEURS	Classes de mesures des facteurs écologiques							
	0…m	I	II	III	IV	V	E1	E2
La température m.a.			+					
Les précipitations a					+			
Les précipitations de chargement du sol					+			
Les précipitations estivales juillet-aout					+			
Les vents				+…	+			
L'humidité relative de l'atmosphère en juillet						>+		
L'acidité		+						
La consistance estivale			+					
Le volume édaphique		+						
La durée de la période bioactive			+>	<+				

Pour le troisième type de station, nous avons la formule suivante:- distrophique et extremement distrophique, excessivement hidrique, humide en permanence : $FM_3-<P_i-T_{0\ldots m}-H_E-U_8$

La fiche écologique du type de station S3

FACTEURS	Classes de mesures des facteurs écologiques							
	0…m	**I**	**II**	**III**	**IV**	**V**	**E1**	**E2**
La température m.a.		+						
Les précipitations a					+…	+		
Les précipitations de chargement du sol						+		
Les précipitations estivales juillet-aout						+		
Les vents	+…	+						
L'humidité relative de l'atmosphère en juillet							+>	
L'acidité							+	
La consistence estivale		+						
Le volume édaphique	+	+						
La durée de la période bioactive		+						

Pour le quatrième type de station, nous avons la formule suivante: FM_2- $<P_i$-T_I-H_{II}-U_0

La fiche écologique pour le type de sol S4

FACTEURS	Classes de mesures des facteurs écologiques							
	0…m	**I**	**II**	**III**	**IV**	**V**	**E1**	**E2**
La température m.a.			+					
Les précipitations a					+			
Les précipitations de chargement du sol					+			
Les précipitations estivales juillet-aout					+			
Les vents				+…	+			
L'humidité relative de l'atmosphère en juillet							+	
L'acidité		+						
La consistence estivale		+						
Le volume édaphique	+							
La durée de la période bioactive		+						

3. CONCLUSIONS

Pour étudier les possibilités de récultivation biologique, on a considéré comme nécessaire d'effectuer des analyses physico-chimiques et organoleptiques sur le matériel qui compose le dépôt.

Pour les analyses, on a prelevé des échantillons de 7 types de terrains dégradés et on a réalisé, pour chaque type de terrain, un type de sol en le présentant.

A la suite de l'étude des facteurs physico-géographiques et écologiques on a établi les fiches écologiques pour chaque type de station. Selon l'étude stationnel et tenant compte des exigences de l'espèce, on a commencé à choisir et à associer les espèces, en établissant, pour chaque type de station, une formule de boisement.

4. BIBLIOGRAPHIE

[1]. Georgescu, M. – *La systématisation et la réutilisation des terrains*, Litographie I.M.P., 1989
[2]. Chirita, C., et. A. - *Des stations forestières*, Ed. Academiei R.S.R., Bucuresti 1981
[3]. Ciortuz, I., - *Améliorations sylviques*, E.D.P., Bucuresti 1981
[4]. Traci, C., - *Le boisement des terrains dégradés*, Ed. Ceres, Bucuresti 1985
[5]. Chirita, C., D., - *Pédologie générale et forestière*. E.D.P., Bucuresti 1955.

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PETROGRAPHIC NATURE AND MODAL MINERAL COMPOSITION OF PSAMMITIC GNEISSES WHICH FORM LAINICI – PAIUŞ GROUP FROM THE JIU GORGE

POSTOLACHE MIHAELA*

Abstract: *The petrographic composition of Lainici Păiuş Group includes crystalline schists which come from detrital – psammitic sedimentary deposits with alternate bands of pelitic and carbonaceous rocks. Among these, the psammitic gneisses and the quartz – sericite schists are the most common/widespread. The psammitic gneiss of Lainici-Păiuş Group presents a chemism similar to greywackes formed from old gneissic granite, where the quartz grains, which are most of the times angular and feldspar are most abundant.*

In the field of debris and detritus/talus material from the right slope of Păiuş brook/runlet (the Jiu Gorge), we have come across the crystalline schists of Lainici-Păiuş Group which meet the crystalline schists of Drăgşan Group, or the schists of Tulişa Group through some important fault lines.

The petrographic composition of Lainici Păiuş Group includes crystalline schists which come from detrital – psammitic sedimentary deposits with alternate bands of pelitic and carbonaceous rocks. Among these, the psammitic gneisses and the quartz – sericite schists are the most common/widespread.

Psammitic gneisses

The rocks are characterized by a white-grey colour and they consist of quarts, feldspar and mica, which can be seen with the naked eye.

In thin sections and using a microscope one could establish the following mineral paragenesis: quartz + plagioclase + microcline + sericite + muscovite ± biotite ± garnet ± apatite + sphene + tourmaline + ilmenite ± graphite + epidote + zoisite.

The groundmass/mesostasis of these rocks chiefly notable for the preponderance of small quartz and albite xenoblasts, contains small cobbles of quartz, with strong wavy extinctions, sub-circular fragments and round fragments of plagioclases with 10 - 13% An, microcline and shales of muscovite partially sericitized along the main rock schistosity.

The garnet occurs sporadically under the form of relict grains with edges highly corroded by the fine-grained quartz and by the micaceous aggregate.

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* *Assist. Prof. Student PhD. Eng. – University of Petrosani*

The epidote, apatite, ilmenite and sphene can be found in the composition of gneisses as small rolled clastic grains.

