ISSN 1454-9174

ANNALS
OF THE
UNIVERSITY OF PETROSANI

MINING
ENGINEERING

vol. 14 (XXXXI)

UNIVERSITAS PUBLISHING HOUSE
Petroşani – ROMÂNIA, 2013

ISSN 1454-9174

EDITOR OF PUBLICATION
Prof.dr.eng, Ioan – Lucian BOLUNDUŢ

ADVISORY AND EDITORIAL BOARD OF MINING ENGGINEERING ISSUES

ADVISORY BOARD

Prof. PhD. Eng. Victor ARAD	University of Petroşani
Prof. PhD. Eng. Andrei KORCEAK	Moscow State Mining University Russia
Prof. PhD. Eng. Lev Alexandrovich PUCHKOV	Moscow State Mining University Russia
Prof. PhD. Eng. Victor HARCENKO	Moscow State Mining University Russia
Prof. PhD. Eng. Vladimir LITVINENCO	Moscow State Institute-Sankt Petersburg Russia
Prof. PhD. Eng. Raimondo CICCU	University of Cagliari - Italy
Prof. PhD. Eng. Carsten DREBENSTEDT	Technische Universitat Bergakademie Freiberg - Germany
Conf.dr.ing. Ventzislav IVANOV	University of Mining and Geology – Sofia - Bulgaria
Prof. PhD. Eng. Zacharis AGIOTANTIS	Technical University of Crete - Greece
Prof. PhD. Eng. Sukumar BANDOPADHYAY	University of Alaska – Fairbanks, S.U.A
Prof. PhD. Eng. Hani MITRI	McGill University – Montreal, Canada
Prof. PhD. Eng. Gheorghe MORARU	Universitatea Tehnică a Moldovei – Chişinău, Moldova
PhD.Eng. Raj SINGHAL	Int. Journal of Mining, Reclamation and Environment - Canada
Prof. PhD. Eng. Işik YILMAZ	Cumhuriyet University – Turcia
Prof. PhD. Eng. Ingo VALMA	Tallin University of Technology - Estonia

EDITORIAL BOARD

Editor-in-chief:	Prof. PhD. Eng. Ilie ONICA	University of Petroşani
Associate editors:	Prof. PhD. Eng. Viorel VOIN	University of Petroşani
	Prof. PhD. Eng. Dumitru FODOR	University of Petroşani
	Prof. PhD. Eng. Mircea GEORGESCU	University of Petroşani
	Prof. PhD. Eng. Ioan DUMITRESCU	University of Petroşani
	Assoc. Prof. PhD. Eng. Ioel VEREŞ	University of Petroşani
	Assoc. Prof. PhD. Eng. C. BĂDULESCU	University of Petroşani
	Assoc. Prof. PhD. Eng. Tudor GOLDAN	University of Petroşani
Editor Secretary:	Lecturer PhD. Eng. Emilia DUNCA	University of Petroşani
	Assist. Prof. PhD. Eng. Daniela CIOLEA	University of Petroşani

Editorial office address: University of Petroșani, 20 University Street, 332006, Petroșani, Romania, Phone: (40) 254/54.29.94, 54.25.80, 54.25.81, 54.25.82, 54.97.49, Fax. (40) 254/54.34.91, 54.62.38, www.upet.ro, E-mail: ibol@upet.ro

CUPRINS

ENERGY PRODUCTION COMPETITION THROUGH THE CHANGE OF THE MINING TECHNOLOGY OF THE MINES OF HUNEDOARA ENERGETIC COMPLEX

VALERIU PLEȘEA[*]
SORIN MIHAI RADU[**]

Abstract: *The economical impact ant the worldwide population increase is moderated by the decrease of the demand of electric energy, as an effect of the structural changes of the economy, the technical progress and the increase of the price of energy. The global market for energy shall be dominated by combustible fuels, their proportion being considered to reach almost 80% of the demand in 2030. Oil, natural and schist gases shall remain the main energetic resource, representing approximately 35% of the demand, the percentage of coal being 30%. By 2030, almost two thirds of the increase of coal supplies will be brought from Asia. As the single and most important player on the energy production market by burning black coal, Hunedoara Energetic Complex – HEC, through its Mining Branch, has the task of increasing the efficiency and improve the underground coal extraction technology, in order to situate the render the complex coal extraction process economically efficient considering the characteristics and rules of a free market, as well as the requirements demanded by labour safety conditions and ore protection. The paper brings forward, considering the undermined front coal exploitation method the proportion of which reaches 65% for the realisation of the total production on the entire coal basin, some of the technical mechanisation solutions of the main operations which define a complete coal face cycle.*

Key words: *coal, exploitation, mechanisation, energy, explosion, coal front.*

1. GENERAL CONSIDERATIONS

As an effect of the actions undergone to improve the efficiency by reducing the exploitation activities HEC, respectively Petrosani Mining Branch Subdivision, as well as the sustained efforts by the mining staff of the four viable operational mines, namely Petrila, Livezeni, Vulcan, Lupeni, the basic nucleus of the black coal extraction process was maintained, supplying to the traditional beneficiaries, respectively to the two main central heating power plants, Mintia and Paroseni, a good quality coal, proving therefore through the recorded accomplishments, a state of economic-financial stability.

Considering all the efforts gone through in order to improve the mining of black coal, the obtained results are not the most illuminating, the entire activity of

[*] *Ph.D. Eng., 1st Degree Scientific Researcher, University "Constantin Brancusi" Tg. Jiu*
[**] *Professor Eng., Ph.D., at the University of Petroșani, sorin_mihai_radu@yahoo.com*

Deva Mining Branch of HEC being touched, on one hand by the rules of the coal market and energy prices, materials and machineries which are bought on the free market, and on the other hand the lack of high productivity technologies and economic efficiency.

The undermined front coal mining method has developed lately considering the participation proportion to the total amount of production on the entire coal basin, recording by the end of the past year approximately 65.2% (Figure 1), out of which, depending on its technological application solutions, 28.3% represent the participation to the mining of reduced inclination layers (α < 25) – the case of Livezeni and Lupeni viable mines, while the difference of approximately 36.9% is recorded in the case of the mining of medium inclined layers ($\alpha = 25^0 - 45^0$) respectively large inclination layers ($\alpha > 45^0$) – in the case of Lonea and Vulcan viable mines and partially in Lupeni mine [1], [3].

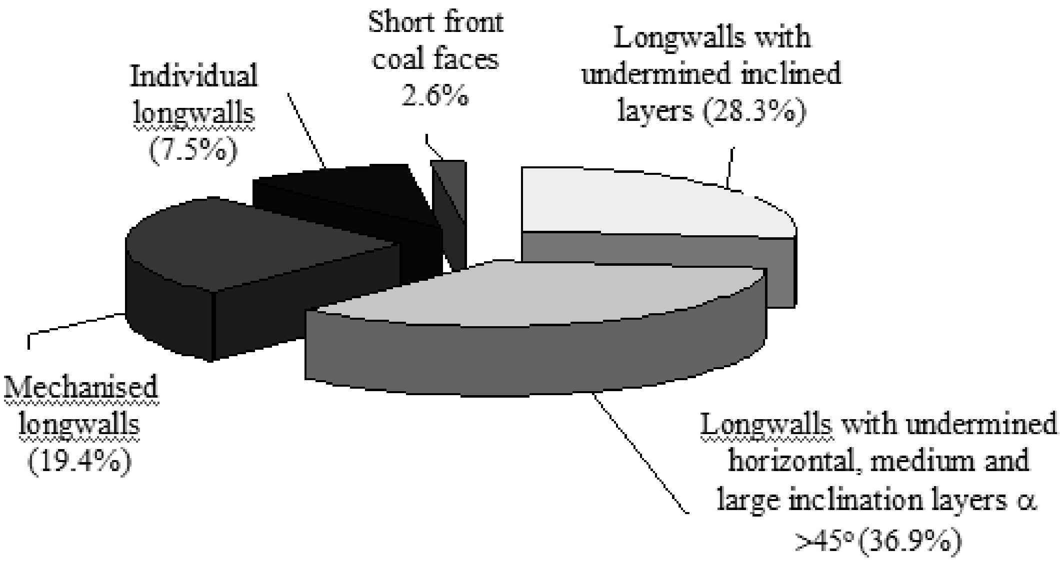


Figure 1. The type and participation proportion of mining methods towards the realisation of the total production per coal basin

Observation The difference of 5.3% is represented by the proportion of the production resulted from the digging of mining preparation works on each layer

The introduction and the application of the undermined coal front method, using a classic individual roof support, has meant a step forward, but the limited technical possibilities and the modest technical-economic indicators are reflected in the financial results which are situated bellow the forecasted limit threshold of profitability. Therefore, changing the technology by mechanising the operations for undermined faces is implied, being an objective requirement, considering as well the possibilities to ensure the performance limits and the quality of coal.

2. OPERATING EQUIPMENTS AND POSSIBILITIES FOR THE MECHANISATION OF THE OPERATIONS OF THE UNDERMINED FRONT METHOD

The undermined coal front mining method applied in Jiu Valley is characterised by the use of individual roof supports composed of SVJ 2500 hydraulic pillar (5 pillars / frame), GSA 1250 link bars GS 570 type short link bars.

In a general context, the undermined front mining method consists in extracting the coal from the basic layer of the coal face, followed by the evacuation through gravitational discharge of coal from the undermined front, behind the working front [2], [3].

The use of the individual roof support and the displacement of coal on the basic layer of the front of the coal face using drilling – explosions, lead to negative influences on the technical – economic indicators, as well as to a series of deficiencies which are recorded, some of which being:

- All the operations of a coal face cycle are carried out manually, leading to important time and manufacturing consumption;
- The high reinforcement density using hydraulic props, rendering their use and the movement of staff and materials through the coal face more difficult;
- The removal and installation operation of the conveyor at the front represents one of the most a technical solutions;
- Small obtained productions (daily productions up to 400 tons and productivities of up to 8 – 10 tons/post), have a negative impact on the economical-financial results.

Following the deficiencies met and considering the performances recorded until present time for the mechanised mining of coal layers in Jiu Valley, as experience acquired abroad regarding the mechanisation of the operations of the method with undermined coal faces, the need to use and purchase, first, is more and more outlined, for the layers which do not meet complex mechanisation conditions, namely L of the front<60 m, of walking frames used for the support and advance of the front on the basic layer of undermined coal faces, when, for the dislocation of coal, either the classic advance per attack, or the coal cutting method may be used with light shearer - loaders.

For such a partial mechanisation solution for the undermined front method, the stepping frame GEROM-GP 250/1200 (Figure 2) was used, the design of which is based on the SALZGITER model, adapted though for the coal undermining method.

The main and secondary support frames (1.2) are closed frame metallic welded constructions, interconnected through the gliding element (3) made of arc steel, with movable segments and hydraulic stepping cylinder Ø 110/60 – 900 (4). The front part of the main frame is equipped with the front catcher (5), which is operated by the hydraulic prop 90/60 – 350 (6).

The two main stepping frames are supported by two open circulation hydraulic props ă ATLAS – S 250 (7), being able to set their bearing capacity to 300 KN each.

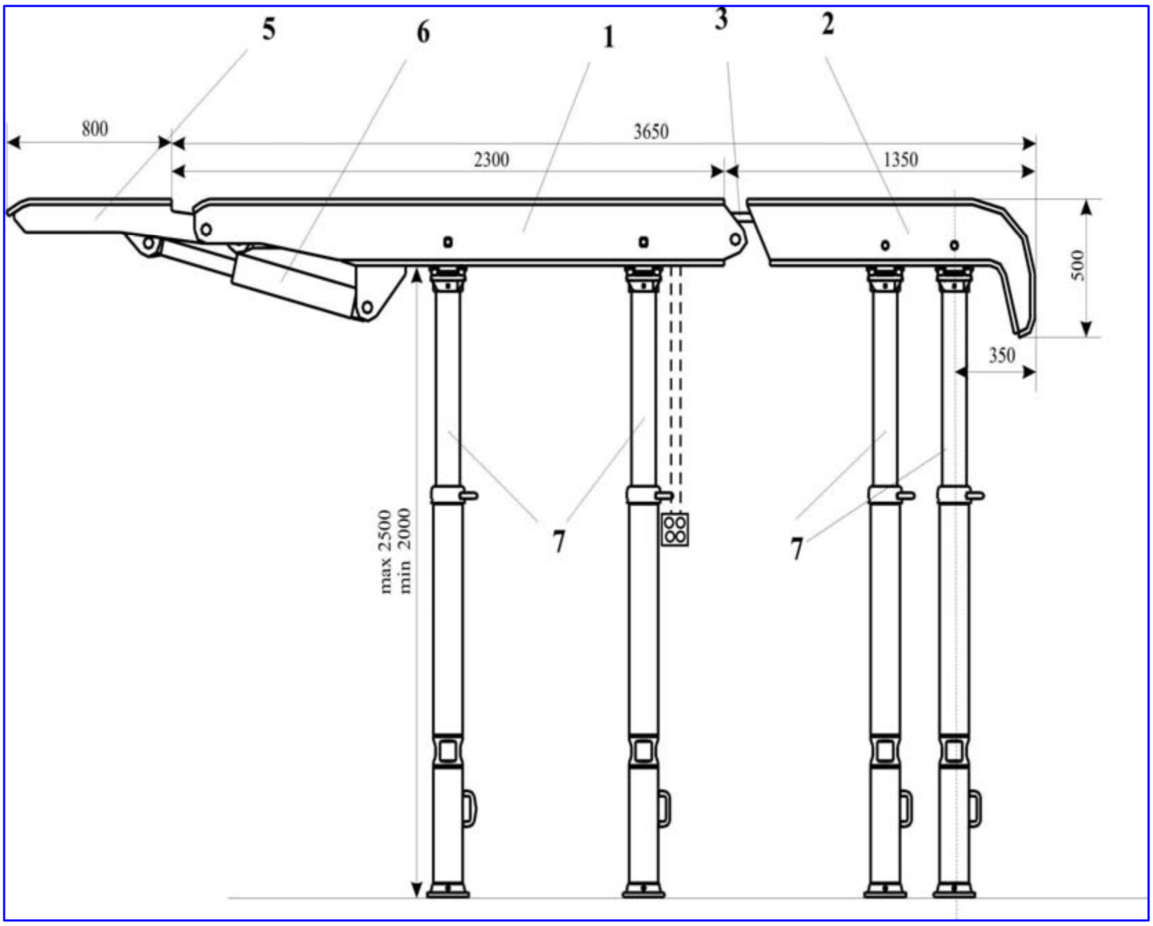


Figure 2. GEROM GP 250/1200 stepping frame: 1-main frame; 2-secondary frame; 3-gliding element; 4-hydraulic stepping cylinder found inside the frame (1.2); 5-front catcher; 6-front catcher hydraulic cylinder; 7-hydraulic props.

3. THE TECHNOLOGY AND THE OPERATING PHASES OF THE UNDERMINED FRONT METHOD

The stepping frames used for undermining may be adapted with good results when applying the mining method in two technological scenarios which are:

A. Coal cutting technology from the basic layer of the coal face using the classic drilling – blasting procedure;

B. Mechanised coal cutting technology, using the shearer – loader from the front of the basic layer of the coal face.

The following working equipment shall be installed at the coal face when the method of coal cutting with explosives is used [1], [3], [4]:

- PR.8 Light rotating drills;
- GEROM-GP250/1200 stepping frames;
- The TR3 chain conveyor.

Taking into consideration the equipment installed, the working technology supposes for the following main coal face operations to be carried out (Figure 3):

Phase I: Drilling the short mine holes, sequentially on sections. The installation of the gauze shield;

Phase II: Holes blasting. Lifting the front catcher and supporting the strip on a 0.8m depth;

Phase III: The removal of coal from the front. The removal of the gauze shield; replacing the front catcher; reducing the tension of props 1 and 2 and moving the main supporting frame along a 0.8m distance – first step. Tensioning the support props (1, 2);

Phase IV: Reducing the tension of props 3, 4 and making a first step with the secondary supporting frame. Routing the mining pressure behind the coal face along a 0.8m distance; tensioning the supporting props (3, 4);

Phase V: Reducing the tension – tensioning of the supporting props, two by two and making the second step. Routing the mine pressure along a 0.45m length;

Phase VI: Cutting the gauze behind the face of the wall, creating the removal windows each two stepping frames; the gradual removal of coal through gravitational discharge from the undermined front;

Phase VII: Installing the chain conveyor on the aisle between props 1 and 2 of the main supporting frame. Shortening the conveyor of the forefront and reinforcing the support of the junctions.

Considering the coal cutting method which uses a shearer – loader, the following equipment shall be installed at the coal face [1], [4]:

- GEROM-GP.250/1200 or similar walking frames;
- ESA 150L or similar shearer loader;
- TR-7A or similar conveyor (for the front coal face);
- TR-3 chain conveyor (for undermining operations).

The coal mechanised cutting procedure supposes, mainly, for the following operations to be undertaken (Figure 4):

Phase I: Preparing the front for coal cutting – cutting a 0.4m deep path for the shearer-loader;

Phase II: Coal face cutting – strip 1. The removal of coal through the first conveyor installed at the front;

Phase III: Setting the shearer-loader on standby. Lifting / tensioning the front catcher and supporting strip 1;

Phase IV: Cleaning off the coal of the floor of the coal face, coal set between the conveyor and the front line. Lifting the conveyor and cutting the new path for the shearer-loader;

Phase V: Repositioning the front catcher and moving the supporting frame by reducing the tension and then tensioning each and every group of 2 supporting props (1, 2, 3, 4) – the first step. Moving the second conveyor on the middle lane of the two groups of props;

Phase VI: Cutting the front – strip 2. Coal removal;

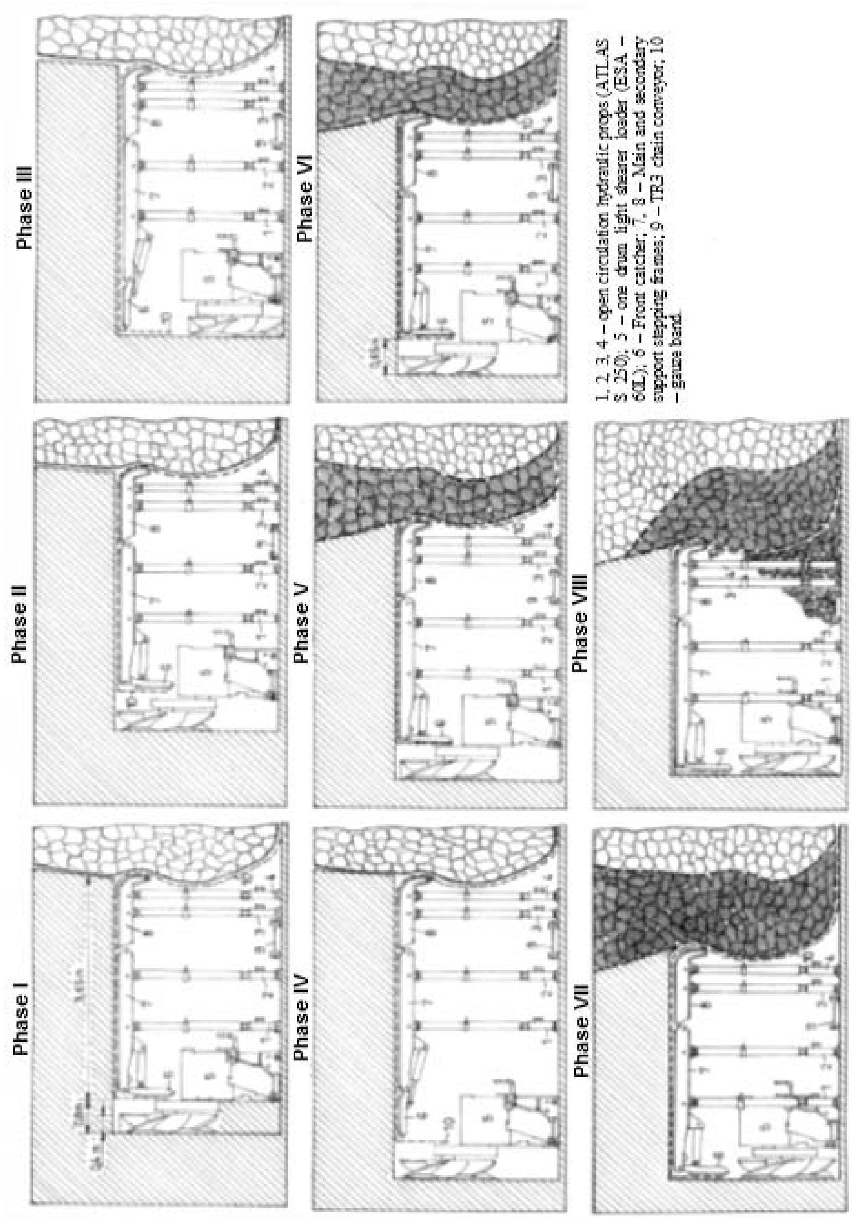


Figure 4 Operation phases during undermined black coal front mining – mechanised coal cutting

Phase VII: Taking the second step with the supporting frame;

Phase VIII: Cutting the gauze behind the coal face, realising the evacuation windows and the gravitational discharge of coal from the undermined front. Shortening the conveyor of the forefront and reinforcing the support of the junctions.

Considering the two technological mining solutions, the preliminary pre-crushing operation of the coal of the undermined front using the drilling-blasting of long holes, respectively of weakening of the structure by injecting water under pressure, shall be similar to the one presently applied in the case of the used classic technology.

4. REALISABLE TECHNICAL-ECONOMIC INDICATORS

In order to be able to assess the indicators which define the efficiency of the solutions, the following characteristics and technological mining parameters have been taken into consideration:

- Number of daily posts 50 p;
- Number of daily shifts 4 shift;
- Duration of the shift 6 hours;
- The height of the basic layer of the coal face 2.5 m;
- The advance of the front per cycle (1.2 – 1.5) m;
- The weight of the volume of coal 1.5x104 N/m^3

Based on the measure of the set parameters and the algorithm presented in the speciality literature [1], [3], [4], by replacing and carrying out the calculation for the classic solution, i.e. undermined front coal mining, and the mechanisation of the operations, the following average values of the indicators are obtained:

Indicator	Classic solution	Mechanised solution
The duration of the coal face cycle, hours	62	42
Number of daily cycles	0.30	0.57
Daily speed, m	0.49	0.71
Monthly speed, m	10	15
Daily production, tons	406	628
Monthly production, tons	8840	13345
Labour productivity, tons/post	9.5	15.7
Operating expenses, out of which, lei/ton		
- Materials	64.6	42.7
- Manufacture	49.5	32.7
- Coverage	5.9	4.4
- Energy	4.3	3.3

Based on the results, it is therefore appreciated that if the coal face operations are mechanised, compared to the classic mining solution, the increase of production and productivity with 50% and respectively 65% is obtained, considering as well the reduction of all operational expenses with 50%.

5. CONCLUSIONS

In correlation to the policies of increasing the efficiency by mechanising the coal mining operations of the units belonging to the HEC and corroborated to the geological-mining conditions of the coal deposit, the use of the mechanising solution of the undermined front mining operations with the use of stepping frame supports and shearer-loader is appreciated.

Comparing the advantages of the superior technical-economic indicators to the classic solution applied at present, it becomes imperative that the researches, for the creation of documentations and the carrying out of experiments for the approval and homologation of the working equipment and the creation of the mainframe project of the mining method, be continued.

REFERENCES

[1] Andraș, I., Radu, S., and others, *Studiul posibilităților de mecanizare a abatajelor cu banc subminat din Valea Jiului*. Research Contract University of Petroșani, 2005.
[2] Onica, I., Chiril, G., *Exploatarea cu banc de cărbune subminat în abataje frontale*. AGIR Publishing House, Year XII, no. 1, Bucharest, 2007.
[3] Pleșea, V., and co., *Metode cadru de exploatare cu banc subminat ptrentru stratele groase de cărbune și înclinări diferite la minele din Valea Jiului*. Design Revision. Construction Documentation, ICPM Petroșani, 2004 – 2013.
[4] Pleșea, V., Popescu, C., Vlaicu Popa, M. E., *Stadiul tehnologic actual și previziuni pentru exploatarea durabilă a huilei în Valea Jiului.* AGIR Bulletin, Year XII, no. 1, Bucharest, 2007.

Scientific Reviewers:
Prof. Ph.D. Eng. Eugen COZMA

DYNAMIC OF THE TECHNICAL AND ECONOMIC INDICATORS OF THE JIU VALLEY COAL BASIN MINES

VIOREL MIHĂILESCU*
ILIE ONICA**
EUGEN COZMA**

Abstract: *In this paper, it is presented an analysis of the main technical and economic indicators, obtained in the last period, for the coal mines from Jiu Valley coal basin.*

Kay words: *coal basin, mine, coal production, work productivity*

1. COAL BASIN TECHNICAL AND ECONOMIC INDICATORS ANALYSIS, IN THE PERIOD 2007-2011

The main indicators that will be analysed are the following: total coal production and net processed and sold coal production; physical labour productivity; the specific expenses achieved for a tonne of extracted coal.

The evolution of total coal production, mined and processed, obtained at the whole coal basin, in the period 2007-2001, is shown in Fig.1. Analysing the data, represented in the graphics, the following conclusions result: production has a decreasing tendency, the coal quantity extracted at the end of year 2011 is less than 20% by report to 2007; the net coal quantity, processed and delivered, at the end of 2011 is less than 463,940 tonnes, by report to year 2007 (decrease being 23.3%).

The causes that led to that situation are, mainly, political and technical - economic. Thus, in the category of the political causes could be included, easily, the *European Commission Regulation (EC) no.1407/2002, regarding the state aid for coal industry*, which led to the continuous decrease of the Romanian state subsidy for the hard coal producers and the *Council Decision 2010/787/EU, regarding the state aid for the closure facility of non-competitive coal mines*.

Among the technical-economic causes that determined the diminution of the coal production at the coal basin level are the ones listed below [4]:

-reduction of the production capacities by incompliance with the openings and preparatory underground workings programme, established by the annual mining plans and by their depletion;

- inability to provide optimal covering, with workers, for the working faces. The absonant placement of the miners in the faces determined the reduction of the

* *Min. Eng. Ph.D - University of Petroşani: vrlmih67@gmail.com*
** *Prof. Min. Eng. Ph.D. - University of Petroşani: onicai2004@yahoo.com; cozmae2003@yahoo.com*

daily advancement speed of the coal faces, increasing the production period cycle and, implicitly, increasing the period of the stress concentration acting on the supports of faces and of preparatory galleries- resulting the supports deterioration and an important degradation of the top coal and major difficulties regarding the rock roof control operation;

- technical accidents (rocks failures, malfunctions of the cutting machines, etc) that led to the increase of the stagnation periods of the faces and a corresponding reduction of the coal production;

- two work accidents, with casualties, produced at the Petrila mine, in the trimester IV, 2008 and at the Uricani mine, in the trimester II, 2010, accidents that led to the closing of the production capacities and the labour relocation toward the rehabilitation of the accident's consequences;

- reduction of the coal demand from the internal market - the main customers being the power-stations of Paroșeni and Mintia.

Physical work productivity evolution, in the frame of the Jiu Valley mines, is shown in the graphics from Fig.1-4. Thus, from these data analysis, the following are concluded [4]:

- work productivity, achieved at the face level, has an increasing tendency, reaching the value of 8.72tonne/man·shift in 2011, more with 1.05tonne/man·shift than in 2007 and the percentage increase being 13.68%;

- the same increasing tendency of the work productivity is observed for all the coal faces workers; in this case, the significant increase, from 6.67tonne/ man·shift, in the year 2007, to 7.4tonne/man·shift, in the year 2011, respectively with 11.09%;

- however, at the level of entire personnel of the Jiu Valley mines, the work productivity records very low values, with insignificant increase. For the underground workers, the increase is of about 0.11tonne/man·shift, in 2011 by report to the 2007. And for all the personnel, the increase is only of 0.07tonne/man·shift, because of the large number of auxiliary workers existing at the coal basin level.

- for the analysed period, it is shown the fact that the achieved productivity in the wall faces, with powered supports, has a favourable influence on all the faces productivity, achieved on the coal basin level.

- uncertain evolution of the physical work productivity is a cause of non-linear dynamic of the production capacities. The coal mining using the complex mechanised system had a positive influence, with a maximum value of productivity of 14.3tonne/ man·shift, in the year 2011, being succeeded by the top coal caving mining method (applied in the case of the thick coal seams, with gentle dips).

- work productivity, on the workers categories, showed the relatively low value by report to the world medium values; the peak values of the years 2008 and 2011, in the faces, being determined by the coal mining with complex mechanised system, that confirm their superiority by report to the classical ones.

The personnel structure of the mining operator suffered major changes, starting with the year 1997, when the number of workers diminished to half. The small economic results implied the same tendency of the reduction of the workers number.

The main argument that determined this decision was the expense of manpower in the price of coal tonne. Thus, by report to the year 2007, 3000 workers were removed, reduction provided by repeated collective dismissal and retirements. However, this politic, beside the targeted positive aspects, also had some negative consequences on the workers structure of the Jiu Valley coal mines. The great majority of the personnel thrown out of the system were from directly productive groups of workers, highly qualified, with very negative impact on the mining processes operations.

The evolution of the workers number, at the coal basin level, along the period 2007-2011, is shown in Fig.5.

The coal tonne cost, mined and processed, has had an uncertain evolution, with a peak in the year 2009, after that the evolution was downward. Thus, in 2011, the production unit coal cost increased by 51.58lei/tonne, respectively 21.26lei/tonne.

The peak, recorded in 2009, was determined by the increase of the materials' prices and by the economical consequences of the technical accidents. These accidents led to a production capacity reduction because of the very important immobilisation of the coal reserves in the closed perimeters and the relocation of the large number of workers for elimination of the accidents' consequences, produced at the Uricani and Petrila mines.

The ratio of the production achieved from the fully mechanized coal faces had a significant increase, by report to year 2007, from 19% to 37%, in the year 2011. At the same time, the ratio of the production from top coal caving faces decreased from 65%, in 2007, to 50% in the year 2011, because of the following causes [4]:

- closing of the coal production capacities afferent to the Petrila and Uricani mines, affected by the technical accidents;

- supplementary restrictions imposed to the top coal mining method, regarding the top coal height that was limited to a maximum of 7.5m and other technical limitations of this method; the top coal height limitation had a positive consequence, concerning the coal quality and the coal losses in the gob.

The production expenses represent a descendant trend: the expenses of the year 2011 being more reduced by report to the 2007, with 20.6% and the peak influenced by the accident produced at the Petrila mine, in 2008. The increase of the rate of production achieved from the fully mechanized faces and from the top coal caving faces led to the significant reduction of the mining expenses.

2. INDICATORS' ANALYSIS OF THE INDEPENDENT COAL MINES, IN THE PERIOD OF 2007-2013

The economic potential of the Jiu Valley hard coal mines must be analysed taking into account the technical – economic factors [2]: coal reserves of every mining perimeter, specific geo-mining conditions, and the existing and necessary opening workings, etc.

The data analysis, represented in the graphics of Fig.8-12, ensure the possibility of assessing the actual activity of these mines, without future economic previsions [4].

The assessments of the indicators represented graphically led toward the conclusion that, in fact, the Vulcan mine had acceptable results from the point of view of obtained production and productivity - because of the reduction of the mining perimeter area and the concentration of production capacity.

On the other hand, the Petrila and Uricani mines, although they dispose of important coal reserves, the affected zones of coal reserves had to be dropped due to the accidents. Thus, it had major implications on the achieved coal production, resulting in a drastic decrease of performance indicators.

Also, these accidents were reflected, directly, on the production expenses: in the year 2009, Petrila mine has recorded a value of expenses of 4432.9lei/1000lei commodity production and Uricani mine, 3292.1 lei/1000 lei commodity production.

3. CONCLUSIONS

In the geo-mining conditions of Jiu Valley thick coal seams, the use of top coal caving mining methods [2], [3] led to a substantial increase of obtained coal production, by report to the classical mining methods [1], in slices, and the productivity approaching the values obtained from fully mechanized faces.

The improvement of the coal mining efficiency in the Jiu Valley coal basin could be made by:

-a concentration of the production capacities in the geo-mining zones where it is possible to obtain an acceptable economic efficiency;

-reengineering of the opening and preparatory mining system for every mining perimeter, taking into account the economic efficiency of every mine;

-increasing the economic efficiency by using the fully mechanized mining technologies in longwall faces, in the appropriate geo-mining conditions of the coal seams.

REFERENCES

[1]. Covaci, Șt., *Exploatări miniere subterane*, Vol.I, Editura Didactică și Pedagogică, București, 1983.

[2]. Onica,I., *Contribuții la perfecționarea tehnologiilor de exploatare cu fronturi lungi de abataj a stratelor groase de cărbune din Valea Jiului, prin utilizarea unor susțineri mecanizate adecvate condițiilor geominiere*, Teză de doctorat, Universitatea din Petroșani, 1995.

[3]. Onica,I., Chiril,G., *Exploatarea cu banc de cărbune subminat în abataje frontale*, Editura AGIR, București, 2005.

[4]. Mihăilescu,V., *Perfecționarea metodelor de exploatare în cazul stratetlor groase cu înclinare mare aplicate în bazinul minier Valea Jiului*, Teză de doctorat, Universitatea din Petroșani, 2013.

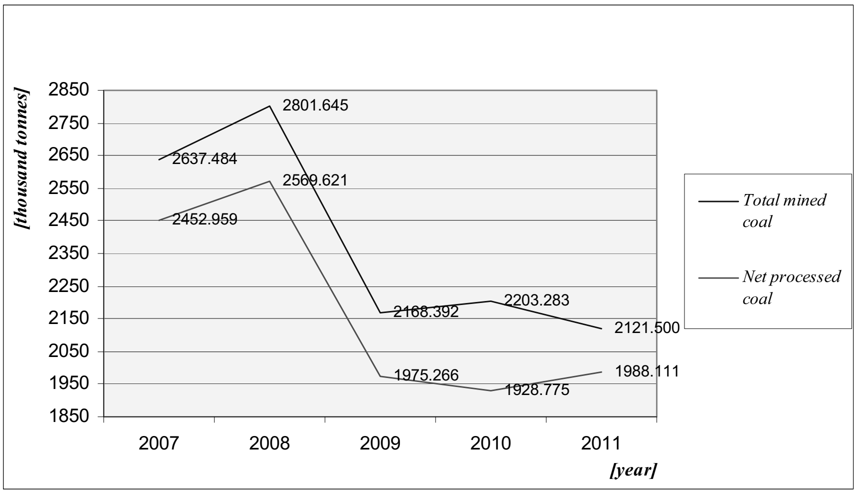


Fig.1. Total net coal production, mined and processed, obtained at the coal basin level

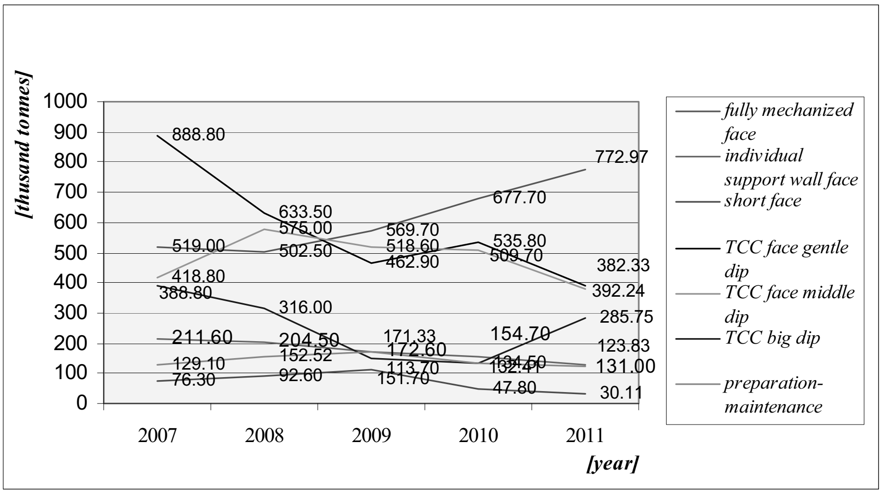


Fig.2. Achieved production, in the case every mining method, for entire coal basin

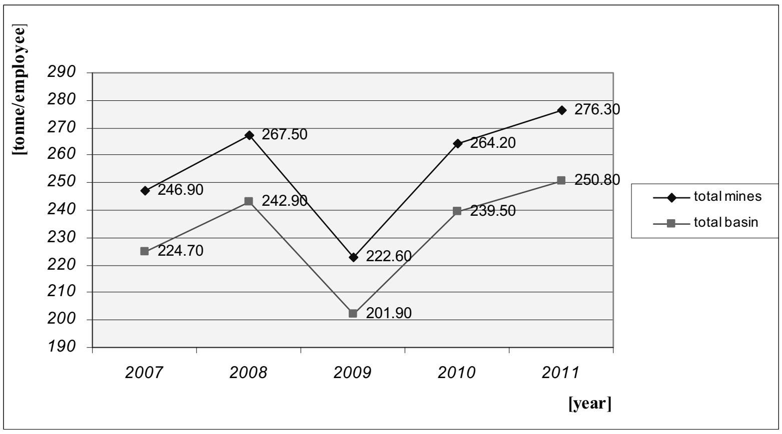


Fig.3. Physical work productivity, for coal basin

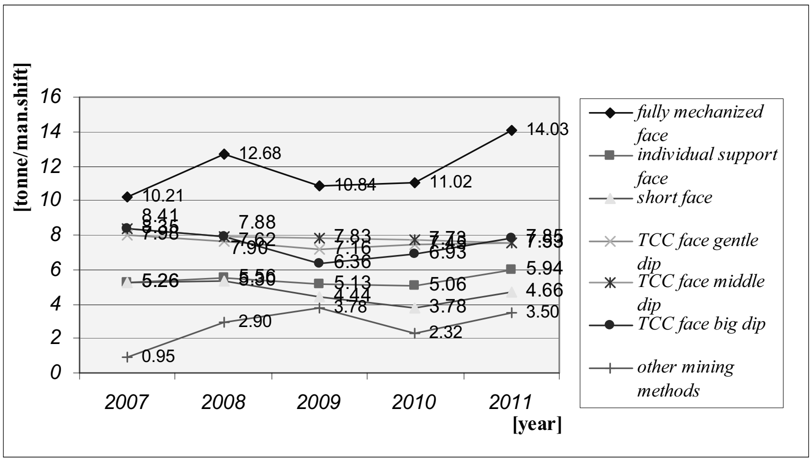


Fig.4. Physical work productivity, in the case every mining method, for the entire coal basin

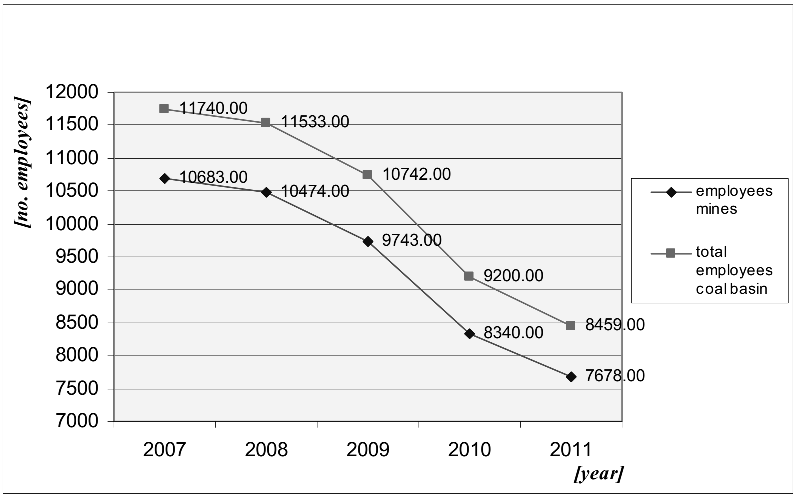


Fig.5. Evolution of the average number of the employees

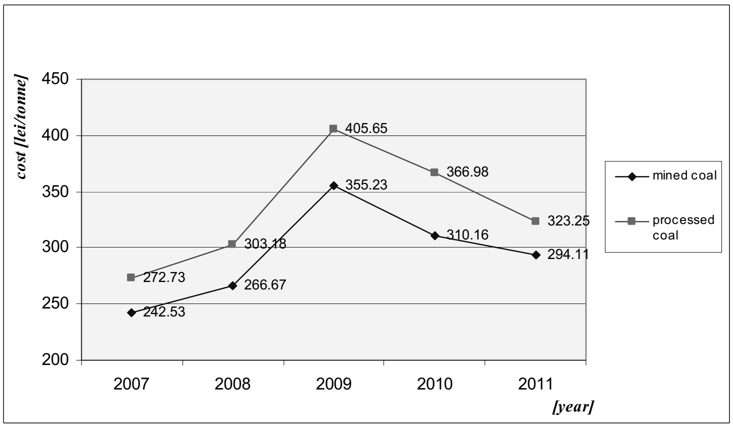


Fig.6. Dynamic of the coal cost, extracted and processed, at the coal basin level

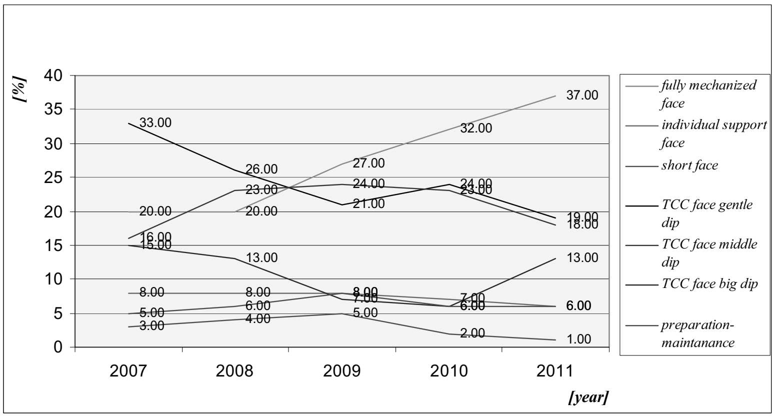


Fig.7. Extracted coal production rate, for every mining method, from the total of coal production of the coal basin

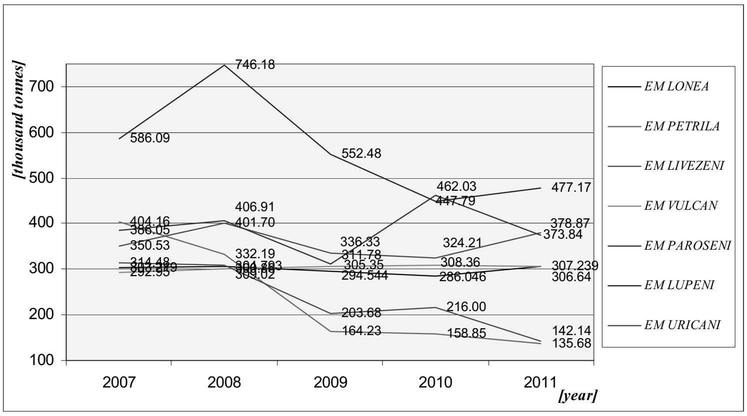


Fig.8. Evolution of the coal production, at the level of the hard coal mines of the basin

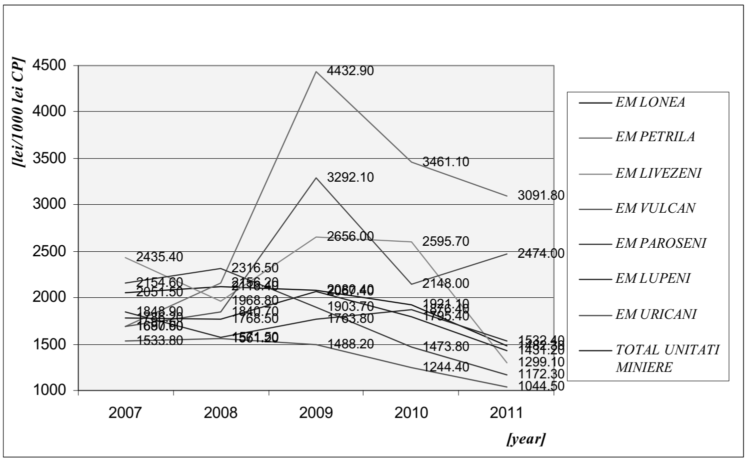


Fig.9. Production expenses evolution, for 1000lei commodity production

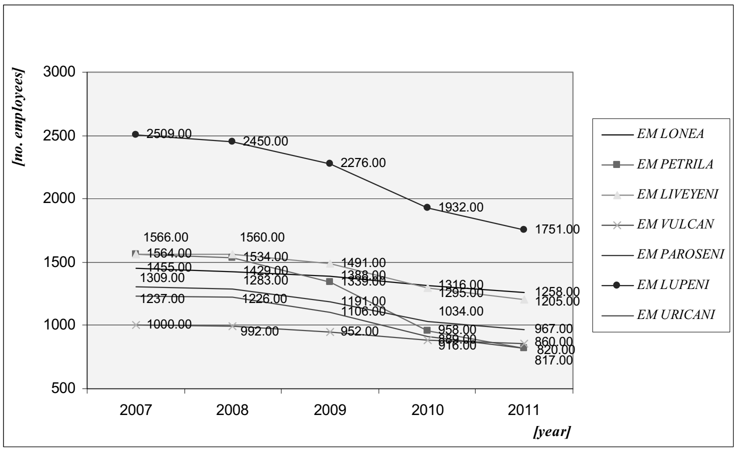


Fig.10. Evolution of the employees' number of every coal mine

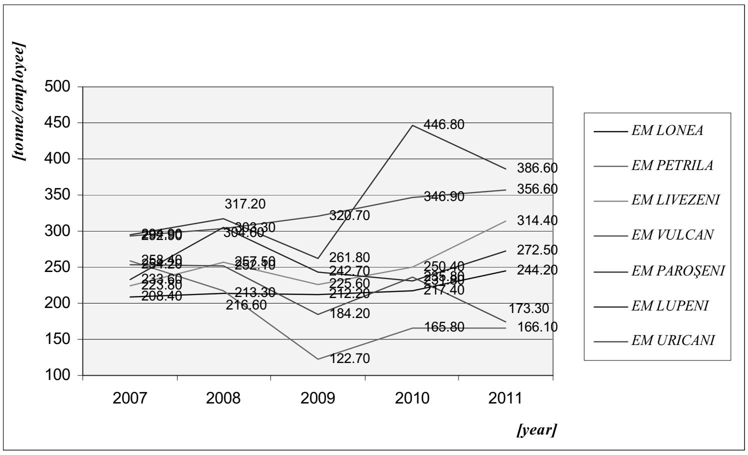


Fig.11. Physical work productivity of every coal mine

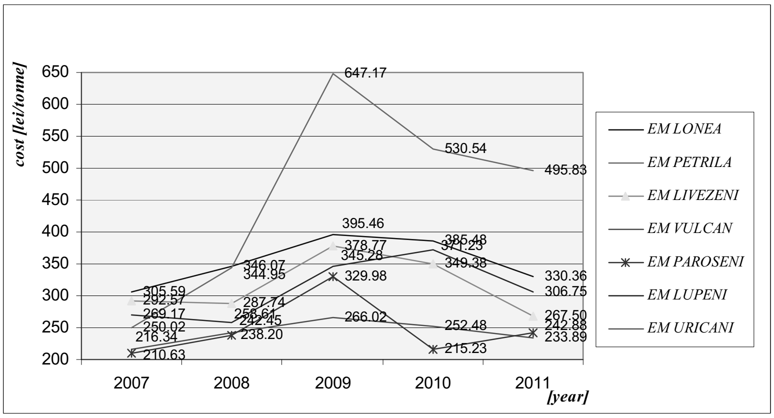


Fig.12. Variation of the unit cost of the gross mined coal and net processed coal, at every coal mine's level

Scientific Reviewers:
Prof. Ph.D. Eng. Dumitru FODOR

IMPROVEMENT OF THE MECHANIZED MINING METHODS WITH SURROUNDING ROCKS CAVING IN HORIZONTAL SLICES, IN THE CASE OF COAL SEAM NO.3 FROM THE JIU VALLEY COAL BASIN

ILIE ONICA*
EUGEN COZMA*
VIOREL MIHĂILESCU**

Abstract: *In this paper, there are presented the main technical deficiencies of the mining method, with rocks caving, in horizontal slices in the case of coal seam no.3, from the Jiu Valley coal basin. There are proposed certain technical improvement of this mining method to increase the face performances by using the mechanised mining technologies.*

Kay words: *thick coal seam; coal mining method; mechanized mining technology; powered support; preparatory working*

1. GEOLOGY OF JIU VALLEY COAL BASIN

The Jiu Valley basin is the most important hard coal basin in Romania. Jiu Carpathians include the following main units: Getic area, Autohton area and the sedimentary complex of the Petroșani basin with the Chattian level, which involve the coal seams [4], [5]. The geological coal reserves of the basin are classified into the categories II and III, from the point of view of geological complexity, being intensively tectonized, with the important variation of the qualitative and quantitative parameters. The mining difficulties are amplified by the large emissions of methane and the coal self ignition tendency. Between the 22 identified coal seams, the coal seams no.3 and 5 represent about 60% of the total coal reserves and the coal seam no.3, 48% of the hard coal reserves, being present in all the mining fields. Coal seam no.3 is situated at 25-50m distance from the Rupellian-Chatian limits. It has variable thickness, ranging between 0.5m and 34m, in some places even 50 m, with large differences following the strike and the dip. The appreciable thickness may be encountered in the mining perimeters Lonea, Petrila, Dâlja, Aninoasa, Vulcan and Lupeni.

Generally, in the mining fields situated in the eastern half of the coal basin, the coal seam has the largest thickness. The coal seam no.3 is consisted by three carbonaceous intercalations, separated by dark grey clays, more compacted in the

* *Prof.Min.Eng.Ph.D. - University of Petroşani, onicai2004@yahoo.com; cozmae2003@yahoo.com*
** *Min. Eng. Ph.D - University of Petroşani: vrlmih67@gmail.com*

upper zone and more non-homogeneous toward the floor, disposed in two complexes. The stratigraphical characteristic of the coal seam no.3 is its balking and its substitution into a gray- greenish, shandy-shale rocks complex, on the eastern side of the basin, starting with the Paroșeni perimeter. The coal seam no.3 roof consists of argillaceous sandstones or limestone, very well cemented, with alternation of shandy-shale and traces of plants, and the floor consists of sandstones with sideritic concretions [5], [8].

The geometrical characteristics of the coal seam no.3, the irregular shape of the coal bodies, complicated tectonics which had fractured the coal deposits into several geologic blocks with reduced strike sizes (Fig.1), are the difficulties that led to the impossibility to efficiently mechanize the mining of the coal seam no.3 [5], [8].

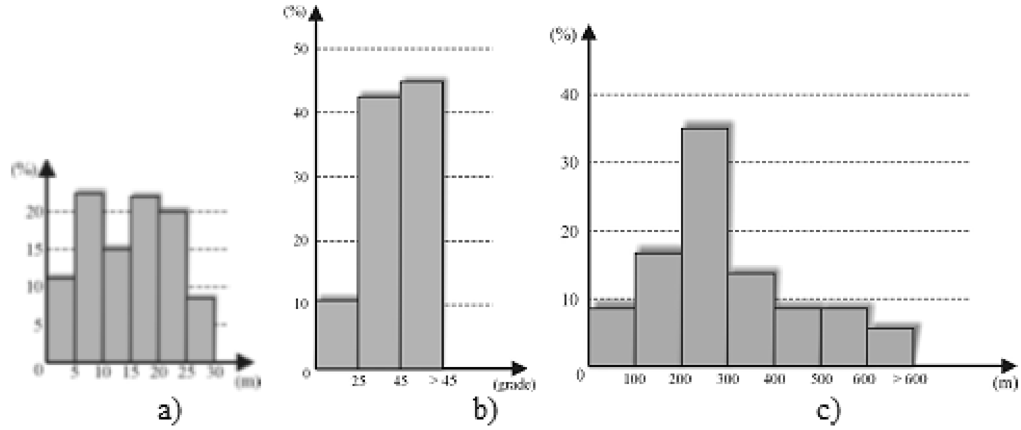


Fig.1. Histograms of the main geometrical characteristics of the coal seam no.3 - Jiu Valley coal basin: a) thickness; b) dips; c) block lengths [5], [8]

2. MAIN FACTORS THAT LED TO THE REDUCTION OF THE EFFICIENCY OF THE MECHANIZED MINING OF THE COAL SEAM NO.3, EXTRACTED IN HORIZONTAL SLICES

In time, various attempts concerning the complex mechanization of the coal seam no.3 mining (Fig.2), in horizontal slices with roof rocks caving have led to reduced economical performances [2], [4], [6], [7]. They were due to a sum of factors. Among them, we mention the following:

a) The complicated development schemas, with underground working with reduced transversal sections. These have created difficulties for the transport of coal face equipments. More often, it required the disassembly of the equipments in small parts, followed by their replacement at the coal face level. These operations were achieved with important expenses and a degradation of the materials because of the several successive dismantling and restoring of the faces equipments.

b) The preparatory workings, complicated and non-adapted to the mechanization of the coal faces. For example, the necessity of the transport of the equipments inside of the small rises and into preparatory galleries, with small sections, at the mining slices level. These conditions impose the transport limitation to small parts of the equipments, with negative consequences on the face equipment's reliability. Also, the arched shape of the gallery and the reduced stability of theses preparatory workings have a negative influence on the performances of the mechanized technology.

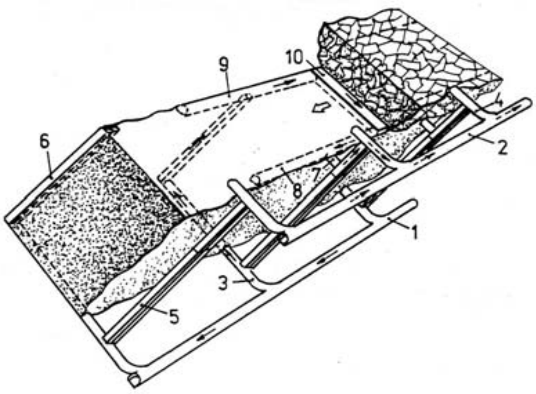


Fig.2. Classical mining method, in horizontal slice, with directional faces [5]
1/2 – level directional gallery of transport / ventilation; 3,4 – panel intermediary cross-cut of transport, respectively of ventilation;5/6 – rise of transport/ventilation; 7-short cross-cut; 8/9-directional preparatory gallery on the floor/under the roof; 10-directional middle wall face

c) The angular ends of the coal faces, determined a complication of the mining technology. Because of the angular shape of the face ends, it was necessary to change the mining technology in theses zones, with the reduction of the speed of the coal face advancement as a consequence.

d) The emphasized variations of the coal seam thickness. It is an important factor because, in the case of the strike faces, it determines a variation of the coal face length in the panel limits. This imposes the introduction of a face zone supported with individual props and articulated beams, with negative consequences on the mechanized face performances.

e) The reduced extensions of the panels imposed by the small length of the geological blocks. It has as a negative consequence the increase of the expenses because of the successive dismantling and restoring of the faces' equipments, reporting to the small coal reserves of the short panels.

