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CONTENTS

A NEW APPROACH OF THE CALCULUS OF THE MINERAL RESOURCES OF A DEPOSIT

DOBRITOIU NICOLAE [1]

EPITOME. From experience and scientific references it is known that during information processing, the following error types are transmitted: technical, analogy errors and method errors. For decreasing the value of these errors, especially of the method ones, old algorithms should be perfected and new ones should be developed for processing, interpreting and achieving the graphical layout by means of automatic data processing.

In this respect, we propose a new deposit model based on numeric mathematical modelling which requires the use of automatic data processing. The utilization of the numeric model of the proposed deposit, allows the obtaining of the following advantages:

-the model is used for any deposit form;
-it is used for the calculation of deposit resources (volume, weight, and content);
-it is used in design due to the facility of obtaining sections through the deposits area;
-it eliminates at "0" the errors of graphical data transcription;
-the use of the model imposes a uniform geological research;
-the algorithm is transposed in a package of programs.

KEY WORDS: model, modelation, the smallest squares method.

1.GENERALITIES

The calculation of the geological reserves is preceded by a large number of operations and studies, of office and on site activities carried out by geologists, engineers, topographers, technicians and workers. Therefore, one can say that, on the whole, the calculation of the geological reserves of a deposit represents the corollary of a vast theoretical, design, interpretation and practical execution activity throughout a long period of time with a considerable consumption of material goods and manpower. The results of the various stages of the geological and technological research are closely interrelated and their positive or negative impact can, in the end, determine the

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accuracy of the results of the determination of the reserves and the capitalization of the deposit.

In calculating the reserves, both standard and geometrical methods can be applied making use of the parameters determined through usual methods or through statistical-mathematical or geostatistical calculations.

Throughout the process of capitalization of a deposit of available mineral substances the data derived from the model used in the description of the deposit underlie the decision making referring to the choosing of the opening, preparation and operation scheme, to the choosing of the technologies of execution of underground and surface mining constructions as well as to the choosing of operation technologies. As a result of the considerable implications these decisions have for the process of capitalization of a deposit, it is necessary for the data base provided by the model used in the description of a deposit to meet the needs and the requirements of the user and to provide highly accurate data at a cost as low as possible.

Research work conducted in the field has led to the development of new deposit models based on numerical modelling enabling, at the same time, their use in computer-aided design. Such a numerical deposit model has been developed by a research team of the University of Petrosani, a model which can be used in the modelling of all the types of deposits.

In order to promote nationwide and worldwide communications in the field of capitalization of available mineral substance deposits, the paper will resort to the specialized terminology provided for in “UN International Framework for the Classification of Reserves/Resources - Solid Fuels and Mineral Products” proposed and conceived by “The EEC/UN Coal Working Group” and which was approved of on the seventh session held in Geneve from 3 to 5 November 1997.

This classification provides information on reserves/resources depending on:

- the stage of the geological evaluation;
- the stage of the feasibility evaluation;
- the degree of the economic viability.

As a result of the complexity of the problem under consideration, the paper will further on deal with the calculation of the reserve of available mineral substances existing in a reserve unit only from the point of view of the stage of the geological evaluation.

2. DETERMINATION OF THE PARAMETERS NECESSARY FOR THE CALCULATION OF RESERVES IN A DEPOSIT UNIT

The determination of the volume of the available mineral reserve of a reserve unit implies the knowledge of the following data:

- the geometric parameters describing the reserve unit;
- the quality characteristics of the reserve;
- volumetric weight.

Practical activity and literature on this field show various methods of determining the values of the parameters necessary for the calculation of the reserve contained within a reserve unit.

Thickness Determination

The thickness of sedimentary deposits is determined through direct measurements and calculations, as a rule in natural openings, in surface mining workings, in underground mining workings or on the basis of the data obtained from drilling workings. By means of such workings, one can determine in the respective places the vertical, horizontal or normal thicknesses depending on the kind of geological survey workings.

For mineral deposits thickness can be determined by means of two methods:

- the direct method, most frequently used, is applied when mineral bodies show well-defined limits in relation to the environment (planes of separation between the deposit and surrounding rocks);

- the indirect method which is used when there are no separation planes between the deposit and the surrounding rocks; it includes the following variants:

1.determination of thickness on the basis of the data obtained from chemical analyses of the collected samples as well as on the basis of a limited content of contour.

2.determination of thickness on the basis of geophysical core-sampling.

The values obtained by means of the two foregoing methods of measurement have a different degree of accuracy: through direct measurement, thickness can be determined with an admissible error of 1 cm while in the case of indirect methods errors are much more serious.

The average thickness of a unit of calculation is determined as an arithmetical mean or as a weighted arithmetical mean.

Observations.

1. The values of the thickness of a deposit of available mineral substances used for the calculation of reserves represent mean values;

2. Within a reserve unit belonging to a deposit, thickness can be a constant value, it can vary uniformly or non-uniformly along the direction or inclination;

3. In the case of reserve units showing non-uniform variations of thickness, special mathematical methods can be used in order to determine the laws of thickness variation along the direction and inclination, and they can be used to determine a mean value close to the true one.

Determination of the Value of the Surface of a Reserve Unit

It is known from practice that the shape of the contour which marks the bounds of the surface of a reserve unit and the latter's value are known with a certain degree of approximation depending on the extent of its survey.

In order to determine the shape of the contour and the value of the surface of a reserve unit the following have to be solved:

- determination of the plane marking the boundaries of the surface;

- specification of the way of determining the contour of the body of available mineral substance;

- delineation of the surfaces to be calculated and determination of their areas.

The position of the projection plane within which lies the surface of the mineral body is recommendable to be as close as possible to the position of the deposit plane. The projection plane is chosen depending on the shape of the body of available mineral substance and on its inclination, thus:

- the surface of the tabular or lenticular-shaped mineral body is delineated in a vertical plane at great inclination, in a horizontal plane at a low inclination and in the median plane of the mineral body in the case of medium inclination;

- the surface of the isometric or column-shaped mineral body is delineated either in the horizontal or vertical plane, depending on the network of exploration workings.

In all the cases, the shape of the reserve unit and the geometry of the units of calculation of reserves are to be determined as clearly as possible. In order to best point out the shape of the reserve unit of available mineral substances, horizontal and vertical sections are executed maintaining the distance between these sections constant, if posssible.

More often than not, in geological survey, the reserve units of available mineral substances cannot be traced continuously by exploring the deposit but by crossing at various points making use of underground mining workings and drills or by using both types of workings while the crossing points are not uniformly distributed within the deposit, and in some places there are missing altogether. In such cases, the determination of the boundaries of the reserve units of available mineral substances becomes complicated because the boundaries lie outside the points of knowledge and the determination of the contour in these cases cannot be achieved accurately. The contour through the extreme points of interception by workings is called INTERIOR CONTOUR and it is sufficiently accurate being also known as INTERPOLATION CONTOUR. The contour determined outside the extreme knowledge points is called EXTERIOR CONTOUR or EXTRAPOLATION CONTOUR.

The exterior contour is traced outside the extreme points of knowledge of the deposit (outside the crossing points) and there are two different cases:

1. the determination of the exterior contour between the extreme workings with positive results and workings outside these with negative results where no deposit was found.

2. the determination of the exterior contour outside the positive extreme workings, without the existence of exterior workings with negative results.

When determining the exterior contour between workings with and without a deposit, two methods are generally used:

The most widely used methods in order to determine the value of the area bordered by a contour traced by using the foregoing procedures are: the measurement by planimeter,by abacus and calculation by means of geometrical relations.

According to the literature on the field, when measuring by planimeter, the difference between the readings out of which the average is calculated must not exceed

5% and the readings are repeated until this condition is met. When measuring by abacus one calculates the average between 2-4 measurements performed with the abacus held in different positions, the scale of the abacus has to be correlated with the scale of the plane of the surface to be measured.

Observations.

1. The determination of the exterior contours using the two procedures can be performed with an error that cannot be known because the distance d_i, from the points with deposits to those without deposits, does not represent the real distance from the point where the deposit was intercepted and the point belonging to the same alignment lying at the boundary between the deposit and the surrounding rocks.

2. The points of knowledge belonging to the exterior contour determined by the two procedures are linked with segments of a straight line or curves.

Determination of Volumetric Weight

The weight of the volume unit of the available mineral substances is also a parameter for the calculation of the reserve without excluding gaps and porosity, unlike specific weight defined as the weight of the volume unit of the compact available mineral substance (without gaps and porosity).

The determination of the volumetric weight can be performed either in the laboratory or on the site. The samples for the determination of the volumetric weight have to be collected systematically and the mean value is calculated as arithmetic mean. In order to avoid errors, it is necessary for the results of the determinations to be expressed in two decimals.

It is recommended that the same samples should be used to determine the humidity value as well as for chemical analyses, besides the determination of volumetric weight, while in the case of ores, porous and cavernous rocks, the determination of the absorption value should also be made.

Observations.

1. The values of the volumetric weight used for calculating reserves represent approximate mean values.

2. On account of the fact that there are no perfectly homogeneous environments in nature it results that the volumetric weight has different values in different points of knowledge.

3. By means of special mathematical methods it is possible to determine a law describing the variation of the volumetric weight within the deposit.

Determination of the Values of Quality Characteristics

The most important question which applied geological research is called upon to answer is whether the mineral substance is really available and in what field of activity this substance can become a raw material in all or through a part of its components.

Qualitative characteristics are expressed and determined depending on the nature of the available mineral substance and on the way in which it is turned to good account. Thus, the available mineral substances that are capitalized thoroughly as raw materials such as: coals, construction rocks, ornamental rocks and some non-metalliferous available minerals the content of available components is not calculated. However, in this case it is average qualitative characteristics that are determined such as: caloric power, percentage of ash, resistance to mechanical effort, elasticity, fissure degree, shades of colours, etc., all resulting from several thermic, physical-mechanical, ceramic and fireproof tests. These mean values do not represent parameters for calculating reserves but quality indicators.

In the case of deposits whose available mineral substances are extracted for capitalizing on one or several main and secondary components contents are calculated for all the components, useful and noxious ones as well as for the main and secondary ones. These contents represent parameters for the calculation of the reserves of available components of mineral reserves.

The qualitative parameters of a mineral substance are determined through chemical analyses which, according to the intended purpose, can be:

- thorough analyses;
- basic, normal analyses;
- analyses of internal check-up;
- analyses of external check-up.

As quality parameters are decision-making factors in the extraction activity it results that the following procedures should be taken into account in exploration practical activity:

- there should be a systematic check-up of analyses;
- the duplicates of the samples and of the material left over after basic analyses should be preserved;
- the external check-up should be carried out in an external laboratory by highly qualified staff;
- arbitration analyses should be carried out;
- the external check-up will verify the way of working at the base laboratory, suggesting steps for the improvement of the activity;
- the results of the check-up will be carefully debated on in order to draw the right conclusions.

The contents, as values calculated on the basis of the analyses data of the representative samples collected systematically from survey activities are calculated step by step, by sections of sampling, by exploration workings, by surfaces (sections) outlined by workings in the reserve unit by calculation units of reserves (panels, blocks, steps, etc.), by categories of reserves, etc.

For the calculation of the mean value of a quality parameter various methods of calculation are used such as: the arithmetical mean; the weighted arithmetical mean (with the sample length, the length of the survey working, by block or panel section, by thickness).

Observation.

For each type of survey working there is a methodology for the collection of samples and a method for the calculation of the mean value of the quality parameter;

On account of the observations made about the methods used for the determination of every type of parameter, we think it necessary to conceive a new model of a deposit capable of solving the observations made. To this effect, such a model has been conceived and it does solve the foregoing observations.

The Numerical Deposit Model

The numerical deposit model has a modular construction, a module which solves a certain group of problems that occurred in the process of modelling a deposit.

The main modules are:

- the module “the numerical model of the block-reserve unit ”;
- the module “the numerical model of the deposit reserve unit”;
- the module “the numerical model of the geological block”;
- the module “the numerical model of the mining field or of the deposit”.

The modules are also made up of submodules which in their turn solve, each of them, a subgroup of problems. Here is the example of the module “the numerical model of the block-reserve unit” which consists of the following submodules:

- the submodule “geometrical parameters of the block-reserve unit”;
- the submodule “qualitative parameters of the available mineral substance belonging to the block-reserve unit”;
- the submodule “the calculation of the available mineral substance reserves of a block-reserve unit”;
- the submodule “physical-mechanical parameters of the available mineral substance of the block-reserve unit”;
- the submodule “hydrodynamic parameters of the block-reserve unit”;
- the submodule “gasodynamic parameters of the block-reserve unit”;
- the submodule “the parameters of the environment of the block-reserve unit”.

As it can be noticed, a new submodel is created for calculating the existing reserves of a reserve unit and it makes use of data provided by all the submodules of the module “the numerical model of the block-reserve unit”.

The numerical model suggested for describing a deposit brings forth the following new approaches in the fields below:

- the way of determining the points belonging to a cross-section in a reserve unit;
- the way of determining the geometrical parameters of the reserve unit (thickness, length, surface, volume, etc.);
- the way of determining the values of quality parameters of a reserve unit;
- the way of systematizing data.

As the shape of a reserve unit is of utmost importance for the knowledge of a reserve unit, the suggested deposit model is based on an algorithm of thickening of the points of knowledge belonging to a section, (points of knowledge arrived at in the process of getting to know the deposit). provides an outline of this algorithm.

The data provided by the numerical model of the deposit represent synthetic data based on the analytical data arrived at in the process of finding the characteristics of the deposit. Here are some of the advantages of this model:

- automated processing of data;
- impossibility of data loss during data processing;
- there are no calculation errors;
- quick upgrading of database in order to improve the process of surveying the deposit;
- it enables the determination of the zones of a reserve unit which can be the object of reserve capitalization;
- it enables the tracing of the movements of reserves from one group of reserves to another;
- it enables various simulations depending on the task to be achieved.

3. METHODS OF CALCULATION OF THE RESERVE OF AVAILABLE MINERAL SUBSTANCES OF A DEPOSIT UNIT

The process of knowledge of a deposit is made up of the following stages:

- the stage of deposit survey, which aims at obtaining data necessary for the knowledge of the deposit by means of survey workings;
- the data processing stage, which involves: the determination of several sets of parameters which describe each field of knowledge description, the determination of the values of the parameters for each set of parameters separately and the determination of the dynamics of these values in time and space;
- the stage of interpretation and evaluation of the results of data processing, which takes place after each phase of survey and data processing and it aims at determining the degree of knowledge of the deposit from a geological, economic and feasibility point of view in order to determine whether it is opportune either to continue or stop the workings of deposit survey.

Literature on the field points out the following methods of calculation of the reserves of available mineral substances:

- the method of arithmetic mean;
- the method of geological blocks;
- the method of exploitation blocks;
- the method of sections (parallel vertical, non-parallel vertical, horizontal);
- the method of polygons;
- the method of polyhedrons (triangular or quadrilateral);
- the method of isolines;
- the method of isohypses.

On the whole, the deposit numerical model proposed to be used in the description and evaluation of a deposit, can provide information referring to the calculation of reserves in the case of the following methods:

- the method of sections (parallel vertical, non-parallel vertical, horizontal);
- the method of isolines (whose outline is presented further on);
- the method of isohypses.

Observation.

Through the development of the model of description and evaluation of a reserve unit any method of calculation of the reserve can be used but accuracy can vary from one method to another.

As the isoline method is the most representative of the group of three methods proposed to be used, it will be outlined further on.

The method of isolines

It is used for determining the volume and reserve of a body of available mineral substance of a complex shape. The body of the deposit of available mineral substance is bounded in all directions by uneven complicated surfaces and it virtually changes into an equivalent volume body, bounded on one side by a plane surface and by a topographical surface for the rest. The method consists in making vertical or horizontal sections, along direction or inclination, through the deposit body. The sections are made on the basis of the isolines of the body.

One of the characteristics of the sections is that they are made at equal distances from each other and the distance from the contour of the deposit body, measured perpendicularly to the first or last section, has to be equal to the distance between sections.

The relations of the calculation of the volume of a deposit unit are:

1. The formula of approximate integration (Simpson's formula):

$$V = \frac{h}{3}(S_0 + S_n + 4\sigma_1 + 2\sigma_2 + \sum S_m)$$

where: - h represents the distance between sections;

- $\sigma_1 = S_1 + S_3 + \ldots + S_{2n-1}$;
- $\sigma_2 = S_2 + S_4 + \ldots + S_{2n}$;
- S_0, the surface bounded by the contour of the section nr. 0;
- $S_1, S_2, \ldots, S_n$, the surfaces bounded by the contours of the respective sections;
- S_m, the surface bounding the marginal prominences and depressions of the system of the section contours (elevations marked "+" and depressions "-").

2. The formula of the frustum of a cone:

$$V = \frac{h}{3}\sum(S_{n-1} + S_n + \sqrt{S_{n-1} \cdot S_n} \pm S_m)$$

3. The formula of the trapezium:

$$V = h\left(\frac{S_0}{2} + \sum_{1}^{n-1} S_n + \frac{S_n}{2} \pm \sum \frac{S_m}{3}\right).$$

In order to determine the values of the sections necessary to apply the three relations for calculating the volume of the reserve unit covered by the overall surface described by the sections of the contours, the following procedures are observed:

- TXT-type files describing section contours are transposed into DWG-type graphic files by being read with the help of a reading program by the programming medium (“AutoCAD 2000”);

- using the “AREA” command each contour is selected separately and the values of the sections of the selected contours are recorded.

Observation.

The “AREA” command of the “AutoCAD 2000” medium of data graphic processing used to determine the value of the area of a section requires that the values of the Z coordinate of the points crossed by the contour line bounding the surface whose area is to be calculated should be constant. In order to determine the volume of a body of available mineral substance the use of horizontal sections is to be preferred and when horizontal sections are not available, the ones that are available will be rotated to be brought to planes parallel to XOY plane.

If the values of the section areas are introduced in the relation for calculating the volume of a body, the volume covered by the contours of these sections can be determined.

The reserve of available mineral substance is determined using the relation:

$R=V*\gamma$, [t]

where: γ represents the average of the volumetric weight of the available mineral substance (t/m^3).

PRACTICAL EXAMPLE

We have the results of a geological survey carried out for a reserve unit belonging to a deposit through a network of drillings in 100-metre-side squares. The results of the geological survey referring to the calculation of the geometrical parameters, after they were interpreted by specialists, were systematized in six fields which represent the contours of the sections resulting from the intersection of the horizontal planes, of a height multiple of 100 m, with the surveyed reserve unit (C1.TXT, C2.TXT,…,C6.TXT). The arrangement of the data in the file is given by the clockwise linking of the points making up the section contour. The graphic transposition of these points situated on the contour of the section at height Z=100 is shown in Fig. 1.

With the help of the iterative algorithm of thickening of the points on a contour section, C1.TXT file comprising 25 points becomes C13.TXT file, after three iterations, comprising 222 points. The plotting is shown in Fig. 2. Fig. 3 shows a detail in Fig. 2 of the zone of points 14,15,16,17

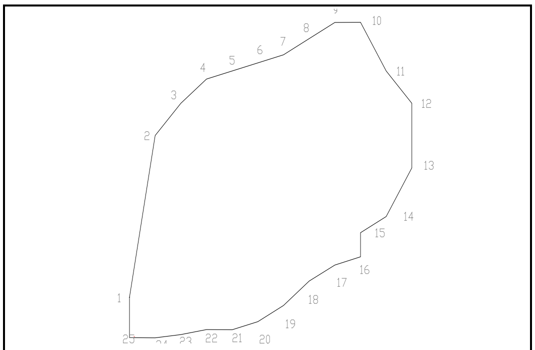

Fig. 1

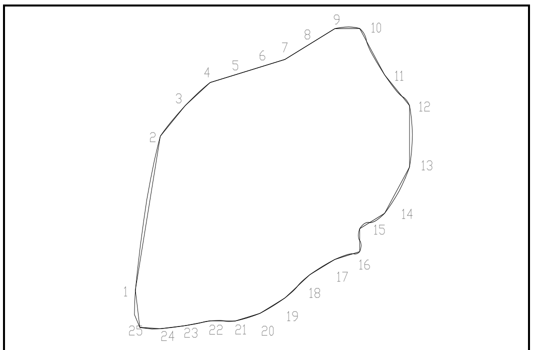

Fig.2

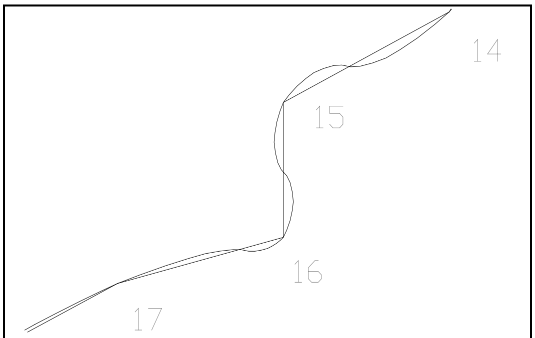

Fig. 3

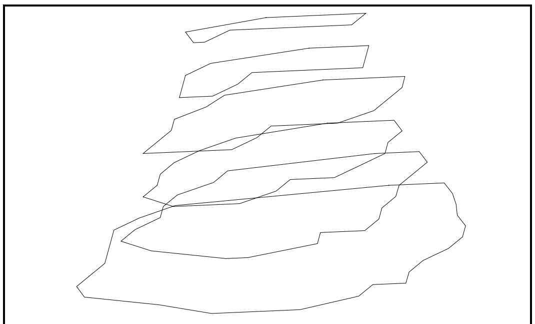

Fig. 4

Next, the iterative algorithm for the thickening of the points situated on a contour is applied for each file separately and the results obtained after iteration 3 is recorded.

The graphic transpositions of the six contours obtained after geological survey are shown in Fig. 4, while the plottings of the contours resulting from the thickening of the points situated on the contour after iteration 3 are shown in Fig. 5.

Using the “AREA” command of the “AutoCAD 2000” program package, we obtain the following values of the section surfaces bounded by the six contours before and after thickening shown in Table 1.

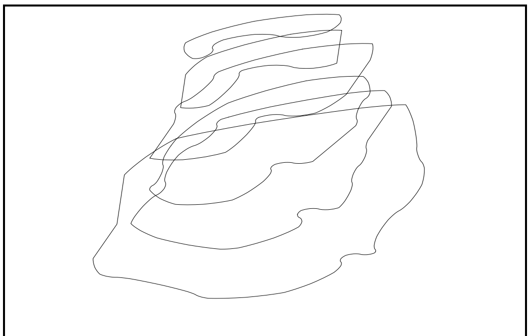

Fig. 5

Table 1

Section	Normal contour section (m^2)	Contour section after iteration 3 (m^2)
S0	728950	736488,3557
S1	392525	399721,9903
S2	252575	257928,8953
S3	197800	205059,9622
S4	85500	89050,2125
S5	36250	42037,0786

The plottings of the deposit unit in Fig. 5 are intersected with vertical planes parallel to the ZOY vertical plane which cross the points of $M_1(200, 0, 0)$, $M_2(300, 0, 0)$,…, $M_{11}(1200, 0, 0)$ coordinates thus obtaining 11 files which represent the contours of the sections resulting from the intersections. The 11 TXT-type files undergo a processing procedure in order to thicken the points on contours. The plotting of the two sets of contours are shown in Figs. 6 and 7.

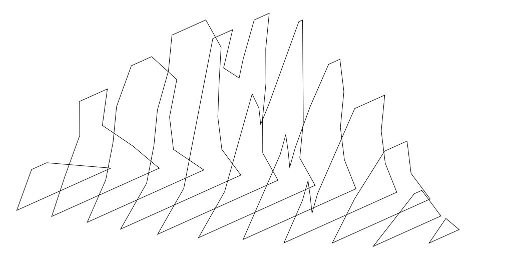

Fig.6

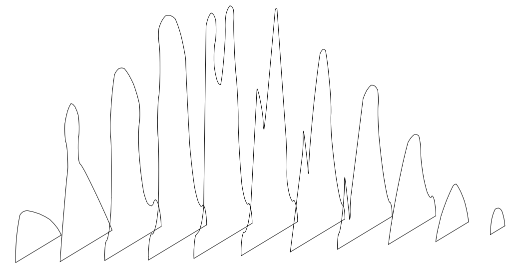

Fig. 7

Table 2 shows the values of the surfaces described by the contours whose plottings are shown in Figs. 6 and 7.

Table 2

Section	Normal contour section (m^2)	Contour section after iteration 3 (m^2)
S0	36300,0000	42724,6022
S1	105075,0000	110061,1974
S2	168100,0000	173819,6955
S3	219750,0000	225002,7983
S4	226841,3350	230266,1178
S5	177820,9100	179824,5042
S6	153817,3100	154889,4367

S7	127580,2500	130159,6416
S8	77500,0000	80194,2356
S9	25000,0000	29363,3624
S10	4987,5000	7618,1119

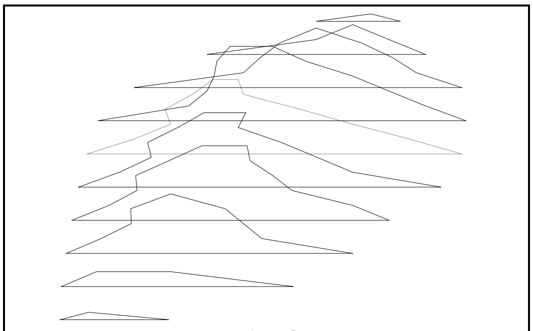

Fig. 8

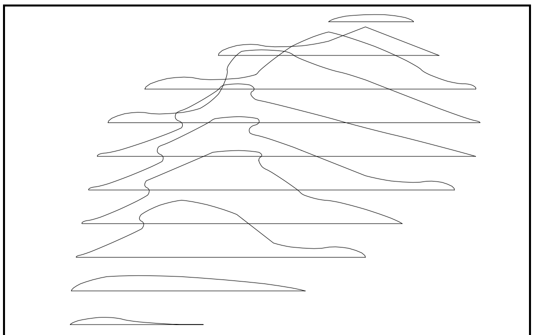

Fig. 9

In order to obtain a more detailed knowledge of the reserve unit under consideration, the body shown in Fig. 5 is intersected with planes parallel to ZOX and which cross the $M_1(0, 150, 0)$, $M_2(0, 250, 0)$, …, $M_{10}(0, 1050, 0)$ coordinate points obtaining 10 sections whose points on the contours are systematized in TXT-type files which are plotted in Fig. 8. The 10 files will be processed using the thickening algorithm of the points thus obtaining another 10 files of the TXT-type whose plotting is shown in Fig. 9

Table 3 shows the values of the surfaces described by the contours whose plottings are shown in Figs. 8 and 9.

Table 3

Section	Normal contour section (m^2)	Contour section after iteration 3 (m^2)
S0	7441.9175	7783.8664
S1	4199.5700	48164.2964
S2	140182.6700	146666.2407
S3	219191.1600	260662.2094
S4	218370.9900	221949.7538
S5	231677.5950	231893.7438
S6	233895.3900	238342.9720
S7	151438.1500	159238.7350
S8	50000.0000	55256.3725
S9	5776.8125	8882.6871

The calculation of the volume of the reserve unit described by the three types of sections is made using:

- the formula of approximate integration (Simpson’s formula);

- the formula of the frustum of a cone;
- the trapezium formula.

The results are shown in Table 4.

Table 4

Specifications		Contour type	Volume (mc)		
			Simpson's formula	The formula of the frustum of a cone	Trapezium formula
Section type	Horizontal	Normal contour	126755000	129367136,8	38446624
		Iteration 3 contour	129720382	132400415,40	39115406,82
	Vertical parallel to YOZ plane	Normal contour	130490314,3	43744836	129170132
		Iteration 3 contour	134210923,4	45354280,67	133545706,3
	Vertical parallel to XOZ plane	Normal contour	124138091,0	122832681	956177,29
		Iteration 3 contour	138031105.7	135107239,2	1152124,833

5. CONCLUSIONS

The new numerical model used in describing a deposit and in calculating reserves has the following characteristics:

- it enables the calculation of the existing reserves in a reserve unit with great accuracy using the methods of sections, isolines and isohypses;
- from the values of the reserve volume given by the normal contours (i.e. the contour lines of the sections making up the reserve unit results from the linking of the points obtained from the geological survey of the deposit) and the thickened contours following iteration 3 higher values are obtained within the interval (2,3%-11%);
- in identical calculation conditions, with the three relations used for determining the value of the volume of the reserve unit, different values are obtained. In the case of the sections parallel to YOZ plane, the differences between the values obtained using Simpson's formula and the formula of the frustum of cone, respectively, on the one hand, and the trapezium formula, on the other hand, are great (Fig. 10);
- from the analysis of the data shown in Fig. 9 it results that the interval of dispersion of the values of the volume calculated with the Simpson's formula of approximate integration is short, (1267550004138031105,7) as compared to the intervals of the values of the volume calculated using the formula of the frustum of a cone, (437448364135107239,2) and the trapezium formula, (9561774 134210923);
- for the determination of the value of the volume of a reserve unit it is recommendable to use Simpson's approximate integration relation;

- the accuracy of the value of the reserve volume calculated using the proposed methodology increases with the increase in the number of sections and with the decrease in the distance between sections;

- it enables the updating of the calculation of the reserve values in a very short period of time if new data are available from the deposit survey;

- as to the value of a contour section, this is considered to be sufficiently accurate following the thickening of the points belonging to the contour after three iterations;

- the methodology of calculation of the reserve of a reserve unit can be applied to any kind of reserve or deposit unit;

- the calculation of the reserves of a deposit, following the geological evaluation stage, results from totalizing the volumes of the reserve units contained by the deposit.

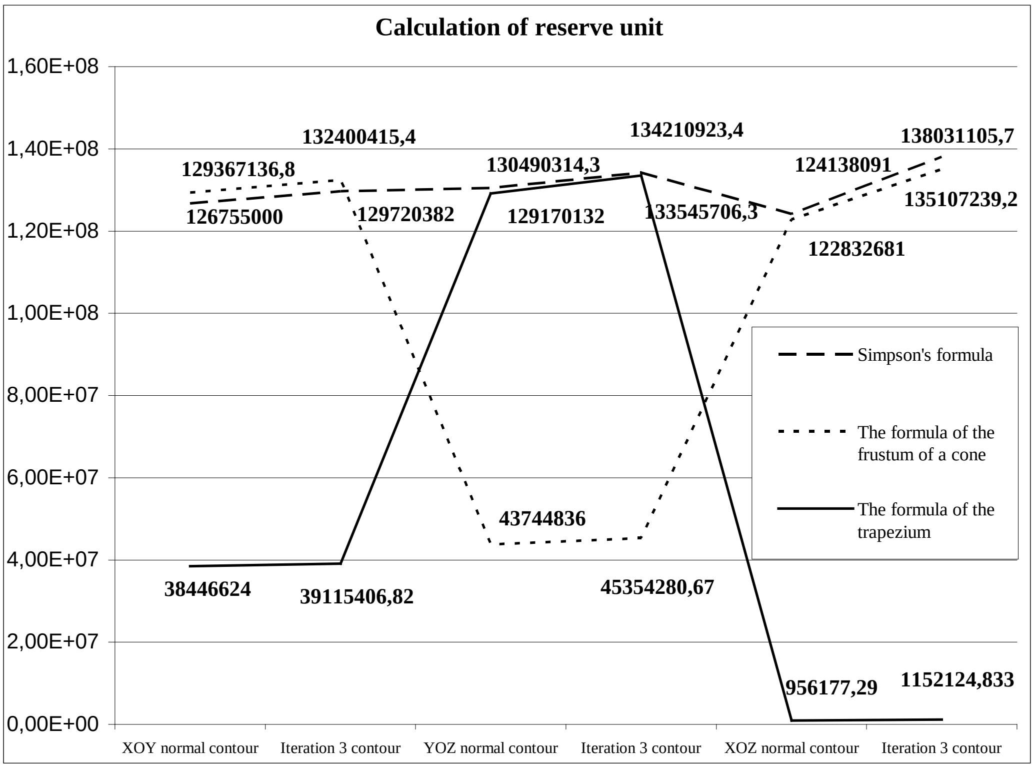

Fig. 10

Bibliography:

1. Dobrițoiu Nicolae -“Cercetări în vederea structurării şi integrării informațiilor geologico-miniere şi topografice într-un sistem CPAC (Cerectarea şi proiectarea asistate de calculator) pentru zăcămintele de cărbune din Valea Jiului" Teză doctorat, Universitatea din Petroşani, 1998 (in roumanian).

2. Hodor P., Dobritoiu N., Simionescu A. -Fundamentarea deciziilor manageriale în proiectarea miniera. Ed. Universitas, Petroşani –2000 (in roumanian).

3. Murgu Marțian –Evaluarea geologică şi industrială a zăcămintelor minerale, Editura Tehnică, Bucureşti 1986 (in roumanian).

THE GENESIS AND THE SOURCE AREA OF THE BAUXITES DEPOSITS ACCUMULATION IN THE SOUTH – WESTERN PART OF SEBES MOUNTAINS (HUNEDOARA COUNTY - ROMANIA)

CSABA R. LORINȚ*

Summary: This paper tries to show the connection between Sebes Mountains geological structure and evolution, and the bauxites materials accumulation in south-western parts of this area. Also, the study present different possibilities for genesis and source area, based to some several geological model.

Keywords: Sebes Mountains, Geological structure, Residual deposits, Bauxites, Genesis, Source area.

1. GENERALITY'S:

The studied region (Fig.1.) is situated in eastern part of Hateg Depression and in south-western part of Sebes Mountains, near Pui Village, Hunedoara County.

Hateg Depression is surrounded by Retezat Mountain (in S), Sebes Mountain (at E and NE) and Poiana Rusca (at N and NW).

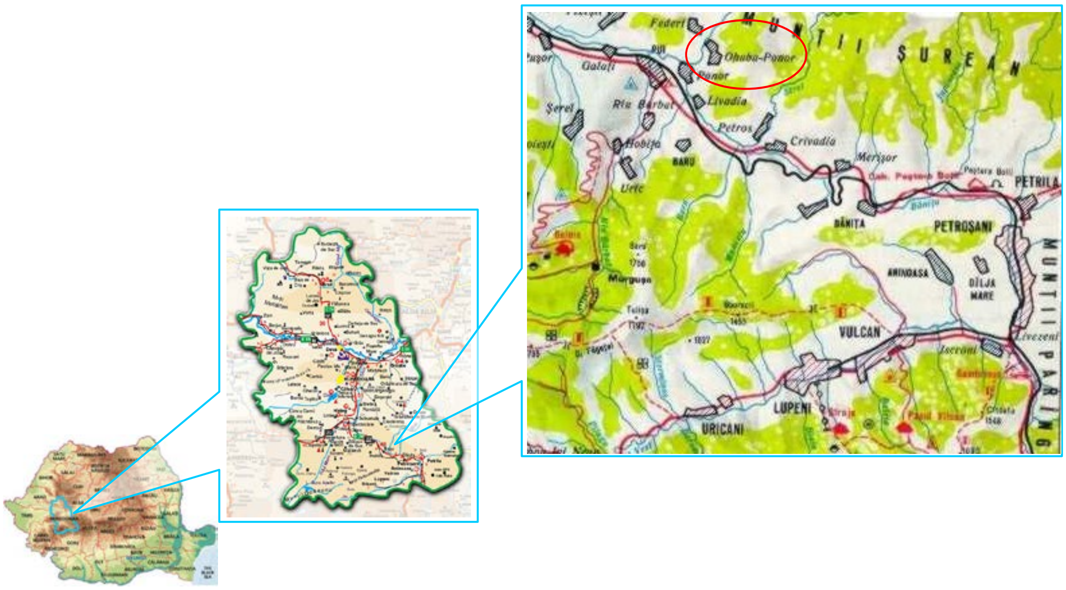

Fig.1. Administrative and geographical localize

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2. REGIONAL GEOLOGY

In the geological structure of studied area enters prelaramical foundation and sedimentary pos tectonic coverlet with Palaeocene and Miocene deposits.

Prelaramical foundation is formed by mezzo-metamorphic and epi-metamorphic crystalline formations of Sebes Lotru serial from Panza Getica and sedimentary Paleozoic and Mesozoic formations.

Crystalline shale of Sebes Lotru serial forms the borders of the basin and is represented by many complexes:

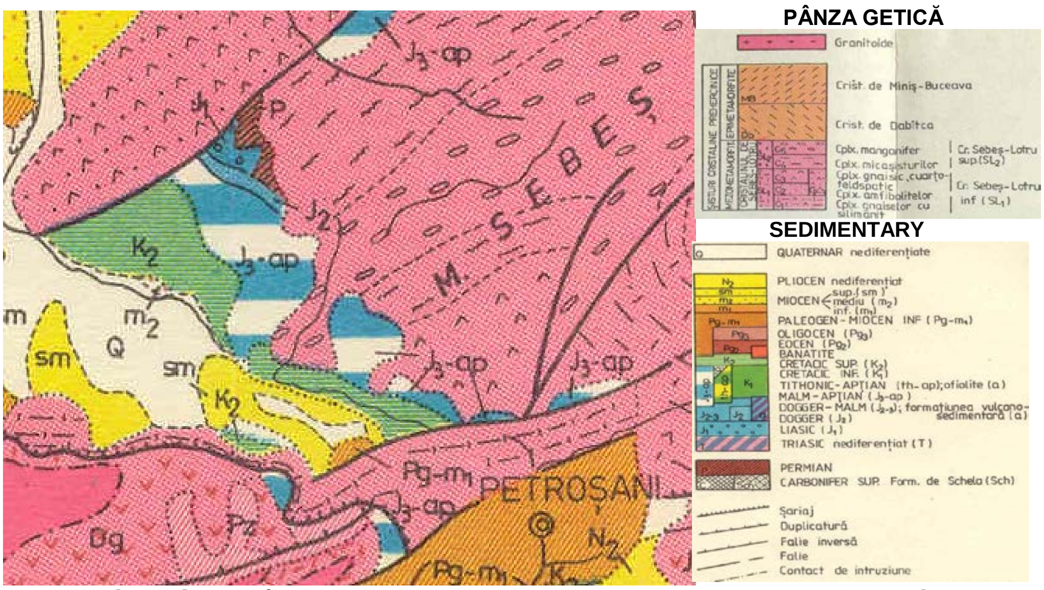

Fig.2. Geological map of region *(V. Mutihac 2004)*

a) inferior complex with gneisses with cordierit and sillimanit, gneisses with quartz;
b) an amphibolites complex alternative with quartz -feldspar gneisses;
c) a complex formed by quartz -feldspar gneisses;
d) a superior complex formed by mica shale with amphibolites and Para gneisses intercalations, shale with iron and manganese silicates. The age of these is superior Anteproterozoic, and in the area studied is represented in principal by the complex from the superior part.

The prelaramic sedimentary formations are represented by deposits:

- **Permian**: with conglomerates and violaceous conglomerate – Verucano Facies
- **Liasic**: with sandstones and conglomerates;
- **Middle Jurassic**: with sandstones and conglomerates with crystalline shale elements and with intercalations of shale clay;
- **Upper Jurassic**: with carbonatice deposits
- **Albian**: with limestone with paleocaves, conglomerates, sandstone and residual deposits;
- **Vraconian – Cenomanian**: with big detrital deposits at base and marls at the superior part;
- **Tutonian**: with limestone and clay;

- **Senonian**: with limestone deposits, limestone–marls with flysch aspect, and at superior part continental-maastrichtian deposits

The postlaramic padding formations are represented by a inferior paleogen-miocen cycle, followed by a sedimentary cycle meddle-superior Miocene, and the depression, is filled in central part with Pleistocene and Holocene deposits.

3. PETROLOGY AND MINERALOGY OF PANZA GETICA

Getic Panza is formed by (*Pavelescu L. & Pavelescu M., 1965*):

A) PARA GNEISSES (Foto. 1 – 1')

In this crystalline shale category are included: macaque gneisses, quartz gneisses, biotic gneisses, macaque gneisses with garnets, biotic gneisses with staurolit, quartz gneisses with disten, biotitic gneisses with sillimanit.

Foto.1. *(x60 II)*

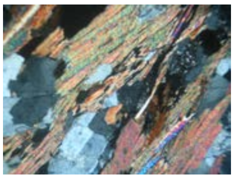

Foto.1'. *(x60 +)*

The texture of these rocs is gneisses with rubanat aspects. The structure of paragneisses is typically granoblastic, with tendency on a larger development.

Mineralogical speaking these rocs include:

Main components: plagioclases (albit:$NaAlSi_3O_8$ – oligoclaz: $(Na, Ca)AlSi_3O_8$): 20-60%; quartz SiO_2: 25-40%; biotit $K_2 (Mg, Fe^{2+}, Fe^{3+}, Al, Ti)_{4-6}(Si, Al)_8O_{20}(OH)_4$: 2-5%; muscovite $KAl_2(AlSi_3O_{10})(OH)_2$: (1-10%); epidot $Ca_2(Al, Fe)_3 Si_3O_{12} (OH)$; zoizit $Ca_2Al_3Sr_2O_7SiO_4$ (O,OH): (4-8%); microcline $M[AlSi_3O_8]$; M=Na, K, Rb, Cs, orthose $K[Al, Si_3, O_8]$: (0-5%)

Accessory components: apatite $Ca_5 (PO_4)_3$, titanit (sfen): $CaTi[O^{\cdot}SiO_4]$, calcite $CaCO_3$, opaque minerals: (1-4%);

Secondary products: clorit $(Mg, Fe)_6(Al, Fe)_2(OH)_8Si_4Al_2O_{10}$, sericit $KAl_2(AlSi_3O_{10})(OH)_2$ etc.: in negligible quantities.

B) MICASHALE (Foto.2-2')

These rocs have appeared frequently in the area we studied. Their structure presents lepidoblastic – porfiroblastic aspects because they have large quantity of garnet crystals, staurolit or tourmaline.

Foto.2. *(x60 II)*

Foto.2'. *(x60 +)*

They were identifying mica shale with garnet, mica shale with disten and staurolit and mica shale with staurolit.

C) MIXED GNEISSES (Foto. 3-3')

Here enter the injection gneisses and migmatite. The structure of these rocs is granoblastic-pegmatoid and their texture is schistose, rubanat to massive.

Mineralogical, these rocs include:

Main components: plagioclases ($CaAl_2Si_2O_8$): 15-30%;_quartz SiO_2: 15-35%; microclin M[$AlSi_3O_8$]; M=Na, K, Rb, Cs: 15-40%;_biotit K_2 (Mg, Fe^{2+}, Fe^{3+}, Al, Ti)$_{4-6}$(Si, Al)$_8O_{20}$(OH)$_4$: 10-25%; muscovite $KAl_2(AlSi_3O_{10})(OH)_2$: (0-2%); ortoză K[Al, Si_3, O_8]: (0-3%); epidot Ca_2(Al, Fe)$_3$ Si_3O_{12} (OH); zoizit $Ca_2Al_3Sr_2O_7SiO_4$ (O,OH): (1-15%);

Foto.3. *(x60 II)*

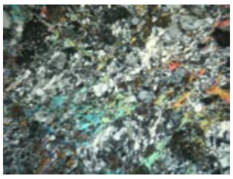

Foto.3'. *(x60 +)*

Accessory components: apatite $Ca_5(PO_4)_3$, titanite (sfen) $CaTi[O^{\cdot}SiO_4]$, zircon $ZrSiO_4$, magnetite $Fe_2O_3.FeO$, ilmenit $FeTiO_3$: (0,5-3%);

Secondary products: clorito (Mg, Fe)$_6$(Al, Fe)$_2$(OH)$_8$Si$_4$Al$_2$O$_{10}$, sericito $KAl_2(AlSi_3O_{10})(OH)_2$ etc.: in negligible quantities.

D) AMPHI B O L I T E S AND AMPHIBOLITES G N E I S S E S (F o t o . 4 - 4 ')

In the studied area amphibolites and gneisses amphibolites appear sporadically.

Mineralogical, these rocs include:

Main components: plagioclases ($CaAl_2Si_2O_8$): 15-60%; hornblende: Ca_2Na (Mg, Fe)$_4$(Al,Fe)[(Si,Al)$_4$O$_{11}$]$_2$(OH)$_2$: 5-75%; quart SiO_2: 5-25%; biotit K_2 (Mg, Fe^{2+}, Fe^{3+}, Al, Ti)$_{4-6}$(Si, Al)$_8O_{20}$(OH)$_4$: 0-10%; epidot Ca_2(Al, Fe)$_3$ Si_3O_{12} (OH); zoizit $Ca_2Al_3Sr_2O_7SiO_4$ (O,OH): (0-2%);

Accessory components: garnet $Fe_3^{2+}Al_2(SiO_4)_3$, apatite $Ca_5(PO_4)_3$, titanit (sfen) $CaTi[O^{\cdot}SiO_4]$, magnetite $Fe_2O_3.FeO$, rutil TiO_2, ilmenit $FeTiO_3$: (0,5-3%);

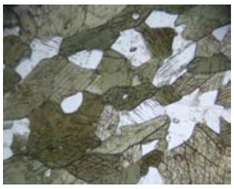

Foto.4. *(x60 II)*

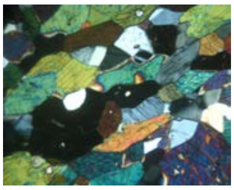

Foto.4'. *(x60 +)*

Secondary products: biotit K_2 (Mg, Fe^{2+}, Fe^{3+}, Al, Ti)$_{4-6}$ (Si, Al)$_8O_{20}$ (OH)$_4$, clorito (Mg, Fe)$_6$(Al, Fe)$_2$(OH)$_8$Si$_4$Al$_2$O$_{10}$, sericito $KAl_2(AlSi_3O_{10})(OH)_2$ etc. 1-2%.

The structure of the rocs is granoblastic-nematoblastic and the texture is rubanat schistose. At garnet amphibolites, the minerals present the same physiographic characters with plagioclases amphibolites. The only differences are the percentage variation of their mineralogical components:

Main components: plagioclases ($CaAl_2Si_2O_8$): 15-40%; hornblende: Ca_2Na (Mg, Fe)$_4$(Al,Fe)[(Si,Al)$_4$O$_{11}$]$_2$(OH)$_2$: 50-70%; garnet $Fe_3^{2+}Al_2(SiO_4)_3$: 2-6%; quartz SiO_2: 0-2%; biotit K_2 (Mg, Fe^{2+}, Fe^{3+}, Al, Ti)$_{4-6}$(Si, Al)$_8O_{20}$(OH)$_4$: 0-1%; **Accessory components:** apatite $Ca_5(PO_4)_3$, titanit (sfen) $CaTi[O^{\cdot}SiO_4]$, magnetite $Fe_2O_3.FeO$, rutil TiO_2, ilmenit $FeTiO_3$: (1-2%);

Secondary products: epidot Ca_2(Al, Fe)$_3$ Si_3O_{12} (OH): 0-3%; biotit: K_2 (Mg, Fe^{2+}, Fe^{3+}, Al, Ti)$_{4-6}$ (Si, Al)$_8O_{20}$ (OH)$_4$, clorito (Mg, Fe)$_6$(Al, Fe)$_2$(OH)$_8$Si$_4$Al$_2$O$_{10}$, calcite $CaCO_3$: 0,5-1%.

The epidot amphibolites presents the same physiographic characters with the difference that in these amphibolites variations, epidotic minerals appear more frequently.

Main components: plagioclases ($CaAl_2Si_2O_8$): 20-40%; hornblende: $Ca_2Na (Mg, Fe)_4(Al,Fe)[(Si,Al)_4O_{11}]_2(OH)_2$: 30-65%; epidot $Ca_2(Al, Fe)_3 Si_3O_{12} (OH)$, zoizit $Ca_2Al_3Sr_2O_7SiO_4$ (O,OH): 6-30%; biotit $K_2 (Mg, Fe^{2+}, Fe^{3+}, Al, Ti)_{4-6}(Si, Al)_8O_{20}(OH)_4$, titanit (sfen) $CaTi[O^{\cdot}SiO_4]$: 0,5-5%; quartz SiO_2: 0-3%;

Accessory components: ilmenit $FeTiO_3$, apatite $Ca_5(PO_4)_3$, rutil TiO_2, magnetite $Fe_2O_3.FeO$, pyrite FeS2: 0,5-3%;

Secondary products: clorit $(Mg, Fe)_6(Al, Fe)_2(OH)_8Si_4Al_2O_{10}$, biotit: $K_2 (Mg, Fe^{2+}, Fe^{3+}, Al, Ti)_{4-6} (Si, Al)_8O_{20} (OH)_4$, epidot $Ca_2(Al, Fe)_3 Si_3O_{12}$ (OH), zoizit $Ca_2Al_3Sr_2O_7SiO_4$ (O,OH), calcit $CaCO_3$: 0,5-2%.

E) DIORITE AND META DIORITE

F) PEGMATITE, APLITE AND QUARTZ

4. THE BAUXITE DEPOSIT

Prospecting and exploitations work point out in the sedimentary formations of Ohaba Ponor area some utile mineral substance. The principal utile mineral substance in this area is represented by bauxites materials.

4.1. MINERALOGICAL COMPOSITION

The main components are represented by:

- Aluminium minerals: Boehmit (Al OOH), [40 – 63,8 %];
- Iron minerals: hematite (Fe_2O_3), [20 – 27,7 % in bauxite, in clay this one go to 2,84%] and goethite ($Fe_2O3\ H_2O$) from 0 to 9,3 %.
- Titan minerals in bauxites rocs: anataz (TiO_2), [0,9 – 3 %]
- Argillaceous minerals: kaolin ($Al_4(OH)Si_4O_{10}$), [3,4 – 76 %] and dickit (0 – 19,6 %).
- Detrial material: muscovite, in deferent grade of kaolinization (0–4,8 %) and quartz (0–8,3 %).
- Rarely we can see neo formation tourmaline (green – blue colour) and detrial tourmaline and zircon.
- In some bauxite we can see $CaCO_3$.

4.2. CHEMICAL COMPOSITION

- Free Alumina - Al_2O_3- appear like monohydrated oxide exclusive boehmit.
- Iron - hematite [20 – 27,73 %]
- Titan appear like TiO_2 (anataz) in the fundamental weight of bauxitic rocs, with contents from 1,5 – 5 % higher in bauxite and smaller in clay.
- Quartz (SiO_2),[0,62 – 14,84 % in bauxite and 8,63 – 43,67 % in clay]
- Calcium (CaO) [0,98 %]
- Rare and disperse elements: V, Ga, Mn, Cr, Ni, Co, Mo, Pb, Zn, Bi, In, Sn, Ag, Nb, Zr, W, Cu, Cd, Sb, As, Ge.

4.3. THE GENESEE OF THE BAUXITES DEPOSITS. RECONSTRUCTION MODEL OF SOURCE AREA

At the end of Aptian, this area was intense eroded in Gargasian time and it formed an ample caves network.

In this formations represented by Tihonic limestone or (Baremian – Aptian), detrito – chemically deposits are accumulating. These deposits contain bauxite, clay and red detritial rocs. The bauxitic materials from Comarnic Poieni are contaminated with detritial material.

In 1965 Al. Stilla shows that material which forms the old rock results from „alterate blanket with tendency for forming residual clay in cristalofilian massive from the northern part of the area”.

Geological proves shows that the accumulation of the transported material from the sectors with crystalline shale was made under torrential conditions.

The source of the material which formed the bauxite and the detritic clay formations from the area is represented by:

- The alterated blanket of the Sebes Lotru – crystalline fundament in a warm and wet climate, the minerals with aluminium and iron from mica shale with garnet, mica shale with disten, mica shale with staurolit, gneisses with sillimanit, gneisses and mica shale with titanit, epidotic shale, amphibolites gneisses, lead to some residual clay;
- Initial bauxites accumulations.

Regarding the maim mechanism for forming the detrial – chemical deposits, Papiu and his collaborators, admit that this happened in two distinct stages. A lateritic or bauxitic material was transported by wind water or mud flow, on versants, to wide basins with calm water, where they were sorted and the granular clastic formations granular detected, generated successions of bauxitic clay material.

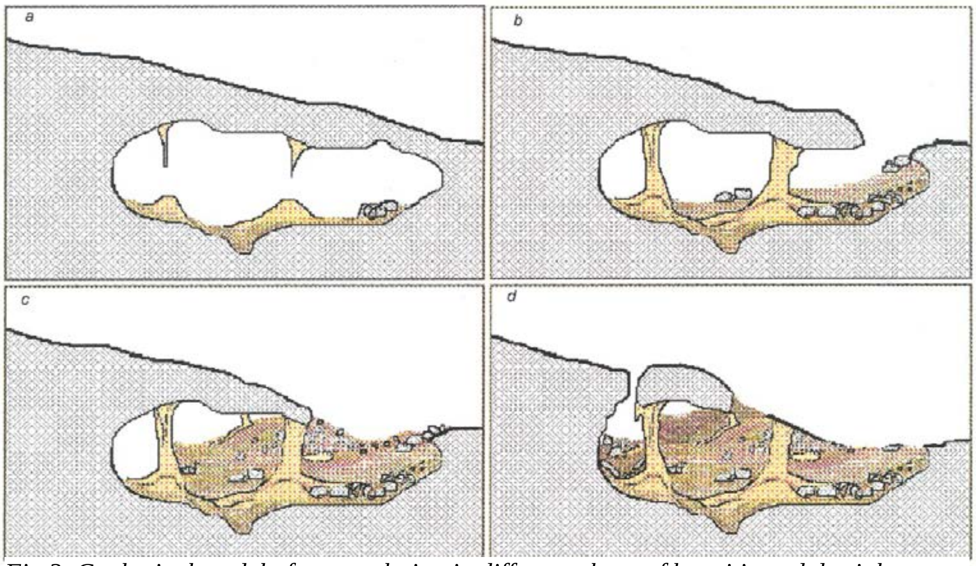

Fig.3. Geological model of accumulation in different phase of bauxitic and detrial materials in Ohaba Ponor paleokarstic formation

In the second faze, determinate by relief regeneration, it produce a removal of the drained acid material bauxitic clay, to karstic depressions – where they precipitate, clastical formations follow them by torrential transport. In the precipitation process from colloidal and ionic solutions of Al, Fe, Ti ions, bicarbonates karstic water precipitated more or less active.

Iron – aluminium solutions, full in suspensions participate in mixing time in bicarbonate waters of limestone karsts, by raisind the pH or by destroying the protection offered by the organic colloid. In this way all the components of red pelitics rocs which don't present any stratification clue, forms and consolidate rapidly in a lit logically mass. The environment where the bauxite were deposited was strong oxidized (the iron is represented like hematite), and the bauxites are named by Papiu in 1970 – *„iron bauxites”*.

After the final accumulation from iron mass, it is installed a torrential regime, bauxitic and argillaceous deposits are covered with a red detritic material.

BIBLIOGRAPHY:

1. BARBADOSSY G., ALEVA G.J.J. – Lateritic bauxites, Akademiai Kiado – Budapest – 1990;
2. BUIA GR., LORINȚ C. – Zăcăminte de substanțe minerale utile solide, Ed. Focus, Petroşani – 2004;
3. Centrala Departament a Geologiei – Întreprinderea de Prospecțiuni şi Explorări geologice „Hunedoara” – Documentație de Sinteză cu calculul rezervelor de roci bauxitice de la Ohaba Ponor – Județul Hunedoara – 1989;
4. IFLGS – Raport geologic preliminar asupra lucrărilor de explorare pt. roci bauxitice din zona de SE a regiunii Ohaba-Ponor – Hațeg, 1970;
5. KALERVO RANKAMA, TH. G. SAHAMA – Geochimia, Ed. Tehnică, Bucureşti – 1970;
6. PAVELESCU L., PAVELESCU M. – Cercetări geologice şi petrografice între Oaşa (Munții Sebeşului) şi Urdele (Munții Parângului), Studii şi Cercetări de Geologie, Geofizică, Geografie, Seria Geologie, Tomul 10, Ed. Academiei 1965;
7. MUTIHAC V., STRATULAT M. I., FECHET R. M. – Geologia României, Ed. Didactică şi Pedagogică – 2004;

THE PRE-CALCULATION OF GROUND SUBSIDENCE IN STEEP-LYING MEASURES

NICOLAE DIMA *
OCTAVIAN HERBEI *
KLAUS GERHART FISSGUS **

ABSTRACT: The desplacement and deformation of the terrestrial surfaces being influenced by the underground mining is a phenomenon met often into the mining areas, the phenomenon being developped depending on the mining deep, on the used mining methon. We hereby present a prognosis model in the case of the coal beds having a high dip the same with the one of the formations existent into the mining field of Jiu Valley.

Key words: coal bed, dip, sinking parameter.

1. GROUND MOVEMENT IN STEEP-LYING MEASURES

In inclined and steep-lying measures, the angles of limit and break along the strike (γ,β) both at the lower ribside (γ_H,β_H) and upper ribside (γ_L,β_L) vary in size (Fig.1). From observation it is known that the limit angle γ_H at the lower face, the horizontal leg of which at B points into the roof of the working, becomes flatter with increasing dip, whereas the limit angle γ_L at the upper face becomes steeper. For example, with a dip of α=40 or 70gr and a limit angle along the strike of γ=60gr, the limit angle in the dip plane can amount to γ_H=45 or 40gr and γ_L =65 or 80gr. In very steep measures this change in angle reaches a culmination point (H. Rom, 1964) and then begins to regress again, with the result that the limit angles for horizontal and vertical stratification are approximately equal. The angle of limit and break fluctuate in size according to the composition and strength of the overlying strata, and they depend in addition on the thickness of the overburden resting discordantly on the steep Carboniferous beds. The limit angles γ, γ_H and γ_L dropped from the surface point P give the cone for the critical extraction area, which is practically elliptical in outline at the seam and at the projection of the working as seen in plan.