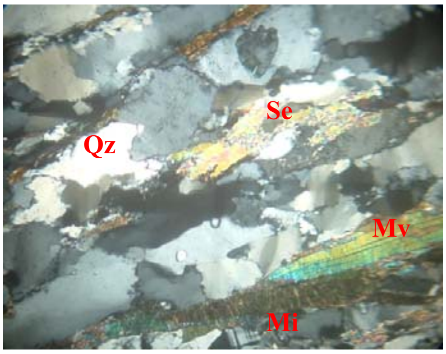


***Foto.1.* Psammitic gneisses**.
Qz. – quartz, Mi – microcline, Mv – muscovite,
Se – sericite (N +, x 60)

These make up most of Lainici-Păiuş Group, and they can be found in the Jiu Gorge between Rafaila brook, in the south and Păiuş brook, in the north.

The word psammitic gneiss derives from the fact that the mesostasis of this rock, chiefly notable for the preponderance of small quartz and albite xenoblasts, contains small cobbles of quartz, with strong wavy extinctions, sub-circular fragments and round fragments of plagioclases with 10 - 13% An, microcline and shales of muscovite partially sericitized along the main rock schistosity. The garnet is an almandine and it represents a small percent of relict grains with the edges highly corroded by the fine-grained quartz and by the micaceous aggregate. The apatite, zirconium, sphene and the epidote, can be found in the composition of gneisses as small rolled clastic grains.

The modal mineralogical composition and the size of composing minerals can be followed in Table 1.

Table 1.

TOTAL	**Psammitic gneisses**	
	100,0 %	**Dimensions (mm)**
Quartz	46,2	0,016 x 0,032 0,724 x 1,207
Plagioclase feldspar	32,1	0,112 x 0,161 0,402 x 0,966
Biotite	2,3	0,064 x 0,161 0,241 x 0,805
Muscovite + sericite	6,2	0,003 x 0,030
Almandine	4,9	0,064 x 0,112 0,322 x 0,724
Apatite	1,4	0,032 x 0,048 0,114 x 0,161
Zircon	0,8	0,022 x 0,037 0,075 x 0,187
Titanite	0,1	0,064 x 0,161
Clorite	4,2	0,064 x 0,080 0,161 x 0,644
Epidote+ zoisite	0,9	0,032 x 0,044 0,112 x 0,322
Clinozoisite	0,1	0,161 x 0,966
Opaque minerals	0,8	0,112 x 0,652

The modal mineralogical composition highlights the fact that in quantitative terms, there are two dominant minerals: quartz and plagioclase feldspar. This finding corresponds at first to the mineralogical composition of quartz-feldspathic sandstones such as greywackes. At the same time, the absolute size of the mineral components is within the limits of fine-grained epiclastic rocks characteristic to psammites.

The chemical composition (Table 2) reveals the characteristic of a pre-metamorphic sedimentary rock with a relatively high content of SiO_2 and Al_2O_3. Moreover, one can notice the predominance of K_2O over Na_2O and the low values of ferromagnesites and CaO.

Table 2.

Oxides / Nr. probe	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	H_2O	PC	*TOTAL*
1	66,29	18,25	1,66	1,42	1,50	2,24	2,56	3,25	0,60	0,10	1,66	1,93	**99,70**

In the following diagram Na_2O – K_2O (fig. 1), the analyzed rock falls in the series of greywackes and meta-acids but it is limited by the series of acidic rocks.

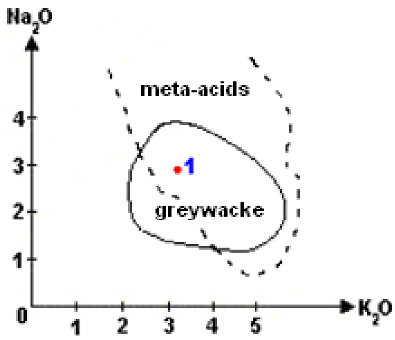


Fig.1. **–** The Na_2O – K_2O diagram. (Mehnert, 1968).

The high silica and aluminum content, and the small values of femic and calcium components are also reflected in the Niggli parameters (Table 3). The value of "**al**" is characteristic to sedimentary rocks, and the value of "$\mathbf{q_z}$" corresponds to the estimate amount of free quartz.

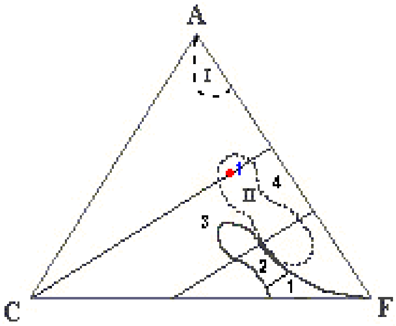
Table 3.

si	al	fm	c	alk	k	mg	o	c/fm	q_z
308	50	16	11	21	0,46	0,63	0,03	0,69	124

The sedimentary nature of the original material, which produced the present psammitic gneiss, can be proved by the ACF values (Winkler, 1967):

A = 46.96, C = 22.56 and F = 30.48.

As you can see in the ACF diagram (Fig.2), the psammitic gneiss falls into the series of sandstones such as greywackes.



I – Clays and argillaceous schists;
II – Greywacke;
1 – Ultrabasics;
2 – Basic rocks and

Fig.2. **–** The ACF diagram for determinate nature of premetamorfic material of psammitic gneisses (după

Finally, the nature of the original material which produced the analyzed gneiss can be determined by the double ternary diagram of Kohler and Raaz (fig. 3), where the following values: + qz = 57.7, F = 16.7, = 25.5 fm and F - = -8.8 fm, place the sample among sedimentary rocks.

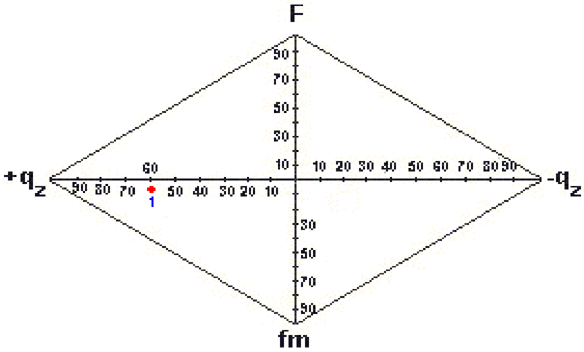


Fig.3. **–** The double ternary diagram of Kohler and Raaz (1951).