3. TECHNICAL SOLUTIONS TO IMPROVE THE COAL MECHANIZED MINING METHODS IN HORIZONTAL SLICES, WITH CAVING ROOF CONTROL

3.1. Replacing the preparatory transport rises with inclined workings, driven in the coal floor rocks

For an opening level with 60-80m of height, the transport rises are replaced with inclines, situated outside the influence zone of the coal mining. From the transport inclines, the cross-cuts workings are driven which make the conjunction with the preparatory slice workings (Fig.3). The main advantages of this preparatory system consist in the reduction of the preparatory workings' volume, the facility of the equipment transport between successive slices and the reduction of the maintenance expenses of the preparatory workings.

The ventilations rises under the coal seam roof will be driven or not, depending on the seam thickness, and the ventilation schema used (general mine ventilation or partial ventilation). The mined coal will be transported on the inclines with the aid of the belt conveyors.

Also, in the other mining method variant, the transport rises could be drilled at 100-150m intervals, which will concentrate the layout at the transport level. In this case, the inclines serve only for the transport of the materials, equipments, workers and ventilation.

The implementations of this system imply the changes in the preparatory slice system (Fig.4). When the rises, driven under the roof, have less stability, the rises support could be a combined bolting system.

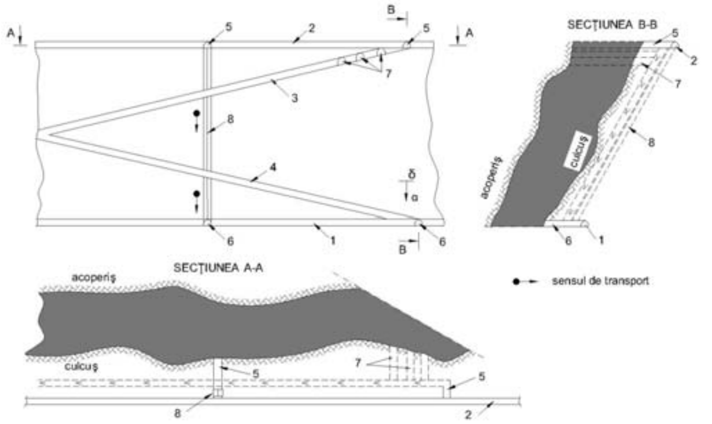


Fig. 3. Preparatory principle of the coal seam no.3, mined in horizontal slices, and the floor inclines [3], [8]

1,2 –directional galleries for transport and ventilation; 3,4- inclines; 5,6 –cross-cuts; 7-short cross-cuts; 8-rises

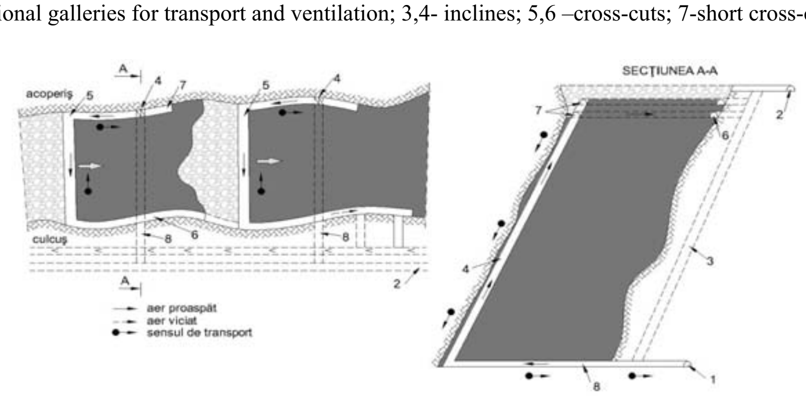


Fig. 4. Mining method of the thick coal seam no.3, with great dip, with the transport inclines, driven in the floor rocks [3], [8]

1,2 –directional galleries for transport and ventilation; 3-inclines; 4-transport rises, under the roof; 5 – coal faces; 6,7 – directional preparatory workings on the floor and under the roof; 8 – transport cross-cuts

3.2. Mining of the coal angular zone of the ends of faces with short-wall mining method

In the case of the classical mining method (Fig.5) with directional wall mining, the coal face is sheared at the same time with the angular zones. The coal from roof and floor angular zones is mined with drilling-blasting and wooden support technology, which determines a reduced advancement speed for the entire coal face.

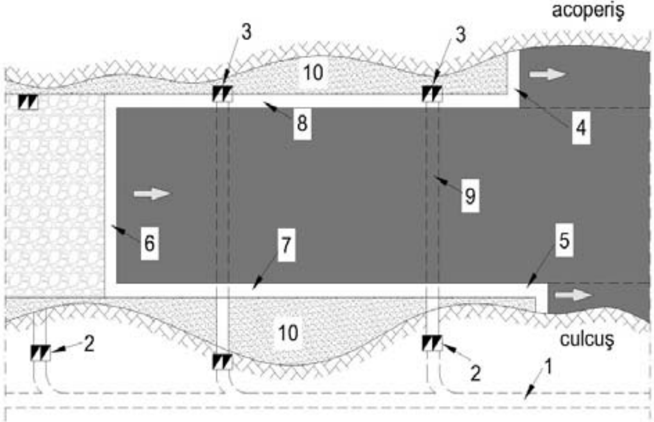


Fig.5. Mining in advance the angular zones of the middle-wall face [3], [8]
1-directional gallery of the level; 2,3 – rises in the rocks floor and under the roof; 4,5- advance short-wall faces; 6 – middle-wall face; 7,8 – directional galleries on the floor and, respectively under the roof; 9 – cross-cut; 10-stowing

The mining of the angular ends of the coal faces with short walls, extracted in advance, at the same time with the driving of the slice preparatory working is a solution to eliminate the previous main disadvantage of this mining method (see Fig.2). Because of the complexity of this mining technology, it is recommended to be applied in the case of coal thickness over 40-50m, favourable for a mechanized coal mining. The main disadvantage of this method is the stability of the preparatory workings. This problem could be solved by using the combined bolting system and the filling of the mined areas with the cemented stowing (Fig.6). The stowing pipelines could be used to fill the stowed ceiling, built to protect the preparatory workings situated in the lower slice. This system is recommended, especially, for the thick coal seams with constant thickness, along the panel length.

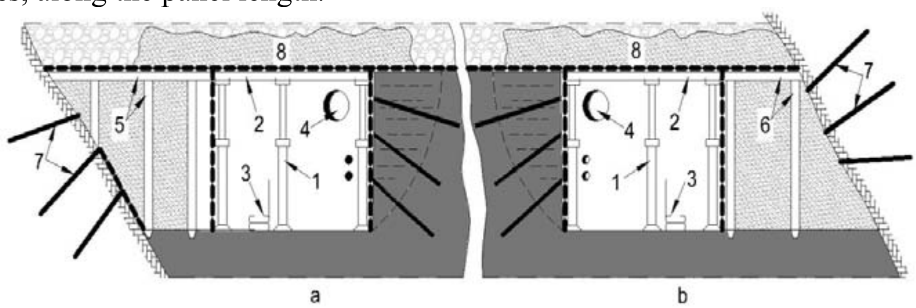


Fig.6. Support of the angular short-wall zones: a) at the coal floor; b) at the coal roof [3], [8]
1-hydraulic or frictional prop; 2-beam; 3-conveyour; 4-fan-tube; 5, 6 - wooden frame supports; 7-bolting support; 8-cemented stowing

3.3. Technical solutions to adapt the mining methods to the coal seam thickness variation

The coal seam mining with transversal middle-faces (Fig.7) is recommended for the coal seams with thickness over 40-50m. In this case, the angular zones are extracted in the moment of the start of mining-the roof zone- and the final slice – the floor zone. Because of the short panels, this method is compatible only with a semi-mechanization of the faces.

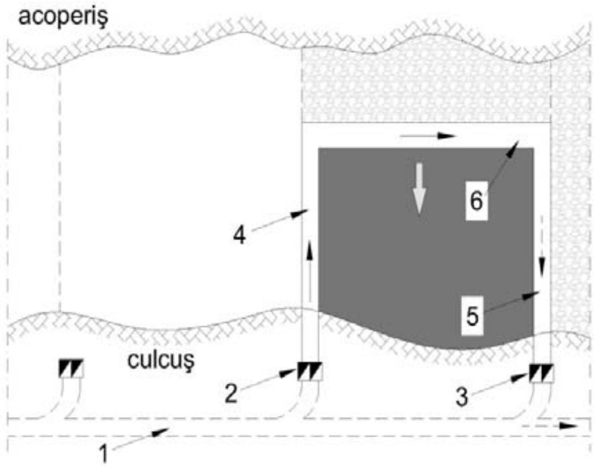


Fig.7. Transversal middle-face mining method, in horizontal slices [3], [8]
1-directional gallery; 2,3- rises of ventilation, respectively of transport; 4,5 – transversal preparatory gallery for transport, respectively for ventilation; 6-middle coal face, with transversal advancement

The obtained results at the horizontal slices mining, using the mechanized technologies were very deeply influenced by the variations of the horizontal coal seam no.3 thickness, in the panel limits, and by the impossibility of the face supports to gear to these variations.

In the Jiu Valley, to solve this technical problem, at the end of the faces, an individual support section was introduced, alongside the powered support system. This section ensured a very speedy operation, disassembly of the individual supports and the change of the distance between the frame lines, in the case of large coal thickness variation. The main disadvantage of this solution is the fact that the advancement speed of the coal face is imposed by the individual support section, not by the mechanized one.

It is possible to solve that problem by acting in the following ways: the mining in advance of the angular sections of the face; using the powered supports with variable width or the frame supports; diagonal variable emplacement of the middle-faces.

The use of the powered supports with variable width could be taken over the length variation of the coal face, in the panel limits. If the thickness is higher, the possibilities of accommodating the supports at the thickness variation are higher. This powered support presents the disadvantage of the important variation of the load capacity between maximum and minimum width, overloading the supports in the maximum width position.

The advantage of the diagonal emplacement of the coal faces (Fig.8), to take over the thickness variation of the coal seam, is obvious. The angle between the coal seam strike and the coal face could not be very large because of the appearance of the following deficiencies: the distance between two adjoining powered support units and the large uncovered ceiling coal face allows the caved rocks to fall inside of the face; the reduction of the stability of the intersection, in acute angle, between the preparatory working and the face; impossibility of using the coal face sustaining element of the powered support, in the case of soft coal; the complication of the intersection zone between the slice galleries and the face, with negative impact on the emplacement of the supports and the armoured conveyors, etc.

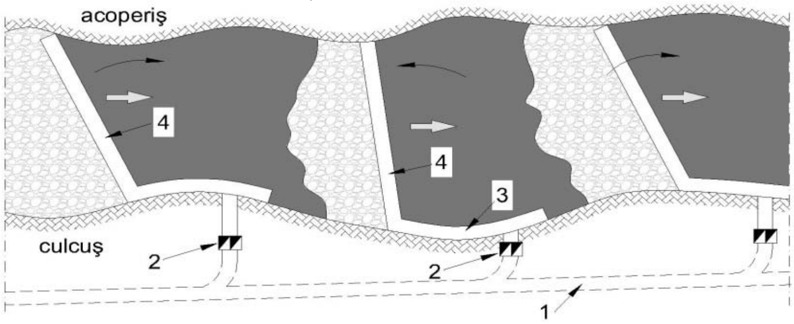


Fig.8. Mining method with diagonal coal faces
1-directional ventilation gallery; 2 - rise on the coal floor; 3 - directional preparatory working on the floor; 4 - diagonal coal face

4. CONCLUSIONS

The mechanization of coal mining in horizontal slices, in the case of coal seam no.3 is very difficult because of the variation of the geometrical characteristics (thickness and dip) of the thick coal seam.

To improve the economical performances obtained with this mining method, it is necessary to fit the technical characteristics of this method to the coal seam mining conditions.

Thus, mainly, the following technical improvements of the mining method were proposed: driving the inclines in the coal seam rocks floor; advancement mining of the angular zones, by report to the face; diagonal emplacement of the coal face; using the powered supports with variable width or using the frame supports etc.

REFERENCES

[1]. Covaci,Şt., *Exploatări miniere subterane,* Vol.I, Editura Didactică şi Pedagogică, Bucureşti, 1983.
[2]. Cozma,E., Onica,I., *Perfecționarea metodelor de exploatare cu subminare aplicate la exploatarea stratelor cu înclinare mare din Valea Jiului,* Lucrările Ştiințifice ale Simpozionului Internațional „ Universitaria ROPET 2002", Petroşani, 2002.

[3]. Oncioiu G., Cozma,E., Onica,I. ş.a., *Perfecţionarea schemelor de deschidere şi de pregătire, a metodelor şi tehnologiilor de abataj pentru minele din Valea Jiului (Lonea, Petrila, Dâlja şi Aninoasa),* Contract U.P. cu R.A.H. România, nr.31/1996.
[4]. Onica,I., *Direcţii de rentabilizare a exploatării zăcămintelor din bazinul carbonifer Valea Jiului*, Revista Minelor, vol.41, nr.8, 1990.
[5]. Onica,I., *Contribuţii la perfecţionarea tehnologiilor de exploatare cu fronturi lungi de abataj a stratelor groase de cărbune din Valea Jiului, prin utilizarea unor susţineri mecanizate adecvate condiţiilor geominiere*, Teză de doctorat, Universitatea din Petroşani, 1995.
[6]. Onica,I., Chiril,G., *Exploatarea cu banc de cărbune subminat în abataje frontale*, Editura AGIR, Bucureşti, 2005.
[7]. Onica,I., Cozma,E., Mihăilescu,V., *Improvement of Economic Efficiency of Longwall Mining in Short Panels in The Case of Jiu Valley Thick Coal Seams, Romania*, Proceedings of the International Multidisciplinary Scientific Geoconference, SGEM2011, 20-25 June, Sofia-Bulgaria, 2011,Published by STEF92 Technology Ltd. Sofia-Bulgaria, pag.801-808. DOI: 10.5593/sgem2011.
[8]. Mihăilescu,V., *Perfecţionarea metodelor de exploatare în cazul stratelor groase cu înclinare mare aplicate în bazinul minier Valea Jiului*, teză de doctorat, Universitatea din Petroşani, 2013.

Scientific Reviewers:
Prof. Ph.D. Eng. Dumitru FODOR

ROCK CHARACTERISTICS OF CETATE QUARRY PERIMETER FROM ROSIA MONTANA

Mihaela TODERAŞ*

Abstract: *The integral quarrying of Cetate rock massif from Rosia Montana was made in the conditions of underground voids networks existent under the quarry platforms resulted from the old exploitations. Some of these voids can not be precisely delimited due to the chaotic development and their removal must be made step by step as the quarry level descent. Other underground voids resulted from the previous exploitation method by rooms and pillars. The quarry platform has reached at the level of the upper bottoms in the breccia area and will proceed to the exploitation of the reserves included in these pillars and floors. This paper is based from the laboratory studies concerning the prevalent rock characteristics encountered in the quarries area from Rosia Montana, the breccia and dacite varieties rock types. The characteristics values obtained for the rock's varieties analysed show that they fall within the medium to high resistance rocks category, semi-rocky to rocky.*

Key words: *quarry, deposit, exploitation, strength, rock characteristics, pillars, floors*

1. ASPECTS REGARDING THE DEPOSIT GENESIS

The most important factor in the geological evolution of the Metaliferi Mountains is the Neogene volcanic activity. The eruptive neogene rocks come into direct contact with almost all pre-tertiary formations from the area of these mountains. The oldest formations are crossed by the crystalline schist's of the northern and southern geosyncline area, namely those that form the Baia de Aries heel and north part of the Poiana Rusca massif [1]. The presence of the crystalline schist pieces in the explosion columns and the brecciated zone of the edge rhyolite bodies too indicate the existence of a basement composed of metamorphic rocks right in the middle of geosyncline. Over these are the sedimentary volcanic formations with different lithological characters. In Rosia Montana, this period is represented exclusively by magmatic formations, large masses of lava and andesitic pyroclastics, deposited directly over the upper Tortonian and over the other older configurations. At the base of pyroclastic deposits and Rotunda's andesitic lava the Pannonian identifies a level of gravels which include the rolling elements: rhyolite, dacite and quartz-andesite.

The recent studies was divided the volcanic activity in the region into three phases: the first cycle that marked the beginning of volcanic activity in the region, hydrothermal changes and mineralization located in the rocks of this cycle are genetic bind of the effects of the second cycle; the second cycle in which the highest volcanic

* *Assoc. Prof. Ph.D. Eng. at the University of Petrosani, toderasmihaela@yahoo.com*

layers were formed; the third, the weakest developed, brief and which is the last act of magmatism' manifestation [1], [2].

2. DEPOSIT AND SURROUNDING ROCKS OVERVIEW

In 1976 when have been confirmed ore reserves at Rosia Montana, based on natural factors, the deposit was classified in the third class. At the basis of deposit classification in this class, were the following considerations: the minerals bodies form is very complicated; the contour of the ore bodies presents the great variations; the variety and intensity of the alteration phenomena; the mineralization has frequent discontinuities; the extension of the ore body is small, less than 0.5 km^2.

The deposit from Rosia Montana consists of several ore bodies, but the natural factors are characteristics of each. Very briefly, we present some data relating to the main types of surrounding rocks of the deposit from the Rosia Montana mining perimeter. The native or visible free gold has a special practical interest and he appears as fine beaten gold form, irregular plates, threads, fine threads on different minerals or as smaller grains included in calcite, rhodochrosite and quartz hole. Frequently he occurs in the large lonely crystals or in the arborescent crystalline aggregates disposed on pyrite crystals, mispichel, sphalerite, quartz and calcite. Also appears as a little stockworks form with 1 to 5 cm thickness or like a metal sulphide inclusions or in the cementing material of breccia. The free gold is not systematically lied by a given paragenesis, such as silicifications or kaolinizations, but occurs in the most whimsical situations [2], [3], [4]. The surrounding rocks deposit is as follows:

Galena (PbS) occurs in the vein cracks as a compact mass or finely crystallized in association with vein pyrite, chalcopyrite and sphalerite; in depth it's present in a lesser extent. Under microscope, the galena occurs associated with sphalerite, chalcopyrite, gold, tetrahedrite, marcasite and silver minerals.

Zinc blende (ZnS) occurs as small crystals of 1 to 5 mm size, compact masses or in bands associated with galena and gangue minerals, very rarely with chalcopyrite and gold. Under the microscope it is intimately associated with chalcopyrite, galena, gold and silver minerals.

Pyrite (FeS_2) is present as a well individualized crystals form of 0.5 mm with grains without well-defined crystallographic outlines in the veins gangue, breccias or surrounding rocks. First time the pyrite is form, and then gold was deposited in the hole resulting from corrosion.

Marcasite (FeS_2) occurs as crystallized form presenting sometimes as a grains and bands, being associated with pyrite, sphalerite and galena. Under the microscope were discovered also two generations of chalcopyrite.

Tetrahedrite (Cu_3SbS_4) is finding as a tetrahedral crystal form, from 2 to 4 mm, associated with small quartz crystals. Under microscope could be identified only the material from the upper zones.

Alabandite (MnS) was found with a microscope in a single location and is not associated with gold or other metal sulphides. She occurs in association with rhodochrosite and quartz.

Silver minerals can not be seen with the naked eye, they are determined by chalcographical studies as follows: polybasite, silver glance. With chemical analyzes has been identified a new element like germanite.

Gangue minerals:

Calcite ($CaCO_3$) is the most prevalent in the veins of Tarina – Orlea, Volbura Cetatii and Rakosi massif.

Rhodochrosite ($MnCO_3$) appears as compact or finely grained form, cementing the rhyolite breccias and forming the gangue of many veins.

Quartz (SiO_2) is finding crystallized and amorphous, sometimes the crystals size reaching up to 6 - 10 cm. The length of the veins is generally below 500 m; the longest vein is breccia vein from Orlea that reach 700 m.

Gold mineralization is disseminated throughout the mediterranean basin without constitute all over the concentration of economical interest.

The deposits constituting and constituted the object of exploitation and exploration works are included in the following mining fields: Carpeni - Orlea - Tarina; Cetate, Cârnic; Cârnicel, Foies, Igre, Vaidoaia.

2.1. Tectonics of deposit

Discordant position of the Upper Cretaceous over the previous formations marks the first tectonic movements in the region. At the end of Cretaceous, the Metaliferi Mountains were emerging and attach to the central nucleus. The most important result of tectonic movements at the beginning of Tertiary is forming the Miocene basin from Rosia Montana, which is filled with Tortonian deposits consisting of detritus material intimately mixed with rhyolite pyroclastic material. In lithological facies distribution of these deposits can be observed the development of the tufitice conglomerates over the whole basin, conglomerate facies with tufaceous material appearing at the top of the series. Otherwise, the whole mass of the deposit is clearly mixed with pyroclastic material [4].

2.2. Elements of structural geology

It's considered that this complex maar-diatreme from Rosia Montana is put in place at the junction of two tectonic structures, oriented north-north-west and north-east. The ample faults system oriented north-east appears in the Cârnic and Cetate massif which intersect. In Cârnic massif this system constitutes the structural support of dyke's breccia contributing to unhook the contact between dacite and intracrateriale breccia. Another system of fractures oriented northwest, has been mapped along the north-eastern slope of Cârnic massif. It's considered that these fractures were active during diatreme formation, because they may contain breccia' dykes freatic-magmatic sin - or post mineralization. Such breccia can be deprived of mineralization, but may cross dacite or breccia zones rich mineralized.

In the Cârnic – Cetate area were identified and interpreted other structures too, with orientation varying between east-west and west-north-west, consisting of polymictic breccia that intercept the dacite of Cetate [1], [4].

2.3. Hydrothermal weathering

The deposit from Rosia Montana is accompanied by a large area of hydrothermal weathering. Distribution of hydrothermal associations has a complex nature, defined by five different paragenesis which can be reduced to two main groups: (1) associations with argillaceous minerals - sericite - pyrite (alteration clay) generally extent in the peripherical zone of the central gold-silver mineralized area; (2) associations with silica - pyrite - sericite (alteration by silification type) which is usually the central areas of different mineralized bodies from Rosia Montana. This type of alteration has a pervasive nature and is associated with precious metal mineralization. The main stages of hydrothermal alteration are affected by a belated alteration stage constituted of carbonate - quartz - clay minerals (illite), sulphides which form a system of thin veins and fracture fillings. In addition, at the regional level by hydrothermal alteration of andesite and vent breccia from Corna Valley, is formed an association of minerals with chlorite - carbonate - pyrite (propylitical alteration). In entire mass of Cetate massive is develop the areas with intense hydrothermal alteration, dominated by silica and clay associations, accompanied by fine granular sulphides.

In conclusion, the petrographic units of economic interest of the deposit from Rosia Montana are dacite, mixed breccia, intracrateriale-breccia, black breccia, brecciated sediments, and mixtures of these units. Dacite are intensely clayish and silicificated. The mineralization consists in disseminated pyrite associated with subordinate amounts of sphalerite local, galena and chalcopyrite accompanied by economic concentrations of gold and silver. In upper basin of Rosia valley, the bedrock consists in pyroclastic and andesitic flows, located along the northern and eastern summits of the valley. Upper and lower parts of the basin and ridge southern include dacite and intercrateriale breccia previously described. The two-tierce lower of the valley (to the west) are dominated by Cretaceous black schist [2], [4]. The surface material in Rosia valley is cohesive sediment to hard plastic, such as residual or colluvial nature, consisting of clayey sand with traces of gravel and boulders. The colluvial deposits cover the slopes and the alluvial valley thalweg.

3. CHARACTERISTICS OF ROCKS ENCOUNTERED IN CETATE QUARRY

From the geological point of view, the analyzed region is located close to the northern side of the crystalline. Following the lithological composition, the state of alterability and cracking the rocks from Cetate quarry perimeter have a differently degree of consistency delimited the following, in order of increasing mechanical strengths: black breccia, sedimentary rocks (sandstone micro-conglomerates); mixed breccia poorly cemented; kaolinizated altered dacite, fractured dacite, silicified mixed breccia; silicified dacite [2]. The base of the region consists in crystalline limestone over which have been formed the lower, medium and superior Cretaceous sedimentary deposits. The sedimentary was developed more in the southern and western of perimeter, consisting in microconglomerate tuffite sandstone deposits. These deposits were classified as soft rock category with low variations of the mechanical strengths (eg uniaxial compressive strength of σ_{rc} = 66 daN/cm²; average tensile strength σ_{rt} = 5.30 daN/cm²). These rocks present low resistance to the action of external agents. The deposits of superior Cretaceous constituted the base of mediterranean basin of the region, basin to whom are belonging conglomerates and tufaceous sandstones, dacite and breccia' complex. In the neogene basin from Rosia - Montana the volcanic activity occurred in three phases, a first stage corresponding to deployment of one phase mainly explosive rhyolite. In the second stage, which is the most important, the effusions of dacite gave rise the central volcano of Cetate and Cârnic hills which lava flowed on surfaces relatively limited and were ordered over the volcano - sedimentary formation which can having sometimes a thickness reach 200 meters and constituting essentially the surface part of this volcanic structure. As a result of mechanical efforts ascension of magma that have dislocated some of less coherent material of volcano - sedimentary formations on the periphery of dacite the breccias have been formed. The dacite pillar of Cetate massif is mostly covered of "black breccia" pelitic formation with a muddy appearance, which includes fragments from the pre-tertiary foundation of volcano - sedimentary party and through the dacite rock as emerging. Black breccia is well developed in the western area and appears in different points in eastern and southern part of study area. The tests carried out on these rocks showed that they are soft rock with great variations of the values of strength characteristics due to the fact that the tests have been made as monolithic samples, as well as the desegregated material.

Due to the mineralogical composition (presence of clay and carbonate material) and excessive humidity too, the lowest values of the internal friction angle and cohesion were observed in disintegrated black breccia in running plastic state. The values of the internal friction angle vary between the limits of φ = 6° - 28° and the cohesion between c = (0.1 – 2) daN/cm². Quickly alteration and humidity have been one of the factors that have been taken into account in the construction of quarry. The presence of running mud material required taking measures to remove it from the bench work, and where the development was more intensely have been taken measures with drainage and consolidation with retaining walls, anchors and jetcrete. The third stage of volcanic activity, predominantly explosive, gave rise so-called diatreme - columns of explosion filled with the breccia, with elements of foundation and dacite fragments. The explosive nature of this stage caused the cracks and brecciated zones of entire structure, thus appearing the major access ways for the hydrothermal solutions with gold and silver mineralization's. Mixed breccias form a central part of the deposit itself (Cornuri area), belong from many kinds, depending on the material composition, its size, the degree of hydrothermal alteration. These kinds of rock constituted mostly the useful area of the reservoir, but were found in the composing of benches work and of the edge of the quarry, especially in the southern part.

The different kinds of mixed breccias presented a large range of variation of the mechanical strengths, depending on the degree of hydrothermal alteration, cement and size fragments. They have been characterized as rock with average strength to hard and compact rock. The average values of the mechanical strengths are between the limits of σ_{rc} = (157 – 1550) daN/cm² and respectively σ_{rt} = (12 – 105) daN/cm². Due to the presence of the zoning intercalations of altered kaolinizated breccia, it was considered that to realize the slopes in such rocks it must reduce the angle of benches work and where it was necessary, they were even consolidation. The dacite comprise the largest part of rock from Cârnic perimeter, according to their degree of alteration being encountered several varieties of dacite. The intense hydrothermal alteration in some areas (kaolinization and propylitization) has quickly advanced, at the same time with rock exposure in the benches work. Due to the different degree of alteration the values of mechanical resistance have a large range of variation, framing like values between: strength uniaxial compressive σ_{rc} = (182 – 1230) daN/cm²; average strength tensile σ_{rt} = (25 – 92) daN/cm². It may specify that intensely altered dacite are the rocks included in the mean strength category, semi-rocky, cracked, easily alterable and degradable. These kinds of rocks doesn't plainly separate from the other dacite, they form the gradual transition, often being close to contact with the mixed breccias. The average values of physical - mechanical characteristics of rocks mostly found in the area of quarries from Rosia Montana are shown in Table 1 and Table 2.

Table 1. Average values of physical - mechanical characteristics for weathered rocks state:

Rock variety	Physical characteristics				Mechanical characteristics			
	Specific weight, $\gamma_s \cdot 10^4$ [N/m³]	Bulk density, $\gamma_a \cdot 10^4$ [N/m³]	Work humidity, W [%]	Porosity, n, [%]	Cohesion established in laboratory, c, [daN/cm²]	Cohesion in massif, [daN/cm²]	Angle of international friction, φ, [°]	Place of sampling
Sedimentary: micro-conglomerate sandstone tufaceous	2.84	2.25	2.15	22.53	130	6.5	28	Area
Sedimentary: micro-conglomerate sandstone tufaceous	2.84	2.25	2.15	22.53	130	6.5	28	Area
Black breccia (Glam)	2.82	2.36	1.41	25.17	5.7 20 19.5	5.7 20 19.5	28 28 27	Area +956m +853m
Weathered breccia poorly cemented	2.72	2.39	0.13	19.48	450 800 300	22.5 40 15	32 33 32	Area +956m
Compacted silicificated breccia	2.77	2.47 2.52	0.55	14.80	1100 1400	55 70	33 35	+956m
Compacted breccia with large elements	2.77	2.42	0.56	14.60	1400	70	36	+956m
Silicificated breccia with fine elements	2.77	2.45	0.56	14.55	1700	85	36	+853m

Hard compacted silicificated breccia	2.77	2.52	0.57	14.35	1400	70	33	+853m
Compacted breccia with large elements	2.77	2.47	0.57	14.15	1500	75	36	+853m
Compacted silicificated breccia with fine elements	2.77	2.52	0.57	13.90	2000	100	37	+853m
Weathered fissured dacite	2.71	2.39	0.75	16.23	900	45	31	Area +956m
Weathered kaolinizated dacite	2.76	2.39	0.58	13.40	575	28.75	32	+956m +853m
Silicificated dacite	2.79	2.45	0.47	13.40	1385	68.5	37	+956m +853m

Table 2. Elastic and strength of rocks from Cetate quarry perimeter:

Rock variety and place of sampling	REZISTENȚA DE RUPERE						Elastic Characteristics			
	Compression, σ_{rc}, [daN/cm²]	Tensile, σ_{rt}, [daN/cm²]	Double shear, τ_{fd}, [daN/cm²]	Simple shear, τ_{fs}, [daN/cm²]			Deformation modulus for 0,5 σ_{rc}, $\cdot 10^3$ [daN/cm²]		Recovery modulus $\cdot 10^3$ [daN/cm²]	
				40°	50°	60°	min.	max.	min	max.
Sedimentary: micro-conglomerate sandstone tufaceous Area +956 m; +853 m	66	5.30	9.4	94	59	36	4.3	8.4	4.5	8.9
Black breccia (Glam) Area +956 m; +853 m	42	3.3	-	-	-	-	2.4	6.3	-	-
Weathered breccia poorly cemented Area +956 m; +853 m	212	21	67	303	186	121	36	88	25	68
Compacted silicificated breccia Area +956 m	765	45	144	664	578	532	173	222	187	255
Compacted breccia with large elements Area +956 m	542	71	207	-	-	-	-	-	-	-
Compacted silicificated breccia with fine elements Area +956 m	1229	67	198	-	-	-	-	-	-	-
Hard compacted silicificated breccia Area +853 m	787	71	175	-	-	-	-	-	-	-
Hard compacted breccia with large elements; Area +853 m	612	105	120	-	-	-	-	-	-	-
Compacted silicificated breccia with fine elements; Area +853 m	1550	90	334	-	-	-	-	-	-	-
Weathered fissured dacite Area +853m; +956 m	338	54	106	-	-	-	-	-	-	-
Weathered kaolinizated dacite Area +853m; +956m	313	25	74	-	-	-	-	-	-	-
Silicificated dacite Area +853m; +956m	898	61	168	-	-	-	-	-	-	-

As it is also noticed from the characteristics' values presented in the previous tables, the rocks present high strength, being a part of medium to high strength rocks (semi-rocky to rocky).

The opening of Cetate quarry was made from the village road Rosia Montana, by realizing a contour main road of deposit at elevation +900 m. From this it's across the connection roads at the quarry benches. The opening of each bench is made by internal individual opening-trenches, fig.1 [3].

Fig.1. Opening of Cetate Quarry

Mostly, the ore production was generally achieved by quarry of the Cetate massif, and the other Cârnic and Cârnicel massif too. The ore blasting was performed using the following work' technologies:

- Classical technology with blasting chamber method and bore holes;
- Rooms and pillars technology
- Special technology around the holes

4. ROCK' CHARACTERISTICS COMPONENT OF PILLAR – FLOORS NETWORK

The bottoms of Cetate massif from Rosia Montana are localized in breccia and dacite. Analysis of geological fragments collected from inside of the bottom showed that most of them fall into the following varieties: mixed silicified breccia, poorly fractured dacite; these varieties were analyzed in terms of physical - mechanical and strength properties (instantaneous and rheological), Table 3.

Table 3. Calculus values adopted for the strength parameters of rocks:

No.	Parameters of rock	U.M.	BRECCIA	DACITE
1.	Bulk density, γ	$N/m^3 \cdot 10^4$	2,5	2,6
2.	Compressive strength, σ_c	$N/m^2 \cdot 10^5$	550	210
3.	Tensile strength, σ_t	N/m^2	86,4	58,8
4.	Shear strength, σ_f	N/m^2	127	227
5.	Cohesion, C	$N/m^2 \cdot 10^5$	21	15
6.	Angle of internal friction, φ	grade	38	36
7.	Elastic modulus, E	$N/m^2 \cdot 10^4$	201.950	245.500
8.	Poisson's coefficient, μ	-	0,126	0,304
9.	Limit degree of load, Δ	-	0,6	0,7
10.	Admitted velocity of the vibration	m/s	0,05	0,04

Full quarrying of the Cetate massif from Rosia Montana was made in the conditions of existence under the quarry' platforms of networks of underground cavities resulted from the old exploitations. Some of these cavities, so-called "coranda" can't be precisely defined due to their chaotic development and their removal is done step by step, as the descent level of quarry based on the special programs over time adapted of in situ realities.

Another part of the underground cavities, namely those resulting from the previous exploitation by rooms and pillars method is contoured on the maps of exploitation allowing the access of peoples inside them, for any controls and inspections.

The platform of quarry reached to the upper bottoms from the breccia area, and will proceed to the exploitation of the reserves contained in pillars and floors.

In the dacite area of massif, the quarry would have in exploitation one bench up to reach of the level of bottoms opposed unlike the "coranda" cavities whose removal impose drawing out this perimeter of the proper quarry and considering a protection berm and filling progressively the cavities with the dislocated ore from western of quarry without prior filling the existent cavities.

In this regard, the work bench of quarry would take a height corresponding to level difference between two successive bottoms and the equipments existent on the platform to work practically under the intermediate floors between bottoms. Given that this working mode assumed that the quarrying take place directly over network overlay cavities of underground, it follows that the security working depends directly of the stability of the pillars and floors below, which must resist both to the loads caused by equipments on the platform and the dynamic loads resulting on blasting.

From the work schema, it resulted that during of 6 successive benches the quarry' platform itself will consist practically of a floor of 2 m thickness in the breccia, respectively 5 m in dacite, the floor that initially has 33 m in breccia area and 54 m in dacite and which in turn is based on a complex system of pillars and intermediate floors extended in depth. In order that the quarrying be carried out properly is necessary to ensure both the stability of the upper floor which is actually the bottom of quarry as well the stability of all resistance structures placed below that support this floor.

CONCLUSIONS

In the existing pillars and intermediate floors network, any loss of stability exercised to one of the elements founded at lower levels can lead a falls' chain transmission up to the quarry' level. Until now, the stability structure has not suffered during the 40 years of existence, and at the first sight the situation doesn't seem to change worthless, if it's considered that with the descent of quarry the charges that weigh on the system was considerably diminished. But, if by descending quarry the static charge on the whole system continuously decreased, at the same time began to visibly increase the dynamic loads due to the current quarry' activities.

Thus, near the working front will soon reach that the quarry equipments (excavators, dumpers, bulldozers, drilling machines) work on a floor with a thickness capacity that has not been seen so far, then blasting operations will be even close to that floor.

Analyzing the characteristics of the rocks considered, it can be appreciated that, from view point of physical-mechanical, the deposit presents a favourable situation, both quarrying as well underground exploitation, without requiring the support of mining works or stowing the excavated areas. Different kinds of mixed breccias present a large range of variation of mechanical strength, depending on the: degree of hydrothermal weathering, cements, size of the fragments, being characterized that medium strength to hard rock, compact.

Dacite, which comprise the largest part of rock from Cârnic perimeter, have been affected by an intense hydrothermal weathering which in some areas has quickly advanced, at the same time with rock exposure in working benches. Intense weathering dacite are rocks from the category of medium strength semistâncoase, cracked, easily alterable and degradable; they don't clearly separate from the other dacite, but also form gradual transitions sometimes being near the contact with the mixed breccias.

REFERENCES:

[1]. Almăşan, B., *Exploatarea şi valorificarea zăcămintelor de substanţe minerale utile solide*, Editura Didactică şi Pedagogică, Bucureşti, 1982.
[2]. Glodeanu, E., *Studiu privind exploatarea prin carieră a pilierilor şi planşeelor conturate anterior prin exploatarea în subteran, la E.M. Roşia - Montană, între cotele +906 m şi +873 m*.
[3]. Todorescu, A., *Proprietăţile rocilor*, Editura Tehnică, Bucureşti, 1984.
[4] *,** *Documentatie tehnica si geologica de la Roşia Montană.*

Scientific Reviewers:
Prof. Ph.D. Eng. Ioan BUD

THE PHYSICAL FEATURE OF THE DEBRIS FRAGMENTS FROM JIU VALLEY'S AREA

MIHAELA POSTOLACHE*

Abstract: *To characterize the geomechanical rock debris for the Jiu Valley, I've chosen the physics features that allowed me to obtain an accurate and conclusive result for the technological quality of the studied material. The obtained geomechanical features from made measurements in the "Geomechanics laboratory " from University of Petroşani.*

Key words: *specific weight, pycnometer, the porosity, paraffin, humidity*

The physical features determined in the laboratory are: specific weight, apparent specific weight, porosity and natural moisture. These properties were determined on predominant rock types in the fields of debris on Jiu Valley slopes (Ogrin limestone marmorean type, massive amphibolite, striped amphibolite, gneiss amphibolite, Lainici-Păiuş psamitic gneiss type, Şuşiţa granodiorites and granite type).

1. SPECIFIC WEIGHT

This physical feature (γ) is defined as the ratio between the weight of solid particles (G) and its volume of these particles (V_s) without voids, to the reference temperature of 20 ° C.

The principle of the method consists in determining the proper volume and weighing - with the help of the pycnometer, as an application of the law of Archimedes, using distilled water as a reference liquid. In addition pycnometer, the equipment and materials used were: oven thermostat with temperature control at 105 ± 2 ° C, sand bath, analytical balance, mortar and pestle and calcium chloride desiccator.

The pycnometer was good clean and empty, I've weighed in analytical balance obtaining its weight G′. I've filled with distilled water up to the mark on the capillary tube and I've weighed it again with analytical balance obtaining the weight of G_1.

From the fine material mortar thoroughly dried in desiccator's cabinet at 105 ± 2 ° C, using a funnel I've put in the pycnometer, respecting the amount of 12 – 20 g, set the STAS 1913/2-76.

I've weighed the pycnometer on the same analytical balance, obtaining the weight G″. After this operation, I've poured distilled water over the rock sample (about 1.5 to 2 cm) and have gradually heated up to boiling temperature (15 minutes) in the sand bath. After boiling and then cooling, I have filled with distilled water up to the mark pycnometer, to analytical balance, obtaining this time the weight G_2.

---

* *Assist. eng., at the University of Petroşani, mihapos@yahoo.com*

By processing the data I have used the following relationship:

$$\gamma = \frac{G}{G + G_1 + G_2} \cdot \gamma_w \cdot 10^4 \text{ [N/m}^3\text{]} \quad (1)$$

$G = G'' - G'$ – the weight of the analyzed material (N)
G_1 – the weight of pycnometer + distilled water to the mark (N)
G_2 – the weight of pycnometer + material + boiling distilled water (N)
γ_w – the specific weight of distilled water at 20 °C.
Note that for each rock sample I made two attempts, I calculated the average, according to data of table 1.

Table 1

Rock type / Specific weight	Ogrin limestone marmorean type	Massive amphibo lite	Striped amphibolite	Gneiss amphibolite	Lainici-Păiuş psamitic gneiss type	Şuşiţa granodior ites	Granite type
$\cdot 10^4$ [N/m^3] Proba 1	2,73	2,93	2,90	2,85	2,70	2,80	2,79
$\cdot 10^4$ [N/m^3] Proba 2	2,78	2,91	2,87	2,82	2,62	2,92	2,80
$\cdot 10^4$ [N/m^3] Media	**2,75**	**2,92**	**2,85**	**2,83**	**2,66**	**2,86**	**2,78**

In conclusion, the rock samples taken from the rock debris of the Jiu Valley in terms of specific weight's fall into the category of half rocky rocks according to STAS.

2. APPARENT SPECIFIC WEIGHT

Is defined as the ratio between the weight of solid particles (G) and the total volume (V_a) including rock's voids, cracks, etc.

$$\gamma_a = \frac{G}{V_a} \text{ (N/m}^3\text{)} \quad (2)$$

Principle of the method consists in weighing the rock sample in order to determine the total volume (apparently). Since most debris rocks belong to some half rocky, I chose the paraffining method and hydrostatic weighing.

In the preparation of the material I've chose pieces of rock samples, which are devoid of inclusions, voids or cracks and has a shape similar to the regular.

The equipment and materials used consisted of analytical balance, precision thermometer, bowl with paraffin and his heating device, a wire basket and more needles.

Below, I have weighted each rock sample, obtaining weight G (N), after that I have switched to their paraffining by immersion in a paraffin bath, heated to 80 – 90 °C. I've repeated the operation several times, to cover with a uniform film over the surface of the sample, taking care that it does not produce air bubbles. After this operation, each paraffin sample I've weighed in the air obtaining the weight (G_1) and then in water (G_2), noting and water temperature.

In order to obtain the apparent specific weight (volumetrical) in the case of half rocky I've chose the relationship:

$$\gamma_a = \frac{G}{\frac{G_1 - G_2}{\gamma_w} - \frac{G_1 - G}{\gamma_p}} \ (N/m^3) \qquad (3)$$

G – the weight of unparaffin sample rock (N)

G_1 – the weight of paraffin sample rock and weighed in the air (N)

G_2 – the weight of paraffin sample rock, submerged and weighed in the water (N)

γ_w – the apparent specific weight of water (N/m^3)

γ_p – the apparent specific weight of paraffin (N/m^3)

For each rock sample I've made five trials, from which I've calculated the average, according to data of table 2.

In conclusion, the comparability of the data presented in table 1 for specific weight and those from table 2 which show the apparent specific weight (volumetrical), in terms of the unit have the same value, differences, and they are close enough consisting of the decimals and decimal. This situation is explained by the fact that the composition of the analysed rocks predominate minerals with glassy luster, namely, the quartz and silicates which have the specific weight (density) of between 2 and 3. Opaque minerals with metallic luster are entirely subordinate to them does not exceed 2% of the total components.

3. THE POROSITY

Porosity is defined as the ratio of the total volume of voids (Vg) and the total volume (V) of the rock or mineral substance, expressed as a percentage.

In the context of the definition of the porous medium (total or effective) porosity of rocks and minerals can be categorized into: total porosity (nt) or apparent, in which case the volume of voids (Vg) includes the totality of interconnected pores or not, existing in the environment, and considered effective porosity (ne) or real, in which case the volume of voids (Vg) includes only the pores that are interposed in the environment considered.

Table 2

Rock type / Apparent specific weight	Ogrin limestone marmorean type	Massive amphibo lite	Striped amphibolite	Gneiss amphibolite	Lainici-Păiuş psamitic gneiss type	Şuşiţa granodio rites	Granite type
$\cdot 10^4$ [N/m^3] Proba 1	2,65	2,88	2,82	2,80	2,64	2,85	2,60
$\cdot 10^4$ [N/m^3] Proba 2	2,69	2,83	2,78	2,72	2,61	2,80	2,68
$\cdot 10^4$ [N/m^3] Proba 3	2,70	2,95	2,85	2,82	2,58	2,82	2,64
$\cdot 10^4$ [N/m^3] Proba 4	2,67	2,82	2,79	2,72	2,60	2,77	2,70
$\cdot 10^4$ [N/m^3] Proba 5	2,75	2,99	2,84	2,79	2,63	2,78	2,66
$\cdot 10^4$ [N/m^3] Media	**2,69**	**2,89**	**2,81**	**2,77**	**2,61**	**2,80**	**2,65**

$$n = \frac{V_g}{V} \cdot 100 = \left(1 - \frac{\gamma_a}{\gamma}\right) \cdot 100 \ [\%] \qquad (4)$$

Pore rate is defined as the ratio between the volume of voids (Vg) and the volume of the solid phase (Vs).

$$e = \frac{V_g}{V_s} = \frac{\gamma}{\gamma_a} - 1 \qquad (5)$$

Porosity values calculated for the seven types of rocks can be followed in table 3.

4. NATURAL MOISTURE

It is defined as the ratio in percentage of the weight of the water that is found in the rock, which can be removed – separated from it – by heating to 105 ° C and the weight of the mineral skeleton, namely:

$$W = \frac{G_W}{G_S} \cdot 100 \ [\%] \qquad (6)$$

G_w – the weight of removed water by heating to 105 ° C
G_s – weight sample after drying

Table 3

Rock type / The porosity and pore rate	Ogrin limestone marmorean type	Massive amphibolite	Striped amphibolite	Gneiss amphibolite	Lainici-Păiuş psamitic gneiss type	Şuşiţa granodiorites	Granite type
n %	2,18	1,02	1,40	2,12	1,87	2,09	4,67
e	0,02	0,01	0,01	0,02	0,01	0,02	0,05

The determination of this parameter is performed by conventional laboratory methods either by rapid method, accepting the mean of three determinations.

Humidity values can be seen in table 4.

Table 4

Rock type / Humidity	Ogrin limestone marmorean type	Massive amphibolite	Striped amphibolite	Gneiss amphibolite	Lainici-Păiuş psamitic gneiss type	Şuşiţa granodiorites	Granite type
W_1	1,3	2,1	1,6	1,6	1,7	1,6	1,0
W_2	1,5	2,2	1,9	1,8	2,3	1,4	1,3
W_3	1,4	2,0	2,2	1,7	2,0	1,5	1,3
W	**1,5**	**2,1**	**1,9**	**1,8**	**2,0**	**1,5**	**1,2**

Physical characteristics of the fragments that make up the debris fields of Jiu Valley slopes reveal that these rocks in terms of quality factor are good, very good or even excellent for various civil engineering and to obtain their crushing gravel aprons, enjoyed split or getting a very good material that can be used to manufacture concrete with mineral binders.

REFERENCES

[1]. Arad V., *Mecanica rocilor*, Editura Didactică şi Pedagogică, Bucureşti, 2004
[2]. Hirian C., *Mecanica rocilor*, Editura Didactică şi Pedagogică, Bucureşti 1981
[3]. Postolache M., *Studiul geomecanic al câmpurilor de grohotiş şi dărâmături de pantă din Defileul Jiului în vederea valorificării acestora*, Teza de doctorat, 2010
[3]. Stamatiu M., *Mecanica rocilor*, Editura Didactică şi Pedagogică, Bucureşti, 1962
[4]. Todorescu A., *Proprietățile rocilor*. Editura Tehnică, Bucureşti, 1984.

Scientific Reviewers:
Prof. Ph.D. Eng. Victor ARAD

DIMENSIONING THE COAL FACES IN THE USED TECHNOLOGICAL CRITERION FROM OLTENIA'S LIGNITE COAL PITS

I.C. PREDOIU*

Abstract: *Because the lignite deposit of Oltenia is comprised of 1-8 exploitable coal layers, their capitalizing calls for urgent arrangements to ensure rational exploitation under conditions of total safety, minimum losses and efficiency. The technology used the coal pits of North-Western Oltenia is the technology of excavation, transport and dumping in a continuous flow by using the complexes of excavation, transport and high-capacity dumping. Geometric dimensions of the benches of the open pits, the height of benches, slope angle and width of berms shall be calculated and shall be based on: the massif structure that forms the benches; physical-mechanical characteristics of rocks from the bench; working conditions, characterized mainly by mining and extraction methods applied; functional parameters of the mechanical equipment used to perform various operations on the coal face etc. For this study it was necessary a broad field for task tracking, measurement, research and design elements of the coal face, for land survey and a desk activity by: processing of topographic data, laboratory analyses on physical and mechanical properties of rocks and numerous specialized studies.*

Key words: *bench sizing, coal face, coal pit, bucket wheel excavator, Oltenia mining basin*

1. FEATURES OF OLTENIA MINING REGION

The mining area of Oltenia is located in South-Western Romania, in the counties Vâlcea, Gorj and Mehedinți, in the hilly areas, going over a long stretch of about 120 km (Figure 1.1), which successively across the valleys between the Danube and the Luncavăț.

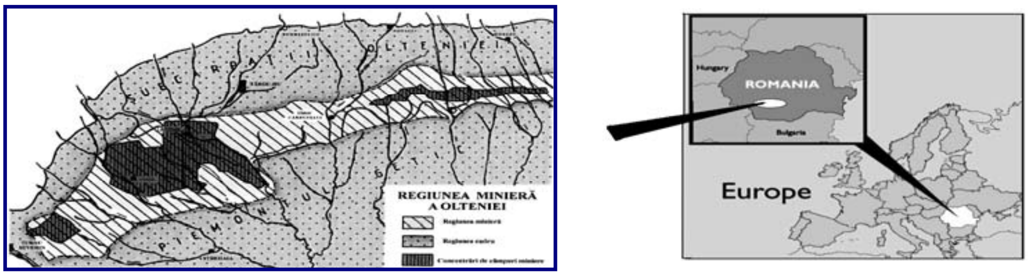


Figure 1- Oltenia mining area

* *Ph.D. Eng. at Oltenia Coal Company*

Geological research and mining practice have highlighted the fact that Oltenia' s lignite deposits present some peculiarities from one area to another, which imposed their grouping in areas with variable expansion.

By the geographical and geological criteria, the economic area of South-Western Oltenia was split into five mining basins: Rovinari Basin; Motru Basin; Jilț Basin; Berbeşti-Vâlcea Basin; Mehedinți Basin.

2. WORKING TECHNOLOGIES APPLIED IN THE COAL PITS OF OLTENIA

2.1. Discontinuous working flow technologies

Characteristic of this technology is the fact that the equipment used for excavation and transport acts discontinuously, being served by the transport equipment which have a working cycle consisting in a discontinuous activity.

Over time the Oltenia mining basin, where over 80% of lignite reserves are located in the hilly area, it has been used the the discontinuous flow technology in small coal pits which have prepared the coal pit for introducing the continuous flow technology.

2.2. Continuous flow technologies

Today we are witnessing an expansion of the continues action excavators in the coal pits with hard rocks, due to the need of increasing the output and labour productivity.

In the continuous flow technologies, which applies to the rocks of a low strength, the excavation operations, transport and dumping runs continuously and the equipment can be assembled in various technological schemes and production workflows

Bucket wheel excavator

The bucket wheel excavator is the most important type of continuous excavator used on the mining sites. This type of excavator exceeds in both its simplicity and productivity the one bucket excavators and the ones with several cups like bucket-chain excavators.

No matter of constructive variants of bucket wheel excavator, we can distinguish a number of constructive elements, as shown in Figure 2.

Since the last activity and so far from the Oltenia mining basin, it has been proved that the most appropriate equipment for the extraction of stripping and coal is the bucket wheel excavator.

In the coal pits from Oltenia, nowadays are used the bucket wheel excavators type SRs 470, SRs 1300, ESR_c – 1400 30/7 and SRs 2000.

In the coal pits of Oltenia, the transport is made by belt conveyors, equipped with continuous flow technologies for coal and sterile as well.

The belt width is between 1200 - 2250 mm and speed of 4.19 - 6.15 m/sec, having an hour transport capacity of 2500 - 12500 m^3/hour.

The transport systems of the working benches ensure the transport of the excavated masses to the coal yards as well.

The spreaders of Oltenia mining basin have a capacity of 2500 m^3/h, with an arm of 50 m, 4400 m^3/h, with an arm of 60 m, 6300 m^3/h, 6500 m^3/h and 12500 m^3/h with an arm of 90 m. For the directly dumping, are used the dumpers with an arm of 120 m and 170 m, which take the material from the last bench of the coal pit.

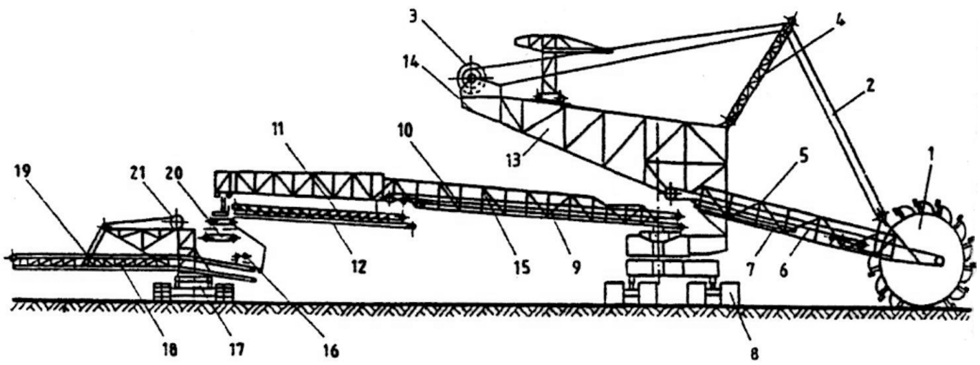


Figure 2 - ESR_c – 1400 30/7 excavator with separate loading equipment
1-bucket wheel; 2-cable; 3-pulley; 4- arm for pulleys ; 5-bucket wheel arm; 6- belt no. 1; 7-cleaning belt; 8-tracks; 9- cleaning belt; 10-belt no. 2; 11-belt no. 3; 12- cleaning belt; 14-box for ballsat; 15-deck; 16-crusher; 17-trolley; 18- ceaning belt; 19-arm of belt no. 5; 20-belt no.4; 21-pulley of belt no. 5.

3. SIZING THE COAL FACES

For sizing the geometric elements of the benches need to be taken into account: the physical-mechanical characteristics of the rocks, the working conditions characterized by the extracting and exploiting method and the functional parameters of the equipment used to perform various operations.

Geometric dimensions of the benches (figure. 3) i.e. the height of benches, slope angle and width of berms shall be calculated and shall be based on: (Predoiu I.C, 2012)

-structure of the massif that forms the benches;

-the physical and mechanical characteristics of rocks from the bench;

-working conditions, characterized mainly by the methods of mining and extraction technologies applied;

-technological parameters of the equipment used to perform various operations on the front, etc.

Height and pitching of the berms. Determination of the benches height can be done in two ways: one, taking into account the physical and mechanical properties of rocks to be extracted, and another practice, which takes into account the equipment and technologies.

The way forward in solving this problem is to determine the height of the bench after both criteria and to accept and work on site with the minimum height that will ensure the stability of slope angle and safety of machinery placed on the fronts and on the berms.