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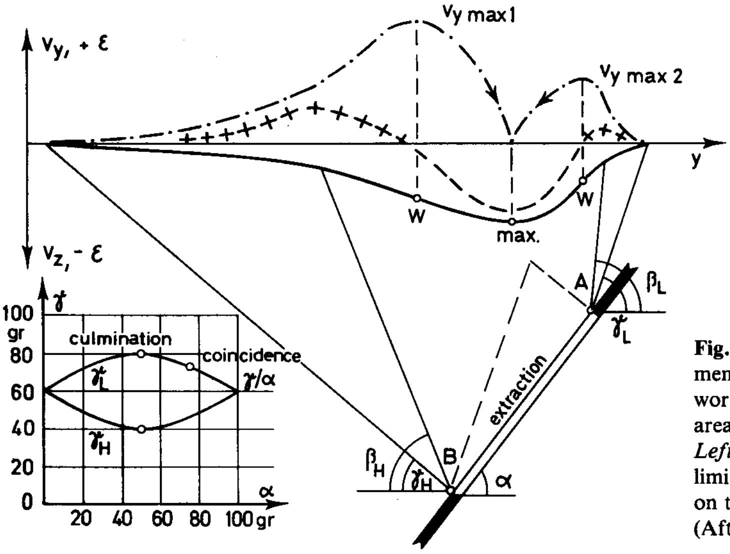

Fig. 1. Ground movement over a steep-lying working (subcritical area), seen in section. *Left:* systematics of the limit angle, as dependent on the dip of the seam. (After Rom, 1964)

With steep stratification the trough is always unsymmetrical. Its lowest point becomes displaced towards the upper third of the panel with increasing dip in the seam, and over the lower ribside B the trough becomes very flat and extends far out over the unworked seam. Over the upper ribside A the subsidence influence can also reach far outwards if the limit angle γ_L is smaller than the seam dip α, as is often the case when there is marked heave in the footwall beds. When the stratification is steep and the depth is considerable, a critical area – seldom attained – cannot therefore be determined by dropping the limit angle from the surface point P. The angle γ_L' must be erected at the lower ribside instead (Fig.2).

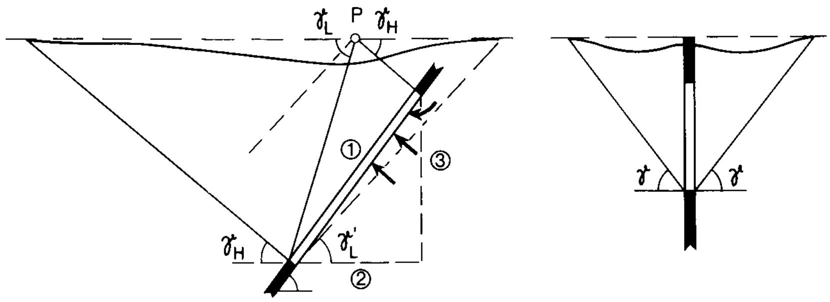

Fig. 2. *Left:* the critical extraction area in steep-lying measures. *Right:* two troughs over extraction of a vertical seam. *1* Critical area at the seam; *2* critical area as projected in plan; *3* heave in relaxed footwall

2. INTEGRATION GRIDS IN STEEP-LYING MEASURES

The circular, concentric integration grids appropriate to flat-lying measures can be used up to seam dips α of 20 gr approximately. With steeper angles of dip the area of critical extraction, which is determined by three limit angles, deviates too much from the circular, and the bottom of the through is no longer at the center of the critical area. In an inclined working the influence k_Z of the extraction elements is distributed asymmetrically (see Fig.4, left). For steep stratification therefore, special grids have to be prepared which take account both of the dip and the difference in depth at the upper and lower working faces.

The distribution function can be modified separately for steep working in the lower [-α in Eq. (1)] and upper (+α) parts of the seam from point P, to the extent that a vertical influence force proportional to the depth attaches to the individual extraction element (Schleier, 1937):

$$k_Z = \frac{dA}{H\cos\alpha}\cos(\zeta \pm \alpha)\cos\zeta$$

$$\mathrm{K_Z} = \frac{1}{2}\left[\left(\frac{1}{2}\sin 2\zeta + \zeta\right)\cos\alpha \pm \sin^2\zeta\sin\alpha\right]. \quad (1)$$

The focal point of all vertical influence forces is represented by an eccentric point Z in the critical area. The K_Z values and the zone angles for each angle of dip α in the main section down the dip and through the point Z can be read from a nomogram (Fig.3).

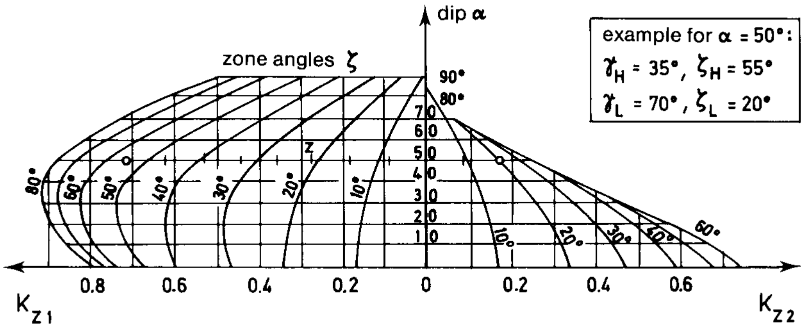

Fig. 3. Zone-angles diagram for Eq. (171). *Example:* the distance between K_{z1} = 0.72 and K_{z2} = 0.17 is divided into 10 equal sections, to enable the zone angles in the dip section to be read off. (After Schleier, 1956)

In the zone angles ζ are related, not to the vertical, but to the seam normal P – N (Fig.4).

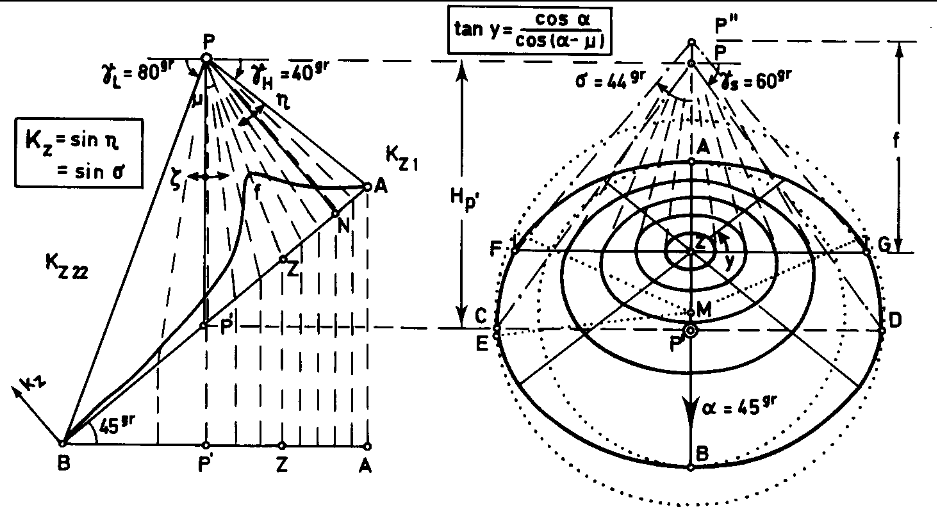

Fig. 4. Constructing an integration grid in steep-lying measures. *Left:* division into zones in the dip section. *Right:* division into zones along the strike line FZG, as done from P″. (Method of Perz and H. Schröder)

$$\eta' = \zeta \pm \alpha \tag{2}$$

the proportions of final subsidence can be obtained from the simple relation

$$K_Z = \sin\eta \tag{3}$$

(Perz, 1940). On this basis the subsidence influence on point P is found for the upper part
N–A and the lower part N-B of the working in the main section A-B, as follows:

$$K_{Z1} = \sin(100-\gamma_H-\alpha)$$
$$K_{Z2} = \sin(100-\gamma L-\alpha) \tag{4}$$

The zone angle $\eta_Z = \alpha-\mu$ to the focal point of influence Z can be calculated by the formula:

$$Z = \frac{K_{Z1} - K_{Z2}}{2} = K_{Z1} - 5K = \sin\eta_Z\,. \tag{5}$$

The influence values of ten zonal sections are

$$K = \frac{K_{Z1} + K_{Z2}}{10}\,. \tag{6}$$

The required zone angles η are obtained from the sine values fro K_{Z1}, K_{Z1} – 1K, K_{Z1} –2K,… K_{Z1} –9K and K_{Z2} (see Table 1).

Table1. The calculation of zone angles for an integration grid in inclined measures (Perz method)

Dip section		Strike section	
Sine values	Zone angles gr	Sine values	Zone angles gr
K_{Z1} = 0.2334	15.0 (η_H)	$K^{'}_{Z1}$=0.6375	44.0 (σ)
K_{Z1} –1K = 0.1248	0.8	$K^{'}_{Z1}$-1K$^{'}$=0.5100	34.1
K_{Z1} – 2K = 0.0162	1.0	$K^{'}_{Z1}$-2K$^{'}$=0.3825	25.0
K_{Z1} – 3K = 0.0924	-5.9	$K^{'}_{Z1}$-3 K$^{'}$=0.2550	16.4
K_{Z1} – 4K = -0.2010	-12.9	$K^{'}_{Z1}$-4 K$^{'}$=0.1275	7.8
K_{Z1} - 5K = -0.3096	-20.0 (α-μ)	$K^{'}_{Z1}$-5 K$^{'}$=0.0000	0.0
K_{Z1} – 6K = -0.4182	-27.5	Division into sectors: $\tan y = \frac{\cos\alpha}{\cos(\alpha-\mu)} = \frac{\cos 45}{\cos 20} = \frac{0.7604}{0.9511}$ y=42.9gr	
K_{Z1} – 7K = -0.5268	-35.3		
K_{Z1} – 8K = -0.6354	-43.8		
K_{Z1} – 9K = -0.7440	-53.4		
K_{Z1} = -0.8526	-65.0(η_L)		

On the basis that the influence figure in steep stratification resembles a titled circular cone, the integration grid seen in plan can be represented as ellipses grouped around the center of influence Z (Fig.4, right). The horizontal distance between their vertices on the small or large axis AB is read from the main section down the dip into which the limit and zonal angles are marked. The intersection of the limit-angle line γ_S with the horizontal through P$^{'}$ gives the two other points C and D of the surrounding curve along the strike. To obtain the limit points for the zonal ellipses on the line of strike trough Z, the diagonal line PZ of the main section is projected on to the horizontal above Z in the dip axis and the angle σ at the point P$^{"}$ read off with a protractor. The end-points F and G of the horizontal through Z are first determined as ellipse points of the grid surround by the so-called paper-strip method, using the small and large axial circles given by the axial center point M and by the points A and B or E (constructed). From Eq.(3) $K^{'}_{Z} = \sin\sigma$, the five zonal angles along the strike are then calculated (Table 1). Finally, the diagonal angles

$$\tan y = \frac{\cos \alpha}{\cos(\alpha - \mu)} \tag{7}$$

for the division of sectors must be calculated and the ellipses for the inner zone drawn.

In the surveying office, web-like subsidence grids such as these are conveniently prepared on transparent paper at a scale of 1:5000 in depth stages of 50m ($H_{p'}$) and for dip angles of 30, 40, 50, 60 and 70gr. Unlike flat-lying stratification, grids of varying size must be used for each calculation point over the working area in steep-lying measures, as the seam depth $H_{p'}$ under each surface point is different. The grids must furthermore be oriented towards the direction of dip. Thus, in comparison with flat-lying strata, the subsidence calculation is much more time-consuming.

Apart from these analytical methods, there are projection methods in which, for example, an integration grid for flat-lying strata is redrawn by reproducing the circular ring zones centrally on a diagonal seam plane (Fig.5, right) or, on the assumption that all overlying beds go down perpendicularly, by reproducing them as elliptical grids (Bals, 1953). As with flat-lying measures, so also with steep-lying, a network of fields of influence can be derived from observations, with the very small fields grouped around the center of influence. It is common practice to project the zonal divisions pertaining to flat stratification centrally on to the steeply inclined seam line of the main section, and to trace the zone boundaries in the ground plan as eccentric circles (Fig.5, left).

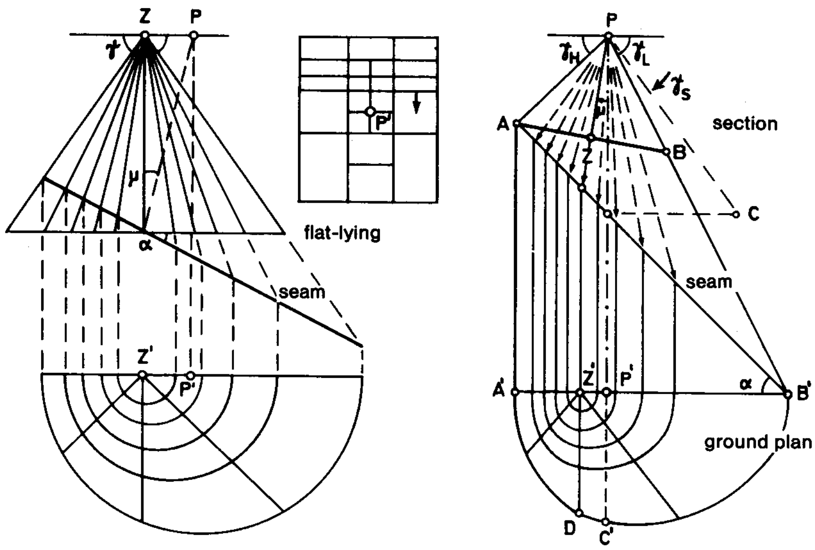

Fig. 5. Re-drawing an integration grid for horizontal stratification by projection. *Left:* equal limit angles (after Wessel). *Right:* unequal limit angles (after Kratzsch). *Centre:* empirically evaluated fields-of-influence grid

For the accuracy of the integration-grid method steep-lying measures, the crucial factor is not so much an exact knowledge of the size of the limit angles as the correct choice of the nadir angle μ, which determines the position of the focal point Z in the integration grid. In some mining districts this nadir angle is of the order of

$$\mu \approx \frac{1}{2}(\gamma_L - \gamma_H), \tag{8}$$

as Table 2 shows.

Table 2. Order of magnitude of limit and nadir angles in inclined to steep-lying measures

Dip gr	Limit angle gr			Nadir angle gr
α	γ_H	γ_L	γ_S	μ
40	55	65	60	5
50	50	70	60	10
60	45	75	60	15
70	40	80	60	20
80	35	85	60	25

Note: $\gamma_L + \gamma_H = 2\gamma_S$

$$\mu = \frac{1}{2}(\gamma_L - \gamma_H)$$

It can, however, be much larger, particularly if the sum of the limit angles in the dip plane

$$\gamma_L + \gamma_H \approx 2\gamma_S \tag{9}$$

differs significantly from double the value of the limit angle along the strike (see also the limit –angle curve in Fig.1, left). In some coal-mining areas the nadir angle is equivalent to 0.7 α, and in other areas to 0.5 α.

In addition, for calculating subsidence it is important to know the correct subsidence factor a. A way of determining the subsidence factor in steep stratification, namely from measured maximum subsidence at the surface, from thickness of seam worked, and from seam dip, is provided by the formula (Kosterin, 1972):

$$a = 1 - \frac{v_{Z\max}}{M\cos\alpha}. \tag{10}$$

In cases where the upper limit angle is smaller than the angle of dip of the seam ($\gamma_L < \alpha$) and consequently a critical area cannot be constructed – which can occur when the extraction influence extends to the footwall strata (Fig.2) – it is sufficient to prepare the integration grid for the overlying strata. Applying the grid as a mirror image to the footwall of the deposit enables movement on that side of it also to be deduced (Schleier, 1964).

References

1. Bals, R.: Die Senkungsberechnung bei geneigter Lagerung nach Anwendung des Gesetzes vom bankrechten Niedergehen der Gebirgsbänke. Bergbau-Rdsch. 1953
2. Dima N., Padure I, Herbei O. – Topografie miniera, Ed. Corvinu.
3. Fissgus, K.G.: Cercetări privind prognoza fenomenului de deplasare a suprafeței terenului în bazinul minier Valea Jiului. Petroşani 2002
4. Kosterin, M.A.: Die Gleichung der Mulde als Funktion der Hauptparameter der Verschiebung. 1972
5. Kratzsch, H.: Bergschadenkunde. Berlin 1983
6. Perz, F.: Der Einfluß der Zeit auf die Bodenbewegung über Abbauen. Mitt. Markscheidewesen 55
7. Rom, H.: Grenzwinkel-Systematik. Mitt. Markscheidewesen 71
8. Schleier, O.: Vorausberechnungen von Bodenbewegungen, Glückauf 1956
9. *** - Manualul inginerului de mine, vol. II, Facultatea Tehnica, 1985

LES LOIS INCREMENTALES POUR LES SOLS

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Abstract :

In this paper there are shortly introduced a few incrementale unlinear models that could be used in the study of the soil's behaviour. These models require on one side, choosing the regular paths (triaxiales or edometrics) and the description of the suitable answers, and on the other side, choosing the insertion way between these answers (linear or unlinear).

Key words : incremental law behaviour, incremental strain, stress, mathematical model, triaxiale test, edometric test, soil, geomaterials.

1. NOTION INCREMENTALE DES LOIS DE COMPORTEMENT

La notion de lois de comportement est une notion relativement récente. Généralement, on peut dire qu'elle résume, avec tous les problèmes éventuels que cela peut poser, l'ensemble de la physique des petites échelles d'un milieu la transformant alors en milieu continu clasique, c'est-à-dire un milieu sans échelle. Du point de vue pratique on peut dire qu'elle est un ingrédient nécessaire à tout calcul de modèlisation, et notamment le choix d'une loi ou d'une l'autre est ce qui permet de traduire sous une forme mathèmatique le fait que différents milieux « ne se comportent pas » de façon analoque (songeons par exemple aux sables et aux bétons). De modèles explicatifs des années 1960 , les lois de comportement sont devenues, en raison des éléments finis, des équation qui doivent fournir la contraintes comme fonctionnelle de l'histoire cinématique ; une telle fonctionnelle doit être objective. A partir de cette vision théorique, une très grande simplification peut être faite, qui consiste à supposer que l'histoire se résume à l'état actuel. On a alors une loi de comportement élastique qui devient hyperélastique si l'on ajoute la contrainte que l'énergie cédée à l'extérieur au cours d'un cycle n'est peut pas être positive. On peut parfaitement utiliser ce genre de modèle si l'on ne cherche qu'à traduire le comportement sur un trajet de chargement quasi monotone. Ceci est couramment pratiqué dans des applications sur les métaux lorsque l'on utilise la théorie de la déformation plastique.

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Si l'on veut pouvoir utiliser un modèle de comportement sur un chemin de chargement un peu plus compliqué, par exemple sur un trajet et sur le trajet retour, c'est-à-dire sur une charge suivie d'une décharge, il faut utiliser une loi de comportement plus élaborée ; la forme incrémentale ou en vitesse s'impose. Si on traite des comportement sans effet du temps – non-viscosité -, les deux formulations : en incrément et en vitesse sont équivalentes.

On suppose connu l'état d'un matériau noté E ; on pourra alors relier une dérivée objective de la contrainte, $\dot{\sigma}$, et une description spatiale de la cinématique (on va considérer la vitesse de déformation, partie symétrique du gradient de vitesse), $\dot{D}$. Une relation de type implicite pourra s'écrire :

$$F\left(\dot{\sigma}, \dot{D}, E) = 0\right) \tag{1}$$

A cause de l'hypothèse de non-viscosité, la fonction F doit posséder la propriété d'homogénéité positive par rapport à ses deux variables $\dot{\sigma}$ et $\dot{D}$. Si cette équation peut se résoudre en $\dot{\sigma}$ et / ou en $\dot{D}$, on pourra avoir :

$$\dot{\sigma} = f\left(\dot{D}, E\right) \tag{2}$$

$$\dot{D} = g\left(\dot{\sigma}, E\right) \tag{3}$$

f et g étant positivement homogène de degré par un rapport respectivement à $\dot{D}$ et $\dot{\sigma}$. Ces deux formes duales l'une de l'autre ne sont pas complètement équivalentes. De l'équation (2) on peut déduire une loi d'évolution d'état ; si l'on donne la forme (3) se pose le problème de l'inversion, ce qui n'est pas toujours trivial.

On simplifie souvent encore le problème en supposant que les fonctions f et g sont linéaires par rapport à leur premier argument et si l'on reste là, on obtiendra un comportement réversible. Une telle hypothèse peut être partiellement justifiée, pour une classe restreinte de vitesses de déformation, par un raisonnement rigoureux dans quelques cas simples. Par exemple, dans le cadre de la plasticité des métaux, si l'on suppose que la déformation plastique est due à un unique mécanisme microscopique de glissement le long d'une direction de plan déterminée par la structure du métal, alors on peut prouver que la fonction f est linéaire lorsque le mécanisme est actif. Si le mécanisme n'est pas actif, le comportement du matériau est élastique et donc la relation (2) se traduit par deux relations linéaires l'une en charge plastique et l'autre en décharge élastique.

La bilinéarité n'est donc pas justifiée que dans le cadre d'un mécanisme plastique bien identifié. Des nombreuses raisons nous poussent à penser que ce n'est pas le cas pour les géomatériaux ; dans de nombreux cas, les modèles modernes de plasticité des métaux font intervenir plusieurs mécanismes. En ce qui concerne les géomatériaux, un examen microscopique des déformations ne montre en aucun cas un mécanisme privilégié qui pourrait supporter l'hypothèse de bilinéarité, et par ailleurs, les résultats expérimentaux sur des échantillons de sols sont connus depuis longtemps pour être aussi en contradiction avec cette hypothèse. Certains phénomènes observés in situ seront mieux ou plus facilement traduits par des modèles qui ne reposent pas sur cette hypothèse simplificatrice. On retrouve dans la littérature deux façons de dépasser la bilinéarité et même la polylinéarité des modèles à plusieurs mécanismes plastiques par les relations (2) ou (3) complètement non linéaires. Une première façon concerne les modèles hypoplastiques en général, capables de rendre compte des comportements variés des géomatériaux (en particulier les modèles CLoE conçus pour décrire de façon réaliste la rupture localisée, c'est-à-dire la rupture des géomatériaux) ; la deuxième méthodologie est consacrée aux lois incrémentalement non linéaires qui en fournissant un cadre plus général que l'hypoplasticité, permettent de décrire les réponses à des sollicitations cycliques et différentes classes d'instabilités et de bifurcations.

2. LES MODELES HYPOPLASTIQUES

La caractéristique générale des modèles hypoplastiques est de considérer comme relation (2) la relation non linéaire suivante permettant simplement de décrire une irréversibilité :

$$\dot{\sigma} = A : \dot{D} + b \left\| \dot{D} \right\| \qquad \dot{\sigma}_{ij} = A_{ijkl} \dot{D}_{kl} + b_{ij} \left\| \dot{D} \right\| \tag{4}$$

Les tenseurs A du quatrième ordre et b du second ordre sont fonction à préciser de l'état. En utilisant la formule (4), il est clair que le modèle est irréversible. L'irréversibilité en hypoplasticité à une dimension peut être mathématiquement modélisée par autre chose que deux relations linéaires l'une pour la charge et l'autre pour la décharge ; une relation unique mais non linéaire suffit. La vision unidimensionnelle est cependant insuffisante pour comprendre complètement la non linéarité incrémentale des modèles hypoplastiques. Si on considère l'hypoplasticité à deux dimensions, en raison de l'homogénéité positive de degré un par rapport au temps, il suffit de considérer les transformées pour la loi de comportement (4) des vitesses de déformation ayant une norme un mais toutes les directions possibles. Graphiquement cela correspond aux vitesses de déformation situées sur le cercle centré dans l'espace des vitesses de déformation. La multiplication par A transforme le cercle en ellipse centrée puis l'addition de b, qui est en général un tenseur, décale cette ellipse et finalement, dans l'espace des vitesses de contrainte, le cercle précédent est transformé en une ellipse décentrée. Alors qu'il apparaît clairement que le terme additionnel lié à la norme est celui qui permet l'irréversibilité.

Pour un modèle bilinéaire comme l'élastoplasticité à un mécanisme la relation se traduit géométriquement par la transformation de deux demi–cercles de l'espace des vitesses de déformation chacun en une demi–ellipse centrée mais différente. Cette différence entre les deux demi–ellipses permet dans ce cas de décrire l'irréversibilité.

Dans les deux cas élastoplastique et hypoplastique, les réponses en vitesse de contrainte aux deux vitesses de déformation correspondant aux symboles sont les mêmes, illustrant le fait que la connaissance de la réponse à un trajet de chargement dans un sens et dans le sens opposé ne détermine en rien la relation incrémentale. Toujours en ce qui concerne l'irréversibilité, on remarque que si b = 0, le modèle hypoplastique dégénère en modèle réversible, donc l'incrémentalement linéaire, donc potentiellement élastique. Un des grands avantages de la formule (4) est qu'il est possible de déduire facilement un certain nombre de propriété du modèle : l'inversibilité ; la plasticité et bien la règle d'écoulement (posé en d'autre termes il s'agit de trouver des conditions sur les tenseur A et b pour lesquels un écoulement plastique parfait est possible) ; le radoucissement (le modèle n'est plus inversible de la même façon que pour des lois élastoplastiques classiques avec écrouissage négatif. Dans le cas de l'élastoplasticité, la demi–ellipse plastique se trouve du même coté que la demi–ellipse élastique et un demi-espace de l'espace des vitesses de contraintes est inaccessible pour le modèle comme dans le cas parfaitement plastique). Un tel modèle permet d'établir la relation de consistance à la surface limite, autrement dit : pour un état potentiellement parfaitement plastique, si on suppose que la surface limite est régulière, elle apparaît comme une droite passant par l'origine dans l'espace des vitesses de contrainte. S'il existe des vitesses de contrainte qui peuvent franchir la surface limite nous avons le cas d'inconsistance de contrainte à la surface limite, tandis que dans le cas où aucune vitesse de contrainte ne peut être dirigée vers la zone interdite, nous dirons que le modèle vérifie la relation de consistance à la surface limite. En élastoplasticité, la relation de consistance est celle qui permet de ne jamais sortir de la surface de charge (qu'il s'agisse de modèles avec ou sans écrouissage). Pour les modèles hypoplastiques il est possible de contrôler la contrainte à rester à l'intérieur d'une surface limite.

La rupture dans les géomatériaux est dans la quasi-totalité des cas localisée. Il est donc fondamental qu'un modèle moderne soit capable de rendre compte de ce phénomène incontournable. Un modèle de comportement non linéaire doit permettre de mener à bien une analyse complète de localisation et d'en tirer une formule explicite. Les bases d'un calcul de localisation sont les suivantes. Guidé par les observations expérimentales et aussi par certaines considérations théoriques on cherche si, à l'intérieur d'un milieu infini homogène se déformant avec une vitesse de déformation homogène, une bande de largeur indéterminée se déformant également de façon homogène, mais différente de ce qui se produit à l'extérieur de la bande. On va établir la condition de compatibilité cinématique entre les deux zones en fonction de gradients de vitesse à l'intérieur respectivement à l'extérieur de la bande de normale et ensuite l'équilibre à la frontière de la bande. L'ensemble de ces équations combinées avec la loi de comportement (ce qui est crucial) conduit, lorsque c'est possible, au critère de localisation en bande de cisaillement. Les modèles hypoplastiques permettent d'aboutir à un critère de localisation explicite.

Le critère de localisation des modèles hypoplastiques obtenu après un calcul complètement rigoureux n'a rien à voir avec un quelconque déterminant de tenseur acoustique. Pour déterminer un tenseur acoustique, il faudrait auparavant linéariser rigoureusement le modèle non linéaire, ce qui est aisé pour les modèles hypoplastiques mais qui n'a d'intérêt que pour résoudre des problèmes aux limites en vitesse. Un calcul de localisation effectué avec le modèle linéaire correspondant à la linéarisation de la loi au voisinage du gradient de vitesse donne un résultat qui surestime parfois largement la résistance à la localisation du milieu. Si le critère de localisation est satisfait dans le cadre d'une hypothèse de petites déformations, alors le résultat n'est pas étonnant, puisque la satisfaction du critère de localisation signifie en fait l'existence de plusieurs solutions pour un problème aux limites. Mais, comme à cause de l'absence d'échelle interne au matériau, la largeur de bande n'est pas spécifiée, le problème global ne peut pas conserver l'unicité de solution. La dernière remarque montre clairement que pour qu'une localisation soit possible, il faut qu'il y ait une faiblesse dans une direction. Le phénomène de localisation est un phénomène orienté. Autrement dit, l'apparition de la localisation dans des essais de laboratoire ne doit pas être considérée comme un effet indésirable, mais plutôt comme une information supplémentaire sur l'anisotropie incrémentale du milieu dans l'état où la localisation apparaît.

Dans les essais de laboratoire homogènes (le cisaillement direct est donc exclus), les axes de la contrainte et de la déformation (si le matériau est initialement isotrope) restent fixes. Si l'on considère, pour simplifier le raisonnement, le modèle Mohr – Coulomb plan, le terme A_{33} de la matrice A (le tenseur élastique isotrope), que l'on appel module de cisaillement dans les axes, est inactif dans ce type d'essais, hormis l'état isotrope où il est fixé à cause de l'isotropie justement et égal à $G = \frac{2E}{1+\mu}$ ce terme est libre. On fait varier le module de cisaillement depuis sa valeur à l'état isotrope jusqu'à la valeur permettant d'obtenir la localisation avec le modèle dans les mêmes conditions (orientation et état, dans notre cas simplifié angle de frottement mobilisé) que ce qui est observé. La consistance à l'état isotrope est respectée, ce qui est fondamental pour l'utilisation en calcul numérique du modèle. Finalement, il faut introduire dans le modèle plan un paramètre supplémentaire qui peut être vu comme décrivant l'anisotropie induite par la sollicitation conduisant de l'état initial supposé isotrope à l'état actuel, et aussi comme le paramètre gouvernant l'apparition de la localisation des déformations plastiques. L'hypoplasticité offre une grande facilité pour traduire l'anisotropie induite. Ces effets sont différents mais similaires à ceux que l'on obtient dans la cadre de la plasticité en utilisant des modèles à « vertex » (à condition qu'il s'agisse de lois de comportement complètes, ce qui est rarement le cas) ou des modèles non coaxiaux (lois avec écrouissage cinématique).

Les modèles de comportement classiques ne faisant intervenir que l'histoire du tenseur gradient du déplacement sont des modèles sans échelles internes. Les géomatériaux sont au contraire clairement des modèles avec échelle interne : taille des grains pour les sols ou les bétons, répartition spatiale des discontinuités préexistantes pour les roches. Dans de nombreux problèmes, on peut ignorer cette carence de principe des modèles utilisés. Cependant, pour la rupture localisée, donc pour la rupture, cela n'est plus possible. C'est un fait expérimental que l'extension, la largeur des bandes de localisation dans les sables dépend de la granulométrie de celui-ci et essentiellement de la dimension moyenne. Si la prédiction du seuil de localisation peut sans difficulté se faire avec des modèle classiques, c'est une pure illusion, cependant encore largement partagée, de penser que la postlocalisation pourra être correctement modélisée à l'aide de lois de comportement classiques. Au niveau numérique, cela entraîne des résultats peut-être indépendants de l'ordinateur, mais par contre dépendants pathologiquement et fortement de la taille des éléments finis utilisés. Sans faire une liste exhaustive des diverses solutions possibles, on va évoquer deux dans la suite, sans entrer dans les détails car il s'agit de domaines en pleine évolution.

Une grande classe de modèles à échelle interne sont les modèles avec microstructures. Leur cinématique est décrite non plus seulement avec le champ de déplacement (qui par dérivation spatiale donne le gradient, la rotation et la déformation usuelle), mais aussi avec un champ de microgradient représentant les déformations et les rotations au niveau des « grains » (dont la dérivation donne un gradient du microgradient). Cette cinématique enrichie nécessite l'ajout par dualité de tenseurs de contrainte additionnels. Les grandeurs énergétiques ou les travaux virtuels ou réels font intervenir ces enrichissements cinématiques et statiques.

Une autre voie consiste à introduire les zones localisées comme des icônes dont le comportement diffère de celui du reste du milieu. Par exemple, la forte dilatance observée dans les sables denses conduit à une diminution de densité dont la valeur tend asymptotiquement vers une valeur limite appelée densité critique. Des expériences bien instrumentées ont clairement montré que ce phénomène était localisé. Il est donc raisonnable de faire entrer ce type de comportement non pas dans une loi «en volume», mais plutôt dans une bande localisée et de construire un modèle spécifique pour la bande qui devra représenter le phénomène de saturation de la dilatance.

3. LES LOIS INCREMENTALES NON LINEAIRES

L'écriture générale des lois de comportement non visqueuses est de la forme :

$$d\varepsilon_\alpha = M_{\alpha\beta}(u_\gamma)\,d\sigma_\beta \quad , \quad \alpha,\beta,\gamma \in \{1,2,\ldots,6\}^3 \tag{5}$$

ou sous la forme duale :

$$d\sigma_\alpha = N_{\alpha\beta}(v_\gamma)\,d\varepsilon_\beta \quad , \quad \alpha,\beta,\gamma \in \{1,2,\ldots,6\}^3 \tag{6}$$

où : u_γ, v_γ - la direction de la contrainte incrémentale $d\sigma_\gamma$, respectivement la direction de la contrainte incrémentale $d\varepsilon_\gamma$:

$$\begin{aligned} u_\gamma &= \frac{d\sigma_\gamma}{\|d\sigma\|} \quad , \quad \gamma \in \{1,2,\ldots,6\} \quad \text{avec} \quad \|d\sigma\| = \sqrt{d\sigma \cdot d\sigma} \\ v_\gamma &= \frac{d\varepsilon_\gamma}{\|d\varepsilon\|} \quad , \quad \gamma \in \{1,2,\ldots,6\} \quad \text{avec} \quad \|d\varepsilon\| = \sqrt{d\varepsilon \cdot d\varepsilon} \end{aligned} \tag{7}$$

Pour la structure de M(u) et N(v) on va considérer les développement en séries polynomiales des éléments de ces deux matrices :

$$M_{\alpha\beta}(u_\gamma) = M^1_{\alpha\beta} + M^2_{\alpha\beta}\, u_\gamma + M^3_{\alpha\beta}\, u_\gamma u_\delta + \dots \quad , \quad \alpha,\beta,\gamma,\delta \in \{1,2,3,\dots,6\}^4$$
$$N_{\alpha\beta}(v_\gamma) = N^1_{\alpha\beta} + N^2_{\alpha\beta}\, v_\gamma + N^3_{\alpha\beta}\, v_\gamma v_\delta + \dots \quad , \quad \alpha,\beta,\gamma,\delta \in \{1,2,3,\dots,6\}^4 \qquad (8)$$

En reportant dans (5) et (6) nous avons l'expression des composantes de la déformation incrémentale et de la contrainte incrémentale :

$$d\varepsilon_\alpha = M^1_{\alpha\beta} d\sigma_\beta + \frac{1}{\|d\sigma\|} M^2_{\alpha\beta\gamma}\, d\sigma_\beta d\sigma_\gamma + \dots \quad , \quad \alpha,\beta,\gamma, \in \{1,2,3,\dots,6\}^3$$
$$d\sigma_\alpha = N^1_{\alpha\beta} d\varepsilon_\beta + \frac{1}{\|d\varepsilon\|} N^2_{\alpha\beta\gamma}\, d\varepsilon_\beta d\varepsilon_\gamma + \dots \quad , \quad \alpha,\beta,\gamma \in \{1,2,3,\dots,6\}^3 \qquad (9)$$

Le premier terme de ces deux équations correspondent à l'expression des lois élastiques incrémentalement linéaire ; l'ensemble des deux premiers terms fournit l'écriture générale des lois de comportement incrémentalement non linéaire du second ordre et représente ainsi une forme générique :

$$d\varepsilon_{ij} = M^1_{ijkl} d\sigma_{kl} + \frac{1}{\|d\sigma\|} M^2_{ijklmn}\, d\sigma_{kl} d\sigma_{mn} + \dots \quad , \quad i,j,j,l,m,n \in \{1,2,3,\dots,6\}^6$$
$$d\sigma_{ij} = N^1_{ijkl} d\varepsilon_{kl} + \frac{1}{\|d\varepsilon\|} N^2_{ijklmn} d\varepsilon_{kl} d\varepsilon_{mn} + \dots \quad , \quad i,j,j,l,m,n \in \{1,2,3,\dots,6\}^6 \qquad (10)$$

Les expressions (10) sont non linéaires et homogènes de degré1 par rapport à $d\sigma$ et à $d\varepsilon$. La forme générale de deux tenseurs M^1, M^2, N^1, N^2 trois hypothèses sont faites : la relation incrémentale est orthotrope ; il n'existe pas de termes croisés en axe d'orthotropie ; la partie « cisaillement » de la relation est incrémentalement linéaire en axe d'orthotropie. Par conséquent, en axe d'orthotropie les expressions (10) se réduisent à une forme simplifiée qui nous amène à la détermination des matrices de dimensions 3 x 3 et des fonctions. L'idée est d'identifier le comportement décrit par les relations obtenues compte tenant de ces trois hypothèses mentionnées au-dessus avec des comportements que l'on peut aisément déterminer expérimentalement. Alors que : pour le premier modèle il s'agit des « chemins triaxiaux généraux » (les axes principaux de contraintes et de déformations sont fixes et confondus et les deux contraintes latérales restent constantes le long du chemin) ; pour le deuxième modèle dual il s'agit des « chemins œdométriques généralisés » (les axes principaux de contraintes et de déformations sont fixes et confondus et de manière duale, les déformations latérales sont constantes le long du chemin).

Pour les deux modèles on peut parler de compression triaxiale et d'extension triaxiale et de manière duale de compression œdométrique respectivement d'extension œdométrique. Les relations finales peuvent s'interpréter comme une interpolation quadratiques entre des réponses supposées connues sur des chemins particuliers (triaxiaux généralisés ou œdométriques généralisés). La littérature offert plusieurs modèles de type d'interpolation : modèle octolinéaire, modèle nonlinéaire du second ordre, modèle non hypoplastique de Chambon, modèle de Doanh ; d'autres modèles ont été proposés par Robinet, Benedetto, Royis, Laouafa (le dernier à unifié les premiers deux modèles précisés). La plus simple est l'interpolation linéaire, qui aboutit à des lois incrémentalement linéaires par morceaux, comportant huit zones tensorielles, dénommée modèle octolinéaire. Pour percevoir les possibilités et les limites de ces modèles ont été analysés deux cas de dégénérescence les plus significatives : le cas du milieu monodimensionnel du matériau élastique et du matériau parfaitement plastique.

Les modèles octolinéaire et non linéaire du second ordre dégénèrent en la même expression dans le cas d'un milieu monodimensionnel où la contrainte incrémentale et la déformation incrémentale sont deux scalaires :

$$d\varepsilon = \frac{1}{2}\left(\frac{1}{E^{+}} + \frac{1}{E^{-}}\right)d\sigma + \frac{1}{2}\left(\frac{1}{E^{+}} - \frac{1}{E^{-}}\right)\left|d\sigma\right| \tag{11}$$

$$d\sigma = \frac{1}{2}\left(E^{+} + E^{-}\right)d\varepsilon + \frac{1}{2}\left(E^{+} - E^{-}\right)\left|d\varepsilon\right| \tag{12}$$

où : E^+ - le module tangent en charge ; E^- - le module tangent à la décharge. Les deux modules dépendent, par l'intermédiaire de variables scalaires de l'histoire de sollicitation. Un comportement élastoplastique monodimensionnel quelconque peut ainsi être décrit par les relations (11) et (12). On note ici, qu'une relation incrémentale non linéaire unique est bien équivalente à la double relation élastoplastique avec un critère de charge – décharge :

$$\begin{cases} d\varepsilon = \dfrac{1}{E^{+}}d\sigma \quad , \quad \text{si} \quad d\sigma \geq 0 \quad (\text{charge}) \\ d\varepsilon = \dfrac{1}{E^{-}}d\sigma \quad , \quad \text{si} \quad d\sigma \leq 0 \quad (\text{décharge}) \end{cases} \tag{13}$$

Si le comportement du matériau est élastique, cela implique que les comportements sur les chemins de base – triaxiaux généralisés et œdomètriques généralisés – vont être identiques en compression et en extension. Dans ce cas les modèles octolinéaires et non linéaires du second ordre dégénèrent en la même valeur :

$$\begin{Bmatrix} d\varepsilon_1 \\ d\varepsilon_2 \\ d\varepsilon_3 \end{Bmatrix} = N \begin{Bmatrix} d\sigma_1 \\ d\sigma_2 \\ d\sigma_3 \end{Bmatrix} \tag{14}$$

où : N – le tenseur d'élasticité non linéaire orthotrope générale. Si aucune hypothèse supplémentaire de symétrie n'est faite sur N, il s'agira d'hypoplasticité ; contrairement, on obtiendra un comportement hyperélastique non linéaire orthotrope par existence d'un potentiel interne élastique qui impose la symétrie de N.

On considère la relation constitutive sous la forme :

$$d\sigma = M^{-1}(u)\,d\varepsilon \tag{15}$$

Un comportement plastique parfait peut être obtenu (s'il existe) en recherchant les solutions correspondant à une déformation indéfinie sous un état de contrainte maintenu constant, soit :

$$\|d\varepsilon\| \neq 0 \quad \text{avec} \quad d\sigma = 0 \quad \text{(dans le cadre de petites déformations)} \tag{16}$$

Une condition nécessaire et suffisante pour qu'il existe de telles solutions est constituée par :

$$\det M^{-1}(u) = 0 \tag{17}$$

ce qui correspond au critère de plasticité du matériau ; dans le cas du modèle octolinéaire, cette condition s'interprète par la nullité au moins de l'un des six modules tangents.

Les solutions en déformation sont fournies par la relation :

$$M^{-1}(u)\, d\varepsilon = 0 \tag{18}$$

On peut trouver une infinité de solutions qui diffèrent par leur norme, la direction de $d\varepsilon$ étant en général déterminée. La condition (18) peut s'interpréter comme une règle d'écoulement singulière du matériau, car les directions de $d\varepsilon$ solutions de cette relation dépendent de la direction de $d\sigma$. Dans le cas du modèle octolinéaire, cette singularité locale de la règle d'écoulement est de type pyramidale.

Pour cerner les capacités prédictives d'un modèle de comportement ont été étudiées les réponses fournies pour diverses classes de sollicitation. Un premier exemple considéré dans le cadre des sollicitations non proportionnelles, porte sur la modélisation d'une sollicitation circulaire dans le plan déviatoire des contraintes. Les sollicitations en boucles de contraintes fermées jouent un rôle important en pratique, car l'on considère que des cycles aux limites répétés en forces ou pression (par exemple le passage de véhicule sur la chaussée) induisent à l'intérieur du massif de sol des boucles sensiblement fermées en contraintes mais ouvertes en déformations. Un deuxième exemple de sollicitations non proportionnelles est constitué par les chemins en escalier. Un chemin proportionnel est suivi de manière approchée par deux autres chemins différents, appliqués successivement en incréments finis. Cette analyse présent double intérêt. Sur le plan expérimental, les presses asservies ne sont en mesure de suivre un chemin donné que de manière approchée à l'intérieur d'une bande d'erreurs entourant le chemin prescrit et donc il introduit une erreur systématique. Par ailleurs, le principe de superposition des sollicitations incrémentales n'est valable dans le cas des lois incrémentalement linéaire.

La liquéfaction des sables lâches saturés est longtemps restée un problème mal compris, essentiellement parce qu'elle était analysée comme intrinsèquement liée à la condition de non-drainage et à la faible densité des sables liquéfiants. L'expérience montre qu'il est possible de liquéfier des sables secs si on peut leur appliquer un chemin isochore (à volume constant). Même cette dernière condition n'est pas nécessaire, et il apparaît qu'il est possible de liquéfier des sables denses en leur appliquant un chemin proportionnel en déformations suffisamment dilatant. Les calculs menés avec le modèle de comportement incrémental non linéaire du second ordre sur un sable à l'état lâche, illustre le fait que la liquéfaction est un phénomène très général dans les milieux granulaires : même un chemin contractant peut conduire à la liquéfaction d'un sable lâche. On trouve dans la littérature un critère général de liquéfaction statique qui consiste à la comparaison du taux de variation de volume imposé par la règle d'écoulement du matériau avec le taux de variation de volume induit par le chemin de sollicitation en déformation. Si ces deux taux sont égaux, il se produira un écoulement plastique parfait du sable. Si le premier est plus fort que le second (avec la convention : dilatance positive, contractance négative), les contraintes vont diminuer jusqu'à leur annulation éventuelle à l'état liquéfié. Ce critère montre qu'en faisant varier l'indice des vides initial - ce qui, à niveau de contraintes identiques, fait varier le taux de variation de volume de la règle d'écoulement d'une légère contractance, pour l'indice des vides le plus fort, à une légère dilatance, pour des indices de vides plus faible -, le sable passe d'un comportement liquéfiant à un comportement à contraintes croissantes. Pour une valeur intermédiaire de l'indice des vides, la « pression critique » est atteinte (le taux de variation de volume imposé par la règle d'écoulement est nul) et un écoulement plastique parfait peut se développer.

CONCLUSIONS

La modélisation non linéaire des matériaux est pleine d'embûches. En particulier, il est extrêmement difficile de savoir si les modèles utilisés conduisent à des problèmes mathématiques bien posés. Dans un ouvrage consacré au comportement, il est indispensable de savoir si les modèles présentés sont effectivement utilisables dans des calculs par éléments finis.

Il est probable, que tous les modèles de comportement de géomatériaux conduisent à des difficultés mathématiques insurmontables. Il est donc toujours intéressant de posséder quelques résultats sûrs concernant le problème mathématique associé à un modèle et quelques expériences numériques précises et quantifiées quant à la précision des schémas d'intégration des modèles. Les modèles incrémentaux non linéaires présentent par rapport aux modèles élastoplastiques l'avantage de ne pas nécessiter l'introduction ni d'une surface de limite élastique, ni d'une règle d'écoulement, dont les déterminations expérimentales se sont avérées très délicates dans le cas des géomatériaux. Ces modèles incrémentaux reposent sur l'explicitation d'une relation non linéaire entre contrainte et déformation incrémentales.

BIBLIOGRAPHIE

[1]. Chambon, R., *Une loi rhéologique incrémentale non linéaire pour les sols non visqueux*, J. Meca. Théorique et Appl., vol. 3, pg. 521 - 544, 1984.

[2]. Chambon, R. et al, *Lois incrémentales, viscoplasticité,endommagement – Modèles de comportement des sols et des roches*, Pierre-Yves Hischer et Jian-Fu Shao, Hermes, Lavoisier.

[3]. Viggiani, C., Tamagnini C., *Hypoplasticity for modelllng soil non linearity in excavation problems*, Prefailure deformation characteristics of geomaterials, M. Jamiolkowski, R. Lancellota, D. Lo Presti (dir.), Balkema, Rotterdam, vol. 1, p. 581-588, 1999.

ETUDE PHENOMENOLOGIQUE DU COMPORTEMENT DIFFERE DES ROCHES

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Abstract :

The soil’s behaviour study, considering the « time » variable in an explicit way, is realized in this case, according to the mechanisms that are at the bottom line of this behaviour. It is mainly dealed with the phisical expansion problem of the clays, as well as the creep phenomen determined by the mechanisms that take place at a microstructural scale – dislocations and slides – into the crystalline network.

Key words: convergence, creep, law behaviour, slide, dislocation, expansion, squeezing rocks, clay, hardening strain, crystalline network.

1. INTRODUCTION

En souterrain, il existe des roches qui ont la fâcheuse propriété de développer au cours du temps, des pressions importantes sur les soutènements et revêtement. Les anglo-saxons les appellent «squeezing rocks», que l'on peut traduire par «roches poussantes». Cette notion trouve son origine à l'époque des pionniers de la construction de tunnels dans des roches broyées, aptes à subir de grandes déformations différées.

Les excavations effectuées dans ce type de terrains peuvent faire l'objet des observations suivantes : des convergences en paroi non stabilisées ; des pressions importantes sur les soutènements et revêtements ; une dégradation des caractéristiques mécaniques de la roche en parement. Selon certains auteurs, « un potentiel réel de fluage du rocher sous les contraintes données est une exigence fondamentale pour que se produise du rocher poussant » ; cela sous-entend que le phénomène de fluage serait systématiquement à la base des désordres observés en paroi d'excavation. En pratique, ces désordres ont parfois des origines totalement différentes. Il faut distinguer : les roches gonflantes comme l'anhydrite et les marnes riches en smectites ; les roches fluantes ; les roches qui se dégradent rapidement au cours du temps.

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Le phénomène de gonflement a été défini par la Commission sur les roches gonflantes de l'International Society of Rock Mechanics (ISRM, 1983): «le gonflement est la conséquence d'une combinaison de réactions physico-chimiques faisant intervenir principalement l'eau et une modification de l'état de contrainte». Selon Aydan et al., ainsi que Gioda, le «rocher poussant» développe surtout des déformations croissantes au cours du temps sous un état de contrainte déviatoire constant ; or cela qualifie précisément le phénomène de fluage. La complexité de ces phénomènes nous impose d'étudier les différents mécanismes qui sont à l'origine du comportement différé. Parmi ceux-ci, le mécanisme de fluage est souvent très présent et mal connu. L'expérience des travaux souterrains et plus particulièrement celle des mines pose directement le problème de la stabilité à long terme des excavations pour lesquelles une aptitude au fluage est reconnue. Potts et Hedly (1964) affirment que l'une des principales conséquences pour un matériau présentant des caractéristiques de fluage est la création de microfissures au cours du temps. Ces dernières peuvent conduire, malheureusement, à la rupture de piliers de mine.

2. CLASSES DE COMPORTEMENT DIFFERE

Le comportement mécanique différé des géomatériaux se distingue du comportement instantané classique (élasticité et élastoplasticité) par la prise en compte explicite de la variable « temps ». Ce comportement correspond à l'un des phénomènes suivants : *la consolidation, le gonflement, le fluage et la relaxation.*

Pour un matériau poreux, la consolidation résulte de la dissipation de la pression interstitielle, u, du fluide considéré (u > 0). Le couplage entre la contrainte qui s'exerce sur le squelette solide (contrainte effective) et la pression de fluide est donné par la relation de Terzaghi pour un milieu saturé :

$$\underset{=}{\sigma}' = \underset{=}{\sigma} - u \cdot \underset{=}{I} \tag{1}$$

où : $\underset{=}{\sigma}'$ - les tenseur des contraintes effectives ; $\underset{=}{\sigma}$ - le tenseur des contraintes totales constant au cours du temps ; $\underset{=}{I}$ - le tenseur identité.

Au cours de la consolidation, la contrainte effective, qui s'exerce réellement sur le squelette solide, augmente et le volume du matériau diminue par réduction de l'indice des vides, e. La consolidation induit des déformations différées, fonction de la perméabilité des matériaux ; en pratique, cela se manifeste par des tassements de surface et des déformations différées autour des ouvrages. On distingue parfois la consolidation primaire qui est celle décrite ci-dessus de la consolidation secondaire qui se traduit par la poursuite des tassements différés quand la pression interstitielle s’est déjà dissipée. Ce dernier phénomène s’apparentait plutôt à un phénomène de fluage du squelette solide, qu’à une consolidation. Le gonflement se traduit par une augmentation de volume du matériau en fonction du temps ; il résulte souvent d’une interaction physico – chimique. On fonction de la nature minéralogique de la roche le type d’interaction peut varier. Deux phénomènes se distinguent :

- le gonflement physique par absorption de molécules d'eau libre : il caractérise le comportement des argiles pour lesquelles les phénomènes physico – chimique se manifestent en fonction du bilan des forces interparticulaire en présence ; l'absorption physique est due à des forces électrostatique (van der Waals). Le phénomène peut être réversible. Il est possible d'affirmer que *« si la consolidation exprime une diminution de la pression interstitielle jusqu'à son annulation, le gonflement exprime quant à lui, la diminution de la succion (pression interstitielle négative, -u) jusqu'à son annulation* » ;

- le gonflement chimique consécutif à une modification cristallographique du matériau : il peut résulter de la formation de corps salins par hydratation. Par exemple, le cas de l'anhydrite qui est un sulfate de calcium $CaSO_4$. Le gonflement de l'anhydrite résulte de sa transformation en gypse $CaSO_4 \cdot 2H_2O$, par dissolution puis recristallisation. Comme la densité du gypse est inférieure à celle de l'anhydrite, le gypse ainsi formé occupe un volume supérieur à celui de l'anhydrite. Une telle transformation se produit sous une certaine température, pression et teneur en eau. Ces considérations démontrent qu'en système fermé (sans apport d'eau) le gypse se forme avec une réduction de volume alors qu'en système ouvert le potentiel de gonflement est très élevé et par conséquent, le gonflement de l'anhydrite n'est pas possible qu'en cas d'apport d'eau (porosité, fracturation) sous circulation faible avec des surfaces d'hydratation importantes. En pratique, la transformation de l'anhydrite en gypse se révèle lente et durable et favorise le colmatage des arrivées d'eau dans un massif.

Les facteurs qui peuvent déclancher des phénomènes de gonflement mécanique et physique sont de différents ordres, principalement :

- l'apport d'eau dans un milieu gonflant non confiné par percolation et migration dans le milieu poreux ;
- l'adsorption d'eau en provenance du massif ou de l'air ambiant, après modification de l'état de contrainte lors du phasage de construction d'un ouvrage souterrain ;
- la variation de composition chimique ou de concentration d'éléments dissouts dans l'eau interstitielle.

Le fluage et la relaxation sont des phénomènes duaux. Le fluage révèle l'aptitude d'un matériau à se déformer dans le temps sous chargement déviatoire constant ; expérimentalement, les déformations sous chargement isotrope sont négligeables devant celles sous chargement déviatoire. Le fluage se développerait ainsi rigoureusement sans variation de volume, du moins tant que le matériau n'est pas endommagé et ne présente pas de dilatance. Le fluage se trouve souvent mêlé au gonflement, ce qui ne permet pas toujours de retrouver un comportement isochore. A ce titre, la consolidation secondaire à l'œdomètre ne relève pas scrupuleusement des phénomènes de fluage, car elle est associée à une diminution de volume. Ces précisions mises en évidence que la définition du fluage induit implicitement une simplification du comportement ; ce dernier est en réalité très complexe, car beaucoup de phénomènes sont couplés. Ainsi, les modèles mathématiques – analytiques et numériques – qui ont été développés ne sont pas tout à fait représentatifs que d'une interprétation mécanique du fluage. En laboratoire, l'étudier le fluage proprement dit d'une roche revient à observer l'évolution des déformations différées, le plus souvent sous paliers de chargement déviatoire ; les essais les plus courants sont en compression simple et essais triaxiaux. Ces essais caractérisent seule la matrice rocheuse, alors que dans la nature, le milieu rocheux est hétérogène et anisotrope, et les discontinuités peuvent jouer un rôle majeur au cours du temps. L'effet d'échelle, difficile à appréhender en géotechnique pour caractériser le comportement à court terme des géomatériaux, se révèle une difficulté majeure pour quantifier les phénomènes différés.

Le phénomène dual au fluage est la relaxation qui exprime le chemin de contrainte suivi sous déformations maintenues constantes. Au laboratoire, seule la déformation axiale et non le tenseur des déformations est par usage maintenue constante, et le relâchement de la contrainte axiale est mesuré en fonction du temps.

3. RAPPELLE SUR LES PHENOMENES DIFFERES

Il sera question du gonflement physique des argiles, donc les remarques seront consacrer aux roches argileuses qui ont des propriétés spécifiques en fonction de la structure cristallographique en feuillets des argiles, des différents types de liaisons microstructurales, ainsi que de la nature de la liaison eau – argile.

Les minéraux argileux appartiennent à la grande famille des silicates hydratés lamellaires dont les feuillets constitutifs sont formés par l'empilement de couches tétraédriques de silicium et de couches octaédriques alumineux ou magnésiens. La particularité d'un minéral argileux réside dans le nombre de couches tétraédriques et octaédriques constituant un feuillet et par conséquent, dans l'épaisseur de ce feuillet. Les feuillets des minéraux argileux se présentent selon trois types de configurations : électriquement neutres pour lesquelles il n'y a pas de cations compensateurs dans l'espace compris entre deux feuillets consécutifs ; avec une concentration en cations compensateurs tels que K^+, Ca^{2+}, Mg^{2+}, très élevée dans l'espace interfoliaire, ce qui confère des liaisons très fortes au sein de la structure et aussi des configurations intermédiaires avec peu de cations et une possibilité de pénétration de molécules d'eau et donc de gonflement. Pour une particule argileuse, on distingue deux types de liaisons entre les éléments :

- les liaisons covalentes ou ioniques, très fortes qui peuvent difficilement être rompues ;
- les liaisons interfoliaires et interparticulaires qui regroupent les liaisons coulombiennes (interfoliaire), les liaisons hydrogènes et les forces de Van der Waals qui constituent la liaisons la plus faible entre électrons et noyaux des atomes constituant les particules d'argiles.