In conclusion, the psammitic gneiss of Lainici - Păiuş Group, presents a chemism similar to greywackes derived from old gneissic granite, where the grains of quartz, which are most of the times angular and feldspar are most abundant.

REFERENCES

[1]. Georgescu, M. - *Geological and Petrographic Studies between Reci Peak and Sadu Valley Regarding the Design of Hydro-technical Constructions*. Technical and Economic Studies, Series F, no. 9, Bucharest, 1975;

[2]. L. Pavelescu and co-authors - *Petrographic and Structural Research in the Jiu Gorge* between *Bumbeşti and Iscroni.* Reports of Com. Geologist. Meetings vol. L / 1, Bucharest, 1964**;**

[3]. Ungureanu, N. - *Geologic and Petrographic Study of the Western Side of Parang Mountains*, Bucharest University Printing House, 1978;

[4]. Ungureanu, N. and co-authors - *Research for Highlighting the New Rocks from the Western Side of Parang Mountains*. Research contract no. 13/1993 and 491c/1994 Petroşani.

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ZEOLITES – “THE STONES THAT BOIL” – A NATURAL WAY OF CLEANING UP NATURE

CSABA LORINŢ[*]
GRIGORE BUIA[**]

Abstract: *The first mineral to be classified as a zeolite was discovered in 1756 from volcanic rocks, since when about 48 natural zeolite types have been identified, in addition to about 150 synthetic species, with possibly more based upon structural definitions. These are unique materials with many highly important applications, particularly in environmental chemistry. The description of zeolites is important for several reasons: first, it provides quantitative information about the effectiveness of a zeolite’s performance. Secondly, a wealth of thermodynamic and kinetic information can be extracted. In Romania there are many occurrences of Badenian zeolitic tuffs.*

Key words: *Alumosilicates, zeolitic tuffs, zeolites, adsorption, molecular sieves, sorption and de-sorption, catalysis, ion exchange*

1. WHAT ARE ZEOLITES?

Zeolites are a class of naturally occurring crystalline porous alumino-silcates. They have three-dimensional structures arising from a framework of $[SiO_4]^{4-}$ and $[AlO_4]^{5-}$ coordination polyhedral linked by all their corners. Collective polyhedral form frameworks that are generally open and contain channels and cavities in which are located metal cations and water molecules. For this reason, when they are heat up, zeolite’s water molecules are vaporized and they are named “the stones that boil”.

Many of the naturally occurring zeolites can be created synthetically. One major advantage of zeolites is that since they are naturally occurring, they are often very cheap. Additionally, since they are composed largely of silicon, a major component of the earth’s crust, they find many uses in a more environmentally aware society.

Zeolites – „The Stones that Boil”, are unique materials with many highly important applications, particularly in environmental chemistry. They are a negatively

** Assist. Prof. PhD.Eng. – University of Petrosani*
*** Prof. PhD.Eng. – University of Petrosani*

charged framework of micro pores of molecular dimensions (2-7 Å, usually less than 13 Å in size) whose charge is balanced by sufficient positively charged cations to provide an overall electrical neutrality. In naturally occurring zeolites, the cations are mostly of the alkali and alkaline earth metals, respectively sodium, potassium, calcium and magnesium. The first mineral to be classified as a zeolite was discovered in 1756, since when about 48 natural zeolite types have been identified, in addition to about 150 synthetic species, with possibly more based upon structural definitions [6].

2. STRUCTURES

As stated earlier, the tetrahedral arrangements of $[SiO_4]^{4-}$ and $[AlO_4]^{5-}$ coordination polyhedral create numerous lattices where the oxygen atoms are shared with another unit cell. The net negative charge is then balanced by cations (e.g. K^+ or NH_4^+).

Small recurring unit can be defined for zeolites named "secondary building units". Some of these building units are shown in figure 1 [4].

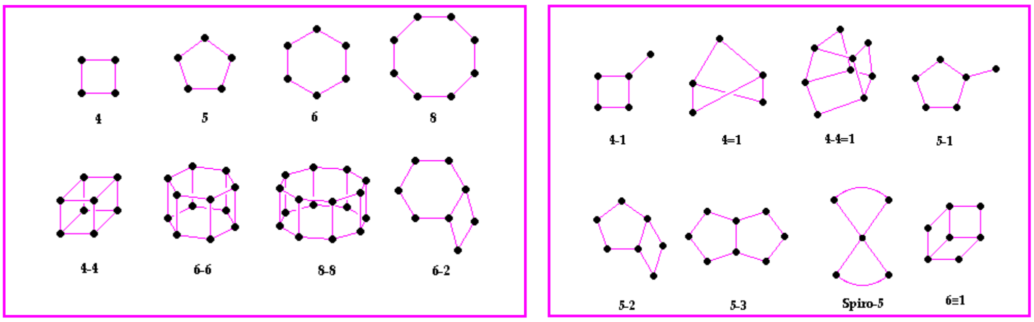

Figure 1. Zeolite building unit (SBU'S) in zeolites. The corner of the polyhedral represent tetrahedral atoms

These unit cell cavities vary with the building units and the number of cations present within a zeolite structure and is determined by the number of $[AlO_4]^{5-}$ tetrahedral included in the framework. This arises from the isomorphous substitution of Al^{3+} and Si^{4+} into the component polyhedral.

3. TYPES

Natural zeolites

The first zeolites recognized where classified from volcanic rocks. Often collected by museums because of there spectacular appearance, it is now recognized that they are one of the most abundant natural occurring species. Natural zeolites are found in various settings such as alkaline lakebeds, soils and land surfaces, marine deposits, and geothermal deposits.