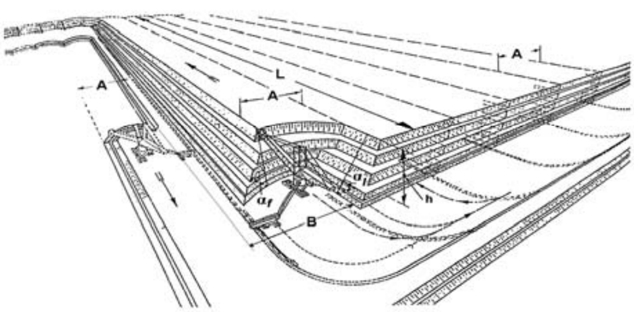


Figure 3 - Complete excavation of a technological block
H - block height; *L*- block length; *A* – block width;
B –berm width; α_f – front end slope angle; α_l – lateral slope angle;

3.1. Determination of heights and pitching of benches and coal faces by the nature and physical and mechanical features of the rocks

The main geo-technical indices of rocks and mixture of rocks, used in the stability calculations are: **apparent specific gravity (γa)** also called **volumetric weight**, **cohesion (c)** and the **sliding angle (φ)**. In the case of a minimum resistance surfaces, along which it can develop slips and crushes, need to determine cohesion and friction of the rocks on these surfaces too.

Over time, in the mining basins of Oltenia, deep drillings have been made and sampled, which have undergone tests to determine the physical and mechanical properties of rocks. These samples are estimated in the hundreds on the perimeter and thousands throughout the area.

For this paper, we have studied the nature of the rocks on exploitation perimeters we have extracted the summary table (table 1) with minimum and maximum values for all types of rocks found in the Oltenia area

Calculation of the bench height performed in rocks of low and very low strength can be done after a series of analytical procedures, which take into account both the slope geometry, the physical-mechanical properties of the rocks, and the shape surface of potential slip, the final results being shown in table 2.

Because in practice, the coal faces of the coal pits are made up in majority of cases by the combination of rocks, we resorted to the real height of the bench size (equations 1, 2, 3 and 4) (figures 4, 5, 6, 7, 8, 9, 10, 11, 12), (tables 3, 4, 5, 6, 7, 8, 9, 10, 11, 12) by taking the weighted average of the values of the main physical and mechanical properties of rocks (c, γ, φ), (s = 1, 2) for various working fronts encountered in practice:

$$C_{med} = \frac{\sum C_i \cdot h_i}{\sum h_i} \qquad (1)$$

Table 1 - Physical and mechanical features of rocks from Oltenia coal pits

Type of rock	**Volumetric weight, γ_v [kN/m^3]**	**Cohesion, c [kN/m^2]**	**Sliding angle, φ [degrees]**
Clay	19.0-21.0	21.0-48.0	16-23
Carbonaceous shale	15.6-19.2	50.0-70.0	30-34
Rich clay	18.8-20.1	40.0-65.0	22-27
Loam	18.8-20.8	14.0-32.0	15-22
Adobe	19.9-20.4	20.0-40.0	13-21
Sandy marl	19.2-20.5	24.0-52.0	23-27
Clay powder	18.5-20.7	16.0-22.0	10-17
Gouge	18.4-19-9	12.0-20.0	17-19
Loam sand	17.0-20.0	5.0-16.0	24-27
Close sand	17.5-19.0	4.0-12.0	22-26

$$\gamma_{med} = \frac{\sum \gamma_i \cdot h_i}{\sum h_i} \qquad (2)$$

$$\varphi_{med} = arctg \frac{\sum tg\varphi \cdot h_i}{\sum h_i} \qquad (3)$$

Calculation of bench height and slope angle, using the procedures from the professional literature (table 2) lead us to the results which can be found in practice of bench sizing of Oltenia coal pits;

Table 2 - Estimation of bench height and slope angle, using the methods from the professional literature

Type of rock	**s (1.2)**	**Physical-mechanical features**			**P.D. Lobasov Method**				**Fisenko**		**Hoek**	**analytic**
		c	**γ**	**φ**	**N (chart)**	**had α=57^0**	**N rated**	**α (h=25 m)**	**α (degree)**	**h_{real} (m)**	**h (α=55^0)**	**h ad (α=55^0)**
Clay		3.4	2	19	0.091	15.57	0.087	46	*45*	21.4	12.92	16
Carbonaceous shale		5.0	1.92	30	0.069	31.45	0.067	65	*50*	37.8	28.65	28.47
Rich clay		4.0	2	24	0.078	21.37	0.039	52	*55*	19.4	18.00	20.13
Loam		2.3	1.98	18	0.095	10.19	0.047	29	*60*	9.9	8.13	12.42
Adobe		3.0	2.15	17	0.094	12.37	0.064	28	*45*	17.3	10.19	14.34
Sandy marl		3.8	1.98	25	0.082	19.50	0.032	51	*50*	29	17.27	22.18
Clay powder		1.9	1.96	13	0.093	8.69	0.028	16	*55*	7.32	5.82	8.57
Gouge		1.6	1.91	18	0.095	7.35	0.019	26	*60*	7.39	5.86	8.95
Loam sand		1.1	1.85	25	0.073	6.48	0.015	28	*45*	9.6	3.57	8.60
Close sand		0.8	1.82	24	0.081	4.52	0.057	26	*50*	5.67	4.40	6.07

The useful mineral substance (lignite) from the coal faces has the following physical-mechanical features (table 3):

Table 3 - Physical-mechanical features

Useful mineral substance	Volumetric weight, γ_v [kN/m^3]	Cohesion, c [kN/m^2]	Sliding angle, φ [degree]
Coal (lignite)	12.5	80	25

- **Example 1:**

Table 4 - Rocks of the extraction bench

Type of rock	γ_v	*k*	*φ*	*h*
Clay	2	2.83	16	**10**
Loam	1.98	1.91	24	**5**
Carbonaceous shale	1.92	4.16	15	**4**
Coal	1.25	6.66	25	**1**
Weighted average	**1.94**	**3.06**	**18.34**	**20**

Checking with the ratio:

$$h_{ad} = \frac{2k \sin\alpha \cos\varphi_1}{\gamma \sin^2\left(\frac{\alpha - \varphi_1}{2}\right)} \quad (4)$$

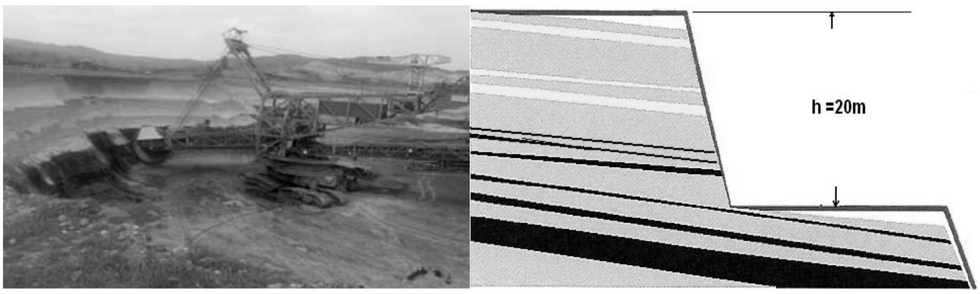


Figure 4 - Coal face and geological profile, bench IV, E 1400 -11M, Pinoasa coal pit

Table 5 - Height calculation for different slope angles

k	α	φ	γ	h_{ad}
3.06	**50**	18.34	1.94	**30.83**
3.06	**55**	18.34	1.94	**24.80**
3.06	**60**	18.34	1.94	**20.51**
3.06	**65**	18.34	1.94	**17.30**
3.06	**70**	18.34	1.94	**14.82**

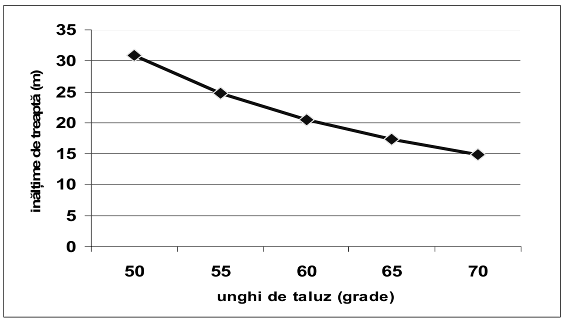


Figure 5 - Height variation h_{ad} according to the slope angle

In this case it is observed that the maximum height for the front slope angle α = 700, is h ≈ 15 m, and as the slope angle decreases, the front height increase to a value more than 30 m.

➢**Example 2**

Table 6 - Rocks of the extraction bench

Type of rock	γ_v	k	φ	h
Clay	2.15	2.5	17	10
Loam	1.98	1.91	24	4
Carbonaceous shale	1.92	4.16	15	1
Coal	1.25	6.66	25	4
Weighted average	**1.91**	**3.34**	**20.15**	**19**

Figure 6 - Coal face and geological profile, bench II, E 1400-04 Pinoasa coal pit

Table 7 - Height calculation for different slope angles

k	α	φ	γ	h_{ad}
3.34	**50**	20.15	1.91	**36.92**
3.34	**55**	20.15	1.91	**29.99**
3.34	**60**	20.15	1.91	**24.48**
3.34	**65**	20.15	1.91	**20.45**
3.34	**70**	20.15	1.91	**17.37**

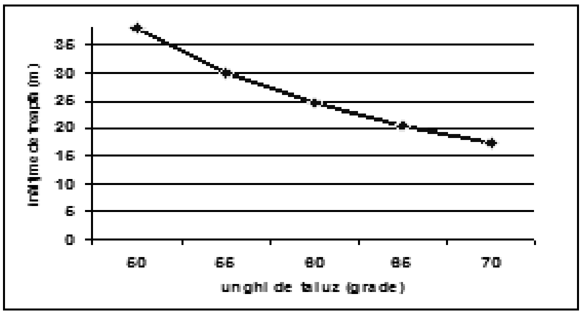


Figure 7 - Height variation h_{ad} according to the slope angle

- **Example 3:**

Table 8 - Rocks of the extraction bench

Type of rock	γ_v	k	φ	h
Clay	2	2	19	15
Sandy marl	1.98	3.16	25	4
Loam	1.98	1.91	18	4
Coal	1.25	6.66	25	7
Weighted average	**1.82**	**3.23**	**21.13**	**30**

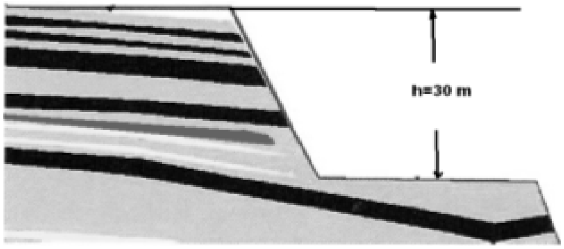


Figure 8 - Geological profile, extraction bench III, Pinoasa coal pit


Figure 9 - Measuring the coal layer


Figure 10 - Bench configuration

Table 9 - Height calculation for different slope angle

k	α	φ	γ	h_{ad}
3.23	**50**	21.13	1.82	**36.81**
3.23	**55**	21.13	1.82	**31.96**
3.23	**60**	21.13	1.82	**25.90**
3.23	**65**	21.13	1.82	**21.50**
3.23	**70**	21.13	1.82	**18.18**

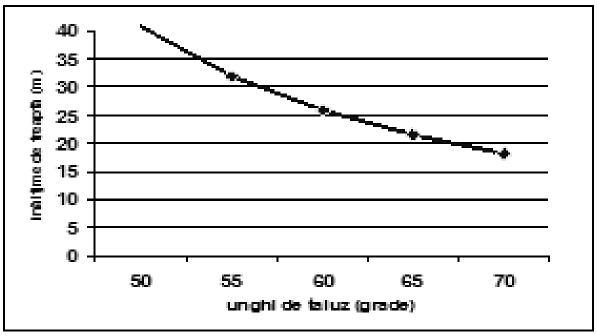


Figure 11 - Height variation h_{ad} according to the slope angle

Although to a slope angle $\alpha = 55^0$, the height can reach to 30 m, results that to a slope angle of $\alpha > 65^0$ this should not be more than 20 m.

➢**Example 4:**

Table 10 - Rocks of the extraction bench extraction bench III, perimeter, E 1400-01M

Type of rock	γ_x	k	φ	h
Clay	2	2.83	19	4
Loam sand	1.85	0.91	25	8
Loam	1.98	1.91	18	2
Coal	1.25	6.66	25	4
Weighted average	**1.76**	**2.54**	**22.95**	**18**

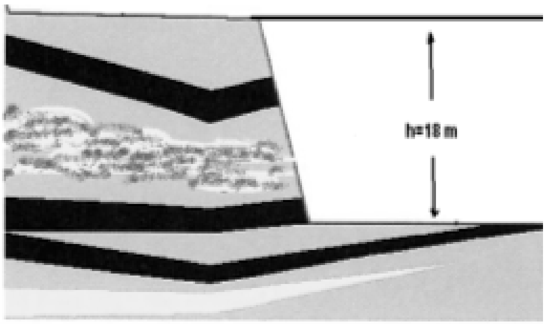


Figure 12 - Geological profile for Rovinari East mining

Figure 11 - Interlayer of loam sand in the coal face

Figure 12 - Configuration of working bench

Table 11 Height calculation for different slope angles

k	α	φ	γ	h_{ad}
2.54	**50**	22.95	1.76	**37.23**
2.54	**55**	22.95	1.76	**28.57**
2.54	**60**	22.95	1.76	**22.80**
2.54	**65**	22.95	1.76	**18.71**
2.54	**70**	22.95	1.76	**15.68**

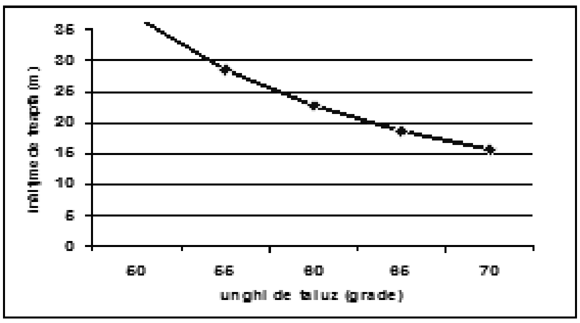


Figure 15 - Height variation h_{ad} according to the slope angle

Although to a slope angle α =55^0 the height can reach 28 m, it results a slope angle α>65^0, this can not be more than 16 m.

Table 12 - Comparison for determination of admissible height of coal faces,
- for the average front end slope angle, $\alpha_{average} = 60^{o}$

<table>
<tr><th rowspan="3">Type of rock</th><th colspan="3">Physical-mechanical features (average values)</th><th colspan="10">admissible h_{bench} (m) - for the front end average slope angle, $\alpha_{average} = 60^{o}$</th></tr>
<tr><th rowspan="2">c [kN/m²]</th><th rowspan="2">γ [kN/m³]</th><th rowspan="2">φ [grade]</th><th colspan="4">Height determination (homogeneous bench), by analytical methods (m)
Fs=1.2</th><th colspan="3">Maximum excavation height of the machinery (m)</th><th colspan="3">Admissible excavation height of the machinery (m) (rocks combinations)</th></tr>
<tr><th>Lobasov</th><th>Fisenko</th><th>Hoek</th><th>analytical</th><th>E2000</th><th>E1400</th><th>E1300</th><th>E2000</th><th>E1400</th><th>E1300</th></tr>
<tr><td>Clay</td><td>34</td><td>20</td><td>19</td><td>15.07</td><td>15.80</td><td>12.20</td><td>16.81</td><td rowspan="3">30</td><td rowspan="3">30</td><td rowspan="3">26</td><td rowspan="2">22</td><td rowspan="2">20 - 22</td><td rowspan="2">20</td></tr>
<tr><td>Carbonaceous shale</td><td>50</td><td>19.2</td><td>30</td><td>29.35</td><td>29.5</td><td>27.55</td><td>28.47</td></tr>
<tr><td>Rich clay</td><td>40</td><td>20</td><td>24</td><td>20.32</td><td>21.22</td><td>17.00</td><td>20.13</td><td colspan="3" rowspan="2">Admissible height (m)
- teorethical -</td></tr>
<tr><td>Loam</td><td>23</td><td>19.8</td><td>18</td><td>9.30</td><td>9.9</td><td>8.10</td><td>12.42</td><td colspan="3" rowspan="3">According to the front end slope angle α_f and declivity angle of the bucket wheel arm β_s (m); (β_s=40°)</td></tr>
<tr><td>Adobe</td><td>30</td><td>21.5</td><td>17</td><td>11.30</td><td>12.1</td><td>10.10</td><td>14.34</td><td rowspan="2">5.5</td><td rowspan="2">5.7</td><td rowspan="2">4.2</td></tr>
<tr><td>Sandy marl</td><td>38</td><td>19.8</td><td>25</td><td>17.90</td><td>18.5</td><td>17.15</td><td>22.18</td></tr>
<tr><td>Clay powder</td><td>19</td><td>19.6</td><td>13</td><td>7.80</td><td>8.00</td><td>5.70</td><td>8.57</td><td rowspan="4">29.73</td><td rowspan="4">27.68</td><td rowspan="4">25.85</td><td colspan="3" rowspan="2">Admissible height (m)
- by measurements and statistical data-</td></tr>
<tr><td>Gouge</td><td>16</td><td>19.1</td><td>18</td><td>6.75</td><td>7.39</td><td>5.50</td><td>8.95</td></tr>
<tr><td>Loam sand</td><td>11</td><td>18.5</td><td>25</td><td>6.05</td><td>6.70</td><td>4.40</td><td>8.60</td><td rowspan="2">5.3</td><td rowspan="2">5.2</td><td rowspan="2">4.1</td></tr>
<tr><td>Close sand</td><td>8</td><td>18.2</td><td>24</td><td>4.30</td><td>4.90</td><td>4.10</td><td>6.07</td></tr>
</table>

The minimum values of the admissible height are recorded for *Evert Hoek chart*;

The maximum values of the admissible height are recorded for the analytical method;

In case of choosing the admissible height of excavation benches in homogeneous rocks, it will select the minimum value (*Hoek method)*.

4. CONCLUSIONS AND SUGGESTIONS

For dimensioning the geometrical elements of the benches it need to take into account of: physical and mechanical properties of rocks, the conditions of work according to the extracting and exploiting method and functional parameters of the equipment used to perform various operations.

Calculation of the benches height performed in rocks of low and very low strength can be done after a series of analytical methods which take into account both the slope geometry and physical-mechanical properties of the rocks, and the shape of the potential sliding surface.

The height of the benches, determined on the basis of physical-mechanical properties of the rocks, it is often a few tens of meters, which cannot be supported in practice, always taking into account the possibilities for work and safety in operation of the equipment.

By comparing the results obtained with the help of topographical measurements, with the values of the coal face height, depending on the front end slope angle, with the main characteristics of bucket wheels excavators, as well as with the results of the analytical processes, based on nature and physical-mechanical properties of the rocks that make up the bench, evidenced by the fact that the machinery of the Oltenia coal pits operate in a safe and secure mode.

As a result of measurements made on the basis of specialized studies and systematic observations on the behavior of the slopes and coal faces of the Oltenia coal pits, it has been concluded, depending on the height of the benches where the bucket wheel excavators were working, values of the active slope, as follows:

$h \leq 10$ m , α_{slope} lateral active 50-65°; α_{slope} front end active 55-70°;
$h = 10\text{-}22$ m, α_{slope} lateral active 50-60°; α_{slope} front end active 55-70°;
$h > 22$m, α_{slope} lateral active 50-55°; α_{slope} front end active 55-65°.

REFERENCES

[1]. Fodor D. *Exploatarea în cariere a zăcămintelor de substanțe minerale şi roci utile*, Exemple de calcul, Editura Agir, Editura Corvin-Deva, 2010.
[2]. Fodor D., Rotunjanu I.. *Tehnologii moderne de exploatare în carierele de lignit,* Revista Mine, Petrol, Gaze nr.6/1979; 1979.
[3]. Rotunjanu I. *Stabilitatea versanților şi taluzurilor,* Editura INFOMIN DEVA; 2005.
[4]. Predoiu, I.C. *Dimensionarea fronturilor de extragere în condițiile tehnologiilor utilizate în carierele de lignit din Oltenia,* Teza de doctorat, Petroşani, 2012.

Scientific Reviewers:
Prof. Ph.D. Eng. Dumitru FODOR

CONSIDERATIONS REGARDING THE METHODOLOGY TO DETERMINE THE PRODUCTION CAPACITY OF COMPLEX MECHANIZED STOPES WITH LONG FRONT

FLORIAN BUŞE*
GHEORGHE-FLORIN BUŞE**

Abstract: *The functional mines from Jiu Valley, apply different methods of coal mining and present concerns consist of introduction and generalization in workings with long front technologies in the main complex mechanization of operations labor intensive and time structure of the production cycle. To streamline the process of exploitation of coal deposits in the Jiu Valley, the paper analyzes the concept of the production capacity of mining production systems and presents the methodology for determining the production capacity mechanized stopes with long front complex, which analyzes the complex major operations within the stope cycle.*

Key words: *mining production system, production capacity, and front stope mechanized stope hourly capacities, production cycle*

1. PRODUCTION CAPACITY MINING SYSTEMS

Production capacity mining systems can be defined only by reference to a production load. In this context we can highlight two components:
- Quantitative ability, which also has the meaning of a "speed extraction" - the amount of tons of coal that can be made per unit of time;
- Ability quality that signifies the degree of correspondence between the technological requirements of the workings of the various equipment and technical possibilities of equipping stopes.

1.1. Quantitative ability

Quantitative capacity is the maximum production of coal of a certain quality that can be achieved in a production mining within a given time interval, optimum organizational and technical conditions, without taking into account bottlenecks. Bottleneck in a production system means quantitative subsystem with a capacity less than the primary subsystem.

Primary subsystem is characterized by the importance in the process of fixed capital invested the maximum weight and / or volume of work required quantities of coal extraction considered.

* *Professor eng. PhD, University of Petrosani, prof_buse@yahoo.com*
** *Lecturer eng. ec. PhD, University of Petrosani, manag_bgf@yahoo.com*

Primary subsystem can be:
- A stope or group of stopes for the manufacturing sector that includes fulfilling the above conditions;
- A stope with long front, for industry covered
- A production sector of the mining company.

Therefore, the quantitative ability, C_p characterizes the extraction potential possibilities in a period considered. It should not be confused with:
- planned physical output, Q_{pl};
- physical output achieved, Q_{ef}.

The units of measurement are the same with the production capacity of production volume per unit time period plan (*utpp*), namely natural units, *tons/utpp*;

A variable performance of manufacturing processes and systems is the capacity of utilization index basically defined of quantitative formula:

$$I_{uc} = \frac{Q}{C_p} \leq 1 \qquad (1)$$

where

Q is the planned production or the one actually carried out, *tons/utpp*;

C_p – quantitative ability, *tone/utpp*.

Quantitative ability and capacity utilization index and are influenced by:
- entries in system resources: means of work, labor, coal reserves, technological processes of extraction, labor standards;
- outputs from the system: production of coal extracted.

These influencing factors are outlined in formula to the calculation principle of quantitative capacity:

$$C_P = M_C \cdot F \cdot N_P = M_C \cdot F \cdot \frac{1}{N_T}, \textit{ tons/utpp} \qquad (2)$$

where M_c is a characteristic size of the equipment means working production system considered;

F – allocated time for the plan period;

N_p – production time;

N_T – standard time.

The outputs of the system, the amount of coal extracted quantitative influences the amount of capacity by the qualitative characteristics of coal extracted (grain, ash content). Geological conditions of the deposit of coal mining (degree of difficulty of extracting) determine different values for normal production or technical regulation time and require different values of size M_c (different working regimes of the machines in equipping stopes).

Mining optimal assortment is the amount of coal extracted, leading to maximum utilization index of quantitative capacity in terms of facilities means work and qualifications of the workforce data.

Means work regardless of their functional and operational diversity can have three characteristic sizes M_c:

- n_u – number of machines in stopes equipment , *buc*;
- *L*, *h* – length respectively stope height, *m*;
- *lca* – length direction of a field of slaughter, *m*;
- *V* – coal output, m^3.

In calculating production capacity taking into account all stopes in operation and planned to be put into operation in the period considered.

Fund of time as expressed in the following sizes:

1) $F_c = n_{zc} \cdot n_s \cdot d \cdot s$, *hours/utpp* (3)

F_c – calendar fund of time;
n_s – number of shifts in the collective agreement usually $n_s = 4$;
d_s – during an exchange (6 hours including breaks covered);
n_{zc} – number of calendar days.

2) $F_n = [n_{zc} - (n_{zn} + n_{zs})] \cdot n_s \cdot d_s$ (4)

F_n – nominal fund of time;
n_{zn} – number of days off (52+52 Sundays and saturdays);
n_{zs} – number of days public holidays (14 - 15 days per year).

3) $$F_d = [n_{zc} - (n_{zn} + n_{zs} + n_{zrp} + n_{zîa})] \cdot n_s \cdot d_s = [n_{zc} - (n_{zn} + n_{zs} + n_{zîa})] \cdot n_s \cdot d_s \cdot k_{rp} \quad (5)$$

F_d – available fund of time;
n_{zrp} – number of days for planned preventive repairs;
k_{rp} – coefficient expressing reducing available fund of time due to repairs, planned preventive equipment, k_{rp} = 0,88…0,97;
$n_{zîa}$ – number of days of disruption approved.

4) $F_{ef} = F_d - n_{zîn} \cdot n_s \cdot d_s$ (6)

F_{ef} – efective fund of time;
$n_{zîn}$ – number of days of disruption approved due to deficiencies in the technical-organizational and management (accidental repair of machinery, accidents tectonic intercalations sterile, power outages, shortage of labor, etc.)

5) $F_u = F_{ef} - n_{zr} \cdot n_s \cdot d_s$ (7)

F_u – useful fund of time;
n_{zr} – number of days used for bringing in the stope front quiescent.

6) $F_t = (n_{zc} - n_{zrp}) \cdot n_s \cdot d_s$ (8)

F_t – technical fund of time.

In conclusion, fund of time structure is as follows:

F_c – calendar fund of time, corresponding n_{zc} – number of calendar days		
F_n – nominal fund of time, without n_{zn} – number of days off and n_{zs} – number of days public holidays	n_{zn} (52+52)	n_{zs} 14-15
F_d – available fund of time, without n_{zrp} – number of days for planned preventive repairs and $n_{zîa}$ - interruptions approved	n_{zrp}	$n_{zîa}$
F_{ef} – efective fund of time, without $n_{zîn}$ - unapproved interruptions	$n_{zîn}$	
F_u – usefull fund of time, without n_{zr} - production interruptions newly composed	n_{zr}	
F_t – technical fund of time	n_{zrp}	

If for quantitative capacity calculation it is used technical fund of time we define *technical and quantitative ability* and when used for available fund of time - *quantitative ability regime.*

Time work expressed by normal production work N_p , *tons/ut*, or N_T standard time, *ut/ton*, has different values for the same complex technological operations performed on the working face, by: coal mining technology, mechanization/ automation, production and employment, qualifications contractors, mining geological conditions of the coal deposit.

Most favorable level (N_p maximum and N_T minimum) taken into account for the calculation of technical capacity. It provides technology, equipment, qualifications and optimal organization of the production process.

In determining the capacity of production system is considered standard or rule prescribed time and technological documentation affected by the average coefficient of performance of procedures. In the mining industry there is a considerable gap between potential possibilities for extraction (technique quantitative ability) and their effective use (quantitative ability of the regime).

1.2. Qualitative capacity

Expresses type of production tasks that can achieved by production system and therefore will be defined by parametric features of production tasks. Each such task requires a certain quality of system capacity, which is achieved by a certain combination of technical features.

Influencing the technological process, in turn, the qualitative capacity and technological means must have features aimed at the requirements of the process. Equipment of stope front combine stope, mechanized conveyor scraper and support depends primarily on the type of technological process. To assess the ability of components of quality, the stope combines can be designed either in relation with the process (takes more complex operations of the same process in a race) or a few types of complex operations. Bridging mode of the machines in front stope influences both the qualitative capacity and the cost of achieving a given task. Capacitive and functional correlation of equipment in stope front is characterized by the spatial distribution and time sequence of complexes of operations. The transport of coal stope can integrate physically, in varying degrees, with the means of production transfer and handling systems transport manufacturing sector. Spatial structure models show how the means of production are placed in accordance with the sequence of operations to achieve a given production tasks and keep the benefits flow structure operations.

1.3. Mining production capacity calculation systems

The peculiarities of production process in mining production systems involves keeping the following key principles to ensure uniform performance across the different production systems mining quantitative capacity calculation, C_p.

1) Ability of a firm is determined only by the coal sector (stopes of different types and different equipment feature). Other sectors: Auxiliary (ventilation, maintenance, repair, power supply) serving (transport and storage of coal) and annexes (repair shops) have influence on the index of capacity utilization.

2) In determining company capacity it starts with the calculation for the lower levels (stopes, coal transportation systems horizontally) and continue sequentially to establish capacity at higher levels (production sectors, enterprise) function main subsystem.

3) In determining the production capacity allowed the existence of a degree of assurance normal production system with human and material resources, without taking into account the deficiencies of any kind that will influence the rate of capacity utilization.

4) Has a dynamic capacity is influenced simultaneously by different factors, making it necessary to recalculate for changes over time.

In accordance with these principles in determining the capacity through the following steps:

- Collection and processing of primary information from departments: production, production, mechanical energy planning.

The primary information required are:

- physical production planned, $Q_{i,pl}$, *tons/utpp*;
- number of machines, *pieces*, on machine groups $m = 1,2, \ldots, u$;
- dimensional characteristics of the stope: front length work, L_f and working front height, h;
- necessary elements for calculating fund;
- rules or production time for each complex technological operation, k;
- average coefficients of fulfillment of norms.

- Calculation of production capacity for the system considered, including bottlenecks (deficient production capacity) and large seats (with surplus production capacity) by one of two methods:

a) Methods based on the relation principle for calculating capacity applied to an enterprise existing physical production duties are imposed according to some optimization criteria (economic juncture balance plan) and are given / known characteristic parameters M_c, N_p, N_T.

b) Methods based on mathematical programming aimed at optimizing the production system by different criteria:
- Minimizing the number of machines;
- Minimum investment required for the development or retooling;
- Maximizing capacity utilization index, which is equivalent with optimizing the production plan.

These methods are applied to new businesses or those that are reorganized / restructured.

- Develop an action plan to eliminate the deficit technical and organizational capacity and excess load.

1.4. Improving utilization of production capacity

Considering the determinants of production capacity regime, improving production capacity can be done through:
- extensive measures of: raising fund for the expansion work available in six days (if you can provide the necessary workforce) and reducing the duration of repairs, including through their non-working days or times to trade, use of all equipment and inventory enterprise increasing labor organization in stopes.
- intensive measures: reducing the normal time and increase the average coefficient of performance of optimizing the technological standards, application of new technologies by increasing the skills of performers, of the production reworked, improved technology for coal extraction.
- intensive – extensive measures: applying advanced management methods and organization of work in stopes, expand cooperation with other companies either deficits or surpluses charging production capacity.
- only after exhausting all these ways to improve manufacturing capacity utilization is justified calling for investment funds for park development machines for achieving production processes.

2. NEED TO DETERMINE THE MAXIMUM HOURLY INTENSITY MASS FLOW MINING

Mining methods currently used for the extraction of coal mining areas are active in the Jiu Valley:
- mining method layers thick horizontal slices stopes with short front directional ventilation system vented part;
- method of operation in horizontal slices with long front individually applied technologies, depending on the length of the stope front;
- bench mining methods undermined the three variants of application: for inclinations small, medium and large bed.

Technical progress in the coal mining industry accounted for by the inclusion complexes and aggregates extraction has led to the transition from cyclic organizational form organizational form continuous flow production. In this technical, technological and organizational new methodology for determining the production capacity, the front stope is based, determining the intensity of the rock mass flow zones (raw coal). In the main phases of the production process that takes place at the stope, the organization of the production process flow of mechanical workings rigorous and rigid not separate production periods when performing complex operations auxiliary organization, but basically involves overlapping partial or total time and space complexes of main and supporting operations.

3. DETERMINATION OF MAXIMUM INTENSITY HOURLY MASS FLOW MINING

To determine the maximum hourly intensity mass flow mining recourse to determine duration for main and supporting complex operations from progressive norms and normative (mandatory for determining capacity) and assuming similar technical and organizational measures, capacity utilization front slaughter.

Possible hourly production at complex operations is determined by formula:

$$P_0 = \frac{60}{t_b + t_a}, \ t/hour \qquad (9)$$

where:

t_b – normative duration for execution of basic operations, the physical unit work, *min;*

t_a – amount of execution time operations supporting overlapping with the basic unit of work, *min*.

The methodology presented below expresses the particular relations process complex operations of mechanized stopes. After determining the maximum hourly production potential by linking complexes and verification operations restrictions, go to setting maximum production per shift and / or day.

As a result, the maximum yield per unit time (the capacity of the complex mechanized slaughter front) of appliance is determined by the type of cut, the type of carrier.

3.1. Maximum hourly production output of slaughter

Maximum hourly production combines the thin strip cutting and cutting height adjustment is determined by the relation:

$$P_0 = \frac{60 \cdot B \cdot m \cdot \gamma}{\frac{1}{v_t} + t_{sc} + \frac{t_c}{L} + t_d}, \ t/hour \qquad (10)$$

where: B – the depth of the extracted, *m*;

m – layer thickness (height stope)*m*;

γ - massive coal volume weight, t/m^3;

v_t – feed rate combined front, *m/min*;

t_{sc} – specific normative time to change blades, *min/m*;

t_c – normative length at the ends of the stope operations that require cutting a strip off the combine by length L, *min;*

L – front length cut with combine, *m*;

t_d – other times the front overlapping operations, *min*;

Despite the apparent simplicity of the relation (10), use is subject to the correctness of normative quantities: v_t, t_{sc}, t_c and t_d.

The complex methodology to determine the production capacity of the mechanized stopes will find multitude of factors that determine the speed of advance and stops the operation of the appliance.

Combines maximum hourly output for slaughter fronts of steeply dipping strata is determined by a formula slightly different due to the fact that in some geo-mining stope support can not overlap with the combined operation and the operation occurs while supporting superimposed according to the relation:

$$P_c = \frac{60 \cdot B \cdot m \cdot \gamma}{\frac{1}{v_t} + t_c + t_{sc} + t_d}, \text{ t/hour} \qquad (11)$$

where:

t_c – normative for stope support, *min/m*;

3.2. Determination stope hourly capacity for other complex operations in stope

Overlaid with the type of cutting operation can be executed: straightening and providing frontline support and guidance stope roof and coal extraction niches.

Each of these complex operations combined operation condition and therefore can speak of a stope hourly capacity according to these complex operations.

The hourly capacity is determined using relations:

- straightening and providing front:

$$P_{ia} = \frac{60 \cdot N_{ia} \cdot K \cdot n_{ia}}{T_{sch} - T_{pi}}, \text{ t/hour} \qquad (12)$$

- supporting and guiding stope roof:

$$P_s = \frac{60 \cdot N_s \cdot K \cdot n_s \cdot B \cdot q \cdot a}{T_{sch} - T_{pi}} \text{ t/hour}; \qquad (13)$$

- support for slipping sections:

$$P_n = \frac{60 \cdot B \cdot q \cdot a}{t_{rs} + t_d}, \textit{ t/hour;} \qquad (14)$$

- coal extraction niches:

$$P_n = \frac{60 \cdot N_a \cdot K \cdot n_a \cdot B \cdot q \cdot a}{(T_{sch} - T_{pi}) \cdot L_n}, \textit{ t/hour;} \qquad (15)$$

where:

T_{sch} – exchange duration, *min;*

T_{pi} – preparation and completion operations during exchange, *min;*

N_{ia}– hourly production standard parts (post) the straightening and providing front, *t/post*;

N_s – hourly production standard parts (post) to support stope, *frames/post*;

N_a – hourly production standard parts (post) to extract coal niches, *t/post*;

K – standard coefficient;

B – the depth of the extracted, *m*;

q – production on m^2 per layer, *t/m^2*;

n_{ia} - legal placement with a maximum number of people to complex insurance operations and straightening the front;

n_s - legal placement with a maximum number of people stope support complex operations;

n_a - legal placement with a maximum number of people to resort to coal mining operations niches;

L_n –niches length, *m;*

a – width of a polling support, *m;*

t_{rs} –displacement duration of a section, *min;*

t_d – other times normal operations supporting the slipping of a polling, *min.*

After determining the maximum hourly production of the complexes of slaughter operations, the values obtained from the calculation are compared with each other and with the maximum hourly production of the appliance. Assuming that the calculated results take into account the technical and organizational measures assimilation capacity utilization stope front, then take the intensity of coal hourly flow at the minimum value between: P_c, P_{ia}, P_s, P_{rs}, P_n.

4. SWEEP OF TECHNICAL AND TECHNOLOGICAL RESTRICTIONS

Further, the methodology provides two checks generated by technical restrictions. Such checks shall concern: scraper conveyor capacity checking and verifying the condition of insurance stope normal ventilation.

4.1. Checking slaughter capacity scraper conveyor (push conveyer)

Scraper conveyor slaughter capacity is calculated as:

$$P_{tr} = 3600 \cdot S \cdot V_1 \cdot \gamma \cdot K_u \cdot K_m \cdot K_i \text{ , tons/hour} \qquad (16)$$

In which:

S – cross-sectional area of the gutter, m^2;

V_1 – the chain speed of movement , *m/s*;

K_u – fill factor calculated as the ratio between the cross-sectional area of the load cross and sectional area of the gutter;

K_m - coefficient of material, volume which occupies scraper chains (*0,6 – 0,8*);

K_i – coefficient that takes into account the angle α of inclination of the conveyor, which has the following values:

α	-10^0	-5^0	0	10^0	20^0
K_i	1,5	1,3	1	0,7	0,3

Correlation condition harvester - forwarder requires: P_c.

Otherwise, the hourly to hourly production stope after the above minimum value will be the appropriate scraper conveyor capacity. The complex methodology that may be found to determine the production capacity of the front of the stope is necessary to include more parameters of the transport stream.

4.2. Verification of insurance normal ventilation

Labor protection rules for mining airflow over the types of mining and methane content limit the output current of foul air from slaughter.

Between methane emanations slaughter, feed rate of the appliance, air flow and flow velocity required front by front there is the following relation: increasing the speed of advance is followed by increasing the amount of coal displaced and newly created front surface therefore increases the amount of methane released into the atmosphere stopped. Dilution methane output current of air from the stopped to content permissible limit is possible by increasing the air flow directed to the front of the stopped. How free profile surface through which air on the front is in constant growth rate that can be achieved only by increasing the speed of air through mining stopped entrance, exit and along the front stopped.

Daily production of stopped extraction machine equipped with provided ventilation should be checked, keeping the methane content in the output current of the stopped below the limit set of rules at a velocity of air through the stopped below the limit set of rules is absolutely necessary.

For verification, it is used the following relation:

$$P_a = \frac{0.6 \cdot T \cdot v \cdot S_d \cdot \alpha}{q_r} \cdot k_{ae} \text{ , t/hour} \qquad (17)$$

where:

T – cutting machine during operation one day (on the coefficient time machine and the practice of the stopped), *min*;

v – maximum speed permitted by the rules of labour protection to air movement on the face, *m/min*;

S_d – the free cross-sectional area of the stair in the processing step when it has the minimum, m^2;

α - maximum permissible concentration of methane in the current rules out of stopped, *%*;

q_r – relative efflux of methane in the atmosphere of the stope, m^3/t;

k_{ae} – coefficient that takes into account the influx of air into the airway through space exploited the direct vicinity of the front.

Maximum hourly flow possible coal that may result from its extraction in compliance with the reporting requirement ventilation obtain Pa value obtained from the relation at 60, namely:

$$P_a = \frac{0.01 \cdot v \cdot S_d}{q_r} \cdot k_{ae}, \; t/hour \qquad (18)$$

and therefore, the hourly production results as stopped:

$$P_{fa} = \min\{P_c, P_{ia}, P_{rs}, P_n, P_{tr}, P_a\}, \quad t/oră \qquad (19)$$

5. DETERMINING THE CYCLE TIME AND THE NUMBER OF CYCLES PER DAY

The next stage of the calculation is to determine the capacity stopped cycle time and number of cycles per day, taking into account the working arrangements adopted as rational.

The cycle time is determined by formula:

$$Tc = t + t_{md} + t_{rd} + t_{tc}, \; ore \qquad (20)$$

In which:

t – duration of the extraction cycle, *hours*;

$$t = \frac{Q_c}{P_{fa}}, \; ore; \qquad (21)$$

where:

Q_c – production cycle, *t/cycle*;

P_{fa} – coal flow intensity adopted in the analysis of complex production potential of slaughter operations and compliance with transportation capacity on the face and condition of ventilation, as shown above;

t_{md} – combined stop during transport, installation and removal of organs (when this happens, otherwise, $t_{md} = 0$), *hours*;

t_{rd} – repairs duration and roof control (overlapping with the combined operation), *hours*;

t_{tc} – transport duration (descent - ascent) combine (when these operations take place, otherwise $t_{tc} = 0$), *hours*.

The problem of determining the degree of overlap between operations both in time and in space is complex, each stope front showing specific aspects.

Once determined cycle duration, number of cycles per day will be determined by the relation:

$$n_C = \frac{T_Z}{T_C}, \textit{cycles/day}; \qquad (22)$$

where:

T_z – duration of one day, *hours/day*;

T_c – cycle duration, *hour/cycle*.

In this way we determined the parameter „n_c" for the daily production of stope (Q) reaches the maximum value. However, it appears that the mathematical point of view, the unit cost of extracting coal from the "c" [*lei / t*] is a function both of the stope length (L) and the number of cycles per day (n_c).

6. CONCLUSIONS

Choosing technological base unit represents an important step in the research conducted. In the case of mine system, to determine the production capacity was chosen, "complex mechanized coal face", as the basic unit.

Determination of complex mechanized stope production is a matter of great importance, as the methodology for determining the annual production capacity is based on relationships established in the main complex of operations in basic production unit, "stopes".

In fact, the essence of applying this methodology is the analytical determination of the value of the parameter (n_c) - number of cycles per day, the daily production of stope reaches the maximum value.

Due to technological peculiarities front stopes workings in the Jiu Valley, long cycle influences negatively the expression of the pressure and mining stope support training and technical and economic results obtained.

REFERENCES

[1]. Covaci Şt., *Underground mining*, vol. I, Didactic and Pedagogical Publisher, Bucureşti, 1983

[2]. Dumitrescu, I., Pleşea, V., *Present and perspective tendencies regarding efficiency of coal long wall exploitation.* Annals of the University of Petroşani – Mining Engineering, vol. 10 (XXXVII), ISSN 1454 – 9174, Petroşani – Romania, 2009, pp. 21 – 26

[3]. Goldan T., Cozma E., Vătăjelu S., *Designing mines*, vol II, Editura Focus, Petroşani, 2005

[4]. Popov V.L., *Osnovî gornovo dela*, Moskva, Nedra, 1990

[5]. Pleşea V., Dumitrescu I., Vlaicu-Popa M. E., *Technology and eficient extraction procedure of coal from Jiu valey mines*, Annals of the „Constantin Brâncuşi” University of Târgu Jiu, Engineering Series, Issue 4/2010, pag. 225-234

[6]. Simionescu A., Dijmărescu I., *Organization and management of mining activities,* Technical Publisher, Bucureşti, 1985.

SURVEYING AND GEODETIC NETWORK DEVELOPMENT METHOD ELIMINATE LEVELING HUBS

NICOLAE DIMA*
IOEL VEREȘ**
LARISA OFELIA FILIP***

Abstract: *The paper analyzes the possibility to determine successively the absolute level for any number of points using a known leveling base and having geometric sizes measured by geodetic leveling.*

Key words: *Geodetic network, elevation, stages, nodes method, successive elimination process.*

1. INTRODUCTION

In underground and surface mining activity, mining objectives coordinated by topographical works are performed in time according to the project for development of mining unit [3]. Consequently, surveying and geodetic measurements, their processing and determination of necessary values are made in stages. These are features that paper has in attention. There are used nodes method and matrix method (successive elimination process).

2. THE WORK CONTENT

Consider a closed path of geometric geodetic leveling, which belongs to a network of geodetic leveling and which is in the limit of a mining area (Fig. 1)

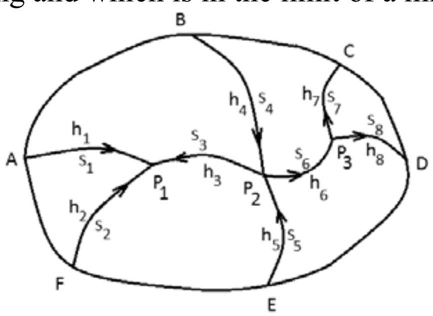


Fig. 1.

* *Prof. Ph.D. Eng., at University of Petrosani*
** *Assoc. Prof.Ph.D. Eng., at University of Petrosani, veresioel@yahoo.com*
*** Lecturer Ph.D. Eng., *at University of Petrosani, larisafilip@yahoo.com*

Points A, B, C, D, E, F have absolute level value known. These points are placed on a route solved in advance. Points P1, P2, P3 are obtained developing the closed path of geodetic leveling network by using the next leveling routes: AP1, FP1, BP2, EP2, ... DP3. The elevation differences h1, h2, ..., h8 are obtained from measurements made along these routes.

To determine the probable elevations of points P1, P2, P3 it is possible to apply indirect measurement theory.

As follows:

$$\begin{aligned} H_{P1} &= x_o + x = H_A + h_1 + x \\ H_{P2} &= y_o + y = H_B + h_4 + y \\ H_{P3} &= z_o + z = H_D - h_8 + z \end{aligned} \qquad (1)$$

Error equations are obtained from the difference between probable values obtained with equalities (1) and measured values of the elevations obtained from level differences h1, h2, ..., h8.

Equations form the system (1), (2):

$$\begin{aligned} x + l_1 &= v_1 \\ x + l_2 &= v_2 \\ x - y + l_3 &= v_3 \\ &\dots\dots\dots\dots \\ z + l_8 &= v_8 \end{aligned} \qquad (2)$$

Free terms in (2) are obtained using the measured level differences.

$v_1, v_2, v_3, \dots, v_8$ are measurements corrections.

Normal equation system is:

$$\begin{aligned} &(p_1 + p_2 + p_3)x - p_3 y + l_a = 0 \\ &-p_3 x + (p_3 + p_4 + p_5 + p_6)y - p_6 z + l_b = 0 \\ &-p_6 y + (p_6 + p_7 + p_8)z - l_c = 0 \end{aligned} \qquad (3)$$

Free terms from system (3) are obtained with relations:

$$\begin{aligned} l_a &= p_1 l_1 + p_2 l_2 + p_3 l_3 \\ l_b &= -p_3 l_3 + p_4 l_4 + p_5 l_5 - p_6 l_6 \\ l_c &= p_6 l_6 - p_7 l_7 - p_8 l_8 \end{aligned} \qquad (4)$$

The weights are the inverse lengths of $s_1, s_2, \dots, s_8$.

System (3) can be written as:

$$P_1 x - p_3 y + L_1 = 0$$

$$-p_3x + P_2y - p_6z + L_2 = 0 \tag{5}$$
$$-p_6y + P_3z + L_3 = 0$$

P_1, P_2, P_3 are sums of the weight in the nodes determined by points P1, P2 and P3.

$$P_1 = p_1 + p_2 + p_3$$
$$P_2 = p_3 + p_4 + p_5 + p_6 \tag{6}$$
$$P_3 = p_6 + p_7 + p_8$$

and L_1, L_2, L_3 are even l_a, l_b, l_c.

System of equations (5) has matrix form:

$$\left(\begin{array}{ccc|c} P_1 & -p_3 & 0 & L_1 \\ p_3 & P_2 & p_6 & L_2 \\ 0 & -p_6 & P_3 & L_3 \end{array}\right)\begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix} = 0 \tag{7}$$

in abbreviated form

$$Ax = 0 \tag{8}$$

Matrix A is transformed by successive elimination follows:

$$A = \left(\begin{array}{ccc|c} P_1 & -p_3 & 0 & l_1 \\ 0 & P_1P_2 - p_3^2 & -P_1p_6 & P_1L_2 + p_3L_1 \\ 0 & -P_1p_6 & P_1P_3 & P_1L_3 \end{array}\right) =$$

$$= \left(\begin{array}{ccc|c} P_1 & -p_3 & 0 & L_1 \\ 0 & P_1P_2 - p_3^2 & -P_1p_6 & P_1L_2 + p_3L_1 \\ 0 & 0 & P_1^2P_2P_3 - p_3^2P_1P_3 - P_1^2p_6^2 & P_1^2P_2L_3 - p_3^2P_1L_3 + P_1^2L_2p_6 + P_1p_3p_6 \end{array}\right)$$

$$= \left(\begin{array}{ccc|c} P_1 & -p_3 & 0 & L_1 \\ 0 & P_2 - \dfrac{p_3^2}{P_1} & -p_6 & L_2 + p_3\dfrac{L_1}{P_1} \\ 0 & 0 & P_2P_3 - p_3^2\dfrac{P_3}{P_1} - p_6^2 & P_2L_3 - p_3^2\dfrac{L_3}{P_1} + L_2p_6 + \dfrac{L_1}{P_1}p_3p_6 \end{array}\right) =$$

$$= \left(\begin{array}{ccc|c} P_1 & -p_3 & 0 & L_1 \\ 0 & P_{2.1} & -p_6 & L_{2.1} \\ 0 & 0 & P_3P_{2.1} - p_6^2 & L_3P_{2.1} + p_6L_{2.1} \end{array}\right) =$$

$$= \left(\begin{array}{ccc|c} P_1 & -p_3 & 0 & L_1 \\ 0 & P_{2.1} & -p_6 & L_{2.1} \\ 0 & 0 & P_3 - \frac{p_6^2}{P_{2.1}} & L_3 + \frac{L_{2.1}}{P_{2.1}} p_6 \end{array}\right) =$$

$$= \left(\begin{array}{ccc|c} P_1 & -p_3 & 0 & L_1 \\ 0 & P_{2.1} & -p_6 & L_{2.1} \\ 0 & 0 & P_{3.2} & L_{3.2} \end{array}\right) \qquad (9)$$

Returning to equation (8), it becomes:

$$\left(\begin{array}{ccc|c} P_1 & -p_3 & 0 & L_1 \\ 0 & P_{2.1} & -p_6 & L_{2.1} \\ 0 & 0 & P_{3.2} & L_{3.2} \end{array}\right) \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix} = 0 \qquad (10)$$

Algorithms from A matrix are determined using a simple rule.

Thus for example:

$P_{2.1}$ is obtained from P_2 less element $(-p_3)$ located above, squared and divided to the first element (P_1)

$L_{2.1}$ is obtained from L_2 less the product of the element located above P2 $(-p_3)$ and L1, divided by P1.

From equation (9) are obtained in reverse order unknowns z, y, x respective absolute elevations H_{P3}, H_{P2}, H_{P1}.

3. CONCLUSIONS

Solving method presented for the development of geodetic leveling network is flexible and can be applied in stages.

Calculation algorithm is achieved using simple rules easy to remember. It used a small number of operations that ensure efficiency and high precision.

REFERENCES

[1] Dima, N. - *Geodezie*, Editura Universitas, Petroșani 2005

[2] Dima, N. – *Teoria erorilor și metoda celor mai mici pătrate*, Editura Universitas, Petroșani, 1999

[3] Covaci, St.; Bădulescu, D.; *Explotări miniere subterane*, Editura Tehnică, București, 1982.

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

PRECIOUS METALS STOCKS INVESTMENTS. THEORETICAL GROUNDS

EMIL G. BIBER[*]
IOAN NICOLAE TIUZBAIAN[**]
LAVINIA HULEA[***]

Abstract: *Precious metals such as gold and silver also exhibit certain features that make them suitable for being employed as currency (money); accordingly, they are homogeneous, divisible, and non-alterable, easily preserved and transported; they are fiduciary and represent a high value gathered within a small volume; they also have a low weight.*

Key words: *gold, investments, silver, numismatic, karat, jewellery, coin, platinum, currency.*

1. INTRODUCTION

The category of precious metals include: gold (Au), silver (Ag), platinum (Pt) and platinum-like metals (ruthenium – Ru, rhodium – Rh, palladium – Pd, osmium – Os, and iridium – Ir).

The appellation of *precious* has been given as a result of the capacity of such metals of resisting chemical agents and of their specific physical characteristics such as: malleability, ductility, conductibility, etc. as well as to the good-looking appearance they display.

Precious metals such as gold and silver also exhibit certain features that make them suitable for being employed as currency (money); accordingly, they are homogeneous, divisible, and non-alterable, easily preserved and transported; they are fiduciary and represent a high value gathered within a small volume; they also have a low weight.

The currency made of precious metals carries out the functions of:

- Measure of value;
- Means of monetary circulation;
- Means of collecting treasury;
- Means of payment;
- Universal exchange currency;
- Numismatic (historical) value.

[*] *Assoc. Prof. Ec.Eng.Ph.D. at the University of Petrosani*
[**] *Lecturer, Eng., PhD. at the University of Petrosani, tiuzbaian@yahoo.com*
[***] *Lecturer Eng. Student PhD. at the University of Petrosani*

International relations have witnessed the functioning of the gold-foreign-exchange system for about three decades, according to the decisions of the Monetary and Financial Conference of the United Nations and associated countries that took place at Bretton Woods, during the period 1 – 22 of July, 1944.

The American dollar has also functioned as an international currency during a period when the United States of America guaranteed the gold convertibility of the dollars set forth by the central banks of the countries detaining dollars. Dollar emission and their launching on the monetary market by the USA, over its gold reserves, determined the critical condition of not being capable to meet its obligations as well as the decision of suspending dollar convertibility in 1971. Subsequently, in 1976, the International Monetary Fund decided to demonetize gold. Accordingly, they eliminated gold's currency functions and mainly its function of measure of value; nowadays, no monetary unit defines its value by comparison to gold.

In case of the gold standard, the value of the monetary unit was expressed by a certain theoretical amount of fine gold considered as a measure unit. In Romania, the last time they settled the official content of fine gold of Romanian leu was in 1945 and it represented 0.148112 g of fine gold.

In case of the other currencies, let's notice that the USA dollar had a theoretical content of 0.888671 g of fine gold, beginning with 1934 until 1971; the English pound had a content of 2.132810 g of fine gold while a rouble contained 0.987417 g of fine gold.

The theoretical content of fine gold a monetary unit contains does not depend on the economic power of a state; it is a matter that regards tradition and monetary policy.

Specialized researches show that gold is considered to be a noble metal which owes its appellation both to its brilliance and to its complete inertia manifested towards air and water. Gold does not oxidize or corrode and is passive before all chemical agents; it is imperishable. A proof that strengthens such statements is the gold jewellery dug out in the centuries-old fortress of Ur – Chaldea, found intact after 6, 000 years.

Nevertheless, gold is dissolved by chlorine water, an acid which is a mixture of hydrochloric acid and nitric acid resulting in mercury tetra-chlorine-auriculatus, as well as by alkaline cyanides.

Gold has various uses, although in most cases it is employed as gold alloys due to the fact that in its pure chemical condition (99.99%) it is too malleable, lacking hardness.

Chemically pure gold is only used, as a rule, for collecting treasury and is traded as bullions.

In order to increase its hardness and to make it easily processed, chemically pure gold should be alloyed with other metals.

Depending on the metals or metal employed when alloying, gold gets various colours and degrees of hardness. Alloy metals are: silver, copper, nickel or zinc. The most frequent alloy is the one between gold and copper or gold and silver. When amounts are properly used, the resulting alloy preserves the natural colour of the chemically pure gold while gaining an optimum hardness required by the manufacturing of jewellery, medals, coins etc.