Les liaisons entre minéraux argileux ne sont pas seules à l'origine du comportement différé des roches argileuses, pour lesquelles l'eau joue un rôle important, donc il convient d'étudier également les liaisons générées par le système eau – argile. Les liaisons susceptibles d'être à l'origine de phénomènes de gonflement ou de fluage sont celles faisant intervenir des molécules d'eau. On distingue les trois types d'eau : l'eau de constitution intégrée au réseau cristallin fortement liée à la structure moléculaire ; l'eau interfoliaire responsable du gonflement et l'eau interstitielle présente entre les particules argileuses qui peut à la fois se mettre en charge, et agir sur les propriétés physiques des argiles (voir les limites d'Atterberg).

La compréhension du gonflement des argiles repose sur la théorie physico – chimique du système eau – argile dite « la théorie de la double couche électrique » imaginée pour la première fois par Helmholtz, avant d'être formulée par Gouy et Chapman, puis par Stern.

Le modèle de Helmholtz (1879) suppose que la différence de potentiel électrostatique, ΔV, générée à l'intérieur de l'interface solide – liquide est due à des charges électriques opposées et réparties dans chacune des phases. La variation de potentiel à l'intérieur de cette interface est supposée linéaire. En 1910, Gouy remarque qu'une simple couche solide n'est pas réaliste car elle est forcément détruite par l'agitation thermique. Chapman (1913) propose que les forces thermiques et électrostatiques régissent l'équilibre de la double couche ; ainsi il propose que le liquide vérifie à l'interface les équations de Poisson (ordre électrostatique, équation 2) et de Boltzmann (désordre thermique, équation 3) :

$$\Delta V = -\frac{\rho}{\varepsilon} \tag{2}$$

$$N_i = N_i^{int} e^{\frac{\Delta G_0}{kT}} \tag{3}$$

où : ρ - la charge électrique au point considéré (unité : Coulomb, C) ; ε – la permittivité électrique en ce même point (unité : Farad, F) ; N_i – la concentration en ion « i » toujours en ce point ; N_i^{int} – la concentration en ion « i » à l'intérieur de la solution ; ΔG_0 – l'énergie d'activation requise pour amener l'ion « i » de l'intérieur de la solution au point considéré ; k – la constante de Boltzmann, $k = 1{,}381 \cdot 10^{-23}$ JK^{-1} ; T – la température absolue en Kelvin.

La théorie de la double couche repose sur l'existence, à proximité d'une surface chargée d'une couche diffuse possédant des propriétés différentes de celles du réservoir contenant cette solution. Le modèle de Gouy – Chapman, fig.1, tient compte de cette couche diffuse dont l'épaisseur est donnée par la longueur de Debye (moment dipolaire électrique de l'interface considérée divisé par sa charge électrique). Au-delà de cette longueur la couche diffuse récupère les propriétés du réservoir. Dans la couche diffuse la distribution des contre-ions est déterminée à la fois par les interactions électrostatiques avec la surface, et par les mécanismes de diffusion liés à l'agitation thermique (qui tendent à rétablir l'équilibre avec le réservoir). Dans ce modèle, les ions sont considérés comme ponctuels et le solvant comme un continuum diélectrique, hypothèses non satisfaisantes surtout lorsqu'on se trouve à proximité de la surface chargée. Il a donc été nécessaire de définir un nouveau modèle permettant de rendre compte de la taille finie des ions. Le nouveau modèle de double couche proposé par Stern (1924) suppose qu'il existe à l'interface des forces d'adsorption qui attirent certains ions et / ou d'autres molécules polaires, puis collent ces éléments à l'interface. L'interface solide – liquide se décompose alors en trois couches. La première constitue le solide, la troisième est la couche diffuse et la seconde est intermédiaire et accolée au solide : il s'agit de la couche compacte dite couche de Stern, fig.2.

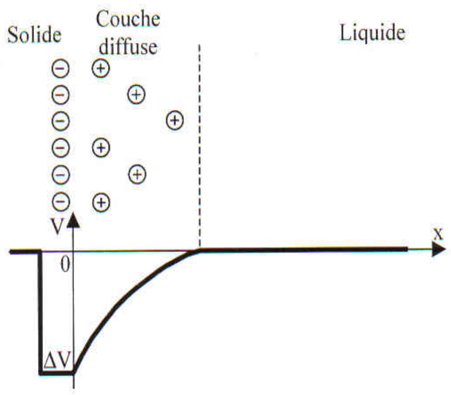

Fig.1. Modèle de Gouy – Chapman

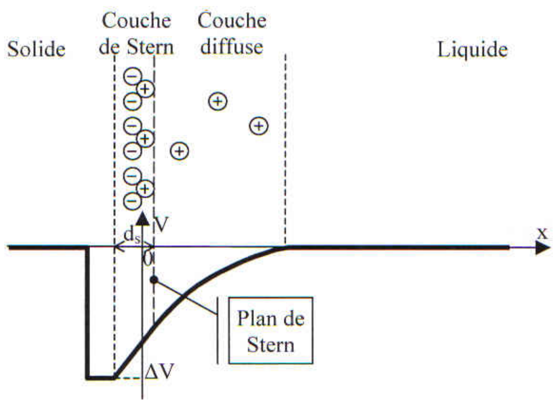

Fig.2. Modèle de Stern

Selon la théorie de la double couche, les molécules d'eau sous forme polaire (dipôle H^+, OH^-) se trouvent orientées par les cations compensateurs, présents dans l'espacement interfoliaire. Il se forme alors une première couche monomoléculaire d'eau (couche diffuse) fortement liée au feuillet et à l'autre extrémité, d'autres dipôles d'eau sont attirés. L'intensité de la liaison décroît alors avec la distance pour aboutir à l'eau libre en bout de chaîne. La répartition des ions autour de la particule argileuse résulte de l'équilibre entre les forces électrostatiques attractives et celles de diffusion qui sont répulsives vers des zones de moindre concentration (principe de la loi de Fick). Le bilan des forces d'attraction et de répulsion qui s'exercent entre deux particules argileuses, ayant fixé des molécules d'eau, montre qu'au-delà d'une distance de 100 nm, les forces attractives l'emportent légèrement. Entre 1 et 100 nm, les forces répulsives sont plus fortes, alors qu'entre 0 et 1 nm, les forces d'attraction conditionnent la liaison. L'épaisseur de la couche diffuse d'eau, fortement dépendante des cations présents dans l'espace interfoliaire tels K^+, Ca^{2+}, Mg^{2+}, va influencer la force des liaisons entre particules argileuses et donc par conséquent la cohésion macroscopique de la roche concernée.

Les roches argileuses présentent deux types de gonflement physique dont le mécanisme peut être illustré par le modèle de la double couche. Il s'agit :

i) du gonflement interparticulaire, pour lequel l'eau ne pénètre pas entre les feuillets d'argile affecte toutes les argiles mais peut être de faible ampleur. Le processus met en jeu des phénomènes physico-chimiques entre une particule argileuse et l'eau dans l'espace périphérique de la particule ;

ii) du gonflement interfoliaire ou intraparticulaire qui intervient à l'échelle des particules argileuses et peut engendrer une augmentation de volume très importante. En pratique, la quantité d'eau nécessaire au gonflement peut être faible. Elle est acheminée par le milieu extérieur soit par des écoulements dans les terrains encaissants soit par l'air et se fixe entre deux feuillets voisins d'argile. Le gonflement devient notable à partir du moment où l'eau interstitielle peut pénétrer entre les feuillets d'argiles et créer une juxtaposition de plusieurs couches monomoléculaires d'eau (le cas des smectites telles que la montmorillonite et de certaines vermiculites qui sont constituées de feuillets dont la distance interfoliaire est très variable).

Le mécanisme de gonflement des argiles qui vient d'être explicité précédemment permet sûrement d'expliquer le comportement différé de certaines roches argileuses. Nous avons la tendance de penser que le fluage pourrait résulter d'une rupture progressive de certaines liaisons au cours du temps. Par exemple, les illites, qui présentent la particularité d'avoir des interfeuillets clavetés par des ions K+, peuvent fluer sous sollicitations mécaniques après rupture par cisaillement de ces clavettes. Ces mécanismes sont cependant très mal connus, et ne peuvent être modélisés. On va se concentrer ensuite sur les mécanismes de déformation des cristaux. Ces derniers ont été beaucoup plus étudiés ; ils nous permettent de mieux appréhender un mécanisme de fluage possible dans les minéraux cristallins.

Les mécanismes de déformation pour les matériaux cristallins sont principalement des mécanismes par dislocations qui constituent l'une des classes de défauts cristallins. Ces défauts ou imperfections microscopiques correspondent aux régions du cristal dans lesquelles un atome est entouré de proches voisins situés en des positions différentes de celles qu'il possède dans le cristal parfait. Dans une roche argileuse, ce type de mécanismes ne peut affecter que les minéraux cristallins, c'est-à-dire les éléments non argileux qui forment par exemple le ciment de la roche. Il peut s'agir de la calcite, de l'anhydrite, du gypse, du quartz ou de tout autre élément cristallin intégrant des défauts microstructuraux.

Géométriquement, on peut classer les imperfections en trois catégories :

a) les défauts ponctuels : regroupent les lacunes cristallines, les atomes interstitiels et les impuretés ; ces défauts contribuent à la résistance du cristal. Les lacunes sont à l'origine de la diffusion de matière et remplissent un rôle important dans la mobilité des dislocations lors d'essais mécaniques ;

b) les défauts linéaires : correspondent à une ligne le long de laquelle l'ordre cristallin se trouve perturbé ; il s'agit le plus souvent d'une ligne d'imperfections permettant à une certaine région d'un cristal de glisser par rapport à une autre. Ces défauts entraînent par réaction en chaîne des concentrations de défauts le long de structures linéaires dans les cristaux. Telle structure l'on appelle dislocation. Il existe deux types importants de dislocation :

- dislocations coin, défini comme un demi-plan qui se termine dans la masse du cristal ; la ligne de dislocation est perpendiculaire à la sollicitation mécanique. La dislocation coin est un défaut important du cristal car ce dernier peut se déformer en glissant perpendiculairement à la ligne de dislocation ;

- dislocations vis qui est une dislocation linéaire autour de laquelle les plans d'atomes s'enroulent en spirales ; la ligne de dislocation est parallèle à la sollicitation mécanique ;

c) les défauts plans.

L'étude de la propagation des déformations plastiques de cristaux a révélé que celle-ci résulte notamment du mouvement des dislocations. Diverses expériences ont révélé que lorsque la contrainte ou la température croît, la vitesse des dislocations augmente. Il existe deux modes de déplacement pour un segment de dislocation :

- le mode conservatif pour lequel la dislocation avance dans son plan de glissement avec franchissement d'obstacles,
- la montée absorbant ou émettant des lacunes qui n'est pas conservative (mécanisme de diffusion) et qui s'enclenche à haute température (supérieure à la moitié de la température de fusion).

Ce dernier mode nous intéresse moins car pour les géomatériaux étudiés même sous chargement thermique, la température est loin d'atteindre de telles valeurs. Une dislocation en mouvement doit franchir localement des obstacles qui constituent le lieu de la résistance au glissement pour la ligne de dislocation considérée. Cette résistance peut être mobilisée par le percement du plan de glissement et la friction due au réseau cristallin ainsi qu'à la présence d'impureté, de précipités, voire d'autres dislocations d'orientations différentes.

Supposons que sous l'effet d'une contrainte de cisaillement, τ, une ligne de dislocation soit poussée et rencontre une série continue d'obstacles. Supposons également que l'agitation thermique fasse vibrer, avec une fréquence, f, l'arc séparant deux atomes consécutifs formant la dislocation. Si la barrière d'énergie d'activation, à fournir pour franchir l'obstacle vaut ΔG_0, la vitesse de déplacement de la dislocation, s'écrit :

$$v = f \cdot d \cdot e^{-\frac{\Delta G_0 - \tau^* V_A}{k T}} \tag{4}$$

où : d - la distance moyenne parcourue entre deux obstacles ; V_A - le volume d'activation ; τ^* - la contrainte effective microstructurale qui fournit le travail $\tau^* V_A$ lors du franchissement de l'obstacle ; f - la fréquence d'oscillation de l'arc entre deux atomes consécutifs de la dislocation.

La contrainte, τ^*, peut se déduire de la contrainte, τ, en lui retranchant la contrainte interne qui va dépendre de la mobilité des autres dislocations et qui est proportionnelle au module de cisaillement, G, du cristal. A une telle vitesse de déplacement de la dislocation, s'opposent deux types d'obstacles majeurs, qui sont :

- la friction intrinsèque liée à l'empilement atomique, nommée force de Peierls – Nabarro, matérialisée par la rupture de liaisons atomiques,
- la présence d'éléments extrinsèques (intersections de dislocations, précipités et atomes d'impureté).

Afin de mieux appréhender l'incidence des mécanismes par dislocations, on va présenter une méthode de déterminer la vitesse de déformation macroscopique du cristal en fonction de la vitesse des dislocations ainsi que de la densité de ces dernières. L'hypothèse d'un mécanisme par cisaillement simple est étudiée en considérant N dislocations coin mobiles de largeur, L, réparties sur une distance, D. Ce mécanisme est représenté sur la fig.3. L'amplitude de la marche de cisaillement est alors de longueur, N x b, où b est plus connu comme étant la norme du vecteur de Burger. La hauteur de cette marche vaut A/2.

Si chaque dislocation se propage avec une vitesse v, la déformation totale en cisaillement, γ, du cristal sera proportionnelle à la distorsion microstructurale b/A ; le facteur de proportionnalité est le rapport de la distance parcourue par les N dislocations au bout du temps t ramenée à la distance D. La déformation totale en cisaillement s'exprime par :

$$\gamma = \frac{N \cdot v \cdot t}{D} \cdot \frac{b}{A} \tag{5}$$

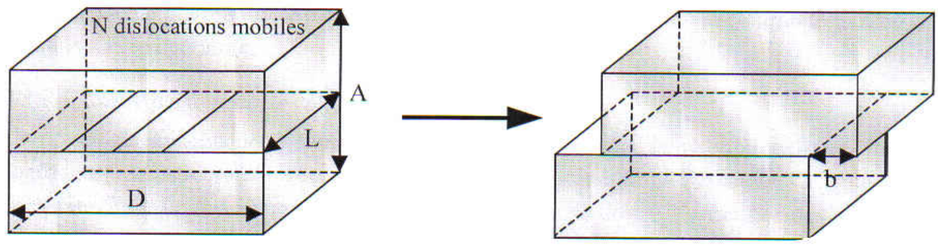

Fig.3.Déformation d'un cristal par glissement d'une dislocation coin

On obtiendra finalement l'équation d'Orowan qui donne l'expression de la vitesse de distorsion macroscopique ; elle s'écrit de la manière suivante :

$$\dot{\gamma} = \rho_m \cdot b \cdot v \tag{6}$$

$$\rho_m = \frac{N}{A \cdot D} \tag{7}$$

où : ρ_m – la densité de dislocation mobiles, souvent mal connue ; b – la norme du vecteur de Burger ; v – la vitesse de déplacement de la dislocation.

En combinant les équations (6) et (4) on obtient :

$$\dot{\gamma} = \rho_m b \cdot f \cdot d \cdot e^{-\frac{\Delta G_0 - \tau^* V}{k T}} \tag{8}$$

La contrainte effective en fonction de la vitesse de dislocation sera alors :

$$\tau^* = \frac{k T}{V} \cdot \ln \frac{\dot{\gamma}}{\rho_m b \cdot f \cdot d} + \frac{\Delta G_0}{V} \tag{9}$$

avec : $\dot{\gamma} \le \rho_m b \cdot f \cdot d$ quelque soit le mécanisme de mobilité par dislocations.

La contrainte microstructurale effective est une fonction décroissante de la température et il en est de même pour la limite élastique du matériau en y additionnant la contrainte interne peu sensible à la température.

CONCLUSIONS

La principale conclusion concerne la relation existant entre la contrainte microstructurale effective et la vitesse de distorsion macroscopique à température constante. Pour un mécanisme de mobilité par dislocations donné, l'ensemble des paramètres microstructuraux reste constant et une augmentation de la vitesse de distorsion macroscopique a pour effet d'augmenter la contrainte effective de manière logarithmique. Ce résultat est intéressant car il coïncide avec les observations faites sur des essais mécaniques en laboratoire. Une augmentation de la vitesse de sollicitation est souvent accompagnée d'une augmentation de la résistance notamment pour les roches. En conséquence, on peut interpréter des essais mécaniques à vitesse de déformation axiale imposée ainsi que des essais de fluage avec le souci de mettre en évidence des mécanismes de mobilité par dislocations. Par contre, selon Cristescu et Hunsche, il n'y a pas de modification de la microstructure lors de phénomènes de relaxation. Pour les roches argileuses, qui contiennent un pourcentage de calcite important, ce cristal pourrait être affecté par ce type de mécanismes. Il est possible de définir, au sens microstructurale, la notion d'écrouissage positif ou de durcissement, qui traduit une augmentation de la densité de dislocations et une diminution de la vitesse de déformation du cristal. Ce phénomène se développe par la simple présence de défauts au sein du réseau cristallin.

Étant donné que l'écrouissage engendre des instabilités d'ordre énergétique, les éléments cristallins cherchent à restituer (après déchargement) une partie de l'énergie élastique qu'ils ont emmagasinée lors du chargement préalable. Ce processus thermique très complexe, s'accompagne d'annihilations de dislocations de signe opposé, et porte le nom de recouvrance ou de restauration. Parfois, la recouvrance est suivi de phénomènes de recristallisation d'après Lemaître et Chaboche. Selon Munson, l'équilibre entre écrouissage et recouvrance conditionne totalement le phénomène de fluage.

BIBLIOGRAPHIE

[1]. Aydan, O., Akagi, T., Kawamoto, T., *The squeezing potential of rock around tunnels: theory and prediction with examples taken from Japan*, Rock Mech. Rock Engng. 29:3, 1996, pg. 125 - 143.

[2]. Cristescu, N. D., Hunsche, U., *Time Effects in Rock Mechanics*, John Wiley & Sons, Inc., 1997, 342 pg.

[3]. Gioda, G., Cividini, A., *Numerical methods for the analysis of tunnel performance in squeezing rocks*, Rock Mech. Rock Engng. 29 : 4, 1996, pg. 171 - 193.

[4]. Gouy, Ann.phys. 7, 1917, 129 pg.

[5]. Kovari, K., Amberg, F., Ehrbar, H., *Maîtrise du rocher poussant dans le tunnel de base du Gotthard*, Tunnels et Ouvrages Souterrains 164, 2001, pg. 55 - 60.

[6]. Lemaître, J., Chaboche, J-L., *Mécanique des matériaux solides*, Dunod, 1996, pg. 253 - 341.

[7]. Munson, D. E., *Constitutive model of creep in rock sait applied to underground room clossure*, Int. J. of Rock Mech. & Min. Sci. 34 : 2, 1997, pg. 233 - 247.

THE CHARACTERIZATION OF THE UPHOLDS WITH CONCRETE SPRINKLER AND WITH ANCHORS, ACCORDING TO THE CONVERGENCE – CONFINEMENT METHOD

CHIRILĂ DĂNUȚ *

Abstract:

The convergence – confinement method, assumes that the convergence displacements and the confinement pressures are independent, so the convergence displacement depends on the uphold type. In the analized case study if the neccessary confinement pressure is equal or smaller than the maximum pressure that could be exerted by uphold, than the sugested uphold is satisfactory, if the pressure is higher than the uphold is being suplimentary.

Key words : concrete sprinkler, convergence – confinement, anchors, rock – uphold interaction, plasticity.

1. THE VALUE OF THE CONVERGENCE DISPLACEMENTS AND THE CONFINEMENT PRESSURES

The convergence–confinement method context, the convergence displacement U_r is normal of the hollowed outline, circularily assimilated with the radius R. The relative convergence, expressed with the U_r/R fraction, varies between 10^{-3} and $4{\cdot}10^{-2}$. It is underlined the fact that the convergence displacements and the confinement pressures are independen, so convergence displacements depends on the uphold type. So:

- considering the flexibile upholds, only with anchors, the relative convergence displacements are much higher, reaching even 10^{-2};
- considering the upholds with templates or with templates and concrete sprinkler, the relative convergence displacements are smaller, barely reaching $5{\cdot}10^{-3}$.

The maximum values of the confinement pressures with could be reached for a certain uphold type, are estimated from the condition that the uphold needs to be mantained, either by breaking the uphold's elements, or the crumbling of the rock. According to the experimental datums and the measurements can deal with the next intervals of values (AFETS, 1993):

- for the anchors' uphold, according to the distance between the anchors, their length and the rezistance of the rock in the zone of the anchorage, the pressures varies between 0,05 MPa and 0,2 MPa;

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- for the easy, deformabile templates' uphold, the confinement pressures varies between 0,5 MPa and 0,1 MPa;
- for the hard templates' uphold, put together in contact with the rock, the confinement pressure reaches 0,2 MPa;
- for the concrete sprinkler uphold, with thickness between 5 cm and 20 cm, the confinement pressure could reach 0,5 MPa in the case of the tunnels or galeries with the diameter of 10 m.

2. CASE STUDY

2.1. General Datums

In the order to underline the way in which an uphold system is being dimensioned and chacked, we consider the case of a circular gallery which was implemented in crystaline schists, which are easily damage, at a depth of H_a = 40 m.

The rock is being characterized by next parameters:

- the specific weight, γ_{rock} = 27 kN/m^3;
- the intern friction angle, Φ = 29°;
- the apparent cohesion, c = 0,12 MPa;
- the elasticity mode, E = 1200 MPa;
- the initial efforts into massif, δ = 1,08 MPa;
- the strength coefficient, f = 0,65.

2.2. The rock's characteristic

The maximum teorethic elastic displacement, is being determined with the relation:

$$U_c^{max} = \frac{1+n}{E}\sigma° R = \frac{1+0,2}{1200}\cdot 1,08\cdot 4 = 0,432\cdot 10^{-2}\,\mathrm{m} = 0,432\,\mathrm{cm} \qquad (1)$$

According the next relation the characteristic parameters of the the plasticity criterium Mohr – Coulomb have the values:

$$K_p = \frac{1+\sin\varphi}{1-\sin\varphi} = 2,882 \quad ; \quad C_p = \frac{2\,c\cos\varphi}{1-\sin\varphi} = 0,40 \qquad (2)$$

The λ_e cote belonging to the maximum teorethic elastic displacement which is being effectively achieved in the elastic stadium is being determined with the relation:

$$\Lambda_e = \frac{1}{K_{p+1}}\left(K_{p-1} + \frac{C_p}{\sigma°}\right) = \frac{1}{3,882}\left(1,882 + \frac{0,40}{1,08}\right) = 0,58 \qquad (3)$$

And from here:

$$U_c^{max} = \lambda_e \cdot U_e^{max} = 0{,}58 \cdot 0{,}432 = 0{,}250\ \text{cm} \tag{4}$$

According to these values there could be determined the A and B points'

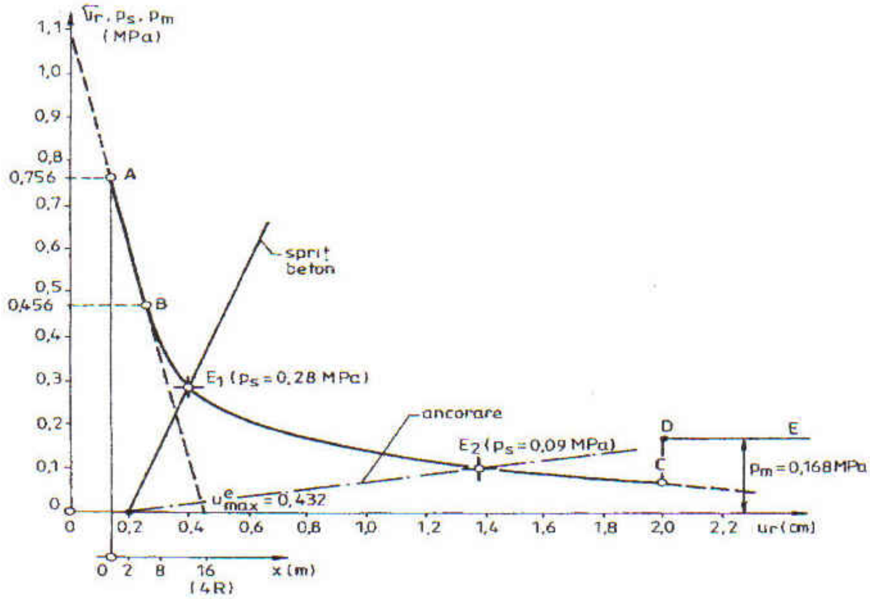

Fig.1. The convergence – confinement diagram for analysing the stability of the gallery in the numerical exemple

$$A\begin{cases}\sigma_{r,A} = 0{,}7\,\sigma^\circ = 0{,}756\ \text{MPa}\\ U_{r,A} = 0{,}3\cdot 0{,}432 = 0{,}129\ \text{cm}\end{cases} \quad ; \quad B\begin{cases}\sigma_{r,B} = (1-\lambda_e)\,\sigma^\circ = 0{,}453\ \text{MPa}\\ U_{r,B} = U_r^e = 0{,}250\ \text{cm}\end{cases}$$

In order to draw the BC section of the characteristic, which corresponds to the elastic – plastic behaviour there are being determined a serie of pairs of values σ_r, U_r, by giving the parameter λ certain values in the domain. The graval relation used in order to determin the plastic zone's radius, and also for the evaluement of the radial displacement are:

$$R_r = R\left(\frac{p}{1-\lambda}\right)^n \quad ; \quad U_e = A\left[2\left(\frac{R_r}{R}\right)^{x+1} + x - 1\right] = A\left[2\left(\frac{R_r}{R}\right)^{x+1} + 0{,}4\right] \tag{5}$$

where:

$$p = \frac{2 - \dfrac{C_p}{\sigma^\circ}}{K_{p+1}} = 0{,}419 \quad ; \quad n = \frac{1}{K_{p+1}} = 0{,}531 \quad ; \quad A = \frac{\lambda_e U_{r\,max}^e}{x+1} = 0{,}104 \tag{6}$$

In the tabel no.1 there are being presented the calculation's results for the 4 characteristic values of the λ parameter, which have served to draw the BC's zone, of the characteristic curve.

Tabel no.1 - The calculation's results for the 4 characteristic values of the λ parameter:

λ	$\sigma_r = (1-\lambda)\,\sigma°$ MPa	$R_p = R\left(\dfrac{0,419}{1-\lambda}\right)^{0,531}$	$U_r = 0,104\left[2\left(\dfrac{R_r}{R}\right)^{2,4} + 0,4\right]$
0,7	0,324	4,776	0,360
0,8	0,216	5,923	0,575
0,9	0,108	8,559	1,33
0,95	0,054	12,300	3,12

The limit from which the plastic component generates the surpation's vault moulding (the C point of the characteristic) is being determined with the relation:

$$R\left(\frac{p}{1-\lambda}\right)^{n} = R + h_{bs} \tag{7}$$

in which the height of the surpation's vault has the calculated value, as in the relation:

$$h_{bs} = \frac{b}{2f} = \frac{8}{2 \cdot 0,65} = 6,25\,\text{m} \tag{8}$$

From the condition relation, it results:

$$1-\lambda = \frac{p}{\left(\dfrac{R+h_{bs}}{R}\right)^{1/n}} = 0,07 \tag{9}$$

The C point coordonates will be:

$$\begin{aligned} \sigma_r &= 0,07\,\sigma° = 0,0756\,\text{MPa} \\ U_r &= 0,104\left[2\left(\frac{10,25}{4}\right)^{2,4} + 0,4\right] = 2,53 \end{aligned} \tag{10}$$

The DE side of the rock's characteristic is a parallel at the U_r axis, and has the ordinate:

$$p_x = \gamma_r h_{bs} = 27 \cdot 6,25 = 168\,\text{kN/m}^2 = 0,168\,\text{MPa} \tag{11}$$

The complete characteristic of the ABCDE rock, can be followed in the fig.1.

2.3. The uphold's characteristic

Continuing the elastic linear behaviour hypotesis of the uphold, its characteristic is the straight line that has the ecuation:

$$P_S = K_S \frac{U_r - U_{ra}}{R} \tag{12}$$

For every uphold type, it should be determined the K_S rigidity and the free displacement of the U_{ra} rock, until it contacts the uphold.

2.3.1. The uphold with concrete sprinkler

It is considered a concrete sprinkler ring, with the thickness of 10 cm, at the crossing moment, the elastic characteristics are E_{sb} = 20.000 MPa and μ_{sb} = 0,16. Then:

$$K_S = \frac{E_{sb} e}{(1-\mu_{sb})\, R} = \frac{20000 \cdot 0{,}1}{0{,}84 \cdot 4} = 595\ \text{MPa} \tag{13}$$

The characteristic straight line is:

$$P_S = 1{,}48 \cdot U_r \quad [\text{MPa}] \tag{14}$$

In the confinement – convergence diagram from the figure 1, we consider that the application of the concrete – sprinkler is made at 2 m behind the front (x = d = 2 m), and the contact with the rock is immediate (U_{ra} = 0). The excavation's equilibration is being obtained in the intersection point of the uphold's characteristic and the rock's characteristic E_1.From the diagram, it results P_S = 0,28 MPa. Taking into account the fact that the maximum pressure that could be implemented cannot outrun the value given by:

$$P_{s.\lim}^{sb} = \sigma_{c,sb} \frac{e}{R} = 6 \cdot \frac{0{,}1}{4} = 0{,}15\ \text{MPa} \tag{15}$$

It results that the uphold is the enough and that it should be associated with anchors.

2.3.2. The anchors uphold

The anchorage is made with anchors without concrete, with the length l = 2 m, from steel bars with the diametre d = 25 mm, willinged in a $e_R \cdot e_L = 1 \cdot 1$ m² system, the maximum force from the anchor T_a snatching is 220 kN, the proportionality coefficient Q = 0,12 mm/kN.

The uphold's rigidity is:

$$K_S = \frac{R}{e_R \cdot e_L} \cdot \frac{1}{\frac{4L}{\pi d^2 Ea} + Q} = \frac{4}{1} \cdot \frac{1}{\frac{4 \cdot 2}{\pi \cdot 0{,}025^2 \cdot 21000}} \quad (16)$$

The characteristic straight line's ecuation is:

$$P_S = \frac{K_S}{R} U_r = 0{,}08\, U_r \quad \text{MPa} \quad (17)$$

By respecting the assembly condition as in the 1st case, the excavation's equilibration is obtained in the 2 point of intersection between the anchor uphold's characteristic and the rock's characteristic. From the graphic, it results P_S = 0,09 MPa.

The maximum pressure that could be exert by the anchors, cannot outrun the limitated value:

$$P_{S.\lim}^{anc} = \frac{T_{a\ snatching}}{e_R \cdot e_L} = 0{,}22 \quad \text{MPa} \quad (18)$$

It results that anchorage assures an adequated uphold of the hollowed void.

CONCLUSIONS

If the neccessary confinement pressure, determinated by the diagram is equal or smaller, but close to the maximum pressure which could be exert by the uphold, when the puggested uphold is satisfactory. If the neccessary pressure is higher than the capable pressure of the uphold, than the uphold is being supplemented (combinated), and of it is smaller, it could be chosen an easier uphold.

We could similarily make the combinated uphold is analyse. Such a way is being imposed in the case in which the excavation will remain a certain time, until the instalation of the definitive uphold, and so existing riscs, conected with the damage rock and the anchors corrosion.

BIBLIOGRAPHY

1. AFTES, Groupe de travail No.7, *Recommendations for use of convergence – confinement method*, Tunnels et ouvrages souterrains, Supplement au no. 117, 1993;

2. Rossi, P.P., *Le indagini sperimentali per la caratterizzazione degli ammassi rocciosi*, Publicazzoni ISMES-277,1991.

3. Stematiu, D., *Mecanica rocilor pentru construcții subterane*, Editura Matrix Rom, București, 2003.

ASCENDING MINING ON DRY WAY OF ROCK SALT DEPOSITS IN THE CASE OF PRAID MINE

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ABSTRACT: Ascending mining of on dry way of the rock salt deposits is insufficient studied and known on global level. Thus, information concerning the voids structures stability, (respectively, ceilings and pillars stability) which require a complex analysis for each actual case from practice. For the design of mining method elements (sizes of pillars, rooms, ceilings, floor structure, blasting technologies, etc.) must be tacking into account, especially, the underground structures stability.

1. NOTIONS CONCERNING THE ROCK SALT DEPOSIT GEOLOGY OF PRAID MINE

Within framework of Transilvania depression there are three vertical structural levels: lower structural level, with the tectonic similar of crystalline –Mesozoic by Carpathian nappe; medium structural level, with Sennonian, Palaeogene and lower Miocene, less tectonically affected; upper structural level, with Baddenian, Sarmatian and Pannonian geological formations, affected by the Pliocene motions and the rock salt massive. Corund-Praid-Sovata (Săcădat) saliferous structure is situated in the contact zone of Transilvania basin, with neoeruptive mountainous chain of Oriental Carpathian, Călimani-Gurghiu-Harghita, at joint of Târnave plateau with orogenic alignment Gurghiu-Harghita. Rock salt massive of Praid, with diapiric pillar shape, classified discordant, penetrate the Mio-Pliocene covering, and arise at surface in the positive relief. The ejected diapiric rock salt body is flanked by sedimentary rocks, partial covered with extrusive volcanic Post-Pliocene geological formations and Quaternary deposits. Rock salt from Praid pillar swell out river meadow and terraces of Târnava Mică and Corund valleys, making a dome morphological shape, with 70m,

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maximum height.

In a horizontally plane, the rock salt body have o quasi-circular (nearby elliptical) shape, with 1,2 and 1,4 km diameter. On the basis of structural soundings (ACEX 401/1949, S 110/1973) is assessed at 2,6-2,8 km deep, being most developed and robust diapiric rock salt body from our country.

The Praid salt have a appearance macro or micro-crystalline, made impure by mechanic synergetic dispersions as argils, marls, crystalline limestone, etc., involved disseminations, impregnations, stratiform inclusions or enclaves with different sizes (Almăşan B., 1983). The sterile inclusions, with over 0,5m diameter arise as synergetic stratiform inclusions or by the brecciated fragments form, results by consequence of halokinetic salt deformations.

These inclusions only partial could be avoid in the mining process. Halite crystals are presented as cubes shape, more or less perfect, with a great velocity development toward the corners directions and more reduced at crystals edges and very reduced at crystal facets. More frequently, the crystals joint is made at coins level and, rarely, at facets. The secondary crystals, arisen from saturation solutions situated in the old rooms, have a less opacity, showing the dominant development directions (milky-white) (Atudorei C., 1871).

In the case of Praid rock salt massive, the stratification is very good represented and is produced by the variable quantities of microscopic and macroscopic inclusions of clay-loamy material. In several situations, the rock salt stratification shows a rhythmicalness relating to alternation of swarthy-gray strata and light gray-whitish strata. The stratification of Praid rock salt deposit is nearby vertical, with values range between 70^o and 85^o- advantageous concerning the rock mechanical strength and implicitly the underground excavation structure stability.
Frequently, the sterile stratiform intercalations are interposed with rock salt strata, with effect on the facility of rock salt detachment along the impure surface of strata. Because the vertical stratification the rock salt caving along the horizontal joints is avoid. In the Praid rock salt perimeter was discovered by bio-geophysical methods the followings types of tectonic accidents:

- tectonic accident from deep until ground surface – salt rock fault (which had, probably, an important role in the diapirism process); this fault, with NW-SE predominant direction, delimit a lower north-eastern sector by an upper south-western sector;
- major geological fractures, which bound the rock salt massive;
- superficial faults, placed at the rock salt massive;
- local lines, hydrological actives, which acted predominantly in the roof of rock salt deposit.

2. PHISICAL AND MECHANICAL PROPETIES OF ROCK SALT AND SURROUNDINGS ROCK

The rock salt is a monomineral rock, consisted of sodium chloride. The mineral is crystallized in the cubical system, having a perfect cleavage and fibrous or granular presentation form. The rock salt solubility is very good and thermal conductibility is very important. The specific weight of rock salt is of $2{,}14 g/cm^3$ (Table 1). For the rock salt deposits in the mining state and surrounding rocks, these physical and mechanical characteristics are presented in Table 1 and Table 2. The rock salt properties are the followings: uniaxial compression strength: $\sigma_{c\,\min}$ =220daN/cm^2; $\sigma_{c\,\max} = 250$daN/cm^2; tensile strength: $\sigma_{t\,\min} = 18$daN/cm^2; $\sigma_{t\,\max}$ =22daN/cm^2; bending strength: $\sigma_i = 27$daN/cm^2; elastic modulus: E=31 500daN/cm^2; angle of friction: φ =55^o.

Table 1 **Average physical and mechanical characteristics of rock salt**

Const. No.	Parameter	U.M.	Average value			
			ICPM Cluj-Napoca	INSEMEX Petroşani	University of Petroşani	Accepted average value
1	Specific weight	g/cm^3	-	-	2.14	2.14
2	Bulk specific weight	gf/cm^3	2.136	2.066	2.09	2.1
3	Uniaxial compression strength	daN/cm^2	210	202	220-250	220
		daN/cm^2	-	-	220	-
4	Tensile strength	daN/cm^2	12.53	11.59	18-22	18
5	Bending strength	daN/cm^2	24	19	27	27
6	Dynamic modulus of elasticity	daN/cm^2	216500	162997	353000	350000
7	Longitudinal weave velocity	m/s	3137	2678	4093	4000
8	Static modulus of elasticity	daN/cm^2	30900	54196	31500	31500
9	Poisson's ratio	-	0.131	0.183	0.24	0.24
10	Conventional yield point	%/h	-	-	-	-
11	Tensile deformation modulus	daN/cm^2	-	-	-	-
12	Failure specific shortening-compression	%	3.14	5.51	4-6	5
13	Cohesion	daN/cm^2	-	45.5	42	40
14	Structural weakening coefficient	-	-	-	0.53	0.53
15	Internal angle of friction	degrees	-	-	55	55
16	Stability coefficient	%	-	-	65	65
17	Porosity	%	-	-	3	3

Table 2 **Average physical and mechanical characteristics of rock salt for mines**

Cons. No.	Parameter	Symbol	U.M	Type of rock						
				Marl	Calc-tufa	Breccia salt with marl and freestone	Marl clay	Freestone gray	Sand soft	Marl argilla ceous
1	Dry bulk specific weight	γ_{au}	g/cm^3	1.53	1.24	-	-	-	-	-
2	Saturated bulk specific weight	γ_{sat}	g/cm^3	2.21	1.57	-	-	-	-	-
3	Moisture	W	%	25.76	34.00	-	2.65	0.56	-	7.80
4	Saturation moisture	W_{sat}	%	-	-	-	-	-	-	-
5	Saturation rate	W/W_{sat}	-	0.669	0.834	-	-	-	-	-
6	Apparent porosity	n_{ap}	%	66.45	42.69	-	-	-	-	-
7	Total porosity	n_t	%	40.76	48.77	-	-	-	-	-
8	Compactification	c	%	59.24	51.23	-	-	-	-	-
9	Free swelling	u_L	%	104.25	-	-	-	-	-	-

10	Longitudinal weave velocity	v_L	m/sec	1450	-	-	-	-	-	-
11	Dynamic modulus of elasticity	E_d	daN/cm^2	45500	-	225600	389500	496000	-	-
12	Yield point	W_c	%	55.52	-	-	-	-	-	-
13	Crushing limit	W_f	%	21.35	-	-	-	-	-	-
14	Plasticity index	I_p	%	33.75	-	-	-	-	-	-
15	Consistency index	I_c	%	0.87	-	-	-	-	-	-
16	Uniaxial compression strength: -natural, h=2·d	σ_c	daN/cm^2	34.0	-	-	-	-	-	-
	-natural, h=d	σ_c	daN/cm^2	46.0	45	50	31	265	-	104
	-dry, h=d	σ_{cu}	daN/cm^2	94.0	49	-	40	-	-	-
17	Tensile strength	σ_t	daN/cm^2	6.0	7.9	5.0	6.6	35	-	17
18	Simple shear strength: $\alpha = 30^o$	$\frac{\sigma_N}{\tau_N}$	daN/cm^2	60/35	-	384/235	-	750/473	-	-
	$\alpha = 45^o$		daN/cm^2	31/31	-	231/231	-	255/255	-	-
	$\alpha = 60^o$		daN/cm^2	10/28	-	100/119	-	116/187	-	-
19	Bending strength	σ_i	daN/cm^2	34	-	12.1	-	-	-	-
20	Static modulus of elasticity	E_s	daN/cm^2	3300	-	4560	7000	45000	-	6100
21	Poisson’s ratio	μ	-	0.2	-	-	-	-	-	-
22	Modulus of deformation	τ_{def}	daN/cm^2	-	-	-	-	-	-	-
23	Conventional yield point	N_2	% h	0.183	-	-	-	-	-	-
24	Failure specific shortening	ε_r	%	3.18	-	1.84	1.85	0.71	-	1.69
25	Real cohesion	c	daN/cm^2	2.25	-	10.25	10.0	65.0	0.36	27.6
26	Apparent cohesion	K	daN/cm^2	3.0	-	14.25	15.0	100.0	-	36.6
27	Internal angle of friction	φ	degrees	24.0	-	35.0	18.0	22.0	28.0	20.0
28	Diameter circle generator of cycloid	K^*	daN/cm^2	-	-	30.50	-	175.0	-	-
29	Permeability coefficient	K_p	cm/sec.	-	-	-	-	-	1.2	-

3. DESIGN OF ASENDING MINING OF ORAID ROCK SALT DEPOSITS

In view to increases the extraction rate of rock salt it is proposed the using of small rooms and with arched roof and rectangular pillars (Covaci Şt., 1975). For establish the optimum sizes of definitive safety pillars of mining rooms we must be know the followings: type, values and stress repartition inside of support pillars; physical and mechanical characteristics of support pillars; type and values of support pillars deformations under the external solicitations (Stamatiu M., 1959).

The calculus and checking methods known until present are classified in four groups:

Group I. Methods based on the hypothesis of uniform stress repartition and constant compression strength: methods of Turrnaire, Haton, de la Goupilliere, L.D.Şeviakov.

Group II. Methods which take into account the hypothesis of uniform stress repartition inside of pillars and compression strength depending on the shape and sizes of pillars, methods of K. Kegal, M. Stamatiu.

Group III. Methods based on the nonuniform stress repartition in the pillars and pressure parabola: methods of S. S. Davidov, M. Stamatiu, P.M.Țimbarevici, K. V. Ruppeneit;

Group IV. Methods of mathematical modelling of stress and strain state, on the basis of dependence lows given by deforming solid body mechanics: methods of P.M.Țimbarevici, K.V. Ruppeneit.

The followings elements for design and checking are necessary: inter-rooms resistance pillars; intermediate plate; roof ceilings; floor plate; barrier pillars (Tudose I., 1990).

The design of pillars and resistance ceilings requires the knowledge of followings elements: vertical load, constituted by the weight of overburden rocks column and protector roof rock salt ceiling; mining load: fundamentals, permanents and semi-permanents; extraordinary, imposed by mining method and technology; strength: *limit strength* of salt massive and rocks which involve the resistance pillars and ceilings, for simple and complex state of loading (uniaxial and triaxial), as creep specific loadings; *limit strength* of surrounding rocks of resistance pillars and ceilings, for simple and complex state of loading as creep specific loadings; period of service.

For checking of floor plate was applied the Ennour’s and Coat’s algorithm. Analysing the calculus results could be concluded that, without the presence of some major fractures in the plate structure, this resist in the biggest loads (6 charged trucks, ranged between the rooms walls). Because the plate haven‘t the evident natural fissures, must be taken all possible measures for to avoid it’s degradation under the blasting influence. In this way, the seism effect of blasting works on the underground structures was studied (Truşcă T., 1989). The seismic wave is characterised by the followings parameters: displacement amplitude, *A*; vibration velocity of soil particle, *V*; vibration acceleration, *a*; vibration frequency, *f*; vibration duration, *t*.

By consequence of seismic effect assessment by several methods has been determined maximum explosive quantity (Tables 3, 4 and 5), corresponding to a blasting reprise for three different boreholes schemes (Figures 1, 2 and 3).

Table 3 **Assessment of total and on reprise blasting explosive quantity in the variant of floor snubber holes and roof and walls kerfs**

Reprise	Number of holes for blasting reprise	Hole explosive quantity, kg/hole		Reprise explosive quantity, equivalent of trotyl, kg
		Astralita	Nitramoniu	
1	9	0.2	1.1	9.7
2	7	0.2	0.7	4.1
3	10	0.2	0.7	7.4
4	15	0.2	0.7	11.4
5	17	0.2	0.7	12.9
6	19	0.2	0.7	14.4
7	21	0.2	0.7	16
8	23	0.2	0.7	17.5
9	23	0.2	0.7	17.5

10	22	0.2	0.7	16.8
11	12	0.2	0.7	9.1
12	10	0.2	0.7	7.6
13	8	0.2	0.7	6.1
14	10	0.2	0.7	7.6
Total	**206**	**41.2**	**147.8**	**158.1**

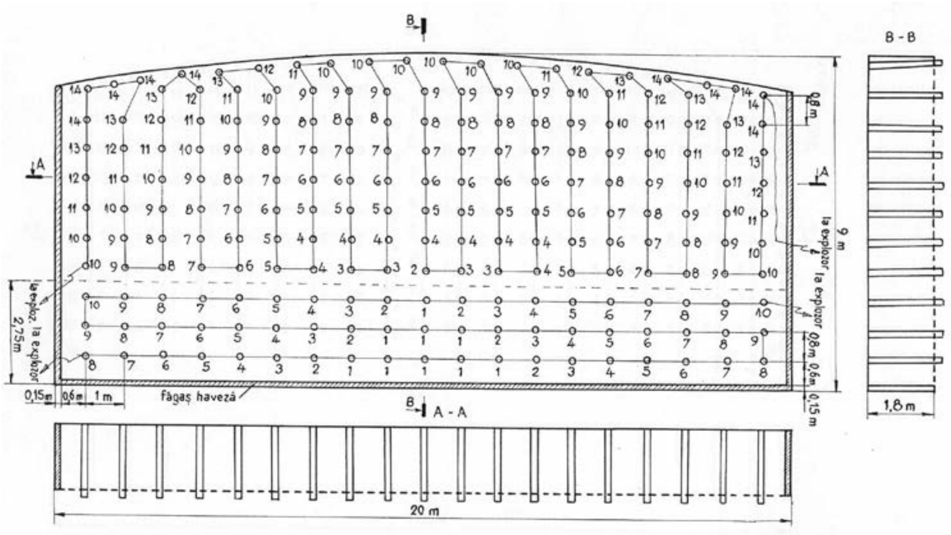

Figure 1. Blasting boreholes schema for floor snubber holes and floor and walls kerfs

Table 4 **Assessment of total and on reprise blasting explosive quantity in the variant of floor kerfs and walls and floor uncharged holes**

Reprise	Number of holes for blasting reprise	Hole explosive quantity, kg/hole		Reprise explosive quantity, equivalent of trotyl, kg
		Astralita	Nitramoniu	
1	9	0.2	1.1	9.7
2	11	0.2	0.7	8.4
3	13	0.2	0.7	9.9
4	15	0.2	0.7	11.4
5	17	0.2	0.7	12.9
6	19	0.2	0.7	14.4
7	19	0.2	0.7	14.4
8	19	0.2	0.7	14.4
9	19	0.2	0.7	14.4
10	19	0.2	0.7	14.4
11	20	0.2	0.7	15.2
12	12	0.2	0.7	9.1
13	12	0.2	0.7	9.1
14	10	0.2	0.7	7.6
15	8	0.2	0.7	6.1
Total	**222**	**44.2**	**15.9**	**171.4**

Table 5 **Assessment of total and on reprise blasting explosive quantity in the variant of vertical wedge snubber and walls and roof uncharged holes**

Reprise	Number of holes for blasting reprise	Hole explosive quantity, kg/hole		Reprise explosive quantity, equivalent of trotyl, kg
		Astralita	Nitramoniu	
1	16	0.2	1.1	17.3
2	16	0.2	0.7	12.2
3	16	0.2	0.7	12.2
4	16	0.2	0.7	12.2
5	16	0.2	0.7	12.2
6	16	0.2	0.7	12.2
7	16	0.2	0.7	12.2
8	16	0.2	0.7	12.2
9	16	0.2	0.7	12.2
10	8	0.2	0.7	6.1
11	6	0.2	0.7	4.5
12	17	0.2	0.7	12.8
13	19	0.2	0.7	14.4
14	12	0.2	0.7	9.1
Total	**206**	**41.2**	**150.6**	**162**

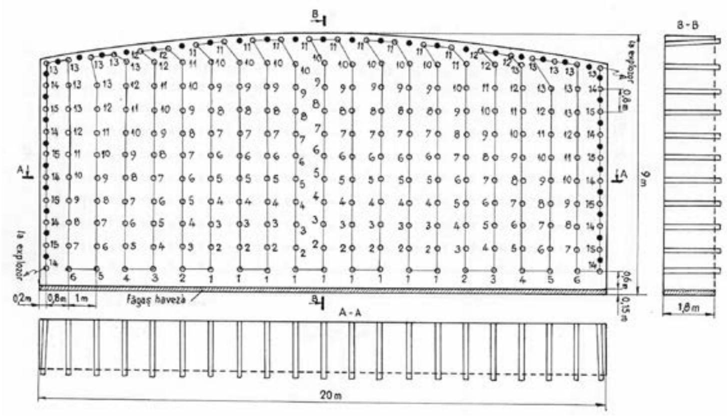

Figure 2. Blasting boreholes schema for floor kerfs and uncharged holes at walls level

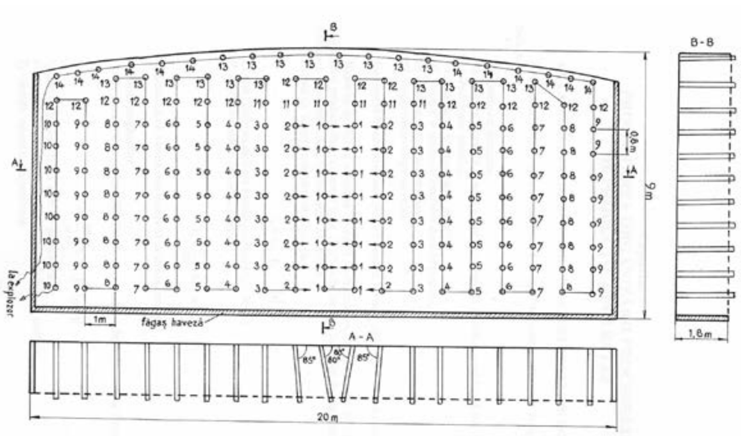

Figure 3. Blasting boreholes schema for vertical wedge snubber and floor and walls kerfs

4. CONCLUSIONS

As result of dimensioning and checking calculus, for the long term safe conditions employment of underground structures, was determined the followings: room span-20m; room height-9m; inter-rooms pillars width-20m; inter-rooms pillars height-8m; floor plate thickness-12m. These characteristics are given by the geo-mining conditions of rooms situated on the level 426 of Praid rock salt mine.

The blasting technology elements were designed taking into account the blasting works impact on the underground structures stability, thus: *reduction* of dynamic effect of seismic waves by creating of reflections surfaces and decreasing of explosives quantities employed in the flanking holes, by using the kerfs around the rooms perimeters (buffer blasting technology) and by using uncharged boreholes at floor and walls level (precutting blasting technology); *employment* of milliseconds blasting technology with a reduce number of boreholes on a reprise, respectively by increasing the number of blasting reprises; *decreasing* the total explosive quantity and the specific explosive quantity by creation of supplementary free surfaces, generated as consequences of boreholes initiation order.

Elaboration of blasting schemas was realised tacking into account the physical and mechanical rocks properties, explosive material parameters and reduction of dynamic effects of blasting works on the pillars and ceilings structure.

In conformity with blasting designed technology, the maximum explosive charge on the hole mustn't exceed 17,5 kg equivalent of trotyl (the maximum quantity of explosive that could be employed on a reprise, which not affect the lower room stability is under 24,6 kg equivalent of trotyl).

REFERENCES

1. Almăşan, B., 1983. *Exploatarea zăcămintelor de minereuri din România.* Editura Tehnică, Bucureşti.
2. Atudorei, C., 1971. *Cercetarea, exploatarea şi valorificarea sării.* Editura Tehnică, Bucureşti.
3. Covaci, Şt., 1975. *Exploatarea zăcămintelor de minereuri.* Editura Tehnică, Bucureşti.
4. Georgescu, M., 1986. *Optimizarea metodelor de exploatare în subteran.* Editura Tehnică, Bucureşti.
5. Leţu, N., Cărpenişanu, D., 1974. *Susţineri miniere.* Editura Tehnică, Bucureşti.
6. Iliaş, N., 1989. *Maşini miniere.* Litografia Institutului de Mine, Petroşani.
7. Marian, I., 1984. *Utilaje de încărcare şi transport minier.* Editura Didactică şi Pedagogică, Bucureşti.
8. Posea, N., 1986. *Rezistenţa materialelor.* Editura Ştiinţifică şi Enciclopedică, Bucureşti.
9. Stamatiu, M., 1959. *Problema dimensionării stâlpilor la minele de sare din R.P.R.* Bucureşti.
10. Tudose, I., 1990. *Rezistenţa materialelor. Aplicaţii.* Editura Tehnică, Bucureşti.
11. Truşcă, T., 1989. *Pirotehnie şi explozivi.* Editura Tehnică, Bucureşti.

SOME ISSUES RELATED TO THE PRESENT-DAY COAL MINING

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Abstract: Coal is the world's most abundant and widely distributed fossil fuel. Coal is still the primary energy source for several countries world-wide. It is used primarily for the generation of electricity and steel production. However, there are important differences between the world areas. The countries with long coal mining tradition face difficulties and new producers arrise.

Key words: coal industry, restructuring, social measures, coal production, export of coal

1. INTRODUCTION

Geographically South America is the continent with the least coal reserves with only 2.2% of total reserves and only 1.5% of the bituminous reserves. Africa has less than 6% of total reserves with these reserves concentrated in the bituminous category and dominated by South Africa with an estimated 90% of the continent's reserves. Botswana and Zimbabwe have the only significant reserves outside South Africa. Both North America and Asia have over 25% each of total reserves. While the reserves in North America are almost equally split between bituminous coal and sub-bituminous/lignite, Asia has a significantly higher proportion of reserves in the bituminous classification, accounting for around 35% of total bituminous reserves worldwide.

Total coal reserves held by Europe were slightly over 30% of the world total, while the individual categories show a higher share of world sub-bituminous and lignite reserves and a lower proportion of bituminous (22%). European reserves are dominated by two countries: Germany (21%) and the Russian Federation (50%). In respect of bituminous reserves, Germany, Poland, Russian Federation and the Ukraine account for over 95% of the European reserves.

Total world recoverable coal was 1,083,259 short tons in 2003. Global hard (black) coal production has grown by over 46% in the last 25 years to 3837 Mt in 2002 (3801 Mt in 2001). Major producers include China 1326 Mt, USA 916.7 Mt, India 333.7 Mt, Australia 276.0 Mt, South Africa 223.0 Mt, Russia 163.6 Mt, Poland 102.6 Mt, Indonesia 101.2 Mt, Ukraine 82.9 Mt, and Kazakhstan 70.6 Mt. Brown coal/lignite

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production totaled 876.5 Mt in 2002 compared with 896.9 Mt in 2001. Approximately 14% (almost 528 Mt) of total hard coal production is currently utilized by the steel industry - almost 66% of total global steel production is dependent on coal.

2. EUROPE

Western Europe has suffered a decline in the traditional hard-coal mining industry, based predominantly on underground mining, much of the region, especially Eastern Europe, remains heavily dependent upon utilisation of indigenous lignite and brown coal for a significant component of primary energy supply. Western Europe is a major importer of steam coal for power generation. Colombia and South Africa dominate coal imports into Europe. The region includes the world's largest lignite producer, Germany, and a number of the principal lignite producers and consumers, including Greece, Poland and Turkey. The largest hard-coal producer in Eastern Europe is Poland.

Following a period of restructuring, Poland's coal production has stabilised, and is now Europe's second largest producer, after Germany with coal operations being owned and controlled by the Ministry of Economy. Germany is the world's largest lignite producer, Greece is a major lignite producer. Other coal producing countries include the United Kingdom and Spain

2.1. West Europe

Coal in Europe is in a particularly delicate situation. On the one hand, after more than three decades of restructuring and modernisation, the coal industry in the remaining coal-producing countries of the EU (Germany, Spain, and UK) is – with a few exceptions - still not competitive when compared with world market prices. On the other hand, the coal industry in the countries of Central and Eastern Europe, fifty years after the introduction of market economy, is today confronted with a big challenge: how to achieve over a short period of time what the coal industry in Western Europe has not managed to achieve in more than three decades?