Given that the empiric formula: $M_{2/n}O$ • $A_{12}O_3$ • $xSiO_2$ • yH_2O, the most common natural zeolites are analcime, chabazite, clinoptilolite, heulandite (there is some speculation as to whether heulandite and clinoptilolite should simply be classified as one mineral), laumontite, phillipsite, ferrierite and erionite (which due to its fibrous nature and high iron content is a Class 1 carcinogen). Overwhelmingly, clinoptilolite is the major zeolite used for commercial applications, while chabazite and mordenite are used on a lesser scale.

Table 1. The most common natural zeolites

Mineral	**Chemical formula**	**Crystallographic Systems**	**Porosity %**	**CEC***
Analcim	$16 [Na (Al\ Si_2O_6)H_2O]$	Cubic	18	4.54
Chabazit	$2[(Ca, Na_2) (Al_2\ Si_4\ O_{12})\ 6H_2O]$	Trigonal	47	3.81
Clinoptilolit	$2(Na_2K_2\ Ca)_3Al_6\ Si_{30}O_{72}\ 21H_2O$	Monoclinic	39	2.54
Erionit	$(Na, Ca_{0.5}\ K)_9\ (Al_9\ Si_{27}\ O_{72})\ 27H_2O$	Hexagonal	35	3.12
Heulandit	$Ca_4\ (Al_8\ Si_{28}\ O_{72})\ 24H_2O$	Monoclinic	39	2.91
Mordenit	$(Na_2\ Ca)_4\ (Al_8\ Si_{40}\ O_{96})\ 28H_2O$	Rhombus	28	2.29
Phillipsit	$(Na, K)_{10}\ (Al_{10}\ Si_{22}\ O_{62})20H_2O$	Rhombus	31	3.87

**CEC – cationic exchange capacity*

Synthetic zeolites

Initial efforts to synthesize zeolites were carried out under high pressure/temperature conditions in order to simulate those natural zeolites first discovered from volcanic deposits. Significant progress was made when synthesis was started under normal atmospheric conditions (<100^{o}C and atmospheric pressure). Synthesis was also focused on recreating natural zeolites, however, it was soon realized that many new structures could easily be created. Computer predictions have say that there are about six million conceivable zeolites [3]. General synthesis starts from crystallization from an inhomogeneous gel, created from a silica source and an alumina source combined with water. Some of the parameters that control the type of zeolite formed are pH of the solution, temperature, pressure, and crystallization time. Synthetic zeolites are very small compared to natural zeolites. This is due to the very long crystallization time of natural zeolites in the earth.

Table 2. Synthetic zeolits (Rocci, 1986)

Mineral	**Chemical formula**	**Crystallographic Systems**	**Porosity %**	**CEC***
Type A	$Na_{12}(Al_{12}Si_{12}O_{48})27H_2O$	Cubic	47	5.48
Type X	$Na_{86}(Al_{86}Si_{106}O_{384})26H_2O$	Cubic	50	4.73

**CEC – cationic exchange capacity*

4. WORLD INDUSTRY STRUCTURE

World production of natural zeolite [5] was estimated to be between 2.5 and 3 Mt based on reported production by some countries and production estimates published in trade journals. Estimates for individual countries were China, 1.5 to 2.0 Mt; the Republic of Korea, 150,000 t; Japan, 140,000 to 160,000 t; the United States, 65,500 t; Cuba, 37,500 t; Hungary and Turkey, 30,000 t each; Slovakia, 25,000 t; New Zealand, more than 18,000 t; Bulgaria and South Africa, 15,000 t each; Australia, 10,000 to 12,000 t; Georgia, 6,000 t; Canada, Italy, and the Commonwealth of Independent 4,000 t each; Greece, 3,000 t; and Ecuador, 2,070 t. Small amounts of natural zeolite also were produced in Indonesia.

In general, countries mining large tonnages of zeolite often have substituted zeolite-containing tuffs for various applications. Natural zeolites were used in large quantities for such applications as dimension stone (as an altered volcanic tuff), lightweight aggregate, pozzolanic cement, and soil conditioners. In these cases, the ready availability of zeolite-rich rock at low cost and the shortage of competing minerals and rocks are probably the most important factors for its large-scale use. Also, it is likely that a significant percentage of the material sold as zeolite in some countries is ground or sawn volcanic tuff that contains only a small amount of zeolite.

5. ROMANIAN ZEOLITIC TUFFS

In Romania there are many occurrences of Badenian zeolitic tuffs, (Bedelean & Stoici 1998). A lot of occurrences of zeolites appear in the Badenian zones from the Transylvania depression known under the name of Dej tuff or Perşani tuff (Mârza, et al. 1991). Badenian zeolitic tuffs are also known in the Simleu depression, (Pop et al. 1982) and in the Maramureş depression (Damian et al. 1991, 2002). [1]

6. APPLICATIONS

The general principles which make the zeolites usable in many practical applications are:

6.1. Adsorption

Zeolites are used to adsorb a variety of materials. This includes applications in drying, purification, and separation. They can remove water to very low partial pressures and are very effective desiccants, with a capacity of up to more than 25% of their weight in water. They can remove volatile organic chemicals from air streams, separate isomers and mixtures of gases.

Molecular Sieves

The three-dimensional framework of zeolites contains a series of channels and voids. Contained in these volumes are cations and water molecules. When the water is removed the voids created can take in other molecules. This process is called “sorption,” and the zeolites act as sorbents. The geometry is the source of the ability of zeolites to separate mixtures of molecules (gases and liquids) on the basis of their effective sizes. Zeolites are therefore described as “molecular sieves”.