The so-called greenish gold results when gold is mixed with a larger amount of silver and small amounts of zinc and copper; in case copper, zinc, and nickel are mixed with gold, the so-called white gold comes out. Pinkish gold or reddish gold is the result of the alloy of gold and copper.

2. SPECIFIC OPERATIONS

Chemically pure gold or fine gold as it is known on the market of precious metals and which is going to be processed in alloys contains 1,000 points (thousandths) as mark-title of ciliates and is standard defined as 24 Kt (technical karats) gold.

The term of karat (Kt), employed in order to measure the degree of alloying, or, in other words, the fine gold that enters the alloy, should be distinguished from that of Karat (Km) used with a view of measuring the weight of precious stones, for instance of diamonds. It is equivalent to a 200 mg weight.

Both appellations have their origin in the Italian word *carato* (or the Greek *karation* and the Arabian *qirat*) that means carob (and is a Mediterranean variety of fruit). In oriental bazaars carob's seeds had been used in order to accurately weigh gold and precious stones as they almost all have the same weight, namely 200-206 mg.

In its purest form (99.999% of fine gold), the 24 karat gold contains 24 parts of gold out of 24. The 18 karat alloy contains 18 parts of fine gold (75%) and six parts of other metals while the 14 karat gold includes 14 parts of fine gold (58.5%) and ten parts of other alloy metals.

The USA usually employ karat gold mark (24 Kt, 18 Kt, 14 Kt) while in Europe decimal marking prevails (0.999‰, 0.75‰, 0.585‰ etc.)

1 gold karat – 1,000/24 – 41.666 thousandths

A division of gold karat is gold "*SEMER*", namely:

1 gold karat = 12 gold "*SEMER*"

1 gold "*SEMER*" *= 1/12 Kt = 3.472 thousandths.*

Gold market accepts a fineness tolerance of maximum 3…

The minimum margin of gold per alloy differs from one country to another. In France and Italy, the law stipulates that the minimal proportion of gold alloy is the 18 Kt one (0.750…). In England, they also accept as gold the 9 karat alloys, and in other countries, such as Turkey, for instance, the 8 karat gold is accepted too.

In the USA, the minimal accepted gold alloy is the 10 karat one and the most frequently used is the 14 karat gold alloy. Generally, the finest pieces of jewellery are made of 18 or 22 karat gold while common jewels are made of 14 karat gold.

In order to determine gold purity, or, in other words, in order to find out the alloy proportion, several methods are employed. The most widely known are acids tests. The gold whose purity is up to 10 karat is attacked by nitric acid while higher purity gold only reacts to royal water (a mixture of nitric acid and hydrochloric acid).

In order to transform karats in thousandths, they are multiplied with 41.666 and in order to express thousandths in karats they are multiplied with 0.024.

E.g.:

- *an 18 karat gold alloy contains 18 x 41.666=749.988‰ fine gold and is defined as gold having a title of 750 thousandths;*
- *a gold alloy containing 583.324‰ fine gold, defined as a gold alloy having a title of 585‰ thousandths is going to display 583.324‰ x 0.024=14 karat*

On gold market, a measure unit for weight is an ounce, shortened as oz.

1 oz (gold ounce) = 31.1035 g

Gold effective price is determined owing to the relation:

Effective gold price = (gold price x Gold fineness coefficient)/1,000

According to the above calculation relation, gold price is given in monetary units (m.u.) per kg, irrespective of its fineness.

E.g.:

Let's consider a gold price of 110,000 m.u./kg, and its fineness of 750‰, then gold effective price is the following one:

Gold effective price = (110,000 x 750)/1000 = 82,500 m.u./kg

Gold price expressed according to a national currency per kg is determined owing to the following relation:

Gold price in national currency = (gold price in $/ounce x currency exchange course x 1,000)/31.1035g.

In case the relation is not multiplied with 1,000, gold price in national currency is going to be expressed in grams.

E.g.:

Let's consider that the price of a gold ounce represents 190 $ and the currency exchange course of the national currency represents 18.000 m.u. for a $; then, gold price in national currency per kg is the following one:

Gold price in national currency in kg = 190 x 18.000 x 1,000/31.1035 = 109955.470 m.u./kg.

Besides the mark that expresses gold purity, jewels also bear other signs. In England, they use to employ, beginning with the 14th century, an intricate mark of the jewellers' guild, the so-called *hallmark* that includes: the fineness and quality mark of gold, the mark of the town where the piece of jewellery had been manufactured, the date of manufacturing, and the jeweller's signs.

In Romania, until 1925, the objects made of gold and silver alloy bore the mark of an aurochs head and owned a title ranging between I and V (900‰ - 500) ‰; after 1925, they bore the mark of a she-wolf while the title also ranged between I and V (900‰ - 50‰).

Chemically pure silver or fine silver, as it is known on the market of precious metals, considered as a standard for this metal, contains 1,000 points, meaning that it bears a title of 1,000 points as a quality landmark and is defined as 16 "*LATZ*" (quality measure) silver. In case of silver, the market of precious metals accepts an up to 5… tolerance.

1 silver "LATZ" = 1,000/16 = 62.5 thousandths.

A division of silver "*LATZ*" is silver "*SEMER*", namely:

1 silver "LATZ" = 18 silver "SEMER";

1 silver "SEMER" = 1/18 silver "LATZ" = 3.472 thousandths.

In case of silver, as in case of gold, the market of precious metals employs the same weight measure unit; it is called ounce and is shortened as *oz*.

1 silver ounce = 31.1035 g

Silver price is determined according to the following relation:

Silver effective price = silver price x fineness coefficient/1,000.

According to the above calculation relation, silver price is given in monetary units (m.u.) per kg, irrespective of fineness (purity).

E.g.:

Let's consider a silver price of 21,000 u.m./kg, and a 500‰ fineness, then silver effective price is the following one:

Silver effective price = 21,000 x 500/1,000 = 10,500 m.u./kg

Silver price expressed in national currency per kg is determined owing to the following relation:

Silver price in national currency – silver price in $/ounce x currency exchange course x 1,000/31.1035.

In case the relation is multiplied with 1,000, silver price in national currency is going to be expressed in grams.

E.g.:

Let's consider that the price of a silver ounce represents 23 $ and the currency exchange course of the national currency represents 18.000 u.m. for a $, then silver price expressed in national currency per kg is the following one:

Silver price in national currency per kg = 23 x 18.000 x 1,000/31.1035 = 13310.399 m.u./kg = 13310.399 m.u./gram

On the market of precious metals, platinum displays a 950 thousandths unique admitted title, with an admitted tolerance of maximum 10 thousandths. Platinum effective price is determined owing to the following relation:

Platinum effective price = platinum price x platinum fineness coefficient/1,000

Platinum price is given according to monetary units per kilogram of platinum irrespective of its fineness.

E.g.:

Let's consider a platinum price of 125,000 m.u./kg and its fineness of 950…, then platinum effective price is going to be:

Platinum effective price = 125,000 x 950/1,000 = 118,750 m.u./kg

Platinum price expressed in national currency per kg is determined owing to the following relation:

Platinum price in national currency per kg = platinum price in $/ounce x currency exchange course x 1,000/31.1035

In case the relation is multiplied with 1,000, platinum price in national currency is going to be expressed in grams.

E.g.:

Let's consider that at London Metal Stock Exchange the price of an ounce of platinum represents 215 $ and the currency exchange course of the national currency represents 18.000 m.u. for 1 $, then platinum price expressed in national currency per kg is the following one:

Platinum price in national currency per kg = 215 x 18.000 x 1,000/31.1035 = 124423290 m.u./kg.

In case of the other precious metals belonging to the platinum group, the calculation relations for the effective price of the metal as well as the price in national currency are the same.

REFERENCES:

[1]. Abrudeanu I., Rusu I., *Aurul romanesc,* Cartea Romaneasca Publishing House, Bucharest, 1933.

[2]. Biber G. Emil, *Eficienta economica a investitiilor, Culegere de exemplificari practice,* INFOMIN Publishing House, Deva, 2000.

[3]. Haiduc Ilie, *Industria aurului din Romania*, Imprimeria Adevarul Publishing House, Bucharest, 1940;

[4]. Haiduc Ilie, *Productia si comertul cu aur si argint,* DIECEZANA Publishing House, Arad, 1938 ;

[5]. Lazarescu I., Barna V., *Aurul si argintul,* Technical Publishing House, Bucharest, 1972.

Scientific Reviewers:
Assoc. Prof. Ph.D. Eng. Petru HODOR

ASPECTS ON ECONOMIC POTENTIAL OF JIU VALLEY COALS

Csaba LORINȚ [*]
Grigore BUIA [**]
Radu LUPULEAC [***]

Abstract: *Within the current context of Romanian energy resources, the hard coal contributes about 5 to 7 percent to the electricity generation sector, as thermal coal. In the light of coal's significance for the Romanian economy, the paper analysis the opportunities of coal valorization, framed by the wider perspective of mineral production technologies, energy factors and geological reserves.*

Key words: *Jiu Valley, hard coal deposit, geological reserves, energy balance*

1. INTRODUCTION

The main aim of this paper is to bring to the attention of interested parties, such as experts from mineral production and energy generation sectors, the current state of hard coal reserves in the Jiu valley; valorization opportunities, dictated essentially by the heating value and geological reserves, are also discussed.

2. REGIONAL SETTING

The beginnings of mining activities in the Jiu Valley date back in the 1840's, when brothers Hoffman and Karol Mardepash, under Austrian -Hungarian protection, initiated the open pit mining of coal reserves at Vulcan, Petrosani and Petrila mines. In 1854, the founders of mining activities in Jiu Valley formed "Societatea de Mine din Transilvania-Vest" (Association of Mines from Western Transilvania).

At the end of the XIXth century, the mining activities in the Jiu Valley were organized into mining perimeters, with a total surface of 8,991.5 ha. The division by perimeters was as follows: Salgotorjan Society, with 5,572.9 ha, Uricani - Valea Jiului Society, with 2,713.1 ha, and Valea Jiului de Sus Society, with 705.5 ha.

Following World War II, a significant and profound restructuring of the coal organizational system was initiated; on September 14, 1956, according to the Order of Ministry of Finances, "Combinatul Carbonifer Valea Jiului" (Coal Entreprise Jiu Valley) was created. "Combinatul Carbonifer Valea Jiului" functioned as a standalone

[*] *Lecturer Ph.D. eng., at University of Petrosani, csabigeo@yahoo.com*
[**] *Professor Ph.D. eng., at University of Petrosani, grigbuia@yahoo.com*
[***] *Student PhD, University of Petrosani, l.radu.f@gmail.com*

authority until the first of April 1969, when it has been converted into “Centrala Cărbunelui Petroşani” (Central of Coal Petrosani). “Centrala Cărbunelui Petroşani” functioned until August 1977, when it became “Combinatul Minier Valea Jiului” (Mining Entreprise Jiu Valley). In 1991, “Regia Autonoma a Huilei (RAH) România” (the Autonomous Romanian Society of Hard Coal) was created, leading to significant restructuring of the mining activities; the restructuring measures culminated with the closing (decommissioning) of the following mining perimeters: Lonea Pilier (1994), Câmpu lui Neag and Petrila Sud (1999), Dâlja (2003), Valea de Brazi (2004), Aninoasa (2006).

The series of emblematic coal history moments in the Jiu Valley are linked to the transformation of RAH into “Compania Națională a Huilei S.A. – Petroşani” (CNH SA) (National Company of Hard Coal- SA Petrosani). On first of November 2012, several mining perimeters dissociated from CNH SA and unified into “Societatea Națională de Închideri Mine Valea Jiului” (the National Society of Mining Decommissioning Jiu Valley). Starting December 18, 2012, the mining perimeters Lonea, Livezeni, Vulcani, Lupeni, “Prepararea Cărbunelui Valea Jiului” (Mining Processing Jiu Valley), “Stația de Salvare Minieră şi Aparat Administrativ” (Mining Rescue Station and Administration quarters), former subsidiaries of the “CNH SA-Petrosani”, constituted by union “Societatea Națională a Huilei SA” (the National Society of Hard Coal SA).

Currently, the mining activities in the Jiu Valley are carried out under the coordination of “Societatea Naționala de Închideri Mine Valea Jiului” (the National Society of Mining Decomissioning Jiu Valley), within the perimeters of the mining sectors Petrila, Paroşeni and Uricani and also under the coordination of the entity known as “Complexul Energetic Hunedoara S.A” (Energy Complex Hunedoara). “Complexul Energetic Hunedoara S.A” was created by the unification of several commercial entities, namely “Electrocentrala Deva S.A.”, “Electrocentrala Paroşeni S.A.” and “Societatea Națională a Huilei S.A.”; its main role consists of electricity generation using hard coal sourced from the mining perimeters Lonea, Livezeni, Vulcan and Lupeni, Figure 1. (CEH Portal, 2014)

3. GEOLOGY OF THE STUDY AREA

The Jiu Valley (Valea Jiului) / Petroşani basin (Figure 2) is an asymmetrical synclinal structure formed during the Alpine orogeny, and sliced by transverse faults (Figure 2). The Jiu Valley basin, with a SW–NE orientation, is 48-km long and 10-km wide on the eastern side and 2-km wide on the western side; the coal mines are distributed along the center of the valley, following the western and eastern tributaries of the Jiu River (Figure 2).

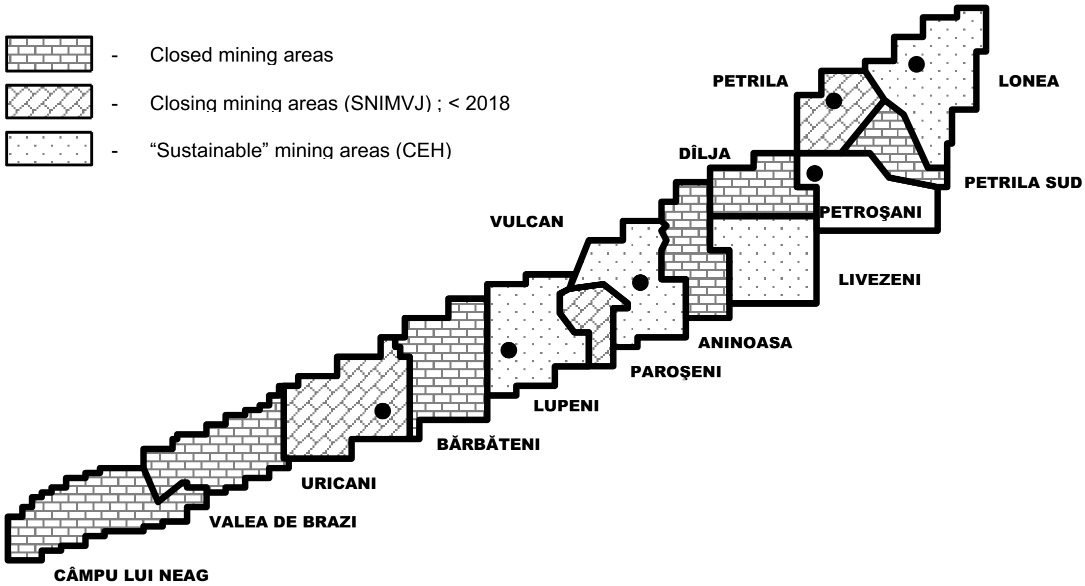


Fig. 1. Spatial distribution and status of mining perimeters in the Jiu Valley

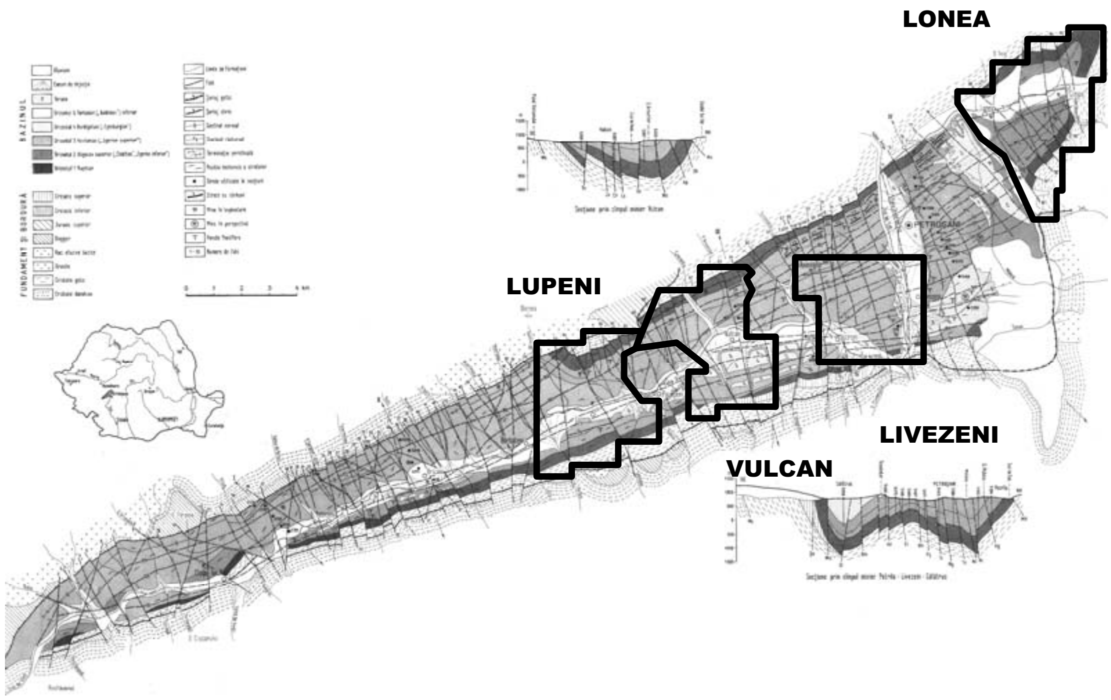


Fig. 2. Geo-tectonic map of Jiu Valley / Petroşani basin study area showing the regional geology, the major synclinal axis, tectonic units and few sections in major point of interest Modified from Pop E.I. (1988)

The Jiu Valley basin (Figure 2) is underlain by a crystalline basement, filled with molasse sedimentary deposits. On the basin rims, rocks of Danubian and Getic ages crop out; these rocks are represented by Neoproterozoic, Paleozoic, and Mesozoic sedimentary, volcanic and magmatic formations, presenting different degrees of metamorphism (Burchfiel, 1976; Pop, 1993; Preda, 1994; Petrescu et al., 1987; Iancu et al., 2005). The Getic crystalline rocks crop out in the north-eastern side of the basin and partially on the southern rim, consisting of gneisses, mica-schists, quartzites, and amphibolites. The overlying sedimentary deposits are of Jurassic, Cretaceous, Paleogene, and Neogene age, mostly covered by Quaternary formations. The oldest sedimentary rocks in the basin are Cretaceous, consisting mostly of flysch deposits, located on the northern and southern rims. The Cretaceous deposits are represented by conglomerates, green-grey sandstones, red marls, and minor limestones. From an economic perspective, the Oligocene deposits are the most important, as these formations contain all the coal layers, of Rupelian and Chattian ages. The Rupelian overlying the metamorphic sediments of the bedrock and the Cretaceous deposits crops out as discontinuous layers on both rims of the basin. The Rupelian deposits, 200 m to 600 m thick, consist of sandstones and green and red conglomerates with ferruginous and limestone clasts. Dîlja–Uricani Formation, of Chattian-age, also known as the „productive horizon", contains coal seams and crops out on the southern rim of the basin, as well as in the northeastern, central, and western rims (Figure 2). The thickness of these paralic deposits ranges from 270-m to west to 350-m to east (Baron, 1998). Twenty-two layers of coal have been identified in the Chattian-age rocks, numbered as beds 0 to 21, from the bottom to the top. Beds 3, 4, 5, 7, 8/9, 12, 13, 14, 15, and 17/18 are economically feasible for extraction, bed 3 being the most productive. The thickness of these beds varies from several meters up to several tens of meters (bed 3); the estimated percentage of the Jiu Valley reserves are as follows: bed 3-48 percent, bed 5-16 percent; bed 13-10 percent; beds 4, 6, 7, 8, 9, 12, 15, 17, and 18 are thin, discontinuous and each contributes about 1-3 percent; beds 1, 2, 10, 11, 14, 16, 19, and 20 are very thin, representing a small fraction of the reserves (Pop, 1993; Preda, 1994; Petrescu et al., 1987; Fodor et al., 2000; Fodor and Plesa, 2006; Belkin et al., 2010; Buia and Lorinț, 2010). The Miocene deposits are between 300 m and 550 m thick, formed of grey sandstones, marls, clays, sands, and coarse conglomerate. The Quaternary consists of alluvial and pro-luvial deposits.

4. TECHNICAL PROPERTIES AND STATISTICS OF HARD COAL RESERVES IN THE JIU VALLEY

This section describes the main characteristics of the hard coal in the Jiu Valley. From a valorization potential perspective, the classification falls into three categories, depending on the current state of the mining perimeters, as follows; Closed (decommissioned) mining Perimeters (Table 1), Closing mining perimeters (Tables 2 and 4) and Sustainable mining perimeters (Tables 3 and 4).

Table 1. *Statistics of the reserves pertaining to the closed mining perimeters (thousands of tonnes at the closing date)*

Group/Category	**Lonea Pilier**	**Petrila Sud**	**Dâlja**	**Aninoasa**	**Valea de Brazi**	**Câmpul lui Neag**
Ab	0	269	746	90	710	54
Bb	0	769	0	72	393	0
C1b	52,660	48,484	56,710	0	59,128	716
C2b	0	10,332	2,657	0	9,766	0
Total recoverable, (proven) geological reserves	**52,660**	**59,854**	**60,113**	**162**	**69,997**	**770**
Aaf.b	0	98	5	461	232	0
Baf.b	0	0	0	632	209	0
C1af.b	41,693	17,783	14,869	75,109	12,270	199
C2af.b	0	9,328	9,380	23,485	5,644	779
Total probable geological reserves	**41,693**	**27,209**	**24,254**	**99,678**	**18,355**	**978**
Total geological reserves/perimeter	**94,353**	**87,063**	**84,367**	**99,849**	**88,352**	**1,748**
Total geological reserves Closed perimeters	**455,732**					
Heating value/perimeter Q (kal/kg)	**5,788**	**5,566**	**5,434**	**5,539**	**5,343**	**4,776**
Average heat content Q (kal/kg)	**5,535**					

Table 2. *Reserves Statistics - Closing mining perimeters (thousands of tonnes)*

Group/Category	**Petrila**		**Paroşeni**		**Uricani**		**TOTAL**	
	Quantity	Aanh (%)	Quantity	Aanh (%)	Quantity	Aanh (%)	Quantity	Aanh (%)
Ab	337	22.05	538	19.74	48	24.43	**923**	**20.83**
Bb	810	22.73	0	0.00	406	30.25	**1,216**	**25.24**
Ab+Bb	1,147	22.53	538	19.74	454	29.63	**2,139**	**23.34**
C1b	16,109	19.42	20,683	21.77	38,980	24.76	**75,772**	**22.81**
A+B+C1	**17,256**	**19.63**	**21,221**	**21.72**	**39,434**	**24.82**	**77,911**	**22.82**
C2b	1,481	32.56	1,213	24.88	8,411	23.37	**11,105**	**24.76**
Total recoverable (proven) geological reserves	**18,737**	**20.65**	**22,434**	**21.89**	**47,845**	**24.56**	**89,016**	**23.06**
Aaf.b	343	22.72	315	23.60	354	26.46	**1,012**	**24.30**
Baf.b	81	29.00	83	20.66	595	30.92	**759**	**29.59**
C1af.b	55,761	18.64	13,216	21.95	50,589	21.47	**119,566**	**20.20**
C2af.b	13,535	18.18	5,425	23.14	11,386	21.74	**30,346**	**20.40**
Total probable geological reserves	**69,720**	**18.58**	**19,039**	**22.31**	**62,924**	**21.64**	**151,683**	**20.32**
Total geological reserves Closing perimeters	**88,457**	**19.02**	**41,473**	**22.08**	**110,769**	**22.90**	**240,699**	**21.33**

Table 3. Reserves statistics – Sustainable mining perimeters (thousands of tonnes)

Group/ Category	Lonea		Livezeni		Vulcan		Lupeni		TOTAL	
	Quantity	Aanh (%)	Quantity	Aanh (%)	Quantity	Aanh (%)	Quantity	Aanh (%)	Quantity	Aanh (%)
Ab	785	19.23	113	22.47	251	24.75	1,117	27.82	**2,266**	**24.24**
Bb	362	18.25	1,246	29.78	308	27.26	1180	26.87	**3,096**	**27.07**
Ab+Bb	1,147	18.92	1,359	29.17	559	26.13	2,297	27.33	**5,362**	**25.87**
C1b	21,501	18.79	70,176	23.74	22,997	21.36	29,379	24.48	**144,053**	**22.77**
A+B+C1	**22,648**	**18.80**	**71,535**	**23.84**	**23,556**	**21.47**	**31,676**	**24.69**	**149,415**	**22.88**
C2b	0	0.00	4949	20.18	13	26.47	0	0.00	**4962**	**20.20**
Total recoverable (proven) geological reserves	**22,648**	**18.80**	**76,484**	**23.61**	**23,569**	**21.48**	**31,676**	**24.69**	**154,377**	**22.80**
Aaf.b	59	15.00	1,390	27.08	288	29.61	471	30.41	**2,208**	**27.80**
Baf.b	317	13.81	1,710	29.72	288	17.73	756	26.27	**3,071**	**26.10**
C1af.b	39,769	17.16	53,225	20.81	24,389	21.42	34,304	22.05	**151,687**	**20.23**
C2af.b	4,280	19.12	36,875	22.74	8605	20.66	16	27.40	**49,776**	**22.07**
Total probable geological reserves	**44,425**	**17.32**	**93,200**	**21.83**	**33,570**	**21.26**	**35,547**	**22.25**	**206,742**	**20.84**
Total geological reserves Sustainable perimeters	**67,073**	**17.82**	**169,684**	**22.63**	**57,139**	**21.35**	**67,223**	**23.40**	**361,119**	**21.68**

Table 4. *Statistics of proven and probable reserves in the active mining perimeters (thousands of tonnes)*

Mining Perimeter	Coal Bed	Characteristics of the coal bed	Proven			Probable			Total		
			Quantity	Aanh (%)	Q (kal/kg)	Quantity	Aanh (%)	Q (kal/kg)	Quantity	Aanh (%)	Q (kal/kg)
Lonea	3	block II - III level 200, block VII, level 380	1,389	40.40	3,861	12,042	41.90	3,739	13,431	41.74	3,752
	5	block II - III level100	127	27.80	4,881	344	32.60	4,492	471	31.31	4,597
	Total		**1,516**	**39.34**	**3,946**	**12,386**	**41.64**	**3,760**	**13,902**	**41.39**	**3,781**
Petrila	3	block II level -300, eastern side block II -200 -250	1,352	40.25	3,922	7,194	45.10	3,537	8,546	44.33	3,598
	Total		**1,352**	**40.25**	**3,922**	**7,194**	**45.10**	**3,537**	**8,546**	**44.33**	**3,598**
Livezeni	3	block VI, VIA, III, VII and VIII to level 150	1,563	47.21	3,332	12,085	50.30	3,088	13,648	49.95	3,116
	5	block VII				3,159	39.07	3,974	3,159	39.07	3,974
	13	block X-VIII Iscroni, between level 50 and 200	197	40.16	3,888	1,121	23.24	5,223	1,318	25.77	5,023
	Total		**1,760**	**46.42**	**3,394**	**16,365**	**46.28**	**3,405**	**18,125**	**46.29**	**3,404**
Vulcan	3	block VI, VII, VIII and IX to level 260	656	44.7	3,837	5,412	36.31	4,532	6,068	37.22	4,457
	5	block VII to level 250, block VIII-IX	55	49.52	3,437	1,247	45.78	3,747	1,302	45.94	3,734
	Total		**711**	**45.07**	**3,806**	**6,659**	**38.1**	**4,385**	**7,370**	**38.76**	**4,329**
Paroşeni	3	block 0 - VI between 350 and 200			7,545	11,032	47.68	3,590	11,032	47.68	3,590
	5	block 0, I and II between level 200 and 400	763	42.95	3,982	1,356	39.94	4,232	2,119	41.02	4,142
	Total		**763**	**42.95**	**3,982**	**12,388**	**46.83**	**3,660**	**13,151**	**46.61**	**3,679**

(continuation table 4)

Mining Perimeter	Coal Bed	Characteristics of the coal bed	Proven			Probable			Total		
			Quantity	Aanh (%)	Q (kal/kg)	Quantity	Aanh (%)	Q (kal/kg)	Quantity	Aanh (%)	Q (kal/kg)
Lupeni	3	block II to 200, block II N, IV,V and VI	2,881	44.12	3,957	13,032	45.10	3,876	15,913	44.92	3,890
	5	block VI level 300-350				744	49.32	3,524	744	49.32	3,524
	Total		**2,881**	**44.12**	**3,957**	**13,776**	**45.33**	**3,857**	**16,657**	**45.12**	**3,874**
Uricani	3	block IIIN, IV, V and VI between level 350 and 250	545	46.61	3,778	13,454	46.92	3,753	13,999	46.91	3,754
	5	block IIIN, IV, V and VI between level 400 and 250	57	38.02	4,483	2,382	33.45	4,859	2,439	33.56	4,850
	Total		**602**	**45.80**	3845	**15,836**	**44.89**	**3,919**	**16,438**	**44.93**	**3,916**
TOTAL	**3**		**8,386**	**43.66**	**3,798**	**74,251**	**45.50**	**3,676**	**82,637**	**45.31**	**3,688**
	5		**1,002**	**41.11**	**4,095**	**9,232**	**39.24**	**4,193**	**10,234**	**39.42**	**4,183**
	13		**197**	**40.16**	**3,888**	**1,121**	**23.24**	**5,223**	**1,318**	**25.77**	**5,023**
	Total		**9,585**	**43.32**	**3,831**	**84,604**	**44.52**	**3,753**	**94,189**	**44.40**	**3,761**

(shaded) - closing mining perimeters

5. CONCLUSION

Based on the data presented in Tables 1, 2 and 3, the reserves of hard coal are as follows: **455.732** millions of tonnes in the closed mining perimeters Lonea Pilier, Petrila Sud, Dâlja, Aninoasa, Valea de Brazi, Câmpul lui Neag, **240.699** millions of tonnes in the closing mining perimeters Petrila, Paroşeni, Uricani and **361.119** millions of tonnes in the sustainable mining perimeters Livezeni, Vulcan, Lupeni –leading to a total of **1,057.550** million tonnes.

Of the total reserves, only the recoverable (proven) reserves are available for valorization, as follows: **243.556** million tonnes in the closed mining perimeters, **89.016** million tonnes in the closing mining perimeters and **154.377** million tonnes in the Sustainable perimeters, totalling to **486.949** million tonnes. To note that within the closed mining perimeters, the recoverable (proven) reserves belong over 90 percent to category C1 of reserves.

As it can be observed from table 4, the reserves from the active mining perimeters, including the closing and sustainable perimeters, amount to **94.189** million tonnes which are currently available.

In current organizational structure of the coal system, the 2013 coal production from the active mining perimeters, respectively closing perimeters Petrila, Paroşeni and Uricani and sustainable perimeters Lonea, Livezeni, Vulcan and Lupeni amounted to 1.5 million tonnes (0.4 million tonnes, respectively 1.1 million tonnes), with a heating value of 3,600 kal/kg; this resulted in 2,700 GWh/year, for combustion factors representative of the current technology of 3.6 Gkal/t hard coal of Jiu Valley and 2

Gkal/Mw), representing about 5-7 percent of the electric energy produced in Romania, this being 54,358 GWh/year.

Given the energy balance, 94 million tonnes of hard coal from the currently proven reserves in the active mining perimeters can sustain the coal consumption for the next 60 years.

The recoverable reserves from the closed and closing mining perimeter can also be valorized through alternative methods, such as internal combustion.

REFERENCES

[1]. Burchfiel, B.C., 1976. Geology of Romania. Geological Society of America Special Paper 158, 82.
[2]. Iancu, V., Berza, T., Seghedi, A., Maruntiu, M., 2005. Palaeozoic rock assemblages incorporated in the south Carpathian Alpine thrust belt (Romania and Serbia): a review. Geologica Belgica 8, 48–68.
[3]. Baron, M., 1998. Cărbune şi societate în Valea Jiului. Perioada interbelică, Editura Universitas, Petroşani 109–130. (in Romanian)
[4]. Fodor, D., Plesa, V., 2006. Present situation of underground coal mining in Valea Jiului-Romania. Journal of Mines, Metals & Fuels 54, 266–273.
[5]. Fodor, D., Baican, G., Pasarin, C., Bonci, G., 2000. Coal mining in Romania at the beginning of the 21st century. In: Ghose, A.K., Dhar, B.B. (Eds.), Mining: Challenges of the 21st Century. A.P.H. Publishing Corp, New Dehli, pp. 117–135.
[6]. Harvey E. Belkin , Susan J. Tewalt, James C. Hower, J.D. Stucker, Jennifer M.K. O'Keefe, Calin A. Tatu, Grigore Buia, 2010. Petrography and geochemistry of Oligocene bituminous coal from the Jiu Valley, Petroşani basin (southern Carpathian Mountains), Romania. International Journal of Coal Geology 82 (2010) 68–80.
[7]. Buia Gr., Lorinț C., 2010. Hard Coal Deposits in Romania/Depozite de huilă din România. Mining Revue/Revista Minelor, vol. 16, No. 3, 9-14.
[8]. Petrescu I., Nicorici E., Bițoianu C., Țicleanu N., Trodos C., Ionescu M., Mărgarit Gh., Nicorici M., Dușa A., Pătruțoiu I., Munteanu A., Buda, 1987. Geologia zăcămintelor de cărbuni (vol. II – Zăcăminte din România), Ed. Tehnică, Bucureşti. (in Romanian)
[9]. Pop, E.I., 1993. Monografia geologică a Bazinului Petroşani, Ed. Academiei Române, Bucureşti. (in Romanian)
[10]. Preda I., Bădăluță A., Turculeț I., Barus T., Androhovici A., 1994. Geologia zăcămintelor de cărbuni (vol. II), Ed. Universității din Bucureşti. (in Romanian)
[11]. CEH Portal, 2014. Mineritul în Valea Jiului - Repere Istorice. Date de referință pentru mineritul din Valea Jiului. (in Romanian) http://www.sdm-cenhd.ro/istoric.aspx
[12]. Transelectrica Portal. https://www.transelectrica.ro/web/tel/productie

Scientific Reviewers:
Assoc.Prof. Ph.D. geog. Laura COMANESCU

THE INFLUENCE OF POLLUTANT EMISSIONS ON SOILS DUE TO THE OPERATION OF DEVA-MINTIA THERMAL POWER STATION

CLAUDIU DOINEL CRIŞAN*[*]
IOAN CONȚ[**]
TRAIAN VASIU[**]

Abstract: *This paper presents the major measures taken with a view to reducing environmental pollution at DEVA – MINTIA POWER STATION. By burning fossil fuels (energetic coal), the Large Combustion Plants, respectively the energetic groups lead to the exhaustion of several pollutants, such as: powders (total, PM 2.5 and PM 10) and gas emissions, in the atmosphere. For the purpose of reducing powders emissions, a re-engineering program is currently being implemented at Mintia Power Station, program which includes No. 3 Energetic Group and No. 4 Energetic Group, part of No. 2 Large Combustion Plant (LCP 2). This program includes rehabilitation works of the electro-filters afferent to the two energetic groups, with a view to reducing powders evacuated through the smoke chimneys in the atmosphere. The final purpose of these re-engineering/rehabilitation works is to reduce powders emissions under the limit values set by the EU law, respectively by Directive 2010/75/EU on industrial emissions (IED), currently in the process of implementation in the national law, and to preserve a clean environment in the power station industry. All of these measures are, in fact, short and long term priorities of Mintia Power Station, whose final purpose is to protect the environment, atmosphere and soil, as well as to protect the health of the population living nearby the power station.*

Key-words: *environmental pollution, electrical power, National Energetic System, Large Combustion Plants, air pollutants, industrial emissions, re-engineering/rehabilitation works.*

1. INTRODUCTION

The electric energy is one of the most utilized forms of energy, without which, in the contemporary era none of the human social activities can be conceived.

The electricity is a non-polluting form of energy, but most of the times producing it is realized based on processes of burning fossil fuels, which are pollution generators. Energy coal usage in producing thermo-electric energy has manifested itself in our country as well, especially during the past years, when the coal steam power plants produced 8-22% of the total electric energy.

Coal-based steam power plants operate on the environment, having a major impact on it. From this point of view, the impact that the coal-based steam power

[*] *MA student at University of Petroşani, România*
[**] *PhD.Eng. at S.C. Energy Complex Hunedoara – Deva Power Plant Subsidiary, România*

plants have may be: an aesthetic and climatic impact, an impact on the groundwater and on the surface waters, an impact on the soil, on the vegetation and on people's health. [4]

The exhaust chimneys of the waste gases represent high sources of pollution of the environment, while the cinder deposits – cinder, are low sources. Both sources operate together, their influence on the environment accumulating. The high sources evacuate large quantities of gaseous pollutant in the atmosphere (carbon oxides, brimstone oxides and nitrogen oxides, unburned hydrocarbons, chlorides and fluorides), metal powders and flying ashes, pollutants which are scattered in the atmosphere on large distances, dependent on the chimney's height, the speed of the gases coming out of it, the direction and intensity of the stream of air. These emissions have a major effect on the environment, especially on the air and soils found in their area of influence. [1]

2. THE PRESENTATION OF THE DEVA - MINTIA STEAM POWER PLANT AND THE ECOPEDOLOGIC CONDITIONS FROM THE SURROUNDING AREA

The Deva - Mintia Steam Power Plant (image 1) is located in the South-East part of Transylvania, on the left bank of the Mureş river, 9 km away from Deva city. The area under analysis belongs to distinct relief units, namely: the Mureş river valley, the Apuseni Mountains and the Banat Mountains.

The surface lithology differentiates itself according to the mentioned relief units. Hence, on the Mureş meadow there are alluvions and alluvial deposits and on the mountain area there are peach stones, phyllites, hones, with local occurence of clays, argillaceous marls and chalkstone. On the Noth slopes the crystalline schists with andesite occurrences prevail. The variety of rocks and parental materials from the area under discussion has as a main effect the formation of a complex coating of soils which influences the differentiated vulnerability towards the degree of pollution produced by the steam power plant.

The studied territory is covered by a mosaic pavement of soils whose diversity is determined by the wide range of pedogenesis factors which are distinctive for the area. In the area most exposed to the steam power plant emissions, the soil coating consists of the following types: chernozem, pseudorendzines, luvisoils and brown luvic soils, brown eumezobazic soils, gleic soils, vertisoils, protosoils and erratic soils (found in various phases of hydromorphism), coluvisoils and anthropogenic protosoils.

The installed power of the steam power plant is 1260 MW, being equipped with 6 turbo-generators of 210 MW each. The steam power plant has been functioning ever since 1969, year when the first energetic group was installed the last of which was installed in 1980.

The main fuel is the energetic pit coal from the Jiu Valley basin (Lupeni, Lonea, Livezeni mines), whose medium caloric content is of 3700 Kcal/kg (15496 kJ/kg). The auxiliary fuels used for outset and for flame stabilization are natural gases and residue oils

The characteristics of the fuels used in the year 2013 are presented in chart 1.

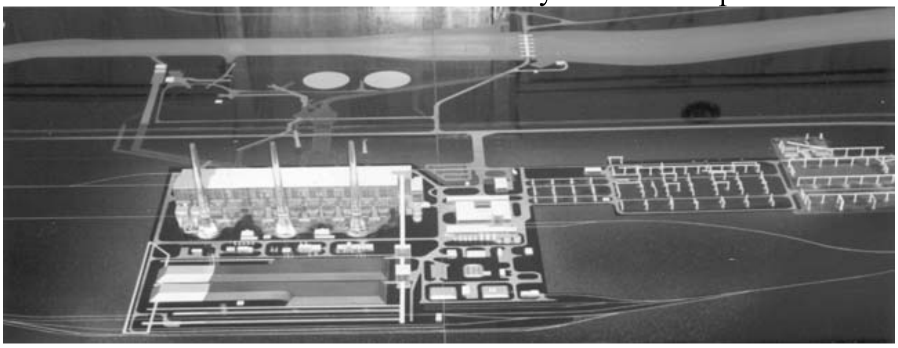


Image 1 – **The Deva – Mintia Steam Power Plant**

Chart 1 – **Utilized fuels at the Mintia steam power plant**

2013	INDICATOR	UM	VALUE
COAL (basic fuel)	Amount	t	1.346.192
	Low calorific power	kcal/kg kJ/kg	3.568,0 15.763
	Ash content	%	41,16
	Brimstone	%	0,82
RESIDUE OIL (support fuel)	Amount	t	-
	Low calorific power	kcal/kg	-
	Brimstone	%	-
NATURAL GAS (support fuel)	Amount	mii m^3	4.744
	Low calorific power	$kcal/m^3$ kJ/m^3	8.230,0 34.457

Through the smoke chimneys, the Mintia steam power plant evacuates in the atmosphere gaseous polluting substances (SO_2, NO_x, CO, CO_2), along with flying ash: particulate matter and sediment particles (image 2).

Burning large amounts of coal and its rather high-grade content of ashes had as an effect the production of large amounts of cinder and ashes which are deposited at the moment in the Bejan cinder-ash deposit.

The emissions derived from fuel burning are presented in chart 2.

Chart 2 – Pollutant emissions evacuated in the atmosphere by the Mintia steam power plant

2013	UM	AMOUNT
SO_2	t	20.758
NO_X	t	6.904
CO_2	t	1.807.029
ASHES	t	3.268

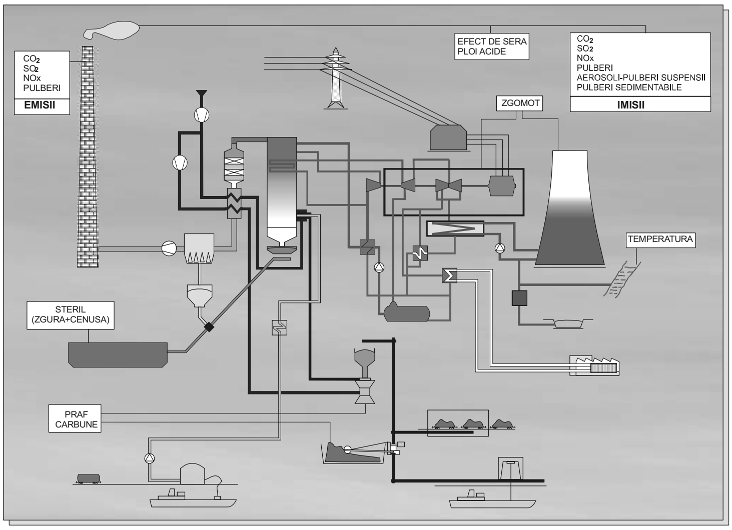


Image 2 – Pollutant emissions from the steam power plant

The amounts of cinder and ash resulted in the year 2013 through coal burning are presented in chart 3.

Chart 3 – **The amount of cinder and ash evacuated in the cinder - ash deposit**

2013	UM	AMOUNT
TOTAL, of which:	t	542.695
- cinder (15 %)	t	9.711
- ash (85 %)	t	444.098

3. The influence of polluting emissions on the soils

3.1. Pollution with heavy metals

Soil pollution with heavy metals in the area of the Mintia steam power plant might be considered to occur due to the presence of these heavy metals in the raw material which is burnt (energy coal).

The burnt energy pit coal's content of heavy metals is illustrated in chart 4.

- **Copper**

Copper content of the soils from the researched region exceeds the normal limit on a specific area.

Chart 4 – Heavy metal concentration in various charges of pit coal

COAL BURNED	**METALE GRELE**(ppm)						
	Cu	**Zn**	**Pb**	**Co**	**Ni**	**Mn**	**Cd**
Coal	74	48	33	26	96	165,5	1,2
Coal	44,5	45,5	30	20,5	75	171	1,15
Coal	44	182	24	22.5	77	488	1,10

The polluted region is bounded by the two hills (Cerbului and Poienilor) located each on one side of the steam power plant, region which expands on the Mureş valley up until the entrance in the Brănişca village. The soils belonging to this area are very slightly contaminated, the level of copper accumulation exceeding the normal content with only 10 ppm.

- **Zinc**

On the sample profile the zinc content of the soils is of 48.5 ppm, below the 50-100 ppm considered normal by the effective regulations. The influence of the emissions on the soils' zinc content can be explained by the quantitative distribution of zinc on the brown luvic soils' profiles belonging to the area of maximum influence. Therefore, the zinc content of the oak leaves collected from the trees growing on the highlands of the two hills is of 17-38 ppm. Unlike these values, at the level of the disintegrated litter the value determined was 63.5-106.5 ppm. The amounts of zinc at the litter level explain the accumulation in time of this metal.

On the two hills, on the upper side of the profiles, a rather thin pedostrat covered both by soil materials and ash particles was identified. The ash formed both from the flying ash coming out of the chimney and the dissipations from the dump located on the right bank of the Mureş river can influence the content of heavy metals from the soil profiles. At the level of fermented litter (OF) the zinc content is of 85 ppm and respectively 106.5 ppm. Just below the litter, on the layers that were affected by ash pollution, the zinc content is of 83.5-101 ppm. On the following soil horizons the zinc content is reduced two fold, reaching 40.5-48 ppm. Consequently, even if the normal value of 100 ppm (according to the effective regulations) is not exceeded, the analysis carried out on genetic soil horizons and the data compared to the values considered normal on the sample profile indicate that there is, notwithstanding, a slight contamination of the soils with this element.

The limits of the polluted area resemble those of copper, the prevailing air circulation towards the North expanding the zinc pollution area across the first chain of hills.

- **Lead**

The normal content of lead of the soils ranges between 30.0-36.5 ppm.

Concentrations above the normal level are found in the alluvial soils from the close proximity of the steam power plant, in the anthropic protosoils from the premises along with the forest soils that form the soil coating of the hills that keep watch over the valley. The allure of the pollution limit resembles that of copper.

- **Nickel**

The normal content of nickel of the soils is of 25 ppm. Compared to this value in the areas of maximum influence, the content of nickel of the researched soils may reach 56 ppm. With regards to the anthropic protosoils from the premises, the nickel exceeds the normal values, their content ranging between 38 and 49.5 ppm.

On the other hand, the alluvial soils from the close proximity and the brown luvic soils developed on the slopes directly exposed of the two hills are vaguely contaminated with nickel, their content being much beneath the alert threshold of this heavy metal.

3.2. Pollution through saturation and swamping

The pedological studies carried out on the alluvial soils from the area of influence of the ash dump from the right bank of the Mureş River could bring forward the existence of the swamping of soil salinization phenomena.

The salinization and the weak alkalization of the soils belonging to the Mureş river meadow is the result of infiltration and losses from the hydro-technical circuit of the cinder deposit – ash.

The reaction of these waters is strongly alkaline, pH=10.4, reaction given by the large content of sodium cations, which, by interaction with the CO_3 and HCO_3 anion, usually transform in sodium hydrogen carbonate. The content of soluble salts of the salinized gleic soils is of 217 mg/100 g of soil.

The losses and the infiltrations had as a consequence the formation of a lake (having a surface of 1 ha) on the infield from the eastern side of the Mureş cinder - ash deposit. In this situation, the land referred to is more than swamped, a great percentage of it being even flooded.

3.3. Pollution with ash dissipated from the cinder - ash deposit

This type of pollution may be due both to the flying ashes evacuated through the smoke chimney and to the cinder and ash particles shattered from the cinder-ash deposit. This way, the process of deposition of the ashes dissipated from the cinder-ash deposits overlaps the process of sedimentation of the flying ashes evacuated through the smoke chimney.

The undertaken research in the cinder and ash deposit area brought forward phenomena of soil pollution with ash.

According to the distance to the cinder-ash deposit, on the eastern side, there were identified typical alluvial soils, gleic alluvial soils, poorly salinized and even alkalized gleic soils transformed through salinization and alkalization.

Normally, the texture on the soil profile is made up of clay, sand and argil, corresponding to a content of 31.0% argil and 40.2% fine sand (profile A). The ash transport on the surface of the surrounding soils determines the substantial metamorphosis of the granulometric features of the soils. Hence, as we approach the cinder-ash deposit, the granulometric composition of the alluvial soils changes in the sense that the argil-sized particles gradually decrease in number (profile B). In the case of profile C, the characteristics of the materials collected on a depth of 0-20 cm are similar to the ash from the deposit, the percentage content of the argil-sized particles being of only 5.0%.

The data regarding some of the features of the soils belonging to the Mureş meadow are presented in chart 5.

Chart 5 – **Characteristics of the alluvial soils neighbouring the deposit**

PROFILE NUMBER	SOIL TYPE AND SUBTYPE	DEPTH (cm)	GRANULOMETRIC FRAGMENT (%)				SYMBOL TEXTURAL CLASS	pH (H_2O)	MINERAL RESIDUE (mg/100)
			Coarse sand 2,0÷0,02	Fine sand 0,2÷0,02	Dust 0,02÷0,002	Argil <0,002			
A	Typical alluvial soil	0-20	0,0	40,2	28,7	31	LL	8,43	80
B	Alluvial soil	0-20	0,0	69,8	15,2	15	SF	8,77	65
	Weak	20-40	0,0	66,3	17,2	16,5	SF	8,64	65
	Alkalized	40-60	0,0	59,2	19,8	21	LL	8,66	61
C	Salinized gleic soil	0-20	0,0	50,8	44,2	5	SS	8,14	217

4. MANAGERIAL PURSUITS FOR REDUCING THE POLLUTING EMISSIONS

The restructuring of the National Energetic System asserts in the present stage important managerial actions regarding the increase of the burning efficiency, but also of the quantitative decrease of the polluting emissions.

In this respect, the Deva-Mintia steam power plant's pursuits have been and are channelled in two directions: the investment attainment for ensuring the storage capacity for the cinder and ashes that occurred after coal burning in the cinder-ash deposit and the execution of certain works of technological development.

The modernizations concerned especially the energetic groups and the electrostatic dust-separators of the burnt gases – electric filters (image 3). The twelve electric filters (two for each electric group) were initially designed and installed in the conditions of energy coal usage having a caloric content of 3.700 Kcal/kg, with an ash content of 35.6% and a degree of ash retention from the burnt gases of 99 %.

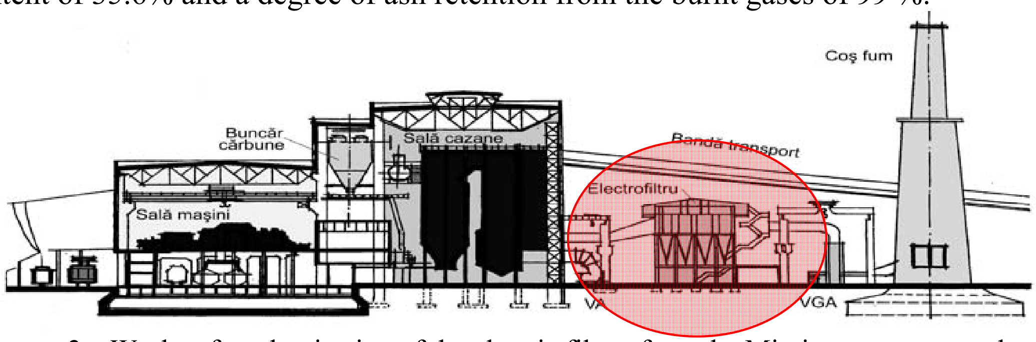


Image 3 – Works of modernization of the electric filters from the Mintia steam power plant

Throughout the years, the quality of coal got considerably deteriorated, the pit coal having a lesser caloric content, ranging between 2200 and 2800 Kcal/kg and a higher ash content, of 50-60%, the electric filters being unable to retain more than approximately 97% of the ash found in the combustion gases. Under these circumstances, the total replacement of the existent electric filters with new, more efficient ones was of high importance. The new type of electric filter has an increased burnt gases cleaning capacity and a superior yield, of about 99%, obtained through the increase in the number of containment field, correlated with the usage of a superior coal, having an inferior caloric content of 3700-3800 kcal/kg.

5. CONCLUSIONS

The monitoring studies undertaken in the Mintia steam power plant area prove a decrease in the level of soil pollution with heavy metals and brimstone.

Nevertheless, due to some pursuits of moistening of the cinder-ash deposit's dry surface, the ash dissipation phenomenon considerably diminished by reason of the wind (the deflation phenomenon).

Taking into consideration the results obtained, as far as the environmental protection is concerned, the follow-up of the technological modernization and development is required in the future.

Likewise, the elaboration of studies regarding the forest recultivation of the cinder-ash deposit and the concrete application of the indicated technologic measures is stringently required, in order to reintroduce the cinder-ash deposit in the sylvan and landscape circuit.

Role of measures and works to reintroduce warehouse landscape and forestry circuit is to reduce soil chemical parameter values of the area of influence of CTE Mintia to normal.

REFERENCES

[1] Ataman E., *Reducerea poluării aerului*", Lucrare ştiinţifică, RENEL, 1995.
[2] Candiani S., *Reducerea poluării cu pulberi*, Lucrare ştiiţifică, RENEL, 1995.
[3] Moţiu C., *Inventarierea surselor poluante*, Lucrare ştiiţifică, RENEL, 1995.
[5] Vaida V., *Pagini ale istoriei energeticii româneşti*, Ed. Mirton, Timişoara, 2003.
[6] Căpitanu V., Vasiu Traian, sa, *Influenţa emisiilor poluante provenite de la termocentrala Mintia – Deva şi preocupări manageriale prezente şi de perspectivă privind protecţia mediului ambiant*, 2001.

Scientific Reviewers:
Prof. Ph.D. Eng. Maria LAZĂR

PRACTICAL MEASURES OF ENVIRONMENTAL POLLUTION REDUCTION WITHIN COMPLEXUL ENERGETIC HUNEDOARA S.A. – ELECTROCENTRALE DEVA

GHEORGHE LAURENȚIU DOBREI[*]
CĂTĂLIN VRÂNCEANU[**]
IOAN CONȚ[***]
TRAIAN VASIU[****]

Abstract: *This paper describes the main measures taken to reduce environmental pollution within MINTIA - DEVA Power plant, part of Complexul Energetic Hunedoara S.A. company. By burning fossil fuels (hard coal), the Large Combustion Plants respectively the power units discharge large quantities of pollutants into the atmosphere, such as dust (under the form of suspensions or particulate matter) and flue gas (SO_2, NO_X, CO/CO_2). In order to reduce such pollutants emission, at Mintia Thermal Power Plant it has been implemented a rehabilitation program for 2 power units within the Large Combustion Plants, no. 2 (LPC 2), respectively power unit no. 3 and power unit no.4. This rehabilitation program involves: - the accomplishment of the flue gas desulphurization system for power units 3 and 4; - the fulfillment of a NO_X reduction installation from flue gas at boilers 3A, 3B and 4A, 4B, pertaining to power units no.3 and no.4; - ESP rehabilitation works at power unit no.3 and no.4 for reduction of dust discharged into the atmosphere through the stack; The final purpose of these rehabilitation/modernization works is to set the emission below the limit values provided by the European laws and regulations, namely Directive 2010/75/EU - regarding the industrial emission (IED), being included in the national legislation and to keep a clean environment in the thermal energy industry. All these measures represents actually the long-term priorities of Complexul Energetic Hunedoara S.A which have as final purpose the environment protection as well as the protection of the operational personnel's health working in the power plant and the health of the population residing next to the facility.*

Key words: *environmental protection, energy, NPG, LPC, air pollutants, industrial emissions, and rehabilitation works.*

1.GENERAL

Energy is a vital problem of humanity, from the point of view of its consumption as well as of its generation. The general trend is related to the generation

** Student PhD. Eng., at the University of Petroșani*
*** Student PhD. Ec., at the University of Petroșani*
**** Eng. General Manager – at the Electrocentrale Mintia-Deva Branch*
***** PhD. Eng., at the Electrocentrale Mintia-Deva Branch*

of green energy. Romania's accession to the European Union puts local production of electricity on one of the worst positions from competitive point of view, on a global and European well regulated energy market.