Even if the situation of coal in west Europe today is extremely difficult, both for economic and environmental reasons, the situation of coal workers and coal mining communities is certainly not desperate. The main reason for that is that the EU has acquired a solid experience with efficient social and regional crisis management. In the EU coal countries, it seems that a few conditions apply to coal restructuring in all countries. Once the economic objectives of a restructuring programme are clear, the methods for its implementation have to be negotiated between the social partners as well as with the local and national authorities. Permanent and efficient social dialogue is essential for the success of a restructuring programme. It is also a question of information, communication and transparency. Once the workers understand the objectives of the programme, they will be prepared to play an active part in the transformation. In other words: the key issue for successful restructuring and reconversion is about human resources. The second element is diversification, which means taking advantage of the technical know-how and skills of the workforce existing within the mining companies to develop new and viable economic activities. From the various coal producing countries a number of examples are known where companies actually succeeded their diversification into non-mining activities. It should be stressed that both for achieving diversification and for reaching competitive production, the research potential of the coal research institutes is of crucial importance. Diversification means social imagination and putting the human factor to the centre of the transformation process.The third element is the quality of the social measures to cushion the job losses resulting from the restructuring. The quality is important because ideally these measures should help those workers leaving the mining industry to find a new professional orientation and personal satisfaction in a new job. This being stressed, the financing of the social measures is a crucial point. If the financial envelope is not satisfactory, one will not succeed in convincing miners to leave the industry. The financial envelope is also essential to ensure the maintenance of purchasing power and thus economic development of the coal mining regions.The last element is that restructuring takes time. This became evident from the experience in several countries. Too rigid a timetable might be an obstacle. On the other hand, slowing down the process is not necessarily a good solution. Successful examples in West European coalfields show that the optimum speed of restructuring is probably when the number of job losses in the mining industry is no higher than the number of the new jobs created in the region during the same period.

As the coal industry in West Europe is reducing the production and the number of mines, the valuable experience of the european mine specialists is used in other parts of the world (for example, the German RAG Coal International, through the acquistion of Cyprus Amax Coal, has several established operations in the USA).

2.2. East Europe

As a result of the change of social and economic systems, by the mid 1990s, GDP had on balance fallen by one third (see Table 1). While GDP began to rise again in CEE as of 1994, in CIS economic activity continued to fall until 1996. Governments have further constrained the speed of energy reform by pursuing a host of (often contradictory) goals.

True, CEE/CIS governments applauded the merits of energy market liberalization. Market forces were expected to enhance energy efficiency, reduce wastage and pollution, improve the profitability and competitiveness of energy enterprises, enhance energy services to customers and reduce the need for subsidies. However, except in Hungary where the government clearly aimed at maximising revenues for energy sector privatization, energy reforms were to meet several goals at a time: to integrate the national energy economies into the European and world mainstream; to protect large segments of the population from the consequences of energy reform; to enhance the international competitiveness of the manufacturing industry by maintaining low energy costs; to preserve integrated energy complexes, infrastructure and systems; to maintain a steady flow of hard currency from energy exports; to reduce import dependence; to cater to sensitivities associated with foreign access to resources or ownership of land or with "strategic" industries; to enhance protection against energy-related pollution and health hazards; to temper the need for regional/industrial conversion.

As a result, energy reforms lacked focus and had to pass through several stages or reformulation, further prolonging transition.

3. Africa

South Africa is by far the largest producer in Africa as well as being a major global producer, after China, Australia, Canada, USA and Indonesia. South Africa has 11% of the world's reserves and produces 6% of global production. Nearly all of South Africa's export coal is sent through the Richards Bay Coal Terminal (RBCT) on the Kwazulu Natal East Coast. Zimbabwe's single mine Wankie is also a significant producer. Zambia has a single struggling operation, the Maamba colliery. Niger operates a single coal mine operated by SONICHAR, whilst Malawi's producer, the Mchenga mine produces approximately 50 000t per year. Swaziland has two small collieries which produce around 400 000t annually. Botswana has a single coalmine (operated by Anglo American) dedicated to supplying Botswana's coal fired power station. Isolated coal-bearing sequences in Niger (Carboniferous), Nigeria (Cretaceous), Morocco (Upper Carboniferous) and Egypt (Jurassic) represent only regionally significant coalbearing potential

4. North America

The USA dominates coal production and is the world's second largest coal producer. Canada is also a dominant coal producer and has a major export market for its coal. Mexico produces coal for domestic coal purposes. The USA was the world's 2nd largest coal producer, after China. Production topped the billion ton mark in 200, an increase of nearly 5% from the previous year. The USA is the world's 2nd largest exporter of coal, after Australia. Exports from the US fell even further to 43 Mt in 2001 as demand from Asian markets fell.

Canada is 11th on the world production list, with production dropping in line with reduced exports. Coal is Canada's single largest export to Japan. Two companies dominate the Canadian coal production scene, Luscar and Fording Coal. Luscar Luscar is Canada's leading coal producer and among the largest suppliers of coal in North America. It currently has 10 opencast operations in Canada.

Mexico produced 11 million tonnes in 2000.

5. South America

Latin America is not well known for its coal production, in particular export coal. Colombia is the only significant producer, followed by minor production from Venezuela, Brazil, Chile and Argentina. Venezuela is a relatively recent newcomer to the coal production scene in Latin America. It aims to produce coal for the export market. The potential for Venezuela appears good, with good quality coal and good infrastructure. Carbozulia is Venezuela's main coal producer and has recently acquired foreign investment in Shell / Ruhrkole / Inter American Cola NV in developing coal reserves in northwestern Venezuela.

6. Australia

Coal is Australia's major mineral export and accounts for nearly 25% of Australia's export earnings. Australia is the world's 4th largest coal producer (358.37 Mt in 2003) and is one of the largest exporters of coking and steaming coal. Approximately 215.57 Mt of coal products were exported from Australia in 2003. The country has estimated coal resources of 69 billion tons (excluding lignite). Black coal was Australia's leading mineral export in 2003 generating revenue of A$10.9 billion – 10% of Australia's total merchandise export revenue. 98% of Australia's export production coal deposits are located in Permian age sediments (250 million years old) in the Bowen Basin in Queensland and the Hunter Valley basins in New South Wales. Western Australia has some producing mines south of Perth. Australia also has reserves of lower grade lignite coal, located in Victoria. Coal is exported from nine terminals at seven ports along the east coast.

7. Asia

Russia, China, Indonesia and India comprise some of the world's largest producers of coal and account for at least 45% of global coal production. Australia and China are respectively the largest and second most important coal-exporting countries. The region also includes the most important coal-importing countries, of which Japan is the largest, followed by South Korea and Chinese Taipei.

The countries of the Former Soviet Union have traditionally been highly dependent on coal as a primary energy source. With the break-up of the Soviet Union a number of countries were able to configure their energy utilisation to local resources. Three countries dominate coal production based on the historic coal production areas of the FSU: Russian Federation, Ukraine and Kazakhstan.

In late China was forced to redirect coal production to feed its internal requirements thus creating a shortage of exports to other Asian countries. At this time northern Asian utilities had become more reliant than ever on Chinese suppliers. This had a rapid effect on other regional coal exporters as a number of major consumers, including Taipower and Korean generators, were forced to tender for emergency supplies from Indonesia and Australia.

Bangladesh will become a coal-producing nation when the Barapukuria mine officially comes into production at the revised date of October 2004; development coal has already been raised. Development of the Barapukuria mine is being undertaken by China National Machinery Import and Export Corp (CMC). The mine is scheduled to produce 1 Mt/y run-of-mine (bituminous high volatile coal; ash 12.4%, 25.68 MJ/kg) from two multi-slice longwalls.

8. Conclusions

As coal is the world's most abundant and widely distributed fossil fuel, its exploitation will continue. The whole economy, as we know it today, is dependent on mining and coal is essential for the generation of electricity and steel production. Allthough the traditional producers in Europe face difficulties, new producers, having better conditions for the exploitation of the coal, have emerged on the market.

Nevertheless, special attention must be oriented to environment and new technologies to ensure a better degree of recovery of the coal from the mines.

9. Refferences

[1] *******, United Nations, Economic and Social Council, ENERGY/GE.1/1998/12
[2] *****,** www.mbendi.co.za
[3] *****,** www.worldenergy.org/wec-geis/publications/reports/coal/context/context.asp

DESIGN OF INTEGRATED INFORMATIC/COMPUTER SYSTEM AT NATIONAL HARD COAL COMPANY SA PETROSANI

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Abstract

National Hard Coal Company SA Petrosani performs its activity in the field of coal industry, and is interested in a total computerization of own activities.

In the period 2003 – 2004, the National Hard Coal Company SA Petrosani has had as major aims the design, installation and development of an integrated informatic/computer system by using a high quality informatic solution.

The integrated informatic/computer system represents a complex project used for management of economic activities and industrial processes within the company, which is geographically dispersed and is aiming a flexible implementation in the management of company with applicability for the company's functions (production, financial – accountancy, commercial, personnel), with different access that is hierarchically organized onto user types.

The main development direction aimed by the company consists in achievement of complex informatic solutions, based on client–server and data base servers technology.

Informatic system aims to obtain higher economic results by means of a strategy simultaneously oriented onto satisfaction of company clients' demands and profit maximization.

***Key words*:** information infrastructure, informatic solution, integrated informatic/ computer system, Intranet, computer network, client–server, information management

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1. THE NEED FOR DESIGNING THE INTEGRATED INFORMATIC/COMPUTER SYSTEM

The National Hard Coal Company SA Petrosani (CNH SA) performs its activity in the field of coal industry and is interested to carry out all its own activities by means of computer. In this aim the following documentations have been elaborated:

- feasibility study (analysis of requirements and proposal of adequate solution) and Technical documentation;
- assessment reports and audit of informatic system (hardware architecture, network, applications) and proposals for their improvement.

In the period 2003 – 2004, CNH SA was concerned in design, installation and development of an integrated informatic/computer system by using a high quality informatic solution.

The integrated informatic/computer system represent a complex project designed for performing the management of economic activities and mining industrial processes within CNH SA, which performs its activity in a geographically dispersed mining basin. This complex project aims the flexible implementation in the management of CNH SA, with applicability for the company functions (production, research – development, financial – accounting, commercial, human resources) with different access hierarchically organized onto end – users.

In order to find the optimum informatic solution to solve and to increase the efficiency of working processes within CNH SA and the units in their structure, the following stages have been achieved:

- analysis of requirements;
- analysis for defining and elaborating the functional parameters of system;
- analysis for defining and elaborating the technical parameters of system;
- selection of designing solution and execution of informatic/computer system, including: integration with other systems, modular and integrated testing, implementation in the production environment.

A project and a cost estimation have been performed for the integrated informatic/computer system regarding the computer network, electric network, communication solution, voice – data structured cable connection.

As result of the analysis afferent for identification of company's needs, for evaluation of existing situation (audit IT) and of opportunities, the solutions are optimum.

Designing and elaboration of the project regarding development of informatic/computer system has been achieved in the context of informational society's development.

2. OBJECTIVE OF INTEGRATED INFORMATIC/COMPUTER SYSTEM

The objectives of integrated informatic/computer system are the following:

- provision of informational support for making the decisions;
- safety daily savings for most important informations;

- development of software applications on the base of the newest technology regarding design and implementation (client/ server technology, GUI interfaces, data distribution, complete utilization of Web resources (Internet/ Intranet/ Extranet etc.);

- development of applications with maximum efficiency, but with provision of high quality and performance parameters in exploitation;

- design of applications in the way to be easily personalized in accordance to requirement and specific needs of end – users;

- complete documentation of developed and implemented applications, both for design and programming part, and for the end – users;

- achievement of high quality software products in the same time with compliance of designing and implementation norms and methodology based on ISO 9001 standards;

- utilization of hardware – software – communications integrated solutions;

- compliance of lawful provisions regarding data publishing, protection of personal data and utilization of informatic/computer programs;

- elaboration of confidential internal reports, which cannot be elaborated by external suppliers;

- reduction of the costs for analysis, design, elaboration, configuration, installation, program implementation, appliances and electronic services specific for the company’s activities;

- provides a short reply time in the case of informatic events;

- utilization of information ex change based on electronic documents;

- promotion of CNH SA image and geographical area onto internal and international scale by means of its WEB page.

3. DESCRIPTION OF INTRANET COMPUTER NETWORK

3.1. System configurations

Its was recommended for CNH SA exactly the network configuration that is adequate for appliances used, or by the company’s specific:

- working stations and servers;

- active network equipments.

In order to achieve the hard configuration afferent for data – voice structured cable system, cupper cable UTP category 7 was used.

Selected solution is based on modern technologies both in the field of passive equipments and in the field of active equipments, in the way to be achieved a high value in time of this investment.

Above mentioned network includes the following systems:

- voice – data structured cable system;

- electric installation and solution for electric power feeding;

- communications: analog/ digital telephonic centrals, VoIP, Radio;

- access control and employee presence.

Informatic system of CNH SA fulfill both the connection between administrative headquarter and sub – units, and the support/ infrastructure that is required by development of certain applications to be used in centralized way by the company and its sub – units.

Integrated informatic/computer system within CNH SA is structured as follows:

At the administrative headquarter:

- 127 computers with following configuration: Intel Pentium 4 – 2,4 GHz, HDD 40 GB, RAM 512 MB, operation system WINDOWS XP;

- 8 servers with following configuration: Intel Pentium 4 – 2,8 GHz. 6 x HDD 30 GB SCSI configured RAID 5, RAM 2 GB, operation system WINDOWS 2003 Server.

The 8 servers have the following tasks:

- 2 file servers;

- 1 backup server, endowed with a magnetic tape unit with which there are performed the periodical backups for data servers, application servers and file servers;

- 1 server performing automatically the updates of operation systems and of main Microsoft applications by using the service WUS – Windows Update Services;

- 1 WEB application server where it is used ISS;

- 2 data bases servers where it is used SQL;

- 1 server that is Domain Controller – which include the data base with all field resources: computers, users, user groups, resources used in common as there are printers, folders, etc. With the service Active Directory that it is implemented onto this Domain Controller all the domain politics are implemented, politics that are used for administration of user groups' rights within the network, soft that are installed, politics connected to system security, etc.

All computers within the company are connected between them as a network having the architecture of star type; this network has central point the as called "server room", where all the above mentioned servers are located, a computer with operation system Linux Fedora Core 2, having the role of proxy to Internet and firewall, the rack with passive and active equipments and the telephonic central.

Passive equipments consist in patch panels where is connected every cable coming from a certain terminal, either a computer or a phone. Due to structured cable system consisting integrally in cable UTP category 7, in every data output it can be connected either a computer or a phone, following just the connection between patch panel and switch or telephone central.

From the active equipments we mention the following:

- 8 switches, every of them with 24 ports of 100 Mb, connected in batches of 2, every batch having available 4 data ports of 1 Gb each. Advantage of batch connection consist in the fact that between the 2 switches the data transfer is performed onto a special magistral with the width up to 2 Gb;

- 1 switch of 24 ports onto 1 Gb, where there are connected the vital equipments within the network, as there are the data servers, appliances servers, domain controller and the other servers;

- 1 router Cisco 3700 very efficient, with which is performed the connection between CNH and sub – units.

At every sub – unit it is installed the as called communication equipment consisting in a radio system, a router and a switch. Connection between CNH and sub – units is achieved by means of 2 clusters located in maximum visibility points from Parang and Straja mountains.

Cluster in Parang is used for the following locations: Paroseni, Uricani, Vulcan, SCSM, Livezeni, Aninoasa, EPCVJ, and administrative headquarters of CNH SA.

Cluster in Straja is used for the following locations: Barbateni, Lupeni, Lonea, Petrila and administrative headquarter of CNH SA.

Connections between administrative headquarter of CNH SA and the above mentioned points in Parang and Straja are achieved with high performance equipments providing a band width able to support informational traffic between central headquarter and sub – units.

As regard the telephone communications, these are performed with a performant telephone central type Siemens HiPaith series 3000. This modern central is provided with an interface type Ethernet; with this interface it is perform the connection to the existing network infrastructure. In order to increase the efficiency of phone calls costs, this central has been provided with flow plates and CNH SA has 2 phone flows, one with fixed telephony operator – Romtelecom, and another one with mobile telephony operator – Connex. These telephone flows increase the possibility for simultaneous calls, reducing considerably their costs.

One of the main advantages of this informatic system consist in, first of all, achievement of a continuous connection between CNH SA and its sub – units, connection with much higher speed than the ones made by dial – up system existing at the moment of putting into operation, due to the antenna system and radio equipments of new technology, that is Canopy equipments manufactured by Motorola company. Due to this continuous connection, it was started the elaboration of certain informatic applications allowing the update online of the company’s data bases, regarding the stocks of materials, production, personnel etc.

Using the VoIP (Voice Over IP) technology by means of the same network there were performed the telephone connections between CNH SA and its sub – units, at a higher quality in comparison to the existing ones, which were using Romtelecom infrastructure. In this way, to every sub – unit there is installed a router CISCO 1750 that analysis in the same time the classic routing on packages with the conversion of data packages used by telephone system.

At Petrila, Lupeni, EPCVJ, Vulcan and Lonea there were installed telephonic centrals of same generation to the one existing at headquarter of CNH SA, which allows additionally a centralized manage of them and achievement of high quality telephone calls, reducing in the same time their costs.

3.2. Advantages of solution regarding the design of computer network

Structured network voice – data allows a large flexibility regarding ports configuration, which can be used for sending informations between computers, and for sending voice (telephony) and images (video).

Network tests, both for cupper cable and for optical fiber are solutions for providing the operation of computer network within the parameters stipulated by Standards.

Wireless computer network (radio) – an ideal solution providing a fast connection for users to other computers, a larger mobility and their independence.

Electric network – there are used certain solutions for reconfiguration of old electric networks, solutions for performing new electric networks, endowed electric panels, all of them manufactured and installed in accordance with present standards.

Electronic trade – elaboration of a special site regarding the sell of products to be used for every customer and partner wishing to purchase on line or to find certain details regarding a product.

4. CONCLUSIONS

1. By using the services provided by the integrated informatic/computer system, the National Hard Coal Company SA Petrosani can easily reach high important objectives, as there are the followings:

- increase of decisional act efficiency by reducing and accelerating the informational flow and by providing the possibility of a complete control of the business;
- management of entire informational flow in correlation to informatic programs dedicated for document management, in order to provide adequate informations at the level of all compartments of company;
- elaboration, personalization and implementation of a performant informatic system providing the complete logistic support for informational flow;
- facilitate the implementation of quality system at the level of business;
- reduction of costs afferent for personnel working in informatic field at the level of company's units;
- reduction of costs afferent for purchasing equipment on the base of certain globo strategies on larger horizons;
- decrease of maintenance costs and intervention time by using an efficient maintenance system;
- optimum management of informatic equipment by purchasing an deciding the size depending on required efficiency and destination;
- management of software packages, with minimum costs and complying the lawful norms.

2. By integrating the compartments within the company there are considerable reduced the maintenance costs.

3. Decided solution is based on modern technologies both in the field of passive equipment and in the field of active equipment, in the way to be provided a large value in time of investment.

4. Optimization of price/ performance ratio, in close connection to the specific of integrated informatic/computer system and to the time afferent for recovering investment, represents an real aim took into account by the company when analysis the issue. In this way similar optimizations have been successfully achieved, which

together with analyze and optimization of informational system, on the base of time/ cost/ user aspects, have lead to stable informational systems. Simultaneous approach of data and telephone networks represent an adequate solution for reducing the costs afferent for a performant network.

5. The possibility for monitoring in real time certain important parameters as there are those regarding telegrizumetry, technological flow sheet and production flow sheet, etc.

BIBLIOGRAFIE

[1]. **Brady, J**., *Concepts in Enterprise Resuorce Planning*, Editura Thomson Learning, 2001
[2]. **Bremmer, K**., *Intranet***,** Editura All, Bucureţti, 1998
[3].**Buşe F**., *Proiectarea sistemelor informatice manageriale*, Editura Focus, Petroşani, 2004
[4]. **Lemoigne, J.L.,** *Vers un systeme d'information dans les organisation***,** Revue Francaise de gestion, 1998
[5]. **Radu, I., Ursăcescu, M., Vlădeanu, D., Cioc, M., Burlacu, S**., *Informatică şi management - o cale spre performanţ*ă, Editura Universitară, Bucureşti, 2005
[6]. **Ursăcescu, M.,** *Sisteme informatice – o abordare între clasic şi modern***,** Editura Economică, Bucureşti, 2002
[7]. *** *Proiect tehnic pentru informatizarea CNH SA Petroşani*, 2003

SEAM FACTOR AND THE SPONTANEOUS HEATING OF COAL

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Abstract: Previously related publications by the authors have identified the spontaneous heating in underground coal mines as a combination of the seam factor, the geological, factor and the mining factor. In this publication the authors pay particular attention to the effects of the seam factor, the effects of the seam factor from research conducted to the deductions of modern day workers .

Keywords: coal mines, seam factor, spontaneous heating, underground.

1. INTRODUCTION

The seam factor affecting the susceptibility of coal to spontaneous combustion may be defined by the following parameters [6]: rank; petrographic composition; temperature; available air; particle size; moisture; sulphur; other minerals; the effect of previous oxidation or heating; physical properties; heating due to crushing or bacteria.

2. SEAM FACTOR

Rank. The rank of coal depends on the character of the original plant debris from which it was formed and the amount of change that its organic matter has undergrone during the period of formation. An increasing carbon content and with it a decreasing oxygen content are the most commonly accepted criteria of increasing rank. The higher the rank, e.g. anthracite, the slower the oxidation process, whilst lignite of low rank, oxidises so rapidly that it is often stated it cannot be stored after mining without ignition.

There are however numerous anomalies to a straight rank order. One part of a seam may be particularly liable to spontaneous combustion, a seam of higher rank may

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prove more troublesome than one of a lower rank or even the seams in different mines may react differently.

Petrographic composition. A series of oxidation tests on fand picked petrographic constituents from five coal ranging from high ramking coking coal to low rank bituminous coal [2]. The results of these tests, showed that in all cases fusain was the least reactive, and in general, durain was more reactive than vitrain. The results enabled calculations to be made of the reaction velocities of vitrinite, exinite and inertinite and showed that exinite has a much greater oxidation rate than the other two constituents. Thus, it appears that a count of these "macerals" may be useful, together with rank in determining the susceptibility of coals to spontaneous combustion.

Temperature. The absorption of oxygen is more rapid as the temperature increases. There is a pronounced temperature coefficient of oxidation, and the average rate of oxidation approximately doubles (1.4 to 2.3) for every rise of temperature.

Most of the authors agreed that the temperature of the coal undoubtedly was one of the main factors in the whole subject of spontaneous combustion, for cases of spontaneous combusted have occurred time and again were probably they never would have occurred if there had not been an initial heating in some way or other.

Available air. Where there is a small amount of air, the rate of oxidation is very slow and there is no appreciable rise in temperature. Where there are large quantities of air passing over or through the coal, any heat produced will invariably be carried away so that the temperature does not rise and the oxidation rate remains at a low level. However, between these two limits there is a state when the air quantity is sufficient to promote oxidation but not sufficient to carry away the heat formed, so that there is an accelerating rate of oxidation until ignition occurs.

Particle size. A solid coal face generally presents very little danger of spontaneous combustion, partly due to the small surface area and partly due to the very low permeability of solid coal to gases. It is, however, generally when coal is shattered in mining, or broken by roof pressure, or when falls and faulting occur that spontaneous combustion is likely to take place.

It is the small coal that is mainly responsible for the heating. The air passes into the mass and oxidizes a little of the coal near the outer surface. This produces a slight rise in temperature, so that, as the air penetrates deeper and deeper, it becomes warmer and warmer and although part of its oxygen has been absorbed there is still enough to produce oxidation. Consequently, it is at some distance inside the mass that heating develops most rapidly. It should be noted that a flame will not necessarily make its appearance, even if a coal is red-hot, as flame is due to the combustion of gas and this requires that a moderately high proportion of oxygen by present. Once the oxidation process has gone beyond the early stages and heat is accumulating, it is only a matter of time before actual ignition takes place.

Moisture. Opinions differed greatly as to what part moisture in the coal plays in its spontaneous combustion. The effect of moisture on spontaneous heating is uncertain. A small quantity seems to assists rather than retard the heating whilst large quantities of moisture retards the heating. However, as in a surface stockpile, alternative drying and wetting of the coal accelerates the heating process. Others authors believed the spontaneous combustion of coal to be due to the formation of ozone by the action of the sun on warm, sunny days following a rain, when the surface evaporation is especially great. If this is true, it was felt at the time that moisture plays a more important part in the phenomenon of spontaneous combustion than had previously been ascribed to it.

That the presence of moisture materially assists the pyretic oxidation was generally conceded, although whether it caused an increase in temperature or merely a disintegration of the coal due to formation of ferrous sulphate was a matter of dispute. Others believed that the only part that moisture played was a mechanical one, where alternate freezing and thawing broke up the coal into smaller particles and so exposed more surface to the oxygen of the air. Again, it is thought that aside from increasing the pyretic oxidation, moisture acts as a catalytic agent between the carbon and hydrogen or unsaturated bodies of the coal and the oxygen of the air.

Sulphur. From the first publication on spontaneous combustion until about the middle of the nineteenth century it was assumed that sulphur in the form of pyrites was the main cause of spontaneous combustion. However, it was shown that coal even in the absence of sulphides would absorb oxygen and heat spontaneously. However, further research work modified this view and led to the present theory that pyrites plays a subsidiary role in promoting deterioration and spontaneous combustion [5].

Other minerals. Many other chemicals affect the rate of oxidation to some extent, either accelerating of retarding it. Alkalies can act as accelerators, and borates and calcium chloride as retardants.

From the effects of previous oxidation on heating from experimental work on the effects of preheating coals in vacuo, cooling, and then comparing their oxygen reaction with that of untreated coals [3] the following conclusions were drawn:

- by preheating coals their liability to spontaneous combustion is greatly increased;
- lump coal previously almost impervious to air and thus without danger from the point of view of heating, may become, through being in the neighbourhood of a fire, a source of danger due to a large increase in its oxygen capacity;
- coal in a sealed area, even after a fire has become completely extinguished, may also have formed fine coal caused by a reduction in the strength following partial distillation.

These factors are important when attempting to re-open an area which had been sealed because of spontaneous combustion. In a number of instances, when attempts have been made to re-open workings that have been sealed sometimes for years, it has been found that there was no indication of fires, but immediately as ventilation was re-established, progressive re-heating occurred within a few days and sections had to be resealed.

Physical properties. A number of physical properties such as porosity, hardness, thermal conductivity and specific heat can affect the rate of oxidation of coal.

Heating due to earth movement. Investigations showed that the heat generated in the crushing of rocks, such as in the goaf of a long wall face or the waste of a pillar extraction area may be sufficient to assist in starting the self heating process.

Occluded gases in the coal. While it is now a well known fact that gases of an inflammable nature are occluded in coal, their relation to the spontaneous ignition of coal had not yet been clearly established by 1910. Whether the gases occluded in the coal are the real cause of spontaneous ignition is doubtful, but if the coal becomes heated up by oxidation or some other cause to a temperature high enough for the oxygen of the air to unite with these gases, then it is seen that the presence of these gases constitute a source of danger. In this case, coals with large amounts of gases occluded in them would be more liable to ignite than coals containing smaller amounts of these gases.

Accessibility of oxygen. That the combination of oxygen with the constituents of the coal causes a rise in temperature seems to be firmly established. Which particular constituent is the cause of the rise in temperature has not, however, been shown with any great degree of certainty. The presence of humic acid in the oxidized coals leads one to believe that the oxygen combines with some of the unsaturated body is shown by the fact that it absorbs large amounts of bromine without the evolution of hydrobromic acid. In fact, one researcher [4] went so far as to devise a practical test to determine the safety of a coal by means of this reaction with bromine.

The idea was also held the oxygen of the air combined directly with the carbon and hydrogen of the coal and so caused an increase in temperature. If amorphous carbon (charcoal and lampblack) can be oxidized to carbon dioxide or exposure to the air by means of bacteria, as had been proved the oxidation of the carbon of the coal is very probable.

3. THE WORK OF MODERN DAY RESEARCHES

It is generally agreed by modern researches that following an initial physical absorption of oxygen, a variety of more or less stable coal-oxygen complexes are formed with the release of some gaseous products. The oxidation reaction of coal at moderate temperatures is generally of two types:

- the formation of oxy-functional groups on the surface of the coal;
- production of gases such as CO_2, CO and H_2O.

The total consumption of oxygen is the sum of the oxygen consumed by these two reactions. Due to the extremely complex heterogeneous nature of coal, the many oxidation reactions of coal that occur make it difficult to examine all the reactions on an experimental level. Coal in its natural state contains varying amounts of oxy-functional groups. During the oxidation process the quantities of these groups increase. The initial chemical process is considered to be chemisorption. The oxy-functional groups include: carboxyl, hydroxyl, carbonyl, methoxyl, ester, ethers, peroxides and hydroperoxydes [1].

Many authors [2] found that an increased temperature produced a much greater increase in carbon monoxide than any other gas. Therefore, they assumed that if carbon monoxide was being produced by a similar mechanism to the other gases, then an additional reaction must take place to increase its quantity. The mechanism suggested was as follows.

The first step is the formation of peroxide which then decomposes to give compounds which are similar to those which have been found during other experiments. The formation and decomposition of peroxides occur mainly within the aliphatic structure of the coal and may proceed via the following reaction:

$$R - H + O_2 \rightarrow R^{\bullet} + HO_2^{\bullet} \tag{1}$$

$$R^{\bullet} + O_2 \rightarrow R - O - O^{\bullet} \tag{2}$$

$$R - O - O^{\bullet} + HO_2^{\bullet} \rightarrow R - O - OH + O_2 \tag{3}$$

$$R - O - O^{\bullet} + RH \rightarrow R - O - OH + R^{\bullet} \tag{4}$$

The peroxide can then decompose in different ways according to its structure.

Although there is universal agreement that oxygen is absorbet on the coal surface during the oxidation, the literature presents many views of the dominant process. Physical adsorption, which may be in single or multiple layers, is due to dispersion forces of van der Waals. This type of adsorbed oxygen is recoverable by phisical means such as evacuation and therefore may be considered a reversible process. On the other hand in chemisorption the oxygen combines to form ionic or covalent bonds on the coal surface, this process is considered irreversible, i.e. the oxygen is not recoverable at reduced pressures.

Coal moisture and the humidity of the atmosphere in which oxidation occurs have been found to influence both the rate of oxidation and products that are formed. In a humid atmosphere where simultaneous sorption of water vapour and oxidation takes place, the rate of heat generation in coal due to adsorption of water vapour becomes the rate-determining factor. For a given coal the rate of heating has been found to reach a maximum within a few hours of the start of the process and to increase with the increase in the equilibrium deficiency of water in the coal.

Other authors [bh] indicated that in a moist atmosphere the coal is faced with any of the following three phenomena:

- oxidation;
- oxidation and sorption of water vapour by the coal;
- oxidation and description of water vapour from the coal.

4. CONCLUSIONS

The authors have attempted to build up a comprehensive picture covering the total spectrum of the research into the seam factor affects on spontaneous combustion. This publication used in conjunction with earlier works of the authors of this paper completes the theory behind the whole phenomenon of spontaneous combustion as an aggregate effect of these situations, which have been classified as:

- seam factor;
- geological factor;
- mining factor.

REFERENCES

[1]. **Adams, W.N., Pitt, G.J.,** *Examination of oxidised coal by absorption methods,* Fuels, No.34, 1955.

[2]. **Chamberlain, E.A.C., Barres, G., Thirlaway, J.T.,** *Gases evolved and possible reaction during low temperature oxidation of coal*, Fuel, No.55, 1976.

[3]. **Coles, G., Graham, J.I.,** *The absorption of oxygen by preheated coal*, Fuel, No.7, 1928, p.21-27.

[4]. **Fischer, F.,** *Uber Lagerungsverluste und Selbstentzundung von Steinkohlem,* Zeitsch angew Chem., No.33, 1899.

[5]. **Li, S.H., Parr, S.W.,** *The oxidation of pyrites as a factor in the spontaneous combustion of coal*, Ind. Eng. Chem., 1926, p.1299-1304

[6]. **Morris, R., Atkinson, T.,** *Geological and mining factors affecting spontaneous heating of coal,* Mining Science and Technology, No.3, 1986, p.217-231.

NUMERICAL SIMULATION OF GAS FLOWS IN THE GOAF OF RETREATING FACES

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Abstract: The present paper deals with gas mixture flow (air, methane, nitrogen) using numerical simulation, in the goaf and in the interface with the face. More knowledge concerning gas flow should lead to improved methods of understanding and, consequently, controlling pit gas (especially drainage), and to optimizing the use of nitrogen against spontaneous combustion implicitly to an increased safety level of mine operations. Setting up experiments in the goaf is very difficult and expensive due to the difficulty of access to this zone. Therefore the use of gas flow simulation is well adapted to the research in this field of concern. This approach has been made possible by CFD codes. We have used the code named PHOENICS. Research as to which equations should be used for these simulations has already been carried out, as well as a first parametric study concerning how the model reacts. Promising first results indicates that the model seams to be reacting correctly, at least from the qualitative point of view.

Key words: gas flow, goaf, retreating face, numerical simulation, CFD codes

1. INTRODUCTION

The use of modern mining methods, having great outputs, of coal seams, is limited, especially for retreating faces, by methane dilution through the ventilation system.

Major problems occur at the intersection of the face with return airway. Several theoretical and experimental research emphasized the fact that 50 - 70 % of the methane flowing in the ventilation network originates from this source, even if high air quantities are in the stream (30 - 40 m^3/s) and a superior demethanisation degree is achieved (reaching, in certain situations to 70 %). Several techniques could be applied for diminishing the adverse effects of this process and to avoid dangerous methane concentration zones (such as the exhausting auxiliary ventilation system, in use at the

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Houillères du Bassin de Lorraine, France, 1990; Back Return System, United Kingdom, 1993).

Unfortunately, the existing techniques are feasible only in specific conditions and their efficiency is, in consequence, limited. The above mentioned considerations imposed us the research directed to the alleviation of knowledges regarding the percolating flow in the goaf.

A relatively significant number of experimental studies have been conducted in the past decades in Valea Jiului coal basin and in worldwide. These studies approached questions such as methane inflow from goaf to the face, the laws of methane migration in the goaf being not well-known at the present. Coal seams mined out in Valea Jiului basin have a great tendency to self - ignition, resulting in spontaneous combustions. Towards to the prevention of such undesirable events inertisation is foreseen in Valea Jiului collieries by nitrogen injection in the goaf. The method is actually in an empirical state, in relation to the location of injection points and of nitrogen quantities injected.

These considerations are highlighting that a better knowledge of gas flows in the goaf will allows:

- the identification of the geometrical mining configuration and the eterogenous air - methane mixtures at the return face end;
- the selection, location and optimal dimensioning of methane drainage workings;
- prevention and fighting with spontaneous combustions by a more efficient way of nitrogen injection.

Setting up experiments in the goaf is extremely difficult of access to this zone. Therefore, the use of gas flow simulation is well adapted to research in this field. This approach has been made possible by Computational Fluid Dynamics (CFD).

The paper presents the results of numerical simulations realized by the author with the PHOENICS software at the Ecole des Mines d'Alès (France). Data in use are achieved from collieries in Valea Jiului coal basin and from Houillères du Bassin de Lorraine. The first part of the paper describes the model set up to simulate an exploitation unit, such as working face, heading, single or multiple entries, goafs, etc. The second part presents the first parametric study concerning the way in which the model reacts. For a given situation, we have varied the slope angle, in order to observe the effects on the methane concentration distribution in the goaf, from a qualitative point of view.

2. MATHEMATICAL MODEL FOR GAS FLOW

The methodology applied for achieving the model which describes the gas flow in the goaf consists in writing the equations system describing this phenomena, the discretization of this system, and finally, solving this system by the finite elements method.

The most usual numerical calculation algorithms are largely presented in the literature, and consequently we will not insist on them.

In the special item of gas flow simulation in the goaf of retreating working faces, it is necessary to solve a system consisting of:

- the continuity equation;

- the equation of motion;
- the transport equation of the chemical substance for which the mass distribution in the considered geometry must to be determined (methane and nitrogen if an inertisation process is simulated).

In a first stage, to simplify the computations, the thermal transfer will not be taken into account. Consequently, the energy conservative equation is not included in the model. Also in view of diminishing the computational time the ensemble “headings - face - goaf” is reduced to a two - dimensional geometry.

While the percolation velocities of gases are relatively low, these can be considered as incompressible, Newtonian fluids. Gas flow modeling must be done in two very different media: the goaf, which can be restricted to a porous media, while in the face and the headings the gaseous flow can be considered as “free”. The nature of the forces exerted on the fluids in these two media is different.

The above - mentioned considerations suggests that in view of modeling these phenomena as a whole, two scenarios should be formulated, one for the free flow (in the face and headings), the other one for the goaf. These two approaches are followed in the next paragraphs.

2.1. Free flow modeling

In a two - dimensional reference system, the equation of continuity for an incompressible fluid can be written as it follows:

$$\frac{\partial p}{\partial t} + \rho \cdot \frac{\partial \bar{u}}{\partial x} + \rho \cdot \frac{\partial \bar{v}}{\partial y} = 0 \tag{1}$$

where:

ρ is the density, kg/m^3;

$\bar{u}$, $\bar{v}$ - the fluid's mean velocities on x and, respectively, on y axis, m/s.

Assuming that the flow is stationary, equation (1) reduces to:

$$\rho \cdot \frac{\partial \bar{u}}{\partial x} + \rho \cdot \frac{\partial \bar{v}}{\partial y} = 0 \tag{2}$$

The equation of motion, as a function of x could be expressed as:

$$\begin{aligned} \rho \cdot \bar{u} \cdot \frac{\partial \bar{u}}{\partial x} + \rho \cdot \bar{v} \cdot \frac{\partial \bar{v}}{\partial y} = -\frac{\partial P}{\partial x} + \mu \cdot \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} \right) + \\ + \rho \cdot g - \rho \cdot \frac{\partial}{\partial y} \left(\overline{u' \cdot v'} + u'^2 \right) \end{aligned} \tag{3}$$

where:

P is the pressure, Pa;

μ - dynamic viscosity, kg/m/s;

g - gravity acceleration, m/s^2;

u', v'- velocities variations along x and y axis.

The presence of the last term in the right side of equation (3), expressing the variation induced by turbulence, makes impossible to find a solution for the system formed by equations (2) and (3), while two supplementary unknowns appears, namely u' and v'.

Most of the CFD codes appeals in such cases to the Boussinesq hypothesis, consisting in considering the turbulent mixing as analogous with the viscosity. Turbulent stresses are expressed as an “equivalent turbulent viscosity”.

To calculate these new measure impose to assess a so - called “turbulence model”. This kind of model can by found, almost completely, in the literature.

The air flow in mine ventilation networks being highly turbulent, significant pressure losses occurs. It appears so as very important to quantify the effect of turbulence for a proper modeling of gas flow dynamics. On the other hand, practice shows that the computing precision depends directly on a good description of geometrical characteristics of mine workings. This implies the obtaining of model meshing for whom a great deal of time is needed in computations, making this approach unviable.

Experimental studies carried out in several countries allowed the assessment of pressure losses induced by mine workings. This facilitates which describes the effect of aerodynamic resistance forces.

The transport equation of any chemical substance in stationary conditions is:

$$\rho \cdot \bar{u} \cdot \frac{\partial Y}{\partial x} + \rho \cdot \bar{v} \cdot \frac{\partial Y}{\partial y} = \rho \cdot D_t \cdot \left(\frac{\partial^2 Y}{\partial x^2} + \frac{\partial^2 Y}{\partial y^2} \right) \tag{4}$$

where:

Y is the mass fraction of considered chemical substance;

D_t - the turbulent diffusion coefficient.

Usually, the turbulent diffusion coefficient can be obtained on the turbulence model basis. Consideration being given to the last remarks, it becomes obvious that this coefficient can not be calculated.

Anyhow it is important to notice that the main objective for free flow regimes is to compute as precise as possible the flow's dynamic (pressure and mean velocity). The proposed model has as goal not to follow the evolution of a chemical substance in the underground atmosphere, but to know his traject in the goaf. In these circumstances, values 10 to 100 times higher as Fick's diffusion coefficient can be considered for D_t.

2.2. Flow modeling for a porous media

In this case, the problem is to solve a system consisting of the equations describing the mass and motion quantity conservation laws. The system must be adapted to the porous media considering a double influence: first, just a fraction of the entire volume participates to the flow, and secondly an additional resistance force is exerted on the fluid. So, equations (2) and (3) will take the following expressions:

$$\rho \cdot \frac{\partial \overline{u}}{\partial x} + \rho \cdot \frac{\partial \overline{v}}{\partial y} = 0 \tag{5}$$

$$\rho \cdot \overline{u} \cdot \frac{\partial \overline{u}}{\partial x} + \rho \cdot \overline{v} \cdot \frac{\partial \overline{v}}{\partial y} = -\frac{\partial P}{\partial y} + \mu \cdot \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right) + \rho \cdot g + R_i \tag{6}$$

the following relationship being retained for R_i:

$$R_i = -\frac{\mu}{k_p} \cdot \overline{u} - \beta \cdot \overline{u^2} \tag{7}$$

where:

k_p is the permeability of the porous media, m^2;

β - permeability function, depending also on Reynolds number, Re.

The major problem in applying eq. (7) is the difficulty to determine k_p. Literature offers several relationships connecting permeability to geometrical parameters of media, to porosity factor φ, to the diameter of grains and of pores.

Ergun and Kozeny-Carman's formula are the most widely used in practice. For example, Kozeny-Carman's relationship gives:

$$k_p = \frac{\varphi^3}{(1-\varphi)^2 \cdot k \cdot S_0^2} \quad for \quad \varphi < 0{,}8 \tag{8}$$

where:

S_0 is the specific grain area, m^2;

k - Kozeny-Carman's constant (k=5-6).

The final system will comprise all equations from (2) to (8), describing the flow in mine workings and in the porous media. Concerning the goaf, in-space distribution of permeability and methane flow toward working face must be defined.

2.3. Permeability distribution in space

Most of the authors connect permeability to porous media stress estate. Considering the rock mechanic laws applied for retreating faces with caving roof control, the following remarks can be made:

- permeability is high in the nearest proximity zone of the face, just behind this one;
- in the fall zone, permeability is inversely dependent on the distance to the face, at a certain length permeability being stabilized.

We must say that old workings have a major importance. Abandoned linings and coal pillars are having a supporting effect, diminishing the recompactation in the fall zone. Consequently, a higher permeability strip exists on three sides of the goaf.

Figure 1 indicates the in-space distribution of permeability which was retained in the model.

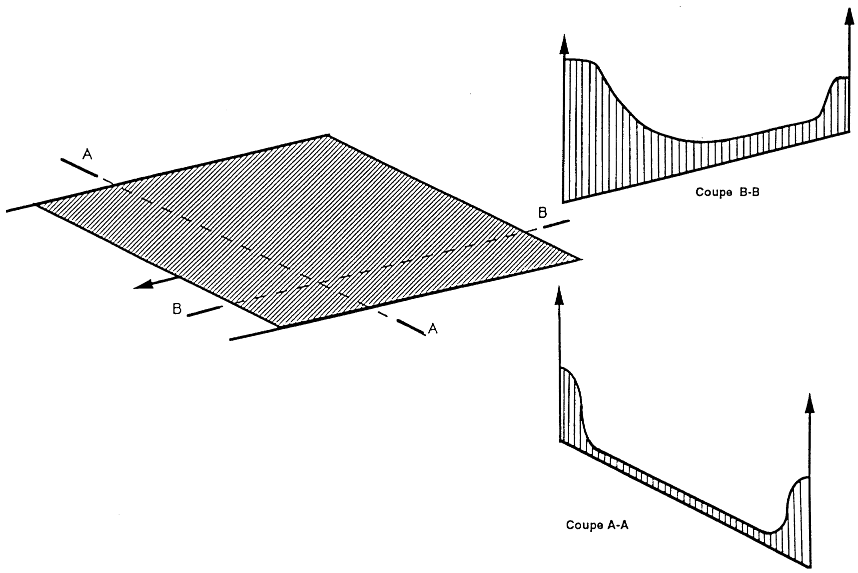

Fig. 1. Permeability distribution in the goaf

2.4. Distribution of methane flow toward working face

Figure 2 shows the methane flow distribution toward the goaf. This distribution results after numerous observations made in Valea Jiului coal basin and worldwide.

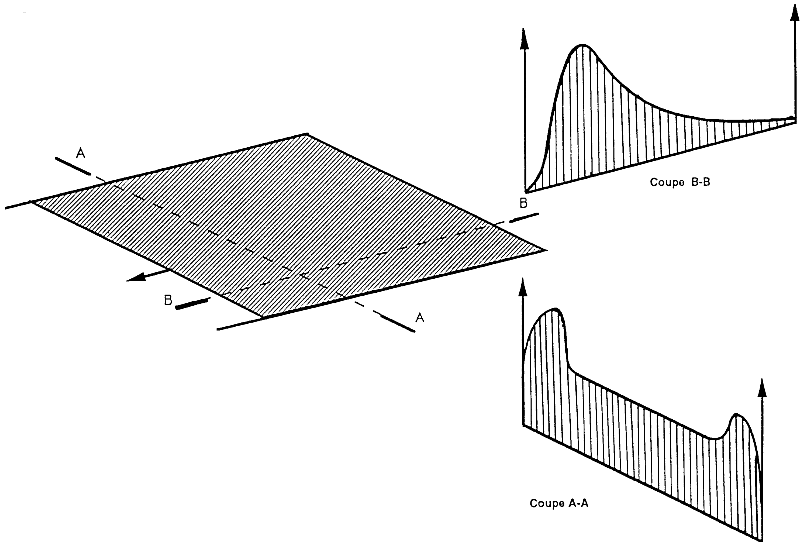

Fig. 2. Methane flow distribution toward the goaf

The following remarks ca is made:

- on a perpendicular line to face, methane flow rises from 0 to a maximal value at a certain length from the face, decreasing then to a value near to zero, corresponding to the exploitation starting point;
- on a parallel line to the face, the methane flow has the highest value in the proximity of exploited panel limits, instead of his centre; this fact is due to the existence on a vertical line of this area, of same fractures produced by rock displacement induced through the roof control process.

These fractures are privileged methane flow circuits, making possible methane migration from coal strata in the roof toward the face. In the central zone, the rock benches suffers a more regularly falling process, so the methane migration occurs especially in coal strata plan, already detensioned, toward the above - mentioned fractures.

3. SIMULATION RESULTS

The author achieved the simulation in the LGI3P from Ecole des Mines d'Alès (France). A representative face was selected from Lorene coal basin (HBL), having the following characteristics:

- face length: 20 m;
- advancing rate of the face: 110 m;
- face slope: fluctuating;
- panel slope in the advancing face direction: 0E;
- total air flow quantity in the face: 33 m^3/s;
- total methane flow: 0.5 m^3/s (correspondent to 1.5 % CH_4 concentration in return airway).

The meshing model describing the face - goaf - heading, up complies 1400 meshes. The simulations objective was to verify model's ability to reproduce the inclination effects on methane concentration distributions in the goaf: 0^o, $+10^o$ and $+20^o$ for homotropal and -10^o for antitropal ventilation were used slope angle values.

Results of simulations, illustrated in figures 3a and 3b, allowed us to conclude:

a. In all the four diagrams, high methane concentration values (with respect to Lower Explosion Limit) at the return airway intersection with the face, namely at the return end. On the other hand, methane migration increase in intensity in old working admits zone. Both these observations are confirmed in practice.
b. For upward ventilation and null inclination it can be observed that methane migration is done after parallel trajects with the face. Methane concentration is higher in return's airway vicinity, which confirms the density difference role between methane and air. As the slope angle increases, the exempt of high concentration area decreases, so the average methane concentration in the goaf is lower.
c. In downward ventilation, it can be noticed that methane migration takes place in the opposite direction to air flow in face. In this case, high concentration values are obtained on the entire such contact surface delimiting the goaf from the face.

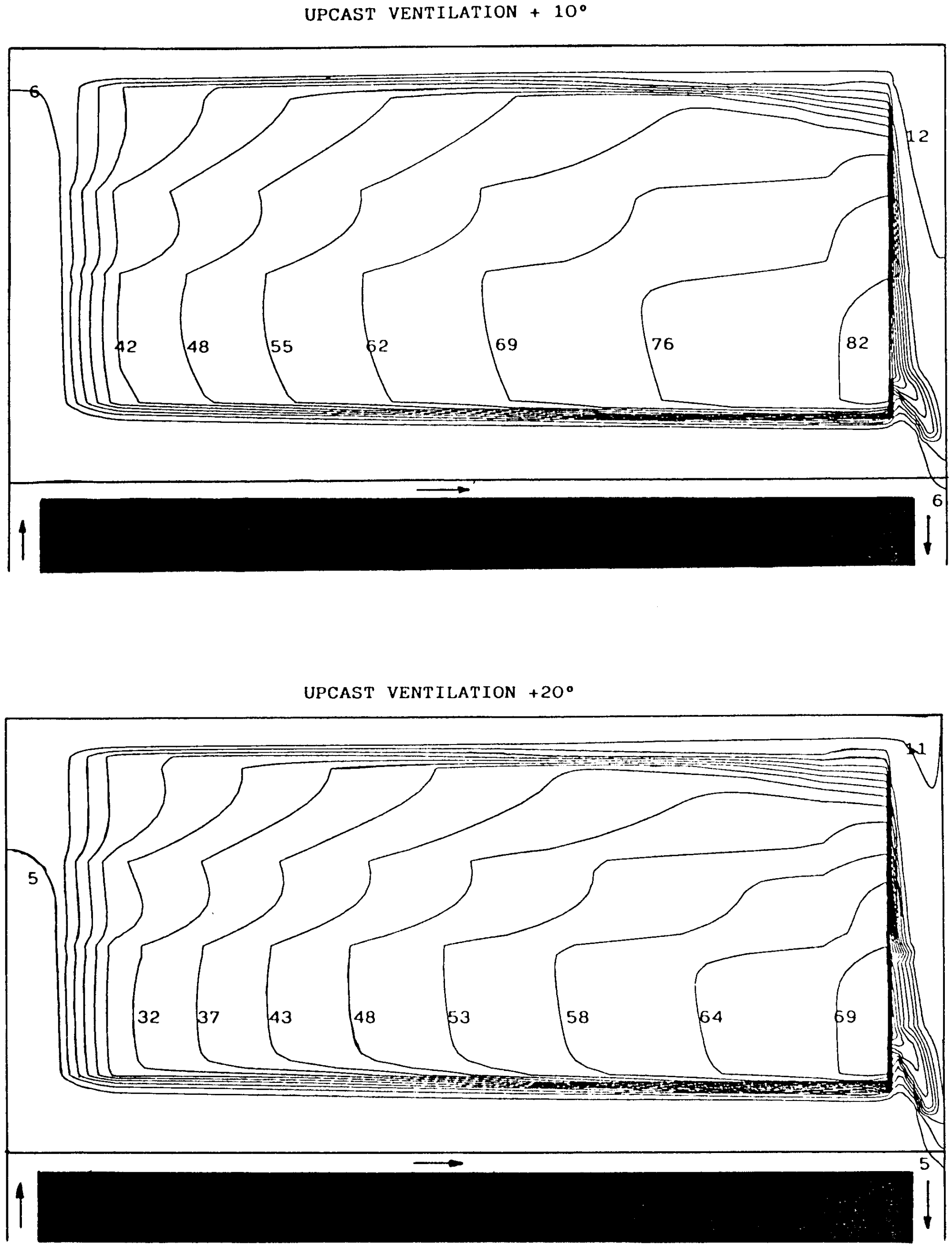

Fig. 3a. Methane concentration distribution in the goaf (upcast ventilation +10°; upcast ventilation +20°)

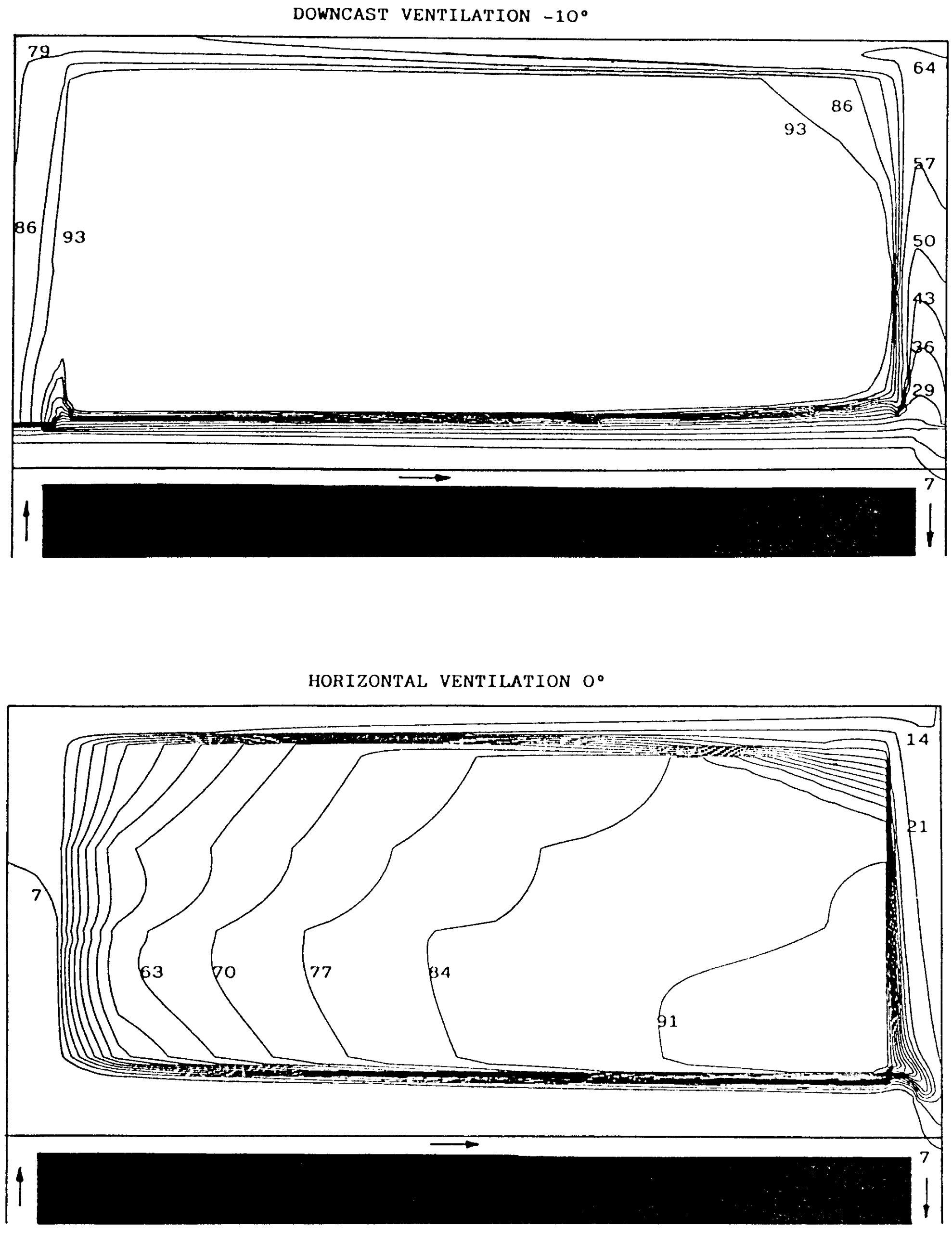

Fig. 3a. Methane concentration distribution in the goaf (downcast ventilation -10^{o}; horizontal ventilation 0^{o})

The limit of higher concentration (e.g. > 5 % CH_4) is placed in the goaf, at an obvious lower distance than with upward ventilation, which is confirmed by measurements results.

4. CONCLUSIONS

The results of these first simulations are in close correlation with direct observations and measurements carried out in the past in real faces.

Even if only from a qualitative point of view the studies phenomena are described, the main goal of the simulation tests was to verify the model's aptitude to give a correct reproduction of effects such as those generated by the differences in density between air and methane.

For a further and complete validation, the model will be subject to successive adaptations, based on its use in practical situations. Computational parameters (such as permeability and turbulence factors) must be adjusted until a greatest correlation degree will be attained between the measurement and simulation results.

The results achieved allow us to consider that CFD codes, such as PHOENICS, are extremely promising tools in raising our knowledge with respect to gas flow in the goaf, allowing to specialists the improvement of prevention and fighting techniques associated to methane explosion and spontaneous combustion hazard.

Consistent benefits can be consequently drawn both concerning safety and work efficiency in coal mines.

BIBLIOGRAPHY

[1]. **Băbuț G., Moraru, R.,** *Finite element method analysis for numerical prediction of methane flow*, Proceedings of the 3rd International Conference on Boundary and Finite Element, section 3, pp. 10-16, Constanța, 1995.