Hydrophobic zeolite (zeolites without water) can be made by controlling the silicon to aluminum ratio. Different types of zeolites have windows from 0.3 to 3.0 nanometers. Changing the Si/Al ratio can affect the size of the window.

Sorption and de-sorption methods:

Rates of sorption or de-sorption of gaseous materials with zeolites can be determined at constant pressure or volume using Fick’s law [2]: $J = -D(c)dc/dx$

J – flux (volume per area-time); D – diffusivity; C – concentration; x – represents a coordinate axis along which diffusion takes place

This equation can be solved according to the geometry involved in the system being studied. An example of an equation for use under constant pressure is:

$$M_t/M_\infty = 2A/V(Dt/\pi)^{1/2}$$

Where M_t, M_∞ are the amounts of sorbate taken up, or released, at time intervals $t=t$ and $t=\infty$, A and V are the external surface areas and volume, respectively, and D is the diffusion coefficient.

A plot of fractional attainment of equilibrium (M_t/M_∞) versus $t^{1/2}$ should give a straight line from which D can be determined. Currently applied zeolites in fixed bed reactors have very non-linear isotherms, which increases adsorption at lower concentrations of volatile organic compounds (VOCs). This allows a removal efficiency of 99% for zeolites versus a carbon’s 95% efficiency [7].

Chandak and Yin have shown that hydrophobic zeolites are efficient at adsorbing and desorbing volatile organic compounds. This is important since VOCs are known precursors to the formation of photochemical oxidants such as ozone.

With this theoretical knowledge of gaseous uptake by zeolites, devices have been built that concentrate volatile organic compounds that would otherwise escape into the atmosphere. This type of concentrator is a temperature-swing adsorber with the zeolite bed mounted on a rotor that gets regenerated on each rotation. The air-vapor flow is axial through the rotor. This particular concentrator is used in conjunction with an incinerator, whereby the effluent of the concentrator feeds the incinerator, minus the VOCs. Additionally, the size and cost of an incinerator is related to the total airflow. The major cost savings comes from reducing the flow of air through the incinerator that reduces the heat needed to raise the temperature of the airflow.

The biggest drawback of this method has been in the small size of zeolite particles that lead eventually to a very large pressure drop through reactive beds. Zeolites now have been created in granules that allow freer airflow and are currently be used in fixed bed adsorbers in Europe.

Other environmental applications include the addition of hydrophobic medium and large pore zeolites upstream of an automobile catalytic converter since typical catalytic converters do not effectively operate until reaching very high temperature. This design would allow VOCs produced on cold start-up to be trapped by the zeolite and eventually released into the catalytic converter once operating temperature is reached.

6.2. Catalysis

Zeolites can be shape-selective catalysts either by transition state selectivity or by exclusion of competing reactants on the basis of molecular diameter. Zeolites can also function as acid catalysts and can be used as supports for active metals or reagents. They have also been used as oxidation catalysts. The main industrial application areas are: petroleum refining, synfuels production, and petrochemical production. Synthetic zeolites are the most important catalysts in petrochemical refineries.

6.3. Ion Exchange

The presence of the counterbalancing cations in the zeolite framework presents the possibility for ion exchange if these cations are mobile. This ion exchange ability accounts for the greatest volume use of zeolites today [6]. For example, zeolite A, a synthetic zeolite with sodium as a cation has widely replaced environmentally harsh phosphates as detergent water softeners. They do this by exchanging the sodium in the zeolite for the calcium and magnesium present in "hard" water. Zeolite cages are occupied by ions such as sodium or potassium; cations that counter the negative charge of the alumina-silica framework. These ions are readily exchanged in external solutions. This property has been intensively studied whereby the introduction of other cations, usually by ion exchange, has been used to modify the actions of the zeolites. These efforts have allowed almost every element on the periodic table to be introduced into a zeolites framework (Dyer). A simple example of ion exchange between a zeolite and solution is:

$$Na^+ + K^+ \leftrightarrow Na^+ + K^+$$

Where the species in bold is inside the zeolite frame. These stoichiometric reactions can be characterized by the construction of ion exchange equilibrium. Consider the case of a system between cation A, initially in solution, and B, initially in a zeolite. These cations have an equivalent valence charge.

These substances are allowed to equilibrate under the simplification of isonormality (solutions are at equal normality). At the point of equilibrium, solution and solid phases are analyzed to determine the distributions of A and B between the phases. An isotherm can now be plotted which records the equivalent fraction of the entering ion in solution, A_S, against that in the zeolite, A_Z. The fraction of A in solution is given by:

$$A_S = Z_A m_A / Z_A m_A + Z_B m_B$$

$m_{A,B}$ are the concentrations of the respective ions in solution.
Similarly, the equivalent fraction in the zeolite is:

$$A_Z = Z_A M_A / Z_A M_A + Z_B M_B$$

$M_{A,B}$ are the concentrations of the ions in solid phase.

This description of zeolites is important for several reasons. First, it provides quantitative information about the effectiveness of a zeolite’s performance. Secondly, a wealth of thermodynamic and kinetic information can be extracted from this as explained by Dyer. Practically, a series of selectivity data can be gained from the zeolites that relate its selectivity to different ions. For example, synthetic zeolite Y shows the ion preference series: Cs>Rb>K>Na>Li, whereas for synthetic zeolite X: Na>K>Rb>Cs>Li. These zeolites possess the same structure but differ in the overall charge on the cage.