Production of electricity by burning coal is the most polluting energy, and Complexul Energetic Hunedoara S.A, one of the largest energy generators in the National Power Grid cannot strike off this issue.

The obligations assumed by Romania during the accession process create pressures on it concerning the compliance with the environmental protections regulations. Moreover, the production of electricity from fossil fuels because of their high costs lead to a high price of the generated MW. This price cannot face a competitive energy market while environmental costs lead to a higher increase of this price.

2. PRESENTATION OF COMPLEXUL ENERGETIC HUNEDOARA S.A.

Complexul Energetic Hunedoara consists of Paroşeni Thermal Power Plant located in Jiu Valley coal basin and Mintia Thermal Power Plant, strategically located in the center of the country, on the right bank of Mureş River, at 9 km of Deva town, the county seat of Hunedoara. Both thermal power plants use as basic fuel in the combustion process, coal (hard coal) extracted from the 4 viable mines: Lonea, Livezeni, Vulcan and Lupeni, belonging to the former National Coal Company (SNH) which merged by absorption with Complexul Energetic Hunedoara S.A.

Electrocentrale Deva has a strategic importance to the National Power Grid due to its geographical location, on the 400 kV line that connects the Western European network, providing the power injection required for permanent operation of the interconnected power system (figure no.1).

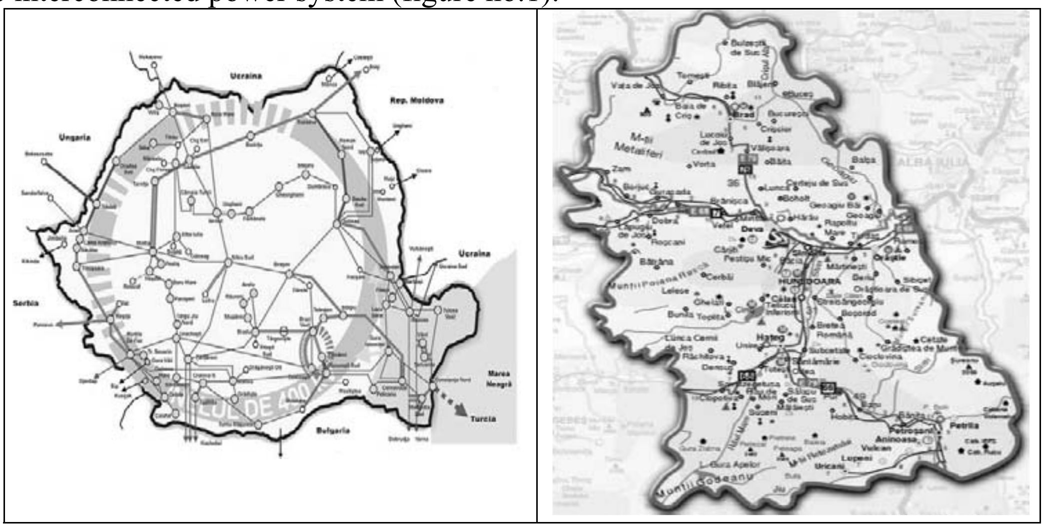


Fig. 1 – The layout of the facilities belonging to Complexul Energetic Hunedoara

At the same time, Mintia TPP is the thermal power supplier to the district heating of Deva town.

The strategic importance of Mintia TPP is socially justified, as together with Paroşeni TPP provides coal consumption coming from Jiu Valley, keeping alive an area in great need which creates difficult social problems.

Complexul Energetic Hunedoara provides approximate 5% of electricity generated in Romania, having an installed power of 1225 MW divided into 6 power units: 5 power units with a total of 1075 MW at Mintia TPP and one power unit of 150 MW at Paroşeni TPP, being at the same time the only generator of electricity from the central and N-W of Romania. (Figure no. 2).

The main field of activity of Complexul Energetic Hunedoara S.A - Electrocentrale Deva is the generation, delivery and distribution of electricity while its main activity is the generation of electricity.

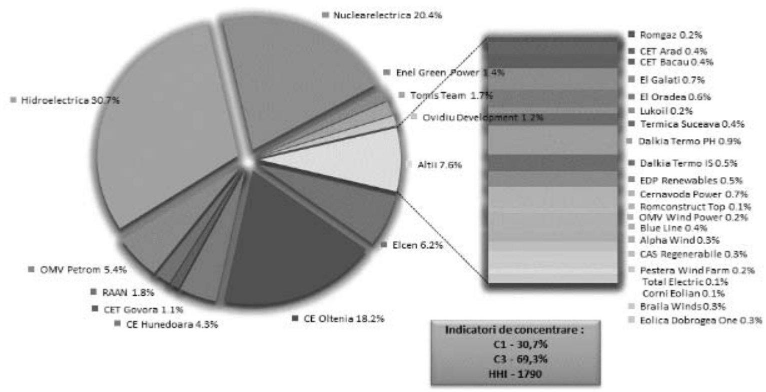


Fig. 2 - The share on the energy market of Complexul Energetic Hunedoara

The main fuel used is hard coal from Jiu Valley and Anina (77-87%) having a lower heating value of approx. 3700 kcal/kg, 41% ash and 1,42% sulphur. It is also used imported hard coal (5÷8%) with a lower heating value of approx. 5000 kcal/kg. For the ignition and flame support it is used natural gas with a lower heating value of 8200 kcal/Nm^3.

3. MEASURES OF ENVIRONMENTAL POLLUTION REDUCTION

Clean air is a basic requirement for human health and for the environment as well as for maintaining biodiversity. Fossil fuel burning in the LCP and thermal power plants leads to the pollutant emission into the atmosphere, such as flue gas (SO_2, NOx, CO_2), dust (particulate matter and suspensions) whose control and assessment represents a priority for the energy sector.

Measures to reduce environmental pollution, within Complexul Energetic Hunedoara SA mainly include rehabilitation / modernization works of power units at both power plants, targeting the installation that have a direct impact on the environment, as well as works performed at mining installations of the coal mines supplying coal to these power plants.

The main rehabilitation works include the achievement of investments that shall be performed on a short-term, such as:

For **Paroşeni TPP**: - Commissioning of the FGD installation at power unit no. 4 of 150 MW and at the Hot Water Boiler of 100 Gcal/h. Such works which will be performed during 31 months, and amount approx. 33 million Euros, are on-going.

For **Mintia TPP**, which consists of 3 LCP, with 6 power units: LCP 1, including power unit 1, being preserved and disconnected from the N.P.G., following to be discarded, and power unit no. 2 which is operating, complying with the limit of 20000 hours until 2015. Then, these two power units shall definitively be put out of service. LCP 3 will also cease its operation starting with the next year, and power unit no.5 and no.6 will be dismantled. A new condensate combined cycle power unit of 400MW will be erected and commissioned in the same location where these two units will be dismantled. LCP 2, comprising power unit no.3 and no.4 shall be included in a wide rehabilitation program. The works to be performed will be related to the reduction of flue gas SO_2, NO_X and dust.

Rehabilitation works at LCP 2 that will begin in 2014, and shall be made to power units 3 and 4 (figure 3 and 4) and will be completed in 2016, providing the emission fit in the limits requested by Directive 2010/75/EU, related to industrial emissions IED (table 1).

Table 1 - **Limit value of emissions according to the environmental legislation**

LEGISLATION	SO_2	NO_X	DUST
	(mg/Nm^3)	(mg/Nm^3)	(mg/Nm^3)
A.I.M. no. 30/2007	2.000 ÷ 4.000	500 ÷ 850	200 ÷ 750
Government Decision no.440/2010 (DIRECTIVE2001/80/CE)	400	500	50
DIRECTIVE 2010/75/UE (IED)	200	200	20

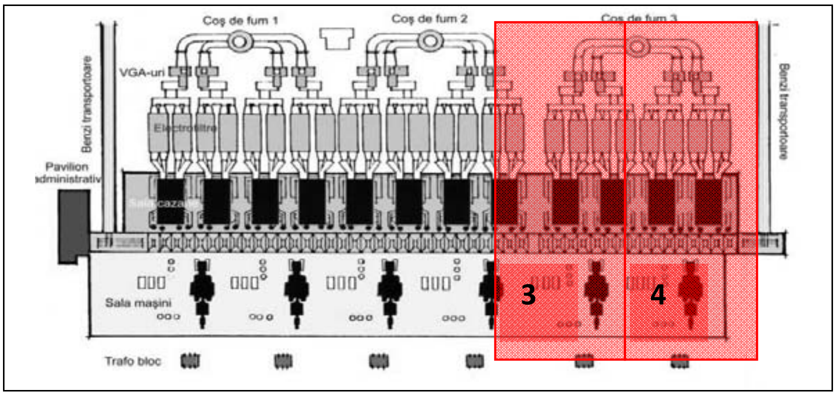


Fig. 3 – Rehabilitation works at the power units in Mintia TPP

Therefore, it is necessary the implementation of measures concerning the reduction of air pollutants, such as:

- Erection and commissioning of a selective non-catalytic reduction system (SNCR) of nitric oxide for DeNOx.

- Erection and commissioning of a wet flue gas desulphurisation system (WFGD)

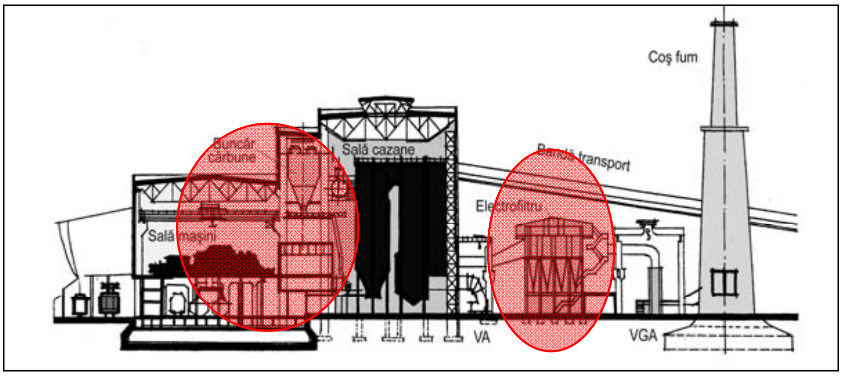


Fig. 4 – Rehabilitation/modernization works at the power units in Mintia TPP

- Accomplishment of several modernization and rehabilitation of dedust equipment (ESP).
- Fulfilment of a collecting, transportation and discharge system into dense slurry of slag and ash and of FGD products as well as the construction of a new silp for storage.

All these measures have been undertaken by the Romanian state in the negotiation process referring to the accession to the European Union represents mandatory measures for the future operation of Mintia power plant.

3.1. Flue gas desulphurization

Taking into consideration that the plant's power is > 200 MWt, it has been established the wet flue gas desulphurization method - WFGD (Figure 5) to reduce the sulfur content from the flue gas, based on the use of limestone as reagent. A WFGD installation shall be made for both CA and CB boilers of power unit no.3 and no.4.

The FGD installation will provide the implementation of measures on SO2 emission reduction to values that will not exceed 200 mg/Nm^3 (for 6% O_2) required by Directive 2010/75/EU - industrial emissions, taking into account some modern technologies that fit to those technologies recommended by the Reference document on the Best Available Techniques for the LCPs. (LCP BAT/BREF).

The WFGD technology, based on the use of limestone as reagent, is a method of wet washing of flue gases, being the most common technology used for the reduction of SO_2 from coal combustion. Powder limestone is used as reagent because of its lower price, compared to other reagents, and due to high degree of spread as resource.

Sizing the flue gas desulfurization installation was achieved for the emission of sulfur dioxide in the flue gas at inlet of 5500 mg / Nm ^{3}.

The FGD installation consists of:

- flue gas evacuation system;

• SO_2 absorption system (absorber which is the main component where the proper process of desulphurization takes place and the smoke stack).

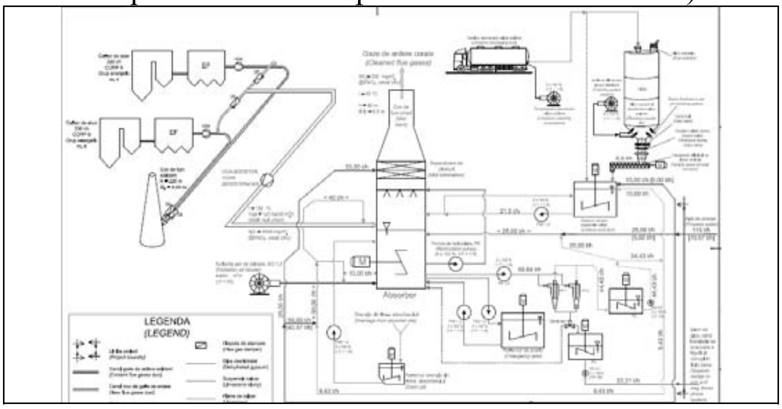


Fig. 5 – Wet flue gas desulphurization – WFGD

• absorbent feeding system (limestone suspension)
• process water feeding system
• end product discharge system, gypsum and dense slurry.
• technological and instrumental air compressors;
• automation and electric installation/equipment.

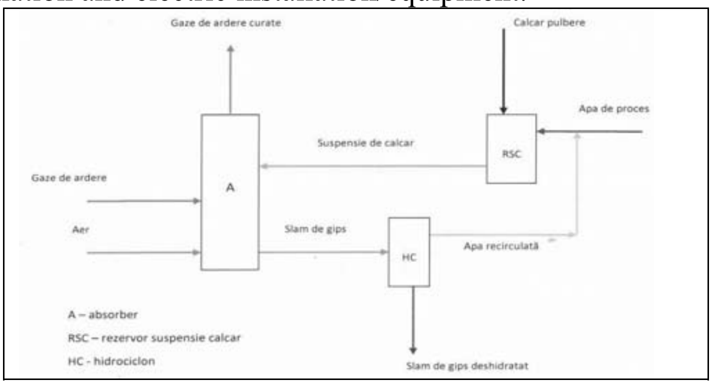


Fig. 6 - Simplified diagram of the process flow

The process of WFGD (figure 6) involves the absorption of SO_2, following the contact between flue gas and a reagent, in this case, limestone suspension.

Gas resulting from the fuel combustion in the boiler, with a maximum concentration of SO_2 of 5500 mg / Nm ^{3} corresponding to a maximum sulfur content in coal of 1.8%, are passed through two ESPs (electrostatic filters), which are designed to retain particles in the flue gas mass, and then routed using fans, to the absorber, entering with a temperature of 152 °C and passed in counter flow through the spray area of the limestone suspension. The absorber used is the powder limestone, mixed with water to obtain a suspension with a concentration of 20% solid part and 80% liquid part. Following the contact with the limestone suspension, the flue gas temperature decreases and the SO_2 concentration is reduced through the absorption chemical process.

After passing the spraying area, the flue gas contains small water drops, having a high degree of moisture (20.000 mg/Nm^3). This moisture is reduced below 100 mg/Nm3 by flue gas passing through a drops separator in 2 stages, located in the upper area of the absorber, in front of the direct discharge into the air through the wet smoke stack, at a temperature of 50 ÷ 65 °C. In order to prevent the clogging of the drop separator, this is automatically washed (once at 8 hours). When the flue gas enters the absorber, a wet/dry area is formed where these are saturated. In this area, there is also the possibility of evaporation of the suspension on the inner walls of the absorber, resulting in the occurrence of deposits in the area surrounding the entry of the combustion gases. Because of this, the inner part will be coated with anticorrosive material with high resistance, being permanently washed.

The chemical reaction between the sulfur dioxide and calcium carbonate leads to the formation of a by-product, the calcium sulfate (gypsum) under the form of slurry, which is transported to hydro cyclones where the water - calcium sulfate concentration reaches 1:1, and then is mixed with slag and ash and sent to the silo for storage. The new buildings and facilities will be located in the middle of the thermal power enclosure between the rear road of the boiler and the defrost tunnel no. 2, and no. 1 and coal belt conveyor B14. At present, this 45 million Euros investment shall be started.

3.2 De NOx of flue gas

For power unit no. 3 and no. 4 it shall be accomplished a selective non-catalytic reduction installation (SNCR) to reduce the NO_X quantities from the flue gas at both boilers of the power units.

NOx Emission values below 200 mg/Nm^3 along total boiler thermal loads are considered to be achieved only by implementing primary measures associated to secondary measures. Emissions reduction from 600 - 700 mg/Nm^3 (maximum values) up to minimum 200 mg/Nm^3 by taking only primary measures, even using advanced technologies, is not possible, taking into account the relative high content of nitrogen in the fuel of 0,5 ÷ 0,7 %. A set of primary measures combined with secondary measures (SNCR) optimal dosed under the aspect of DeNOx efficiency, is the solution that provides the requirement of NOx reduction below 200 mg/Nm^3 limit values according to Directive 2010/75/EU on industrial emissions (IED). By commissioning the non-catalytic reduction (SNCR) installation for each boiler, as a secondary measure using urea as reagent, more restrictive emission limits of 200 mg/Nm^3 will be achieved, while the costs of such works amount to approximate 1,5÷ 2 million Euros /power unit.

It shall be taken into consideration that at power unit no. 3, during the rehabilitation works performed in 2003÷2009 primary measures of NO_X emission reduction were applied, by replacing the existing burners with new burners with reduced NO_X emissions, (figure 7). Therefore, it has been complied with the limit values of emissions according to Environment Integrated Permit and to the national legislation, respectively 500 mg/Nm^3. For power unit no. 4 the primary measures of NO_X reduction will be taken when the unit is to be rehabilitated.

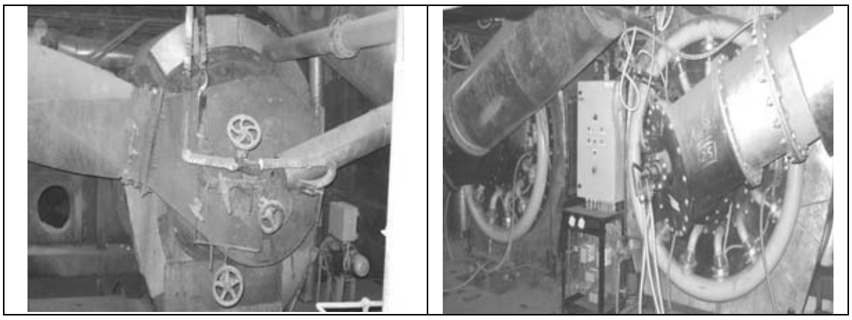


Fig. 7 – Burners with reduced NO_X for unit no. 3.

Based on the technical solutions studies used now as secondary measures, the most efficient NOx reductions is the one known as "NOx non-catalytic reduction (SNCR) with donor reagent “NH_2”. The most used reducing agent (NH_2 donor) is the urea $(NH_2)_2$. The SNCR technology for NOx reduction is based on the NO reduction by NH_2 amine groups, according to the reaction:

$$NH_2 + NO \rightarrow N_2 + H_2O \qquad (1)$$

As NH_2 agents, there are usually used the urea and the ammonia. Taking into account the advantages of urea, regarding its availability, shipping and handling, urea is chosen to be used as reducing agent. In this case, the chemical reactions with NO and NO_2 are the following:

$$4NO + 2(NH_2)_2CO + O_2 \rightarrow 4N_2 + 4H_2O + 2CO_2 \qquad (2)$$

respectively

$$2NO_2 + 4(NH_2)_2CO + 4O_2 \rightarrow 5N_2 + 8H_2O + 4CO_2 \qquad (3)$$

The above mentioned reactions are made through injecting a diluted hydrous solution of urea in the flue gas flow. Since the reaction speed is strongly influenced by temperature, it is very important to choose the injection area for the reaction balance. Generally, the best temperature range is between 870°C and 1080°C so as to provide the activation energy for the NO molecule breakdown.

The temperature range is also very important in the injection area. Knowing the range, it allows to use selective injections both in plan and on floors (injectors are grouped and the activation of various groups is made according to requirements). The optimal reaction temperature depends on the flue gas composition. If the oxygen concentration rises, the optimal temperature decreases. In the same way, the optimal temperature is affected by the carbon monoxide and water vapors. The injection system will not require significant changes of the furnace (permissible deviation of pipe screens for creating injection ports) or major changes imposed by injectors layout (i.e. changes on pressure pipes near the boiler). We consider that the area where the temperature level is provided is located between the upper area of the furnace (ZSR 1) and before the SCP (Figure 8).

The reducing agent (urea in hydrous solution of 40% and eventually, an additive for reaction activation) will be transported and stored in proper conditions. Injection will be made with compressed air. The SNCR system is designed to operate within 50 ÷ 100 % thermal loads ranges.

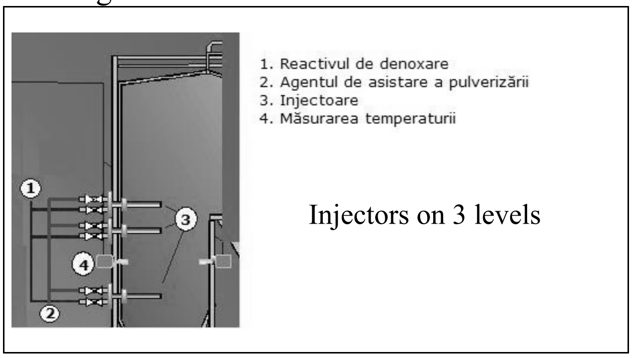


Fig. 8 – Flue Gas DeNOx using the non-catalytic process – SNCR

Each of the two boilers' cylinders is equipped with a coal dust preparation system consisting of 4 mills. Grinding is based on crushing principle. Each mill feeds two burners with coal dust located on one of the two side walls, on the same floor (same level). There are a total number of 8 burners, 4 located on side walls and on two floors (11m and 14 m levels).

Following this rehabilitation, the NOx emissions will be reduced below the value required by the legislation, which is 400 mg/Nm^3 raw emissions in the furnace (Directive 2001/80/CE); this value is provided by the Beneficiary through the combustion management including the control of the excess air into the furnace, reduction of the natural gas add-on and operation fitting the system.

Based on the technical solutions study used now as secondary measures for NO_x emission reductions, the most efficient technology for De NOx efficiency of 50% decrease (reduction from 400 mg/Nmc to 200 mg/Nmc) is the non-catalytic (SNCR) technology with "NH_2" donor agent. The reduction agent (NH_2 donor) will be provided by the reagent -urea, in hydrous solution of 40% NH_2), injected using the compressed air.

Urea injection in the flue gas will be made in the area where the flue gas temperature is optimal for the De NOx reaction, thus the installation of the injectors, as per this requirement, is made according to the actual operational reports and to the performed tests.

The whole De NOx installation is independent. Taken into consideration the above mentioned, the selective non-catalytic reduction (SNCR) installation will be thus sized in order to reduce the NO_x emission below 200 mg /m^{3}N (retrospect to 6 % O_2), given the fact that the NOx concentration, as a result of primary measures applied, does not exceed 420 mg/Nm^3 (retrospect to 6 % O_2). This maximum level of raw emissions (from the furnace) is ensured by the Beneficiary through the furnace combustion management (primary measures for NOx emissions reduction including the control of excess air in the furnace, reduction of natural gas add-on and operation with the OFA system). Under these conditions, it is necessary that the Bidder of the De NOx installation shall comply with all primary measures of NOx reduction implemented within the power plant. The selective non-catalytic reduction system - SNCR is a unitary system and includes:

- The reagent unloading and storage system, including mainly the storage tank and the pumping system;
- Dosing, mixing and distribution system (located near the injection ports)
- Injection system (spray);
- The independent compressed air system for spraying and control;
- Control system (located in the control room);
- Automation system including control;
- The furnace temperature measurement system.

Among the supplies necessary for the operation of this installation, we can mention: the dilution water which will be provided by the Beneficiary and will be clarified and whose hardness is below 15dH, compressed air (at 6 bar pressure for spraying the reducing agent that will be also provided by the Beneficiary).

Among the technological efficiencies of the SNCR installation, we also mention the boiler thermal load of 200 t/h live steam (min.) and 330 t/h of live steam (max.); the system is operating between 50% and 100% boiler thermal loads ranges.

3.3. Electrostatic precipitators (ESP) rehabilitation

The ESP rehabilitation works for power unit no.3 will be performed in the same period in which the FGD installation works are to be executed. To reduce particulate emissions it, there will be performed rehabilitation and modernization works of the electrostatic precipitators, which will reduce emissions to max.50 mg/Nm^3 of particulate combustion in the flue gases discharged to the stack (figure 9). Compliance with the emission requirements of Directive 2010/75/EU on industrial emissions, respectively 20 mg/Nm^3 will be achieved by the WFGD system operation, which by spraying limestone suspension into the flue gas, it shall be provided the reduction of emission limits from 50 mg/Nm^3 to 20 mg/Nm^3. The work costs for this investment reach 5 million Euro.

The rehabilitation and modernization works performed for power unit no. 3 will consider the reuse of the existent ESP housings, spare parts and subsystems of indoor installation. The implementation of a revised designed indoor installation where spare parts and components from the existent installation are included, at the same time with the modernization of the electrical and automation installation as well as with the application of new solutions that are carefully studied on the model regarding an adequate gas flow through the ESP, keeping their circulation in the active area and together with a new concept of electrodes shaking which represents a system used for reducing the dust driving, will allow the increase of the performances so as to reach the limit values required by the GD no.440/2010 (50 mg/Nm^3).

Rehabilitation works performed to the ESP for power unit no. 4 are achieved by totally replacement of the old ESP with a new efficient one; these works refer to construction and steel structure works The works will be performed to: foundations and concrete pillars supporting the ESP, electrostatic metal housing that separates the closed space required for the indoor equipment used for dust separation, flue gas ducts and pipes required to lead flue gas before / after the ESP. It is also replaced the indoor equipment consisting of subassemblies: the deposit system, the shake-deposit system, emission system and shake-emission system.

Fig. 9 – ESP layout

3.4. Fulfillment of collecting, transportation and discharge system into dense slurry of ash, slag and of FGD products and construction of a new silo.

At present, the slag and ash resulting from coal combustion in the boilers' furnaces is discharged from the power plant under hydro mixture form (almost 10 parts water/1 part of shoot); water is re-circulated to be used again. This harmless waste is considered liquid waste and its storage in the existent silo (Bejan slag and ash silo) must be stopped.

Referring to Mintia TPP, the lack of a market request for slag-ash mixture recovery requires the necessity of a final storage, using a new discharge technology for these two products under the form of dense slurry.

The base of the dens slurry technology consists in continuous mix of wet slag from the power unit and dry ash from the ESP, with water, through powerful hydraulic circulation, with a solid/liquid 1:1 ratio, leading to the activation of the chemical substances of cement type, found in ashes, and the creation of homogenous slurry which is pumped to the slag-ash silo, that is solidified in time, resulting into a "ash rock". The FGD by-product, respectively the gypsum slurry is added to this mixture.

For this purpose, the fulfillment of an ash and slag as well as of FGD products handling system coming from power unit no.3 and no.4 is on-going. The investment amounts to 10 million Euros and will be completed in 2016. Dense slurry storage will take place in a new slag-ash silo which is subject to another important investment: horizontal extension of the slag and ash silo, on the right bank of Mureş River, whose first stage has been already accomplished.

By applying the dense slurry technology and storage of the shoot–ash rock, the surface of the silo is hardened, thus being resistant to the wind blowing actions (deflation phenomenon).

4. CONCLUSIONS

The Power Development National Strategy seeks to introduce the evolution of the power sector into the sustainable development strategy of the Romanian economy in the context of efficient use of energy resources and to take the necessary measures to protect the environment.

In the future, hard coal will continue to play an important role on the power resources market, given the potential exploitable reserves, the tendency to reduce unit costs and the existent infrastructure. For this purpose, it shall be consider investments attraction in order to reduce pollutant emissions generated by power plants for complying with the limit values required by the EU legislation.

According to the Romanian Power Strategy for 2007-2020, Complexul Energetic Hunedoara S.A- Electrocentrale Deva seeks:

- The rehabilitation and the modernization of the existent installation for efficiency increase and reduction of the environmental impact;
- The fulfillment of investments in the environmental protection domain;
- Compliance with the requirements stated by Directive 2010/750/EU on industrial emissions (IED);
- Efficient operation of power units, by keeping the operational parameters to the values required for such equipment. The main impact on the environment of the investment implementation shall be a positive one, while a direct consequence of pollutants emission reduction *will be the improvement of air quality in the area* having positive effect on human's health, and on flora, fauna, soil quality and surface waters, contributing to the protection of resources. The implementation of the project will also generate a positive social impact, locally, by *supporting existing jobs* due to the possibility of power units' continuous operation as a result of compliance with the legal provisions as well as *by creating new jobs* during installation and operation of the power plant, and at national level, by *supporting the mining sector* providing the fuel used for the power units.

REFERENCES

[1] ECOTECH PROIECT Bucureşti, *Audit tehnic şi implementarea măsurilor primare privind arderea huilei şi a gazului natural, la cazanele grupului energetic nr.3*, Bucureşti, 2012.

[2] ICEMENERG Bucureşti, *Monitorizarea comportării în exploatare a electrofiltrelor cazanelor 3Aa şi 3B aferente grupului energetic nr. 3 de la S.C.Electrocentrale Deva S.A*, Bucureşti, 1997.

[3] ISPE Timişoara, *Instalații de desulfurarare a gazelor de ardere*, Bucureşti, 2008;

[4] ISPE Timişoara, *Extinderea pe orizontală a depozitului de zgură - cenuşă mal drept râul Mureş*, 2008.

[5] Vaida V., Bereş F., *30 de ani în slujba energeticii româneşti*: 1969-1999. Monografia Centralei Electrice Deva, Ed. Mirton, Timişoara.

Scientific Reviewers:
Prof. Ph.D. Eng Ioan DUMITRESCU

THE MAINTENANCE OF THE HYDROTECHNICAL SYSTEM IN TERMS OF ENVIRONMENTAL PROTECTION AT MINTIA TPP

GHEORGHE LAURENȚIU DOBREI[*]
IOAN CONȚ[**]
TRAIAN VASIU[***]

Abstract: *This paper deals with the concerns and accomplishment at MINTIA TPP in relation to the special works performed, for providing the maintenance of its own hydro-energetic system that is specific to a thermal power plant. There are described some topics related to the maintenance, repairing and cleaning works following the drainage of the industrial water feeding barrier lake, upstream the dam; this operation is rarely performed and takes place every 15÷ 20 years. There are also presented the concerns on environmental impact, in terms of thermal pollution of emissary - Mures River by describing some aspects of related to the pollution of this river. It is also described a project developed by Mintia TPP together with the National Research Institute and with the Polytechnic Institute, conducted at national level, which included the Danube basin as border river and the main hydrographical basins in the country, including Mures River basin. This project was implemented by the practical achievement of an on-line pollution monitoring installation of Mures River due to discharge of cooling waters." By fulfilling this project, Mintia thermal power plant is the only company within the National Power Grid that has implemented a continuous measuring system of temperature and of main chemical indicators on raw water and cooling water, which can alter Mures River downstream the thermal power plant. The efficiency operation of the hydrotechnical circuit is one of the main premises for complying with the environmental legislation, much more when some disturbances or defaults can cause ecological hazards.*

***Key words**: environmental protection, hydro-technical system, barrier lake maintenance, thermal pollution, cooling waters, on-line monitoring.*

1. INTRODUCTION

For power generation, the plants operating with steam turbines generally use (thermal) energy provided by fuel combustion in boilers' furnaces.

Since thermal energy cannot be completely transformed into electricity, a large part of this energy is discharged into the cold source - emissary, thus most of the heat

[*] *Student PhD.Eng., at the University of Petroșani*
[**] *Eng. Manager General at the Electrocentrale Mintia-Deva Branch*
[***] *Ph.D. Eng. at the Electrocentrale Mintia-Deva Branch*

entered into the thermodynamic cycle is discharged into the river, and most of it is represented by heat loss at condensers.

In order to condensate the steam on condenser, the most used solution is the one used as a feeding industrial water cooling agent. Cooling water, whose temperature at the discharge into the outlet, can vary between 5÷12°C in relation to 2-5°C as allowed, may adversely affect the existing ecosystem, with a negative impact on the environment, respectively, on water.

The hydrographical network of this area where Mintia TPP is located is exclusively dominated by Mures River, while its tributaries Strei and Cerna do not have such a great importance in this area.

In this area, Mures River crosses through a large tectonic couloir, between Apuseni Mountains and Poiana Rusca Mountains; The Mures couloir is set in the middle of Hunedoara County between Aurel Vlaicu and Zam Villages, on the NE-SW direction, following an old marine armlet that used to connect the Pannonia and Transylvania basins.

When entering into Hunedoara County, upstream Aurel Vlaicu Village, Mures River has an annual average flow of 93 m^3/s, and downstream Zam Village, the flow reaches 142 m^3/s.

Mintia Thermal Power Plant, which is one of the greatest electricity and thermal energy generators within the National Power Grid, uses as main fuel coal (hard coal from Jiu Valley and from import), but also auxiliary fuels (black oil and natural gas).

Mintia TPP (Figure 1) is located in the S-E of Transylvania on the left bank of the Mures River, at 9 km away from Deva.

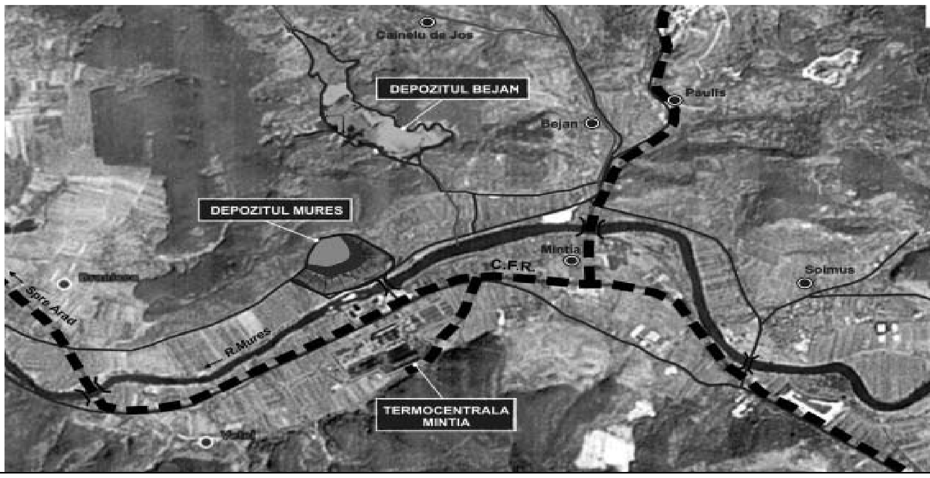


Figure 1 – The location of Mintia TPP

It has an installed power of 1.075 MW, divided into 5 power units: 4 units of 210 MW each and 1 power unit of 235 MW, in block system, each being fed by 2 identical boilers of 330 t/h, 13,72 MPa, 550 ^{0}C, each power unit being considered independent.

The feeding water source is Mureş River, whose bed has been modified by building an excavated channel of 640m length (Figure 2), which can allow the plant's operation for 1285 MW output in open circuit with water from Mureş River during 97% of time or in mixed circuit with cold water mixture from this river and cooled water to the 2 natural draft cooling towers, having a 2 x 27.000 m^3/h capacity and where a discharge dam for keeping a 5 m water constant level was built.

Water is captured by a water intake sized for 60m^3/s which fits the needs of cooling water for the 210MW and 235 MW power units.

On warm water discharge channel, there is a micro-hydro thermal power plant (MHc) which is operating, with 1,5 MW output, used for partial recovery of electricity from the water circuit.

The cooling pumps station is provided with 12 rotating sieves, where 8 sieves with front planes and 4 tubular sieves with side entrance of water.

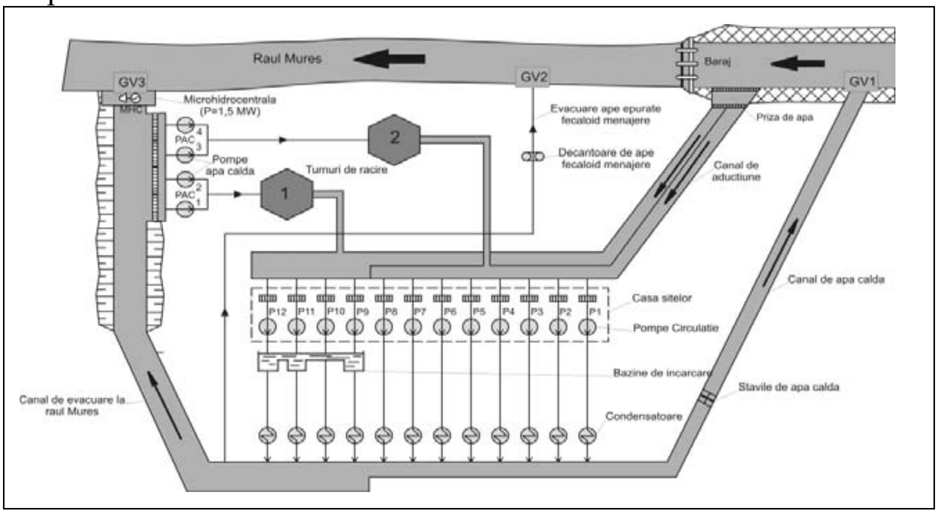


Figure 2 – **Industrial water supply source – Mures river**

2. MINTIA TPP CONDITION DESCRIPTION

Mintia TPP cooling waste waters, discharged into the emissary, can negatively influence the quality Mureş river, through river water temperature increase by approx. 2÷5°C downstream the discharge opening, respectively within micro-hydro thermal power plant area (MHc), except rare situations, when the outdoor temperature has been extremely high and when the variation of Mureş River's temperature and of cooling waters discharged into the river has exceeded 12°C.

Average values measured during some representative years, upstream (supply raw water – dam) and downstream the thermal power plant (discharged cooling water –

MHc) are actually the variation of the temperature measured on thermal power plant inlet and outlet and are stated in table 1 and figure 3.

The commitments that Romania has regarding the pollution prevention of Danube as border river, have led to the need to approach the problem of internal emissaries thermal pollution, thermal power plants with opened or mixed cooling circuit located on the internal rivers.

One of the thermal power plants, which has been the subject of such research works, was Mintia Thermal Power Plant, which performed the study regarding "*Mures river thermal pollution under the impact of Mintia TPP operation.*", which represented an initial performance on national plan within power field and was part of a more extensive work: "*Determining RENEL power plants contribution to Danube and internal rivers thermal pollution*". Both works were otherwise carried out together with the specialists within the power plant.

Table 1 – Mures River thermal pollution

Year	**VLA**	**Measured value** (average)	**Temperature variation** (average)	**Temperature variation** (average)
		Upstream	**Downstream**	
	(ºC)	(ºC)	(ºC)	(ºC)
1990	30	21,5	23,8	3,4
1995	35	20,6	24,0	3,6
2000	35	20,5	24,1	3,8
2005	35	20,6	24,4	3,7
2010	35	20,5	24,2	12,0
2012	35	20,4	32,4	3,9

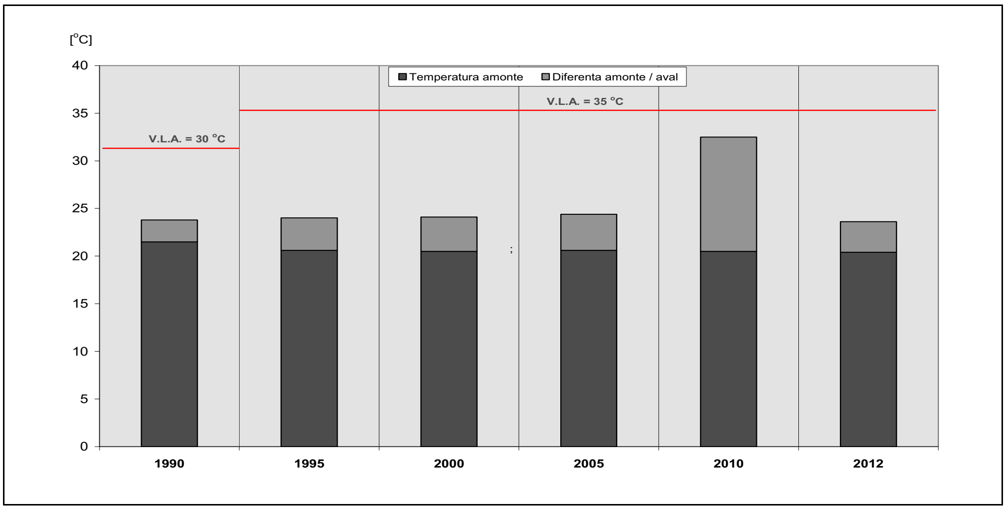


Figure 3 – Mures river water temperature variation

The analysis performed included measurements of Mures River water temperature (upstream the thermal power plant) and of discharged cooling water (downstream), through *infrared thermography method* (M.T.I.R.), and further physical and chemical analysis of the water in the supply and discharge areas.

The measurement points (figure 4) have been established so as to provide data regarding intake supply water temperature (upstream the dam, feeding water intake), discharged cooling water temperature (MHc), as well as Mures river water temperature, downstream the discharge area (in Brănişca and Ilia, at 3 km, respectively 15 km downstream of the power plant).

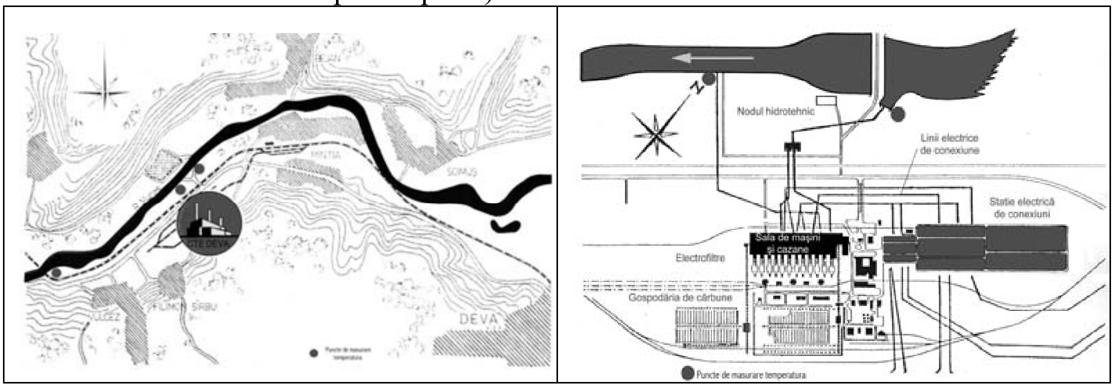


Figure 4 – Mures river water temperature measurement points

Red thermography measurements have been carried out during summer, on four stages, aiming to catch some various hydro-meteorological conditions, which had as a purpose the analysis of some different conditions, both meteorological and operational point of view of thermal power plant, providing as much data as possible on Mures River thermal pollution by Mintia TPP.

Discharged warm waters temperature measurements have been correlated with the values of some external parameters, related both to the atmospheric conditions, as well as to the flow and quality of Mures River waters (generated electricity, intake/discharge water flow, Mures River flow, atmospheric pressure and temperature).

Because the issues related to the emissary thermal pollution are worsen by the availability of chemical polluting agents, at the same time with the temperature measurements, there have been also carried out some series physical and chemical analysis: pH, conductivity, calcium and magnesium ion concentration, CCOMn, ion ammonia concentration, dissolved oxygen concentration.

At the same time with these measurements, there have been collected data regarding thermal power plant operation and data regarding the microclimate conditions: power plant operational data (power generation; intake water flow; discharged water flow), meteorological data (atmospheric temperature, wind speed, solarization duration), hydro-technical data (Mures river flow and speed).

Measurements from infrared thermography method (M.T.I.R.) have shown that within the four stages, there have not been registered maximum allowable temperature excess (30°C during that period of time) on water discharge into the outlet, even if during summer period, measured warm water temperature has sometimes reached the maximum allowable value (table 2 and figure 5).

It can be seen that downstream the discharge area, warm water mixing with cold water of the emissary (dilution) is carried out quickly, this mixture area being developed on a distance of approx. 500 m.

Table 2 – Mures river thermal pollution

Stage	**Allowable value**	**Measured value** (average)		
		Upstream (DAM)	**Downstream (MHc)**	**Brănişca**
	(ºC)	(ºC)	(ºC)	(ºC)
I	30	16,0	24,0	18,0
II	30	21,0	29,0	22,0
III	30	18,0	25,0	18,0
IV	30	20,0	27,0	20,0

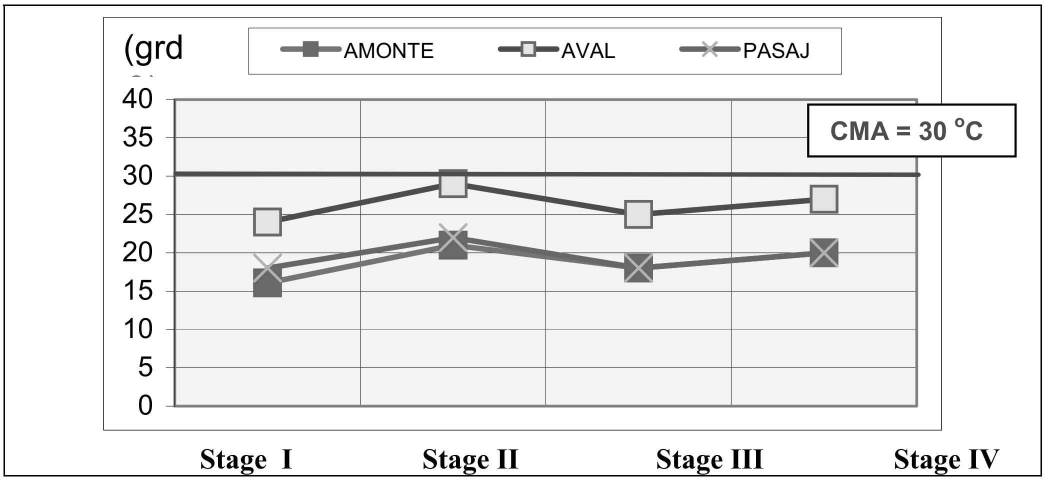


Figure 5 – Mures river water temperature variation through M.T.I.R.

Moreover, there have not been determined any influences of Mures River water quality, due to the discharge of some waste waters from the thermal power plant, except some short periods of time, through the presence of some blue algae, condition also determined by the thermal gradient of Mures River surface water, during summer, when the external temperature and that of Mures River upstream the thermal power plant were very high.

For a good determination of outlet level pollution, there was performed a mathematical modeling of warm water into cold water of Mures river dispersion process, for conditions of the days when there have been carried out measurements and for some hypothetical situations, when hydro-meteorological parameters would have equal values to those multiannual monthly average. Mathematical modeling results show a temperature increase of the emissary with about 1÷2°C over a distance of 1000÷1500 m.

The measurements and analysis that have been carried out led to the conclusion that in normal meteorological conditions during summer time for our country, with high temperatures and reduced rainfall quantity, warm waters temperature discharged into the emissary can register values above the allowable ones.

Experimental data and those provided by mathematical modeling have shown that there is the risk to exceed the temperatures imposed by legislation, when hydro-meteorological conditions become advantageous for this process (high atmospheric temperature, emissary flow low, high intake water temperature, etc). In this case the cooling circuit operation in mixed condition with the cooling towers is compulsory

4. THE MAINTENANCE CONCEPT

The maintenance of the hydro-technical network within the thermal power plant has special concepts and particularities and includes all the repairing and service operations related to the hydro-technical system, so that it could operate under proper conditions.

The follow up of the hydro-technical operating installation and damage reparation may be sometimes possible only if the entire circuit operation has been shut down.

The controlled shut down of the hydro-technical network, as happened at Mintia TPP, is an event that takes place about 2 ÷ 3 times during the lifetime of a TPP similar to Mintia.

The main works performed were related to the safety of the under-water installations and construction that cannot be controlled during operation of the TPP, and also to some modernization works of the mechanical pre-filtering systems for the entrapped water and of drainage of the alluvial sediments deposited in the water intake. (figure 6). The discharge and filling up of the barrier lake from where the TPP is supplied with industrial water, located on the Mures River, has been carefully analyzed and the discharge-filling up periods were precise calculated so that the nature and environment in the area not to be affected.

The discharge-filling up works of the barrier lake were performed during summer, when the Mures River water quantity was altered because of blue algae. This condition was encouraged by the thermal gradient of surface water when the outdoor temperatures and Mures River temperature upstream the power plant is extremely high.

Firstly, it has been taken into consideration the flood danger in the downstream of the dam and the run-out of the river banks in the upstream area, and then, when filling-up, it was considered the avoidance of lake silting and provision of a safety level flow downstream in respect of the underwater fauna and flora.

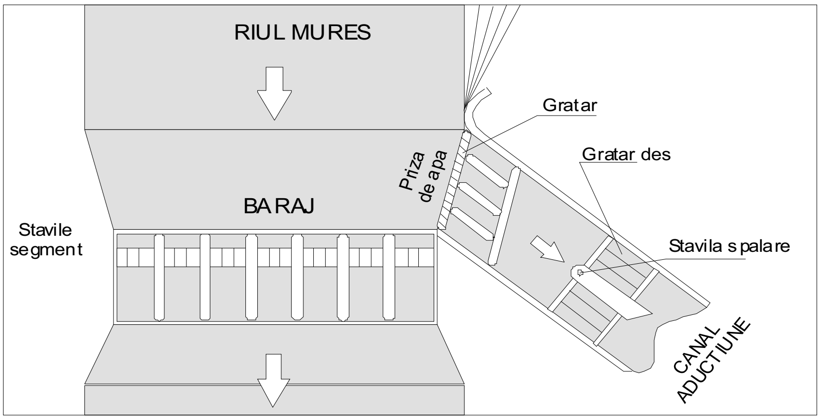


Figure 6 – Hydro technical works at Mintia Thermal Power Plant

The works regarding the lake draining have been carefully prepared and analyzed, taken into account two important issues: technical and ecological.

A quick draining of the lake could have led to floods downstream of the dam and the run-out of the banks in the upstream area, while, from the ecological point of view, it has led to ecological hazards by destroying the fauna and flora upstream and downstream of the dam.

Furthermore, the flow speeds and the water flows necessary for a slow use have been determined, correlated with the variation of the fluctuant flows caused by water processing by the hydro power plants located on Raul Mare-Retezat, Sebes and Strei Rivers, located upstream at approx. 100 km.

By draining the barrier lake, it was able to inspect the special hydro technical constructions, performing cleaning and rehabilitation works to the mechanical filtering and drainage installation.

When the lake was drained, profile topometrical measurements of the lake bottom have been performed, resulting the time-occurrence of deposits on the right border due to drought phenomenon. The barrier lake from Mintia thermal power plant has as particularity the fact that the deposits drain in the periods of floods by manipulation of dam's sluiceways.

These screens have a special profile and were designed and tested within Mintia power plant during two years by a research and design institute together with the specialists from Mintia power plant having been appreciated and caught the attention of the specialists.

An important attention for providing maintenance of the hydro technical circuit is given to the good operation of the cooling pumps (circulation), by providing a rigorous level of suction water, this condition being determined by the correct operation of the entire catchment and adduction of water. The cooling pumps, of axial type are very sensitive to variations of the external hydro dynamic characteristics (backpressure). Through repeated flow measurements, it has been determined an important oscillation of the flow which interfere with the cost-efficiency operation of the steam turbine.

After many measurements and tests performed as well as after different operations conditions, it was established that the cooling pumps that operated in syphon system have lost their flow because of air infiltrations on the water circuit of the condenser. Under these circumstances, detailed measurements of the water circuit have been performed so as to eliminate the above mentioned deficiencies, putting into question the replacement of these pumps.

Thus, by replacing the initial circulation pumps with modern pumps, of higher pressure (approx. 15 mCA), with fluctuant flow and with operation in direct backpressure scheme, there were acquired important fuel savings necessary for energy and thermal power generation.

Another aspect related to the maintenance of the hydro technical circuit is given by safety operation, from the point of view of design and environmental protection of the ash and slag storage in Mintia (whose activity is interrupted so as to be closed and to be rendered ecological) and of the ash and slag storage in Bejan, being in operation.

By providing an adequate operation of Bejan storage, it is rigorously kept the hydro mixture level of ash and slag and by measures of rapid interventions in case of pipe breaks of hydro mixture transportation, it is provided a safety operation of ash and slag discharge and transport system, avoiding the spread of the liquid slag and ash, soil and ground water pollution (underground waters).

The most important issues are related to the dam aggradations, having a high degree of dust pollution of air and soil. In order to provide the stability of the main dams and the division of the storage, as well as to avoid the pollution of ground waters (underground waters), of air and of soil, it was performed the monitoring of the storage, through periodic measurements of the dam settling and by chemical analysis of ground water's quality from the river that passes under the storage at the same time with the water quality monitoring of Mures River.

5. CONCLUSIONS

The good operation of the hydro technical system of Mintia thermal power plant has an essential impact on the main power installation and which, implicitly, leads to the reduction of pollutants (CO_2 , SO_2 and NO_X) emissions by reducing the fuel consumption necessary for burning.

The replacement of the cooling pumps (circulation) has led to important fuel savings required for energy and thermal power generation.

The safety operation from the point of view of construction in an adequate exploitation of Bejan storage and of the ash and slag transportation, as well as from the point of view of environmental protection, through performing dam aggradations, maintenance, repair and division, together with periodic monitoring of the storage, are measures that lead to the maintenance of the hydro technical system in Mintia thermal power plant.

By implementing and fulfillment of the continuous monitoring system of cooling raw water quality parameters that are discharged into the emissary, namely of the temperature parameter, Mintia TPP has worked up once again the interest for the issue related to the environmental protection, this time water, and by its operation, this installation allows the thermal power plant to keep under control the thermal pollution phenomenon, removal of Mures River pollution by the occurrence of the eutrophication and underwater ecosystem damage.

The efficiency operation of the hydro technical circuit is one of the main premises for complying with the environmental legislation, much more when some disturbances or defaults can cause ecological hazards.

REFERENCES

[1]. Dadu V., Mânea L., Reducerea pierderilor de sarcină la prizele centralelor electrice cu o nouă soluție constructivă a grătarului. Simpozion: Hydrovision – Charlotte North Caroline, USA, sept. 2000.

[2]. G.S.C.I. Bucureşti, Poluarea termică a râului Mureş sub impactul funcționării C.T.E. Mintia, Bucureşti, 1997.

[3]. G.S.C.I. Bucureşti, Determinarea aportului centralelor RENEL la poluarea termică a Dunării şi a râurilor interioare, Bucureşti, 1997.

[4]. ISPE Bucureşti, Regulament de exploatare a barajului, lacului de acumulare şi a prizei de alimentare cu apă de la C.T.E. Mintia, conf. Ordinului nr. 396 / 1997 emis de MAPPM Bucureşti, 1998.