[2]. **Băbuț G., Matei, I.,** *Modele și metode de prognoză a emanațiilor de metan*, I.N.I.D. București, 1995.

[3]. **British Coal,** *Methane control for retreat faces,* CEC Research Project 7220-AC/838, 1993.

[4]. **Ediz I.G., Edwards, J.S.,** *Numerical simulation of time dependent methane flow,* Mining Science and Technology, 1991.

[5]. **Houillères du Bassin de Lorraine,** *Gestion moderne de la conduite de l'exploitation,* Project de recherche CEC 7220-AF/309.

[6]. **Pantekar S.V.,** *Numerical heat transfer and fluid flow,* McGraw Hill Book Company, New York, 1979.

[7]. **Tauziede C., Pokryszka, Z.,** *Prévision dynamic du dégagement de grisou en taille,* 25ème Conférence Internationale des Instituts de Recherche sur la Sécurité dans les Mines, Pretoria, 1993.

BASIC PRINCIPLES APPLIED TO EVALUATE AND SELECT THE SOFTWARE TOOLS FOR RISK ASSESSMENT AND MANAGEMENT

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Abstract: Managing risk within an organization is now a key activity not only from a good business management perspective but also as an audit compliance requirement driven by regulation and legislation which is being drafted to ensure risks are minimized or contained. The paper is aimed at identifying what is required from the process of risk management and therefore what facilities a software tool should be able to provide to ensure an organization's corporate responsibilities are met and to what extent risk management software can help or hinder the process.

Key words: risk, assessment, management, software tools, organization

1. INTRODUCTION

The risk management standard AS/NZS 4360: 2004 defines risk as "the chance of something happening that will have an impact on objectives". Impact may be positive or negative. Key to the good management of risk is understanding the likelihood of these events and how exposed or vulnerable the organization or environment is. It is recognized that risk awareness and management can be considered across 3 areas: Security which considers those risks which are deliberate, malicious and humanly initiated, Safety which considers accidents or failures and Natural events. Each must be considered when addressing the overall corporate approach to minimizing risk within the organization.

2. APPROACH TO RISK MANAGEMENT

Simplistically the approach is fairly well defined – identify risk, assess the likelihood of this happening and evaluate the resultant impact. In a large number of

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cases this approach to risk management is based on experience, following the industry trends or gut feeling. Many would say that this has been a successful approach with a few notable exceptions. Strategic investment decisions however are not based on gut instinct and an auditor would not be satisfied with a risk management strategy based on copying another organization’s arrangement.

Investment decisions today must be qualified, monitored and constantly reviewed to ensure they are effective. All threats have a direct or indirect implications for the security risk management of an organization’s assets, whether intellectual, reputational, people or property. Furthermore, security risks are ongoing, changing and dynamic making risk management a process rather than an objective. These uncertainties make it difficult to justify investment in risk management strategies and, from a business perspective, demonstrate a good “return on investment” from the control measures that have been selected. From a risk manager’s point of view this makes for a very difficult balancing act – what can be justified and how will this benefit the business whilst ensuring the likelihood of any incident occurring in minimized.

The process of risk assessment can and should be carried out for all aspects of the organization’s operational process – project management, corporate investment, premises technology, health and safety, personnel, and environmental management. This can be done manually using simple applications and record keeping techniques or make use of the many software tools available that will provide reports and recommendations based on standards and regulatory or legal requirements. The question is when is it necessary to make use of a software tool to assess risks and when can its use being justified. It could be argued that a well designed spreadsheet is more than sufficient for 80 % of the time. Where software can make a difference is when one or more of the following applies:

- the sheer volume of risks is so large that they become unmanageable to administer in a spreadsheet (i.e., more than several hundred);
- there is an audit or other requirement to track changes to risk analysis scores etc through proper permissions or authentication functionality;
- the software itself becomes the actual business process, there is full integration between the risk management process and the tool that supports it.

3. STAGES OF RISK MANAGEMENT

Just to recap, managing risks should essentially follow a series of steps. These are clearly defined in standard AS/NZS 4360: 2004. The first is an assessment or understanding where the risks lie. This will provide the starting point or frame of reference for defining, justifying and implementing appropriate mitigating controls. Secondly, the environment must be monitored to ensure the threats and exposures that the assessment initially identified and upon which the controls were implemented, remain valid. Finally there must be a review stage to ensure the controls are operating effectively and achieving the intended aim of minimizing the likelihood or impact of the risk.

The monitoring and review stages are essential to ensure the original risks assessment remains valid and any changes in circumstance can reflected in the overall risk profile and control measures.

In order to fully appreciate how a “tool” can support the overall risk management process the individual stages must be understood. There is a danger that should too much reliance be placed on a specific tool to provide the answers the risk manager’s skills and experience may be overlooked.

4. RISK ASSESSMENT

The first stage in the risk management process is assessing the risks. Simply put, this is a matter of identifying potential threats, assessing how likely they are to occur, weigh up the exposure or vulnerability and then valuing the likely impact. There is a very real danger that too much emphasis will be placed on a threat list that is not really applicable to organization or the environment within which it operates.

a. Threat identification

- these are constantly evolving so must be able to be added to as they are identified;
- must be able to be categorized for relevance to the organization;
- must be able to be categorized in terms of threat type – e.g. environmental, health and safety, technology etc.
- the threat narrative must be descriptive enough to enable it to be used by all staff.

b. Likelihood or exposure

- has the threat occurred before;
- what is the prediction for occurrence;
- what is the current status from monitoring centres – CERTs, Meteorological services, earthquake commission, intelligence services.

The likelihood of occurrence of each threat must be able to be included in the assessment tool as a quantifiable or qualified value.

This may be done automatically through connection to the (tool) vendor’s site or manually by constantly reviewing information sources. It is essential that the relevance of the threat to the corporate infrastructure or environment that is being assessed is recognized. The possible exposure may be through testing, operational assessment or qualified evaluation.

c. Impact assessment

The tool must be able to capture a range of impact values and affects on the organization. Ideally these should be able to be tailored to accommodate the business or operation type.

- the value of impact for different aspects – direct financial, market share, investor or public confidence, loss of property, loss of life etc.
- The value of impact over an extending period – immediate through the next few hours to longer term (months).

5. MONITORING AND REVIEW

The monitoring stage provides direct feedback on the operational effectiveness of the control measures. To support this stage the tool must be able to capture input from various sources and raise event alerts against predefined scenarios. This may require different forms of input automated, log analysis or manual. Ideally the tool should also be able to suggest recommended courses of action or have predefined procedures to deal with expected events.

The analysis and monitoring stages enable the risk manager to ensure the control measures are properly defined and operating effectively. The tool supporting this stage must keep a record of events over time and assess whether:

- the risk profile is correct;
- the number of events affecting the organization are reducing;
- the costs of events affecting the organization are reducing.

6. TYPES OF RISK MANAGEMENT TOOL

Risk management is an extensive subject covering a number of disciplines described below. Understanding the nature and function of the software tool required is essential to ensure that:

- it delivers the expected and required results;
- its cost can be justified.

In all cases they should enable the risk manager to plan for events and ensure crises can be effectively managed. In a number of cases the tools are able to support more than one discipline enabling compliance with corporate risk objectives to be measured and monitored through a single mechanism.

a. Technical and operational

Specifically aimed at assessing the technical and operational infrastructure of the organization, these tools are able to gather data on the network and computing systems and assess potential impact of failure. Threats are in the main those that will affect the technical infrastructure such as viruses, hacking, power failure etc. and will assess potential impact on the business over time. Recently these tools are designed to reflect the structure and objectives of AS/NZS ISO/IEC 17799: 2001 - Information technology - Code of practice for information security management. Along with Asset Management applications these provide a good basis for Business Continuity Plans.

b. Project

The risks associated with the successful running and completion of a project is now an essential element of the project startup. These should address all the external influences on the project and identify alternative strategies at an early stage giving greater confidence in project success.

c. Finance and investment

Key financial and investment decisions must be managed and any exposure identified. This is especially relevant in foreign exchange transactions but should also consider the exposure arising from project and development investments.

d. Environmental

Tools assessing environmental risks provide valuable sources of information on environmental hazards and potential affects. These do not only consider natural events but in some cases can assess the impact of changes to the structure or composition of the environment through chemical effects, removal of natural structures or population changes.

e. Health and safety

The health and safety tools tend to be incident registers however they are able to provide the risk manager with valuable information on trends and costs to the business either through claims or lost time.

f. Enterprise or corporate

These are extensive and relatively complex risk management tools designed to capture data on a very broad scale. This includes personnel, environmental, legal and legal issues amongst others. Generally these rely on input from a wide range of sources, primarily the business units. This may give rise to various interpretations so the overhead of training, interpretation and user management must be considered.

g. Auditing

Audit tools provide a structured framework for review of the infrastructure with the ability to compare status against previous audits. In themselves these are simply a data capture and reporting device however used with a risk register they can prove valuable monitoring tool.

h. Asset and risk register

Tools are available to capture details of the assets owned by an organization or to capture and manage identified risks or incidents. Although on the face of it these can be fairly simplistic, value can be added through asset relationships, sensitivity, locations, ownerships and in the case of risks can monitor progress and status.

7. SELECTING AN EFFECTIVE APPROACH

Risk management tools have been developed to make the process of risk management “easier”. Generally these tools provide a simple user interface and are able to generate numerous reports on the organization’s security status designed to provide business area managers and auditors with a simple view of the risk profile. These do however tend to be on a snapshot basis unless the analysis values for threat and impact have been maintained.

Crucially it is also dependant on the attention paid by the risk manager to maintaining the status of the data. More often now this is being passed on to business unit managers as being the best, most accurate and current source of information on new risks and the potential impact on the business or the environs.

Before embarking on the potentially costly exercise of selecting a suitable risk management tool the following should be considered:

a. Does the executive accept their corporate responsibility to demonstrate they are managing their risks?

A key starting point for managing risk within an organization is the support of board members. Recent years has seen emerging legislation and regulatory drivers that require senior management to comply with accepted risk management procedures. It is likely that this will become the norm for many industry sectors.

b. Does the organization have a complex, changeable environment with an extensive risk profile?

A key feature of risk management tools is their ability to capture and analyze large amounts of data to provide a simple risk profile able to be viewed and understood by different functions within the organization. It should be recognized though that, for simple cases, this data can be captured and analyzed in a spreadsheet. A qualified view must be taken of the time required to develop a simple spreadsheet if this is able to provide sufficient and suitable information against the cost of a risk management tool.

Where the environment is complex and changing it is necessary to be able to capture new threats and make changes to the values in the profiles. This will provide the risk manager with the ability to conduct "What if" queries against the risk profile and ensure that potential threat scenarios can be accommodated.

c. Are there regulatory or legal obligations with which the organization must comply?

There is a growing quantity of legislation and industry sector regulations with which organizations must comply in order to continue to hold a license to operate, to avoid swinging fines or to ensure the services they offer are not curtailed in any way. In recent years this has included "management of operational risks". Some of the risk management tools available are specifically designed to incorporate the needs and objectives of the applicable legal or regulatory requirements.

d. Will the risk profile be maintained by the risk manager or by the individual business units?

The business unit managers are clearly in the best position to understand the potential impact of any risk to their business area. However it may be detrimental to their normal role to ask them to maintain a risk profile. They should be able to provide accurate input whether it is directly into a risk management tool or through structured interviews. If the managers are required to maintain it then it must be simple to use and relevant to their function.

e. What aspects of risk must be addressed (technical, environmental, financial, political etc)

Risk management tools tend to be produced for a particular aspect of the risk framework. The objectives, scope and functionality of the tool must be clearly understood to ensure that:

- the expected risk model is defined;
- the correct individuals are providing input and acting on the recommendations.

f. How will the output from the tool be used?

Generally, the more complex and expensive the tool is, the more difficult it is to maintain and the more information is provided; this is not always of benefit. If however it is only being used to set a budget and is updated on an infrequent basis, only a very simple (spreadsheet) type approach will suffice. Demonstration of compliance however requires a more detailed level of analysis. A properly structured and comprehensive risk analysis tool should provide a simple user interface with the ability to tailor reports depending on the audience.

g. How will the effectiveness be monitored?

Clearly it is only possible to demonstrate the effectiveness of the controls and consequently the accuracy of the tool if the results are monitored. This will require an integral mechanism to gather data on the number of events, the seriousness and the cost to the organization. This will enable the risk manager to verify that the controls are operating as expected and can also be used to demonstrate the controls are justified.

h. What are the budgetary constraints?

As with all expenditure a budget must be established. Generally this is done through demonstrating a return on investment over time. With risk management however it is necessary to demonstrate a reduced level of loss. It is necessary therefore to show that a risk management tool can add value to identify how losses to the business are being reduced potentially through an event logging and cost analysis capability.

8. OVERVIEW OF AVAILABLE RISK MANAGEMENT TOOLS

The following summarizes some of the tools currently available and their usage in the risk management process (see table 1). It is not intended as an evaluation or comment on the software tools and their capability.

These are grouped into – Technology, Project, Investment, Environmental and Health and Safety risk. Those identified as Enterprise or Corporate risk have multiple applications and are aimed at maintaining or demonstrating corporate compliance. Other software tools are available to support internal audit and to provide the basis of an Asset Register.

Table 1 **Overview of available risk management tools**

No.	**Risk management tool or application name**	**Supplier**	**Technology**	**Project**	**Investment**	**Environment**	**H&S**	**Corporate**	**Audit**	**Register**
0	1	2	3	4	5	6	7	8	9	10
1.	4Technology	4Technology (http://www.4technology.net/4tsite/default.asp)						X		
2.	@Risk	Palisade (http://www.palisade.com/html/risk.asp)			X					
3.	ACEIT	U.S. Government (www.aceit.com)		X						
4.	Active Risk Manager	Strategic Thought (http://www.strategicthought.com)		X				X		
5.	Analytica	Lumina Decision Systems Inc. (http://www.lumina.com)			X					
6.	AUDITWorks	Primatech, Inc (www.primatech.com)				X	X			
7.	AgenaRisk	Agena (http://www.agena.co.uk)			X					
8.	Biomathematics	RAMAS Software (www.ramas.com)			X					
9.	CRisk	BMT Reliability Consultants Ltd. (www.bmtrcl.com)					X			
10.	CAMEO	National Safety Council (cameo@nsc.org)					X			

0	1	2	3	4	5	6	7	8	9	10
11.	CardMap	Paisley Consulting (http://www.paisleyconsulting.com)							X	X
12.	CARES	Nonprofit (http://www.nonprofitrisk.org/cares/cares.htm)	X					X		X
13.	CASCADE	Mantix Systems (www.mantix.com)		X						
14.	ChoicePoint	Bridger Insight (http://www.bridgerinsight.choicepoint.com)	X					X		
15.	COBIT	ISACA (www.isaca.org)	X							
16.	Cobra	Welcom (www.welcom.com)		X	X					
17.	CRAMM	Insight Consulting (www.insight.co.uk)	X							X
18.	CRIMS	Expert Choice, Inc (www.expertchoice.com)			X					
19.	Crystal Ball	Decisioneering (www.decisioneering.com)		X	X					
20.	dbsAccord dbs	Technology Solutions (http://www.dbsfinsys.co.uk/dbsaccord_solution .htm)							X	
21.	DecisionPro	Vanguard Software Corp (www.vanguardsw.com)		X						
22.	Designsafe	Design Safety Engineering, Inc. (www.designsafe.com)					X			
23.	DPL Decision Programming Language	Applied Decision Analysis (www.adainc.com)		X					X	
24.	Earned Value Program Management Solution Software	Robbins-Gioia Inc (www.pmboulevard.com)		X						
25.	Enterprise Risk Assessor	Methodware (www.methodware.com)						X		
26.	EQE Checklist	Natural Logic, Inc. (www.natlogic.com)								X
27.	fiCS High	Profile Solutions (www.highprofile.co.nz)						X		
28.	forMIS	Figtree Systems (www.figtreesys.co.nz)					X			
29.	Futura	DA Futura International Oy (www.futurada.fi)		X						
30.	iDecide 2000	Decisive Tools (www.decisivetools.com)		X						
31.	iHex	Future Route (http://www.futureroute.co.uk)			X					
32.	IKANDepend	IKAN (www.ikan.co.uk)						X		
33.	IRAM Information Risk Analysis Methodologies	Information Security Forum (http://www.securityforum.org/)	X							
34.	ISO 14001 Workplace Environment Audit Information	ICF Consulting Group Inc. (ww.icfconsulting.com)								X
35.	LiveAudit	Data Mirror (http://www.datamirror.com/products/liveaudit)							X	
36.	MyOB	MYOB NZ Ltd (www.myob.co.nz)		X	X					X
37.	Monte Carlo Primavera P3	Primavera Systems Inc. (www.primavera.com/)			X					
38.	Orcas	Methodware (www.methodware.com)						X		X
39.	Pandora	BMT Reliability Consultants Ltd. (www.bmtrcl.com/)		X						
40.	Pertmaster Professional +Risk	Pertmaster Limited (www.pertmaster.com)		X						
41.	PetroVR	Caesar Petroleum Systems (www.caesarsystems.com)		X						
42.	Portfolio Defender	Environmental Risk Communications, Inc. (www.erci.net)				X				
43.	Powersim Solver	Powersim (www.powersim.com)		X				X		

0	1	2	3	4	5	6	7	8	9	10
44.	PRA – Project Risk and Contingency Analysis	Katmar Software (http://users.lia.net/katmar/pra.htm)		X						
45.	Predict Risk Analyzer	Risk Decisions Ltd. (www.riskdecisions.co.uk/)						X		
46.	Project SelfAssessment Kit	KLCI (www.klci.com)		X						
47.	Princess Risk 2	WS Atkins (www.wsatkins.co.uk)						X		
48.	PROAct	Resource Calculations (www.maxvalue.com)						X		
49.	Quantate	Jarvis Risk + Assurance Ltd, NZ (www.quantate.com)						X	X	X
50.	RBCA Tool Kit	Groundwater Services, Inc (http://www.gsinet.com/software.htm)				X				
51.	RIP	Golder Associates (www.golder.com/)				X				
52.	Ris3	Line International Ltd. (www.ris3.com)						X		
53.	Risk Advisor	Methodware (www.methodware.com)						X		
54.	RiskPac	CSCI (http://www.csciweb.com/riskpac.htm)	X							
55.	RiskWatch	Risk Watch (http://www.riskwatch.com/)	X					X		
56.	RISK*ASSISTANT RISK*WORKS	Hampshire Research (http://www.hampshire.org)				X				
57.	Risk+	C/S Solutions Inc. (www.cssolutions.com)								
58.	RiskEZ	Pinyon Software (www.pinyonsoftware.com)								
59.	RiskFolio	Risk Laboratories, LLC (www.risklabs.com)								
60.	RISKMAN	PLG Inc. (www.riskdriver.com)								
61.	Risk Navigator	Paisley Consulting (http://www.paisleyconsulting.com)						X	X	X
62.	RiskEase RiskMaster	Master Solutions (http://www.riskease.com/index.html)								
63.	RiskSafe	Dyadem International Ltd. (www.dyadem.com)								
64.	RiskTools	Risk Management Solutions (http://www.riskinc.com)				X		X		X
65.	RiskTrak	Risk Services & Technology (www.risktrak.com)								X
66.	Safeti	Det Norske Veritas Risk Management Software (www.dnv.com)					X		X	
67.	SafeTrac	SafeTrac Minter Ellison (http://www.safetrac.com.au)						X		X
68.	SARA Simple to Apply Risk Analysis	Information Security Forum (http://www.securityforum.org)	X							
69.	SERIM	IEEE Computer Society/Dale Karolak (www.computer.org)	X							
70.	SiteSafe	BMS Solutions (www.bmssolutions.com)				X				
71.	SLIM/SLIM-Control	Quantitative Software Management (www.qsm.com)	X							
72.	SmartRISK	PIONEER Technologies Corporation (www.uspioneer.com)				X				
73.	Software Risk Evaluation	Software Engineering Institute (www.sei.cmu.edu)	X							
74.	SPRINT Simplified Process for Risk Identification	Information Security Forum (http://www.securityforum.org/)	X							

0	1	2	3	4	5	6	7	8	9	10
75.	STAR – System Trade and Risk Analysis	Mainstay Software (www.mainstay.com)			X					
76.	StarView (Real Estate)	VISTA Information Solutions, Inc (www.vistainfo.com)		X						
77.	TRAKKER (Risk Management Module)	Dekker (www.dtrakker.com)							X	X
78.	TRIMS	Navy's Best Manufacturing Practices Center of Excellence (www.bmpcoe.org)						X		
79.	WebProject	WebProject, Inc. (www.wproj.com)		X						

9. CONCLUSIONS

Risk management tools can provide enormous benefit to an organization through better understanding of the operational environment, improved monitoring of the effectiveness of controls and a more robust response to compliance auditors. There is the danger however that they detract from the skills and experience of the corporate risk managers and business unit managers.

The use of these tools within an organization must be clearly understood and the roles and areas of responsibilities for the various individuals defined ensuring the output is accurate and accepted. Like other security controls, a risk management tool will not be effective unless it is used and maintained properly. It is worth spending the time at the outset to determine exactly what is needed and following the accepted approach for application testing and procurement. This can be a major expense so the return on investment must be clearly demonstrated. This is only possible through a well structured, well managed and well understood process.

BIBLIOGRAPHY

[1]. *** * *,** *AS/NZS ISO/IEC 17799: 2001 - Information technology. Code of practice for information security management*, Standards Australia/ Standards New Zeeland, Sydney/Wellington, 2001.

[2]. *** * ***, *AS/NZS 4360: 2004 - Risk management*, Standards Australia/Standards New Zeeland, Sydney/Wellington, 2004.

GENERAL INACTIVATING METHODS FOR THE ELIMINATION OF SPONTANEOUS COMBUSTION, APPLICABLE TO THE MINING METHODS

MUNUNAR GHEORGHE *,ŞINK ADRIAN **, JUJAN CONSTANTIN*, DĂBULEANU IOAN******

Abstract : Nitrogen is widely used in combating underground fires, first of all in France, Germany, Ukrain and India. Because of the inactivating properties of Nitrogen, this was used throughout the world mining history for the following purposes: elimination of explosion hazard, reduction of fire range and fire intensity, chilling fire workings. Inactivating by means of Nitrogen was first applied among others in the following causes: longwall mining both advancing and retreating; fire outbreak in workings with circulating ventilation;fighting fires in workings with the auxiliary ventilation;reducing the fire range and eliminating the seat of fire. The paper presents two basic methods of inactivation for fighting underground fires occurring in workings sealed with sealing dams, applicable to the mining methods used in Jiu Valley.

Key – words : inactivating, mining, methods, spontaneous combustion,nitrogen, dam.

1. INTRODUCTION

This paper serves the purpose of studying possibilities of application of several methods of inactivation by means of Nitrogen, so as to prevent and to fight against spontaneous combustions inside mining abates with the coal undermined behind the production line.

The inactivating with nitrogen application should have a positive impact in the normal performance of mining activity, because of:

-endogenous fires' producing hazard reduction, by means of applying the preventive method;

-the diminution of the risk of explosion due to methane accumulation from the working area, by means of creating the inert atmosphere in this space

These results will implicitly lead to a decrease in the number of endogenous fires, respective, of the immobilization time of the coal store, thus creating the pre-requisites of the increased safety at mining work.

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2. GENERALITIES CONCERNING THE INACTIVATING PROCESS

The large-seal use of Nitrogen in the inactivating process is the result of the multiple advantages this gas has, namely:
-the possibilities to use it as a fluid or as a gas; it can be easily transported, as a fluid, in tanks; the large-seal production of fluid Nitrogen and the possibility of turning large quantities in gas Nitrogen; the high safety degree of the inactivating technology; it is the secondary output produced in Oxygen production process; it can be produced inside the mining medium (which is also the usage medium) by using certain semi-movable units, with molecular filters.

The Nitrogen Inactivation Objectives

In connection with the terms of application, the Nitrogen inactivation rejoins the following objectives:
-the decrease of Oxygen content in the inactivated space, thus avoiding the explosion hazard by keeping the gas concentration inside the IV area (non-explosive compound/mixture, fig 1); the decrease of combustion intensity, as a result of the decreased alimentation with Oxygen; the oppression of spontaneous heating or fires occurring in working spaces, as a result of -the elimination of the optimum conditions in which appear the coal self-heating and self-ignition phenomena; the reducing of the immobilization period of the dammed-up coal store., which allows the reprise in the workings affected by fire in a very short time; the working and safety conditions' improvement in the rescuers' intervention;

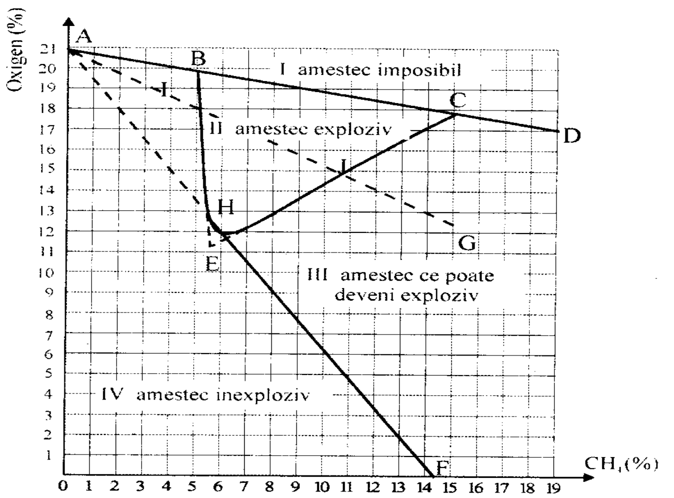

Fig. 1 - COWARD Diagram

2.2. Inactivation Processes

From the point of view of application strategy, there are known two Nitrogen inactivating techniques, namely:

a) space inactivating;

b) object inactivating.

a) Space Inactivating – consists of Nitrogen introduction in large amounts, between 100-500 m**Error! Bookmark not defined.**3/min. in a fire area, dammed-up totally or partially, case in which at least the air stream entrance part is closed. The main purpose of this inactivation consists of the removal of the explosion hazard, by turning gas-air compounds into non-explosive mixtures. Through this, it can be accomplished a reduction of the dammed volume, as well as a reduction of fire intensity or even a complete extinction of the fire.

This method is basically used in fighting against open fires. Rarely, it has been applied also in fighting covered fires, when there is an explosion hazard.

b) Object Inactivation- consists of direct flooding of the inactivation area with the inert gas in an amount under 100m3/min., without interrupting the ventilation in the area (eg. for preventing spontaneous combustions; for fighting against covered fires from working spaces). In this case, the air stream which ventilates the inactivation space is replaced, as much as possible, with inert gas.

By applying this procedure, there can appear cases when the spontaneous combustion is not fully extinguished, but, by continuously introducing Nitrogen and taking some conventional measures (as: sealing, respective proofing of the working area) it could pass in a regress phase. In this case, the mining can be continued up to the field limit, respective up to the ending of the useful mineral substance.

In terms of the place of Nitrogen production, of the way of introducing it up to the fire area , as well as of the types of equipments used, there are:

1. central inactivation ;
2. local inactivation .

1.The Central Inactivation- mainly consists of producing Nitrogen in specialized units and the transporting, respective the required processing in the beneficiary units.

In accordance with the type of production unit of the Nitrogen, there are 2 types of Central inactivation, namely:

Type I- producing cryogenic Nitrogen as a fluid, with the possibility of turning it into a gas;

Type II - producing the non-cryogenic Nitrogen as a gas.

The Local Inactivation – consists of loading and transporting the fluid Nitrogen in mobile receptacles, whose weight allow their transporting underground, close to the area that would be inactivated.

These receptacles are fitted with their own evaporators, which partially turn fluid into gas, thus creating a sufficient overpressure for discharging the fluid Nitrogen out of the receptacles.

The mobile receptacles can be loaded from a hoarding tank of fluid Nitrogen or from an auto-tank, which was previously filled from a hoarding tank.

Another type would consist of charging the receptacles directly from the Nitrogen production unit, in the case in which this is at a small distance from the inactivation place. In this case, the mobile receptacles are transported by means of an auto-stage.

According to the distance between the inactivation place (burning point) and the place where the receptacles are, the Nitrogen can get:

- as a fluid, when the distance is small, of 20-50m , in which case its turning into a gas accomplishes at the scavenging place(underground);
- as a gas, if the distance is more than 50-100m, in which case the transformation into a gas takes place on the way.

This type of inactivation has not found an extension in application yet, being used in starting stage of the inactivation in Germany, Czech a, and , more recently, in Hungary(since 1993).

Nitrogen Obtaining Processes

So as to obtain Nitrogen at a large-seal, two methods of air-separation are used:

1. the cryogenic method ;
2. the non-cryogenic method .

1.The Cryogenic Method-consists of air compression and it's cooling low to cryogenic temperatures.

In this way, the compressed fluid air is separated in a distillation column, thus mainly obtaining the components: Nitrogen and Oxygen.

This separation is realized in specialized units (creels, factories) in which there are also produced, in addition to the two components mentioned above, other compounds, as for example: Argon.

The cryogenic method is preferred when there are no applications for large amounts of highly pure Nitrogen.

2. The Non-Cryogenic Method of air separation offers the possibility of Nitrogen or Oxygen production right at the place of use (mining unit).

This method includes two procedures, namely:

- membrane procedure ;
- the PSA system procedure .

The membrane procedure- is based on the selective permeability theory, using special membranes, which are included in the Nitrogen production installation.

For the polymeric membranes, the permeability of each gas is determined by the solvability degree of the gas in the material of the membrane and by the diffusion speed through molecular-free volume in the membrane's wall.

These different permeabilities allow some 'faster' gas, such as O_2, CO_2 and the water vapors to be separated by 'slower' gas, such as Nitrogen.

3. GENERAL INACTIVATING METHODS FOR THE ELIMINATION OF SPONTANEOUS COMBUSTION, APPLICABLE TO THE MINING METHODS IN JIU VALLEY

In making these general inactivating methods, there has been taken into consideration only the mining methods with the coal undermining behind the production line (with undermined bench), method used in most mines from Jiu Valley.

Consequently, from the analysis of, on one side, the data concerning the mining method mentioned above, and, on the other side, the data obtained from specialized literature, it comes out that the following schemes of inactivation can be used:

- preventive inactivation, respective that of fighting against the spontaneous combustion from the working place, without the isolation of the abates;
- the inactivation for fighting against the endogenous fires from dammed-up abates.

The preventive inactivation of the working place can be realized concomitantly with the performing of the coal extracting process.

The fighting inactivation against the spontaneous combustions can be realized concomitantly with the performing of the coal extracting process, by using execution personnel, in the cases when the CO and CO2 concentrations do not surpass the accepted limits, or rescue personnel when these concentrations are surpassed.

For both types of inactivation, the maximum value of the Nitrogen amount that should be introduced in the working place must be chosen so that it would not produce a decrease of Oxygen under the accepted limits, admitted for the situation in which there would occur an accidental appearance of it in the working place.

In this paper, accent will be put on the inactivation for fighting against spontaneous combustions in the mines from Jiu Valley, used for treating the space used for extracting coal. The treatment of the exploited space is also important because of the fact that the coal extracting advances vertically and horizontally, and the distillation gas emission from the exploited area or even open fires from abates can lead to their closure and, thus to the immobilization of coal store.

In the cases in which the active fighting by classical means against an endogenous fire is not successful, it turns to passive fighting, respective the closing of the affected space with isolating dams.

In these cases, the fire extinction process is long and very slow until a part of the Oxygen amount is used in the burning process. Additionally, in this period the heat quantity resulted from the endogenous fire is transferred to the rocks around.

Therefore, the time to put of a fire through passive fighting is according to the diminishing tendency of the Oxygen content from the closed area and respective to the area cooling.

Through Nitrogen injection in a closed area the wastages are compensated by dams and by permeability of the area, making the process of Oxygen concentration reduction faster. Additionally, with Nitrogen passing through hot areas, takes place the convection heating transfer, phenomenon through which the cooling of the area is realized faster and the quantity of heat transmitted to the rocks around is importantly diminished.

The fighting against endogenous fire inactivation from abates closed with isolating dams can be realized through 2 types of frame schemes, namely:

1. frame scheme to inactivate through the pipe placed in the isolating dam;
2. frame scheme to inactivate through drillings, whose nitrogenic rams intercept the abates area.

3.1. In case of type 1

For the inactivation to occur (fig.2) in the dam realized in the fresh air gallery it is put a pipe with Ø 50-100mm (2) which is coupled at the main pipe (4), and the free extremity is at 10 m behind the dam. So as to avoid the dynamic effect created by the gas upsetting through the free extremity of the pipe (the last section), this will be fixed in minimum 2 points.

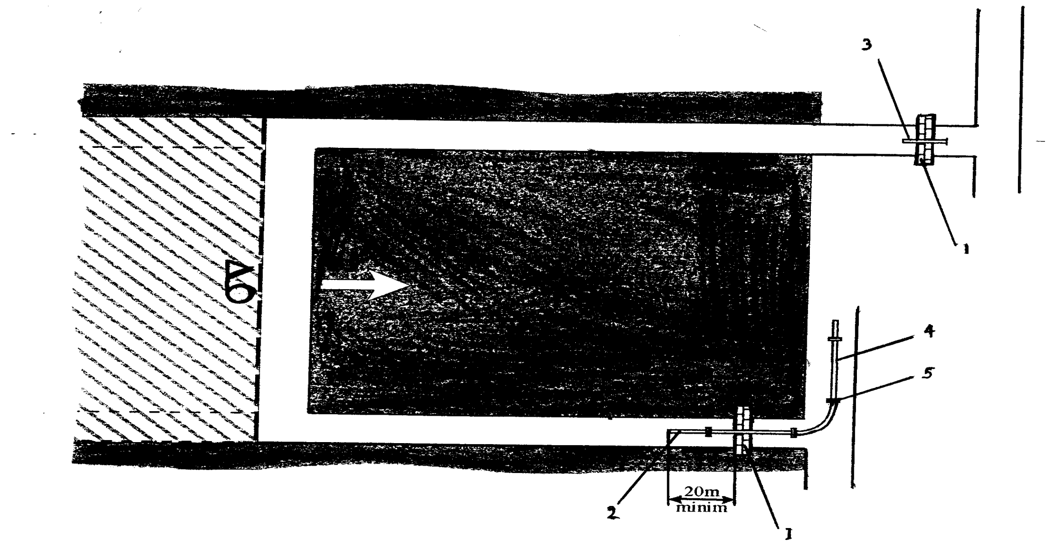

Fig. 2 - Scheme to inactivate through the pipe placed in the isolating dam;

Legend Fig. 2:
1-dam,
2- pipe for nitrogen introduction,
3- pipe for prevailing gas specimen,
4- main pipe for nitrogen transport,
5- flanges, collars.

3.2 In case of type 2

The inactivation is realized by means of long drillings, which are made in the fresh air gallery (eg. the base or the pre-abates on the roof in case of thick layers). The placement of these drillings is before the isolating dam and its free extremity is approximately in the upper side of the bench and at a distance as reduced as possible from the intersection opf the abates band and the main gallery.

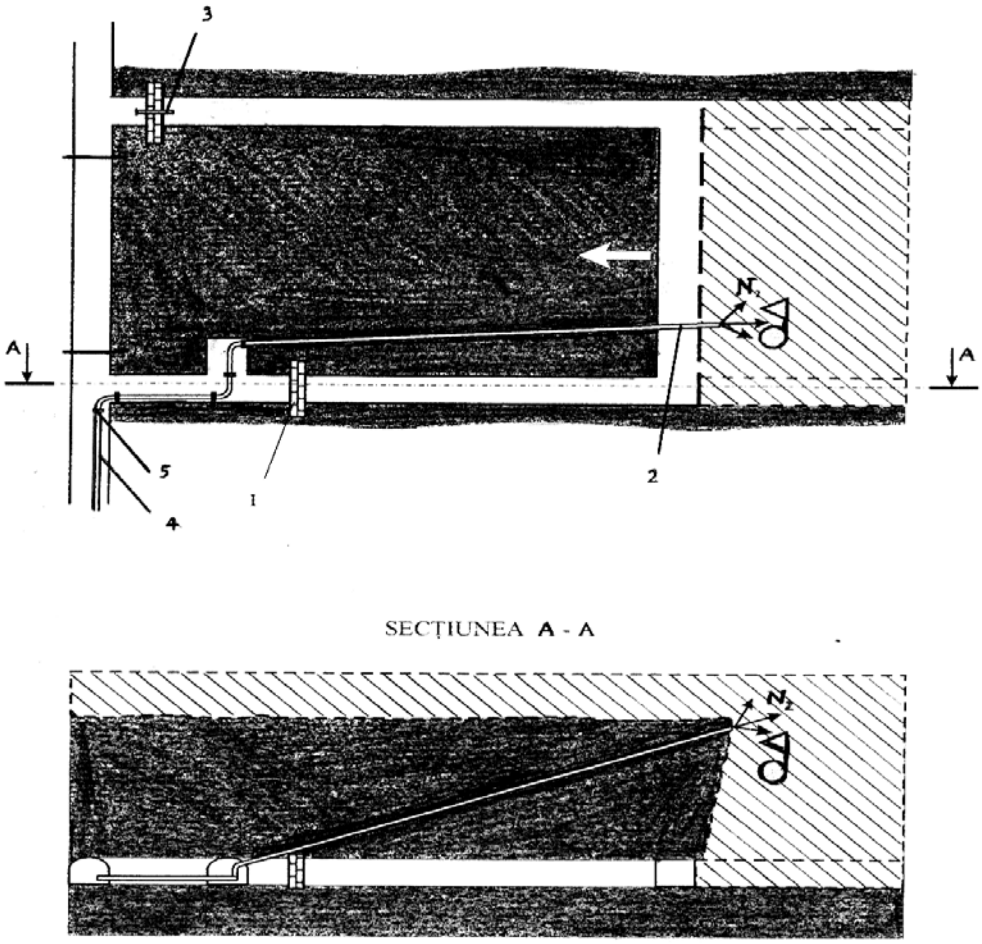

Fig. 3 - Scheme to inactivate through drillings, whose nitrogenic rams intercept the abates area.

Legend fig 3:

1-dam,
2- nitrogen introducing pipe,
3- prevailing gas specimen pipe,
4- main pipe for transport,
5- flanges, collars .

4. CONCLUSIONS

In case of both types, several elements are necessarily to be taken into consideration:

-space inactivating is always done by introducing a minimum volume of nitrogen which should represent three times the free volume to be inactivated. It is continued or not with the inactivation, according to the Oxygen concentration determined in the dammed area whose value should be ≤ 5% and to the results of the prevailed tests' interpretation , which should say the fire is extinguished.

- the inactivation results' interpretation in closed area and, especially after the workings in vicious air stream, can be realized through prevailing specimens, either from pipes specialized for this, or from the drillings through which the nitrogen has been introduced.

The assurance of the optimum work safety during the appliance of the inactivation (available for both types of inactivation) imposes:

- gas measurements effectuation(O_2, CO_2, CO, CH_4), with portable equipment(eg. type MX 2000, mx-21, tx-11) in the fresh air gallery, the abates' strip, band, the evacuation gallery of the vicious air in case of closed abates, respective behind the isolations dams and inside the drillings in case the closed bates with dams;

- automatic control of the Oxygen concentration, by means of the Oxygen conductors tied at the CH_4 control station, in the areas where this can reach under accepted limits;

- the alarming through a system (telephony, interphony) of the accidental decrease of Oxygen concentration lower than accepted limits;

- the equipage with self-rescue mask with Oxygen chemically tied, of all personnel inside abates and respective of that in the ranges where the Oxygen concentration could get lower than accepted limits.

BIBLIOGRAPHY

[1]**Adamus,A**. – *Optimizarea tehnologiei de injectare a azotului* – Lucrările celui de al 6- lea Congres Internațional de Ventilație Minieră,17-22 mai 1997, Pittsburg, Pennsylvania, USA.

[2]**Cioclea,D.;Toth,I.;Gligor,C.** – *Clasificarea instalațiilor de inertizare folosite la prevenirea şi combaterea focurilor de mină.* A V-a Conferință Minerit, Metalurgie, Geologie – Zalău – 2003.

[3]**Gligor,C.;Jurca,L.;Cioclea,D**.- *Scheme cadru de inertizare posibile de aplicat în condițiile minelor din Valea Jiului* .Studiu – Internațional Seminar "HEALTH AND SAFETY AT WORK" – SESAM 2004.

[4] **Matei,I.;Toth,I;Cioclea,D.** – *Combustiile spontane la minele de cărbuni* – Ed.Print Everest,Deva,2003.

[5]**Matei,I. – Focuri, incendii şi explozii.** Curs Master U. Petroşani – 1996.

[6]**Stef,E.** – *Proiect cadru pentru metoda de exploatare a stratelor groase prin subminare în spatele liniei de front*, Studiu ICPM Petroşani – 1996

ASSESSMENT OF SEISMIC RISK FOR MULTI-LAYER STRUCTURES DURING THE UNDERGROUND SALT MINING

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Abstract

When blasting the rock salt, a shock wave is being produced, which turns into a seismic wave at the limiting zone of elastic deformation, thus putting a dynamic strain on the underground multilayer excavations.

The researches carried out in this field of activity have focused mainly on determining a connection between the admitted speed of the oscillations of the particles within the environment where the underground multilayer mining is performed and the seismic effect admitted for this objective.

When determining the speed, which allowed for the oscillations in compact environments, such as the underground multilayer excavations, it is very important to assess the characteristics of deformation of the rocks where the mining operations are performed.

Accordingly, whether the maximum strain produced by the face of the seismic wave is higher than the value of the strain when there occurs an elastic compression and detension remanent deformations can occur inside that environment.

A summing up of these remanent deformations, the result of repeated blasting operations, may destroy the stability of the multilayer structure of resistance by changing the strains inside it.

Consequently, the researches carried out in this field of activity intend to size blasting so that multilayer underground structures be strained under the limit of remanent deformations.

Key words: SEISMIC RISK, SALT MINING, blasting, rock salt, underground multilayer mining.

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1. INTRODUCTION

The underground mining makes changes in the initial state of primary strains currently existing inside the massif; accordingly, there follows a new relocation of the stains, with their concentrations on the points situated along the mined area when the value reached by these strains exceeds the mechanical – elastic strains of rocks, they start to deform or even to crack.

Consequently, there has to be said that, besides the above-mentioned changes, additional stains are being induced along the outline of the mine working which are generated by the seismic effect of the explosives.

The study of the seismic effects produced blastings is quite complex as it considers the bunch of the relations of interdependence which conditionate the birth and the assessment of this effect.

Considering the problems related to the stability of floors and pillars at the salt mines which use the abandoned type chamber – and – pillar, it should be necessary a study of the seismic effect produced by mine blastings over underground goats. The final purpose of these studies is to determine the amounts of explosive possible to be blasted in underground so that the seismic effect of the blastings in underground should not aversely affect the stability of multilevel structures in salt mines.

As the seismic effect is complex, the following stages should be covered for getting a correct prediction:

- an analysis of the geological and mining conditions of salt mines where the blasting are performed;
- an analysis of the floors in between levels and of the coaxiality of the abandoned pillars and of the pillars between chambers;
- field measurements concerning the seismic effect of blastings over the floors in between levels and over the abandoned pillars and over the pillars between chambers.

2. EFFECTS OF BLASTINGS OVER UNDERGROUND GOAFS

A shock wave is born during a rock blasting operation; when reaching the border of the elastic strain, it turns into a seismic wave which puts a stress on underground goafs.

The dynamic stress produced by the seismic wave in the structures of resistance of underground goafs con give birth to deformations that can lead to their further damage.

The researches carried out in this field intend to make a correction between the approved speed of the oscillations of the environment, the semi-protected structure and the seismic effect admitted for this structure.

If we get a certain value of the seismic effect for a certain structure, one can determine the maximum, admitted speed of the oscillations of the particles that are part of the environment where the underground mining is performed.

When determining the admitted speed of the oscillations in a compact environment, as underground goofs, it is very important to ascertain deformation characteristics of the rocks in which the underground mining is performed. Consequently, whether the maximum stress developed by the front of the seismic wave exceeds the value at which both the rock compression and recover is elastic, the environment in question can suffer remanent deformations. A summing up of these remanent as a result of several blasts shall affect the stability of the structures of resistance, as the stress inside them change.

Usually, the value of a remanent deformation on rocks that exceeds the limits of an elastic deformation shall occur during relative deformations that exceed 0,003 that can be produced by the multiple seismic effects after underground blastings.

Table 1 shows the recommended values of the relative deformations, within rocks elasticity limits under the action of stretching and compression forces) reached inside the structures of resistance of underground goofs, during blasting operations.

Class of the undergorund mining structure	Characteristics of under-ground mine workings and length of mining	Admitted relative deformation
I	Mine structures of special importance with a long service period 10÷15 yours.	0,001
II	Underground mine structures of high importance with a service period between 5÷10 years.	0,002
III	Underground mine structures with a service period between 3÷5 years.	0,0003
IV	Mine structures with a service period between 1÷3 years	0,0004
V	Underground mine structures with a service period of up an year.	0,0005

3. CONSIDERATIONS CONCERMING THE EVALUATION OF THE SEISMIC EFFECT

During a blasting operation, a part of the explosive energy breaks and removes the rock from the massif and the rest shall spread inside the surrounding massif under the form of seismic wares.

The most frequent used criterium to assess the seismic effect produced during a blasting operation is the oscillation speed of the particles in the environment of the structures protected against seismic waves.

The general equation that express the oscillation speed of the particles in the environment of the structures protected against seismic waves may take the following form:

V = oscillation speed of the particles in the environment with a seismic protection;

Q = maximum amount of explosive blasted;
R = minimum distance between the epicentres of the explosion and the limit of the area with elastic deformation;
n = number of delay intervals used;
Δt = delay interval between two successive stages; K = synthetic coefficient which characterise the geo-mining and technological conditions specific to each studied perimeter and which is determined by experiments;
Kg = coefficient for the reduction of the maximum speed of oscillations depending on the frequency the seismic protected environment is put to stress.

$$R = f\left(h, l, r_{em}\right) \tag{2}$$

where h = height of chamber; l = width of chamber; R_{em} = radius of the area submitted to elastic deformations;

$$R_{en} = f\left(V_L, Q_g\right) \tag{3}$$

where V_L = propagation speed of longitudinal wares; Q_g = amount of explosive in each drillhobe.

Usually, there are used blasts with micro delays; consequently, the function f(n) for the diminuation of the seismic effect shall be considered.

The calculation equations of the function f(n) are the following ones:

$$f\left(n\right) = 1 - 12.9\left(\sum \Delta t\right)^2 \text{ for } \sum \Delta t \le 0.15 \tag{4}$$

and

$$f\left(n\right) = 0.275 / \sqrt{\sum \Delta t} \text{ for } \sum \Delta t \succ 0.15 \tag{5}$$

By considering the general equation [1] and based on certain experimental blastings during which the oscillation speed at some points is measured, there shall be determined the, different values taken by the synthetically coefficient „K″; subsequently, there shall selected the value that characterize the most accurate possible the intricacy of the geological and mining conditions of the structures that are to be protected against seismic hazards.

4. THE MAXIMUM ADMITTED DYNAMIC PARAMETERS OF UNDERGROUND BLASTS WHICH PROVIDE PROTECTION AGAINST SEISMIC HAZARDS FOR MULTILVEL UNDERGROUND STRUCTURES

Usually, the conditions for rock deformation within the elastic limits are highlighted by deformations of 0.001÷0,0005, depending on the length of service of the mining operation, and for the case of salt mines, depending on length of mining on the level where blastings are performed.

Consequently and considering the values of admitted relative deformations (All table no.1), one can determine the maximum admitted dynamic parameters of blastings carried out in salt mines and which assure the protection against seismic hazards for the multilevel structures (the floor between levels and abandoned pillars).

Accordingly, in relation to the elastic characteristics of the rocks in which the underground goafs are mined and to the admitted relative deformation, one can determine the maximum admitted value of the oscillations where the multilevel structures are located, with the help of the following equation;

$$V_{\max a} = V_{\max} Kf \qquad (6)$$

where $V_{max.}$ = maximum speed of the oscillations where the multilevel structures are located; Kf = coefficient for the diminution of the maximum speed of oscillations, in relation to the frequency to which a certain spot is stressed to the maximum admitted.

As, the mine, one spot of the structure of resistance shall be stressed at the maximum value of oscillations at least 10 times; consequently, a Kf=0.99 (see table nr.2) is recommended.

Table no.2

Amount of blasts performed yearly	Coefficient for the diminution of the speed of oscillations
up 10	0.99
51 ÷ 100	0.95
101 ÷ 250	0.8
over 250	0.75

The maximum speed of the oscillations recorded by the structures of resistance shall depend on the elastic characteristics of the area where the underground goafs are mined, with the help of the equations generated by the following form:

$$V_{\max} = f\left(V_L, V_T, \mu, \varepsilon_{ra}\right) \qquad (7)$$

where V_L = propagation speed of longitudinal waves; V_T = propagation speed of cross waves; ε_{ra}= admitted relative deformation in relation to the length of operation at the level where blastings are performed; μ = Poisson’s ratio.

5. CONCLUSIONS

An evaluation of the seismic hazard performed on multilevel structures of resistance during salt mining operations:

- provides a high safety level during underground salt mining;
- shows the special characteristics of each underground mine area;
- provides a vertical and an horizontal extension of the mining limits, with an increment of the extraction level of the deposits of mineral substances;
- provides solutions for an efficient management of blasting operations.

REFERENCES:

Mosineţ, V.N., 1975. *Dislocarea rocilor prin lucrări de împuşcare şi efectul seismic al acestora.* Ediția Nedra,

Ciocoiu,D.C., 1993 – 1999 Studii INSEMEX. *Studiul efectului seismic al lucrărilor de împuşcare în saline, asupra structurilor supraetajate.*

PRESENTATION OF INSEMEX PETROSANI AND ITS PART PLAYED IN THE HARMONIZATION OF THE ROMANIAN MINE LEGISLATION

CONSTANTIN LUPU [*], EMILIAN GHICIOI [**], LADISLAU KOVACS [***]

1. INTRODUCTION OF INSEMEX PETROŞANI

The research and development activities carried out at INSEMEX observe the specific trend well-known both nationally and internationally in the field of health and safety at work, aiming at: a development of national capacity to assess, prevent and limit the risks generated by industrial applications carried on in potential explosive and/or toxic atmospheres, for providing health and safety of workers, to protect the surrounding environment, the mineral resources and the materials.

As Romania aims to integrate the European economic and research areas both industry and the related national regulations in the field of health and safety at work should be harmonized with the European regulations.

A brief presentation of our institute may cover the following aspects: For more than 50 years the profile a National Institute for Mine Safety and Explosion proof Protection is unique being at the same time one of the most successful institute for research and development activities in Romania. The experts here have produced a lot of useful solutions in the filed of safety in mining. It has also settled complex aspects with interdisciplinary implications for several industries. The service provided includes all the stages of a research operation, starting from a preliminary investigation and up to the stage of implementation.

The activity at INSEMEX is carried on in organization departments:

- ➪ the department for research and development and for technological transfer;
- ➪ bodies involved in providing public service;
- ➪ laboratories for testing, expertise and analyses;

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↳ For scientific activities, carried on in the best possible conditions, INSEMEX includes:

- ⇨ widely recognized laboratories;
- ⇨ a center of excellence;
- ⇨ highly performant equipment;
- ⇨ modern I.T. technique, internet;
- ⇨ service for providing the quality of products.

↳ The licenses granted to INSEMEX Petrosani as company of strategic interest and national authority involved in the prevention of industrial, risks, cover the following domains:

- ⇨ certification of equipment, of electric installations, materials and of outfit locally made or imported;
- ⇨ verification, testing and approval of explosive materials and of initiating means;
- ⇨ training and certification of the rescue teams which operate in explosive and/or toxic atmospheres;
- ⇨ classification of mines with respect to the emissions of toxic and/of explosive gases.

The co-operations INSEMEX Petrosani has had direct contacts settled with the partner-type beneficiaries and have led to a sustainable support in developing a highly competitive Romanian industry, with a good work and environment protection based on the research carried out and on implementing the results.

The international co-operations have allowed an improvement of our methods for research and development as new concepts and knowledge have been applied, modern staff training methods have been used; there have also been changes of experience with similar institutes and experts from abroad and certain laboratories have been modernized and at present they comply with the requirements in the European Union.

↳ The institute has the mission to carry out carry out scientific researches and provide expert service in the field of health and safety at work and for the environment protection in rewarding conditions for: people-industry-surrounding environment.

↳ At the request of mine units, of industrial units, institutions, at the request of state management bodies or of local communities the research activity and the expert service provided by our institute cover:

- ⇨ projects for research and development;
- ⇨ know-how provided by expert service;
- ⇨ advisory service;
- ⇨ expertise;
- ⇨ training and certification of staff for:
  - health and safety at work;
  - environment engineering;
  - quality management;
  - certification and authorization.

✎ If speaking about our relations, INSEMEX Petrosani has close contacts with local and foreign companies, undertakings and institutes for running technical and scientific interchanges in the following domains:

➪ health and safety at work;
➪ different mining techniques and technologies;
➪ environment engineering;
➪ certifications.

✎ In the field information, IT and training INSEMEX Petrosani:

➪ develops norms and standards for health and safety;
➪ provides highly qualified training in the specific fields;
➪ uses the latest software and IT available on the market;
➪ publishes a lot of expert papers with a view to disseminate the results of our activities.

✎ With reference to the "health and safety at work" and "environment engineering", INSEMEX Petrosani is involved in the:

➪ implementation of the quality management for health and safety at work;
➪ prevention and fight against natural and technical risks both in mining and in other industries;
➪ assessment of toxic elements which may occur in the working and in the surrounding environments;
➪ testing and certification of protective equipment;
➪ implementation of the environment management in the mining units, in compliance with ISO-1400;
➪ protection of the environment parameters adversely affected by the mining operations;
➪ monitoring of the surrounding environment.

✎ Considering the economic importance of the extractive industry INSEMEX is strongly involved in developing methods used for extractive purposes, focusing on:

– blasting techniques;
– concentration of the output;
– geology, hydrogeology and geophysics;
– protection at surface and of the structures located within mining areas;
– cleaner technologies for the extraction of mineral resources;
– new materials for the mining industry.

As Romania orientates towards the European economic and research area, both the local industry and the regulations in the field of health and safety at work shall have to be harmonized with the European requirements.

The co-operations INSEMEX Petrosani has had direct contacts settled with the partner-type beneficiaries and have led to a sustainable support in developing a highly competitive Romanian industry, with a good work and environment protection based on the research carried out and on implementing the results.

INSEMEX Petroşani possesses a high logistics and a good material base for our activities of research and development, some of them being unique for Romania; we have also here highly qualified and well trained expert personnel.

The international cooperation has allowed our institute to improve the methods used for research and development through the use and implementation of new concepts and knowledge, a suitable training of the personnel, changes of experience and modernization of certain laboratories reaching the level of the one in the European Union.

In order that our research results, which involve testing and measurements, be compared with the results obtained in other international laboratories, the traceability of testing and the comparison of the results with the national and international standards is being provided.

Another important aspect in our activity is the yearly plan for training and improvement of skills; consequently, our experts participate in seminars, training stages and post graduate courses. This is a continuous process which goes on both during the proper research, mainly during the stage for gathering documents, during the preparation period for becoming a PhD.; there is also a permanent change of ideas among our own research teams and with the researchers with similar preoccupations.

The management strategy and the politics of our institute drawn up for research show continuity and coherence and have focused mainly on:

1. The National Plan for Research-Development and Innovation in Romania - PNCDI and on the programs which are compatible with the specific character of the institute. In relation to their final goal, the projects under contract in the last years can be grouped into the following categories:

A) Projects that strengthen the infrastructure of the institute, i.e.:

– the preservation of status as excellency center in research;

– certification and recognition of the body for the certification of civil use explosives - SECEMTI, based on SR EN 45011 and the European Directive 93/15/EC;

– certification and recognition of the laboratory for testing of explosive materials and for blasting methods - LETI, based on SR EN ISO IEC 17025;

– the organization of the body for the certification of personnel, OCP, based on SR EN 45013;

– certification and recognition of the body for the certification of technical equipment used in potential explosive atmospheres and of the testing laboratory for Ex equipment LIEx, based on the European Directive ATEx 94/9/EC, the Directive Machinery 98/37/EC, the European Directive PPE 89/686/EEC and the standards SR EN 45011 for the body and SR EN ISO IEC 17005 for the laboratory.

B) Projects which intend to improve the methods for the mining of mineral resources or those methods used in the industries with potential explosive and/or toxic atmospheres. The aim of these methods is to improve the working conditions or the economic parameters as they develop suitable technical solutions for diminishing certain risk factors; we have also developed here fully new solutions, all applicable in the Romanian economy.

II. National and international scientific events, either as participant or as organizer.

III. All those parties interested by the Romanian economy and carrying out their activities in potential explosive and/or toxic atmospheres, in the field of mineral resources, in the field of explosive materials for civil use or in the fields related to the above-mentioned ones.

To put everything in a nutshell and taking into consideration the accomplished goals in research and development activities and all the recognitions gained for the high quality of the produced papers, we daresay that INSEMEX Petroşani fully shows its promoting role in a sustainable development of the Romanian economy.