7. DISCUSSION AND CONCLUSION

Zeolites are a class of naturally occurring crystalline pourous alumino-silcates. The first mineral to be classified as a zeolite was discovered in 1756 from volcanic rocks, since when about 48 natural zeolite types have been identified, in addition to about 150 synthetic species, with possibly more based upon structural definitions. Many of the naturally occurring zeolites can be created synthetically. These are unique materials with many highly important applications, particularly in environmental chemistry. The description of zeolites is important for several reasons: first, it provides quantitative information about the effectiveness of a zeolite’s performance. Secondly, a wealth of thermodynamic and kinetic information can be extracted. In Romania there are many occurrences of Badenian zeolitic tuffs. The creation of the isotherms allows the exploitation of zeolites in several applications. For example, there is a constant need to remove protein breakdown products from wastewater. Some areas of the world where naturally occurring zeolites clinoptilolite, and phillipsite are found; they have been employed in the effective removal of ammonia and ammonium ions from aqueous effluent [5]. The control of pH is related to the ability of the zeolite to function as a slow-release agent to improve nitrogen retention in the soil. Adding a zeolite to soil adds a high capacity selective exchanger. Finally, Emadi, et al. have reported that clinoptilolite is much more effective than carbon in removing ammonia from aquatic fish environments. This has important consequences since the ammonia concentration in aquatic environments is vital to several physiological factors of fish such as growth rate, oxygen consumption, and disease resistance.

REFERENCES

[1]. Gheorghe Damian, Floarea Damian, Gheorghe Macovei, Ciprian Constantina & Gheorghe Iepure – *Zeolitic tuffs from Costiui zone - Maramures basin*, Carpathian Journal of Earth and Environmental Sciences, Vol. 2, No. 1, p. 59 – 74;

[2]. Geankoplis, C.J. – *Transport Processes and Unit Operations*, 3rd Ed. Prentice-Hall, New York, 1993;

[3]. Dyer A. – *Zeolite Molecular Sieves*, Wiley, Chichester, 1988;

[4]. Szostak R. – *Molecular Sieves*, Principles of Synthesis and Identification, Van Nostrand Reinhold, New York, 1989;

[5]. Robert L. Virta – *Zeolites* – Minerals Yearbook, USGS, 2005;

[6]. Marcus B.K., Cormier, W.E. – *Going Green with Zeolites*, Chemical Engineering Progress. June 1999;

[7]. *Zeolite*, *A Versatile Air Pollutant Adsorber,* EPA Technical Bulletin 456/F-98-004, July 1998;

[8]. http://www.uvm.edu/~ssolberg/Startside.html

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CURRENT ISSUES OF THE CONCURRENCIES MARKET IN BUSINESS ENGINEERING ACCEPTANCE

CATRINA IOANA*

1. GENERALITIES

In the current context, globalization involves awareness and action / reaction reporting of all social, political and economic level to the movement for creating unified market both regional and global. Globalization means the process by which distances between countries and continents including borders are not relevant in establishing and developing economic and socio-cultural cross-border relations. Thus, the relationships and dependencies acquire a potential support in an effort to capture the international character and global dimensions. With the development of new technologies and strategies for sustainable development and application solutions at the international level, the phenomenon of globalization acquires a greater relevance.

In these conditions, globalization generates in some situations and risks, due to the dynamics of the deployment process of globalization that some countries integrate quickly to new conditions while others can not keep up and show erratic and ineffective.

Countries and companies that can become competent members of the global recorded remarkable economic growth while those that do not meet required levels of performance remain the same stage or even disappear from the market.

Seizures recorded at the level of countries of Latin America have shown that opportunities associated with globalization entails risks from volatile capital movements, plus the risks of economic, social and even loss of markets already acquired.

2. THE CONCURRENCIES MARKET ISSUES

The new economy must be dynamic, innovative and conducted in accordance with unpredictable changes, the expansion of the use of science in the sphere of basic services. The digital economy aimed at developing production and services assisted information on and off line. New economy involves the interaction of the information economy and the digital economy in order to increase the special production and sales,

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**Lecturer PhD. Ec. - University of „Titu Maiorescu" Bucharest – Tg.-Jiu branch*

low inflation and unemployment. The concept, descriptor of the new economy, describes a productive connected with the competitive market in which the final products containing a dose of information that provides access to the global scale and allow enhanced efficiency in conventional business practices to create financial base for emergence of new processes and produced high resolution. Switching to the digital economy warns the companies to mobilize resources so as to face new opportunities and to overcome the restrictions of the new business model non-conventional.

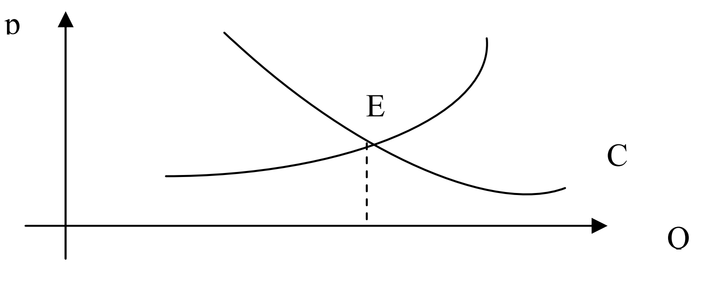
This guidance aims to overcome competition whereas consumers have broad access to information, products, and services, in terms of improving the purchasing power. This fact has a support based on the exchange of power from producer to consumer on the merits of reducing the ability of sellers to impose price not covered by the value of goods and services.

The digital economy (electronic) is a complex process that allows the development of processes and systems business based on analysis of operating performance data.

In this way the assisted competitive market information will cause a severe selection from the suppliers of goods and services worldwide. The competitive price and quality that will develop that will benefit uncompetitive to bear the risk policy from production to the total elimination of the competitive market created new concept of globalization in international relations. Practice has shown that global penetration and remain on the electronic regional economic agents is possible only if the prices fall between the globalize market (30 ÷ 50)% compared to prices on a traditional market.