[5]. Vaida V., Bereş F., 30 de ani în slujba energeticii româneşti: 1969÷1999. Monografia Centralei Electrice Deva, Ed. Mirton, Timişoara, 1999

Scientific Reviewers:
Prof. Ph.D. Eng. Ioan DUMITRESCU

THE DIFFERENCE BETWEEN THE WGS84 AND THE ETRS89 COORDINATE REFERENCE SYSTEMS

KLAUS GERHART FISSGUS*
RAREŞ MUNTEANU*

ABSTRACT: *Internet searches often imply that the Reference System WGS84, which is used with GPS measurements and the European Reference System ETRS89 are virtually identical and that Coordinate Transformation between the two systems is unnecessary. In fact, the positions calculated by these two Reference Systems currently deviate by more than half a meter. For the purposes of navigation or geo-infonomics, this does not represent a problem as here the need for precision is negligible, and thus a conversion between the two systems is superfluous. However, for high-precision surveying work within the framework of geodesic spatial referencing and for data with legal effects, like the Land Survey Register, this difference must be accounted for.*

Key words: *GPS, WGS84, ETRS89, Coordinate Reference System, Continental Drift.*

1. INTRODUCTION

Mapping out the Earth can be a very comprehensive, long, drawn-out task. The fact of the matter is, it is sometimes a very underappreciated but extremely important body of information. Many applications involving navigation and topographical data would be non-existent without such information. Modern technology has facilitated the development and maintenance of established mapping parameters. Two of the most significant developments in the last couple of decades are the establishment of WGS84 and ETRS89.

The World Geodetic System (WGS84) is the standard used when it comes to cartography and navigation as well as geodesy. This system sets the parameters for which certain measurements are made in determining the reference points on the planet based on the establishment of a standard coordinate frame for the Earth and other details (such as the datum and the geoid). WGS84 uses the GRS80 ellipsoid as the basis for its parameters. The importance of this system stems from the fact that WGS84 is the system used by the Global Positioning System (GPS).

At the other end, the European Terrestrial Reference System 1989 (ETRS89) is an Earth-Centered Earth-Fixed (ECEF) geodetic Cartesian reference frame utilized primarily for the European areas (whereas WGS84 is global). This is the basis by

* *Lecturer PhD. Eng., at the University of Petroșani*

which the coordinates of maps and locations in Europe are derived from. Within its parameters, it treats the Eurasian Plate as a static, non-changing constant; thus, the continental drift is not factored in on maps based on ETRS89. This system was established and officially accepted in the year 1990. This occurred in the Florence meeting of the EUREF (Regional Reference Frame Sub-Commission for Europe).

ETRS89 was developed with the International Terrestrial Reference System (ITRS) geodetic datum being taken into consideration. EUREF's Resolution 1 led to its development as a means of adopting the ITRS using the constantly stable section of the Eurasian plate. Because of this, the ETRS89 and ITRS have very little divergence and disparity. Unlike WGS84, the numerical part of ETRS89 is not based on what year the system was established but rather when it was completely in sync with the ITRS. To reflect this, solutions produced through using ETRS89 have comparative ITRS solutions. ETRS89 is constantly monitored and updated by the EUREF through its Permanent Network (EPN).

2. UNIFIED GEODETICALLY EUROPE

INSPIRE (Infrastructure for Spatial Information in the European Community) is a European commission with the goal to create a unified spatial data base for all of Europe. Background of this scientific article is that in all domains of geodesy by INSPIRE guidelines required conversions of local Coordinate Reference Systems (CRS) of the European countries to Europe-wide uniform CRS, based on the Reference System ETRS89, must be done. Under European legislation INSPIRE proposes for different applications and scales following CRS:

- ETRS-TMzn: ETRS89 Transverse Mercator Coordinate Reference System (UTM)
- ETRS-LCC: ETRS89 Lambert Conformal Conic Coordinate Reference System
- ETRS-LAEA: ETRS89 Lambert Azimuthal Equal Area Coordinate Reference System

The Reference System WGS84, used for GPS measurements, is based on the global International Terrestrial Reference System ITRS that is fixed on the earth's center of mass. Due to plate tectonics, the Eurasian continent within the ITRS is slowly moving upon the surface of the earth in a north-easterly direction.

ETRS89 is a geocentric Reference System for Europe based on the state of the International Terrestrial Reference System ITRS as of January 1, 1989. As the Eurasian continental plate is largely static, ETRS89 provides Europe with a Reference System that is uniform and time-independent. The relationships between coordinates located on the stable part of the European plate thus remain unaltered with ETRS89.

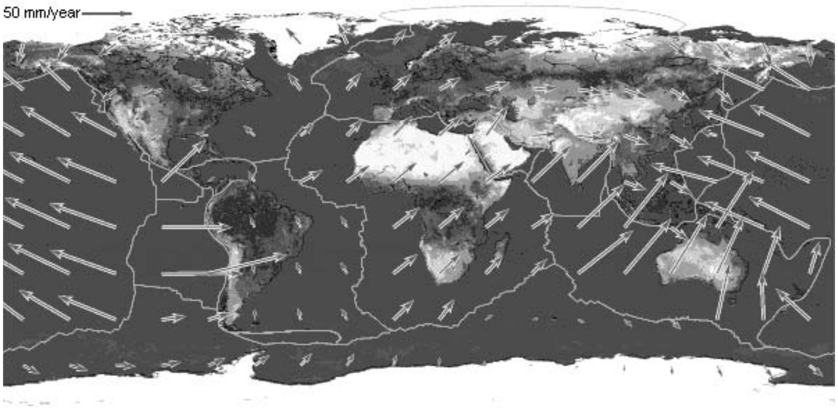


Image 1: The drift of the continental plates within the ITRS

3. CONTINENTAL DRIFT

Since ETRS89 was realized until today (2013), a shift of 50 to 60 centimeters has accrued between WGS84/ITRS and ETRS89 which continues to grow dynamically at a rate of approximately 2.5 centimeters annually. The difference varies depending upon the location of a given coordinate on the Eurasian plate because, in addition to the shifting, rotation also takes place. The vectors representing shifting and the angles representing rotation are graphically depicted in Image 2.

Image 2: Difference between ITRS and ETRS89 due to continental drift

4. ACCURACY OF GPS MEASUREMENT METHODS

For civilian use GPS satellites furnish signals by which positions with simple GPS receiver directly can be determined within accuracy about 8 meters.

DGPS is a service, which improves the accuracy of positioning by a radio-transmitted error correction of one or more reference stations in the range between 0.3 and 2.5 meters.

Satellite positioning services such as ROMPOS or SAPOS, for instance, can increase the positioning accuracy to within mere centimeters.

5. CONVERTING GPS COORDINATES TO ETRS89

For direct measurements the conversion to ETRS89 is usually not necessary, as it in terms of the systemic high inaccuracy of several meters would not lead to a significant improvement. Here, the equating of WGS84 and ETRS89 can be tolerated. However, to maintain the high accuracy of DGPS and ROMPOS or SAPOS, for the transformation of GPS coordinates from the WGS84/ITRS Reference System to ETRS89 exact transformation parameters are required. To this end, precise parameter sets are calculated and regularly made public as ITRS annual realizations or WGS84 epochs. The WGS84/ITRS GPS coordinates are converted to ETRS89 with their given epoch's parameter set. For an exact calculation, it is therefore necessary to know the epoch, that is, the year the GPS data was implemented. These realizations are issued using the year in the form of ITRS89 for the year 1989, successively up to ITRS13 for the year 2013 and annually ongoing.

REFERENCES:

[1]. Augath, W. – *Beiträge des Vermessungswesens zur Ortung und Navigation im Wandel*. Tagungsband der DGON-Jubiläumsveranstaltung (1951 - 2001), S. 195-210, Bonn, 2001

[2]. Boucher, D., Altamini, Z. – *Specifications for Reference Frame Fixing in the Analysis of a EUREF – GPS – Campaign*. Veröffentlichungen der Bayrischen Kommission für die Internationale Erdmessung (BEK) Nr. 56, S. 265-268, Beck'sche Verlagsbuchhandlung, München, 1995

[3]. Celine A. – *Difference Between WGS84 and ETRS89*, DifferenceBetween.net, 2012

Dima N., Herbei O., Filip L. – *Realizarea rețelelor geodezice utilizând sistemele globale de referință*, Simpozion Simpro Petroşani, 2005

[4]. Fissgus K. – *All about GPS*, Annals of the University of Petroşani, Mining Engineering, 4, 2003

[5]. Killet F. – *Are the Reference Systems WGS84 and ETRS89 really identical?* gis.Business, Das Magazin für Geoinformation, Booklet 8/2010, http://www.killetsoft.de/t_1009_e.htm

[6]. Popescu, G., Marian, D.P. – *Monitorizarea deplasării suprafeței terenului utilizând tehnologia GPS – metoda RTK – la mina Livezeni*, Revista Minelor Vol. 18, Nr.2/2012. http://www.upet.ro/revistaminelor/arhiva/rmpdf2012/nr2ro.html

[7]. Vereş I. – *Automatizarea lucrărilor topo-geodezice*, Editura Universitas, Petroşani, 2006

Scientific Reviewers:
Assoc.Prof. Ph.D. Eng. Ioel VEREȘ

GENERAL THEORY OF PROCESSING THE MEASUREMENTS SIZE

LARISA OFELIA FILIP*

Abstract: *For processing the measured size is consider a unitary theory on building systems error equations, systems of equations and to determine normal weight coefficients.*

1. INTRODUCTION

Information that forms the basis of concrete data to solve problems on surveying, photogrammetric and topographic come from measurements made on some sizes to work with frequently and who are mainly angles and distances. The quality measure is based on information obtained from direct observation volume and precision equipment used.

It is necessary, therefore, that from the purpose for which measurements are made to determine the proper size and precision values, taking into account the economic aspect but on the observation volume needed.

Processing theory quantities measured favorably resolve these issues. Given the layout and conditions are executed measurements are grouped into:

- direct measurements;
- indirect measurements;
- conditioned measurements;
- indirect measurements with multiple observations;
- indirect measurements, subject to conditions.

Processing measurements as specified group, use appropriate theories same precision measurements and different accuracies.

It is possible, however, processing the measurements using a general theory that can be subject to customizations to get known methods of processing and applied to groups of measurements.

This paper aims at establishing the general theory of measurement and customization processes.

* *Lecturer PhD. Eng., at the University of Petroșani*

2. THE SYSTEM ERROR EQUATIONS. THE NORMAL EQUATIONS

We consider the general case of measurements that indirectly determine sizes based on multiple observations are observed at the same time some relationships that correspond to conditions imposed.

Mathematically, this general case is expressed by the following matrix relations:

$$\begin{aligned} &av + Ax + L = 0 \\ &Bx + W = 0 \end{aligned} \quad (1)$$

where:

$$\begin{aligned} &a = a_{rn}; \quad A = A_{rh}; \quad L = L_{r1}; \quad B = B_{nh}; \quad W = W_{nh}; \\ &X = X_{hi}; \\ &v = v_{n1} \end{aligned} \quad (2)$$

inequalities are fulfilled:

$$\begin{aligned} &r \le n \\ &r \ge h \\ &n \le h \end{aligned} \quad (3)$$

The system of equations (9.1) is solvable if condition is attached:

$$\mathrm{F = v'pv - 2K'(AV + ax + L) - 2K'(Bx + w) =\ minim} \quad (4)$$

where:

$$K = K_{r1};\ K_1 = K_{n1};\ p = p_{nn} \quad (5)$$

The minimum function (4) exists when:

$$\frac{1}{2}\frac{\partial F}{\partial v} = 0;\ \frac{1}{2}\frac{\partial F}{\partial x} = 0 \quad (6)$$

so when:

$$
\begin{aligned}
&pv - a'K = 0 \\
&A'K + B'K_1 = 0
\end{aligned}
\tag{7}
$$

The equalities (7) together with the equalities (1) forming system:

$$
\begin{aligned}
&v = p^{-1}a'K \\
&A'B + B'K_1 = 0 \\
&av + Ax + L = 0 \\
&Bx + W = 0
\end{aligned}
\tag{8}
$$

which completely solve the general case of measurements.

The system (8) can be written in the form:

$$
\begin{aligned}
&(ap^{-1}a')K + Ax + L = 0 \\
&A'K + B'K_1 = 0 \\
&Bx + W = 0 \\
&v = p^{-1}a'K
\end{aligned}
\tag{9}
$$

From equalities (9) we obtain the customization for each type of measurements considered above.

For example, to indirect measurements we have in (1):

$a = E$ (matrix unit)
$B = 0$

Then from (9) we obtain:

$$
\begin{aligned}
&p^{-1}K + Ax + L = 0 \\
&A'K = 0 \\
&v = p^{-1}K
\end{aligned}
$$

or:

$K = -P(Ax + L)$

$(A'pA)x + A'pL = 0$ - normal equation system.

$v = -(Ax + L)$ - equations system errors.

3. THE EXPRESSIONS WEIGHTING COEFFICIENTS

In determining weighting coefficients matrices for sizes x and v, be the first to establish a connection between the linear size and measured size „l”.

For the system (9) we can write:

- from the first equation

$$K = -Q_0 Ax - Q_0 L;\ \ Q_0 = \left(ap^{-1}a'\right)^{-1} \tag{10}$$

- shall be inserted also the second equation

$$-A'Q_0Ax - A'Q_0L + B'K_1 = 0$$
$$B'K_1 = A'Q_0Ax + A'Q_0L$$

and

$$x = \left(A'Q_0A\right)^{-1}\left(B'K_1 - A'Q_0L\right)$$
$$x = Q^0\left(B'K_1 - A'Q_0L\right); Q^0 = \left(A'Q_0A\right)^{-1}$$

- is inserted a third equation

$$Ba^0\left(B'K_1 - A'Q_0L\right) + W = 0$$

where

$$Ba^0B'K_1 - BQ^0A'Q_0L + W = 0$$

from where

$$K_1 = \overline{Q}\left(BQ^0A'Q_0L - W\right); \overline{Q} = \left(BQ^0B'\right)^{-1} \tag{11}$$

- the equalities (10) and (11) used from the second equation leads to the equality:

$$-A'Q_0Ax - A'Q_0L + B'\overline{Q}\left(BQ^0A'Q_0L - W\right) = 0$$

from where:

$$x = \left(Q^0B^X\overline{Q}Ba^0A'Q_0 - Q^0A'Q_0\right)L - Q_0B'\overline{Q}W \tag{12}$$

as

$$L = al$$

results:

$$\begin{aligned} x &= Q^0\left(B'\overline{Q}BQ^0 - E\right)A'Q_0al - Q \\ R &= Q^0B'\overline{Q}W \end{aligned} \tag{13}$$

Analogue, for corrections v. It follows:

$$\begin{aligned} & v = -p^{-1}a'Q_0\left[AQ^0\left(B'\overline{Q}BQ^0 - E\right)A'2_0 = E\right]al + R_0 \\ & R_0 = p^{-1}a'Q_0AR \end{aligned} \quad (14)$$

The measured „l" after the netting set values:

$$L = l + v$$

Taking into account only the terms in l, the relations (13) and (14) become:

$$\begin{aligned} & x = Cl \\ & L = Dl \end{aligned} \quad (15)$$

or:

$$\left(\frac{L}{x}\right) = \left(\frac{D}{C}\right)l \quad (15')$$

where:

$$\begin{aligned} & C = Q^0\left(B'\overline{Q}BQ^0 - E\right)A'Q_0a \\ & D = 1 - p^{-1}a'Q_0\left[AQ^0\left(B'\overline{Q}BQ^0 - E\right)A'Q_0 + E\right]a \end{aligned} \quad (16)$$

We note $l = p^{-1}$

As presented, can be formed the matrix weighting of coefficients:

$$(Q) = \left(\frac{QLL}{QxL}\,\frac{QLX}{Qxx}\right) = \left(\frac{DQD'}{CQD'}\,\frac{DQC'}{CQC'}\right) \quad (17)$$

Using expression (16) can be obtained:

$$Q_{LL,} Q_{XX}, Q_{XL}$$

For example:

$$Q_{xx} = CQC' = Q^0 - Q^0B'\overline{Q}BQ^0 \quad (18)$$

y customizing the expressions of the matrix elements (17) are obtained weighting matrix for each type of measurement.

4. THE MEAN SQUARE ERROR OF THE UNIT OF SHARE

If we reduce the general case to the case of indirect measurements with multiple observations can be applied to the relationship:

$$m_0 = \pm\sqrt{\frac{v'pv}{r - h_1}} \quad (19)$$

h_1 - number of unknowns to be determined after reduction but:

$$h_1 = h - n$$

if:

$$m_o \pm \sqrt{\frac{v' pv}{r - h + n}} \qquad (20)$$

where:

$$v' pv = -L' K - X' A' K \qquad (21)$$

After customizing the relation (21) is obtained for each type of measurement the relation.

5. CONCLUSIONS

All categories of measurements are analyzed using a single theoretical procedure. Using matrix calculus allows expression of mathematical precision quantities determined more easily.

REFERENCES

[1]. Botez, E. - *Teoria erorilor și metoda celor mai mici pătrate,* Editura Didactică și Pedagogică, București, 1961
[2]. Dima, N. - *Contribuții la studiul asupra rețelelor topografice subterane şi a problemelor de străpungere,* Teză de doctorat, Petroșani, 1975
[3]. Dima, N. - *Teoria erorilor și metoda celor mai mici pătrate,*Editura Universitas, Petroșani, 1999
[4]. Rosculeț, M. - *Analiză matematică,* Editura Didactică și Pedagogică, București, 1961

Scientific Reviewers:
Prof. Ph.D. Eng. Nicolae DIMA

IDENTIFICATION AND ASSESSMENT OF THE RISK AND IMPACT GENERATED BY ROŞIA POIENI QUARRY AND DEALUL PICIORULUI PROCESSING PLANT

MARIA LAZĂR*
FLORIN FAUR**

Abstract: *This paper aims to conduct two studies, a risk assessment and an environmental impact assessment generated by the activities at Rosia Poieni (copper ore quarrying and obtaining through preparation of a metal concentrate at Dealul Piciorului processing plant). For this purpose the two main activities are analyzed (from the technological point of view), the mining objectives are described (the quarry, the processing plant, waste dumps and tailings ponds), the pollution sources are identified after which the risk and environmental impact are identified and assessed. The paper ends with a number of conclusions that can be drawn from the content.*

Keywords: *waste dumps, tailings ponds, quarry, processing plant, risk, environmental impact*

1. DESCRIPTION OF THE STUDIED AREA

1.1. Objectives location

Geographically, the poor copper ore deposit at Rosia Poieni is located at 23°10min. east longitude and 46°20 min. north latitude, in the Apuseni Mountains, in the southern extremity of the Metaliferi Mountains, at approx. 7 km from Aries River (Fig. 1). [2]

The area is administrated by Lupşa village, Alba County. The surrounding area of the deposit is mountainous, with heights of 600 to 1250 m and is furrowed by deep valleys.

The area in which the mining activities are located is on the territory of Abrud, Lupşa, Bucium, Bistra and Rosia Montana localities, in the north-eastern part of Metaliferi Mountains.

1.2. Site characterization

From the geological point of view, the copper deposit belongs to the Bucium ÷ Rosia Montana area, Bucium fossa, where Cretaceous and Tertiary formations are found, the basic structure being represented by andesitic rocks and subordinate sedimentary rocks. The same structure is respected for the materials stored in waste

---

* *Prof. Eng., Ph.D. at the University of Petroşani, e-mail: lazar@upet.ro*
** *Assist. Prof. Eng., Ph.D. at the University of Petroşani, e-mail: faurfloring@yahoo.com*

dumps and tailing ponds. The hydrographic network within the mining area is developed in accordance with the structure and nature of the formations that are found in the region. The valleys are mostly narrow, with a profile in "V" shape, developing a strong transport energy (for example: Geamăna Valley, Şesei Valley, Ruginoasa Valley, Muntari Valley, Ştefancei Valley of which the Şesei Valley and Ştefancei Valley are used for storing flotation sterile in Ştefancei I and II and Şesei tailings ponds. [5]

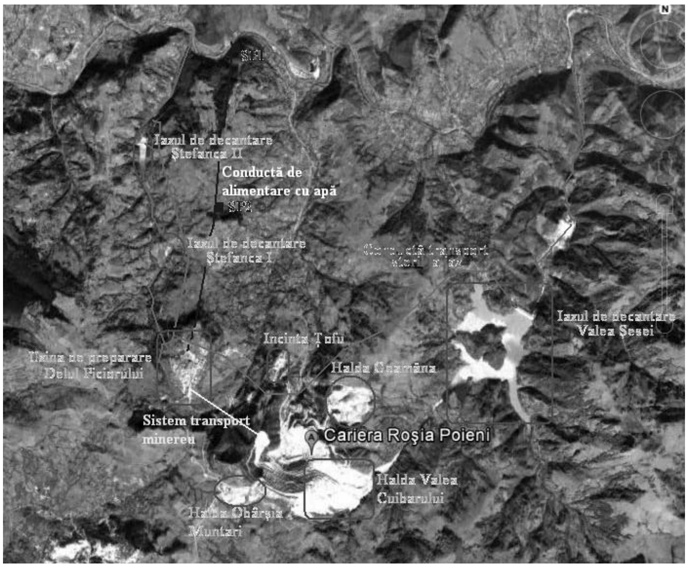


Fig. 1. Objectives location

The main source of water that collects the creeks from the area is the Aries River, whose tributaries on the right are: Şesei creek, Muşca creek, Ruginoasa creek and Ştefancei creek. In these valleys converge and drain a number of streams and torrents that deeply furrows the slopes, giving them a characteristic appearance.

Groundwater horizons are confined in terrace deposits that have a larger development along Aries Valley and a smaller one along the valleys of its tributaries. They were identified in an exploration drill in the northern part of the deposit (Muşca Valley), where in the range 200 ÷ 250 m an aquifer that comes to the surface at a debit of approx 5 - 6 l/sec was encountered.

From observations of hydrometeorological stations it can be stated that the hydrographic basins from Roşia Poieni area are characterized by averages values of specific drainage of 10 - 12 l/sec and km, for the basins with average altitudes of 800 ÷ 900 m, which increases at 18 l/sec and km at an average altitude of 1250 m. [6]

Regarding the flora and fauna there are known no species protected by law that populate the area around the Aries River and its tributaries.

2. ACTIVITIES ON SITE

2.1. The working technology in the quarry

Geological reserves of copper ore at Rosia Poieni deposit were approved as exploitable by quarrying at a limit of 0.2 % copper content. They are located above the elevation of +550 m, respectively +760 m, depending on the quarry model. Above the elevation of +550 m the deposit is suitable for quarrying the ore having an average of 0.3 % copper content and below this elevation by underground operation (the average copper content is of 0.4 %). [2]

Quarry activity comprises: drilling the blasting holes, blasting with explosives, uploading the material with electric excavators, transporting the material with trucks.

The overall slope angle of the quarry is of 40°. The minimum gap between works fronts located on the same level is 60 m, and the gap between work fronts located on successive steps at a minimum of 100 m. In accordance with the quarry model approved in the documentation necessary to obtain the operating license, the quarry's geometry is as follows: general slope for a stability coefficient of 1.19 - 1.64 - 40°, the maximum surface elevation - 1210 m elevation at the base of the steps (sterile from opening works) at Ruginiş massive - 985 m, at Curmătura massive - 1030 m and at Melciului massive - 1030 m; elevation at the base of the steps (sterile from preparation works) - 925 m; average height of steps - 15 m; step width - 20 m; elevation at the base of the quarry - 880 m; depth of the quarry - 300 m; number of steps in the quarry – 24; single step slope angle - 70-75; quarry' opening at the surface - 1500 m; quarry's opening at the base - 80 m; line shape of the steps – arc. [4]

The displaced material after blasting, is loaded with excavators EKG-type, with bucket capacity of 5 m^3 and 8 m^3, in high capacity trucks type Belaz of 27 and 40 tones or DAC of 55 and 110 tones and Komatzu of 92 tones, and is transported as follows:

- ***the ore*** containing more than 0.2% Cu is directed to the primary crushing station at Dealul Piciorului processing plant equipped with a gyratory crusher KKD 1500/180 and located in Fountains Valley.
- ***the waste material*** (from the quarry) containing less than 0.2% Cu, is transported to dumps located outside the perimeter of Rosia Poieni quarry, namely: Cuibarului and Geamăna waste dumps. When exploiting the upper steps of the quarry Obârşia Muntari waste dump may be used.

2.2. The working technology in the processing plant

He processing plant is located to the northwest of the quarry, at a distance of about 2 km. The plant has four identical production lines, whose designed capacity is of 7500 tons/day, and the certified one is of 5250 tons/day and line. [2]

The main technological operations in the processing plant are:

- primary crushing, is done in the gyratory crusher;
- transport of the crushed ore on the main conveyors (1400 mm width) to the processing plant on a total length of 2.432 km;
- two-stage ore grinding (semi - autogenous mill 8500 ÷ 3800 mm and ball mill 5200 x 8000 mm) and its classification in hydrocyclones batteries of D = 500 mm and D = 700 mm ;
- sequence - selective flotation of the copper ore to obtain a concentrate with min. 16.5 % copper content;

- thickening the concentrate in thickeners with D = 25 m, filtration in press or vacuum filters and storage of copper concentrates;

- thickening the flotation sterile in thickeners with D = 80 m, gravitational transport of the flotation sterile by pipelines with D = 600 mm on approx. 7.5 km to Şesei Valley tailing pond and, in case of malfunctions, to Ştefancei Valley II tailing pond;

- storage of flotation sterile in Şesei Valley tailing pond or in case of malfunctions in Ştefancei Valley II tailing pond with the discharge of clarified water into natural water courses.

The technological flux from Rosia Poieni is shown in Figure 2.

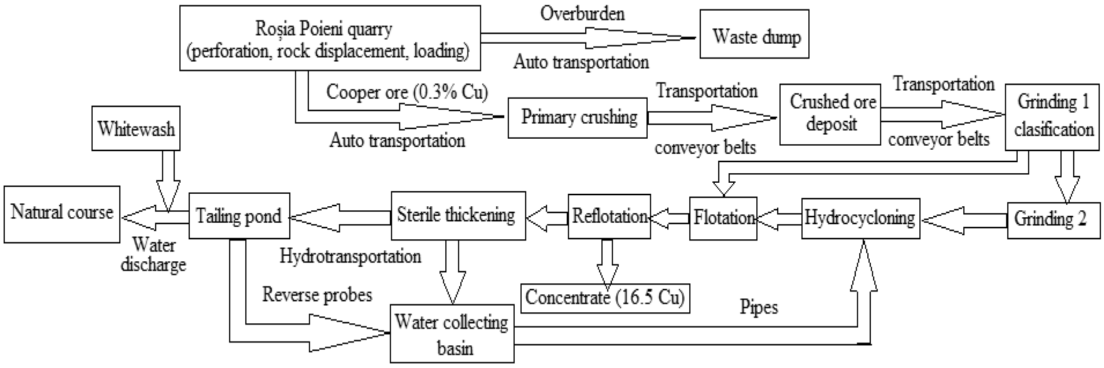


Fig. 2. Technological flux

Mining product of the company is a copper concentrate which also contains other useful elements such as: gold, silver and sulfur.

2.3. Depositing the waste from the overburden

The waste dumps were constructed under the execution projects carried out by specialized designers and in compliance with the relevant legislation of the period. They are located in the vicinity of the quarry, thus: on the NE side Geamăna waste dump, on the SE side Cuibarului Valley waste dump and on the SW side Obârşia Muntari waste dump. The waste rocks resulting from the stripping of the copper deposit is stored in Geamăna and Cuibarului Valley waste dumps. Obârşia Muntari waste dump will be used only if the production capacity extends.

Cuibarului Valley waste dump - is the most important waste dump from the mining site. It has a footprint of 64 ha and a stored volume of approx. 44.7 million m^3 of waste rocks. It is located on the eastern slopes of Ruginiş and Curmătura massifs, on one side and the other of the tranche. The waste dump comprises of nine steps in Curmătura massive - 1180 m, 1165 m, 1150 m , 1135 m , 1120 m, 1105 m, 1075m , 1060 m and 1045 m, each of them is located at the eastern end of the sterile step in the massif and three dumping steps in Ruginiş massive - 1090 m, 1075 m and 1060 m. [4]

The height of the dumps end step ranges between 100-250 m , and the slope angle is in the range of 30-50° . According to data from the geotechnical studies relating to the stability of the dumps, in which the strength characteristics of the rock were determined, for these heights, the stability angle is 28°. Since the deformation and settlement processes - stabilization of the dumps unfolds in time, their operation will be carried out by dividing the deposit in sectors, so that some areas are for dumping and others for stabilization.

Geamăna waste dump - is located on the eastern slope of the Jgheabului hill and has the dumping platform at an elevation of +996 m.

The total area of the site is 100 ha, currently occupied 20 ha, and in the dump are stored approx. 5.5 million m^3 of waste rocks.

Dump's height is 150 m and the slope angle is of 30°.

Obârşia Muntari dump - is located on the southern slopes of Vârşii Mici and Curmătura massifs, the dumping platform is at an elevation of 1170 m and is designed to occupy a surface of 46 ha. In this dump are deposited 5.3 million m^3, which effectively occupies an area of 27 ha. Dump's height is 120 m and the overall slope angle is of 30°. Currently, this dump is conserved.

2.4. Flotation tailings storage

Flotation tailings resulting from the activity of copper ore concentration in the processing plant Dealul Piciorului, after it is thickened, is hydraulically transported to Şesei Valley tailing pond (or in case of malfunctions to Ştefancei Valley II tailing pond).

The tailing ponds are located downstream of the processing plant, to the east Şesei Valley pond and to the north Ştefancei Valley I and II ponds. The ponds are provided with all hydrotechnic works needed for their safe operation. [2, 4]

Table 1 presents the current situation of the tailing ponds.

Table 1. ***Surfaces and volumes occupied/designed - 2011***

Crt. no.	Tailing pond	Designed surface (ha)	Occupied surface (ha)	Designed volume (m^3)	Occupied volume (m^3)	Elevations in 2011 (m)
1	Ştefancei Valley I	26	11.5	5400000	2100000	Dam: 730 Tailing: 728
2	Ştefancei Valley II	50	12.5	11000000	1650000	Dam: 638 Tailing: 633
3	Şesei Valley	221	153	66000000	35850000	Dam: 695 Tailing: 693.5
4	TOTAL	297	177	82400000	39600000	-

Şesei Valley tailing pond - tailings resulting from the processing activities is stored in this pond which is located in the Lupşa village, on Şesei Valley.

It is a valley pond, located on a creek with a retention area of 23 km^2, who's waters enters the pond on several valleys of which the most important are: Vința, Geamăna, Holhorii, Steregoi, Cărbunari.

The pond is made of a limestone rockfill dam with filtering mask on the upstream slope, located in a narrow area of Şesei Valley downstream of Carbunarilor Valley. The limestone rockfill dam is constructed at 3.2 km from the point of confluence between Şesei Valley creek and the river Arieş. Tailings dam is built between 610 ÷ 695 m elevations of limestone rockfill constituting the resistance elements of dam.

Ştafancei Valley I tailing pond – malfunction pond Ştefancei Valley I - inoperative - was removed from service in february 1993. It is located on the territory of Bistra and Lupşa villages, on Ştefancei Valley creek, with the dam located about 3 km from the confluence with the river Arieş. The pond functioned as an experimental one until 1986 and sporadically thereafter.

The pond's components are: main dam – constructed with rockfill, with upstream filtering mask, approx. 25 m high; a low height dam that delimits the deposition of coarse tailings downstream of the main dam and the system projected to evacuate the excess water, composed of a metal pipe with a diameter of 1400 mm embedded in the concrete in the upstream portion, and a diameter of 1600 mm in the downstream portion, with ramifications of 600-1000 mm diameter on the slopes. The ramifications on the slopes are equipped with reverse wells with a discharge elevation situated 1 m above the inferior one. There is a large water discharge channel, built after the damage of the initial drainage system.

Ştefancei Valley II tailing pond – is a reserve pond and is located on Stefanca creek, downstream of Ştefancei Valley I pond. It is designed to operate throughout the lifetime of the Delul Piciorului processing plant as a reserve pond, taking tailings for short periods, in case of short-term damage to the transportation system towards Şesei Valley tailing pond. Also, it collect all the water drained accidentally or due to malfunctioning of the processing installation, including on-site rainwater, because all spillage naturally moves to Ştefancei Valley.

2.5. Wastewater treatment

Wastewaters resulting from the processing of the copper ore by flotation and rainwater that washes the quarry and the dumps are routed to settling ponds. Normally the clarified water should pass through a treatment plant before being discharged into natural water courses (the Arieş river). For the objective studied in this paper there isn't such a treatment plant. The only solution currently adopted to reduce to some extent the impact of these waters discharge into the Arieş river is their neutralization with whitewash.

In these circumstances it may speak of direct discharge of clarified water from the ponds into natural water courses, with a drainage system only for clarified water from ponds. Drainage facilities are: [2, 4]

- reverse probes for Ştefancei Valley I pond - water is discharged in Ştefancei Valley II pond, Ştefancei Valley creek and then into Aries river;

- coastal spillway and waters gallery Ştefancei Valley II pond - from here in Ştefancei Valley creek and then in Aries river;

- coastal spillway, reverse probe and waters gallery for Şesei Valley pond – from here in Şesei Valley creek and then in Aries river;

From Geamăna and Cuibarului dumps, rainwater crosses the dumps, they get acidified and mineralized due to the natural phenomenon of bacterial leaching in dumps and leaks, flowing by gravity to pond downstream, namely Şesei Valley pond. Here, after a preliminary neutralization, demineralization and substantial dilution the waters reach the Şesei Valley creek and then the Aries river.

From dump Obârşia Muntari, the rainwater, acidified and mineralized leaks from the dump, flows by gravity to Bucium creek, which reaches Abrudel creek and then the Aries river.

3. POLLUTION ON SITE

Pollution of air and soil is negligible; however a particular problem is water pollution in Şesei Valley area. Due to the natural onset of bacterial leaching phenomenon inside the dumps situated upstream of the pond, there was an increased pollution of the water downstream. Thus, the acidified and mineralized waters drained from the waste dumps reach Şesei Valley pond, where they are neutralized and partially demineralized by the sterile slurry with a pH of 10 - 12, that comes gravitationally from the Dealul Piciorului processing plant.

Table 2 presents data on the quality of water discharged from the Şesei Valley tailing pond (annual averages) and their pollutants loading limit values under the Water Management Permit (WMP) no. 180/16.10.2009, revised in 28.02.2011 (included in approval no. 1539/2011 of exceedance of GD no. 188/2002 with subsequent amendments). [4]

Table 2. ***Quality parameters of the water discharged during 2009 - 2011***

Parameter	Annual medium values			Limit values in cf. W.M.P 180/2009 revised in 2011
	2009	2010	2011	
pH (unit pH)	4.74	4.54	5.23	4.7 – 8.5
Suspensions (mg/l)	86.44	91.5	83.4	100
Fixed residue (mg/l)	2127.41	1702.69	1309.46	2000
Cu (mg/l)	8.0	7.34	4.63	7
Fe (mg/l)	1.81	23.39	11.85	30
Zn (mg/l)	4.38	3.59	2.61	3.5
Mn (mg/l)	6.38	3.48	2.8	4
Flotation reactive (mg/l)	absence	absence	absence	absence
Medium evacuated flow (m^3/s)	0.129	0.321	0.218	-

The terrains downstream the Geamăna and Cuibarului dumps are affected by alluvial material brought by heavy rains from the dumps, but is mentioned that this terrains belongs to the areas expropriated for those dumps, that have not been occupied so far only in a proportion of 20 - 50%.

By stabilizing the dumps upstream of Şesei Valley pond, by providing a sufficient quantity of whitewash to neutralize and demineralize the acid water upstream the pond, the natural process of bacterial leaching in the dumps can be controlled so as to avoid some special problems such as landslides from Cuibarului and Geamăna dumps; the bacterial leaching process in Şesei Valley pond where pyrite is deposited in the flotation tailings and continuous and gradual pollution of the Şesei Valley creek and Aries river.

4. IDENTIFICATION AND ASSESSMENT OF THE RISK

There are a range of different methodologies for assessing the risk associated with specific activities conducted at the studied objective, both quantitative and qualitative. The risk is the probability of occurrence of a negative effect on a given period of time and can be output in the form of the equation:

$$\text{Risk} = \text{Hazard} \times \text{Exposure}$$

Risk assessment involves an estimation (including hazard identification, size of the effects and the probability of an event) and the calculation of risk (including quantifying the importance of the hazards and consequences for individuals and/or affected environment. [7]

The degree of risk depends on the nature of the impact on the receiver and the probability of this impact to occur.

Calculation/quantification of the risk can be based on a simple system of classification where the probability and severity of an event is classified descending, randomly assigning them a score.

Classification of the probability	Classification of the severity
3 = high	3 = major
2 = average	2 = average
1 = small	1 = minor

The risk may then be calculated by multiplying the probability factor with the gravity one to obtain a comparative number, such as 3 (high) X 2 (average) = 6. This will allow comparisons between different risks. The greater the result is the higher the priority that must be given to control the risk. [7]

Source and nature of pollutants

Following the generation of acid mine waters results a liquid effluent with the following characteristics:

- liquid aggregation state;
- pollutants contained: iron salts, manganese salts, calcium salts, sulfate ion, heavy metals, total dissolved salts (global highlighted by TDS and conductivity);
- the pollutant chemical agents mentioned, being soluble, are highly mobile. Due to the existing crystalline foundation under the entire surface of the deposit and the surrounding areas, their mobility in the area is limited only horizontally, but not in depth.

Salts of heavy metals accumulated in excess in the soil, are toxic both for flora and for ground microfauna. Under aerobic conditions, by oxidation under the action of air, iron and manganese ions oxidize and precipitate. By consuming the plants grown on these soils, the heavy metals in the soil can reach animals and humans.

Heavy metals remain unoxidized in the groundwater due to anaerobic conditions. Following the flow of groundwater, heavy metal ions are diluted and dispersed on very large surfaces. Sulfate ion affects building foundations by the concrete swelling phenomenon.

Acidic surface waters are dangerous to aquatic flora and fauna and water consumers.

Hazard nature

• materials present in the leaks of acid mine waters are especially dangerous for aquatic flora and fauna as well as for terrestrial flora and fauna (groundwater);

• due to the high concentration of ionic salts, namely high electrical conductivity, waters are corrosive to metals;

• gaseous products formed by these processes can be released into the air, causing odors (hydrogen sulfide).

Targets/Receivers

• underground water, in which case is recorded an increase in the concentration of heavy metals and sulfate ion from upstream to downstream in relation to their the outflow direction;

• human receptors by using water from boreholes for drinking, washing or cooking;

• domesticated animals can become ill due to consumption of water or plants contaminated with pollutants accumulate in the soil.

Paths

• migration of pollutants through the hydrographic network in big water courses, including across the border;

• migration of pollutants through the upper soil layers in swamps and to a lesser extent to agricultural terrains;

• transmission by air of gases formed in the process of acid mine waters generation as well as ore particles engaged by air currents.

Pollutants transmission paths can be blocked by the existing crystalline bedrock under the entire surface of the deposit and by vegetation that greatly limits the dispersion in the air of particles containing heavy metals.

Risk assessment

Given the type of activities analyzed on the site and the vulnerability of ecosystems present in the area, in terms of soil, groundwater and surface water contamination risk with heavy metals for the probability of occurrence of undesirable events was given the value 3, and exposure a value of 2.

$$R = 3 \times 2 = 6$$

In conclusion, the deposits analyzed pose a moderate risk to the environment.

5. IDENTIFICATION AND ASSESSMENT OF THE IMPACT

Procedure for environmental impact assessment is defined by law as a process meant to identify, describe and determine, depending on each case and in accordance with the law, the direct and indirect, synergistic, cumulative, primary and secondary effects of a project on human health and the environment. [3]

The step of identifying the impacts consists of a series of identification operations of the certain or probable interactions between the basic actions of the project and the environmental components characteristic for the reference area.

Before this operation the elementary actions of the project are decomposed and selected as well as the significant environmental elements for the reference area, which are the subject of operative steps described before.

5.1. The impact matrix method

Matrixes consist of double-entry tables, in which on the lines are entered environmental components and factors involved, divided and grouped into categories, and on the columns are entered the elementary actions of the project. Each intersection of the matrix represents a potential impact relationship between the project actions and environmental factors. [1]

In this paper work it is used a matrix system which follows a logical path of analysis that leads to a summarized scheme, in four or more passages of decomposition or causal relations (method similar to the method of coaxial matrixes), connecting elements generating impact (causal factors) to environmental systems, to the areal typology in which the objective of the study is placed and potential environmental interactions.

There may be assigned various causal factors to each on-site activity. It is possible to build a matrix whose lines is a list of activities or actions considered relevant and the columns a list of possible individual causal factors.

The existence of a relationship between a relevant activity and a causal factor is emphasized by placing in the cell at the intersection of the line representing the project with the column corresponding to the causal factor. This intersection can be marked in different ways according to the relevance of the represented relationship, and it can be considered certain (3), probable (2), uncertain or unlikely (1) or absent.

For the activity of the quarry and the processing plant it can be constructed matrix presented in Table 3.

At this point it can be introduced a third dimension of the problem, consisting of environmental components. In fact, it can be individualized a possible causal relationship between the causal factors, already defined, and the various environmental components, reflected also by a matrix B (predefined).

For each project, from matrixes A and B it can be obtain a third matrix, C, which has the same dimensions as matrix B (lines: environmental components, columns: causal factors), but whose cells contain a combination of the probability contained in the corresponding cell from matrix B with the probability contained in the line corresponding to the analyzed project from matrix A.

Table 3. ***The association between the activity list and the list of causal factors (matrix A)***

	Causal factors									
Activities	Macropollutants emissions	Micropollutants emissions	Radioactive emissions	Noise emissions	Water consumption	Wastewater discharge	Surfaces flooding	Soil occupation	Soil waterproofing	Auto traffic
Quarrying	3	1		3		2		3		3
Processing	3	3		2	3	3		3	2	2

To define associations between matrixes interactions the following rules shall be respected: 3*3→3; 2*3→3; 2*2→2; 2*1→1; 3*1→2; 1*1→1; absent*absent or 1 or 2 or 3→absent.

It is possible to define a matrix D, whose columns are types of areas (where the project is located) and lines are environmental components. The matrix is completed with the vulnerability (certain probable unlikely or absent) customized for different types of areas (columns) and environmental components (lines). For the objectives analyzed in this study was chosen the mountainous areal typology.

The combination between matrix C and matrix D is a matrix E, whose columns and lines are the causal factors and environmental components. The cells of the matrix contain an indication of the probability of the existence of the impact on the environment (Table 4).

The last line respectively column sums up the values resulting from multiple combinations of matrixes, and depending on the amounts earned in each row and column it can be appreciated which of the environmental factors will be most affected and which of the specific actions of the project will generate the most severe impacts.

If we analyze the data in Table 4 the following conclusions can be drawn:

- total scores indicate that the activity in the Dealul Piciorului processing plant has a greater potential to exert a significant impact on the environment in the study area;
- because of the exploitation of copper ore in Roșia Poieni quarry, the environmental components on which the most significant impact will be manifested are: fauna (18), flora (12) and landscape (12);
- the specific actions carried out in the quarry, those that will generate the most significant impacts are: wastewater discharge (18) macropollutants emissions (12) and soil occupation (12);
- because of the activity of copper ore preparation in Dealul Piciorului processing plant the environmental components on which the most significant impact will be manifested are: fauna (21), flora (15), surface water (15) and landscape (15);

Table 4. ***Interaction between matrix C and matrix D „mountainous areas" (matrix E)***

	Causal factors										
Environmental components	Macropollutants emissions	Micropollutants emissions	Radioactive emissions	Noise emissions	Water consumption	Wastewater discharge	Surfaces flooding	Soil occupation	Soil waterproofing	Auto traffic	**TOTAL**
Air quality											
Microclimate											
Surface waters	3 (3)	2 (3)			(3)	3 (3)			(3)		8 (15)
Underground waters					(3)	3 (3)			(3)		3 (9)
Fauna	3 (3)	3 (3)		3 (3)	(3)	3 (3)		3 (3)		3 (3)	18 (21)
Flora	3 (3)	3 (3)			(3)	3 (3)		3 (3)			12 (15)
Ecosystems											
Soil						3 (3)		3 (3)	(3)		6 (9)
Lithosphere					(3)						(3)
Noise level											
Radiation											
Landscape	3 (3)				(3)	3 (3)		3 (3)		3 (3)	12 (15)
Risk											
Mobility											
Resources availability											
Socio-economic ambient											
TOTAL	12 (12)	8 (9)		3 (3)	(18)	18 (18)		12 (12)	(9)	6 (6)	59 (87)

Values without brackets are for quarrying and values in the brackets are for processing

- of the specific activities in the processing plant those which will generate the most significant impacts are: water consumption (18), wastewater discharge (18) macropollutants emissions (12) and soil occupation (12).

5.2. Impact networks

They are composed of flux diagrams or chains of multiple relationships that interrelate project actions with environmental components likely to suffer changes. In order to identify the complex of impacts of an activity, the impact networks reconstruct chains of events, or potential effects, induced by specific actions of the project on the initial environmental conditions, potential changes in ambient conditions, multiple effects of impacts and possible corrective interventions that may be propose. [1, 3]

Since it would be almost impossible to build a single impact network encompassing the two main activities conducted at the studied site (cooper ore exploitation at Roşia Poieni quarry and preparation at Dealul Piciorului processing plant) there will be built two such networks for each activity (figures 3 and 4).

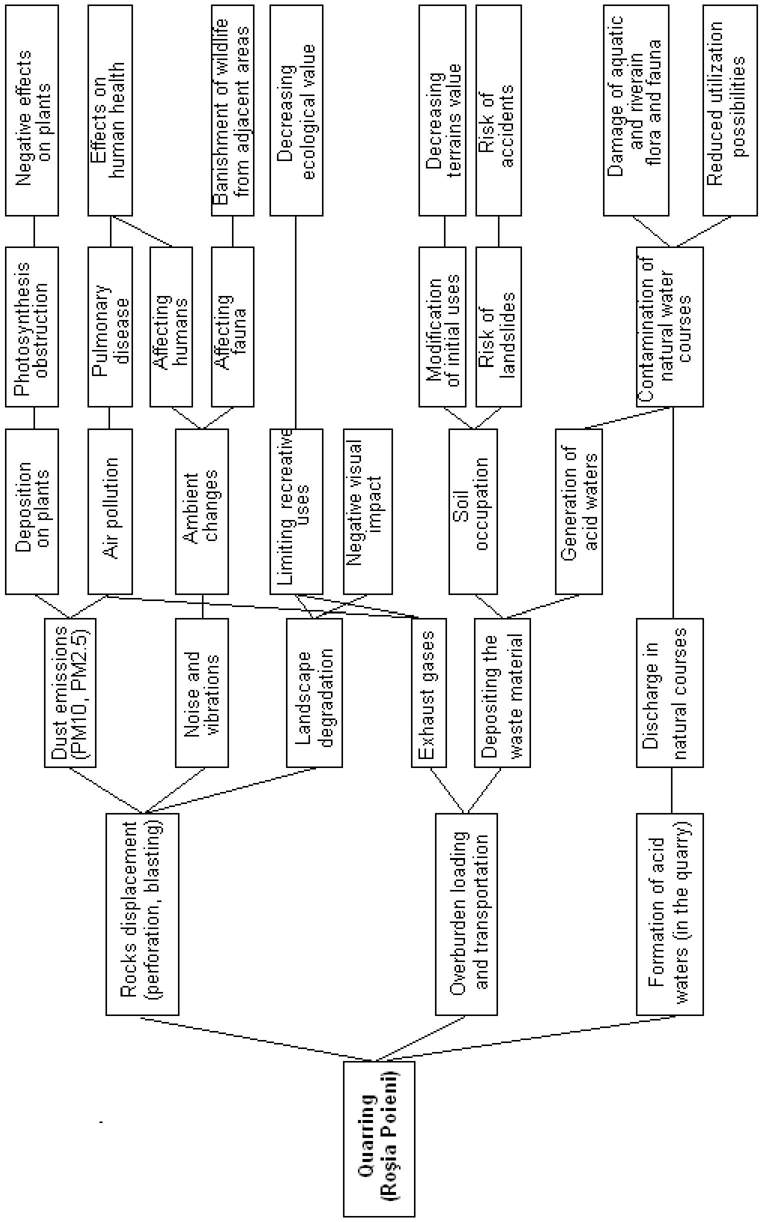


Fig. 3. Impact network for quarrying activities (in Roşia Poieni quarry)

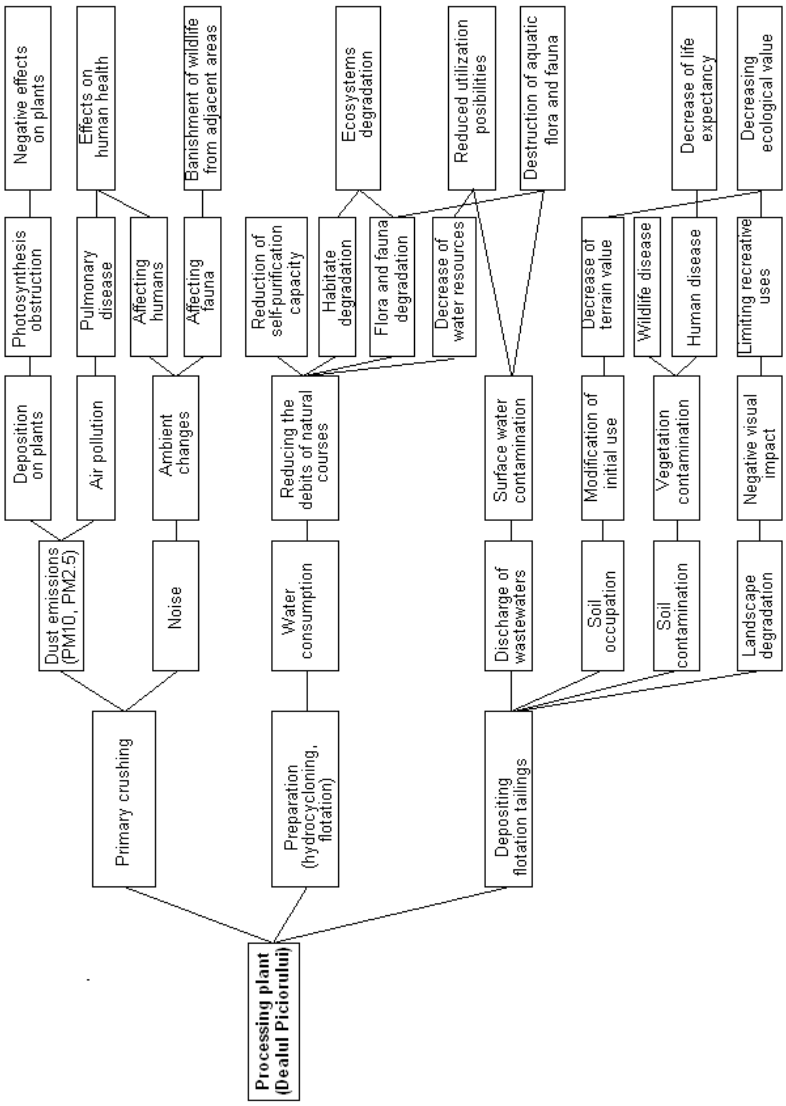


Fig. 4. Impact network for preparation activities (Dealul Piciorului processing plant)

CONCLUSIONS

The activities conducted in the studied area are the exploitation of the poor copper ore in Roşia Poieni quarry and the obtaining of a metallurgical concentrate by applying the sequence - selective flotation process in Dealul Piciorului processing plant. The sterile from te overburden is deposited in Cuibarului Valley waste dump, the other dumps (Geamăna and Obârşia Muntari) will be used in the event of expansion of the operating capacity of the quarry. Flotation tailings are transported hydraulically, gravitationally to the Şesei Valley tailing pond, the other ponds (Ştefancei Valley I and II) being used only in case of emergency . Currently, there isn't an actual station for wastewaters treatment. For the wastewaters discharged from the Şesei Valley pond the only action taken for depollution is the application of lime solution (whitewash). However data on the quality of waters discharged in natural water courses in 2011 (the Aries river) shows that they are, from the permissible concentration point of view, within the limits legally set by WMP.

By applying the risk assessment methodology provided by Order 184/1997 it can be concluded that the waste deposits (waste dumps and tailings ponds) studied pose a moderate risk to the environment.

By following the procedure of environmental impact assessment it was found that activity in the Dealul Piciorului processing plant has a greater potential to exert a significant impact on the environment in the studied area on flora, fauna, surface water and landscape; impact generated especially by water consumption, wastewater discharges, macropollutants emissions and occupation of soil. Regarding the quarrying activity, it has a significant impact on flora, fauna, surface water and landscape; impact due to wastewater discharges, macropollutants emissions and occupation of soil

Although in applying both the matrix method and network method, the two main activities were treated separately, it should be taken into account that the two activities are closely connected, and so there is a high probability that between the impacts resulting from two activities to exist interactions (cumulative, synergistic, antagonistic or neutralization of the effects manifested in time and space on the environment and human health).

REFERENCES

[1]. Lazăr M., Dumitrescu I., *Impactul antropic asupra mediului*, Editura Universitas, Petroşani, 2006.

[2]. Lazăr M., Rotunjanu I., Dumitrescu I., Traistă E., Georgescu M., Faur F., *Impactul de mediu al activităţilor desfăşurate în obiectivul Roşia Poieni asupra zonelor învecinate şi a comunităţilor locale*, Contract de cercetare nr. 3892/03.10.2008, Universitatea din Petroşani, 2008-2009.

[3]. Lazăr M., Faur F., *Identificarea şi evaluarea impactului antropic asupra mediului*, Îndrumător de proiect, Petroşani, 2011.

[4]. Lazăr M., Traistă E., Dunca E., Faur F., Kovacs L., *Raport de amplasament pentru depozitele de steril aparţinând S.C. Cupru Min. S.A. Abrud*, Contract de cercetare nr. 18/23.11.2011, Universitatea din Petroşani, 2011.

[5]. SC IPROMIN SA, *Bilanţ de mediu nivel 2 la obiectivul minier Roşia Poieni,* 1999.

[6]. SC OCON SRL, *Bilanţuri de mediu în vederea privatizării pentru obiectivul Roşia Poieni*, 2008.

[7]. *,** *Ordinul 184/21 septembrie 1997 – Pentru aprobarea procedurii de realizare a bilanţurilor de mediu*, Ministerul Apelor, Pădurilor şi Protecţiei Mediului, publicat în Monitorul Ooficial nr. 303 bis din 6 noiembrie 1997.

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

RISK OF ACID RAIN PRODUCTION, DUE TO THE EMISSIONS GENERATED BY THE THERMAL POWER PLANT PAROŞENI

**MARIA LAZĂR*
VLAD VIRGIL SANDU****

Abstract. *Production risk may occur due to the conduct of certain human activities, with a potential risk, and it includes thermal power plants that run on fossil fuel. Any risk is the result of hazard and exposure, the present paper being aimed at analyzing the hazards (gas emissions that generate acid rain) and the exposure (vulnerability) of the environmental factors (the consequences of that acid rain production on the environment).*

Key words: *acid rain; power plant; emissions; risk assessment; environment*

1. APPROACHING THE ENVIRONMENTAL RISKS

Risks depend on the magnitude of the impact generated by pollution and become significant with exceeding pollution limits beyond which the risk factor affects the value of ecosystems and the human factor /1/. Thus, we can highlight two aspects of risk:

- Risks that produce short-term effects are felt particularly in the ecosystem, requiring pollution mitigation measures to protect the ecosystems. This category includes the expected risks assumed by man.
- Risks that produce long-term effects generated by major changes over a long period of time very large, effects that are difficult to predict. Due to the complexity of estimating these risks, they perceived are insufficient or distorted, the behavior of decision makers often depends on their power to think ahead. These risks involve strategies, policies, instruments and funding, in other words, a joint effort of all individuals in the human ecosystem.