2. HARMONIZATION OF THE ROMANIAN MINING LEGISLATION WITH THE EUROPEAN LEGISLATION

In reply to the current economic situation, the strategy of the mine sector until 2010 focuses on the following major objectives:

a) a business - like approach of the mining industry which means the sell of the mine products on the free market, a re-shaping of the mining perimeters, highly competitive mine outputs, a reappraisal of the staff number and costs and the modernization, rehabilitation and re-equipment of reliable mines;

b) a diminution of the state direct involvement together with a gradual participation of the private sector with a view to close the non-reliable mines and to reorganize the production capacity, a stepwise diminution of subventions, a full removal of the subventions granted for social protection, privatization of reliable mines and a market type efficient management;

c) the mining operations shall observe the requirements for environment protection; there has to be drawn up an inventory with the environment damages, there have to be stated the duties for mine operators, the management of the environment shall have to reach the European level and the regulatory and institution framework has to be supplemented;

d) mitigation of social problems arisen after the closure of non-reliable mines and a revitalization of the economy in the adversely affected mine regions. For being able to reach the said objectives, the strategy of the mine industry drawn up until 2010 also states, among other things, the politics, the instructions, the human resources and groups of measures necessary to be applied.

The concept of sustainable development of the extractive industry shall have to consider three aspects: an economic development, social protection and the environment protection. Consequently, an integrated approach of the three major problems is necessary.

The mining industry both in Europe and in other countries of the world is subject to important structure changes.

Each national mine legislation stands for the policy of that state in relation to its natural resources, also being influenced by the monopole position of the state.

At present, in Europe there is no law that regulates the whole range of mining activities together with its component elements, i.e. prospecting, exploration, extraction, closure, rehabilitation etc.

Among other things, this thing is due to the fact that each country decides how to use its own natural resources.

On the other hand, the European legislation influences the legislation on royalties, in the field of health, safety and environment protection.

The main tools to transpose the requirements stated in the European legislation into the national legislation are the European directives.

The essential element of a directive consists in the fact that each Member State has to implement these directives into their national legislation.

The European Law Court has drawn up a set of criteria necessary for a correct implementation of these directives. Whether the national bodies don't implement correctly or in due time these directives, it is thought that the European legislation has been breached.

The European directives with impact over the extractive legislation can be divided into general directives and specific directives. Among these, the following ones can be mentioned:

- Directive 94/22/EC on the conditions for granting and use of permits for exploring and extraction of hydrocarbons (oil and gases);
- Directive 92/91/EEC on the minimum requirements for improving health and safety of workers involved in the extraction of natural resources by drilling methods (the second individual Directive within the meaning of art. 16 (1) in the Directive 89/91/EEC.
- Directive 92/104/EEC on the minimum requirements for improving health and safety of workers involved in the extraction of solid mineral resources at surface and in underground.
- Proposal of Directive on the wastes management in the extractive industry.

1. Directive 94/22/EEC intends to encourage the best practice for prospecting, exploration and extraction of hydrocarbons, the state making no discriminations with respect to the investors.

This directive underlines two aspects:

– the procedures and the criteria applied for granting of permits, licenses and leases;

– state involvement in these activities.

2. Directives 92/91/EEC and 92/104/EEC.

The first directive applies to the extractive industry which uses drilling methods (mainly for oil and gases).

The second directive is for mining of solid mineral resources in open-casts and in underground.

These two Directives are quite flexible so as to stimulate the both parties concerned (employee and employer) to act as responsible partners in all the problems connected to the mining activity (health, safety, environment protection).

Another basic principle of these directives is the one according to which there are general regulations which shall apply in relation to their own decisions.

3. Other directives.

Besides the said directives, there is an increasing number of general European directives for all industries, especially for the extraction of mineral resources, paying a special attention to the environment and health and safety at work.

The impact of these activities over the extractive industry is very strong.

Among these directives, the following ones have to be mentioned:

- ✓ Machinery Directive (requirements for machines);
- ✓ Levels for professional exposure;
- ✓ Use of working equipment;
- ✓ Directive Physical Agents. Vibrations.
- ✓ ATEX Directive (explosive atmospheres);
- ✓ Directive Assessment of the Impact over the Environment;
- ✓ Framework directive for underground waters. Injection of used waters in depth geological beds.
- ✓ Directive for mine and residual wastes.
- ✓ Directive IPPC - Prevention and complete control of the environment pollution.
- ✓ Directive SEVESO II. Applications to processing operations.

Other directives refer to the preservation of protected (inhabited) areas, of natural monuments, a.s.o.

All these aspects show the extend to which the extractive sector is influenced by the European general legislation mainly in the field of health, safety and environment.

The implementation of the said directives is also necessary because of the challenge materialized in the concept of sustainable development of the mining activity in the economy of each country.

In Romania, the Ministry of Environment and Water Management is the state authority which provides the legislation for environment protection; this legislation has to be observed by all industries including by the extractive industry considered as having a significant impact over the surrounding environment.

Among the directives which have been totally or partially transposed by the Ministry of Environment and Water Management, there have to be mentioned:

• The Directive of the Council 91/271/EEC on 21 May 1991 on the water treatment, modified by Directive 98/15/EC	→	• HG no. 352/21.04.2005 that modifies HG no. 188/28.08.2002 to approve the norms concerning the discharge of used waters into the surface waters
• The Directive of the Council 76/464/EEC on 4 May 1976 on the pollution produced by certain hazardous substances discharged into the surface waters of the Community (together with the 7 ”daughters” directives)	→	• HG no. 118/07.02.2002 concerning the approval of the Action plan, to reduce pollution of the surface and underground waters due to the discharge of hazardous substances • OM of MAPM no. 1406/03.03.2003 and of MSF no. 191/07.03.2003 to approve the Methodology for a fast assessment of risk over the environment and human health
• The Directive of the Council no. 80/68/EEC on the protection against	→	• HG no. 118/07.02.2002 on the approval of an Action plan for

pollution of underground waters with certain hazardous substances		diminishing the pollution of surface and underground waters due to the discharges of hazardous substances
• Directive 96/61/EC - IPPC	→	• OUG no. 34/2002 on the prevention, diminution and the complete control of pollution

Other normatives transposed from the legislation of the European Union and related to ponds:

✓ MMGA Order no. 119/2002 - Order to approve the Procedure for the conservation, post-use or abandonment of tailing dams - NTLH - 033;

✓ MMGA Order no. 120/2002 - Order to approve the Procedure and the competences regarding the control the operation safety of tailing dams - NTLH - 034;

✓ MMGA Order no. 121/2002 - Order to approve the content of Record Sheet of tailing dams - NTLH - 035, etc.

3. Conclusions

The extractive industry represents an essential element of the national and European economy.

All industries depend more or less on the extraction of raw materials.

A solid extractive industry is essential for the long-term existence of the whole European economy as producer and consumer of raw materials.

The main purpose for improving the modern mine legislation is to provide a legal framework for a regular development of the extractive industry, by taking into consideration the requirements for the extraction of mineral resources, mainly concerning the right of extraction, providing health and safety at work and clean environment.

THE STAGE OF IMPLEMENTATION OF EUROPEAN REGULATIONS IN THE FIELD OF ELECTRICAL AND MECHANICAL EQUIPMENT PROTECTION

GHICIOI EMILIAN [*], MONICA IACOB RIDZI[**], SORIN BURIAN [***] , MIHAELA PĂRĂIAN[****]

ABSTRACT

The European Union has established original and innovative instruments to remove the barriers to free circulation of goods. Among these, the New Approach to product regulation and the Global Approach to conformity assessment take pride of place. On the basis of the new instruments European Union issued and adopted a set of directives, which have progressively come into force.

The candidate countries of central and Eastern Europe, including Romania, have to adopt the European directives.

This paper shows some aspects about the European directive 94/9/EC-ATEx and Romanian law regarding health and safety requirements for equipment intended for use in potential explosive atmospheres.

1. GENERAL ASPECTS ON THE NEW EUROPEAN APPROACH

The purpose of this New Approach is to create one single economic market where all goods, service, finance and labor force can move freely in such a manner so to supply a solid foundation for the further development of the European Union in the 21st century.

The European Union has established original and innovative instruments for removing the barriers and support the free circulation of goods. Among these instruments, the New Approach that includes regulations on products and the Global Approach used to

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assess conformity, take pride of place. These two Approaches are complementary and they intend to limit the public interference into the essential problems and to offer the greatest chances possible both to industry and business so as to be able to perform their public duties.

Ever since 1987, 20 European directives adopted based on the New Approach and on the global approach, have progressively come into force into the European Union and the process for establishing, adapting and improving the directives is a continuous one.

The candidate countries in the European Union, among which Romania too, should also implement the European Directives that are part of the New Approach and of the Global Approach. Like any other innovative systems, this New Approach has generated several questions. For being able to answer all these questions, the European Commission has produced several guidelines for the implementation of the European Directives. But best, these guidelines show the meaning and the consequences of the concerned directives. They cannot replace the official text and cannot change what the legislation body has already stated in these directives.

The member states shall transpose the directives of the New Approach into the national legislation; they shall also issue laws, regulations and administrative provisions in compliance with the directives and shall state the reference to the concerned directive.

As the directives of the New Approach are harmonized directives, the member states shall withdraw all legislation that contradicts.

Also, the member states should not allow to preserve or to introduce certain conditions which are more restrictive than the ones stated in the directives, in compliance with the article 138 of Ec Table (the purpose of these directives is to improve health and safety at work).

Romania, a candidate country, has begun the harmonization of the national legislation with the European legislation, including in the field of technical equipment designed for use in normal atmospheres in potential explosive atmospheres and of the personal protection equipment. Accordingly, the law for Labor protection was delivered in 1996, whose Methodological Norms of implementation include the European Directive ATEx in the section B for technical equipment.

In 2000 and 2001, Romania adopted the Law no. 608 on the conformity of products and of the Methodological Norms for implementation; it includes the general framework for the procedures used in the assessment and in the certification of products on health and safety at work.

2. GENERAL ASPECTS RELATED TO THE PRINCIPLES THAT FROM THE BASIS FOR THE IMPLEMENTATION OF PROVISIONS STATED IN THE EUROPEAN DIRECTIVE ATEX 94/9/EC

2.1. ATEx analysis

2.1.1. Explosive atmosphere

In compliance with ATEx directive, an explosive atmosphere is a mixture:

a) of gases, vapors, mists or dusts;

b) with air;

c) in atmospheric conditions, i.e. temperatures between $-20^0C \div +60^0C$ and pressure between 0.8 and 1.1 bar;

d) after initiation, the combustion shall propagate through the whole unburt mixture (the combustible dust shall not always burn in totality).

An atmosphere that can become explosive due to local and/or operation conditions, shall be called a”potential explosive atmosphere”.

According to ATEx directive, an atmosphere shall become potential explosive only in the above-stated requirements (from *a)* to *d)*) are met; for other explosive mixtures, either without air, or with oxidants, others than air, or with other pressure and/or temperature domains, or with instable mixture, these mixture are not cover by Directive ATEx.

Also, this directive shall not apply for those explosive atmospheres which are deliberately initiated.

2.1.2 Products

ATEx directive shall apply to the products that can be defined as:

a) equipment;
b) protective systems;
c) components;
d) regulating, control and safety devices.

2.1.3 Potential sources for igniting an explosive atmosphere:

- electrostatic discharges;
- electromagnetic waves;
- ionizing radiations;
- hot surfaces;
- hot flames and gases;
- mechanical sparks.

2.1.4 Situations when ATEx directive shall be implemented

Table 1 shows the situations when ATEx directive 94/9/EC applies:

Situation	Analysis			Result
	Equipment with its own ignition source	Equipment used in/or related to potential explosive atmospheres		Equipment with its own ignition source
A	YES	YES	YES	YES
B	NO	YES	YES	Generally: NO / YES, in relation to notes ❶ and ❷

C	YES	NO	YES	Generally: NO / YES, in relation to notes ❶ and ❷
D	YES	YES	NO	YES
E	NO	NO	YES	Generally: NO / YES, in relation to notes ❶ and ❷
F	YES	NO	NO	Generally: NO / YES, in relation to notes ❶ and ❷
G	NO	YES	NO	Generally: NO / YES, in relation to notes ❶ and ❷
H	NO	NO	NO	

NOTES:

❶ The result of the analysis is YES for the products inside potential explosive atmospheres. More, the equipment should be considered as an entity capable to operate in accordance with the parameters determined by the producer and to provide a protection according to Annex II, point 1.0.1. ”Principles of integrated safety to explosion”.

Also, the result of the analysis is YES for non-opened mechanical equipment that has inside a potential explosive atmosphere (such as: fans or compressors that operates with inflammable atmospheres) and a potential source of ignition that has to be considered

❷ The result of the analysis is YES for the regulating, control and safety devices covered by ATEx directive, according to point 1.2 in the directive

3. RELATION BETWEEN ATEx DIRECTIVE 94/9/EC AND OTHER APPLICABLE DIRECTIVES

Mainly, if a product falls simultaneously under several directives, all the directives shall be applied in parallel for being able to meet the special demands applicable in each directive.

3.1 Regarding the relation between ATEx directive 94/9/EC and the Directive with respect to Electromagnetic Compatibility 89/336/EEC (EMC), ATEx Directive 94/9/EC should be applied to meet the demands on explosive atmospheres and the safety requirements.

EMC directive shall be applied in such a manner that the product does not produce electromagnetic disturbances and that the personal operation of the equipment shall not be affected by such disturbances.

For example, the protective systems shall meet the requirements both in ATEx directive and in EMC Directive, as their characteristics for data acquisition and transmission shall influence the safety to explosion.

3.2. Relation between ATEx Directive 94/9/EC and the Law Voltage Directive 73/23/EEC (LVD)

The products that shall be used directly in potential explosive atmospheres shall be excluded from the scope of LVD.

All the essential purposes in LV Directive shall be covered by ATEx directive (point 1.2.7 in Annex II to 94/9/EC).

The standards published in the Official Journal of the European Community, with the reference to Directive 73/23/EEC can be listed in the attestation of conformity for the certification of the requirements in 1.2.7, Annex II to Directive 94/9/EC.

LV Directive does not exclude the safety, regulating and control devices stated in art. 1(2) - Directive 94/9/EC - for use outside potential explosive atmospheres but that support a safe operation of the equipment or of the protective system inside explosive atmospheres. In this situation the both directives shall apply (i.e. LVD and ATEx).

3.3 Relation between ATEx directive 94/9/EC and Machines Safety Directive 98/37/EC

Directive 94/9/EC is a special directive according to art. 1(4) in Machinery Directive and includes detailed and specific requirements for risk prevention against potential explosive atmospheres. Machinery Directive covers only the general requirements for protection against explosions (Annex I, point 1.5.7 in Machinery Directive).

With respect to protection to explosion in potential explosive atmospheres, Directive 94/9/EC shall be considered prioritary and shall apply. For other relevant risks related to machinery, the requirements in machinery Directive shall also apply.

In Romania, the essential health and safety requirements on the safety of machinery were introduced in the HG 119/2004.

3.4 Relation between ATEx directive 94/9/EC and Directive for Personal Protection Equipment (PPE) 89/686/EEC

The equipment covered by PPE Directive is clearly excluded by the scope of ATEx directive 94/9/EC. However, the structure of the personal protection equipment intended for use in explosive environments should meet the health and safety requirement stated at point 2.6 in Annex II to PPE Directive. The equipment intended for use in explosive atmospheres shall be designed and manufactured in a manner so they don’t become a source of electrical, electrostatic or impact induced arcs or sparks, capable to ignite an explosive mixture.

By following the health and safety essential requirements stated in ATEx Directive, the producer of the personal protection equipment can find a way to demonstrate compliance with point 2.6 in Annex II to PPE Directive.

In Romania, PPE Directive 89/686/EEC was introduced in the HG 115 / 2004.

4. THE ROMANIAN LEGISLATION RELATED TO THE PROTECTION OF ELECTRIC AND MECHANICAL EQUIPMENT

In Romania the labour protection and health and safety at work a component part of the social protection is regulated by the Law of Labour Protection no.90/1996. Basically, the labour protection has a preventive character, its purpose is to prevent the occurrence of accidents during the working process and/or of occupational diseases. An essential element to reach this purpose is the use of safe equipment. Consequently, the art.12 in the Law of Labour Protection no.96/1996 states that: *The equipment shall meet the requirements in the norms, standards and in other regulations related to the labour protection and shall not put to hazard personnel's health or safety, or of those persons which are in that working place on business or of those for which the labour protection is provided. The equipment may be made, imported, traded or used only if they meet the conditions for labour protection, certified by competent bodies, according to the law.*

4.1. Legislation for assessing conformity

In Romania the Law no.608/2001 lates the assessment of conformity of products; it states that „the products which are part of the regulated field shall be marketed and used only I they meet the essential requirement, whether their conformity has been assessed according to the applicable assessment procedure and whetheir they are marked in compliance with the provisions of the applicable technical regulations in force".

The procedures to assess conformity Law no.608/2001 are stated in the Government Decision no.115/2004 for EIP; the Government Decision no.119/2004 for industrial machines and the Government Decision no.752/2004 for technical equipment and protective systems intended for use in potential explosive atmospheres.

The procedures used to assess the conformity of products, called modules, covered by the Methodological Norms for the application of the Low no.608/2001 are the following ones:

Module A: Internal control of production
Module Aa: Internal control of production with examinations carried out by the notified body
Module B: CS type examination
Module C: Conformity with the type
Module D: Providing the production quality
Module E: Providing the product quality
Module F: Verification of the product
Module G: Verification of the product unit
Module H: Quality assurance

The flowchart with the possibilities to use the modules for assessing conformity and for affixing the CS marking is the following one:

Procedurile de evaluare a conformităţii echipamentelor şi sistemelor protectoare destinate utilizării în atmosfere potenţial explozive prevăzute în HG 752/2004 sunt:

Module: CE type examination (Annex 3)
Module: Providing the product quality (Annex 4)
Module: Verification of the product (Annex 5)
Module: Conformity with the type (Annex 6)
Module: Providing the product quality (Annex 7)
Module: Internal control of production (Annex 8)
Module: Verification of the product unit (Annex 9)

According to the analysis of the procedures used to assess conformity and stated in the Methodological Norms for the application of the Law no.608/2001 and of those stated in the Government Decision no.752/2004, the following correspondence results:

Table 2

Government Decision no. 752/2004	**Methodological Norms for the application of Law no.608/2001**
Annex 3	Module B
Annex 4	Module D
Annex 5	Module F
Annex 6	Module C
Annex 7	Module E
Annex 8	Module A
Annex 9	Module G
-	Module H

The full quality assurance – Module H – which derives from ISO 9001 and covers both the design and the production hasn't been adopted by the G.O. no 752 / 2004 (Directive ATEx 94/9/EC).

The G.O. no 752 / 2004 includes the assessment procedures that should be observed by the producer or by his authorized representative to show the conformity of the product with the applicable requirement stated in the method norms.

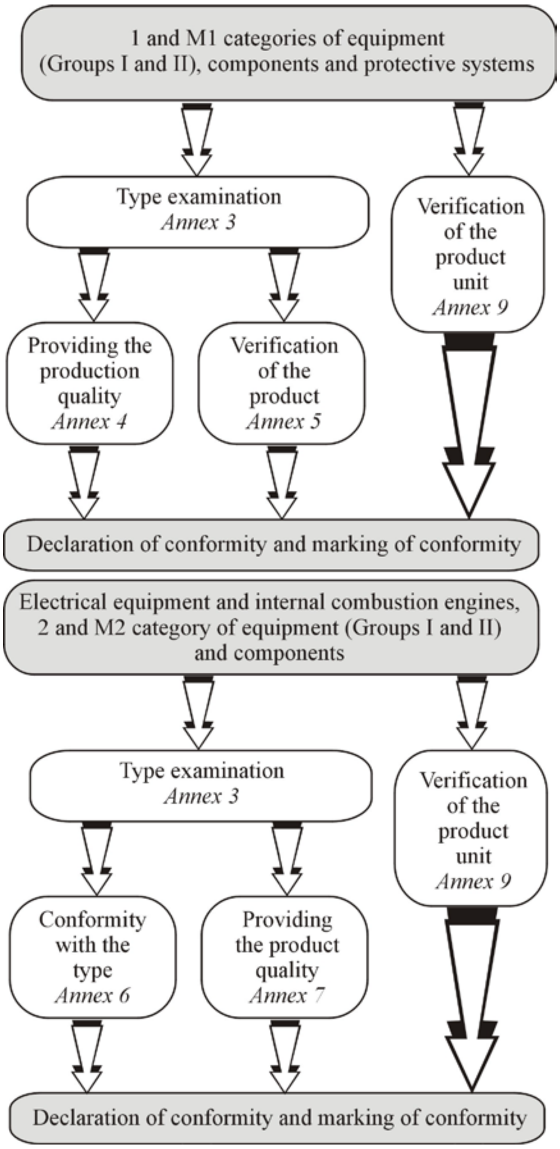
For being able to determine which procedure to assess conformity is the best, first the producer shall have to take a decision based on the "intended use" in relation to the group and category valid for its product. The Annex 1 of the Government Decision no.752 lists the classification criteria in categories for groups of equipment used in potential explosive atmospheres. Basically this classification shows as it follows:

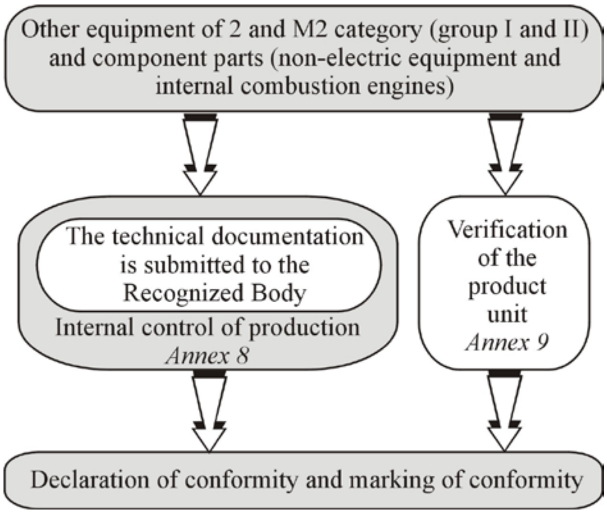
Group I equipment: - category M1 (electric and mechanical equipment which stay energized in explosive atmospheres)
- category M2 (electric and mechanical equipment which de - energize)

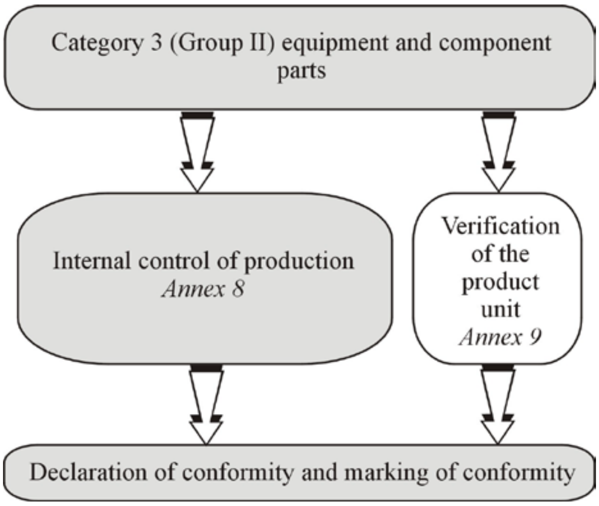
Group II equipment: - category 1 (zone 0)
- category 2 (zone 1)

- category 3 (zone 2)

The flowcharts with the procedures to assess conformity are the following ones:







4.2. The part played by the standards in assessing the conformity of the equipment and of protective systems intended for use in potential explosive atmospheres

Health and safety essential requirements covered by the Annex II in the Government Decision no. 752/2004 transposed in technical standards.

According to the basic principles of the New Approach, the products made in compliance with the harmonized European standards benefit by the presumption of conformity with the corresponding essential requirements.

As 1.02. in the Annex II says, the products shall be designed and made with the consideration of the possible operating faults so as to avoid hazardous situations as much is possible.

The purpose of the requirements stated in Annex II is to consider the current or the potential risk which derive from designing and production. In sprite of all these, the intended use specified in the instructions is very important. It is also important that the producers provide full information on the possible operating faults and on the risks they generate so as to be able to determine suitable protective measures.

To meet the essential health and safety requirements said in the Government Decision no. 752 / 2004, it is compulsory to assess the risk. According to the EN 1127-1, the ignition sources may be identified as it follows: electric sparks, hot surfaces, flames and hot gases (including hot particles, mechanical sparks, static electricity, electromagnetic waves, ionizing radiations, ultrasounds, adiabatic compression and shock waves, optic radiations etc.

Consequently, the procedure to assess conformity with the requirements in EN 13463-1 shall be applied to non-electric equipment to assess risk.

For the electric equipment designed in compliance with EN 50014, it is necessary to assess the risk so as to identify other hazards not covered by the harmonized standard, such as the risk produced by optic radiations.

All the modules used to assess conformity settle the duty of the producer to draw up a documentation which as to show conformity with the essential health and safety requirements.

Whether technical standards are used as reference standards for assessing the conformity of the product by type examination (Annex 3), for the case of the modules for providing the production quality (Annex 4) and the product quality (Annex 7), there have been considered the standards for quality assurance ISO 9002 and ISO 9003.

4.3. ISO 9001: 2000 – a necessary but not sufficient condition for the quality management system for protective equipment and systems intended for use in potential explosive atmospheres

The issuing of SR EN ISO 9001: 2000 has (the Decision of the EEC no. 93/465 of July 1993 on the modules valid for the different stages of assessing conformity and the regulations to implement and use CE marking, intended for use in the harmonized technical directives).

It is important to notice that the modules used in the directives for individual technical harmonization may differ in some respects if compared to the ones described in the Decision EEC no. 93/465. For all the cases, the annex to the applicable directive(s) is compulsory from a legal point of view.

Three of the modules listed in the Council Decision, i.e. the modules E, D and H say that „the producer shall operate based on an approved quality system''. The application field of the quality systems required by these modules makes reference to the:

- Inspection and final testing of the product (module E);

- Production, inspection and final testing (module D);
- Design, production, inspection and final testing of the product (module H).

The Decision 993/465/EEC settles that it is provided the presumption of conformity with the relevant requirements in the modules H, D and E by the compliance with the harmonized standards EN 29001, EN 29002 or EN 29003.

The modules for ensuring the production quality (Annex 4) and the product quality (Annex 7) derive from the standards for quality assurance ISO 9002: 1994 and ISO 9003:1994.

As the standards ISO 9002: 1994 and ISO 9003:1994 were replaced by the new EN ISO 9001: 2000 for the assessment of the quality system which has to provide the compliance between the equipment and the type the manner it is described in the Type Certificate and with the requirement stated in the Government Decision no. 752/2004, there shall be considered the requirements of the new ISO standard 9001:2000 together with the requirements in EN 13980. Potential explosive atmospheres – Implementation of the quality systems.

The European Standard EN 13980 is a supplement to EN ISO 9001:2000 for using a production practice considered as satisfactory for those products intended for use in potential explosive atmospheres.

This standard covers the specific requirements and information on the introduction and preserving a quality management system which corresponds to the requirements in the annexes 4 and 7 to the Government Decision no. 752 / 2004 (Directive 94/9/EC).

5. COMPARISON BETWEEN THE ATEx 94/9/EC AND THE GOVERNMENT DECISION 752/2004 – FOR THE EQUIPMENT INTENDED FOR USE IN POTENTIAL EXPLOSIVE ATMOSPHERE

The Romanian regulation – the Government Decision no. 752 / May 14, 2004 takes over ATEX and covers all the requirements and provisions applicable to Romania which holds, the date when this Decision was delivered, status of candidate country to the European Union.

The Government Decision no. 752 / May 14, 2004 includes a chapter called ,,Final and transitory provisions which covers articles making reference to the next stage of the Romanian adheration to the EU or to the signing of PECA agreement, respectively the recognition of CE marking..

The European level mechanism of the treatment of non-compliances which might appear in affixing CE marking certain equipment (Art. 7, par 2 in ATEx) has been included and explained by the Government Decision no. 891/03.06.2004 which settles measures to control the market of the products for the regulated domains.

Note: The connection between Romania and the EU Commission is ensured by the Ministry of Industry and Economy (Art. 24, par. 3)

Until the Romanian adheration to the European Union or until PECA agreement is signed, it is compulsory for Romania to affix CS marking, according to the procedures used to assess conformity applicable to the groupes and categories of ET.

ENVIRONMENTAL AND SOCIAL CONFLICTES OF THE ROŞIA MONTANĂ PROJECT

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JOHN ASTON **, HOREA AVRAM****

Abstract: *Today's world requires that the promotion of economic activity be integrated with social and environmental concerns, to produce genuine development that can be sustained over time. Such concepts are central to Romania's sustainable development and form a challenging framework for change. The Roşia Montană Project, started in 1997 in the valley of Roşia Montană in the Apuseni Mountains, faces this challenge. The Project, currently in its planning, land acquisition, and pre-approval stage, recognises that this challenge is made more critical by both past and present environmentally unsustainable mining, which resulted in the generation of Acid Rock Drainage, and significant biodiversity degradation and risk to human health. A further complication is the extremely negative image of gold mining which developed after the cyanide spill from Baia Mare.*
This paper presents a number of the challenges confronted by the Roşia Montană Project in achieving its goal of creating a successful Romanian mining operation in accordance with EU and international standards and policies, and in so doing, creating a catalyst for sustainable social, environmental, and economic regional renewal. It also presents an overview of the Project's plans that will enable the management of the new mine to internationally recognized environmental and management standards. One of the conclusions of this paper is that the Roşia Montană Project has enormous potential to reverse the current levels of environmental, economic, and social degradation in this region, and to initiate a new era for Romanian mining, that will contribute to Romania's efforts to achieve a robust and realistic sustainable development.

1. INTRODUCTION

Roşia Montană is situated in the Metaliferi range of the Apuseni Mountains, in central western Romania (Figure 1).

Figure 1 Project location in Romania

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Closure, if implemented in the absence of any new development, would imply an extremely high cost for environmental rehabilitation. Indeed, without new development, a substantial risk exists that suspension of the current operations would result in both the long-term neglect of the current highly impacted environment and much further hardship to the workforce and the community.

Surface waters in the Rosia and Abrud valleys are heavily polluted by acid drainage and heavy metal loadings – both the result of the current State-owned, and

Figure 2 Historic pollution of waters in Rosia Montana areal

previous, mining activities (Figure 2). Proposals for a new mining project (the “Project”) are, at this time, being developed by a joint venture company, the Roşia Montană Gold Corporation SA (“RMGC”). The Project’s development activities are funded by Gabriel Resources Ltd, a Canadian public company. The other major share holder (19.3%) is the Romanian State. The Project incorporates the area impacted by current mining into a new and efficient high production mining operation.

The Project commits to proceed only in full compliance with national and EU legislation and within the structure of “best practice” for each component of the Project. As a result, the Project will clean-up historic pollution in its impact area and provide a secure livelihood over several decades for members of the local population. The knock-on effect is that the local community will then have sufficient wealth and a sufficiently sustainable environment for them to provide a foundation for their own future developments.

2. KEY FEATURES OF THE NEW PROJECT (THE ROŞIA MONTANĂ PROJECT)

The Roşia Montană Project is in the process of developing a definitive plan of implementation and operation, while progressing through the steps of permitting and approval defined under Romanian Law. Contrary to some misconceptions, neither RMGC nor the Project has yet undertaken any mining in Roşia Montană. The existing mining operation is being run entirely by the Romanian State. To date, RMGC activities have been limited to geological, archaeological, and site investigations; economic, environmental, and social baseline studies; property acquisition and the beginning of the development of the new village. Construction can only begin after issue of the environmental agreement, together with the other endorsements required in the permitting and planning process, which will hopefully culminate in Government authorization and the eventual issue of the Construction Permit.

Based on current estimates and the base ore reserves, the operations phase will last approximately 17 years at a nominal processing rate of 13 million tones of ore per annum (Mt/a) There is potential for this operations phase to be extended should additional ore reserves become proven.

The Roşia Montană Project's mineral reserves have been evaluated in four main ore deposits, identified as the Cetate, Cirnic, Orlea, and Jig ore bodies, each of which will be developed as a separate open pit. They contain approximately 218 million tones of ore, with average ore grades of 1.52 g/t gold and 7.47 g/t silver. This is equivalent to 331 tonnes of gold, although only 274 tonnes are economically recoverable; and 1,634 tonnes of silver (946 tonnes economically recoverable).

The Project includes the following principal elements:

• Archaeological excavation, protection, preservation and public presentation of important cultural heritage assets, including designation of a "Protected Area" (governed by law) around the heart of the historic village of Roşia Montană, together with proposals for conservation of architectural and industrial archaeology assets,

• Regional economic and social development planning, supporting sustainable development objectives,

• A resettlement programme, managed in view of the "Equator Principles", with the construction of a new village including homes, social facilities, and administrative buildings at the lower end of the Roşia Montană valley; construction of new homes in Alba Iulia, the county town, is also planned,

• Conventional open pit mining activity in four pits,

• Removal and stockpiling of overburden, soil, and waste rock (i.e. rock which does not contain levels of gold or silver sufficient for economically attractive recovery),

• Ore production at a nominal rate of 13 million tones per year,

• Crushing and milling of ore to a small size to allow processing using well proven, industry standard, cyanide-based leaching technology: once the precious metals have been recovered from the fine grained ore, the waste will be subjected to cyanide detoxification before storage in the tailings management facility (TMF), • Smelting of the gold and silver recovered to doré (product in high assay bar form that is not highly enough refined for sale as pure metal: the doré would need to be refined further elsewhere (at specialist internationally recognized companies) before the gold and silver can be sold),

• Site water, including the runoff and seepage in Rosia Montana and Corna valleys, some of which is contaminated by decades of environmentally neglectful State-owned mining activities, will be managed by diverting clean water and collecting contaminated water: contaminated water will be sent to a newly constructed water treatment plant for treatment and subsequent reuse or discharge,

• Deposition of detoxified process waste in the tailings management facility (TMF), which is being designed to contain approximately 250 million tonnes of tailings. The TMF dam, together with its secondary dams, are being designed to capture any downstream seepage: the water in the tailings that is transferred to the TMF will meet soon-to-be-implemented EU standards for cyanide content, while water decanted from the TMF will be recycled to the process plant for re-use, thereby reducing the consumption of fresh water,

• Installation and operation of the necessary associated infrastructure, including: process water supply pipelines, tailings delivery and reclaim water pipelines, power lines, an electrical substation, local and wide-area electronic communication networks, mine roads, workshops, warehouses, a laboratory, offices, and a wastewater treatment plant,

• Closure, decommissioning, and rehabilitation of the mine area and facilities in accordance with a formal mine closure plan developed during the Environmental Impact Assessment (EIA) process. A fund will be established for these tasks before the Project is commenced.

3. HOW CAN A MINING PROJECT BECOME A BASIS FOR SUSTAINABILITY?

The Project's permitting process is being undertaken in compliance with Romanian legislation, EU directives, and international guidelines. A point of reference from which to start to examine this question is the largely accepted "Brundtland" definition of development sustainability, being "development that meets the needs of the present without compromising the ability of future generations to meet their own needs…" – in other words, ensuring that today's growth does not jeopardise (i.e., destroy or damage) the growth possibilities of future generations.

This definition of sustainable development, dating from the 1987 World Commission on Environment and Development (known as the Brundtland Commission) has received broad support, not least because it is an elegantly simple formulation. The original Brundtland Commission definition can be broken down into four conditions for sustainable development:

• creating the means for providing material and other needs for people of this generation to enjoy a better quality of life…

• as equitably as possible…

• while respecting ecosystem limits, and…

• while building the basis on which future generations can meet their needs as well.

An additional relevant point also made by the commission is that a development needs to be considered together with its surrounding effects when assessing its sustainability.

The Roşia Montană Project will bring at least five clearly identified economic and social benefits to the community, including:

• clean-up of previously negatively impacted sites and currently polluted water courses;

• development and subsequent maintenance of significant new employment;

• financial means for the reconstruction of modern communities with improved social and domestic facilities;

• greatly increased fiscal resources for the local councils; and

• preservation and enhancement (through proposed conservation work) of the rich cultural and historical heritage of the entire Roşia Montană region.

RMGC consultation indicates that a majority of people in the area, including their elected representatives, expect the Project to improve presently harsh living conditions. In addition, it is reasonable to expect that this will provide a platform upon which future generations can build their future, not only through increased economic activity but also through the addition of infrastructure and services. Against this background, a key result expected of the Project is that its operation and continued development will, in turn, be the chief driving force for the continued development and environmental sustainability of Roşia Montană, with positive ripple effects for the neighboring region.

In order for the full beneficial effects of such a project, however, to result in a sustainable environment, the environmental, social, and economic aspects surrounding the Project need to exist in equilibrium and ultimately support each other. A breakdown of this equilibrium is presented below.

4. THE ENVIRONMENTAL BALANCE SHEET

The creation of a sustainable environment requires the application of best practice to environmental protection. This environmental best practice cannot, however, be an aim without regard to the total cost, as this could conflict with the economic requirements of sustainable development, on which a sustainable environment depends. Environmental protection must apply from the start of the life-cycle of mining activity, meaning the construction of the mine and related facilities themselves, all the way through operation, decommissioning and restoration or redevelopment of the site. This long-term, life-cycle commitment to good environmental practice is reflected in the legislation forming the basis of the development plans for the Roşia Montană Project.

It is universally recognized that mining as an industry commonly has significant impacts on the environment. The commitment to sustainable development requires that these impacts are minimized and managed to be compatible with equitable economic and social performance. A simple concept is that there is a Project “balance sheet” that must be unequivocally positive in its benefits both to the environment and to society.

The negative impacts of a major open pit operation, such as planned for the Roşia Montană Project, are primarily in terms of landscape change and the occupation of land for the term of the mine related activities, including the excavation site and the location of waste rock dumps, tailings disposal facilities, access routes, and water management structures (Table 1, 2, 3, 4).

Table 1 Categories of potential water pollution during phases of the Project

Categories of pollution	Project phases			
	Existing	Construction	Operations	Closure
Acid Rock Drainage – old operations	X	X	X	X
Acid Rock Drainage – proposed operations			X	X
Domestic Wastewater from on- site facilities		X	X	
Miscellaneous Chemicals in Runoff fromPlant Site			X	
Process Effluent (Including residual cyanidein closed TMF)			X	X
Soil Erosion from the Site	X	X	X	X

Table 2 Potential sources of emissions to air

Mining operations	Blasting, excavation, loading	Blasting fumes and dust emitted by blasts; dust emitted by blast hole drilling rigs; dust raised by excavators and mobile equipment; wind erosion of non-vegetated surfaces; emissions from mobile equipment and vehicle exhausts.
Processing	Ore stockpile	Ore dust raised by stockpile creation; wind erosion of stockpile; vehicle and equipment exhaust emissions.
	Crushing	Ore dust from the crusher and handling of crushed ore.
	Crushing and milling	Essentially a wet process with little potential for dust emission.
	Gold recovery	Wet process; potential for lime dust emissions at point of addition; potential for incidental CN gas emissions; fumes from elution process; gold furnace fumes.
	Reagent storage	Reagent dust at point of mixing and gases.
	Detoxification plant	Release of SO_2.
Tailings disposal	Dust raised by wind erosion of dried tailings surfaces (there is an operational procedure to keep surfaces moist).	
Waste rock disposal	Dust raised by haulage, mobile equipment, and unloading oftrucks; wind erosion of non-vegetated surfaces; emissions fromvehicle and equipment exhausts.	
Mine, plant and office facilities	Emissions from vehicle and equipment exhaust; wind erosion of non-vegetated, unsealed ground.	
Ore haulage and transport of personnel	Vehicle exhausts emissions, dust from the surface of the road.	

Table 4 Potential soil pollutants and activities during operation

Pollutant / Activity	Location / Feature
Soil loss and land use loss as a result of Project development.	Areas including: open pits; waste rock disposal sites; TM impoundment; processing plant; topsoil stockpiles; and, ancillary facilities.
Agricultural and forestry land use degradation as a result of deposition of particulates.	Zone around the Project area with the potential for impact on vegetation.
Temporary degradation and erosion of soil quality during storage.	Topsoil stockpiles.
Contamination of soils from leaks or spills of process chemical and effluents such as cyanide, caustic soda, hydrochloric acid, lime, flocculants, fuel oils/lubricants.	Soils and sub-soils at or near the roads, plant site and storage areas.

These impacts are transitory, as the Project's commitment to sustainable development requires that the land be available, in an environmentally sustainable form, for other uses when the mining operations cease. In reality, the positive side of the balance sheet reflects:

• the results of good environmental management practice during the life of the mine;

• the long-term remediation or mitigation of impacts, as detailed in a comprehensive mine closure and rehabilitation plan currently under preparation; and • the ongoing benefits available from economic activities and improved infrastructure and services that came to be as a result of the establishment of the mining operations.

For the Roşia Montană Project, the relevant details of environmental impact may be summarized as:

• just under 400 hectares of ground will be occupied by residual ground rock (tailings) deposited behind a dam in the Corna Valley (this is the largest land-take impact that the Project will take on currently none mining land): upon closure, this will become a vegetated plateau for future recreation/sporting facilities and/or agriculture;

• approximately 215 hectares of land will be occupied by waste rock dumps: this will become a "man-made" vegetated hill after mine closure;

• approximately 210 hectares of land will be excavated to form four open pits (the majority of this land-take is previously mined land): this will become a habitat for wildlife and/or recreation facilities at end of new mine life; and

• approximately 50 hectares of land will be occupied by the plant site: this will become a vegetated terraced landscape once the plant is decommissioned.

In the case of the Roşia Montană Project, the abovementioned positive impacts are further enhanced by specific programmes to clean up the impacts of centuries of mining and, in particular, the long-term management and clean up of heavily impacted polluted waters which currently affect the Rosia and Corna valleys. It is worthy of note that the costs for this cleanup activity may be borne by the Roşia Montană Project, although the contamination in the areas being cleaned up was created well before RMGC was present at the site.

The additional positive environmental results likely to result from the additional environmental cleanup activity proposed under the Roşia Montană Project include:

• in excess of 5 to 30 liters per second of heavily contaminated acid water resulting from current State and former mining, currently flowing directly into the regional river system, will be captured and treated;

• the acid-producing underground galleries – approximately 140 kilometers in length – will be stabilized;

• just under 400 hectares of disturbed ground and small waste dumps due to the former underground mining activity will be cleaned-up; and • modern environmental standards will be encouraged within the community to help stop the current dumping of domestic waste in the streams and countryside.

5. SOCIAL PARAMETERS OF THE PROJECT

In addition to the creation of such financially-based economic benefits to the economy as listed above, the Roşia Montană Project has already created a significant number of temporary and permanent jobs and will create further direct and indirect employment as the Project develops. Many of the new jobs will require extensive training in modern mining methods, operational and personal safety, environmental control, and awareness and product quality.

Depending on various parameters, including the length of the construction period, between approximately 1,200 and 2,000 direct jobs will be created during the construction phase, of which the majority will be as Romanian contractors or locally-employed staff. During the operations phase of the Project, the total number of direct employees will be some 600 staff at the beginning of actual mining. In order to maintain efficiency and to promote a climate of change management and adaptation critical to sustainable development, this total staff number will gradually decrease to fewer than 400 employees toward the end of mining operations. An extensive training programme for the operations staff will be an essential part of the development both prior to the Project's commissioning and during the early years of operation. General worldwide experience suggests that 3 to 8 indirect jobs can be created in the impacted and surrounding communities for every direct mine job created – the number tends to be higher in developing regions like that found in the Project area.

It is recognized that the long term social sustainability of Roşia Montană and the surrounding area is dependent upon the encouragement and growth of local enterprises and that such enterprises must have broader objectives than simple response to and dependence on the mining development. A Community Development Action Plan forms a critical part of the management and mitigation proposals in the EIA report. As currently envisaged, this Community Development Action Plan will include specific proposals for access to soft capital for small business enterprise start-ups, capacity extension and skills enhancement of suppliers to the Roşia Montană Project, community assistance in planning and developing social organizations, and development proposals for new commercial activities potentially to include cultural tourism, craft workshops, etc.

The development of the Project industrial zone will necessitate the resettlement or relocation of some 900 households located on some 2,000 properties. In addition to strict compliance with both Romanian law and recognized good practice in the EU, RMGC has made a commitment to follow, as much as possible, the "best practice" principles as specified by the World Bank Group. In this regard, project-affected persons are offered a choice between:

• resettlement: the receipt of a new house and parcel of land at one of three locations, or;

• relocation: the receipt of monetary compensation for their current property and investments leaving the choice of where to move to the recipient.

The "best practice" principles also provide that, in the process of land acquisition and planned resettlement or relocation, all activity proceeds in compliance with the following:

• published procedures for valuation and negotiation in the purchase of properties;

• specified ancillary support to affected households (e.g., assistance to move, rights of salvage, etc);

• a policy of compensation for affected households at full replacement value;

• full transparency in all transactions; and

• an accessible grievance mechanism.

Another important element of planning for site development has been the recognition of the interesting, although much deteriorated, combination of: village architecture, reflecting a vibrant mining past and culturally diverse social structure; access to abandoned underground mine workings; industrial archaeological remains; some Roman artefacts; and a number of Roman sites reflecting domestic and social occupation in the area. RMGC has proposed to designate the core area of the village of Roşia Montană as a "Protected Zone". In this zone, existing buildings and features could be conserved and used as the basis for developing a unique cultural heritage facility, which might extend to a museum, craft workshops, and other activities in a combination that would encourage tourism. These proposals are necessarily in an early stage of development and are subject to planning consent, environmental assessment, permits for conservation proposals, consultation, agreement with the local community, and

development of a viable foundation or similar body with an economic basis and an ownership and management structure able to support their long-term activity and growth.

RMGC has demonstrated its commitment and concern to minimize impacts on, and support the recording and display of, the cultural heritage assets of the Roşia Montană region. Since 1999, RMGC has funded intensive archaeological field investigations in conjunction with an evaluation programme led by the National Museum of History, Bucharest. Plans for mine and infrastructure development are under active review in conjunction with applications for, and award of, archaeological clearances in full accordance with the provisions of Romanian law.

The Roşia Montană Project will undoubtedly represent a major focus for investment, commercial development, and long-term employment opportunities. A commitment between RMGC and the local authorities for cooperation beyond the minimum requirement of the legal framework will offer opportunities for a broader, sustainable economic future for the region, extending well beyond the specific opportunities related to the mining industry.

6. ECONOMIC PARAMETERS OF THE PROJECT

A basic concept for all industrialized economies is that major investment projects generate a range of important benefits for the local, regional and national economies. The primary source of direct benefit to the economy is through taxation and royalties; other significant benefits include increased employment, enhanced skills training, and especially the stimulation of other local economic activity through the purchase of local goods and services. In most large scale investment activities such as the Roşia Montană Project, an important aspect of the considerable analysis required for the preparation of documents such as the EIA report, the Feasibility Study, and documents supporting permit applications is the projection of these economic benefits. RMGC is in the preparatory phases of conducting such an economic analysis, and as there is little in-country Project-related information as yet, it uses studies of similar mining projects worldwide. The RMGC study reveals to date that, for each dollar spent on capital investment or operations activities, approximately 2.3 dollars of economic benefits accrue to the local and national economies. This “multiplier” of 2.3 should be considered with the following figures (calculated on the basis of the current fiscal regime in Romania, and on the market prices of gold and silver of USD350 /troy oz and USD4.50 /troy oz, respectively):

- total capital investment over the Project lifetime of over USD650 million;
- investment to date in excess of USD80 million;
- capital investment allocated to environmental protection in excess of USD130 million;
- total environmental operation costs over the Project lifetime in excess of USD120million;
- total operation costs over the Project lifetime of over USD1,400 million, most of which will be paid to Romanian suppliers;
- direct benefits to the State in excess of USD550 million (including taxes on profit and profit earning in excess of USD200 million and USD160 million respectfully); and
- direct local taxes and charges, including payroll taxes, in excess of USD30 million (of which approximately 65% goes to local authorities, 20% to county and 15% to State).

7. CONCLUSIONS

Ultimately, the creation of a sustainable environment in today’s Roşia Montană will require significant financial input coupled with sustainable development to maintain the required environmental work over time. Such development is based on strong social, economic and environmental performance. The best guarantee for good social and environmental performance is that effective and enforceable legislation is in place to govern project development, that this development is able to sustain itself economically, and that the economic activity it encourages is extended to other activities to supplement the economic sustainability of the region. It is hoped that Romanian legislation, undergoing change to conform to EU standards and practice, will support these aims. The Roşia Montană Project, however, is committed not only to compliance with the national legislative framework but also to compliance with EU directives and with “best international practices” as required by leading international institutions.

In common with all major industrial projects, the Roşia Montană Project will have significant impacts both socially and environmentally in and adjacent to the Project’s “footprint.” Plans for project development embrace “best international practices” to mitigate or minimize negative impacts and to enhance positive impacts during project development, construction, operation, and closure. An important aspect of the Roşia Montană Project as proposed by RMGC is that it offers a range of positive benefits for both the economic and social development over the long term in the Roşia Montană region. It accomplishes this via implementation and observance of “best environmental practices” for mining operations and site rehabilitation, and via the clean-up of environmental damage from centuries of uncontrolled mining for which no other cost effective solution is proposed or even foreseeable. Thus, development of the Roşia Montană Project as proposed by RMGC will deliver solutions entirely compatible with the principles of sustainable development that will in turn lead to the rebirth of a sustainable environment in Roşia Montană.

8. BIBLIOGRAPHY

1. John Aston, John Knight *- The Roşia Montană project and sustainable development.*

2. ** * * -* ***Roşia Montană Project -*** *Project Presentation Report.*

DES POLITIQUES INTERNATIONALES SUR LE CHANGEMENT CLIMATIQUE

Tudor GOLDAN*, Eugen COZMA, Ilie ONICA****

Abstract: This article gives an analysis of the major scientific questions underlying the decision making process dealing with forest monitoring under the topic land use, change and forestry as a driving force for climate change. It first gives the major scientific findings used as guidelines for political decisions. It than gives the head-lines of scientific reports which were requested as decision tools in the international negotiation on climate change and describes the redaction process in the Intergovernmental Panel on Climate Change.

Keywords: climate change, international negotiation, land use, monitoring, scientific expertise, political decisions.

1. INTRODUCTION

Les implications au niveau local des textes de droit international sur l'environnement en général et sur le changement du climat en particulier se développent en cascade. Dans la Convention Cadre des Nations Unies sur le Changement Climatique (CCNUCC), sous le thème de "l'affectation des terres et des forêts", c'est toute la politique environnementale sol-faune-flore-atmosphère qui este concernée, vue tant sous l'angle de la conservation des espaces naturels in situ que sous celui de la surveillance globale et de la sécurité de l'environnement.

2. INSTITUTIONS INTERNATIONALES ET DES RAPPORTS SCIENTIFIQUES DANS LA PROBLÉMATIQUE DU CHANGEMENTS CLIMATIQUES

Sous l'impulsion de l'Organisation Météorologique Mondiale (OMM) et du programe des Nations Unies pour l'Environnement (PNUE), les préoccupations

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relatives au changement climatique ont donné naissance au Groupe Intergouvernemental d'Experts sur le Climat (GIEC). Il n'aura donc fallu au GIEC que trois ans, après la première "prediction" par les modèles climatiques d'une hausse de températures due aux activitiés humaines, pour mettre la CCNUCC sur les rails, sous la présidence G. Bush (père).

Les objectifs principaux du GIEC sont:

- évaluer la littérature scientifique disponible sur le changement climatique;
- évaluer les conséquences environnementales et socio-économiques du changement climatique;
- formuler des réponses stratégiques.

Depuis 1988, les travaux du GIEC ont servi de base aux négociations dans le cadre de la CNUCC et au Protocole de Kyoto (1997), que reflète les principales tendances des discussions scientifiques et politiques en matière de changement climatique. Il contient des procédures bien déterminées en cas de non-respect des obligations. Ce type de contrainte n'existe dans aucun autre Traité international de conservation de la nature, ce qui lasse à penser que le Protocole de Kyoto sera le cœur de toute action future de conservation, ainsi que le montrent les diverses manœuvres de rapprochement de la Convention sur la Diversité Biologique et de la Convention pour Combattre la Désertification avec la CNUCC. En tout état de cause, il ne subside aucun doute que la surveillance des forêts, telle que mise en place par le Protocole de Kyoto, monopolisera l'essentiel des ressources financières additionnelles requises en matière d'inventaires forestiers. Ceci donne la mesure de l'intérêt qui doit être porté à cette question.

Le GIEC est la premiere organisation mondiale don't les membres sont des gouvernements, capables de produire des rapports scientifiques circonstanciés et de portée globale. Jusqu'à présent le GIEC a publié trois rapports d'évaluations scientifiques et une longue série de publications techniques et des guides pour préparer les inventaires de gaz à effets de serre.

La CCNUCC et la Protocole de Kyoto relèvent de la politique internationale. Ces textes internationaux reflètent la prise en compte de la recherche scientifique en matière de décision politique. Mis à part les domaines militaires et nucléaires, la science n'a jamais exercé une telle influence sur les choix politiques. Les parties sont convenues de suivre le premier guide d'inventaire d'émissions de gaz à effet de serre.

Les rapports du GIEC se sont avérés pertinents, mais non-ordonnateurs. Dans la mesure où ils laissent toutes les portes ouvertes pour les négociations, ces rapports de portée scientifique jouent pleinement leur rôle de soutien à la décision politique lors des négociations. Ils sont dès lors pris en considération à la fois par les gouvernements de pays développés et ceux des pays en développement, quelle que soit leur orientation politique. Le GIEC s'est fondé une niche, entre la science et la politique et a introduit de façon irréversible la science des changement climatiques dans la sphère des préoccupations politiques internationales. Les rapports d'évaluation scientifique du GIEC en matière de changement climatique sont une référence incontestée, dans le mesure où ils rassemblent tout l'acquis scientifique pertinent.

Le premier rapport d'évaluation et la Convention Cadre des nations Unies sur Changements Climatiques a confirmé la réelle menace du changement climatique pour l'humanité et a mis en évidence la contribution de l'homme à travers ses émissions de gaz à effet de serre. Les acquis scientifiques mis en lumière dans ce rapport furent la base des négociations dans la cadre de la CCNUCC. Ainsi, l'objectif de la convention est clairement de "permettre la stabilisation des concentrations de gaz à effet de serre dans l'atmosphère sous un niveau qui cause des interférences anthropiques dangereuses avec le système climatique". Cette conclusion figurait dans le premier rapport d'évaluation du GIEC. La CCNUCC reprend à son compte cette connaissance scientifique et c'est à ce titre une contribution scientifique majeure dans les orientations politiques internationales.

Le deuxième rapport d'évaluation fait une synthèse détaillée des connaisances scientifiques sur le changement climatique, ses effets et les possibilités d'adaptation. Ce fut un effort collectif international majeur, associant plusieurs centaines de scientifiques de toutes les nations, soumis à une révision internationale et gouvernementale. L'adoption de ce texte par le GIEC et l'adoption ligne par ligne du résumé pour les décideurs politiques lors d'une session plénière du GIEC, élèvent ce deuxième rapport d'évaluation à un niveau jamais atteint antérieurement par aucun document scientifique: une publication scientifique endossée par tous les gouvernements du globe.

Ce deuxième rapport d'évaluation confirme plus avant la réalité du changement climatique et donne la probabilité des forces motrices du changement climatique. Cette confirmation scientifique de l'existence d'une influence humaine parmi les causes du changement climatique a justifié une action concertée au niveau international destinée à empêcher l'accroissement de la concentration de gaz à effet de serre dans l'atmosphère, comme premier pas dans la lutte contre le changement climatique. L'idée d'engagements quantitatifs de réduction des émissions de gaz à effet de serre est centrale dans le Protocole de Kyoto.

La deuxième rapport d'évaluation présente les forêts à la fois comme source et comme puits de dioxyde de carbone. Le bilan global est un puits de dyoxide de carbone pour l'atmosphère. Sous les Tropiques, les forêts sont une source de CO_2, principalement en raison de la déforestation et des dégradation forestières. Les forêts tempérées et boréales sont quant à elles un puits, principalement en raison des activités de gestion des forêts, des mesures de restauration des dégradations historiques des massifs forestiers et des reconversions d'autres usages du territoire en forêt. Le deuxième rapport d'évaluation identifie la promotion des pratiques de gestion des forêts dans la logique de la conservation des stocks de carbone (C) existant. Parmi les voices possibles de réduction nette des émissions de CO_2, le deuxième rapport prône également la création de nouveaux puits de C dans le forêts par un développement de leur potentiel de stockage du C et par un accroissement des surfaces boisées. Le GIEC liste encore dans ce rapport comme options possibles: la substitution de matériaux consommateurs d'énergie par du bois, l'accroissement de stocks de produits de bois en favorisant les produits de bois à longue durée de vie et la substitution des combustibles fossiles par la biomasse.