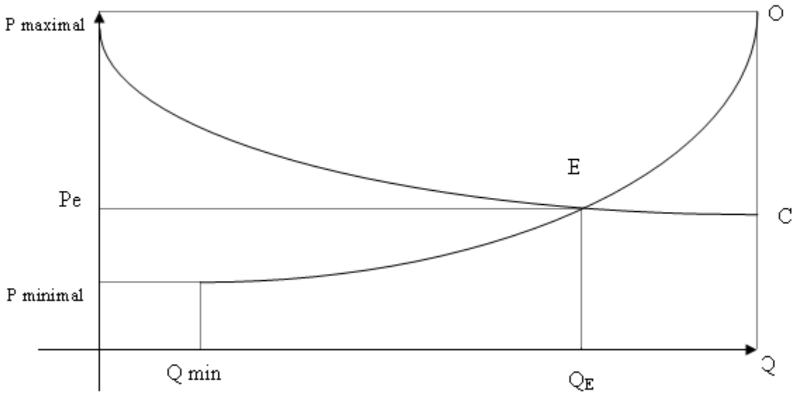
The mechanism of the competitive market given by the demand, supply and price compose the balance of the amount requested by the consumer goods and offer total includes all goods destined for buyers. Correlation supply-demand balance determines the price (the market balance for this product. Graphic representation of the application (C), supply (A), the coordinated price (p) and quantity (Q) is presented in label. 1.

E = equilibrium point E



Label. 1. Graphic representation of application - offer to evaluate the price balance

Uncorrelating the application in time with the bid, generates technological and commercial risks. The risks can be prevented if is made correlations between the demands - supply and prices (maximum, and minimum). Graphic representations of these correlations are presented in label 2.



Label. 2 – Determination of equilibrium point (E)
- $P_{maximal}$ > supplier protection → supplier protection
- $P_{minimal}$ < consumer protection → supplier protection

In a market economy are two competitive systems, namely pure competition (perfect) and imperfect competition.

Pure competition (perfect), leads to an increase in the number of economic agents participating in linking supply with demand for products. Bidders and consumers are in equal numbers with the market. The products on the market have the same features and a utility which allows free entry and exit of goods on the market. Perfect competition allows full transparency of the market (suppliers and buyers are fully informed on goods and prices) and facilitates perfect mobility of factors of production (capital and labor are directed towards profitable activities, profits and higher wages).

Imperfect competition creates a distinction between the producers and consumers, the products are not identical utilities, market transparency is disturbed, and the mobility of capital and labor does not realize the circuit of high efficiency. Market with monopolistic competition has a large number of producers that do not affect the activities of mutual own decisions.

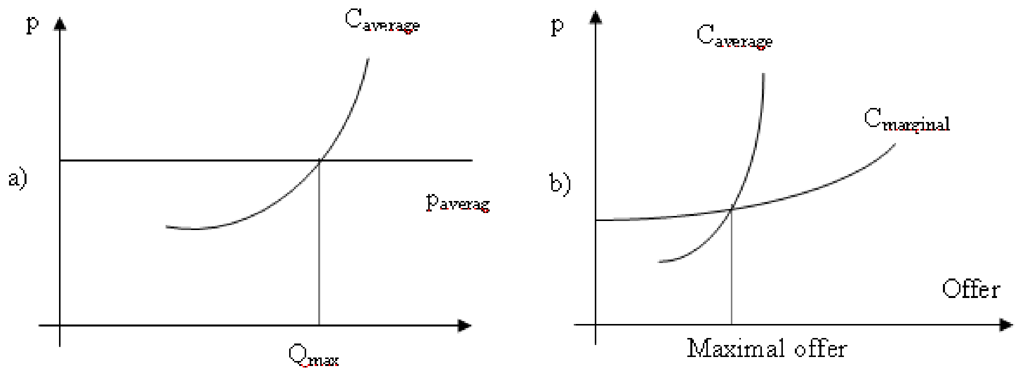
Also, the market is not homogeneous, namely the goods have identical features and consumers have assets diffuseness of goods abundance.

In these circumstances the profitability depends on the policies applied in production practice. These policies are built taking into account the behavior of society in terms of competition (perfect and imperfect), depending on the behavior of consumers quantified by the curves of indifference by the demand and position the balance of those who take the products from the market.

To meet the requirements of consumers each manufacturer must shape behavior and taking account of the competition pure (perfect) ensure uniformity of products (C = 0), free entry and exit the market, the transparency issue under perfect information and total mobility factors production which allows manufacturers equal footing in the market.

In such situations manufacturers can design a strategy to ensure maximum profit (label. 3ab) (profit = $V_{total} - C_{total}$ = maxim).

The profit maximization is based on variables had available by the manufacturer (the quantity of products, the price of each product and production costs).



Label. 3 a. b. – Cost correlations with competitive prices

At the intersection of average cost (cm) with the average price (pm) to obtain the quantity of products that maximizes production (Q) max. Maximum bid is obtained at the intersection with the average cost marginal (Cmarginal).

The manufacturer behavior to the imperfect competition (heterogeneous products, lack of information on purchases and limited mobility of factors of production) is determined according to the price of products related to balance producer. The price, in the imperfect competition with values greater than that of perfect competition which amended the required quantity of products on the market. The production which can be used on imperfect market at prices higher than marginal costs may be optimal even if not used throughout the production capacity. Optimum conditions for the competition may be imperfect: maximizing turnover, rational use of resources, increase product quality that distinguishes the existing ones on the market, etc.

3. THE MECHANISM OF BUSINESS ENGINEERING

The business engineering is a complex activity that seeks the design work on a new design approach of our production - the market in the context of a production quality and marketing profits.