Any risk can be defined as the probability of an adverse effect to a certain period of time, which allows for its expression in the form of:

$$\text{Risk} = \text{Hazard x Exposure} \quad (1)$$

Risk assessment has the purpose of controlling possible risks due to the conduct of human activities by identifying the following:

---

* *Prof. PhD. Eng. at the University of Petrosani, email: lazar@upet.ro*
** *MA student Eng. at the University of Petroșni, email: sandu_vlad_virgil@yahoo.com*

- the most important pollutants or hazards;
- the resources and receptors exposed to the risk;
- mechanisms through which the risks take place;
- important risks that are likely to take place;
- general measures necessary to reduce the risk to an acceptable level.

2. FORMATION AND EFFECTS OF ACID RAIN ON THE ENVIRONMENT

2.1. The mechanism of acid rain formation

Sulphur dioxide and nitrogen oxides present a significant risk, because once released into the atmosphere have the ability to produce a number of negative effects over the environment of which the most important may be their ability to produce acid rain that has a negative effect not only on flora and fauna present in the affected area, but also to the structures present in the area where they form. /2, 3/.

The acidity of the precipitation depends not only on the level of emissions, but also mixtures of chemicals which interact with the SO2 and NOx in the atmosphere. Formation of sulfuric acid and nitric acid is a complex process consisting of several chemical reactions. It is important to consider both phases, solution and gas, in the conversion process.

One possibility is photooxidation of sulfur dioxide by ultraviolet light. Light from this region of the electromagnetic spectrum has the potential to excite molecules and lead to subsequent excitation of O_2. This reaction has a negligible contribution to the formation of sulfuric acid. A second possibility is the reaction of sulfur dioxide with oxygen in the atmosphere, through the following reactions:

$$2SO_2 + O_2 \rightarrow 2SO_3 \qquad (2)$$

$$SO_3 + H_2O \rightarrow H_2SO_4 \qquad (3)$$

The second reaction occurs rapidly, and therefore the formation of sulfur trioxide in a humidified atmosphere leads to the formation of sulfuric acid. Anyway first reaction is very slow in the absence of a catalyst, although it does not have a significant contribution. There are also several other potential reactions but for different reasons prove to be insignificant. Although each of these effects may contribute to the oxidation of sulfur dioxide, there is only one significant reaction. The reaction occurs thus:

$$HO + SO_2(+M) \rightarrow HOSO_2(+M) \qquad (4)$$

In the solution phase sulfur dioxide exist in three forms:

$$[S(IV)] = [SO_2(sol)] + [HSO_3] + [SO_3] \quad (5)$$

This dissociation occurs through two processes:

$$SO_2(sol) = H + HSO_3 \quad (6)$$

$$HSO_3(sol) = H + SO_3 \quad (7)$$

The establishment of balance depends on factors such as pH, droplet size, etc.

Solution of sulfur dioxide oxidation with molecular oxygen is based on a metal catalyst such as Fe or Mn, or a combination of these. Oxidation through ozone is a more considerable because it does not require a catalyst and is more abundant in the atmosphere than molecular oxygen.

The oxidation process is dominated by hydrogen peroxide (formed in the gas phase with free-radicals). The reaction involves the formation of an intermediate (A), possibly an acid peroximonosulfuros ion and occurs as follows:

$$HSO_3 + H_2O_2 \rightarrow A + H_2O \quad (8)$$

$$A + H \rightarrow H_2SO_4 \quad (9)$$

Like with the Sulphur dioxide, the most important contribution in forming nitric acid, is the reaction with hydroxyl radicals. These radicals are highly reactive and abundant in the atmosphere. The reaction takes place in the following manner:

$$HO + NO_2(+M) \rightarrow HONO_2(+M) \quad (10)$$

There are several other possibilities, such as oxidation with atmospheric oxygen, however none are produced at a substantial rate in the atmosphere to contribute significantly to the formation of nitric acid.

There are 3 equations to be considered in the oxidation of the NOx solution:

$$2NO_2(g) + H_2O(l) \rightarrow 2H + NO_3 + NO_2 \quad (11)$$

$$NO(g) + NO(g) + H_20(l) \rightarrow 2H + 2NO_2 \quad (12)$$

$$3NO_2(g) + H_20(l) \rightarrow 2H + 2NO_3 + NO(g) \quad (13)$$

These reactions are limited by their dependence on the partial pressure of NO_x present in the atmosphere and NO_x solubility law.

2.2. Sulfur dioxide and nitrogen oxides imissions generated by thermal Paroşeni

Data regarding emissions generated by the power plant Paroşeni during the years 2011 - 2013 were taken from website of the National Environmental Protection

Agency and are presented in table 1. It is noted that continuity exists only in the sulfur dioxide concentration measurements, because for the most part of the analysis period, nitrogen oxides analyzer was defective.

Although the nitrogen oxides analyzer was defective the data can still be used estimate the risk of acid rain nitrogen oxides are within the limits imposed by the by legislation in effect, and they remain in the atmosphere for a longer period of time, being transported by currents air distance from the source of emission.

Table 1 Measurement made at the station HD-5

Month	Pollutant (UM)	Minimum hourly	Average hourly	Maximum hourly	Exceeding
2011					
January	SO_2 (μg/mc)	-	-	-	-
	NO_2 (μg/mc)	1,68	14,88	47,03	-
February	SO_2 (μg/mc)	-	-	-	-
	NO_2 (μg/mc)	3,29	14,15	39,69	-
March	SO_2 (μg/mc)	-	-	-	-
	NO_2 (μg/mc)	1,45	15,39	33,86	-
April	SO_2 (μg/mc)	-	-	-	-
	NO_2 (μg/mc)	3,88	13,98	27,71	-
May	SO_2 (μg/mc)	3,50	*	309,19	-
	NO_2 (μg/mc)	4,72	13,04	26,67	-
June	SO_2 (μg/mc)	3,91	15,58	330,49	-
	NO_2 (μg/mc)	1,1	*	18,66	-
July	SO_2 (μg/mc)	4,73	6,81	27,21	-
	NO_2 (μg/mc)	0,5	6,40	14,09	-
August	SO_2 (μg/mc)	6,04	20,61	567,47	-
	NO_2 (μg/mc)	-	-	-	-
September	SO_2 (μg/mc)	-	-	-	-
	NO_2 (μg/mc)	-	-	-	-
October	SO_2 (μg/mc)	9,32	26,31	368,27	1
	NO_2 (μg/mc)	-	-	-	-
November	SO_2 (μg/mc)	14,76	43,66	380,26	1
	NO_2 (μg/mc)	-	-	-	-
December	SO_2 (μg/mc)	15,38	43,78	271,32	-
	NO_2 (μg/mc)	-	-	-	-
2012					
January	SO_2 (μg/mc)	16,22	37,45	249,02	-
	NO_2 (μg/mc)	-	-	-	-
February	SO_2 (μg/mc)	17,38	47,57	364,06	1
	NO_2 (μg/mc)	-	-	-	-
March	SO_2 (μg/mc)	16,28	35,72	526,73	3
	NO_2 (μg/mc)	-	-	-	-

(continues table 1)

April	SO_2 (µg/mc)	17,79	30,26	345,12	-
	NO_2 (µg/mc)	-	-	-	-
Month	Pollutant (UM)	Minimum hourly	Average hourly	Maximum hourly	Exceeding
May	SO_2 (µg/mc)	17,78	29,43	463,23	2
	NO_2 (µg/mc)	-	-	-	-
June	SO_2 (µg/mc)	17,14	28,36	274,16	-
	NO_2 (µg/mc)	-	-	-	-
July	SO_2 (µg/mc)	18,46	38,23	350,17	1
	NO_2 (µg/mc)	-	-	-	-
August	SO_2 (µg/mc)	14,65	25,82	357,93	1
	NO_2 (µg/mc)	-	-	-	-
September	SO_2 (µg/mc)	18,88	26,19	371,89	1
	NO_2 (µg/mc)	-	-	-	-
October	SO_2 (µg/mc)	21,08	39,29	681,55	4
	NO_2 (µg/mc)	-	-	-	-
November	SO_2 (µg/mc)	4,92	29,57	667,36	8
	NO_2 (µg/mc)	-	-	-	-
December	SO_2 (µg/mc)	4,03	29,89	163,58	-
	NO_2 (µg/mc)	-	-	-	-
2013					
January	SO_2 (µg/mc)	4,61	28,42	184,33	-
	NO_2 (µg/mc)	-	-	-	-
February	SO_2 (µg/mc)	4,32	22,93	272,75	-
	NO_2 (µg/mc)	-	-	-	-
March	SO_2 (µg/mc)	4,06	19,74	345,32	-
	NO_2 (µg/mc)	-	-	-	-
April	SO_2 (µg/mc)	4,32	19,52	397,91	2
	NO_2 (µg/mc)	-	-	-	-
May	SO_2 (µg/mc)	2,75	15,48	336,29	-
	NO_2 (µg/mc)	-	-	-	-

The excess emissions are analyzed in relation to the standards provided by the regulations in effect (Law. 104/2011).

2.3 Acid rain effects of on the environment

Effects on the atmosphere

Besides their ability to produce acid rain these pollutants, can exist as particles in the air and contribute to the formation of fog affecting visibility. This makes travel difficult, especially for pilots.

Effects on architecture

Acid particles are also deposited on buildings and statues, causing corrosion. For example, the building of the capitol building of Ottawa was disintegrated due to excess sulfur dioxide in the atmosphere.

Limestone and marble turns into a powdery substance called gypsum upon contact with the acid, which explains the corrosion of buildings and statues. Bridges corrode faster, and road and airline industry must invest more money in repairing the damage caused by acid rain.

Effects on materials

Acid rain also affects materials such as fabrics. For example, flags are "eaten" by chemicals in acidic precipitation. Books and art objects dating back hundreds of years are also affected.

Ventilation systems of libraries and museums, where they are kept, do not prevent acid particles from entering the buildings therefore the pollutants can reach the objects in question and cause considerable damage.

Effects on trees and soils

One of the most serious impacts of acid precipitation is the one on forests and soils. Major damage occurs when sulfuric acid falls to earth as rain and the nutrients found in soils are removed. Therefore the trees are doomed to die, being deprived of vital nutrients such as calcium and magnesium which are replaced by hydrogen atoms useless that slow photosynthesis. Aluminum also present in the soil is released and this element is toxic to tree roots /2, 3/.

Severe frosts may worsen this situation. With sulfur dioxide, ammonia and ozone present in the air reduces the tree's resistance to low temperatures. Ammonia oxidizes with sulfur dioxide to form ammonium sulfide.

When the ammonium sulphide reaches the ground, it reacts to form sulfuric acid and nitric acid. Such conditions, also stimulates the appearance of fungi and pests. Nitrogen monoxide and nitrogen dioxide are also components of acid rain can force trees to grow, even if they have do not have the necessary nutrients. Therefore trees are often forced to grow in late autumn when they should to prepare for winter.

Effect on lakes and aquatic ecosystems

There are several ways in which acidic chemicals can enter the lakes. Some chemicals exist as dry particles in the air, while others end up in lakes as wet particles such as rain, snow, sleet and fog.

Furthermore lakes can be considered as the 'sinks' of the earth, because of the water that flows in them during rains. Acid rain that falls on the ground also washes nutrients from the soil and carries toxic metals released from the ground into the lakes.

Another way the acids can reach the lakes is in springtime, when the snow melts and the chemicals seep into the earth being carried to rivers and lakes. This causes a drastic change in lake's pH level.

In addition the spring is a vulnerable season of many species being the breeding period for amphibians, fish and insects. Many of these species lay their eggs in water, and the sudden change in pH is dangerous because these acids can cause malformation to the young or could even annihilate an entire species, since they spend most of their life in water.

3. RISK ANALYSIS AND ASSESSMENT OF THE RISK OF ACID RAIN

Environmental risk analysis requires a broader approach, including quantitative and qualitative descriptions of an environmental hazard, potential negative effects, and the risk involved in these effects, and uncertainties related to each aspect.

The analysis and qualitative assessment of environmental risk undergoes three main stages /1/:

- Hazard identification that determines specific causes or particular effect on the environment;
- Exposure - effect assessment, this step determines the relationship between the magnitude of exposure and the probability of an effect on the environment;
- Risk characterization, which describes the nature and magnitude of risk, including the degree of uncertainty, determined by the first three stages.

One of the risks with long term effects is the risk of acid rain due to sulfur dioxide emissions and nitrogen oxides generated by the functioning of power plants, which are found in high concentration in the atmosphere.

Acid rains are related to a number of negative effects, including:

- destruction of vegetation, especially coniferous forests through direct destruction of chlorophyll;
- soil over fertilization, plants growing very quickly, prematurely;
- acidification of lakes, which leads to the loss of fish fauna;
- dissolved calcium and magnesium salts in the soil, thus causing deficiencies in these elements, acidification of soil and plant nutrition deficiencies.

Risk assessment involves identifying the danger and consequences that may occur as a result of the events considered risk sources.

Depending on the importance of the consequences, it will be decided whether or not remedial action is needed.

Risk quantification is based on a simple system of classification, where the probability and severity of an event is considered descending and given a random value.

$$R = H \times E \qquad (14)$$

The matrix proposed for qualitative estimation of risk is shown in Fig. 1 and takes into consideration, on the one hand, the probability of exceeding limit values for emission and immission of sulfur dioxide, on the other hand, the severity of the effects of acid rain on the environment affected.

Data obtained through monitoring emissions were statistically processed and determined a probability of exceeding the limits provided by legislation by 31.42%, corresponding to a medium exposure, which is assigned the value 3.

Acid rains can cause a significant impact on soil, water and biota in the area of influence and, therefore, the hazard was assessed as high, which is assigned a value 4.

Hazard / Exposure	**Very low 1**	**Low 2**	**Medium 3**	**High 4**	**Very high 5**
Very high (90-100%) 5	**5**	**10**	**15**	**20**	**25**
High (70-90%) 4	**4**	**8**	**12**	**16**	**20**
Medium (30-70%) 3	**3**	**6**	**9**	**12**	**15**
Low (10-30%) 2	**2**	**4**	**6**	**8**	**10**
Very low (0-10%) 1	**1**	**2**	**3**	**4**	**5**

1 – 5	**5 – 12**	**15 – 25**
Low risk	**Medium risk**	**High risk**

Fig. 1 Risk assessment matrix

$$R = E \times H = 3 \times 4 = 12 \quad (15)$$

According matrix designed for qualitative assessment, the risk of acid rain in the influence area has an average level, which means that it is very likely that such precipitation could occur and affect the environment.

4. CONCLUSIONS

Due to the location and mode of operation of the power plant Paroşeni, there is a risk of sulfur dioxide and nitrogen oxides being released into the atmosphere as a result of the combustion of fossil fuels that may lead to the formation of acids by chemical reactions described in the paper.

Either through dry deposition or acid rain, all environmental factors in the emissions dispersion area can be affected more or less serious depending on their vulnerability.

The qualitative risk assessment matrix was built starting from emissions and from vulnerability of the environmental factors found in Jiu Valley basin, which shows that the occurrence of acid rain and their effects in the studied area is possible and very likely.

REFERENCES

[1]. Gavrilescu Maria - *Estimation and Risk Management*, Second edition. Ecozone Iași, 2006.
[**2]. Lazăr Maria, Dumitrescu Ioan** - *Antropic impact on the environment*. Publisher Universitas, Petroșani 2006.
[3]. Lazăr Maria, Faur Florin - *Identification and assessment of antropic impact on the environment*. Publisher Universitas, Petroșani 2011.
[4]. Ozunu Alexandru, Anghel Călin - *Technological risk assessment and environmental security*. Publisher: Accent Publishing House, Cluj-Napoca, 2007.
[5]. Ozunu Alexandru - *Hazard şi risc în industrii poluante*. Publisher: Accent Publishing House, Cluj-Napoca, 2000.
[6]. INCD – ECOIND - *Report Location S.E Paroseni*, Bucuresti, 2010.
[7]. www. http://apmhd.anpm.ro/

Scientific Reviewers:
Prof. Ph.D. Eng. Romulus-Iosif SÂRBU

TECHNOLOGICAL OPTION FOR THE RECOVERY OF THE COAL FRACTION FROM FLOTATION TAILINGS STORED IN PONDS

CĂTĂLIN VRÂNCEANU[*]
DIANA MARCHIŞ[**]
ROMULUS SÂRBU[***]

Abstract: *After processing coal by hydrogravitational and flotation methods, there were released considerable amounts of tailings, generally under 3 mm, with a 30 percent content of coal fraction. These were stockpiled in ponds and were considered secondary sources of solid fuel. The technology for the recovery of the coal fraction from flotation tailings stored in ponds consists in the combination of attrition-sizing, primary concentration in centrifugal field in a special apparatus called centrifugal concentration apparatus connected at the overflow with a conventional hydrocyclones battery, obtaining in the downflow a coal-bearing product, which is drained through screening, and the overflow of the cleaning hydrocyclones, with a considerable content of argillaceous fraction is drained through centrifugation. The waste waters are totally recirculated in the installation and in order to obtain the right dilution, to sprinkle the riddles and to cool off the installation there is used technological water. The argillaceous tailing is deposited in authorized landfills. This technology has the advantage that, on one hand it helps discharging the ponds in order to be used for their primary purpose and on the other hand permits the exploitation of a secondary energy source.*

Key words: *tailings, coal, hydrocyclones, secondary energy source*

1. INTRODUCTION

This paper is about a technology and a processing plant used for sterile raw tailings with a variable content of coal fraction. The raw sterile tailings are stock-piled in ponds that contain millions of cubic meters of tailing and extend for tens of hectares. The purpose of processing these tailings in centrifugal field in a special apparatus called centrifugal concentration apparatus connected at the overflow with a conventional hydrocyclones battery is to recover the coal fraction that has proper characteristics to be burnt in steam power plants or other power installation.

[*] *student PhD, ec. at the SC LCC MINIG SRL - Resita*
[**] *PhD.Ecologyst at the SC LCC MINIG SRL - Resita*
[***] *Prof.PhD.Eng., at the University of Petroşani*

2. TECHNOLOGY DESCRIPTION

The main characteristic of the proposed technology is that after cleaning the material in a scrubber, the coal fraction, separated from the argillaceous compound, regains its natural shine. The next step is a sizing below 14 mm on a rotating screen, trammel type, and part of the scrubber. The screenings are mainly foreign material from the ponds' shore, that represents about 1 to 3 % from the inlet and are removed from the plant like a course material. The sifting is the inlet of the processing plant in centrifugal field, obtaining the coal fraction as a finite product in the down flow, and the argillaceous fraction in the overflow. The final products are stock-piled on special platforms.

Figure 1 shows the technological flux of the processing of raw sterile tailings extracted from the ponds through mechanical and/or hydraulic methods. The extracted raw sterile tailing is transported in the mixing tank (1), where water is added, in order to obtain a minimum dilution of 3m^3/t.

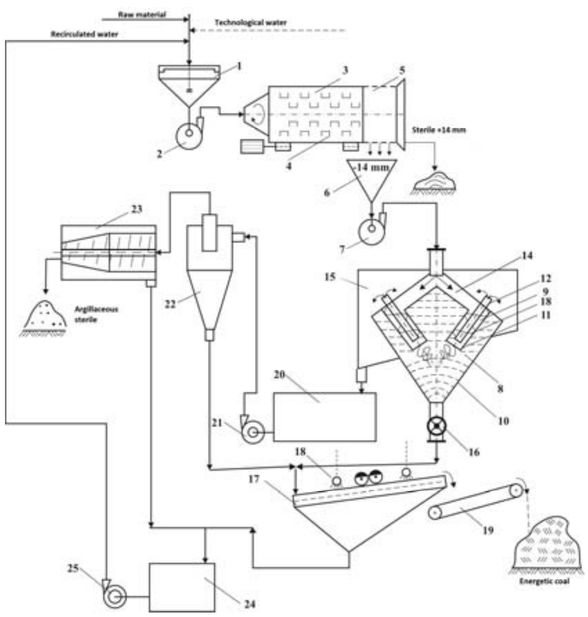


Fig. 1. Technological flux of the processing of raw sterile tailings with coal fraction
1. Mixing tank; 2. Centrifugal pump; 3. Attrition scrubber; 4. radial palettes ; 5. Trommel screen 6. Receiving tank ; 7. Centrifugal pump; 8. Centrifugal concentration apparatus; 9. Special hydrocyclone 10. Conic drum ; 11. Cylindrical part; 12. Siphon pipe 13. Fix spiral; 14. Pressure chamber ; 15. Gutter ; 16. Rotating discharger ; 17. Vibrating screen ; 18. Sprinkler; 19. Belt-type carrier 20. Transfer tank ; 21. Centrifugal pump; 22. Hydrocyclons battery; 23. Sedimentation centrifuge; 24. Transfer tank; 25 Centrifugal pump.

From tank (1) the homogenized slurry is transferred with the centrifugal pump (2) to a rotating scrubber (3) which has inside radial palettes (4) that raise the material to a certain height above the water mirror. Afterwards the material falls again in cascades in the slurry current thus accomplishing attrition which consists in the scaling of the argillaceous minerals from the coal grains.

Next the slurry is separated through a rotating trommel type screen (5), with the 14 mm meshes. The raw material is discarded from the plant and deposited on the ponds' shore; the sifting passes to the receiving tank (6) and that through the centrifugal pump (7) gets to the centrifugal concentration apparatus (8), which consists in a battery of 6 ÷ 8 special hydrocyclones (9) installed into a conic drum (10).

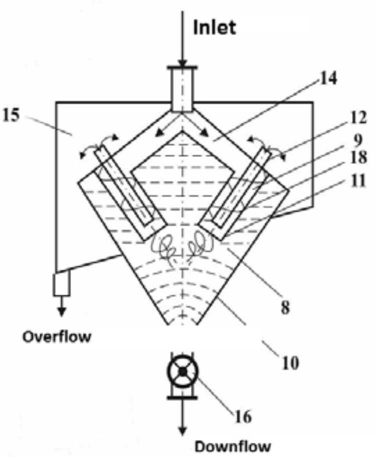


Figure 2. Centrifugal concentration apparatus – functioning scheme

A hydrocyclone from the battery consists in a cylindrical part (11) in which there is installed the siphon pipe (12). In the space between the two cylinders there is a fix spiral (13) with a constant declivity angle, that takes into account, on one hand the separation dimension and density, and on the other hand the resultant force created by centrifugal, centripetal and gravitational forces, giving a descending helicoidally movement to the mineral particles.

The inlet to the 6 ÷ 8 hydrocyclones is achieved through the pressure chamber (14). The raw material leaves the hydrocyclones and settles at the top of the conic drum (10) from where it is continuously removed with the rotating discharger (16). The fine product leaves the apparatus through the siphon pipes and it is collected in the gutter (15). Without the conical part of the hydrocyclones they have to work underwater in order to achieve the separation density and the right thickness. The usage of the rotating discharger is compulsory because it achieves the consolidation of the apparatus and the humidity of the evacuated product. The overflow collected into the gutter passes to the transfer tank (20) from where through the centrifugal pump (21) it supplies the hydrocyclones battery (22), which retains the fine coal fraction in the downflow and the sterile material in the overflow. The downflow material obtained from both hydrocyclones batteries 8 and (22) goes on the vibrating screen (17), which has clear water sprinklers (18) where the downflow is drained. the drained product is transported with a belt-type carrier (19) in a warehouse. The overflow containing mainly argillaceous minerals -0,063mm, it's drained through a sedimentation centrifuge (23) with flocculant agents. The drained material is deposited on a special platform while the fugat (clear water) with the sifting (17) are collected in a tank (24), from where with the pump (25) it is recirculated in tank (1). Waste waters are totally recirculated in the installation and in order to obtain the right dilution, to sprinkle the screens and to cool off the installation there is used technological water.

The technological indicators obtained using this method, are shown in table 1.

Table 1 **Technological indicators**

Indicator	**Material**	**Value**
Weight Rate A, [t/h]		150
Flow Q, [m^3/h]		450
Ash content, [%]	Raw	58.13
	Coal	27.70
	Sterile	69.52
Calorific power, [kcal/kg]	Raw	1720
	Coal	4100
	Sterile	780
Coal recovery, [%]		28.32
Water recycling degree, [%]		75

3. CONCLUSIONS

The presented technology is good for all the sterile deposits with coal content, below 3 mm, from tailing ponds or alluvial areas.

It is known that when the fine fraction, usually under 63 micrometers, has a high percent, the gravitational methods of separation are inefficient therefore there are needed higher forces (10-100) g. These forces can be obtained only in centrifugal field.

The presented technology is innovative, at least nationally, and it is based on coal fraction separation in centrifugal field using hydrocyclonig in two stages:

- A harsh stage - separating the fraction over 250 micrometers, into a special constructed hydrocyclones battery;
- A fine stage - separating the fraction below 63 micrometers, in conventional hydrocyclones.

Generally the over 63 micrometers fractions consist mainly of merchantable coal, while the under 63 micrometers fraction is composed of argillaceous minerals, representing tailings.

The proposed technology is flexible depending on the characteristics of processed raw material and is suitable for automation responding to the requirements of modern mineral and environmental engineering.

REFERENCES

[1]. Sarbu, R. I., *Gravitational processing – Gravitational concentration methods,* Lithography of Technical University Petroşani**,** 1993.

[2]. Sarbu, R. I., Sîrb N.A, Ştefan A., *Centrifugal concentration apparatus*, Innovator certificate no.798/1988 Mining Institute Petroşani, 1988.

[3]. Vrânceanu C, G,V,Calamariu N, Sârbu R,I., *Technology and installation for the recovery of coal tailings in centrifugal field*, Invention proposal OSIM A/00742 from 19.10.2012.

Scientific Reviewers:
Prof. Ph.D. Eng. Sanda KRAUZ

INCONVENIENTS ET PIEGES EN EVALUATION DES RISQUES PROFESSIONELS: EXAMPLES EN ROUMANIE

ROLAND IOSIF MORARU*
MIHAI POPESCU STELEA**

Résumé: *L'évaluation des risques est une exigence explicite de la Loi roumaine de la Santé et Sécurité au Travail et est également expressément requise par les règlements générales et d'autres spécifiques à l'industrie. Une évaluation des risques adéquate et suffisante est considérée comme faisant partie intégrante du système efficace de gestion des risques professionnels. Cependant, il y a un certain nombre d'erreurs les plus courantes, des inconvénients, voire des "pièges" qui sont souvent rencontrés lors d'une évaluation des risques. Cet article se propose d'illustrer quelques-unes des erreurs fréquemment rencontrés et des pièges en vue de sensibiliser les spécialistes de la sécurité. Le présent ouvrage ne porte que sur l'évaluation et la maîtrise des risques pour la santé et la sécurité résultant d'activités professionnelles.*

Mots-clés: *évaluation des risques, la ristourne, un piège, une bonne pratique.*

1.INTRODUCTION

L'article 7, paragraphe 4, lit. a) et b) conjointement avec l'article 12, paragraphe 1, lit. a) de la Loi du santé et sécurité au travail [6] place une obligation générale de l'employeur de procéder à leur entreprise de manière à s'assurer, autant que raisonnablement possible, que les employés et les personnes hors de leur emploi qui peuvent être affectés, ne soient pas exposés à des risques pour leur santé ou leur sécurité. Un certain nombre d'autres règlements, à la fois générales et spécifiques du secteur de l'industrie, inclut notamment l'obligation générale pour tous les employeurs à évaluer les risques pour les employés et tous ceux qui peuvent être affectés par leur entreprise, afin de leur permettre d'identifier les mesures nécessaires pour se conformer à leurs obligations en vertu de loi la santé et la sur la sécurité. L'évaluation des risques est donc reconnue comme faisant partie intégrante du un système efficace de gestion de la sécurité [1].

La gestion efficace de la santé et de la sécurité dépendra, entre autres choses, sur l'évaluation des risques adéquate et suffisante, menées sur les résultats étant utilisés de manière efficace [4]. Un certain nombre d'écueils sont cependant fréquemment rencontrées par l'industrie lors de la réalisation des évaluations des risques. Simpson [7] décrit les problèmes communs et les malentendus soulevés par les praticiens de

---

* *Assoc.Prof.PhD.Eng. at the University of Petroşani*
* * *Ph.D.Student at the University of Petroşani*

l'évaluation des risques et identifie cinq des pièges les plus courants qui peuvent compromettre l'utilité de l'approche d'évaluation des risques.

Notre objectif est de présenter une synthèse systématique en ce qui concerne les inconvénients et les pièges couramment observés dans la pratique roumains de l'évaluation des risques, de sorte que les pièges peuvent être comprises et plus facilement évités à l'avenir.

2.LE PROCESSUS D'EVALUATION DES RISQUES

Le but de la réalisation d'une évaluation des risques consiste à déterminer si le niveau de risque découlant d'activités en milieu de travail est acceptable, ou si reste à faire beaucoup pour contrôler ou réduire le risque. L'évaluation des risques implique à la fois une estimation de l'ampleur du risque (c.- quelle est sa taille?) et une évaluation de l'importance du risque (est-il acceptable?).

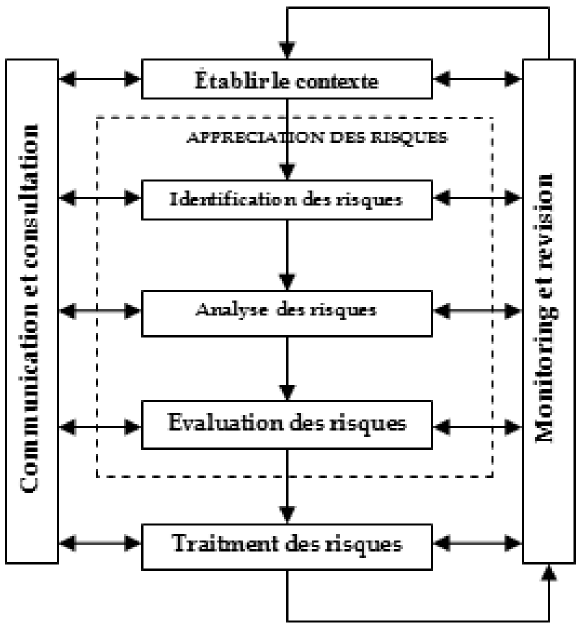


Fig. 1. Le processus d'évaluation des risques dans le cadre général de gestion des risques

Le processus d'utilisation de l'évaluation des risques (voir Fig. 1) pour éclairer les décisions relatives au contrôle et à la réduction des risques en milieu de travail peut être commodément divisé en trois étapes [5]:

- la préparation de l'évaluation;
- procéder à l'évaluation;
- des activités post-évaluation.

Dans la pratique, les distinctions entre les trois étapes décrites ne sont pas clairement marquées, mais cette division fournit un cadre utile pour esquisser les principes directeurs et les facteurs qui devraient être considérés dans le processus.

Lors de la préparation de l'évaluation, les facteurs suivants doivent être considérés:

- quel est le cadre approprié pour l'évaluation?
- ce qui est une approche appropriée, et quel est le niveau de détail requis?
- qui va être impliqué?

Dans l'exécution de l'évaluation, les étapes de base à suivre sont:

- identifier les dangers;
- identifier les conséquences possibles;
- estimer la probabilité des conséquences possibles;
- estimer le risque (voir Fig. 2);
- évaluer le risque;
- consigner les résultats.

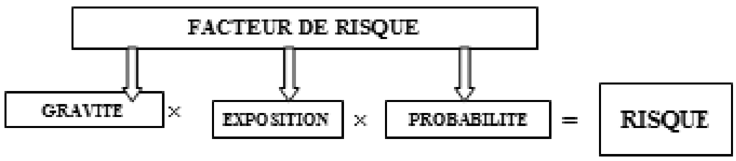


Fig. 2. La définition du risque

L'ordre présenté pour l'identification des éventuelles conséquences et l'estimation de leur probabilité n'est pas destiné à être normatif; ces mesures peuvent être complétées dans n'importe quel ordre ou simultanément, mais les deux sont nécessaires afin d'estimer et d'évaluer l'acceptabilité du risque (voir Fig. 3).

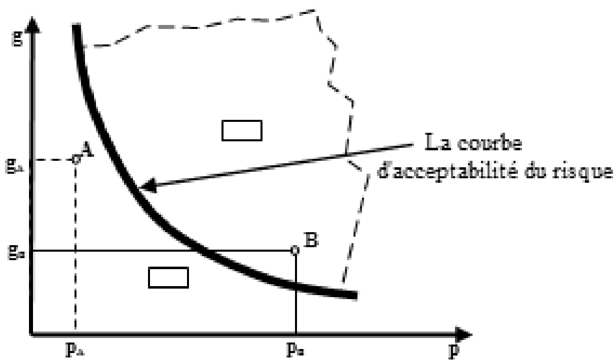


Fig. 3. La courbe Farmer d'acceptabilité du risque

Dans l'exécution de l'évaluation des risques, il est également très important de:

- en sure transparaître throughout the procès;
- assurer un examen approprié et adéquat des facteurs humains;
- assurer le traitement adéquat de l'incertitude.

Une fois l'évaluation terminée, il est essentiel que des mesures appropriées soient prises (voir Fig. 4).

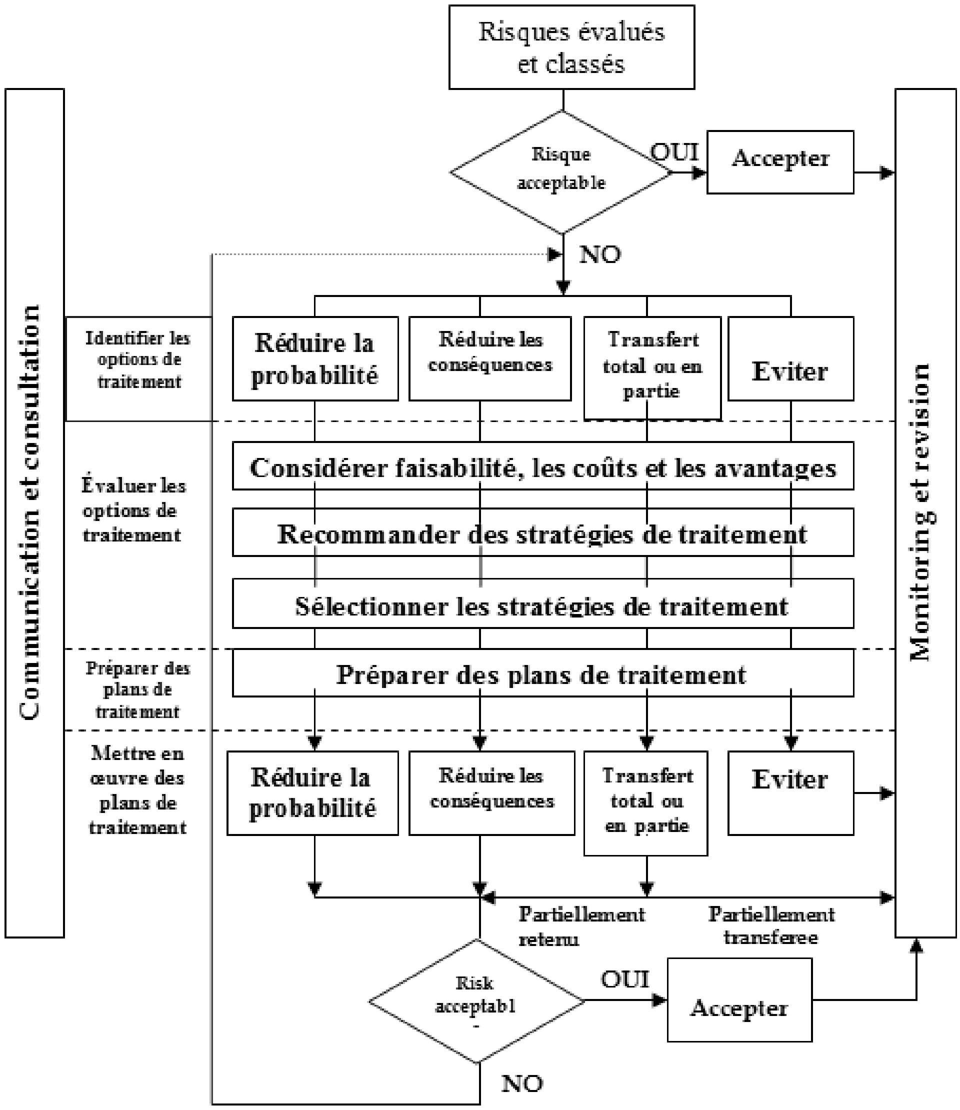


Fig. 4. La structure de la phase de traitement des risques

Il est aussi essentiel que:

- les résultats sont sollicités et les mesures appliquées;
- il existe un système de contrôle régulier de l'évaluation.

3.RESULTATS ET DISCUSSION: INCONVENIENTS ET PIEGES IDENTIFIES

Des études de cas tirés de l'industrie roumaine ont été examinées afin d'identifier certains des pièges les plus couramment rencontrés. Les pièges qui ont été recensées sont les suivantes:

• **Réalisation d'une évaluation des risques pour appuyer une décision qui a déjà été fait**: les résultats d'une évaluation des risques peuvent être utilisée pour prendre des décisions éclairées quant à savoir si toutes les précautions existantes ou des mesures de contrôle sont satisfaisants ou si la prévention ou des mesures de contrôle supplémentaires sont nécessaires. L'évaluation des risques peut également être utilisé pour effectuer une comparaison systématique des différents options de contrôle / réduction des risques de sorte que la décision optimale peut être faite.

• **Utilisation d'une évaluation générique quand une évaluation spécifique au site est nécessaire:** une approche qui est communément prises pour évaluer les risques en milieu de travail, où il y des activités similaires et des risques à travers différentes activités de travail, les surfaces du lieu de travail, ou dans différents sites appartenant à la même entreprise est de réaliser une évaluation des risques génériques, compte tenu de toutes les communes dangers d'une seule évaluation. Pour toute activité professionnelle particulière ou d'un site, il est nécessaire de se demander si tous les risques sont inclus dans l'évaluation générique, et si les circonstances sont telles que l'évaluation générique est valable, même si elle a examiné le cas échéant des risques

• **Réaliser une évaluation détaillée des risques quantifiés sans considérer d'abord si une bonne pratique en la matière:** les bonnes pratiques en la matière fournit détenteurs d'obligations avec des conseils génériques pour maîtriser le risque d'un danger. Dans la mesure qu'ils peuvent adopter des bonnes pratiques pertinentes, les détenteurs d'obligations sont soulagés de la nécessité (mais pas de obligation légale) de prendre explicitement en compte le risque individuel, les coûts, la faisabilité technique et l'acceptabilité du risque résiduel, car ceux-ci ont tous été pris en compte lors de la bonne pratique a été établie [2].

• **Réalisation d'une évaluation des risques à l'aide d un guide inappropriée des bonnes pratiques**

• **Prendre des décisions sur la base des estimations de risque individuel en cas que le risque de la société est la mesure plus appropriée:** pour décider s'il y a lieu de tenir compte des risques individuels ou collectifs, ou les deux, il est important de tenir compte du nombre de personnes qui pourraient être touchées en même temps de la réalisation des risques considérés. Si les risques envisagés sont susceptibles d'affecter les individus seulement, ou quelques personnes en même temps, il serait approprié de ne considérer que le risque individuel. Les risques pour la société peuvent ne pas être négligeable en raison du grand nombre de personnes susceptibles d'être exposées, même si chaque individu a une exposition minime. Par exemple, les risques de feu / évacuation / surpopulation ont été calculés comme le risque individuel et le risque non pas sociétal. Il a ensuite fait valoir que, parce qu'un voyageur régulier ne serez pas passer de temps (lorsqu'il est calculé sur une base annuelle) dans le terminal, le risque peut être considéré comme négligeable.

• **En ne considérant que le risque d'une activité:** lorsque l'on considère le risque auquel un travailleur est exposé, il est important de considérer toutes les tâches qu'il entreprenne. Il n'est pas approprié de ne considérer que le risque de ce qui semble être l'activité la plus dangereuse. Tous les risques auxquels est exposé un travailleur doivent être pris en compte lors de l'estimation du risque individuel global. Il convient également de tenir compte de la durée d'exposition globale du travailleur, par exemple pour estimer le risque sur une semaine typique de travail.

• **Diviser le temps consacré à l'activité dangereuse entre plusieurs individus - le «saucissonnage» pour l'estimation des risques**; lorsque l'on considère le risque d'une activité, la situation ou un processus auquel les individus sont exposés pendant une courte période, il faut veiller à s'assurer qu'une image précise du risque est obtenue. Il n'est pas approprié de diviser le temps consacré à l'activité dangereuse entre plusieurs individus et d'estimer le risque sur cette base (le technique «*saucissonnage*»). Par exemple, si une seule personne n'est exposé au risque pendant une courte période, mais quelqu'un est toujours exposé, il donnerait une image trompeuse du risque, pour estimer le risque en prenant en compte le temps d'exposition de chaque individu. Au lieu de cela, une image plus fidèle du risque serait obtenue en construisant une personne hypothétique. Une personne hypothétique est une description d'une personne qui est dans une relation fixe au risque, par exemple, la personne la plus exposée, ou de la personne vivant à une certaine distance fixe [3]. Dans ce cas, il serait nécessaire de définir précisément l'emplacement de la personne hypothétique / interaction par rapport au danger. La personne hypothétique sera exposé au risque 100% du temps, ou pour la proportion du temps que tout individu est exposé.

• **Ne pas impliquer une équipe de personnes dans l'évaluation y compris les employés ayant une connaissance pratique du processus / activité évaluée:** les individus ou les groupes de travail impliqués dans le processus d'évaluation des risques doit être familiarisé avec les méthodes d'évaluation utilisées, avoir une connaissance approfondie du sujet à l'étude et d'autres connaissances spécialisées nécessaires devraient être fournis et intégrés dans l'évaluation selon les besoins. Autrement dit, tous ceux qui sont impliqués dans le processus d'évaluation des risques devraient être compétente pour entreprendre la tâche.

• **Utilisation inefficace de consultants:** le recours à des consultants pour effectuer des évaluations des risques devraient être traitées avec prudence. Une dépendance excessive sur les consultants (qu'il soit externe ou interne à l'entreprise) peut signifier que les responsables de l'activité perdre une partie de la valeur de l'évaluation des risques, que leur propre compréhension des enjeux ne se développe pas à la même profondeur. En outre, une évaluation des risques qui est irréaliste ou avec des conclusions inappropriées peut être produit si le processus n'est pas parvenu à faire en sorte que les consultants aient une connaissance suffisante du processus / opération, et de travailler en étroite collaboration avec les responsables de l'activité.

• **Ne pas identifier tous les dangers associés à une activité particulière:** les risques associés aux activités de travail peuvent être présents en raison de l'une quelconque ou d'une combinaison des éléments suivants: les substances, machines / processus, l'organisation du travail, les procédures, et les gens et les circonstances dans lesquelles se déroulent les activités, y compris les aspects physiques de l'usine et / ou locaux. Il est important que tous ces différents éléments soient abordés afin de s'assurer que le processus d'identification des dangers est aussi complet que possible. Ainsi que d'identifier les «dangers intrinsèques» dans le lieu de travail, le processus d'identification du danger comprend également l'identification de tous les itinéraires possibles à l'échec, à savoir

- **L'utilisation inappropriée des données:** si une évaluation des risques quantitative ou semi quantitative est effectuée, puis les estimations des probabilités d'événements dangereux sont généralement dérivées de manière quantifiée. Ceci est basé sur l'utilisation de tout ou partie des éléments suivants: analyse des données historiques, jugement d'expert et des techniques de modélisation analytique. Pour de nombreux AQR (Analyse Quantitative des Risques) rigoureuses, la quantification complète des arbres de défaillances et d'événements est nécessaire. Par conséquent, il est essentiel que les ensembles de données appropriés soient utilisés pour informer l'évaluation des risques. Les statistiques d'accidents, selon l'exposition limitée de l'échantillon doivent être utilisé avec soin et mis en place des techniques statistiques pour calculer la probabilité d'un événement doivent être utilisés.
- **Définition inappropriée d'un échantillon représentatif d'événements:** une approche utile pour estimer le risque qui est souvent utilisé dans des analyses plus approfondies (par exemple typiquement dans les régions semi quantitatives ou quantitatives détaillées des évaluations où le nombre de séquences d'événements possibles peuvent devenir très grand et ingérable) est de procéder à l'évaluation d'un échantillon représentatif des événements. Plutôt que d'analyser l'ensemble du système explicitement, un ensemble discret de scénarios est sélectionné pour représenter l'ensemble. Des précautions doivent être prises si une telle approche est adoptée pour faire en sorte que l'ensemble choisi des scénarios est vraiment représentatif de l'ensemble du système.
- **L'utilisation inappropriée des critères de risque**: En Grande Bretagne, le HSE a établi indicatifs numériques des critères de risque individuels (applicable aux estimations du risque total d'une activité) pour les frontières entre les régions inacceptables, tolérable et acceptable de la cadre de tolérance du risque (TOR). Ces critères, ainsi que les hypothèses sous-jacentes à leur calcul sont donnés par HSE [3]. Développer des critères sur la tolérance des risques donnant lieu à des préoccupations sociétales s'est avérée plus difficile, mais les critères qui ont actuellement été adoptées par HSE sont également décrits le document cité. Il est important de veiller à ce que le critère de risque approprié soit utilisé selon que vous envisagez de risques individuels ou collectifs.
- **Aucune considération de ALARA ou d'autres mesures qui pourraient être prises:** en général (pour les risques qui sont au-dessous de la région inacceptable), dans les décisions relatives à la praticabilité raisonnable de mettre en œuvre d'autres mesures de contrôle des risques, plus le niveau de risque considéré, plus le degré de rigueur et de robustesse (et par conséquent le plus grand niveau de détail) HSE exige des arguments pour montrer que les risques ont été réduits ALARA, voir Fig. 5 [2].

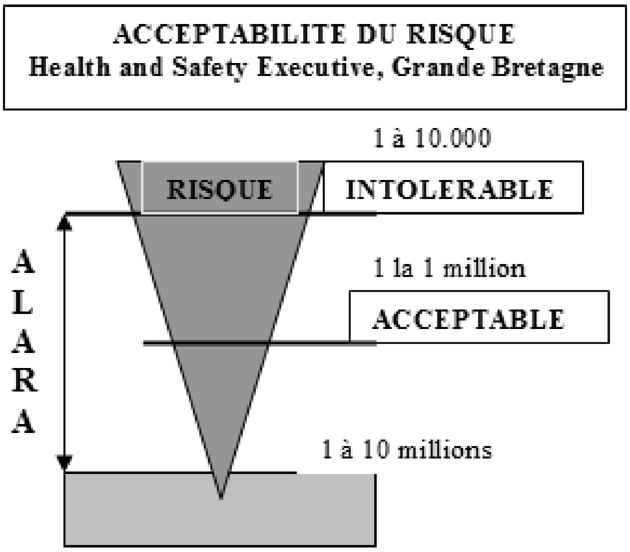


Fig. 5. La notion ALARA d'acceptabilité du risque

• Dans la pratique, pour les risques dans la région largement acceptable ou vers le bas de la région tolérable, on peut accepter l'application des bonnes pratiques pertinentes d'une manière appropriée comme une démonstration suffisante de tout ou partie d'un calcul risque. Une bonne pratique est un terme générique pour les normes de contrôle des risques. Dans la mesure du risque d'être réduite, et l'effort impliqué dans les mesures pour atteindre cette réduction, le point de départ devrait être la situation actuelle; si il y a plusieurs options, elles doivent donc être considérées comme contre la situation actuelle.

• **L'utilisation inappropriée de l'analyse coût bénéfice** (ACB): il est important d'examiner s'il existe une bonne pratique pertinente applicable à la situation examinée avant d'effectuer des analyses détaillées des coûts avantages pour évaluer la faisabilité raisonnable de mettre en œuvre les mesures possibles de réduction des risques. Lors de la réalisation d'une analyse coûts - avantages, des précautions doivent être prises pour fournir des estimations de coûts valides et pas seulement considérer l'option la plus coûteuse. (Par exemple dans les charbonnages, nous ne considérons pas que la station de surveillance du méthane, mais également des détecteurs de méthane individuels).

• **L'utilisation de „inverse ALARP arguments":** (à l'aide analyse coûts avantages pour tenter de faire valoir qu'il est acceptable de réduire les normes de sécurité en vigueur). Des tentatives sont parfois d'utiliser l'analyse coûts avantages pour plaider en faveur de la suppression d'une mesure de contrôle du risque existant qui ne réalise qu'une faible réduction du risque à un coût élevé. Dans ces cas, il est affirmé que l'analyse coûts avantages montre que le coût de la mesure existante est exagérément disproportionné à l'avantage obtenu en termes de réduction des risques, et donc que la mise en œuvre continue de la mesure de contrôle n'est pas raisonnablement possible. Cependant, ces arguments ne sont pas acceptables comme la suppression d'une mesure de contrôle existant se traduirait par une augmentation du niveau de risque, et cela signifierait que les risques ne sont plus ALARP contrôlée; la mise en œuvre actuelle de la mesure de contrôle a effectivement démontré sa praticabilité raisonnable. Les arguments long de ces lignes sont parfois appelés "Reverse ALARP" ou arguments ALARP„inverses".

- **Ne pas relier les risques aux contrôles des risques**: les résultats de l'évaluation des risques doivent être documentées et comprennent:
  - des précisions sur les risques identifiés liés à l'activité de travail;
  - des précisions sur la gravité des conséquences possibles;
  - des précisions sur les précautions qui sont (ou devraient être) mises en place pour maîtriser les risques;
  - améliorations / actions supplémentaires jugées nécessaires pour maîtriser les risques ALARP.
- **Ne rien faire avec les résultats de l'évaluation:** il est essentiel que des mesures soient prises à la suite des conclusions de l'évaluation des risques. L'évaluation des risques ne devrait jamais être un simple exercice théorique, l'ensemble du processus aura été une perte de temps si les conclusions sont simplement noté, mais aucune mesure prise en conséquence

4. CONCLUSIONS

Le processus d'évaluation des risques doit être effectuée de manière rationnelle, logique et structurée. Les résultats d'une évaluation des risques peut être utilisée pour prendre des décisions éclairées quant à savoir si toutes les précautions existantes ou des mesures de contrôle sont satisfaisants ou si la prévention ou des mesures de contrôle supplémentaires sont nécessaires. L'évaluation des risques peut également être utilisé pour effectuer une comparaison systématique des différents options de contrôle / réduction des risques, de sorte que la décision optimale peut être faite. l n'est pas approprié de procéder à une évaluation des risques pour tenter de justifier une décision qui a déjà été fait. Il est probablement plus utile d'utiliser les évaluations des risques génériques comme point de départ pour les évaluations des sites spécifiques, et d'envisager de manière systématique s'il existe des risques supplémentaires ou des différences importantes dans la situation particulière qui nécessitent des ajouts ou des modifications à l'évaluation générique. Dans la pratique, le cas échéant bonnes pratiques existe et est adopté pour tous les dangers en milieu de travail, des évaluations explicites du risque rarement besoin d'être faite en ce qui concerne au jour le jour des risques; dans ces situations, le devoir de l'évaluation des risques peut être dit d'être déchargé par le adoption appropriée de bonnes pratiques pertinentes. L'évaluation va conduire presque inévitablement lieu à des recommandations pour des améliorations et nouvelles mesures pour contrôler et réduire les risques identifiés; toutes les mesures nouvelles ou supplémentaires de réduction des risques ou des systèmes de contrôle des risques doivent être mises en œuvre.

REFERENCES

[1]. Băbuț, G., Moraru, R., *Evaluarea riscurilor-Transpunerea cerințelor Directivei 89/391/cee în legislațiile statelor membre ale uniunii europene*, Editura Universitas, Petroşani, 2009, ISBN: 978-973-741-127-3

[2]. HSE, *Principles and guidelines to assist HSE in its judgements that duty-holders have reduced risk as low as reasonably practicable*. Health and Safety Executive, 2002, Available at http://www.hse.gov.uk/dst/alarp1.htm. Accessed: 10.09.2012.

[3]. HSE, *Assessing compliance with the law in individual cases and the use of good practice.* Health and Safety Executive, 2002, Available at http://www.hse.gov.uk/dst/alarp2.htm. Accessed: 10.09.2012.

[4]. Moraru, R., Băbuț, G., *Managementul riscurilor: abordare globală - concepte, principii şi structură*, Editura UNIVERSITAS, Petroşani, 2009, ISBN 978-973-741-128-0

[5]. Moraru, R., Băbuț, G., *Evaluarea şi managementul participativ al riscurilor. Ghid practic.* Ed. Focus, Petroşani, 2010, ISBN 978-973-677-206-1

[6]. Parlamentul României, *Legea securității şi sănătății în muncă nr. 319/2006,* Monitorul Oficial al României, Partea I, nr. 646/26.07, 2006.

[7]. Simpson, G.C., Toward a rational approach to risk assessment. *Mining Technology* 78 (893), 1996, 19–23.

Scientific Reviewers:
Prof. Ph.D. Eng. Nicolae BĂNCILĂ

THE HOTELLING RULE AND ITS USE IN THE ROMANIAN MINING INDUSTY

RAREŞ MUNTEANU*
KLAUS-GERHART FISSGUS*

Abstract: *In order to have an efficient development in the mining industry, not only the technical issues must be taken into consideration, but the economic ones as well. Therefore it is very important that the price for the exploited raw materials to be fair. The Hotelling rule helps to draw a forecast of the evolution of the prices in the mining industry.*

Key words: *Hotelling rule, forecast, discount factor, mining, prices*

1. INTRODUCTION

All the mineral resources are depletable; in the meantime, the need of the society for raw materials is increasing. These aspects must be taken into consideration when the price of the useful mineral substances are established, or when a forecast of the evolution of the prices is made.

In 1931, Harold Hotelling worked out the theory for this special case. In the case of the depletable resources, the producer has to decide how best to optimizes production between now or the future so as to maximizes profits, since any production level will see the eventual depletion of the resources.

2. HOTELLING’S RULE

Hotelling's rule states that the most socially and economically profitable extraction path of a non-renewable resource is one along which the price of the resource, determined by the marginal net revenue from the sale of the resource, increases at the rate of interest. It describes the time path of natural resource extraction which maximizes the value of the resource stock. (Gaudet, Gérard, "Natural Resource Economics under the Rule of Hotelling").

* *lecturer PhD. Eng. at the University of Petrosani, email:rares72@yahoo.de, kfissgus@yahoo.de*

According to the Hotelling rule, in a competitive market, the price of a depletable resource must increase at the same rate as the discount rate. The theory for this special case was worked out in the classic paper of Hotelling (1931).

The Hotelling rule could be explained as follows. Take a competitive market with identical producers that have depletable resources on the ground. Any production level will cause eventually the depletion of the resources, and the producer must decide how to plan the production between now or the future so as to maximize profits.