Le Guide des Bonnes Pratiques (GBP) a pour objectif de fournir une méthodologie cohérente en complément du premier guide. L'objectif ultime de ce guide est de faciliter le développement des inventaires de gaz à effet de serre émis ou séquestrés dans les écosystèmes terrestres. En matière de forêts, il vise en particulier à un développement des inventaires forestiers qui soient transparents, bien documentés, cohérents dans le temps, complets, comparables, quantifiés en termes d'erreurs et susceptibles de contrôle de qualité et de confiance. Le GBP est un ouvrage de référence et vient en aide aux agences, organismes ou structures qui réalisent ces inventaires.

Le recours aux mesures peut varier d'un pays à l'autre et même dans un pays, entre regions. La fréquence minimale de mesures dépend de l'historique de la disponibilité de l'information ou de l'information produite par modélisation, de la dynamique du changement d'affectation des terres et de la variabilité interannuelle, du développement économique, de la dynamique des populations, de la migration, de mesures de détail relatives à la protection de l'environnement etc. De façon générale, plus le niveau de développement économique est grand et stable, plus basse est la fréquence de mesure requise. Une limite objective à la plus basse fréquence possible serait une période de cinq ans, résultant de la durée de la période d'engagement.

Les rapport d'évaluation du GIEC trouvent leur raison d'être ultime dans le besoin qu'ont les organes en charge de la politique globale d'atteindre un accord politique sur les questions relatives au changement climatique, y compris de conclure qu'une telle décision politique n'est pas encore requises. La contribution scientifique est particulièrement appréciée lorsque de possibles décisions politiques ont des conséquences sociales et politiques significatives dans le futur.

L'implication des organisation gouvernementales dans ce processus vise à renforcer la cohérence entre la contribution scientifique et l'orientation politique. Elle vise également à délivrer un document aussi utile que possible pour les négociateurs. En contre-partie, les représentants des gouvernements facilitent l'intégration de leurs équipes de recherche dans la communauté scientifique mondiale et placent ainsi leurs experts dans la filière du GIEC.

3. LE PROTOCOLE DE KYOTO, UN ENJEU MAJEUR POUR L'ENVIRONNEMENT DE LA TERRE

Dans l'hypothèse d'une entrée en vigueur du Protocole de Kyoto, la politique climatique sera la question la plus importante de notre époque et l'objet de controverses politiques et économiques mondiales majeures. Selon les termes de ce Protocole, 55 pays des Nations Unies au moins devaient s'engager pour atteindre les 55 % de réduction d'émissions requis. Le Protocole dispose dès à présent d'une trés large assise territoriale et d'un espace temps favorable. En effet, 120 pays on déjà ratifié le Protocole, soit 44,2 % des réductions d'émissions attribuées aux pays de l'Annexe 1. De janvier 2004 à décembre 2008, cela rprésente cinq années pour conclure ce processus. La fin de la première période d'engagement se profile dans dix ans. Le Protocole de Kyoto sera une source de travail majeure avec des enjeux globaux prioritaires. Il supposera des fonds pour sa réalisation et imposera des procédures en cas de non-respect des engagement. Les besoins de surveillance des principaux stocks de C terrestre en général et des forêts en particulier, requis dans le cadre du Protocole de Kyoto, attireront donc les principales sources de financement et méritent à cet égard un effort soutenu.

Pour atteindre les 55 % de réduction requis, la Fédération de Russie doit encore traduire ses déclarations publiques officielles en faveur du Protocole en formule de ratification. Le processus de la CNUCC est quant à lui irréversible et les engagements européens en matière de réduction des gaz à effet de serre indifférents à cette conjoncture.

Avant l'annonce US de rejet du Protocole de Kyoto, le scénario le plus probable aurait été que la mise en œuvre du protocole débouche sur une large mise en vente de crédits d'émission par la Fédération de Russie: la mise en vente de son "air chaud" résultant de l'écroulement de ses structures de production suite à l'effondrement du mur.

À l'heure actuelle, suite au rejet US du Protocole de Kyoto, ces crédits ont fortement perdu de leur valeur et la Russie entretient son potentiel à exploiter sa situation de monopole pour accroître la valeur de ses permis, par exemple en recourant au "banking", c'est-à-dire en ne comptabilisant pas ses permis d'émission durant la période d'engagement et en décidant de les reporter à une période ultérieure, dans l'attente d'une flambée des prix du marché par exemple, en résultat de la reprise en considération de la CCNUCC par une future administration US, voire du "succès/échec" de l'UE à atteindre ses propres objectifs de réduction par la politique qu'elle s'est tracée.

La décision russe ne se résume toutefois pas à l'alternative: mettre ses permis d'émission sur le marché ou "banking". En effet, la Russie est d'abord et avant tout un important exportateur de pétrole et d'énergies fossiles. Si elle ne met pas sur le marché ses permis d'émission, le prix de son énergie fossile ira à la baisse et ainsi la valeur de ses rentrées énergétiques. Dans une logique de marché, la décision russe fera un équilibre entre la maximisation du revenu de ses permis d'émission et du revenu de la vente d'énergie fossile. En présence des US, les prix des crédits d'émission est plus dans les mains US que dans les mains russes. En l'absence des US, l'impact russe sur le marché est d'abord fonction d'élasticité de la demande. Et il se confirme que les mécanismes de développement propres ont relativement peu d'impact sur le prix des permis.

Il semble donc que l'intérêt de la Fédération de Russie soit de ratifier le protocole même si au sein de la Russie tous les intérêts ne convergent pas sur cet objectif. D'une part, du retrait US du Protocole, toutes les parts de marché resteraient, dans l'état actuel des choses, sans acquérer potentiel. D'autre part, la Fédération de Russie montre sur de nombreux points de politique internationale, une tendance à "soutenir" la politique menée par des européens.

La poursuite de Kyoto permettra cependant de ne pas devoir reconstruire totalement le processus en conservant la structure actuelle et en essayant pour la seconde période d'engagement d'intégrer les pays en développement plus avant.

Du fait que toutes les nations jouent un rôle important dans processus du protocole de Kyoto, l'Europe par sa politique volontariste en matière d'environnement global, la Russie par son rôle devenu central dans la ratification de Kyoto, les US par leur mainmise sur le marché des permis d'émissions et les pays en développement par leur rôle clé pour la seconde période d'évaluation, font qu'à court terme il n'y ait pas de réelle alternative au protocole de Kyoto.

4. CONCLUSIONS

Toutes les négociations sur le climat bénéficient du balisage scientifique du GIEC depuis 1988. Les différents points qui précèdent ont mis en évidence l'influence considérable et incontestable de la science sur les choix politiques. La complexité de la problématique sur le changement climatique nécessite une expertise scientifique et un décryptage avisé.

Il s'agit de prendrre en compte les avancées asientifiques les plus pertinentes et de poursuivre une analyse pro-active des négociations et options politiques. Les travaux préparatoires aux conférences internationales doivent rester du domaine de l'administration et les négociations doivent rester du domaine politique. Dans cette matière toutefois, la science a balisé, balise et balisera le terrain. Les décisions politiques restent dans les mains du politique mais nécessitent une information avisée et une expertise scientifique particulière. La crédibilité du support scientifique n'existe en effet que parce que le balisage scientifique est non-prescriptif, pertinent pour les utilisateurs potentiels, correct en ce qui concerne la méthode scientifique mise en œuvre et légitime dans sa structure. C'est au travers de ce rôle de charnière et de mise en réseau des ressources intellectuelles scientifique devrait se développer et agir.

BIBLIOGRAPHIE

[1]. **Houghton, J.T., Jenkins G.J., Ephraums, J.J.,** *IPCC First Assessment Report. Scientific Assessment of Climate Change – Report of Working Group,* Cambridge University Press, 1990.

[2]. **Houghton, J.T., Meuira Filho, L.G., Callender, B.A., Harris, N., Kattenberg, A.,** *Second Assessment report. Climate Change 1995: The Science of Climate Change. Contribution of Working Group 1 to the Second Assessment of the Intergovernmental Panel on Climate Change,* Cambridge University Press, 1995.

[3]. **Watson, R.T., Noble, I.R., Bolin, B., Ravindranah, N.H., Verardo, D.J., Donken, D.J.,** *Land Use, Land-use Change and Forestry. Special Report of the Intergovernmental Panel on Climate Change,* Cambridge University Press, 2000.

A NEW RESEARCH FIELD IN THE ENVIRONMENTAL PROTECTION

Tudor GOLDAN*

Abstract: The new concept "ecohydrology" – launched for a worldwide programme in water management – is aimed at scientist working in the water domain. Through the analysis of ecological and hydrological components, ecohydrology takes place in various and interconnected sectors: water storage, water self-purification, biofiltration. As a first step, the paper defines the term "ecohydrology" more widely. The concept is then discussed on three points: topicality, involved actors and innovative research axes. The latest briefly present phytoremediation and biomanipulation.

Keywords: ecohydrology, environment, neologism, water domain.

1. INTRODUCTION

The Brundtland report (WCED) edited in 1987 and the International Conference of Rio in 1992, both organized by the United Nation Commission for Environment and Development, obviously showed the endless damage to environment and the unconditional report of application of draconian solutions towards the coming generations. Both manifest plead for a sustainable development able to assume, simultaneously and at long term, economic growth, improvement of environment and protection of natural resources.

Among the latest, a crucial importance must be dedicated to fresh, drinking water. The management of this resource will be one of the major challenges for the new Millennium, as well as the allowance for the whole population to reach fair conditions of nourishment and hygiene.

Since 1970, UNESCO has launched studies of integrated management of watershed throughout the world, through the development of two programs: "Man and Biosphere", followed by the "International Hydrological Program" in 1975. The fifth phase of the latest program begin in 1996 with ecohydrology as a major theme.

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2. ECOHYDROLOGY

Ecohydrology, considered as a new paradigm, is a neologism arising from the coalescence of both terms “hydrology” and “ecology”. It was first postulated in Dublin in 1992 at the International Conference on Water and Environment [11] and suggest a new watershed approach methodology. Scientists wished to bind biological and physical sciences together with the goal of a better understanding of the studied ecosystems [10].

The concept “ecohydrology” is aimed at scientists working in the water domain. It tries to heighten the awareness of engineers in hydrology to more ecological methods and vice versa. Indeed up to now, many scientists and industrialists take into consideration solutions from their own skills, whilst into consideration solutions from their own skills, whilst a co-operation between hydrologists and ecologists would result in more adapted solutions for the aquatic environment.

Figure 1, taken from the Fifth Phase booklet, sets ecohydrology as a link between past and future in water management. Ecohydrology is a current phase which will allow at middle term a development and a management of aquatic environments. Up to now, water management is limited to the reduction or even to the elimination of periodical phenomenon such as catastrophic floods, droughts, pollution or erosion. The future must go beyond this concept and “amplify the chance” through ecohudrology. Indeed, biological methods allow to strengthen technical methods for an equivalent price and moreover rise their efficiency. Unfortunately this amplification of opportunities is, nowadays, still too often neglected.

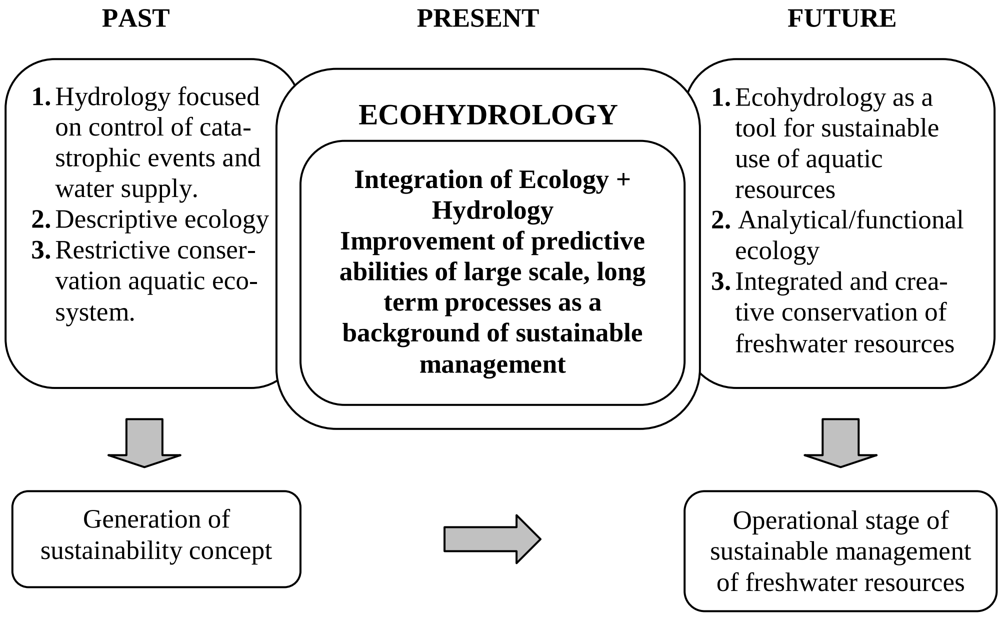

Figure 1. Evolution of ecological and hydrological sciences.

The postulate of ecohydrology considers the watershed as a “super-organism” (ecological macrosystem) where an action in a local ecosystem generates a reaction in an another one, through the hydrographical network, which is equivalent to both a receiving and transmitting system. The environment “physiology” (functioning) and its water dynamics must be understood above all. Three main objectives are described:

- the knowledge of “hydrosystems” (aquatic ecosystems) and comprehension of their relations with climatology, biology, hydrology, water, chemistry, toxicology, biology, geology, physical as well as biological processes, and mankind;
- integration of computerized models based on this knowledge;
- prediction of changes in the hydrosystem – simulations, scenarios – with random variations of hydroclimatological, chemical and biological data or variations due to management politics.

Through the analysis of ecological and hydrological components, ecohydrology takes place in various and interconnected sectors, i.e. water storage, denitrification, water self-purification, biofiltration. The paradigm is applicable to natural as well as to artificial aquatic ecosystems. The itinerant course provided practical applications in ecohydrology through four cases described below. A last case will be discussed as a recent appraisal conducted by the Ecology Laboratory.

2.1. Concept topicality

As far as we know, Pedroli [8] first used the term “ecohydrology” in an underground water study. However the correlation of both domains was evoked one year before [3]. They tackle respectively the hydrological impacts on vegetation ecology, and the use of ecological ranges of plant communities to estimate the quality of surface and underground waters [5]. The term remains use in both international journals and in search engines of websites specialized in hydrology.

2.2. Involved actors in ecohydrology

Ecohydrology brings an additional dimension to water management. The paradigm consists in a thought process which allows a synergy through the complementarity of various research sectors. The concept was first dedicated to civil engineers and to hydrologists sensu stricto. Hydrology has neglected the natural environment for too long. Ecohydrology is a way to open up to this green wave, to apply methodologies in association with environmental solutions and co-operate with other scientists, ecologists in particular.

The above examples show that bioengineers cooperate with other actors such as civil engineers, physicists, meteorologists, chemists. A multidisciplinary reflection rallies all scientists in such a way that each of them is able to step into his own domain. Similarly, ecohydrology represents a way to share knowledge for a better identification of adapted solutions for the aquatic environment. A large network is thereby constituted by actors involved in water management, linking international specialists of various disciplines.

Let's emphasize that the perception of the problem will be different according to the involved specialist – hydrologist, ecologist or bioengineer – and therefore, distinct processes will succeed. For instance, the hydrologist will consider the paradigm as a growing awareness for a "more ecological" hydrology in partnership with actors working in the environment. In particular, this was the case during the itinerant course above quoted, where hydrologists represented the majority. On the contrary, the ecologist will discover applied hydrological methods, which will bring him a relevant information for the management of biotic systems. Through his multidisciplinary education, the bioengineer has a thorough knowledge of hydrology and ecology which allows him to build up complementary ecohydrological solutions in partnership with other actors. Ecohydrology will be valorized by a better knowledge of this science and the spread of the concept. It is important to link partners between them and promote exchanges of knowledge, experiences, solutions. Each actor, working in his own domain, will provide, according to his sensibility, elements adapted to the aquatic environment. The joint examination of sector-related propositions should come out on an optimal collegial proposition (figure 2).

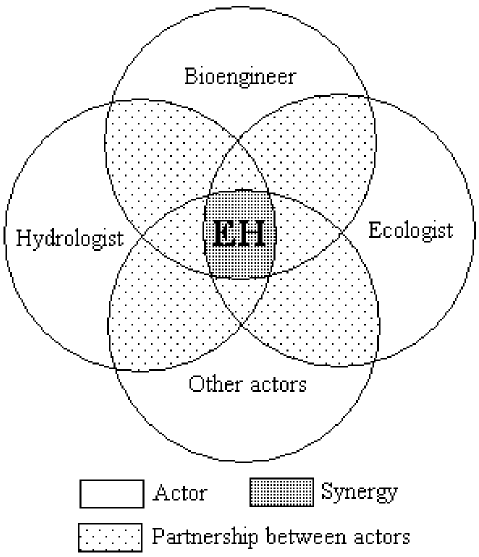

Figure 2. Multidisciplinary approach of ecohydrology.

2.3. Innovative research axes

Ecohydrology objectives show by themselves the framework for the methodology (summarized in figure 3). This is based on three steps:

- the preliminary study of a catchments starts with an in-depth ecological understanding of the environment (climate, soil science, vegetation, human occupation);
- the prevention of pollution, basement of a sustainable development, represents the second step. This implies to establish a catchments model in view to precise sources and to assess pollutants fluxes. From this model, a sustainable land-use management programs will be constituted for the catchments;
- bioengineers implement several technologies to strengthen the ecosystems, like phytoremediation and biomanipulation. They consider long-term management scenarios, in particular through the model previously established.

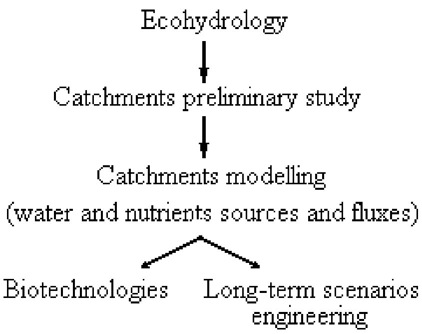

Figure 3. Methodology for ecohydrological research.

It is advisable to insist on phytoremediation and biomanipulation, both important innovative research axes for ecohydrology.

Phytoremediation consists of using vegetation for in situ treatment of polluted ecosystems [9]. When two biotic communities overlap without defined limits we are in presence of a continuum. But when there is, between these two ecosystems, a tight zone with its own characteristics and species, we have an ecotone [4]. Several different ecotone exist, depending on whether they are located between two terrestrial ecosystems, two aquatic ecosystems or a terrestrial and an aquatic ecosystem. Ecotones studies have been for a long time the subject of numerous researches, in ecohydrology particularly.

In an aquatic ecosystem the purification function of the aquatic vegetation is an important measure for the water biological treatment.

Conservation and management of ecotones by phytoremediation studies are called to play an important role at long-term in freshwater quality.

The “trophic cascade theory”, postulated for the first time in 1992 [2], must be understood before suggesting a definition of biomanipulation and assessing its importance.

The trophic cascade is a theory in which the manipulation of a trophic pyramid level induces modifications in the immediate upper and/or lower levels. These modifications will further create by a cascade phenomenon, changes in upper or lower levels ans so on [6]. When these changes go up the trophic pyramid, the manipulation is called “bottom-up”. On the contrary, when they go down, it’s called “top-down” [l]. Both models are complementary and non-contradictory [2].

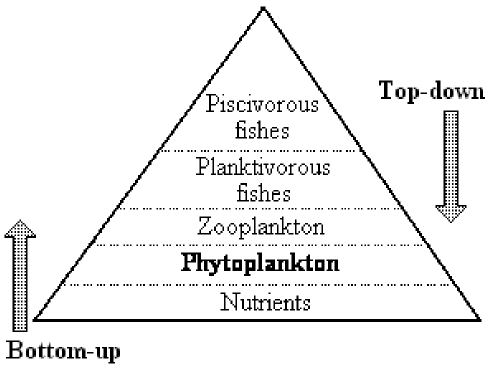

Figure 4. Trophic cascade theory applied to aquatic ecosystems.

The control of the trophic pyramid by “top-down” is biomanipulation [1]. Moss [7] provided a good example of a strategy for the control of internal lake processes through a deliberated ichtyologic community modification {figure 4). On the other hand, the “bottom-up” strategy will consists of a reduction of external nutrients, pollutants and organic matter supplies. The figure 4 shows these manipulations.

The concept was first formulated by Shapiro [1].

3. CONCLUSION

Nowadays, ecology is a well-considered value in the scientific world. Particularly, the complementary effect between ecological solutions to hydrological problems constitutes a paradigm in the search of sustainable projects. The originality of ecohydrology consists of using well-known concepts (e.g. ecotone, biomanipulation) and gathers them in an innovative, integrated and intellectual network leading to a synergy for the aquatic ecosystems management. The paradigm, new for some scientists, should be diffused and spread among all as a modern transdisciplinary approach. Contacts between different scientific groups will serve to build a proactive ecohydrological network, at the catchments scale, which ultimate goals is the management and the perennial of freshwater, essential for life and the economy of territories.

BIBLIOGRAPHY

[1]. **Benndorf, J.,** *Possibilities and limits for controlling eutrophication by biomanipulation,* Int. Revue ges. Hydrobiol., No.80, 1995, p.519-534.

[2]. **Carpenter, S.R., Kitchell, J.F.,** *Trophic cascade and biomanipulation: Interface of research and management,* Limnol. Oceanogr., No.37, 1992, p.208-213.

[3]. **Falkenmark, M., Chapman, T.,** *Comparative hydrology: an ecological approach to land and water resources,* UNESCO editions, Paris, 1989.

[4]. **Fischesser, B., Dupuis-Tate, M.F.,** *Le guide illustré de l'écologie,* Édition de la Martinière – Cemagref editions, Paris, 1996.

[5]. **Hobma, T.W., Gibert, J.E., Mathieu, J., Fournier, F.,** *Hydrochemistry and ecohydrology of the transition area of the Netherlands Delta and the Brabantse Wal,* in "Groundwater/surface water ecotones: biological and hydrological interactions and management options", Cambridge University Press, 1997.

[6]. **Lampert, W.,** *The relationship between zooplankton biomass and grazing: a review,* Limnologica, No.19, 1988, p.11-20.

[7]. **Moss, B.,** *Ecology of fresh waters. Man and medium,* London: Blackwell Science, 1988.

[8]. **Pedroli, B.,** *Ecohydrological parameters indicating different types of shallow groundwater,* J.Hydrol., No.120, 1990, p.381-404.

[9]. **Schnoor, J.L.,** *Phytoremediation of organic chemicals at hazardous waste site. COST Action 837,* Workshop "Phytoremediation 2000 – State of the art in Europe (an intercontinental comparison)", Hersonissos, Greece, 2000, p.21-22.

[10]. **Viville, D., Littlewood, I.G.,** *Ecohydrological processes in small basins,* IHP, Paris, 1997.

[11]. **Zalewski, M., Janauer, G.A., Jolánkai, G.,** *Ecohydrology. A new paradigm for the sustainable use of aquatic resource,* Technical Document in Hydrology, Paris, 1997.

MODELS OF THE MOUNTAINOUS ECOSYSTEMS IN CONCORDANCE WITH CLIMATIC CHANGES

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Abstract: Mountainous forests fulfil a multitude of functions, and climatic changes may have a strong impact on many of them. Modelling approaches have often been used to evaluate the possible impact of climatic change on forest structure and functioning, but little is known about the applicability of the models in changing climate. Light availability, drought stress, summer warmth, and nutrient availability are important for determining tree growth; low winter temperature, browsing, and again light availability are required to model sapling establishment.

Keywords: climatic change, environment, models, mountainous ecosystems.

1. CLIMATIC CHANGE AND MOUNTAINOUS FORESTS

Carbon dioxide and other gases in the earth's atmosphere are relatively transparent to the incoming solar radiation, but they absorb a large portion of the infrared energy radiated back into space [12]. This phenomenon is known as the "greenhouse effect". It causes the average surface temperature of the earth to be 35˚C higher than is radiation temperature as seen from interplanetary space. Without the greenhouse effect, our planet simply would be too cold to support life.

With the onset of fossil fuel burning, large amounts of carbon dioxide were emitted into the atmosphere, causing a steady of its concentration from the preindustrial level of 285 ppm to 335 ppm at present [13]. The palaeoclimatic record shows that the concentrations of carbon dioxide and methane were closely correlated with temperature and have been changing continuously during the last years [6].

During the last 1,500 years the 20-years means of summer temperatures oscillated less than ±1˚C around modern values [4], with some longer warm as well cool periods. Relatively small climatic changes had major impacts on agricultural yield and, consequently, on the welfare of the human population.

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Many studies dealt with the possible impact of climatic change on soils [3], agricultural land, forests [11], and on the whole biosphere [10]. The fate of forests is of particular interest not only from a regional or national, but also from a global perspective: the equivalent of the entire atmospheric carbon dioxide passes through the terrestrial biota every 7 years, with about 70% of the exchange occurring through forests [16]. Thus, climate-induced changes of primary productivity, soil respiration or the areal extent of forests may lead to a significant biospheric feedback to the climate system. For example, many authors [14] hypothesized that the carbon content of temperature forests in the northern hemisphere is currently increasing, thus removing part of the emitted CO_2 from the atmosphere ("missing sink").

Forests in mountainous areas have a multitude of functions: they may protect settlements and roads from avalanches, they regulate runoff and prevent erosion, and they form a part of the largest terrestrial biotic carbon pool. Forests and meadows make a varied landscape and provide the environment necessary for many touristic activities, and – last but not least – forests are exploited for fuel, pulpwood, and timber. Climatic change may have a strong impact on all these functions. Hence studies of the impact of the climatic change on mountainous forests could be of practical relevance to politicians, foresters, and the broad public [15].

The major emphasis of the present study is to contribute to impact assessments of climatic change on mountainous forests. To achieve this goal, the climatic and ecological factors governing the long-term dynamics of near-natural forest ecosystems in this area shall be elaborated.

2. METHODS FOR THE ANALYSIS OF MOUNTAINOUS ECOSYSTEMS

The term "forest dynamics" spans huge ranges both in time and space: the enzymatic reactions of photosynthesis operate within fractions of a second; foliage development takes a few weeks, while tree growth lasts decades to centuries, and the dynamic of soil organic matter span millennia. On the other hand, the germination of a seed takes place on a few square centimeters, a sun fleck moving over the forest floor covers a few square meters; a dominant tree in the canopy occupies 0.01-0.1 ha, and the quasi-equilibrium of a forest landscape may be reached on the scale of several hectares only. One study hypothesized that the central problem in ecology is that of pattern and scale, and that the various temporal, spatial, and organizational scales should be interfaced in order to understand the dynamics of ecosystems [8].

Due to the size of trees, even the measurement of simple indices of forest ecosystems, such as allometric relationships or total biomass, requires much personnel, time, and money. On the other hand, the longevity of the dominant organisms makes measurements on a temporal scale appropriate for the whole ecosystems practically impossible. Not surprisingly, empirical studies of forests typically cover a few years and a few areas at most. For example, many investigations on the direct effects of carbon dioxide on vegetation dealt with the short-term increase of photosynthesis, growth rates of tree seedlings, or competition in model ecosystems.

Unfortunately, ecologists continue to be substantially separated into those who build and use quantitative models, ant those who don't. In fact, ecological models can be neither built nor tested without a sound empirical basis. The "empirical" (field-oriented) and the "theoretical" (model-oriented) approaches have complementary functions and depend on each other: field data serve as a basis for developing and testing an ecological model; on the other hand, sensitivity analyses conducted with the model can be used to test our understanding of the system and to identify research needs, which may serve as guidelines for future field work in the daunting complexity of ecosystems.

3. SPATIAL SCALES AND CORRESPONDING MODELS

Many authors have classified forest models according to a wide variety of criteria [7]. All these classifications concentrate on a few types of models only, none of them covers models across many scales. Thus, the following review of forest models will be organized according to a scheme similar to the one used by Ågren et al.[1]: the classification criterion used here is the spatial scale of the models, ranging from landscape models to physiological ones. Global models are excluded from the review because their large spatial scale renders them inappropriate for a detailed study of the behaviour of mountainous forest ecosystems. Moreover, even the most detailed global models are not capable of predicting species composition.

3.1. Landscape model

Most landscape models view a landscape as composed of patches of ecosystems or vegetation types, or they assume the vegetation cover to be homogenous. Models to predict the distribution of vegetation types on the landscape scale were presented in 1981 [10]. A disadvantage of this approach is that the transition probabilities are aggregate indices which implicitly parameterize many phenomena, including competition and climatic effects. The application of these models in a changing climate thus would require to formulate time-variant transition probabilities. However, such a formulation would not be causal and does not appear trustworthy enough for a study of climatic change.

A major drawback of models on the landscape scale is that none of term was designed to predict the structure of the landscape (e.g. species composition or vegetation types) and its productivity simultaneously. However, both features are of interest in the present study, and landscape models therefore are of limited value.

3.2. Ecosystem models

A large effort for building ecosystem models was initiated by the International Biological Program. Models on this scale typically assume either that a forest consists of a single species or that its composition does not change with time. The temporal resolution of these models is on the scale of hours to weeks, and the compartments ignore any differences between individuals, species, and often even trophic levels.

They take the forest as a functional entity with superorganism-like behaviour. This makes it difficult to apply such models to study the transient behaviour in function of climatic variables. However, they can be quite useful to assess productivity, assimilate allocation, transport mechanisms, and energy flow through ecosystems.

A major problem with models formulated on the ecosystem scale is the lack of sufficient validation data, such as gross ecosystem respiration or the effects of defoliating insects on net primary productivity. Moreover, the scope of these models was to increase the understanding of forests as they are today. This justifies their basic assumptions but renders them inappropriate for studies of climatic change.

3.3. Models using populations and functional groups

Models at this scale were used to simulate the management of single-species stand. Other applications included studies of the interactions between a few populations or functional groups of organisms, most often plants [9]. These models typically were built for management purposes, thus ignoring many ecological factors and emphasizing those aspects of forest ecosystems that are relevant for managers, such as stand structure and wood volume. Most of models neglect climatic effects completely or treat only marginally. Hence their application to study climatic change appears to be questionable.

3.4. Individual-based models

Yield tables commonly used in forest management are a prominent type of static single tree models for monospecific stands. Bossel developed the dynamic model to simulate the effects of air pollution on tree growth; a disadvantage is that model restricted to single species stands. Bossel [2] developed a similar model for tropical forests that explicitly simulates every tree in five distinct canopy layers; yet it still does not allow for changes of species composition. The development of mixed-species, mixed-age stands as a function of their environment was simulated with a very detailed spatial model [5].

Another type of individual-based forest models is based on the theory of gap phase replacement. The model simulates the establishment, growth, and mortality of trees on small patches, a patch being the area that can be dominated by a large canopy tree. Within a patch, the location of a tree thus could be neglected, which avoided the need to use a distance-dependent approach; the prototype is named “forest gap models”. The models include many biotic and abiotic influences on establishment, growth, and mortality of trees. These three processes operate on different spatial and temporal scales; forest gap models couple them explicitly and allow to study their effects on long-term forest dynamics. Moreover, the models integrate processes on different organizational levels, such as the growth of individual trees, competition of tree populations at the patch level, and ecosystem characteristics at the scale of many patches.

Forest gap models are fairly general tools can be used to study a variety of phenomena, ranging from age structure and species composition to primary productivity and nutrient cycling of forest ecosystems. This is a distinct difference to all the other models reviewed above, which were built to answer specific questions; for example, productivity models are not usually capable of treating succession because the choice of state variables implicitly assumes that forest composition is constant. Moreover, forest gap models are an explicit quantification of a sound ecological theory which is consistent with many observations.

3.5. Physiological models

Models of physiological processes like photosynthesis and respiration typically work on time scales of minutes or hours; they simulate tissue development and plant growth. An application on larger time scales and for whole ecosystems is impractical, if not impossible due to the different scales involved. However, these models can give important guidelines about processes to be incorporated into more aggregated models and about the choice of adequate equations for process formulations.

4. CONCLUSION

from the above review I conclude that the forest gap models offer the highest potential for modeling forest dynamics in mountainous terrain: these models bridge several spatial, temporal, and organizational scales, they consider many abiotic and biotic factors explicitly, and they represent quantifications of distinct hypotheses of the factors determining forest dynamics.

BIBLIOGRAPHY

[1]. **Ågren, G.I. et al.,** *State-of-the-art of models of production-decomposition linkages in conifer and grassland ecosystems,* Ecol. Appl., No.1, 1991, p.118-138.

[2]. **Bossel, H., Krieger, H.,** *Simulation model of natural tropical forest dynamics,* Ecol. Modelling, No.59, 1991, p.37-71.

[3]. **Bowman, A.F.,** *Soils and the greenhouse effect,* Proceedings on the international conference “Soils and the greenhouse effect”, Wageningen/NL, 1989.

[4]. **Briffa, K.R. et al.,** *Fennoscandian summers from AD 500: temperature changes on short and long timescales,* Climate Dynamics, No.7, 1992, p.111-119.

[5]. **Ek, A.R., Monserud, R.A.,** *A computer model for the growth and reproduction of mixed species forest stands,* College of Agricultural and Life Sciences, Univ. of Wisconsin, Madison, 1974.

[6]. **Jouzel, J. et al.,** *Extending the Vostok ice-core record of palaeoclimate to the penultimate glacial period,* Nature, No.364, 1993, p.407-411.

[7]. **Joyce, L.A., Kickert, R.N.,** *Applied plant growth models for grazinglands, forests, and crops,* in: Wisiol, K., Hesketh, J.D., Plant growth modelling for resource management, vol.I, CRC Press, Boca Raton, Florida, 1987.

[8]. **Levin, S.A.,** *The problem of pattern and scale in ecology,* Ecology, No.73, 1992, p.1943-1967.

[9]. **Malanson, G.P.,** *Linked Leslie matrices for the simulation of succession,* Ecol. Modelling, No.21, 1984, p.13-20.

[10]. **Prentice, I.C., Sykes, M.T., Cramer, W.,** *A simulation model for the transient effects of climate change on forest landscapes,* Ecological Modelling, No.65, 1993, p.51-70.

[11]. **Schugart, H.H., Prentice, I.C.,** *Individual-tree-based models of forest dynamics and their application in global change research,* Cambridge Univ. Press., 1992.

[12]. **Schneider, S.H.,** *The greenhouse effect: Science and policy,* Science, No.243, 1989, p.771-778.

[13]. **Siegenthaler, U., Oeschger, H.,** *Predicting future atmosphericcarbon dioxide levels,* Science, 1978, No.199, p.388-395.

[14]. **Tans, P.P., Fung, I.Y., Takahashi, T.,** *Observational constraints on the global atmospheric* CO_2 *budget,* Science, No.247, 1990, p.1431-1438.

[15]. **Tranchet, Ch. et al.,** *Klimaänderung: Herausforderung zur Walderhaltung. Ein forstpolitischer Diskussionsbeitrag.* Schweiz. Z. Forstwesen, No.144, 1993, p.5-22.

[16]. **Waring, R.H., Schlesinger, W.H.,** *Forest ecosystems; concepts and management,* Academic Press, London, 1985.

LE CHOIX DES EXPLOSIFS AYANT Á LA BASE LE CRITÉRIUM ”LE DEGRÉ DE POLLUTION”

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Abstract: *Performing blasting works in various fields determines at world level the use of a large quantity of explosives, estimated for 2003 at about 9-10 milions of tons. De pite all advantages caused bz the use of explosives, there are also negative affects regarding the environmental pollution, especially the atmospheric pollution with dust and gases. The theoretical approach with regard to the evalution of atmospheric pollution withdust and gases considers the determination of certain specific parameters, a fact which allows the identification of the pollution degree for various sorts of industrial explosives and implicity to the establishing of technical solutions leading to the reduction of negative effects.*

Keywords: des explosifs, des réactions chimiques, des produits d’explosion, le degré de pollution le degré de poussiérement, des gaz toxiques et polluants.

1. INTRODUCTION

Le critérium actuel de chois des explosifs est le criterium énergétique qui poursuite la détermination de l’énergie nécéssaire pour la fragmentation des roches en correlation avec leurs caractéristique physiques, mecaniques et elastiques, et ayant á la base l’énergie specifique des explosifs se determine le consommation specifique d’explosif et la quantité totale pour un volume des roches connu.

L’acord de Tokio met á l’industrie des charges de diminution du degré de pollution. L’utilisation des explosifs est un processus trés polluant par des gaz toxiques et polluants, par de poussiére dégagés dans l’atmosphére, qui contribuent á la pollution d’environement.

La choix des explosifs faut faire pas seulement par le critérium enérgetique mais aussi par le criterium “du degré de pollution” pour diminuer la quantité des gaz toxiques et polluants et aussi la quantité de poussiére degagés.

Il faut etablir des critéres d’evalution du degré de pollution avec des gaz et de poussiére et de classifier des explosifs en fonction de leurs degré de pollution.

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En principal, la pollution de l’atmosphére par l’utilisation des explosifs est représantée par:

- le lever d’un nuage de poussiére;
- le degagement des gaz rezultés par la réaction chimiques des éxplosifs.

2. POLLUTION DE L’ATMOSPHÉRE AVEC DE POUSSIÉRE

Les tirs representent une importante source de pollution d’air par la formation d’un nuage de poussiére qui se deplace á longues distances en pollutant les sourface situées en voisinage du lieu d’utilisation des explosifs.

Les solutions téchniques de diminution du degré de pollution d’environement imposent la determination des caractéristiques qui se differencient de celles d’atmosphéres par la pression, par la temperature et par le poids specifiques.

En conformité avec la deuxiéme loi de Newton, l’equation de deplacement du nuage est:

$$m \times a = F_a - P \qquad (1)$$

m – la masse des gaz et du poussiére de nuage (kg);
a - la célérité du centre du nuage (m/s);
Fa – la force ascensionale du nuage (N);
P - le poids du nuage (N).

En exprimant m, Fa et P en function de volum du nuage, de densité des gaz et d’air á la temperature du nuage et après la transformation de la equation (1) résulte:

$$a = g\left(\frac{\rho_a}{\rho_g} - 1\right) \qquad (2)$$

avec:
ρ_a - la densité d’air á la temperature T_1
ρ_g - la densité des gaz á la temperature T_2

$$\rho_a = \mu_a \frac{P_a}{R \cdot T_1} \;; \qquad \rho_g = \mu_g \frac{P_a}{R \cdot T_2} \qquad (3)$$

μ_a, μ_g – les poids specifiques d’air et des gaz du nuage (g/mol)
P_a – la pression atmospherique
T_1, T_2 - les temperature d’air et des gaz,
resulte pour „a” l’expression:

$$a = g\left(\frac{\mu_a}{\mu_g} \cdot \frac{T_1}{T_2} - 1\right) \qquad (4)$$

L'analyse de l'equation (4) met en evidance que la valeurs de l'acccleration de deplacement du nuage est en fouction de typ d'explosif, de réaction chimique generée.

Les réaction chimique pour les principaux explosifs utilisés sont:

TROTIL (TNT)

$4{,}40\ C_7H_5(NO_2)3 \rightarrow 11\ H_2O + 15{,}4\ CO + 15{,}4\ C + 6{,}6\ H_2$ (5)

NITRAMON (AM-1)

$11{,}81\ NH_4NO_3 + 0{,}275\ C_{14}H_{32} \rightarrow 28{,}02\ H_2O + 3{,}56\ CO_2 + 0{,}29\ CO + 11{,}82\ N_2$ (6)

NITROGEL

$8{,}38\ NH_4NO_3 + 0{,}785\ C_7H_5(NO_2)_3 + 8{,}33\ H_2O \rightarrow 5{,}495\ CO_2 + 27{,}05\ H_2O + 17{,}93\ N_2 + 0{,}07\ O_2$ (7)

ROVEX 650

$8{,}145\ NH_4NO_3 + 0{,}542\ C_7H_5(NO_2)_3 + 3{,}33\ Al + 7{,}52\ H_2O \rightarrow 1{,}253\ CO_2 + 2{,}541\ CO + 1{,}665\ Al_2O_3 + 8{,}958\ N_2 + 25{,}168\ H_2O$ (8)

DYNAMITE G

$1{,}35\ C_3H_5\ (ONO_2)_3 + 0{,}009\ C_{24}H_{31}O_{38}N_9 + 0{,}17\ C_7H_6(NO_2)_2 + 0{,}3\ C_7H_5(NO_2)_3 + 7{,}1625\ NH_4NO_3 + 0{,}044\ C_6N_5O_5 + 0{,}013\ C_{15}H_{22}O_{10} \rightarrow 8{,}015\ CO_2 + 19{,}3525\ H_2O + 9{,}848\ N_2 + 0{,}7135\ O_2$ (9)

EMULSION EXPLOSIFES

$9{,}5\ NH_4NO_3 + 0{,}2\ C_{14}H_{32} + 1{,}85\ Al + 8{,}33\ H_2O \rightarrow 0{,}725\ CO_2 + 2{,}075\ CO + + 0{,}925\ Al_2O_3 + 30{,}35\ H_2O + 9{,}5\ N_2$ (10)

Les réaction chimiques sont présentées pour 1 kg d'explosif. On détérmine la moyenne pondérée du poids specifique des produits d'explosion en deux variantes:

- sans vapeurs d'eau *μ*;
- avec vapeurs d'eau *μv*.

par les expressions:

$$\overline{\mu} = \frac{\Sigma n_i \cdot g_i}{\Sigma n_i} \quad (\text{g/mol}); \quad \overline{\mu}_v = \frac{\Sigma n_j \cdot g_j}{\Sigma n_j} \quad (\text{g/mol}) \tag{11}$$

n_i,n_j – le numero de molécules de produits gazeux resultées par l'explosion sans vapeurs d'eau (n_i) et avec vapeurs d'eau (n_j).

g_i, g_j – le poids moléculaire des gaz du nuage.

Les valeurs des moyennes pondérées μ et μv et aussi le raport des vapeurs d'eau ($\overline{\mu}$) et des volumes totales des gaz resultés ($\overline{\mu}_v$) sont presentées en tableau 1:

Tab 1. **Les valeurs de μ, $\bar{\mu}_v$ et Va/Vg pour les explosifs analyses**

Explosif	$\bar{\mu}$ **(g/mol)**	$V_a / V_{\rho g}$	$\bar{\mu}_v$ **(g/mol)**
TNT	28	0,333	24,6
Nitramon	31,63	0,541	22,9
Nitrogel	31,75	0,585	24,4
Rovex 650	29,57	0,663	21,90
Dynamite G	35,06	0,51	26,35
Emulsion	29,00	0,67	21,16

L'analyse des données presentées en tab. 1 met en evidence que la plus grande force ascensionale du nuage est réalisée par l'utilisation du TNT et la plus réduite par l'utilisation d'une emulsion éxplosife.

Pour determiner la valeur de la célérité du nuage (a) est nécéssaire de determiner les valeurs Va et V_{pg}:

$$V_a = \frac{m_1}{\mu_1} \cdot \frac{R \cdot T}{P} \;; \quad V_{pg} = \frac{m}{\bar{\mu}} \cdot \frac{R \cdot T}{P} \tag{12}$$

et

$$\frac{V_a}{V_{pg}} = \frac{m_1 \cdot \bar{\mu}}{m \cdot \mu_1} = \frac{n_{H_2O}}{\Sigma n} \tag{13}$$

mv – le poids des vapeurs d'eau;
m - le poids totale des produits gazeux;
nH_2O – le numero des des molecules d'eau;
Σn - le numero totale des molecules resultées.

Aprés la detonation d'explosif, le produits resultées augmenteut en volume et passent d'un état de compression á une détente caracterisée par la temperature T_2:

$$T_2 = T_1 \cdot \left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}} \tag{14}$$

T_1, P_1 – la temperature et la pression resulteés par la detonation d'explosif ^oK;
T_2, P_2 – la temperature et la pression á la fin de la détente;
K – le coefficient adiabatique k = 1,33.
Utilisant les expression du T_1 et P_1 résulte :

$$T_1 = T_o + \frac{Q_E}{C_v} \tag{15}$$

$$P_1 = \frac{\rho_v}{\bar{\mu}_v} \cdot R \cdot T_1 \tag{16}$$

T_o – la temperature initiale d’explosif (^oK);
Q_E – la chaleur d’explosion (Kcal/kg, KJ/kg);
C_v – la chaleur specifique au volume constant.
Aprés la transformation des relation 14,15,16 resulté la valeur T_2.

$$T_2 = \left(\frac{P_2 \bar{\mu}_v}{\rho_v R}\right)^{\frac{k-1}{k}} \cdot \left(\frac{Q_{ex}}{C_v} + T_o\right)^{1/k} \tag{17}$$

La temperature d’explosion T_2 aprés la détente rapportée á la temperature pour trotil (T_{2TNT}) est:

$$\frac{T_2}{T_{2TNT}} = \left(\frac{\bar{\mu}_v \cdot \rho_{TNT}}{\bar{\mu}_{vTNT} \cdot \rho_v}\right)^{\frac{k-1}{k}} \cdot \left(\frac{Q_{ex} + C_v^{ex} T_o}{Q_{TNT} + C_v^{TNT} T_o}\right)^{1/k} \tag{18}$$

Pour determiner le raport T_2/ T_{2TNT} s’utilise des parameters termodynamiques des explosifs analysés tab.2.

Tab.2. **Les parametres des explosifs et les valeurs T_2**

Explosif	**Paramétres**					
	Q_{ex} (kJ/kg)	**T_{ex}**	**ρ_{ex} (kg/m^3)**	**C_v**	**T_2/T_{2TNT}**	**T_2 (^oK)**
Trotil	4522	2700	940	0,78	1	464
Nitramon	3700	2733	800	0,74	0,89	412
Nitrogel T	4316	3300	1300	0,76	0,88	408
Rovex 550	4281	3250	1350	0,75	0,76	352
Dynamite G	4750	3750	1500	0,79	0,95	440
Emulsion explosife	3650	3600	1250	0,77	0,68	316

La relation finale de la célérité du centre du nuage est:

$$a = g\left(\frac{\bar{\mu}_{TNT}}{\bar{\mu}_{ex}} \cdot \frac{T_2}{T_1} - 1\right) \tag{19}$$

Par la determination des valeurs de la célérité pour des explosifs analysés resultent les valeurs de tab 3 :

Tab 3. **Les valeurs de la célérité pour des explosifs analyses**

Type d'explosifs	La valeur de la célérité
Trotil	0,76g
Nitramon	0,179g
Nitrogel	0,19g
Rovex	0,11g
Dynamite G	0,65g
Emulsion explosive	- 0,3g

Les calculs realises pour T_2 et a mettent en evidence que le rayon de distribution du poussier est en dependence de type d'explosif utilisé. Pour trotil et dynamite les valeurs de la temperature T_2 á la fin de detente des produits gazeux sont trés élévées (167° - 191°) et H_2O est sous forme de vapeurs surchauffés, qui justific les valeurs plus grandes de la célérité.

Pour l'emusion explosive la valeur T_2 est 43°C, les vapeurs d'eau se condesent, humectant la poussiere qui se dépose et la valeur de la célérité est negative.

En function de valeur de la célérité les explosifs sont classifies, après le degree de poussierement, ainsi:

- des explosifs puissant polluants a > 0,5 g;
- des explosifs moyen polluants a = 0,25 – 0,5 g;
- des explosifs faible polluants a = 0 – 0,25 g;
- des explosifs trés faible polluants a = -0.3 g – 0.

3. LA POLLUTION DE L'ATMOSPHÉRE PAR L'EMISION DE GAZ

Une autré source de pollution d'atmosphére est l'emision de gaz. Chaque explosif est caracterisé par le dégagement d'un certain volume de gaz représentés de CO2, CO, NO. Le volume de gaz degage est determine par l'expression:

$$V_g = \frac{22{,}4\Sigma n \cdot 1000}{M_{ex}} \quad (\text{l/kg}) \qquad (20)$$

Σn – la somme du numero de molecules des produits gazeux résultée par l'explosion;

Mex – le poids moleculaire d'explosif.

En determinant, pour les reactions chimiques pressentées, les valeurs du volume total de gaz et aussi pour chaque type de gaz resultant les valeurs du tab. 4 :

Tab. 4. **Les valeurs du volume des gaz pour des explosives analyses**

Type d'explosif	**Volum de gaz (l/kg)**				
	Total	**CO_2**	**CO**	**NO**	**N_2**
Trotil	739	-	345	-	147,8
Nitramon	978	79,7	6,5	-	264,8
Nitrogel	1130	123	-	20,4 CO_c* 3,14	398,5

Rovex 650	850	28,06	57,4	-	200,66
Dynamite G	805	179,5	-	20,7 CO_c* 3,96	188,64
Emulsion explosife	954	16,24	46,5	-	212,28

De tableau 4 résulte que tous des explosives sont generateurs de gaz toxiques (CO, NO) au poluants (CO2). La plus grande quantité de gaz polluants est determine pour trotil (345 lCO/kg) et pour dynamite G (200,12 l/Kg), et la plus réduite pour l'emulsion explosife (62,7 l/kg).

En function de la valeur du volume des gaz toxiques et polluants, les explosifs peuvent être classifies ainssi:

- des explosifs trés polluants v > 200 l/kg;
- des explosifs moyen polluants v = 100-200 l/kg;
- des explosifs faible polluants v = 70-100 l/kg;
- des explosifs trés faible polluants v < 70 l/kg.

4. CONCLUSIONS

L'utilisation des explosifs ont une puissante influence sur l'environement par la pollution avec de poussiére et des gaz.

La méthodologie présentée pour l'evaluation des parameters specifiques des explosifs, permet la choix des explosifs en function de degré de poussierement et de pollution avec des gaz.

La diminution du degré de pollution est réalisée seulement par une correctement choix d'explosif qui degage des quantités réduites de gaz toxiques et polluants (CO2, CO, NO) aussi bien un "depoussiérement" du nuage par la condensation des vapeurs d'eau qui humecter le poussiér.

En function de deux parameters specifique (la célérité du nuage et le volume de gaz degage) les explosifs ont été classifies par l'evaluation du degree de pollution – le criterium de base dans la choix de explosifs.

BIBLIOGRAFIE

[1]. **Karkashadze G.G.,** *The problem of dusts reduction by mass blasting on open pi*t UNIVERSITARIA ROPET, 2001.
[2]. **Lețu N., Semen C.,** *Explosifs miniers*, Litografia Universității din Petroşani, 1995.
[3]. **Fodor D., Semen C**. *Influence de l'utilisation des explosifs sur l'environement*, Revue des mines nr. 3,4,5/ 2001.

REHABILITATION OF THE WORKING FLOW LINE AT LIGNITE OPEN-CASTS LOCATED IN OLTENIA

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ŞTEFAN GHIOC***

Abstract: *The achievement of performances comparing with the traditional countries from point of view of energetic coal open pit mining production is possible only by equipments modernization of actual technological lines. The "rehabilitation–new technologies implementation" action is focused on the substantial reducing of functional breaking periods for all of flow sheets equipments. Existing rigging up at coal open pits was used in great part, and for obtaining the required performances is necessary their rehabilitation-modernization, imposing rather great costs. The Romanian economy, in actual stage, is subjected to certain compulsions created especially because the absence of the investments capital and net current assets generated by financial blocking. The consequences of these major compulsions are felt in the steps of modernization and rehabilitation of lignite mining industry, economical sector, which demand the important founds from state budget in the form of subventions and capital expenses.*

1. Why the flow charts need to be rehabilitated

It is possible to reach high performances comparable to the ones in the countries with long traditions in power coal mining in open casts by modernizing the equipment

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in technological flow. They purpose the program for the rehabilitation of the lignite open casts part of SNL Oltenia intents to provide the necessary lignite for CONEL thermoelectric power stations and was drown up based on the analyses performed under the direct assistance of

RHEINBRAUN ENGINEERING Gmbh (RE) Germany (the preliminary expertise in 1990), followed by a „long and short term action plan" and the specification amounting 50 million dollars, of the materials necessary to be obtained from import because the local materials are not suitable from a quantitative and a qualitative point of view.

This action plan focused mainly on the following open-casts: Roşia de Jiu, Pinoasa, and Jilț Sud, the main lignite supplies to Rovinari and Turceni thermal power stations; it also made reference to the other open-casts with respect to a high standard of the dynamic switching over electric equipment.

The total credit granted to SNL Oltenia of 35.7 million dollars and was spent integrally for the modernizations and the rehabilitation of 15 working flow-lines in operation at the said open casts:

- Roşia de Jiu: four mining flow lines and two waste dump lines;
- Pinoasa: one mining flow lines and one waste dump line;
- Jilț Sud: two mining flow lines and two waste dump lines;
- Lupoaia: two mining flow lines and one waste dump line.

The rehabilitation and the modernization of the subassemblies and the high power equipment part of the mining-transportation-waste dumping complex of the operations aims to improve the main operation parameters:

- the intensive use index;
- high annual and hourly outputs;
- a diminution of the outage periods because of the scheduled repairing or of overhaul operations, as well of non intended outage periods.

The rehabilitation and the modernization of the equipment focused on a substantial diminution of the outage periods for the entire equipment witch are part of the working flow line. The current equipment in operation at the open casts is overused so they have to be modernized to reach the required performances, but all this things involve high costs.

At present, the Romanian economy is subject to certain shortages due to a lack of investment money and of current net assets. The consequences lead to a slow modernization and rehabilitation of the lignite extractive industry as this sector needs important funding from the state budget under the form of subventions and capital expenditures.

2.Rehabilitatated open-casts and working flow lines

The proper rehabilitation of the subassemblies found on the essential equipment operating in open-casts consisted in dismounting, a full and complex check-up of all their component elements their recondition aiming to get the characteristics they had at the beginning (and stipulated in the manual of equipment), or their replacement with new reliable elements produced in Romania or imported (rubber carpets, kit for vulcanization, mobile or fixed contacts, relays, etc.).

The modernization and the rehabilitation of the 15 working flow lines at Roşia de Jiu, Pinoasa, Jilț Sud and Lupoaia continued in the other open-casts.

The rehabilitation program of the equipment operating in open casts covered mainly:

- the rehabilitation of the 57 working flow lines in the open casts witch use Sch/Rs 1400 and SRs 1300 excavators;
- the rehabilitation of the 27 working flow-lines witch use MH 6500, A2Rs 6300 and A2Rs 12500 dumpers;
- the modernization of the cutters used on SchRs/ERc 1400 excavators – 54 pcs and SRs 1300 excavators–3 pcs;
- the rehabilitation of 454 high capacity conveyors, with lengths between 1400-2250mm and a total length of 300 Km;
- the replacement of around 640 Km rubber carpets on the belt conveyors operating in open-casts;
- the modernization of the coupling system made of reducer-driving drum for 874 pcs of driving groups on the belt conveyors;
- the rehabilitation of the electric installations and of the control gears at 16 open-casts;
- the dispatching installation for managing the activity at 10 open-casts;
- the supply with the equipment for radio communication at the whole system for surface mining in Oltenia.

3. Strategy for the rehabilitation of the working flow lines for mining transportation dumping operations

In compliance with the programs drown up for the mining units, branches and SNL Oltenia there have been envisaged the following directions to rehabilitate and modernize the main subassemblies on the base equipment operating in open-casts:

- excavators: the proper wheel, the reducing gear, the belt conveyors, the gear that rotates the superstructure mounting of roll bearings on the connection bridge, the turning gear, the crusher, the traveling gear, the resistance metallic construction, the lifting gear of the jib on the bucket wheel and the electric installation.
- high capacity belt conveyors;
- the mechanical part: the fixed and driving station: shockproof wall, scrapers and wipers, cleaning belt, interchangeable traveling system, driving, stretching turning and deviation drum; brake for the main parts, stretching hoist and the electric housing;
- route elements: section units and cross-pieces, connection section unit, rollers, wreaths of rollers and snap hooks;
- fixed and flitting driving station: increasing the incline of the side walls from 30 to 45 new scaling and delta plane type plough in front of the return drum;
- taking over table: increasing the incline of the side walls from 30 to 45 and capstan driving for traveling;
- the electric part:
- power circuit: increasing the reliability of the starting device and improving the power factor;

- driving and protection circuits: a diminution of the start time, simplified electric diagrams, a diminution of the mines of resistances and contacts, increased safety operation;
- dumpers: traveling mechanism, driving reduction gear, support carriage, overfull belt, drive of the turning motion of the overfull belt and the electric installation.

4. Effects of the rehabilitation on the working flow lines existing in open-casts

Considering the variety of the component elements in a working flow line used for mining purposes-transportation-waste dumping and following certain accurate analyses performed on the main and intermediate carriages, high capacity belt conveyors and dumpers, the efforts of rehabilitation focused mainly on poor subassemblies part of the structure of the equipment under analysis.