Any business involves carrying out the following stages:

- Prospecting appropriate framework for the design and conduct business on the basis of information gained in the theoretical-practical application of theory and the theory of search prognosis explorative and the normative one;

- Needs study in order to schedule products that will be sold without restrictions. This desideratum reclaims a market study in order of acquisition of resources in economic conditions and effective training of the human factor that the new products will be required to make the offer prices competitive;

- Negotiation of prices so as to satisfy parts of the business both quantitatively and qualitatively;
- Establish levels of quality and price negotiated to satisfy customers in real time;
- Closing a profitable business and developing strategy for development cooperation with both business customers and products sold to new products required by the competitive market.

At any type of business it should be conducted on the basis of a project of the customer.

The scheme of links between customer and supplier includes investor who initiates the project, the implementation of the project (builder, contractor, service provider) and provider resources. In this context, the engineer seeks business risk that may arise and seek means of prevention. It must invent technical and commercial solutions and monitor the implementation of their entire production-chain sales, the collection of deserved amounts of companies from the started business.

The business engineer comprises four features, namely: the mission, responsible relations and criteria for evaluating the performance.

In all cases the business engineer is responsible for business operations and management track results taking into account both its own logistics and taking into account the requirements of customers.

Steps for an engineer to cover through the business are:

1. The prospecting stage reclaims analyzing successes and failures of previous businesses, seeking new business opportunities and establishes contacts with new customers in competitive market conditions.
2. The study step reclaims research processes and decisions made by the customer into the true needs of theirs. Display and sale of new business proposal in the entourage own consulting suppliers and drafting an offer adaptable and seducing after which the team is preparing for performers who will begin work after the arrival of command.
3. The negotiation step tracks processing contacts in profitable contracts based on creating customer at a climate of partnership (trust, loyalty, collaboration).
4. The business post sales outline step starts with a new business by preparing documentation for new customers. At the end of last stage of the business to draw up the balance sheet of commercial operations performed and received contract.

In all phases of the business engineer is present under three main aspects: the appearance of commercial, technical design and design management steering.

In response to current issues of market competition, the business engineer should have the following features: enterprise, and animal trainer of the team, the initiator of rational decisions, show no aversion to risk, to lead the team effectively, to ensure profits and profitability the company to provide confidence both to the company's owners and the workers who contact customers and achieved profitable business, generating solutions for overcoming the bankruptcy, to print an atmosphere of cooperation based on effective communication and understanding, to drive to work Sales at competitive prices in that market conquest, to optimize the work taking into account the capabilities and skills in the business of all members of that team boss is an example to follow.

CONCLUSIONS

- Globalization generates economic growth but also great risks due to the competitive dynamics of the market economy;
- The competitive market is very complex mechanism involving a study of the market and participants in business processes;
- Profitability of enterprises in the current situation depends on policies implemented in practice production, taking into account the behavior of society in terms of competition, the behavior of consumers and the balance of those who take the products on the market;
- The advanced technologies, the disappearance of boundaries between national markets and changing customer requirements show managerial failures of the big concerns that lead to crisis.

BIBLIOGRAPHY

[1]. J. Bari – *Globalization and global issues,* Editura Economică, Bucureşti 2001.

[2]. Ovidiu Niculescu – *Systems, methods and organization management techniques Sisteme, metode şi tehnici manageriale ale organizației,* Editura Economică, Bucureşti 2000.

[3]. *** - *Expert commentary article – The advent of Risk Management Websites,* http://www.imi.cam/expert/articles/2000.

[4]. *** - *Knowledge Management, of the Scientific Project and Innovation*. Support for training, Editura Sudura, Timişoara 2003.

Index of authors

Instructions for Authors

THE TITLE OF THE PAPER WILL BE WRITTEN WITH CAPITAL LETTERS, CENTERED, AT 7.0 cm FROM THE UPPER EDGE OF A4 FORMAT, ALONG THE ENTIRE WIDTH, TIMES NEW ROMAN, 14 POINTS, BOLD.

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The first name and the family name will be written with CAPITAL LETTERS, BOLD, CENTERED, 130 mm width, Times New Roman, 12 points, being followed by asterisks, *and in the footnote the didactic and scientific degree, the position and place of work of the authors are indicated, with italics, 130 mm width, Times New Roman, 11 points.**

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<Tab> **ABSTRACT:** (Capital letters, Times New Roman, 10 points, bold) *The Abstract will only be in English and will have between 50 and 100 words, arranged all over the entire width, single, left – right alignment, all over the width of the printed space, Times New Roman, italics, 10 points.*

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1. THE TITLE OF THE CHAPTER IS WRITTEN WITH CAPITAL LETTERS, BOLD, TIMES NEW ROMAN, 11 POINTS AND WILL BE NUMBERED WITH ARABIC NUMBERS.

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* *Prof., Ph.D., University of Petroşani, Romania*

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1.1 Subchapter. Subchapters can be used in the text, numbered with the number of the chapter and a number showing the number of the subtitle within the chapter. The subchapters are Times New Roman, 11 points, bold.

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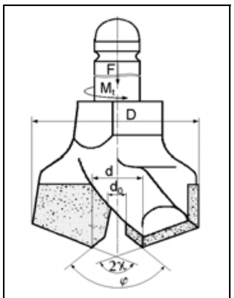

Figure 1. Detachable bit

2. PRESENTATION OF THE FIGURES

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The mathematical equations will be with Times New Roman, 11 points, center of the page and numbered on the right with Arabic numbers between round brackets.

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$$X^2 + Y^2 = Z^2 \qquad (1)$$

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[1]. Dardac, N.; Barbu, T. - *Monedă, bănci şi politici monetare*, Editura Didactică şi Pedagogică, Bucureşti, 2005

[2]. Greuning, H.; Bratanovic, S. - *Analyzing and Managing Banking Risk*, The World Bank, Washington, 2003

[3]. *** - European Private Equity & Venture Capital Association (EVCA) - *Annual Survey of Pan-European Private Equity & Venture Capital Activity*, Yearbook 2007