As a result of the comparative analysis performed on rehabilitated working flow lines in the Romanian lignite open-casts, the following remarks related to technical and economic effects of the rehabilitation can be made:

- an increase of the general use indices, after the finalization of the operation, with values from 0,115 to 0,238 at Lupoaia open-cast, from 0,063 to 0,161 at Pinoasa open-cast, from 0,056 to 0,158 at Roşia de Jiu open-cast and from 0,064 to 0,158 at Jilț Sud open-cast;
- however this values are under the possibilities and have not led to the values reached worldwide in similar mining conditions (minimum 0,35); not even the values witch have been envisaged when the operation started (around 0,22-0,29 have been reached);
- an increase of the intensive use indices up to 0,292 (Pinoasa open cast), 0,302 (Roşia de Jiu open-cast), 0,336 (Jilț Sud open cast), and 0,395 (Lupoaia open cast), but however far away from the values reached worldwide;
- an increase of the extensive use indices up to 0,289 (Jilț Sud open-cast), 0,324 (Roşia de Jiu open cast), 0,347 (Pinoasa open-cast) and 0,411 (Lupoaia open-cast), values witch can be compared to the ones obtained worldwide (around 0,43-0,46);
- an increase of the yearly output however the world output cannot be reached;
- 3 million (m^3+t) of mined rock - for SRs/ESrc 470 excavators;
- 5 million (m^3+t) of mined rock – for SRs 1300excavators;
- 6 million (m^3+t) of mined for SRs/Erc 1400 excavators;
- an increase of the operation period of the rehabilitated flow-lines, reaching 270 and up to 397 hours/months; they are still inferior to the values registered worldwide;
- a diminution of the outage periods due to accidental stops for vulcanization operations. This is the sector where massive imports made with the loan from the World Bank can be found and consequently, this outage periods have been reduced 1,9 times at Pinoasa open-casts, 2,3-3,5 times at Lupoaia open cast, 1,9-2,8 times at Roşia de Jiu, and 2,36-3,53 times at Jilț Sud open cast. After this rehabilitation, the increase registered at Lupoaia open cast is smaller compared to the previous period, but this finding can be put on the account of a poor organization of the technical and the production activities.

Roşia de Jiu open cast registered higher values of the parameters under analysis, but not so high as one expected. Consequently the geological and the mining conditions in this area shall have to be considered and especially those problems raised by a serious drainage and distress of the water bed.

Pinoasa open cast saw considerable increase of the parameters under analysis after the rehabilitation of excavation flow line of E.03 excavator. There has be mentioned to the great importance given to the rehabilitation of this open-cast, both with respect to physical and value – related accomplishment of the rehabilitation and the use of the rehabilitated equipment for monitoring the technical and economic results of this rehabilitation. The results at the end of rehabilitation of all the parameters under analysis show favorable effects, still without reaching spectacular values.

Consequently, one may say that, in order to get a clear picture on the effects of the re-equipment and rehabilitation, the indices of exploitation of equipment and the specific costs shall have to be monitored before and after rehabilitation for minimum one year. These has to be underlined the importance of monitoring the effects of rehabilitation so as a to be able to assess the most accurate possible the efficiency of this action for being able to take relevant decisions on the places and movements where to operate for an larger scale extend of this action.

5. Modernization and reliability of the equipment operating in open-casts

Of all the types of excavators in operation at the open-casts located in Oltenia coalfield, the most suitable ones for the geological and mining conditions existing here are SRs 1300excavators (delivered from the former East Germany by TAKRAFT Company) and SRs 1400 excavators (delivered in totality or in part by KRUPP company or delivered in totality from Romania under KRUPP licensee).

This is the reason why a program for mechanical and electrical modernization of this equipment was started; this operation is performed with outfits and imports for supplement (hydraulic coupling, reducer with planetary gear. From a mechanical point of view, the program for a technical reorganization aims at:

Full modernization:

- replacement of the bucket weal with a fully designed wheel equipped with twenty loading-cutting buckets;
- replacement of the present cylindrical-tapered reduction gear (weighting 43 tons) with a reducer with planetary gear weighting aprox.23 tons; it results a longer lifetime of the metallic structure of the excavator;
- protection to overcharge of the bucket wheel gear by a turbo coupling with the survey of slide.

Partial modernization:

- increasing the ground clearance of the equipment;
- the reconstruction of certain parts of gears, with an increased reliability;
- the use of rubber carpets with steel core;
- diminution the transportation speed of belt conveyors circuits by using transmission gearing with a ratio of I=16.

If speaking about the electric part, after 1997 a new generation of electric driving based on the high power electronics has gained importance to the detriment of the traditional driving. Consequently, the program of reorganization aims at:

- replacing the resistance system which triggers the start of the starting motors both of the belt conveyors along the transportation circuit and of the bucket wheels with asynchronous motors with EMIIB double-caged short circuit motor;
- replacing Ward-Leonard groups and the DC motors as well the resistive systems and the asynchronous motors with winded rotor from the driving of swelling and traveling gears on the equipment with frequency static converters and asynchronous motors with short-circuit rotor;
- replacing the electric apparatus with dynamic commutation by implementing programmable automatic devices;
- replacing the home-made electric apparatus with highly reliable imported electric apparatus;
- mounting installations witch increase the power at 20/6KV transformer stations locally, on the driving motors of the belt conveyors along the transportation circuits nod on the bucket wheels;
- an operational type mounting and with the help of the programmable automatic device of all the gears used for the traveling swiveling operations of the superstructure for rotating the bucket wheel so as to improve the excavating power of the machine.

First of all, these modernization operations have been tested and then they were implemented in relation to the financial possibilities of each open cast. In this respect there is full modernization (excavators, belts, dumpers and partial modernizations (of certain gears and transportation equipment on the flow line).

A qualitative approach involves an assessment of the concrete results (table’s no.1 and no.2) and of the economic results (fig.1) and operating safety of the transportation equipment after modernization.

6. Technical and economics benefits of modernization

Modernization and turning the equipment reliable means the selection of the state of the art electric and mechanic component parts witch involve less maintenance.

The implementation of mechanical and electric modernization of the equipment operating in opencasts has certain benefits:

- it extends the life of the equipment witch can operate in full safety;
- it simplifies a lot the electric diagrams;
- it diminishes a lot maintenance, checking and repairing operations as certain electric machinery and electric component parts (generators and DC motors, asynchronous motors with winded rotor, rheostats with liquid, collectors brushes and brush collar holders, dry resistances rotor contactors, etc.) go away;

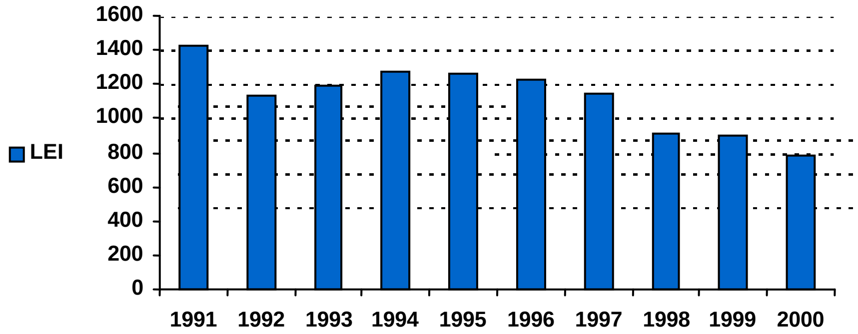

Fig no. 1. Diagram of total expenses for 1000 lei prodution of goods

- an increased electric reliability by replacing the apparatus with dynamic commutation with apparatus with static commutation; a high reliability of the cinematically chair and of the
- electric installation as a result of no moving parts, of a simplified electric diagram, aspects that lead to an improved general index of use of equipment;
- an improvement of power;
- a noiseless operation;
- a low overall weight of the equipment witch doesn't need an extended surface for location;
- a substantial diminution of the specific consumption of electricity with no additional empty running certain installations (the situation of Word Leonard groups from the swiveling and traveling gears of equipment a diminution velocity of the rubber carpet), table no.1.

The physical and psychic strain of operators and of maintenance persons is reduced.

The economic benefits of modernizing the electric parts at Oltenia open-casts are the following ones:

-a diminution of the number of personnel working on the electric part with more than 40% in 2001, compared to the year 1997, consequently the yearly savings with the human labor force reach about 6.6 mil USD;

-the savings with the yearly operating expenses (including the expenses with the electric energy) reach aprox 2 mil USD, (table no.3).

The reuse of the machinery and the electric apparatus taken from the newly modernized equipment and used for the equipment that hasn't been modernized (as spare part) leads to savings with the material expenses.

Table no. 1. Rezults obtained by the modernized SRs 1300

Specification	Rezults					
Equipment	1300.01 Lupoaia	1300.03 Lupoaia	1300.04 Lupoaia	1300.05 Lupoaia	1300.03 Tismana I	1300.05 Roşia de Jiu
Manufacturing No.	513	19003	19004	19005	19011	19012
PIF date	1976	1978	1979	1980	1979	1981
Period of time when the modernization was made	apr – dec”00	mai”00 – mai”01	oct”94– mart”95	jun– sept”95	apr”01 – oct”01	apr”01 – nov”01
Hours of operation starting from PIF date until the moment of modernization, [m^3 + t]	65.745	65.090	43.257	39.453	77.488	51.075
Mass of mined rock starting from PIF date until the moment of modernization, [m^3 + t]	55.593.234	52.801.631	34.936.147	33.260.677	51.251.232	37.553.000
Average hourly output reached between PIF date until the moment of modernization, [(m^3 + t)/hour]	846	811	808	843	661	735
Hourly output reached by the capacity test pieces [mined rock, (m^3+t)/hour]	1.496	1.448	1.415	1.478	1.298	1.479
Hours of operation after modernization on 01.01.2004, [hours]	9.579	8.797	29.684	27.702	6.985	6.689
Mass of mined rock after modernization on 01.01.2004, [m^3+t]	10.105.845	9.650.310	29.980.840	28.311.440	6.537.960	29.625.580
Average hourly output after modernization on 01.01.2004, [m^3+t/hour]	1.055	1.097	1.010	1.022	936	1.020

Table no. 2. Rezults obtained by the modernized SRs 1400

Specification	Rezults							
Equipment	1400.01 Rovinari Est	1400.01 Tismana I	1400.04 Roșia	1400.01 Jilț Sud	1400.01 Roșiuța	1400.12 Jilț Sud	1400.12 Roșia	1400.01 Olteț
Manufacturing No.	2	1240-1242	16	1	23	38	29	14
PIF date	1977	1969	1979	1978	1985	1988	1986	1983
Period of time when the modernization was made	mai”98 - oct”99	sep”98 - mar”00	iun”99 – oct”00	iun”99 - nov”00	iun”99 - dec”00	mai”00 - sep”01	apr”01-nov”01	apr”01-oct”01
Hours of operation starting from PIF date until the moment of modernization, [m^3 + t]	74.925	78.216	52.809	62.826	39.431	33.953	32.217	50.358
Mass of mined rock starting from PIF date until the moment of modernization, [m^3 + t]	64.119.147	58.609.055	41.456.000	51.795.694	30.647.366	25.625.848	23.219.089	35.644.072
Average hourly output reached between PIF date until the moment of modernization, [(m^3 + t)/hour]	853	749	785	824	777	755	721	708
Hourly output reached by the capacity test pieces [mined rock, (m^3+t)/hour]	2.120	1.750	1.769	1.646	1.682	1.685	1.985	1.564
Hours of operation after modernization on 01.01.2004, [hours]	13.748	12.676	11.785	9.568	8.423	6.942	7.596	6.604
Mass of mined rock after modernization on 01.01.2004, [m^3+t]	14.146.690	13.626.700	14.672.325	11.338.080	10.309.750	7.816.690	8.423.960	5.851.145
Average hourly output after modernization on 01.01.2004, [m^3+t/hour]	1.029	1.075	1.245	1.185	1.224	1.126	1.109	886

In the last 5 years, around 5,5 millions USD have been spent by the open-casts formerly subordinated to CNLO Tg.Jiu for modernizing the electric part, but the savings with this modernization reach around 2 millions dollars/year.

Table no.3 Economic results of the modernization performed on the part of the equipment used in the open-casts of Oltenia coalfield.

No.	Modernaization	Amount (pcs)	Cos of investments ($ USA)	Foreseen yearly savings($ USA)
1.	Rotor-static converters (C.S.R.)	194	1892858	545334
2.	Frequency static converters (C.S.F.) for the swivelling gear	77	1103352	278932
3.	Frequency static converters (C.S.F.) for the travelling gear	48	477592	161327
4.	Programmable automatic devices	27	151416	106666
5.	Condensers	380	468201	418000
6.	Asynchronous motors with E.M.I.B.short circuit rotor	45	382500	450000
7.	**Total:**		**4475919**	**1960259**

Note:

1. The table includes the modernization operations performed between april 1997-october 2001
2. The calculations have considered an average currency exchange rate of 28000 lei for 1 $ USA.
3. The values don't include VAT.
4. The values of the modernization performed between 1997 and 2000 where updated for 2001.
5. There has been considered an average period of operation of 3000 hours/year.

7. Conclusions

With no habitation one may say that the programs of rehabilitation have had beneficial effects over the whole activity at Roşia de Jiu, Pinoasa, Jilț Sud and Lupoaia open-casts; these effects extend into the coming years with minimum material costs.

The lasts 25 years have seen an important development of the equipment used at present in open-casts and taking into account the fact that around 25% of the most important equipment used in Oltenia coalfield is in operation for more than 20 years (certain subassemblies are worn out), they have to be replaced with modern and more minimum maintenance operations; consequently claims related to the performances reached worldwide can be put forward.

After rehabilitation of open-casts and marketing the resulted producers, good results have been obtained if compared to the results obtained when operating old equipment:

- an increase of the hourly output for SchRs/ERC 1400 excavators, the most widely used excavator in CNL Oltenia open-casts, from 817 m^3/h to 1175 m^3/h i.e a volume of mined rock of around 4000 (m^3+t)/year;
- a diminution of the personnel involved in servicing/monitoring operations with 5-10%;
- a diminution of the expenses on the electric energy materials and spare parts with 5-15%; all the measures taken for the modernization and turning things reliable

have shown their efficiency and have led to an improvement of the technical and economic indicators of the said open-casts.

The age of equipment, their level of unsafe ness, the moral wear of the component parts of the equipment (from the ’70 es) require a continuation of modernization of all the electric and mechanic equipment, mainly of the excavators with rotor both for extending the life of the life of the equipment and providing a safe operation and for demising the operation costs. Safety, reliability and the specific costs depend on the quality of the component parts aspect that obliges us to make some additional imports from world famous companies.

For increasing the efficiency of modernization, modern dispatching equipment are being installed at SNLO Oltenia open-casts with the end to:

- manage the mining operation;
- monitor the engineering parameters (flow rate, the quantity of coal, operating or outage periods, etc.);
- monitor the energy consumption;
- perform the diagnose analysis of stops.

Taking into account the production capacity of the usual partners (local and foreign) and the low financial support the programmer for the modernization of the main equipment shall last for another 10 years, i.e a maximum for 4 working lines per year.

8. References

1. Bercea N., Petrescu A. şi Băluţă V. – „Modernizarea şi fiabilizarea utilajelor din dotarea C.N.L. Oltenia”, Revista Minelor, nr. 2/2002.

2. Bercea N. şi Petrescu A. – „Stadiul modernizării şi fiabilizării utilajelor de carieră din componenţa unui flux tehnologic de excavare, transport şi haldare la C.N.L. Oltenia”, Revista Minelor, nr. 7/2002.

3.GHIOC, St. – „Durata de viaţă economică a utilajelor şi liniilor tehnologice din carierele de lignit din Româ̦ni”a. Referat de doctorat, Universitatea din Petroşani, 2004.

4. Huidu, Emil – „Monografia mineritului din Oltenia”, volumul I – Bazinul Rovinari 1950-2000, Editura Fundaţiei „Constantin Brâncuşi”, Târgu-Jiu, 2000.

5. ICSITPML Craiova – „Cercetarea ştiinţifică în sprijinul eficientizării extracţiei lignitului prin mine şi cariere”, lucrările prezentate la SITECH Craiova, 1996.

ANALYSIS OF DOCUMENTS REPRESENTING ENVIRONMENTAL AWARENESS IN COMPANY MANAGEMENT

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The social judgement of environment protection, public opinion concerning environmental issues have undergone a substantial change in recent years. As a result, the environmental awareness of the society has been enhanced and environment protectional considerations have gained greater importance in judgements about social issues. This is due to the fact that people are becoming increasingly aware of what damage and probably irreversible changes may be caused in the flora and fauna of the Earth, in the global ecosystem, by human interference.

One of the serious problems of the future is that ever growing production and consumption demand more and more natural resources so that in the last 100 years the exploitation of these resources has reached such a level that the running out of certain resources (minerals, fossil fuels) endangers the living conditions of future generations.

The assessment of environmental performance first appeared in the United States in the 1970s. Ever toughening environmental regulations and the need to meet the expectations of society both contributed to the emergence of environmental auditing. A special reason was represented by accidents taking place at different US companies.

Initially, cases of environmental auditing were exclusively targeted at compliance with environmental regulations. In the USA the number of auditing cases kept on increasing with chemical companies taking the lead first and all the other industries following suit at the end of the 1980s.

One of the examples of environmental performance assessment is the Environmental Self Assessment Programme (ESAP). ESAP was created in the USA with the objective to help companies with the continuous evaluation of their environmental performance. After the example of the USA, environmental audits have spread all over the world.

In Europe the European Bank for Rebuilding and Development (EBRD) published its guidelines on environmental auditing in 1992.

A possible device of the permanent improvement of corporate environmental performance is the documented system of environmental management, which is actually a controlling system incorporating environmental considerations into the management system and operations of the company and thus making environment

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protectional activities more efficient. This way, an environmental management system may be an efficient device in solving environmental problems and tasks.

With the help of the environmental management system, the management:

- sets up the environmental organisation,
- coordinates environmentally related planning, control, monitoring and information supply,
- ensures the proper documentation of the system and its operations.

The setting up of the environmental management system requires teamwork where:

- everybody does his/her best to improve the company’s environmental performance,
- therefore environmental performance is continuously getting better,
- success is becoming a permanent element and motivational factor of corporate culture.

The environmental management system must be set up in the way that it should be able to enforce environmental considerations (maximising favourable effects) and decrease the burden on the environment (minimising adverse effects).

The adoption of environmental management systems involve a number of advantages for the companies, which are as follows:

- work becomes better organised;
- information flow is improved;
- a higher level environmental awareness is developed;
- a better compliance with legal regulations becomes typical;
- there are fewer fines or lawsuits;
- an economical use of resources becomes typical;
- costs go down;
- pollutant emission decreases;
- environmental risks decrease;
- confidence in the company increases;
- the company’s assessment by credit banks improves (it can get credit under better conditions);
- insurance fees go down;
- there are better chances of conquering markets, market share increases (here, of course, the environmental awareness of customers is of decisive importance). This advantage will probably be eliminated parallel with the increase of the number of participants;
- a better relationship is developed with the authorities and local communities;
- company image improves.

The advantages listed above are closely related. Advantages present themselves during the operation of the system but setting up may involve considerable expenses. It is even more important than the advantages for the companies that the application of environment management systems brings positive results for both the environment and society. Such results are:

- compliance with environmental regulations;
- reduction of environmental risks;

- improvement of the employees' environmental consciousness.

As a result, the quality of the environment also improves.

The elements of an environmental management system are:

Environmental Management System

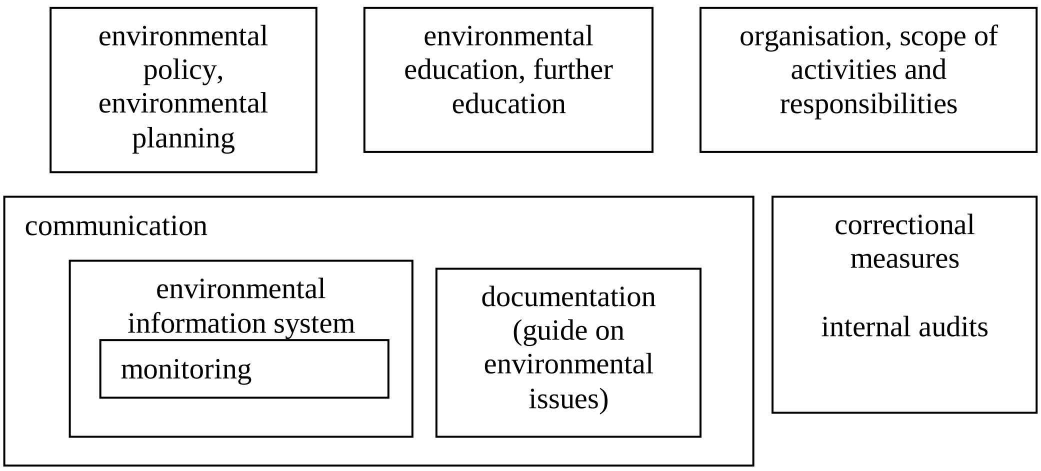

Figure 1 Auditing, management systems, 1997

COMPARISON OF EMAS AND ISO 14001

Features of EMAS

- it can only be registered in the countries of the European Union and in Switzerland
- premises-oriented environment control,
- performance-oriented so it requires the application of the best available and economically viable solution (EVABAT: "economically viable application of best available technology")
- it requires preliminary environmental assessment,
- it sets the requirement of the declaration of environmental policy,
- it requires issuing an environmental declaration certified by an external party, the content of which is fixed,
- its objective is to meet the demands and expectations of the governments, populations and customers of the EU member states,
- it is incorporated in the legal and regulatory system of the member states, which makes its much more prescriptive environmentally,
- the regulation demands immediate compliance with its requirements, otherwise registration is impossible,
- premises fulfilling the requirements are registered and become entitled to using a certification mark,

- in external communication it sets much stricter requirements than the standard; not only remarks from the outside are to be documented, investigated and answered but it should be attested to the certifier, as well, that the company conducts an open dialogue with the customers, the authorities, the press, professional organisations, that is, with anybody interested in the environmental impacts of the activities, products and services of the company,
- it requires a declaration certified by an external party,
- its certifiers are auditors and environmental experts at the same time, allowed to work in all the EU countries but only in the sector defined in their accreditation,
- it is a requirement to have an audit performed by an external expert
- it is a requirement to have an internal audit with its content precisely defined
- pressure groups have greater confidence in EMAS

Features of the standard ISO 14001

- certification is possible in any country all over the world,
- it is applicable to any organisation,
- it is not restricted to industrial companies, takes into account the ecological features of the product, it is more practical, can be better adapted to quality control systems,
- certification need not be done for premises but can be done for the whole organisation, as well,
- in setting their objectives and assessing them, companies should take into account technical possibilities and avoid putting a burden on the environment,
- it mentions continuous improvement as a major requirement,
- it does not prescribe preliminary environmental assessment,
- it requires the declaration of environmental policy,
- it assumes the volunteership of the parties concerned and therefore must maintain a balanced relationship between the demands and expectations of these parties,
- it does not require immediate compliance with legal regulations, the organisation merely has to undertake the obligation for compliance,
- it does not require the issuing of an environmental report checked by an independent external party, moreover it only makes vague references to the form of external information dissemination,
- it is supported by economic pressure groups,
- its auditors are primarily management experts; if there is no suitable certifier available in the given country, he/she can be invited from abroad, as well,
- it requires an internal audit but sets no requirements as to how often it should be performed,
- it does not require any audit performed by an external party,
- it does not set any environmental requirements so the company which possesses a certification under ISO 14001 is not necessarily environment-friendly. Certification merely indicates that the company operates a proper environment

control system, checks and assesses its environmental performance and undertakes continuous improvement. When certification is performed under ISO 14001, the real environmental performance of the company is hardly investigated. What is put in focus is what kind of control the system exerts under the assumption that otherwise there is no problem with the environmental burdens originating from the activities of the company. In accordance with the principles of the standard, it is to be expected that operations on the basis of the environment control system will be efficient in the future, which results in the reduction and elimination of negative environmental impacts. Thus, in the case of ISO 14001 the problem is not so much getting the certification, keeping it is a harder task (experience shows that it is less problematic to get the certificate than to fulfil the requirements of regular supervisions.)

ISO 14001 offers several possibilities of controlling the system:

- the company issues a declaration formulated something like: “Our company possesses an environment-focussed control system in accordance with the requirements of ISO 14001.” Such a declaration is less reliable for the surroundings but may have a favourable effect within the company;
- the company may ask some major customers or even suppliers to conduct an official audit. This way it is possible to convince customers as well as suppliers that the company does operate an environment control system;
- certification by an independent external party is the most widespread and most reasonable solution, and likewise the most attractive for market and communication purposes.

If a company possesses an ISO 14001 certificate issued by an external, accredited party, it only has to make a few extra attestations for getting EMAS certification (naturally where the institution exists):

- honest information dissemination to the parties concerned and to the public
- improvement of environmental performance
- full legal compatibility

EU regulations are not only clearer but “fully ISO 14001 compatible”, as well; annex 1 describing the set of requirements of an environment control system adopts the text of ISO 14011 verbatim. Besides, it sets further requirements (e.g. registration and issuing an environmental declaration).

Experiences, possible problems

Although it is voluntary to adopt ISO 14001, it is obvious that the introduction of environment management systems is a practice spreading rapidly all over the world. Shortly after the publication of the ISO 14001 international standard, in autumn 1996, the European Organisation for Standardisation (CEN) published it unchanged as a European standard, thus superseding the slightly different BS 7750 standard on the same issues. It is to be expected that the certification or registration of environment-focussed control systems will be a primary requirement for maintaining competitiveness on the market. In the future, ISO 14001 and EMAS will compete for popularity. However, it can be predicted that ISO 14001 will spread all over the world as approval and registration under EMAS is only possible in the European Union.

The following diagrams show the number of EMAS registrations and ISO 14001 certificates.

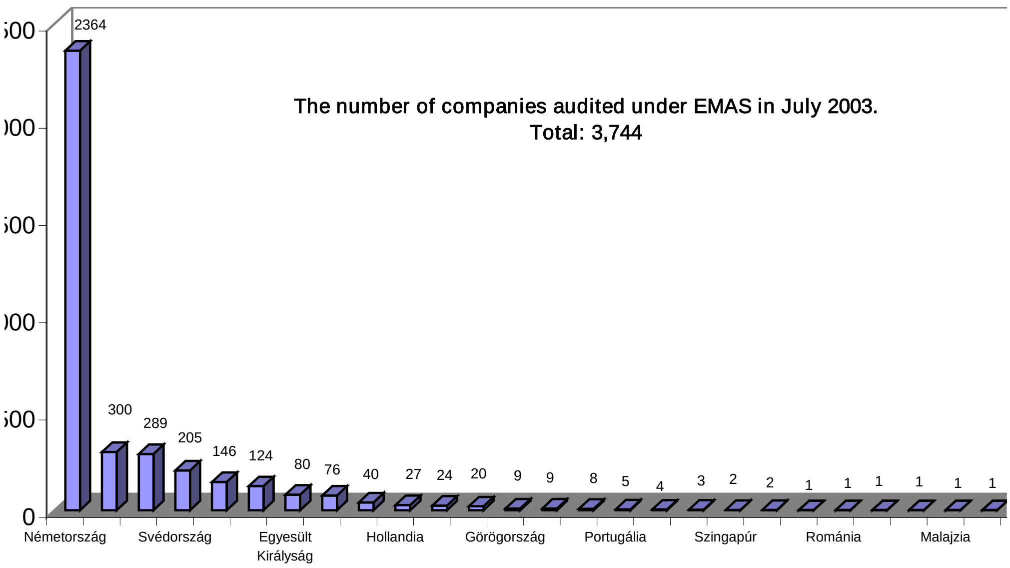

Figure 2

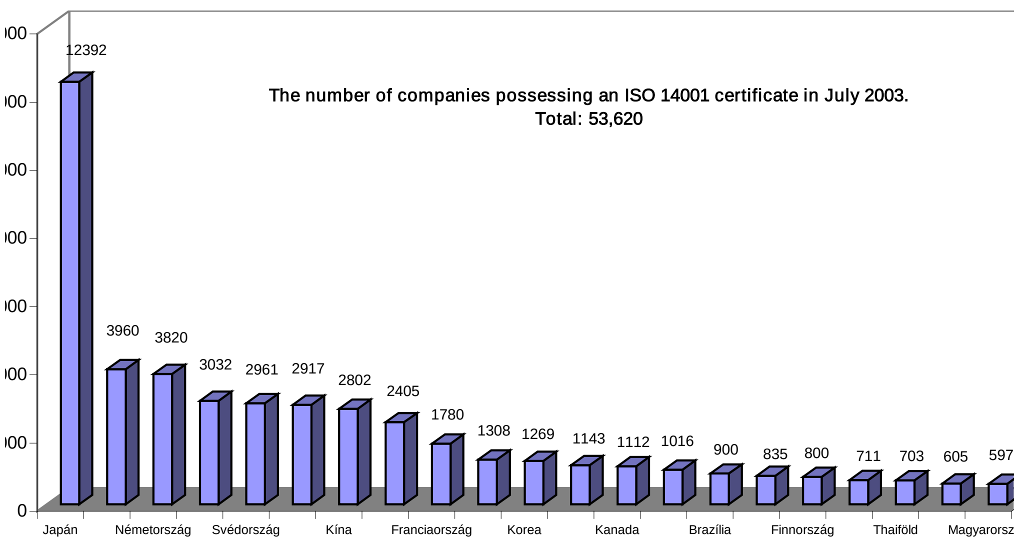

Figure 3

In countries not shown in the diagram: Austria: 500; Czech Republic: 471; Singapore: 441; Poland: 434; Mexico: 369; Malaysia: 367; Norway: 366; Argentina: 308; Hong Kong: 365; Belgium: 264; South African Republic: 264; Indonesia: 229; Slovenia: 192; Philippines: 189; Ireland: 170; Portugal: 151; Turkey: 135; Israel: 112; Egypt: 101; New Zealand: 100; United Arab Emirates: 92; Greece: 90; Iran and Chile: 80; Slovakia: 73; Columbia: 69; Estonia: 67; Lithuania: 51; Croatia: 42; Costa Rica: 40; Russia, Vietnam: 33; Uruguay: 32; Luxemburg: 23; Cyprus, Pakistan: 21; Latvia, Liechtenstein, Peru: 20; Tunisia: 18; Venezuela: 17; Jordan: 16; Morocco: 11; Bulgaria, Nigeria, Zimbabwe: 10; Yugoslavia: 9; Saudi Arabia, Syria: 8; Trinidad & Tobago: 7; Oman: 6; Bolivia, Lebanon, Romania, Sri Lanka, Mauritius: 5; Brunei, Namibia, Paraguay, Puerto Rico, Ukraine: 4; Nigeria, Azerbaijan, Bangladesh, Barbados, Guyana, Iceland, Kuwait, Malta, Monaco: 3; Andra, Bahrein, Belarus, Belize, Botswana, Cameroon, Ecuador, Greenland, Guatemala, Honduras, Macau, Qatar, Senegal, Zambia: 2; Bosnia-Herzegovina, Dominican Republic, Macedonia, Ghana, Kenya, Jamaica, Kazakhstan, Mianmar, Nigeria, Palestine, Panama, Saint Lucia, Sudan, Turkmenistan:1

However, criticisms have also been formulated in relation to EMAS:

- low participation rate of small-scale enterprises (due to, among others, participation fees, although it is a misbelief that auditing would only concern large companies as the interest of small scale enterprises can be enhanced by state subsidies),
- only partial realisation of the advantages expected,
- Regarding confidentiality issues, the expert who gets insight into company matters and records has a high responsibility. Only after clarifying all significant environmental issues can the expert certify the declaration. Therefore it would be necessary to standardise the contents of the declarations, as well.
- It is a negative experience in connection with declarations that a significant percentage of these is hard to understand.
- A more publicity-efficient form of the participation declaration should be elaborated as this would boost not only company images but would also enhance their reputation.
- The text of the participation declaration reveals that the system does not assess the performance of companies outside the European Union, which means that they may show up as the champions of environment protection at home even if they show complete environmental insensitivity outside the Union.
- It discriminates against companies already endorsing higher quality requirements.
- The system may distort competition on both the corporate and member state levels as not only do companies display different levels of environmental sensitivity but they also have to undertake in their policy compliance with environmental regulations different from country to country.
- It does not settle properly the relationship between the right of the public to corporate environmental information and the right of companies to corporate and business confidentiality (according to Article 5, the environmental declaration should include data related to polluting emissions, waste production and raw material import “to the necessary extent”. To define this is a source of conflicts in itself.)
- It would be likewise necessary to extend the scope of the regulation, i.e. that besides the industrial sectors listed in it, other sectors could also take part in the system of EMAS (the regulation itself makes it possible for member states to extend the scope of enterprises eligible for participation in the EMAS on their own in the area of trade

and services. Several member states, e.g. Germany, Great Britain, Spain and Austria are considering it currently.)

- The requirements of the regulation towards experts should be concretised, e.g. it could define the maximum number of audits an expert can perform in a given company without loss of impartiality.
- A considerable part of the literature considers voluntarihood a disadvantage of the system and does not exclude the possibility of participation in the EMAS becoming mandatory later, although it is possible that participation should rather be made more attractive as mandatoriness is alien to the system. As a matter of fact, when the regulation was passed, Germany and some industrial pressure groups prevented making it mandatory.

BIBLIOGRAPHY

1. ***Bándi,Gyula, 2000:*** Környezetjog ('Environmental law'), Osiris Kiadó.
2. ***Bezegh, András, 1996:*** A környezetvédelem szabványosítása a gazdálkodó szervezetek irányításában ('Standardising environment protection in the management of economic organisations'), Környezet és fejlődés VI/7-8.
3. ***Fodor, László, 1998:*** Öko-audit: A környezetvédelmi teljesítményértékelés európai rendszere ('Eco-audit: the European system of the assessment of environment protectional performance'), Sectio Juridica et Politica, Miskolci Egyetemi Kiadó.
4. ***Fodor, László, 2000:*** Integratív környezetjog ('Integrative environmental law'), Bíbor Kiadó.
5. ***Kósi, Kálmán – Kovács, Endre – Kőmíves, József – Varga, József, 1997:*** Auditálás, Menedzsment rendszerek ('Auditing, Management systems') (Környezetvédelmi Kiskönyvtár 5.), Közgazdasági és Jogi Könyvkiadó.
6. ***Kun-Szabó, Tibor, 1999:*** A környezetvédelem minőségmenedzsmentje ('Quality management in environment protection'), Műszaki Könyvkidó.
7. ***Nádudvari, Zoltán, 1997:*** Az öko-auditálás gyakorlati példái ('Practical examples of eco-auditing'), Országos Műszaki Információs Központ és Könyvtár.
8. ***Várnai, Mónika, 1996:*** A vállalati környezet menedzsment rendszer európai szabályozása ('European regulation of corporate environment management systems'), Környezet és fejlődés VI/7-8.
9. ***MSZ EN ISO 14001, 1997***
10. ***"EMAS" regulation No. 761/2001 of the European Parliament and Council***
11. ***Preparatory and auditing materials for environmental control systems***
12. ***www.ecology.or.ip/isoworld/english/analy14k.htm***

COMPARISON AND EVALUATION OF EVAPOTRANSPIRATION CALCULATION METHODS

MARIANNA VADÁSZI*

In the investigation of the problem of flood protection and water management our starting point is usually the water balance equation. In the specification of evapotranspiration it is advisable to separate evaporation of water and soil surfaces and transpiration, i. e. the amount of water coming from the vegetation. In the calculation of the specific items we can work on a physical thermodynamical basis, also taking meteorological features into account. Reliable data can be collected with measurements and observations. The present paper gives a summary of the different calculation methods based on literature research.

In the investigation of evapotranspiration or in a broader sense evapotranspiration first of all let me summarise the major influencing factors. Monograph [1] summarises agricultural factors, monograph [2] the technical ones, i.e. those related to water resources management and flood protection. The extent of evapotranspiration is decisively influenced by three groups of parameters: rock and groundwater specifications, meteorological features and the impact of vegetation. Rock and groundwater specifications include rock moisture content, the depth of groundwater, rock quality and rock temperature. Decisive meteorological features include the amount of precipitation, the moisture content and temperature of the air, and changes in wind direction and air pressure. The impact of the vegetation on evapotranspiration depends on the plant species and their physiological features, the growth of vegetation, light intensity, the root system of plants, their nutrient content, the humidity of the soil, the role of foliage, the temperature of soil and air and the humidity and movements of air.

1. CALCULATION OF THE EVAPORATION OF FREE WATER SURFACES

As regards soil and land covered with vegetation, the value of potential evapotranspiration (PET) must be distinctly separated from the value of actual evapotranspiration (Hungarian abbreviation: TET), the former coming into effect when water shortage does not hinder the process of evapotranspiration. In the evaporation of

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free water surfaces it is not justified to distinguish between potential and actual evaporation as there is no water shortage in this case.

One of the best known methods in the calculation of water surface evaporation is the Penman method. [1] The natural parameters of the function given are saturation vapour pressure depending primarily on the temperatures of land surface and air, vapour pressure measured at a given altitude (generally at 200 cm) above sea level and the effect of wind velocity. The calculation formula contains an energetic and a thermodynamical member and takes the major decisive factors into account in an exact way.

The method of Tanner and Fuchs [1] is a simplified form of the Penman calculation model. The simplification brings several constants and empirical factors into the calculation.

The Szász method [1] takes into account atmospheric factors and processes which have a decisive impact on water evaporation, including: air temperature, the relative moisture content of air, wind velocity and microadvectional boundaries. Unlike other methods, the given formula specifies a relationship that can be used in a correct way and also gives the meaning of the independent variables in the formula.

The Meyer method [1,3] is used to define the evaporation losses of larger water surfaces. Independent variables here include saturation vapour pressure [temperature dependent], vapour pressure belonging to surface temperature, average wind velocity and sea level altitude.

General sources [3,4] also include aerodynamical methods and empirical relationships.

2. CALCULATION OF THE EVAPORATION OF FREE SOIL SURFACES

The methods specifying the natural evaporation of free soil surfaces include: empirical relations, methods based on the turbulent diffusion of water vapour, methods on the water balance of surface soil and those based on heat balance.

The methods of Oldekopp – Schreiber and Budiko [2] define the evaporation of soil surface as the function of precipitation and radiation energy with an empirical relation. The formula suggested by Ramin D. calculates the changes of evaporation as a function of groundwater depth in the knowledge of the evaporation of free water surface. The formula given by Ramdas E. and György Kovács is built up in a similar way. L. F. Meyer gives a diagram to calculate evaporation. The value of surface evaporation is also defined in an empirical way in the formula given by Károly Szesztay [6].

Monograph [2] mentions the methods of M. K. Baranoev, A. A. Dorodnicin, Lutersein – Tsudnovski, M. N. Budiko and M. E. Swetz among the ones based on turbulent diffusion, water balance and heat balance, and also makes use of the measurement data of C. W. Thornthwaite and B. A. Holzman for the constants of the particular formulas.

3. CALCULATION OF POTENTIAL EVAPORTANSPIRATION

It is suitable to give the definition according to monograph [1]: potential evapotranspiration is the amount of water evaporating from a short cut surface of grass under given meteorological conditions in a unit of time provided that the process is not restricted by a shortage of water. According to the references the value of PET is determined by the following meteorological factors: the radiation energy reaching the surface, wind velocity, the degree of saturation of water vapour in the air, air temperature, the temperature of the evaporating surface and microadvectional impacts.

Starting from the method elaborated for the calculation of water surface evaporation, the Penman method gives the degrees of potential evapotranspiration as the function of water surface evaporation.

The Thornthwaite method, primarily suitable for the specification of the total PET of large regions, uses temperature as a primary determining parameter. As regards the applicability of the method it is to be mentioned that, on the one hand, due to the fraction exponent in the formula it cannot be used for negative temperatures and on the other hand, the constant values determined on the basis of the meteorological conditions in the south-western states of the USA, where there are no negative monthly temperature averages, would yield extreme evaporation values under Hungarian (temperature zone) conditions.

The Turc method develops the calculation formula on the basis of global radiation and daily temperature averages.

The Antal method assumes that the increase in both temperature and saturation deficiency enhances evapotranspiration exponentially.

4. CALCULATION OF ACTUAL EVAPOTRANSPIRATION

Actual evapotranspiration (TET), the joint value of evaporation and transpiration with a certain approximation, is the value per time unit of the evaporation of the space round the soil surface covered with natural or agricultural vegetation. The concept of the space round the surface includes: the system transporting and delivering water, the soil, the intermediary subsystem, the vegetation, the subsystem absorbing and transporting water vapour, the surface and the air above the vegetation. [1]

Three sets of factors of environment physics determine the value of actual evapotranspiration: the factors of potential evapotranspiration, the water supply and water balance of the soil and the hydrobiophysical features of the vegetation.

Taking into account the triple distribution of the water delivery system, the following possibilities of the quantitative definition of evapotranspiration arise [1]:

- aerodynamics methods are based on the physical parameters of the subsystem absorbing and transporting water vapour,
- the energy traffic components of the three subsystems, including those of evaporation can be determined with methods based on the principle of the conservation of energy,
- the application of methods based on the principle of the conservation of mass makes it possible to specify the components of soil water balance,

- the complex specification methods jointly apply energetics and aerodynamics principles.

Sources on different methods do not always specify for a given method what physical principles it is based on, therefore I do not think it necessary to give a strict classification.

The Thornthwaite – Holzman method regards water vapour concentration and wind velocity as decisive parameters.

Konstantinov also draws up calculational relations according to the principles of aerodynamics, with two independent variables, vapour pressure as measured at a height of 2 metres and daily air temperature average, both remaining in a formula simplified on the basis of experimental results. [1]

The Monin – Obuhov method has a solid theoretical basis and is widespread all over the world but its application requires the use of a computer. The relatively complicated formula incorporates altitude, water vapour pressure, temperature and wind velocity values. [1]

The E. Antal formula starts from the value of potential evapotranspiration and calculates the value of TET using correction factors including a vegetational constant and air moisture content.

The Blaney – Criddle and Blaney – Morin calculation formulas take temperature, daylight hours (heat of radiation) and available precipitation into account.

The calculation methods of A. R. Croft and L. V. Monninger are practically based on the principle of the conservation of energy, drawing up a water balance equation. [2]

In determining TET, the Turc method takes precipitation and annual average temperature values into account. [1,3]

Based on empirical data, the Kuzin method gives a diagram to estimate the monthly value of evapotranspiration as the function of monthly mean temperatures. The diagram refers to ‘cold’ climate conditions, so in Hungary it can be used to calculate the monthly distribution (%) of evapotranspiration.

There are several other methods to calculate actual evapotranspiration, which are more or less based on principles similar to those of the methods mentioned. Hungarian authors include e. g. I. Oroszlány, L. Erdős and Á. Pintér, of the foreigners A. R. Konstantinov, B. F. Puskarev, K. P. Samolina, G. Yamamoto, Polhauser and Éliás can be mentioned. [2]

5. SHORT EVALUATION OF THE METHODS PRESENTED

The methods presented are basically evaluated according to the general Hungarian sources [1,2,3]. The methods essentially assume that evapotranspiration (in the broader sense) is the result of a consistent process taking place in the system of soil – vegetation – air.

The methods based on aerodynamics features take into account as basic parameters air temperature, the values of water vapour (steam) pressure measured at different altitudes above soil surface and those of humidity (moisture content) as well as the specifications of wind – air velocity (vertical water vapour transport) as the physical state characteristics of the system absorbing water vapour.

The methods based on the principle of energy conservation take into consideration the energy (content) of soil and air as well as the thermodynamical characteristics of evaporation and evapotranspiration according to the radiation balance.

The methods assessing the features of mass conservation and water balance strive to define the extent of actual evapotranspiration on the basis of the factors of precipitation, inflow, runoff, seepage and capillary flooding. As some of the factors listed above are difficult to measure, actual calculations rely on the specification of the values of monthly temperature averages, precipitation, average saturation deficiency and potential evapotranspiration, however.

Besides the basic parameters involved in the other three methods, biophysical ones also take the characteristics of the life cycle of natural and agricultural vegetation into account with special weight. This means that besides the specifications of air and soil temperature, and features of aerodynamics (wind) and water balance, the parameters of vegetation (development stages), agrotechnical characteristics and the energy flow-energy balance parameters of parts of the day (night, daylight) also function as independent variables in the determination of actual evapotranspiration. In these calculations the theory of the so called direct current analogy e. g. represents a special method. [1]

In drawing up the particular formulas the different methods specify constants (coefficients, exponents) connected to meteorological and other features, in relation to the (given) region studied. In general, it does not even turn out on what kind of natural feature(s) and to what extent these constants are dependent. As regards the generally empirical formulas to be found in the sources, it often cannot be found out what dimensions the author uses.

The analysis of methods leads to the general conclusion that there is no real ‘general’ formula, calculation method or diagram that could be applied to any region in every month.

Based on what has been mentioned above, I think that in the analysis of flood protection – draining – bailing in mines as well as in that of floods (surface runoff) primarily applicable data are provided by the data sets characteristic of annual averages for a longer period and of larger areas, which are often projected onto maps, as well.

6. BIBLIOGRAPHY

[1] Szász, G., Tőkei, L.: **Meteorológia (mezőgazdáknak, kertészeknek, erdészeknek)** Budapest, Mezőgazda Kiadó, 1997.

[2] Juhász, J.: **Hidrogeológia.** Budapest, Akadémiai Kiadó, 1987.

[3] Zsuffa, I.: **Műszaki hidrológia I.** Budapest, Műegyetemi Kiadó, 1996.

[4] Szesztay, K.: **Hidrológia. II.** Budapest, Tankönyvkiadó, 1975.

[5] Ubell, K.: **A szabad vízfelület párolgása.** Budapest, Vízgazdálkodási Tudományos Kutató Intézet, 1952. 31. old.

[6] Szesztay, K.: **Hidrológia. I.** Budapest, Tankönyvkiadó, 1970.

[7] Kovács, Gy.: **A tényleges evapotranspiráció meghatározása.** Hidrológiai Közlöny 1983. 12.szám 534-543. old.
[8] Thorthwaite, C.W.: **Report of the Committee on Transpiration and Evaporation** 1943-1944 TAGU 1945
[9] Thortwaite, C.V., Holzmann, B.A.: **Measurement of evaporation from land and water surfaces.** Washington, US Department of Agriculture Technical Bulletin, No. 817 May. 1942
[10] Wilm, H.G., Thornthwaite, C.W.: **Report of the Committee on Transpiration and evaporation.** 1943-1944

HISTORY, MODERN STATE AND DEVELOPMENT PROSPECTS OF ROCK MECHANICS

G. PIVNYAK*, A. SHASHENKO*

The history of geomechanics development covers comparely not a long period since the beginning of last century tills our days. From 1904 M.M. Protodyakonov publishes cycle of articles dedicated to a problem of mining pressure, which later becomes the base of his monography "Mining rock pressure to mining support" published in 1907. That was first great theoretic work in the field of rock mechanics. There was considered a hypothesis of natural balanced arch over mining works and described the calculation method of supports for not deep mines. So development of geomechanics in Russia began.

V.Budrik's works in the field of mathematical modelling mechanical processes in a rock mass at working off of layers of coal with longwall method became the beginning of geomechanics development in Poland. Ideas of V.Budrik have been after advanced in works of his disciples A.Salustovich, S.Knote, E.Litvinishin etc.

In 1911 T.Karmman's works on research of mining rocks in conditions of thorough compression appeared. He checked the correctness of Moor's theory there. Moor's theory of durability received wide application later in the decision of tasks of a limiting condition in geomechanics.

In 1920-1950 O.F.Graf, F.A.Belaenko, A.A.Borisov, V.Budrik, F.K.T. Van-Iterson, R.Kvapil, M.I.Koyfinan, G.N.Kuznecov, V.D.Slesarev, A.Salustovich, D.S.Rostovcev, A.I.Celigorov, P.M.Cimbarevich and others authors' works were published. It was dedicated to questions of mining pressure definition to a support, investigation of rock physic-mechanic properties, rock stability. Researches of this period are mostly based on simple models of mediums and explored objects.

Later in 1950-1980 fundamental works in the field of mining pressure based on limiting condition theories (V.V. Sokolovsky, N.N. Maslov, G.L. Fisenko, V.N. Zemisev, Stomatiu, etc.), on theoreis of elasticity, plasticity and creep (F.A. Belaenko, V.V. Vinogradov, J.S. Erjanov, L.V. Ershov, B.A. Kartozia, A. Labass, U.V. Liberman, G. G. Litvinskiy, L. Y. Parchevskiy, A. G. Protosenya, K. V. Ruppeneyt,

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M.M. Rozovskiy, R. Fertner. A.N. Shashenko, E.I. Shemyakin and others) were published. In that period the articles where the natural massive was considered on a base of statistic models appeared (I.V.Baklashov, M.A.Dolgih, V.V.Matvienko, L.Y.Parchevskiy, K.V.Rupeneyt, A.N.Shashenko, V.I.Sheynin and otrhers).

In the same time deep investigation in the field of rock destruction, including controlling loading mode, were conducted in such well-known geomechanic scientific-research centers as VNIMI, Mining institute named by Skochinskiy, 1GTM MAS of Ukraine, Dnepropetrovsk mining institute, Doneck polytechnocal institute, Leningrad mining institute, Moscow mining institute and others leading scientific research centers in SAR, Japan, England, Poland.

Reviews of this researches by V.V.Vinogradov, Z.Benyavskiy, A.Cook, A.N.Stavrogin, L.I.Baron, E.I.Ilnitskaja, J.M.Kartashov, Z.Klechek, G.N.Kuznetsov, B.V.Matveev, T.Majherchik, A.G.Protosenja, V.V.Rzhev, V.S.Jamshchikov, G.T.Kirinichanskiy and by other authors were done. It allowed to create qualitatively new models of the rock mass, to put and solve elastic - plastic tasks in new statement.

By that time independent direction in rock mechanics was formed. It was connected with research of mining pressure gas-dynamics showing: sudden throwing out of coal, rock, gas, mining blow (S.G.Avershin, B.Drzhezla, Z.Klechek, I.Dubinsky, M.Chudek, L.N.Bikov, A.N.Zorin, I.M.Petuhov, V.V.Hodot, E.I. Shemyakin and others).

Deep studies of surfaces movement under influence of mining were carried out. They are S.G.Avershin, V.F.Galahov, V.N.Zemisev, M.A.Iofis, S.Knote, E.Litvinishin, R.A.Muller, V.I.Mjakenkij's works and other authors.

In that period such often event like floor heave in mining workings was explored (P.M.Cimbarevich, V.D.Slesarev, A.P.Maximov, Y.Z.Zaslavskiy, I.L.Chernyak, V.A.Litkin, V.T.Glushko, A.N.Shashenko and others).

A large piece of work on exploring of mining pressure showing in natural conditions was carried out by scientific collectives under the rule of V.T.Glushko, Y.Z.Zaslavskiy, A.N.Zorin, A.G.Krupennikov, K.V.Koshelev, A.P.Maximov, T.Majherchik, I.D.Nasonov, G.I.Pokrovskij, I.L.Chernyak and others.

In the same time wide laboratory research on geomechanical processes modeling (G.N.Kuznecov, G.I. Pokrovskij, V.F.Trumbachev and others) had lean provided.

In 70-80 determinative models in geomechanics were explored deep enough. As a rule, they were led to research of single long gallery stability, which was the main structure unit of underground objects. Determinative model required idealization of the research object (mining working, rock mass), and boundary conditions. This circumstance allowed to use solid mechanic techniques and to get distinct solutions of tasks. But comparing natural measuring and analytical calculations showed that high idealization of the object in geomechanics leads to a such situation: a range of results in natural conditions, fluctuated around a forecasted result, correspond to a single distinct result in theoretical calculation. The reason of these deflections is the range of factors, which were not included into physical model because of their unimportance (for a first view).

This circumstance makes distrust of designers and practical engineers, compelling them to correct analytical calculations and to accept technological and technical parameters intuitively, first of all basing them on experience of underground building in similar mining conditions. This way allows to make optimal engineer decisions very rarely, what leads to adding expenses for recovering mining works or superfluous increasing stability and costs of support. It is especially seen in mines, which were built in difficult mining-geological conditions in Eastern and Western Donbass, Krasnoarmeysk coal region, Lvov-Volyn coal region etc.

Obviously the reason of such situation is the unconformity of determinative models with real objects. It is impossible to forecast a behavior of such difficult object like rock mass, which includes a mining working, using only models where everything is defined and there is no place for an accident. Any high-organized system is formed and exists effectively when it has some internal unstability. Then the strict connection of one structural units, existing by action of some common physic laws, would not make any strong restrictions to others elements, which should have an opportunity to be changed with a random way.

It shows that geomechanical researches should be based on stochastic models, which are more complicated and reflect fluctuation of parameters around determinative values. Understanding of this problem has led to occurrence of some researches based on probability models during last 15-20 years (K.V.Rupeneyt, L.Y.Parchevskiy, A.N.Shashenko, S.B.Tulub, V.P.Pustovoytenko, G.T.Rubec, E.A.Sdvijkova and others). Spectrum of these works is wide enough: strength - strain state of rocks, floor heave, building expense optimization for long underground objects, deformation of support, quick analyze of managing decisions etc.

Now we can surely say that statistic geomechanics became the independent branch of science about mechanical processes, taking place in rocks.

At the end of 80-th geomechanical models became so difficult, that using analytical methods (as they are) stopped to be effective. At that time personal computers became more powerful and accessible for carrying out researches. With the development of personal computers numerical methods became very effective. There are researches by B.Z.Amusin, J.S.Erjanov, T.D.Karimbaev, S.Krauch, L.V.Novikova, E.A.Sdvijkova, A.Starfield, B.A.Fadeev and others.

This direction in geomechanics is considerable and perspective.

Combination of continuum and discrete medium methods with new geoinformation technologies, geophysics, theory of mathematical statistic make the base for creating of global geomechanical computer system monitoring. Then exploration of underground space became more effective and safety.

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.

· (14 points)

· (14 points)

The first name and the family name will be written with CAPITAL LETTERS, BOLD, CENTERED, 130 mm width, Times New Roman, 12 points, each name being followed by asterisks, *and in the footnote the didactic and scientific degree, the position and place of work of the authors (possibly fax, E-mail) are indicated, with italics, 130 mm width, Times New Roman, 11 points.*

· (12 points)

· (12 points)

<Tab> **Abstract: (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, 10 points.

· (10 points)

· (10 points)

<Tab> **Key words: (Times New Roman, 10 points, bold)** 5 – 10 words, in English, along the entire width, Times New Roman, 10 points.

· (10 points)

· (10 points)

· (10 points)

<Tab> **1. THE TITLE OF THE CHAPTER IS WRITTEN WITH CAPITAL LETTERS, BOLD, TIMES NEW ROMAN, 11 POINTS AND WILL BE NUMBERED WITH ARABIC NUMBERS.**

· (11 points)

<Tab> The paper text paragraphs will be left – right aligned. The lines of the entire text will be single spaced with Times New Roman fonts, size 11 points.

The paper will be edited in a language of international circulation (English, French, German) on A4 format (210 x 297), page setup: top 5,6 cm, bottom 4,6 cm, left 3,7 cm, right 3,7 cm, in WORD or WORDPERFET or WINDOWS. The size of the symbol is given next and is written in the instructions used to assist in editing the text. It indicates a blank line and does not show in the text of the paper, being obtained by pressing <ENTER>. The size of a <Tab> is 1,27 cm. No blank line is left between the paragraphs. Between the last line before the title and the title of the chapter and between the title and the first next line a blank line is left for each.

**Professor, Ph.D. at the University of Petroşani*

<Tab> **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 and the numbers are Times New Roman, 11 points, bold.**

· (11 points)

The text is written in new paragraph and not continuing the subtitle, an 11 point blank line being left between the subtitle and the following text.

· (11 points)

2. PRESENTATION OF THE FIGURES

· (11 points)

Figures should be enclosed in the text in the order of their presentation, as far as possible on the page where reference is made to them. They shall be numbered with Arabic numbers. Black – and – white, high contrast figures are recommended. Photos can be used as well, but they should be of good quality, clarity and sufficient contrast. The figures will have a legend (name of the figure), which, along with the number, will be written underneath with Times New Roman, 10 points, centered as to the figure. The figures will be surrounded by text.

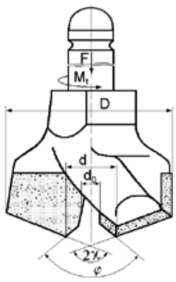

Fig. 1. Detachable bit

· (11 points)

3. PRESENTATION OF THE TABLES

· (11 points)

The tables will be enclosed in the text, a 10 points blank line being left above and under the table, and will be numbered with Arabic numbers. Both the number and the explanations to the table are written with Times New Roman, 10 points, italic, for the number and bold for the explanation to the table, centered in the space of the table and above it. The table entries will be Times New Roman, 10 points, bold, and the data in the table will be Times New Roman, 10 points. The thin lines of the table will be ½ points (0,02 cm), and the thick ones will be ¾ … 1 points (0,03 … 0,04 cm).

· (11 points)

4. PRESENTATION OF THE MATHEMATICAL EQUATIONS

· **(**11 points)

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.

· (8 points)<Blank line 8 point high>

$$X^2 + Y^2 = Z^2 \tag{1}$$

· (8 points) < Blank line 8 point high>

An 8 point high blank line is left between the last line before the relation and the relation and between the latter and the next first line.

The last page will be at least 2/3 full.

The pages of the paper will only be numbered by a pencil outside the printing space.

· (11 points)

BIBLIOGRAPHY (will be written according to the model, Times New Roman 10 points).

· (10 points)

[1]. Marian I., *Mecanizarea în minerit,* Editura Tehnică, Bucureşti, 1969.

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