If he increases his production high enough by increasing present supply and lowering present prices, his resource stocks will deplete at a faster rate, and the rate of future price will increase γ to be high. In this case, $\gamma>r$ (discount rate). But his competitor may find it better not to follow his lead. This will enable them to enjoy future higher prices, which grows higher than the discount rate. As a result, in order to reach equilibrium, the producer will lower his production enough so that $\gamma = r$.

On the contrary, supposing that he limits his production, causing the present prices to become higher whilst stocks are depleted more slowly. Future price increases now become less, such that $\gamma < r$. Competitors now find it better to increase their production, and invest the money into the money market for a higher return. In this situation, equilibrium sets that the producer will increase his production enough so that $\gamma = r$.

In Jeffrey A. Krautkraemer's words, "Hotelling's formal analysis of nonrenewable resource depletion generates some basic implications for how the finite availability of a nonrenewable resource affects the resource price and extraction paths." (Krautkraemer, Jeffrey A., *Nonrenewable Resource Scarcity*)

Hotelling's rule addresses one fundamental question of the firm involved in the exploitation of the non-renewable resource: How much of the asset should be consumed now and how much should be stored for the future? That means that the firm must choose between the current value of the asset if extracted and sold and the future increased value of the asset if left unexploited. This rule can be expressed by the equilibrium situation representing the optimal solution.

$$\frac{P'(t)}{P(t)} = \delta \qquad (1)$$

when:

$P(t)$ is the unit profit at time t and

δ is the discount rate (the inverse of rate of return).

The stock of a non-renewable resource, being an asset, holds a market value which yields returns to its owner at a certain rate. This rate of return can be determined by three components:

- flow of product generated by the marginal unit of the resource, marginal productivity or dividend rate;
- change in the physical characteristics of the asset over time;
- the rate at which market value of the asset will change over time.

The equality of this rate of return to the rate of return of alternative investments (e.g. if the yield obtained from asset's sale is invested elsewhere) determines the asset market's equilibrium. Taking into consideration a nonrenewable resource, such as a stock of oil in the ground, it is subject to two characteristics:

- it has a fixed size which cannot be increased over time and
- the in-situ asset is unproductive.

This makes the first component, marginal productivity, zero. Assuming that holding the asset in-situ will not lead to its depreciation, even the second component is rendered zero. Remainder is the rate of appreciation of the asset's value which is in fact the only determinant of rate of return of the stock of oil.

According to Hotelling, the evolution of the prices of a non renewable resource over the years, starting with the present and until the resource is depleted is as follows:

$$P_{(0)}<P_{(1)}<P_{(2)}<P_{(3)}<P_{(4)}<\ldots<P_{(T)} \tag{2}$$

$$P_{(0)} = \frac{P_{(1)}}{\delta} = \frac{P_{(2)}}{\delta} = \frac{P_{(3)}}{\delta} = \frac{P_{(4)}}{\delta} = \cdots = \frac{P_{(T)}}{\delta} \tag{3}$$

The pricing for products from exhaustible natural resources has not only the function to bring in accordance the offer and the demand through the influence of the price. It also has the task to add an economically based distribution of the consumption of the natural resource (optimization of the exploited quantity-time profile) (D. Slaby, F.L. Wilke, *Bergwirtschaftslehre Teil 1*).

For instance, in the Jiu Valley coal mining, if during the year 2013, a fair price per tonne were of around 100 RON and if the mining continued for the next 20 years, the evolution of the prices, according to the Hotelling rule, would be the following (100 RON/tonne 265,33 RON/tonne in 20 years, in present day currency):

Table 1. The evolution of the prices for a tonne of Jiu Valley coal (RON/tonne)

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20
105,00	110,25	115,76	121,55	127,63	134,01	140,71	147,75	155,13	162,89	171,03	179,59	188,56	197,99	207,89	218,29	229,20	240,66	252,70	265,33

3. THE LIMITATIONS OF HOTELLING'S THEORY

However, one of the basic statements of the Hotelling rule, the growing trend of the prices and the decreasing trend of the exploited quantities is not always proved in practice. In future, there will be no price escalation and no reduction to zero for the exploited mineral resources. The difference between the practice and the theory comes from the limits of the model and in the abstract assumptions for the models:

- world's natural resources are not homogenous quantities

- world's natural resources are at no point mined out completely
- there are many possibilities for substitution between the natural resources
- the evolution of the costs and prices can be only unrealistically described by stable functions and discrete models
- the realistic horizon of time that can be used in practice is too short.

3. CONCLUSIONS

Although it has quite a lot of limits, the Hotelling rule can be used in periods of time when nothing extraordinary happens (wars, disasters etc). It offers a perspective for the prices of the natural resources, at least in the short run, if not until certain deposit is depleted.

REFERENCES

[1]. Gaitan B., Tol R.S.J., Yetkiner I.H. *The Hotelling's Rule Revisited in a Dynamic General Equilibrium Model,* Proceedings of the Conference on Human and Economic Resources, 2006 pp. 213–238.
[2]. Gaudet G. *Natural Resource Economics under the Rule of Hotelling*, Canadian Journal of Economics, 2007
[3]. Hotelling H. *The Economics of Exhaustible Resources*, Journal of Political Economy, 1931
[4]. Krautkraemer J. A. *Nonrenewable Resource Scarcity*, Journal of Economic Literature, 1998

Scientific Reviewers:
Prof. Ph.D. Ec. Florian BUȘE

REINTRODUCING THE INTERNAL WASTE DUMP TISMANA IN THE AGRICULTURAL CIRCUIT

DUMITRU FODOR[*]
ALIN-COSMIN SMEU[**]

Abstract: *One of the areas of Romania in which the environment has suffered from human activities is Oltenia, area where the main activity was and continues to be mining (by extracting lignite in quarries), which aimed to make productions as high as possible. This activity generates a series of environmental problems. One of these, which also constitute a drawback of this type of operations, is the appearance of large internal and external waste dumps. Reconstruction and ecological rehabilitation of lands degraded by quarrying activities is mandatory and must be done in accordance with the political and economic objectives of the country. This paper is intended to be a study that provides solutions for reintroducing into the economic circuit (mainly agricultural) of the internal waste dump Tismana.*

Keywords: *mining, internal waste dump, agricultural rehabilitation, waste dump's stability*

1. DESCRIPTION OF THE AREA

The terrain's topography is mostly hilly with a general north-south direction of the ridges. The hills have heights between 300-500 m, are relatively homogeneous as petrographic composition, but heterogeneous in terms of the degree of modeling and morphological characters.

Because of the lithological composition of formations of the Getic plateau (marls, clays, sands), the hillsides are affected by landslides that permanently changes the geomorphology of the area.

The hydrographic network in the area is represented by sections of the rivers Jiu and Tismana, along with their tributaries: Pinoasa, Galeşoaia and Răstăcioasa. The total length of watercourses totalizes about 200 km, quantitative the water resources are relatively low, except for the Jiu river.

Mining basin of Oltenia has a climate specific to the Getic Subcarpathians and piedmont, dominated by a temperate continental climate with mediterranean influences, with an annual average temperature of 10.3°C, average annual precipitation is 753 mm and winds greatly influenced by the proximity of the mountains and hills, the frequency and high intensity of the winds predominating on a N -NW direction.

[*] *Prof. Eng., Ph.D. at the University of Petroşani*
[**] *Ph.D. Eng., at CEO, Mining Division, e-mail: smeualincosmin@yahoo.com*

The very complex structure from the orographic, soil and climate conditions of the area of Oltenia, causes a high biodiversity of flora and fauna. In Oltenia there are reported about 28 rare and important potential species (existing before the commencement of lignite mining). Terrestrial fauna and bird species consists of elements common to almost all hardwood forests, interwoven with elements of the steppe. The most common reptiles are lizards and snakes encountered especially in the meadow areas. The aquatic fauna is characteristic for hilly areas and is represented by: the chub, barbel, broad snout, carp, pike and zander.

Soils in the studied area are mostly of alluvial nature, consisting of coarse material deposited over a layer of gravel.

Anthropic protosoils are identified on waste dumps, and they have less humus and reduced fertility. If the chemistry of these materials can be improved, their biological recovery is a matter of time, so the conservation of the natural soil from the overburden and its relocation on the materials forming new land surfaces is very important.

2. ESTABLISHING THE REHABILITATION VARIANT FOR TISMANA WASTE DUMP

Reintroducing in the economic circuit of degraded terrains by mining requires the redevelopment and modeling of the surfaces and then their re-cultivation. Mining redevelopment and modeling are activities that require several technological steps to be followed. Recultivation is the action of soil reconstruction by technical and biological treatments.

Among the possible reuse options for Tismana internal waste dump (agricultural reuse, forestry or fruit growing), in accordance with reconstruction plan of the area (which is part of the documentation needed for obtaining the operating license) and taking into account the requirements of the local population, is chosen the agricultural rehabilitation option.

In determining the recultivation variant, namely agricultural, were considered the environmental planning principles, the principle of globality or intercasuality showing that the territory should be regarded in its entire.

In addition to modeling the waste dump, during the construction phase, is proposed the formation of a lake at the bottom, between the final slopes of the quarry and dump’s slopes. The main goal of this lake is to take rainwater and the recovery of the hydrostatic level in the dump’s body, but it can be used for future irrigation of the agricultural terrain, in periods with lack of precipitation by installing a water pump and a system of pipes.

The improvement of the productive capacity of the terrains primarily concerned the branches of agriculture and fruit crop production. Because Tismana interior waste dump is surrounded mainly by farmlands it was concluded that agricultural rehabilitation is the most appropriate, least costly and with beneficial results.

For the implementation of the rehabilitation variant there must be considered a number of issues during the construction phase of the waste dump (selective recovery of topsoil and sterile intercalations with fertility properties, the stability of the dump etc.) and then a series of works must be carried out on the dump's surface: leveling, remodeling, depositing topsoil, ensuring the hydrostatic level, filling the remaining hole with water, identifying plant species to be cultivated, establishing a monitoring program.

3. ELEMENTS OF DESIGN

3.1. Applied mining method

Open pit mining methods are classified into five classes. Within each of the five classes of methods there are several groups of methods, depending on the position on the position of the dumps and the work required.

The combined mining method used in Tismana quarry is characterized by the fact that a part of the sterile is directly deposited in the dump by transshipment, and the another part is transported to the interior waste dump. This method of operation is applied to horizontal or slightly inclined layers, of limited thickness, when the cover rocks are of great thickness and medium or low strength.

3.2. Construction of interior dump Tismana

The open pit mining sterile handling systems are made up of various equipments forming a chain, with the final link being the dumping machine. Deposition of sterile in waste dumps is achieved in several ways, depositing options are shown in Figure 1.

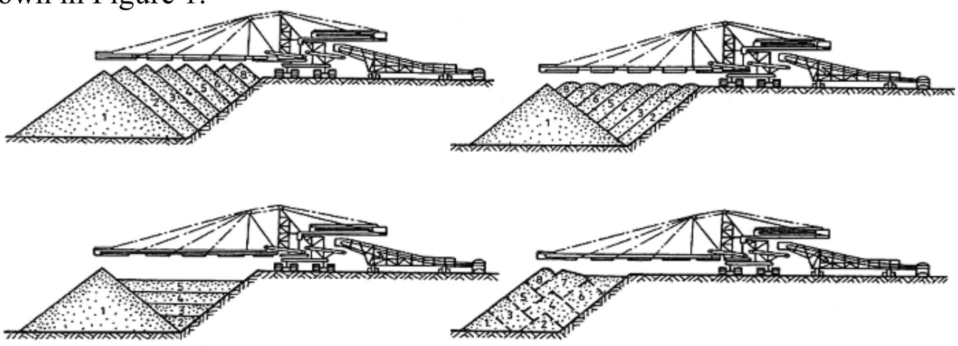


Fig. 1. Construction of waste dumps using dumping machines.
1, 2, 3. - The order in which the material in deposited

Tismana internal dump is characterized by the following elements: number of steps – 7, steps width 150-200 m, total height 120 m, working step height 10-15 m, general angle of slope 6º, working step angle slope 30 -40º .

The general scheme of construction of the interior waste dump Tismana is shown in Figure 2.

The depositing width on a tour (route) of the dumping machine depends on the geometry of the depositing arm and whether the dumping machines can travel on freshly deposited material.

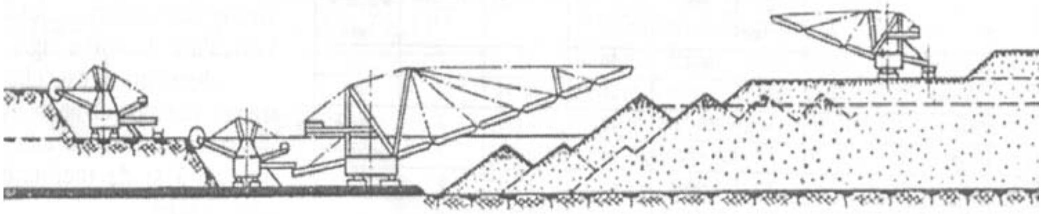


Fig. 2. Dumping technology by transshipment, transport circuits and dumping machine

3.3. Current technical conditions

Currently the interior dump Tismana is under construction (which allows the adoption of constructive solutions allowing minimal intervention in order to its reintegration into the agricultural circuit) and occupies an area of about 460 hectares (of the 644 ha designed the termination of lignite mining activity). A large part of the 460 hectares currently occupied is represented by deposition cones.

The volume of waste material deposited so far is 320 million m^3, and the total volume of the Tismana waste dump at the end of mining activity (2020) is designed for the value of 565 million m^3. The difference in volume of 245 million m^3 sterile is to be stored between 2012 and 2020.

In terms of technical condition, because the dumping technology was not respected (exceeding steps designed height and overcome the angle of slope) in recent years there have been observed superficial landslides of individual steps, without affecting the overall stability of the dump. [9]

Another problem identified is that the accumulation of water in shallow depressions caused by uneven settlement of the deposited material and the formation of relatively small puddles in the twinning areas between the dump and the natural terrain (on the north side).

There were observed areas of failure plastic of the dump's slopes, areas that occur due to exceeding the carrying capacity due to the relatively high plasticity of the material stored and the dump steps height.

The field observations showed that at the present the technical conditions of Tismana dump is relatively good but there is a risk of negative geomining phenomena to occur in the absence of adequate measures (compliance with the dumping technology, water drainage of the accumulated water on the north side at the contact with the natural terrain, in the twinning areas of the two dump bodies and in areas affected by uneven settlements).

3.4. Description of proposed technological flux

Because it is aimed at building the waste dump so as to be reintroduced in the agricultural circuit, it is proposed selective exploitation of clay layers with fertility properties located on top of VI and VII strata and the topsoil and storing them in temporary deposits arranged on the eastern and western sides of the quarry. These temporary deposits will be constructed with deposit-loading machines and for transporting the clays and topsoil will be using conveyor belts installed in distribution nodes on both sides of quarry (to be included in the technological flux fig. 3).

The material from these deposits will be reexcavated, transported by conveyor belts and deposited with the dumping machines on the steps located at 200, 215 and 230 m. For the remaining steps of the dump (located at 245, 260 and 275 m) because it does not exist at the time of cessation of the activity a continuous transportation flux, the mixture of fertile topsoil and clay will be transported by trucks, unloaded and leveled by bulldozers. [9]

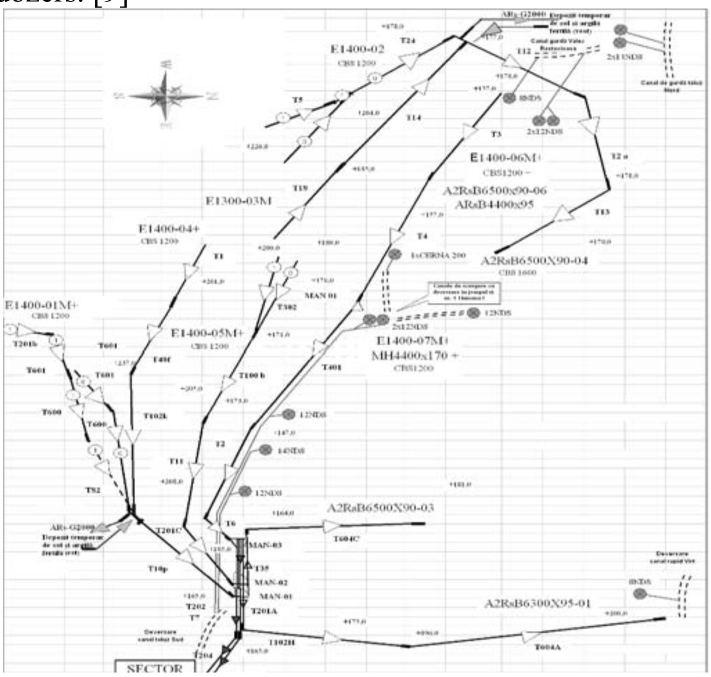


Fig. 3. Proposed technological flux

For the reexcavation of the fertile material from the deposits two deposit-loading machines will be used type Ars-G2000.

3.5. Dimensioning the steps of the waste dump

For the determination of the overall height of the dump needed in order to store the entire volume of the waste material from the overburden the following relation can be used: [1, 2, 3]

$$H_{cr} = K_a H_d L_d \frac{1}{L_h} \qquad [m] \qquad (1)$$

In limit conditions, the height of the forerunner step, respectively the vehiculation level of the depositing machine, h_1 will be:

$$h_1 = H_h - h = K_a H_d L_d \frac{1}{L_h} - h \qquad [m] \; (2)$$

In which:

H_d – thickness of the overburden, m; L_d – length of the working front (in overburden), m; K_a – loosening coefficient; H_h – total height of the dump, m; L_h – length of the deposition front, m; h – maximum lifting height of the depositing machine, m; h_1 – the height of the forerunner step, m.

For the computing parameters the following average values were considered: H_d – 90 m; L_d – 2500 m; K_a – 1,73, L_h – 3000 m

By replacing in the first relationship results a maximum height of the dump of 130 m

To determine the height of the forerunner step by replacing in the second formula results a maximum height of 30 m.

A method generally applied for dimensioning the geometric elements of a waste dump steps is that elaborated by A.M. Demin (Fig. 4).

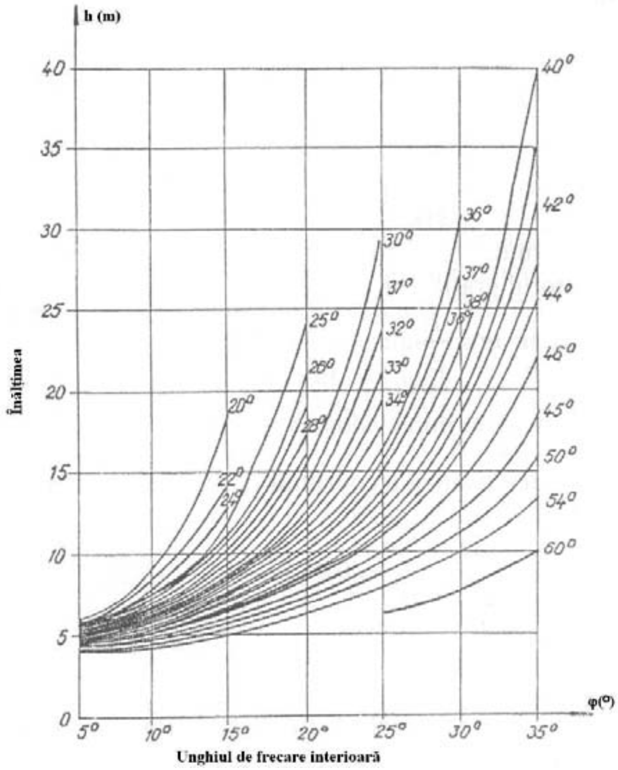


Fig. 4. A.M. Demin calculation chart for slopes of equal stability

Instead of laborious calculations based on limit equilibrium theory the author proposed a simple chart based on physical-mechanical parameters of deposited rocks, that can establish, expeditiously and with sufficient accuracy, the theoretical limit highs of the dump's steps assuming various slopes. [7]

In order to obtain the theoretical limit height h, the size h' determined from the chart based on the internal friction angle φ and the angle of slope α is multiplied by the ratio $\frac{c}{\gamma_a}$, where c is the cohesion of the material from the dump, and γ_a - the volumetric weight.

$$h = h^1 \frac{c}{\gamma_a} \qquad [m] \qquad (3)$$

To find the limit slope angle α, at a given height h of a step, first is determined h' by using the relationship:

$$h^i = h \frac{\gamma_a}{c} \qquad (4)$$

and then, knowing the angle φ, the slope angle α is graphically determined.

The results obtained by this method depends on the accuracy with which the deposited rocks parameters were determined (γ_a, c and φ).

If we consider the following values for the calculating parameters for the rocks deposited in Tismana dump (obtained by statistical processing of data on the physical and mechanical properties of rocks from Tismana waste dump) and we impose a slope angle of 31°: γ_a = 16.5 kN/m^3; c = 18.5 kN/m^2; φ = 15.5° and by interpolation with the curves in Demin chart, results in a high of the steps of 15 m (Fig. 5).

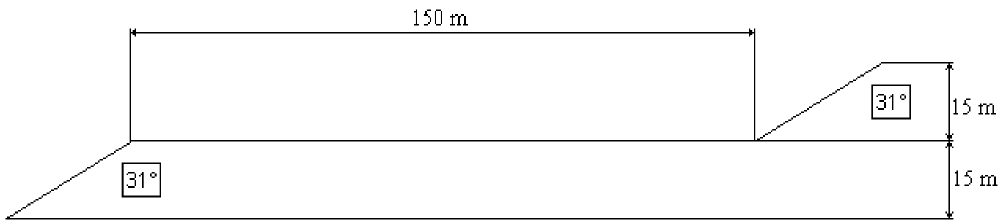


Fig. 5. Individual step's geometry

Given the configuration of the terrain from the exploited area, the total volume of waste material to be stored and the surface expected to be occupied by the dump results a configuration with 8 steps facing the final steps of the quarry, 7 steps on the eastern and western sides and 4 on the north side (the situation plan presented in fig. 10). The overall slope angle on the south side will be of 5°.

The maximum overall height of Tismana waste dump will be of 120 m, and the width of the steps of 150 m, except for the first and the third which are designed to be of 200 m.

3.6. Stability analysis for the proposed geometry

To perform the stability analyses for the studied waste dump in this study there were modeled longitudinal and transversal sections on the situation plan.

Stability analysis for individual steps and general slope

It was performed using the specialized software Slide.

The characteristic geometry of Tismana dump and for each step was determined graphically (from the considered sections) and the values of the physical-mechanical parameters considered in the stability calculations are presented in Table 1.

Table 1. ***Characteristics of the rocks from Tismana waste dump***

Rock type	Natural humidity		
	Volumetric weight γ_{nat}, (kN/m^3)	**Cohesion c, (kN/m^2)**	**Internal friction angle φ (degree)**
Rocks from the waste dump	16.5	18.5	15.5
Natural Terrain	19.0	22.0	16.0

The results obtained from this analyses, using the mentioned software, are presented below (Table 2 and Figure 6) for a single step, for the overall slope of the dump (on 4 directions north, south, east and west), the system of steps and given that the proposed variant involves creating a lake in the remaining hole of the quarry (between the final slopes of the pit and the first 2 steps of the dump) it was considered the case of a submerged slope.

Table 2. ***Stability analyses results***

Section T - T	**Maximum height**	**Slope angle**	**Analyses method**		
	H (m)	α (degree)	Fellenius	Bishop	Janbu
Individual step (initially)	15	31	1.206	1.252	**1.179**
S general slope	120	5	3.518	3.587	**3.513**
N general slope	120	5	3.411	3.538	**3.401**
Section L - L					
E and W general slope	120	5	3.503	3.597	**3.496**

Since the steps dimensioning calculations and following the final geometrical design of Tismana waste dump showed that all steps are identical, the stability analysis was performed for a single step.

As can be seen in the analysis of the stability of a single step, the minimal value, obtained by the method of Janbu is 1.179. Although a value higher than one, and theoretically the slope is stable, current standards recommend a minimum value for the stability factor of 1.3 [10]. To achieve this remodeling works are required, works presented in the next paragraphs.

In the case of the general slopes stability analyses on the four sides of the dump, there were obtained values of the stability factor higher than 3, which means that the whole waste dump is stable.

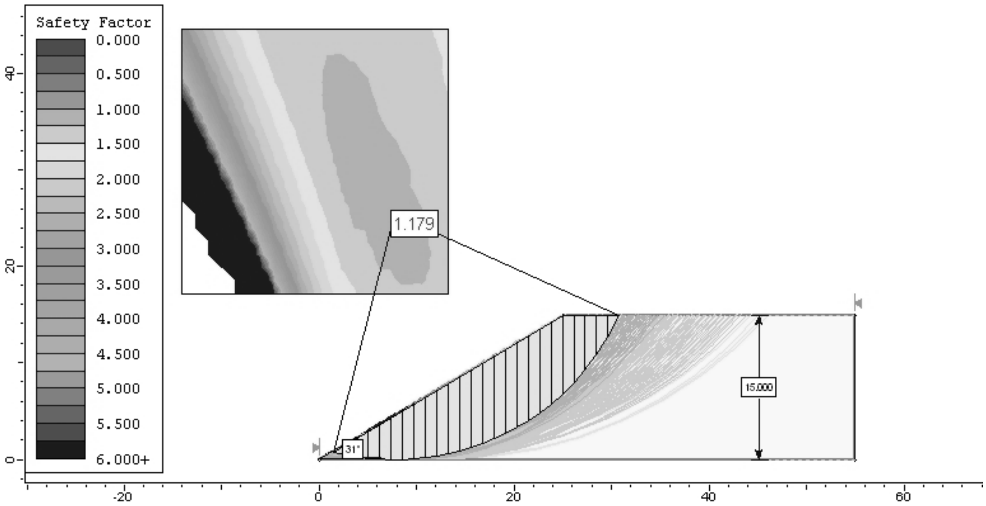


Fig. 6. Stability analyses for a single step (initial geometry)

Stability analysis for submerged steps

Because it is considered water filling of the remaining hole of the quarry up to +185 m quota, the first two steps of Tismana dump will be submerged. To avoid the occurrence of landslides by liquefaction, especially during water filling operations, before the first step there will be built throughout its length, a rock fill counter fort. [9]

Table 3 presents the values calculated for the stability coefficient of the submerged steps.

As shown in Table 3 and Figure 7, if in front of the slope a counterfort of rocks is built at a slope angle of 18°, the minimum value of the stability coefficient is 2.586, or in other words, the embankment is stable and there is no danger for it to be involved in sliding movements.

Table 3. ***Stability analyses results for the submerged step***

Section T - T	**Maximum height**	**Slope angle**	**Analyses method**		
	H (m)	α (degree)	Fellenius	Bishop	Janbu
Submerged slope	15	31	2.686	2.752	**2.586**

Analysis of the stability for the system of steps

To analyze the stability of the system of steps it was used a method recommended by the literature (horizontal contact surface between the dump and the base terrain) and were considered the following values of the parameters involved in the calculations: $h_1 = 15$ m; $h_2 = 30$ m; $\alpha = 31^o$; $\lambda_p = 1.73$; $\lambda_a = 0.58$; $c_c = 22$ kN/m^2; $c = 18.5$ kN/m^2; $\gamma_v = 16.5$ kN/m^3; $\varphi_c = 16^o$; $\varphi = 15.5^o$.

Introducing these values in relationship the stability coefficient will be:

$$s = \frac{\gamma_v h_1^2 \lambda_p + 4ch_1\sqrt{\lambda_p} + \gamma_v\left(h_2^2 - h_1^2\right)ctg\alpha tg\varphi_c + 2c_c\left(h_2 - h_1\right)ctg\alpha}{\gamma_v h_2^2 \lambda_a - 4ch_2\sqrt{\lambda_a}} = 3.04 \quad (5)$$

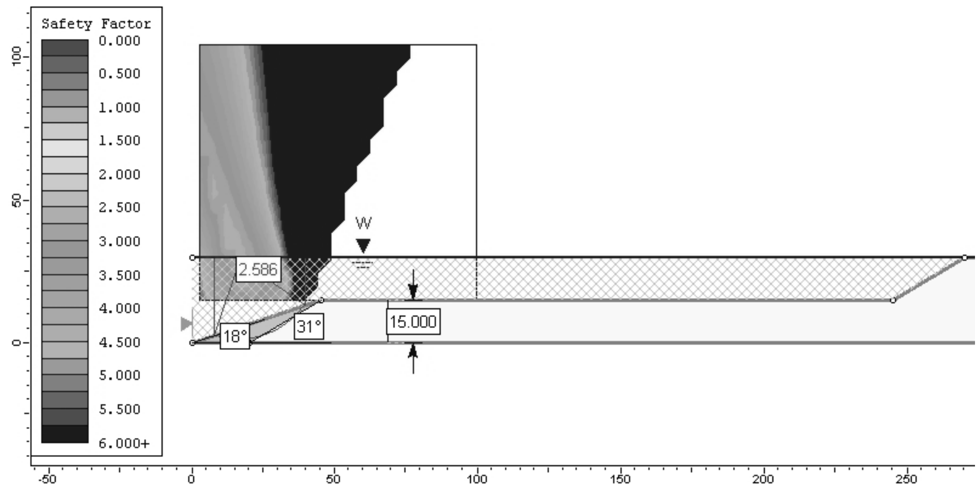


Fig. 7. Stability analyses for the submerged step

The resulting value from the calculations satisfies the condition $s \geq 3$, which means that the system of steps of Tismana interior waste dump is stable.

4. MINING RECONSTRUCTION WORKS

For open pit mining, unlike for underground mining, there are opportunities to improve the environment, particularly through development and optimal integration of waste dumps in the surrounding landscape and by reintroducing their surfaces in the economic circuit. [9]

To achieve this it is necessary to remodel the waste dumps, and then a biological reconstruction (recultivation) of the terrains from this dumps.

Mining reconstruction requires several technological steps to be followed, namely the recovery and conservation of topsoil, construction of the waste dumps, leveling woks, depositing the topsoil on the leveled surfaces and improvement of the terrains.

Biological recultivation is the action of reconstruction of useful or productive capacity of soils by technical and biological treatments. [6]

4.1. Recovery and conservation of topsoil

Recovery and conservation of soil are binding activities for mining units, giving them a special importance, from determining the thickness and continuing with the excavation, transportation, storage and conservation. [4]

Because of difficulties in the correlating the productive activities with the restoration of degraded terrains (Tismana waste dump) it was chosen the variant of depositing the topsoil in temporary storages along with clays (with fertility properties) from top of the VI and VII layers. Both soil and clay material will be excavated and transported selectively with conveyors to the distribution nodes on the eastern and western sides of the quarry where they will be picked up and transported to the two temporary deposits where they will be manipulated with deposit-loading machines type ARs - G2000.

Deposits of topsoil should be conserved for some period of time, determined by the duration of reaching the final geometry of the dumps. Their conservation consists of a number of works, such as leveling, creating drainage slopes and drains, respecting the construction rules for waste dumps [5]. Also, during the storage, their grassing is recommended.

4.2. Leveling the surface of the dump

Leveling works must create the conditions for regeneration of soil fertility and plant crops or conditions for constructive purposes, this activity being mandatory for mining units.

These works will be done with bulldozers, and for water drainage they will provided slopes of 2-3% (up 5%) towards the marginal drains of the dump and slope angles from 1:1.25 to 1:4 [5]. For Tismana dump that will be recultivated agricultural, the height of the steps will be of 15 m. In order to determine the volume of leveling works there was constructed a leveling scheme that applies to all the steps of the dump (since they are identical) shown in Figure 8.

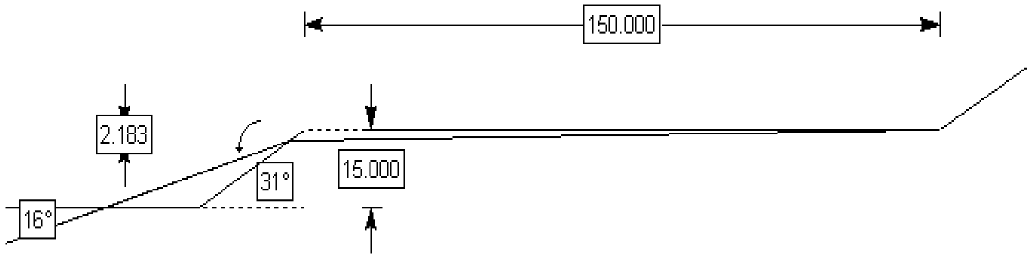


Fig. 8. Leveling scheme

Basically the leveling works involves some remodeling works, the slope angle decreasing from 31º to 16º, which is extremely favorable in the context of the proposed rehabilitation type (agricultural) in the sense that it provides easy access to the machinery and equipments used in agricultural works. [8].

Reduction of the slope angle has a beneficial effect on the stability of the individual steps of the waste dump, as it can be seen from Table 4 and Figure 9.

Table 4. ***Stability analyses after remodeling***

Section L1-L1	**Maximum height**	**Slope angle**	**Analyses method**		
	H (m)	α (degree)	Fellenius	Bishop	Janbu
Individual step (remodeled)	15	16	1.942	2.004	**1.905**

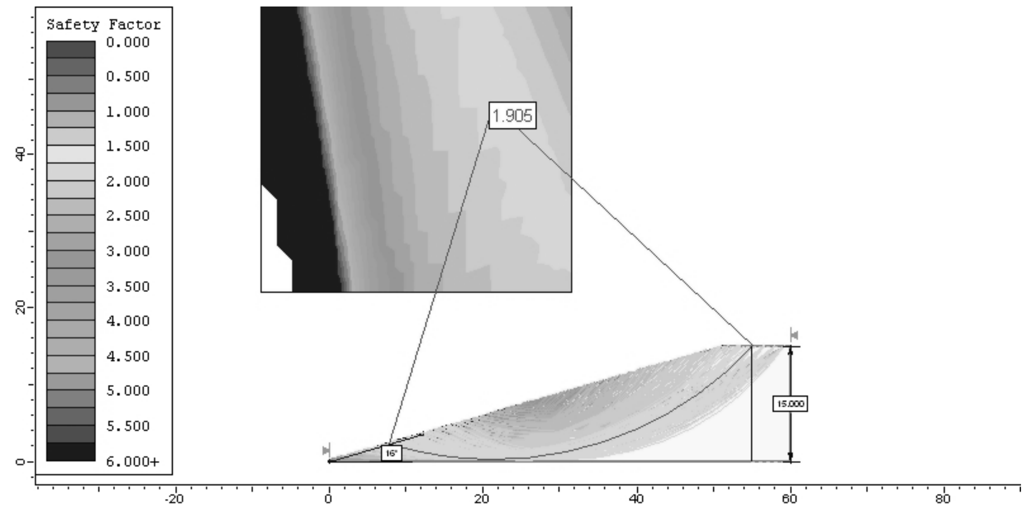


Fig. 9. Stability analyses for a single step (final geometry)

The total volume of material required to be vehiculated for leveling/remodeling works will be:

$V_{n/r}$ = surface of the leveling triangle x total length of the steps

$S_{tr} = 163.5\ m^2$

$L_t = 51100\ m$

$V_{n/r} = 163.5\ m^2 \times 51100\ m = 8354850\ m^3$ material required to be vehiculated for leveling/remodeling works

4.3. Deposition of vegetal soil on the leveled surfaces

The mixture of topsoil excavated selectively along with fertile clays will be reexcavated from the two temporary deposits deposit-loading machines type ARs - G2000, and will be transported by conveyor belts to the dumping machines serving the steps 3, 4, 5 where it shall be deposited in a uniform layer of 0.5 m thickness.

On the second step there will not be deposited fertile soil, the being a buffer area (it will be just grassed, which does not require deposition of fertile soil) between the area destined for agricultural recultivation and the lake formed in the remaining hole.

For the rest of the waste dump (steps 6, 7 and 8) there will be used the traditional means of transport, trucks, and leveling the uniform layer of fertile soil with a thickness of 0.5 m will be made with bulldozers.

The total volume of the mixture of topsoil and fertile clays will be:

$V_{sol} = 4565000\ m^2 \times 0.5\ m = 2282500\ m^3$ fertile material

On 245.5 ha the fertile material will be deposited by continuous technology (using dumping machines), and the rest of 211 ha by conventional methods.

$V_{sol1} = 2455000\ m^2 \times 0.5\ m = 1227500\ m^3$ fertile material deposed by continuous technology

V_{sol2} = 2110000 m^2 x 0.5 m = 1055000 m^3 fertile material deposed by discontinuous technology

4.4. The improvement of the terrains from the dump

Land improvement works on dumps aims at reducing the acidity and obtaining of an optimal pH, able to ensure the conditions necessary for the development of different plant species used for the reintroduction of the dump into the economic circuit. [5]

Mechanized spread of lime (limestone) can be done with: a sputtering machine type D-352, with tanks of 1.2 m^3 of lime, having a splashing width of 2.85 m; a sputtering machine type D-027, with three tanks of 1.2 m^3 of lime, with scattering width of 7.50 m; a machine type MIC -1 etc.

4.6. Construction of guard channels and hydrotechnical drilling

To avoid the accumulation of water, on the dump's contour, at the contact with the surrounding natural terrains there will be built guard channels to take water from surface runoff and direct it to the lake formed in the remaining hole or towards the southern spillway channel.

Hydrotechnical observation drillings, in number of 24 (for tracking the hydrostatic level in the dump) will be performed on the steps of the dump at at the elevations +200, +230, +260 and +275 at a distance of 500 m between them, all around the dump.

On the north side of the dump there will not be drillings at the elevation of +200, since the first step of the dump is at +215 m elevation.

The location of the hydroobservation boreholes can be traced on the final situation plan (after reconstruction) presented in Figure 10.

5. RECULTIVATION WORKS

For the internal dump Tismana, on a 456.5 ha surface, following the reconstruction works carried out, results flat terrains, with general slopes of up to 5º.

The resulting terrains, taking into account the analyzed features, have potential for productive agricultural activities. The previous result (for example on Roşia de Jiu external waste dump) recommends this type of redevelopment of Tismana waste dump.

Thus, it is proposed a gradual agricultural recultivation, divided into at least three years: autumn vetch (peas and barley) - corn - wheat.

The vetch - pea (Pisum arvense L.) and an autumn grain - barley (Hordeum vulgare L.) is a fodder crop that can be successfully used as fertilizer - green mass - to improve the structure and organic matter on anthropogenic lands.

Corn - the silage maize crop purpose is to be use it as green meal fertilizer to improve the soil from the dump in organic matter.

Winter wheat - (Triticum aestivum L.) is present in almost all agricultural rotation systems, is considered a very good run plant because it has a relatively short growing season and promotes the attainment of the optimum conditions for seedbed preparation for the next culture.

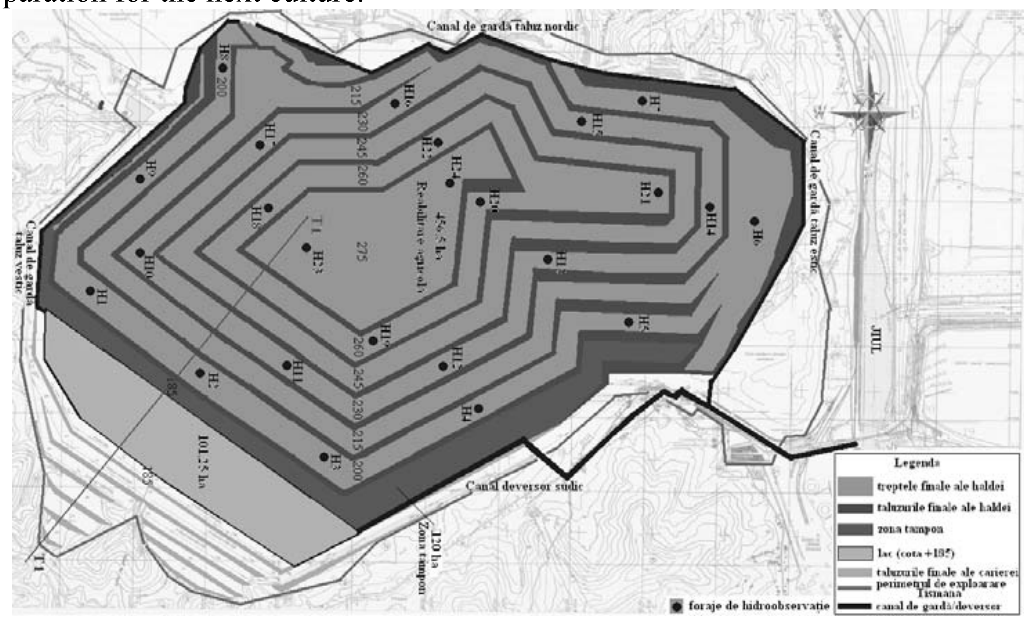


Fig. 10. Situation plan for Tismana waste dump after reconstruction

Winter wheat can be grown in our country under the following conditions: very favorable on 19.5% of arable land, favorable on 70.4% and less favorable on 7.2%. In most areas of culture in our country wheat production is mostly influenced by the degree of natural fertility of the soil and the technological measures applied to improve the fertility.

6. CROP MONITORING

Crop monitoring will be carried out by specialists (agronomists, researchers from land reclamation institutes, etc.) and they will follow the growth rhythm of plants, number of mature plants, mature plant coverage of the surface etc.

To make these determinations there will be established observation areas, that are representative for the entire surface reclaimed in the agricultural circuit and frequency of measurements will be consistent with development periods of the cultivated species.

Monitoring of the agricultural output will be seasonal.

7. ECONOMIC CONSIDERATIONS

For the works needed to reintroduce Tismana waste dump into the economic circuit (by performing the work described in the previous paragraphs) the conditions under which the works can be performed largely in parallel, it takes about 160 days (taking into account the work of sowing), the total investment will be of 4959970 lei.

Given the variability of prices (and their trends) it can be taken into account the allocation of 5,000,000 lei for the works needed to reintroduce Tismana internal waste dump into the agricultural circuit. [9]

CONCLUSIONS

The area where Tismana quarry and internal waste dump are located is characterized by a climate regime specific to Getic Subcarpathians and piedmont.

Choosing the recultivation variant, namely agricultural, had regarded to the principles of environmental planning and it also considered the needs of local communities, the mine closure plans and the extent to which these plans have been included in landscaping plans developed by the City Council of Câlnic.

For the reintroduction of the waste dump into the agricultural circuit is necessary to establish methods to eliminate, control or reduction of land degradation phenomena related to anthropogenic activity carried out in the quarries.

Total maximum design height of Tismana waste dump will be of 120 m and the width of the steps is of 150 m, except the first and the third which are designed to be of 200 m.

From the stability analysis conducted results that the individual steps, general slopes and the steps system presents good stability, the stability reserves being consistent with those provided by the regulations in force.

The lake that will be created in the remaining hole at the contact with the dump will multiple functions: ensuring the recovery of the hydrostatic level in the dump's body, intake of the water from precipitations collected by the guard channel on the western side of the dump, provide a source of water for irrigation during periods of rainfall deficit. The calculated volume of water required to create an accumulation of water up to +185 m elevation is of 17,668,125 m^3 and the lake's surface will be of 101.25 ha.

Agricultural recultivation will be done by practicing crop rotation of vetch, corn and winter wheat on an area of 456.5 ha (the difference between the total area of the dump of 644 ha and surface agriculturally recultivated is given by the submerged portion and the buffer area).

By considering the optimal variant for reintroduction into the economic circuit of Tismana dump since its construction phase, it may increase the economic efficiency of the process of rehabilitation. Thus constructive solutions can be adapted to allow obtaining a consistent geometry with the rehabilitation chosen variant (low heights and angles of slope of the steps, giving access to agricultural machinery).

By designing a geometry consistent with the reintroducing in the economic circuit option minimizes the amount of mining redevelopment works to and thus reduce the costs entailed, increasing the overall effectiveness of the rehabilitation process.

REFERENCES

[1]. **Florea, M.N.,** *Alunecări de teren şi taluze*, Editura Tehnică, Bucureşti, 1979.
[2]. **Fodor, D.,** *Exploatarea zăcămintelor de minerale şi roci utile prin lucrări la zi*, vol. I şi vol. II, Editura Tehnică, Bucureşti 1995.
[3]. **Fodor, D.,** *"Stabilitatea taluzelor în cariere, la halde şi iazuri"* - O.D.P.T. - M.M.P.G. Bucureşti, 1973.
[4]. **Fodor, D., Baican, G.,** *Impactul industriei miniere asupra mediului*, Editura Infomin, Deva, 2001.
[5]. **Lazăr, M.,** *Reabilitarea terenurilor degradate*, Editura Universitas, Petroşani, 2010.
[6]. **Rojanschi, V. ş.a.,** *Protecţia şi ingineria mediului* – Editura Economică, Bucureşti, 1997.
[7]. **Rotunjanu, I.,** *Stabilitatea versanţilor şi taluzurilor*, Editura Infomin Deva, 2005.
[8]. **Smeu A. C.,** *Soluţii de redare în circuitul economic a haldelor de steril din Oltenia*, Raport de Cercetare nr. 2, Petroşani, 2010.
[9]. **Smeu A. C.,** *Soluţii eficiente de construire şi gestionare a haldelor de steril din bazinele miniere Rovinari şi Motru pentru redarea în circuitul economic*, Teză de doctorat, Petroşani, 2012.
[10]. *****,** *Prescripţii tehnice la „Norme specifice de protecţie a muncii pentru minele de cărbune şi şisturi bituminoase*, MMPS, 1997.

Scientific Reviewers:
Prof. Ph.D. Eng. Maria LAZAR

SOURCES OF POLLUTION OF THE SURFACE HYDROGRAFIC SYSTEM AND THE UNDERGROUND WATER IN THE JIU VALLEY MINING DISTRICT (VALEA JIULUI-ROMANIA)

ANA NICOLETA SEMEN*

Abstract: *The sources of pollution of the hydrographical system as follows: industrial waters resulted from the mining activity; technological waters generated by other economic activities; domestic waste waters produced by the towns and villages. Mining is the main activity in the region and is the main polluter with mine water and is represented by three mines (E.M. Lonea, E.M. Petrila, E.M. Livezeni) as polluters of the East Jiu, respectively four mines (E.M. Vulcan, E.M. Paroseni, E.M. Lupeni, E.M. Uricani) as polluters of the West Jiu. In order to know the quality of the surface waters, samples from the East Jiu upstream Cimpa (where the water is not polluted) as well as downstream Livezeni and from the West Jiu upstream Campu lui Neag and downstream Iscroni have been taken. The index of global pollution for the East Jiu is placed in the class II of quality and is in the process of natural regeneration; The waters of the West Jiu are more polluted than in the eastern side of the district, being placed in the class IV of quality and measures must be taken to collect and treat the technological and domestic waste waters.*

Key words: *pollution, hydrographic system, industrial waters, mines, quality indicator*

1. INTRODUCTION

The surface hydrographic system of the Jiu Valley mining district is represented by the East Jiu and the West Jiu, having a total length of 69.8 km (down to the entrance in the Jiu's defile. Out of the total length, 60% lies in the populated area. Until Cheile Butii for the West Jiu and Răscoala area for the East Jiu the rivers do not cross populated areas and as a result the pollution is insignificant. In addition to the two Jiu rivers, the hydrographic system encompasses secondary rivers (Voievodu, Rosia, Maleia, Slatinioara, Salatruc, Aninoasa, Dealul Babii, Baleia etc) which go through inhabited areas or areas economically active, rivers with a low debit of water, causing a high pollution for these rivers. The underground water related to the secondary rivers is situated at about 4-12 m under the surface of the earth and is affected by the surface water, by the biochemical processes that affect the pluvial water quality and by its route in the underground water.

* *student Ph.D. Eng, at the University of Petroșani*

The organic matter carried by the rain water or contained in the domestic and technologic waste water, the metals and the hydrocarbons retained in the filtering bed use oxygen, produce ammonia, phosphates, dissolved organic carbon, elements that produce an alteration of the quality of the underground water.

The springs fed by the underground water, which are numerous in the district, do not have clean „spring water”, but have contaminated water.

2. SOURCES OF POLLUTION OF THE HYDROGRAPHIC SYSTEM

From the point of view of the economic activity in the area we can identify the sources of pollution of the hydrographical system as follows:

- industrial waters resulted from the mining activity;
- technological waters generated by other economic activities;
- domestic waste waters produced by the towns and villages.

The industrial, technological and domestic waste waters affect the emissary as follows:

- change of the physic quality by changing the colour, the temperature, the electric conductivity, by generating deposits, foams or floating pellicles;
- change of the taste and smell;
- change of the chemical quality by changing the pH, increasing the content of toxic substances, change of the hardness;
- decrease of the quantity of dissolved oxygen due to the organic substances;
- destruction of the flora and fauna, favouring the development of the microorganisms.

2.1. The characteristics of the industrial waters resulted from the mining activity

Mining is the main activity in the region and is the main polluter with mine water and is represented by three mines (E.M. Lonea, E.M. Petrila, E.M. Livezeni) as polluters of the East Jiu, respectively four mines (E.M. Vulcan, E.M. Paroseni, E.M. Lupeni, E.M. Uricani) as polluters of the West Jiu (fig. 1).

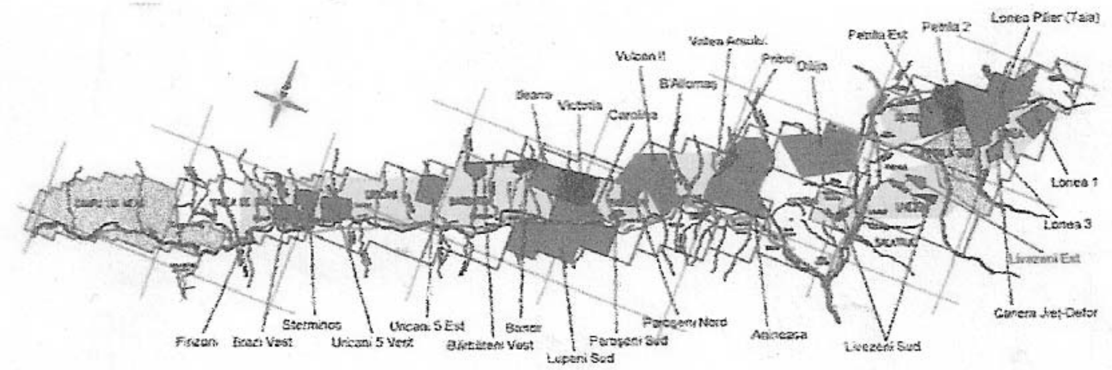


Fig. 1. The coal mining district of the Jiu Valley

In order to know the quality of the surface waters, samples from the East Jiu upstream Cimpa (where the water is not polluted) as well as downstream Livezeni and from the West Jiu upstream Campu lui Neag and downstream Iscroni have been taken.

The laboratory analysis have tried to determine some quality indicators: organic substances (CCO), suspensions, phosphor, ammonium (NH_4), considered to be the main polluters, and based on this to determine the global pollution indicator. The reliability notes of the quality indicators for the East Jiu are presented in Table 1 and for the West Jiu in Table 2.

Table 1 *Reliability notes for the quality indicators for the East Jiu*

Quality indicators	**Reliability note Nb**	
	Upstream East Jiu Section Cimpa	**Downstream East Jiu Section Livezeni**
Suspensions	8.7	6.3
Ammonium (NH_4)	9	7.7
Phosphor (P)	8.3	5
Chemical consumption of oxygen **(CCO)**	9	6.5
Global pollution indicator I_{pg}	I_{pg}=1.31	I_{pg}=2.49

The global pollution indicator for the Section Cimpa, upstream the mines have a value of 1.31 – the water is naturally polluted in acceptable limits, the effects are not harmful. The pollution indicator downstream the polluters (2.49) reveal that the acceptable limits are exceeded.

Table 2 *Reliability notes for the quality indicators for the West Jiu*

Quality indicators	**Reliability note Nb**	
	Upstream West Jiu Section Campu lui Neag	**Downstream West Jiu Section Iscroni**
Suspensions	9	4.2
Ammonium (NH_4)	8.7	5.8
Phosphor (P)	9	4.8
Chemical consumption of oxygen **(CCO)**	8.5	5.6
Global pollution indicator I_{pg}	I_{pg}=1.29	I_{pg}=3.90

The global pollution indicator reveals that the I_{pg} has a normal value in the sections not affected by the mining industry (1,29) and downstream the polluters it is 3,9 meaning over the acceptable limits and very harmful effects on the flora and fauna.

The global pollution indicators resulted after the mining activity were represented graphically taking into consideration the reliability notes compared to the ideal status (fig. 2).

The evaluation of the quality of the mixed mine and domestic waste waters done by the Environment Laboratory of the National Hardcoal Company show variations from one mine to another (see Table 3).

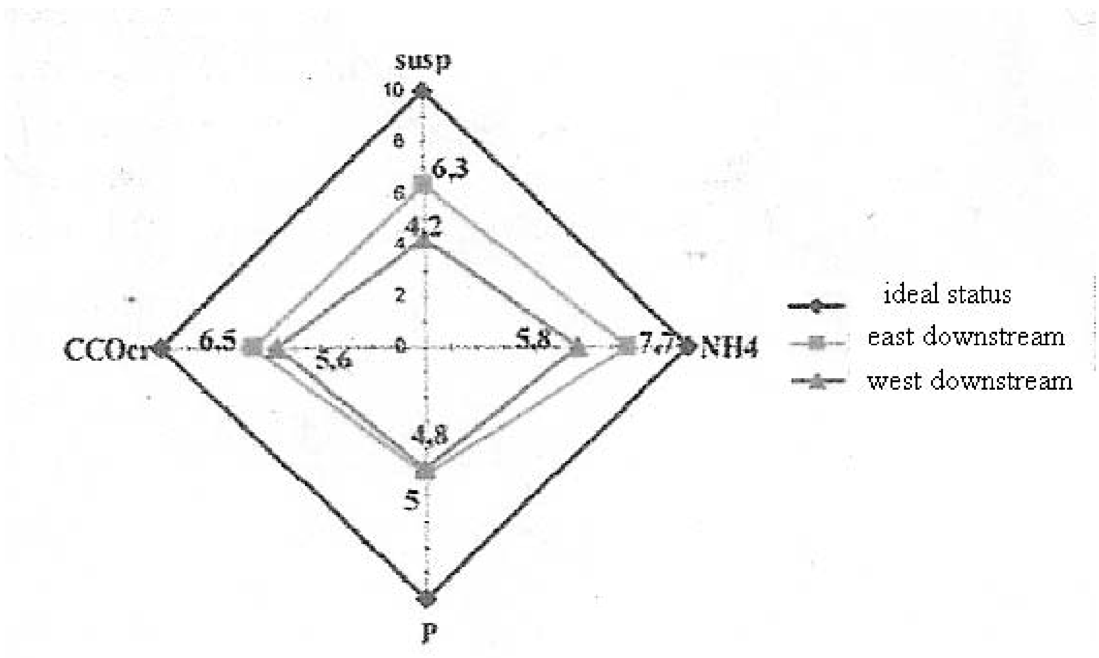


Fig. 2. Graphical representation of the global pollution indicators for the East Jiu and the West Jiu downstream the main polluters

Table 3

Mine	Fix residuum mg/l	Suspensions mg/l	pH	Ammonium NH_4	Dissolved oxygen Mg O_2/l
E.M. Petrila	780-1334	26-123	7.06-7.85	4-48	26-100
E.M. Lupeni	814-2145	37-149	7.09-8.4	5-52	28-96
E.M. Uricani	620-1440	24-96	6.8-7.4	3-36	23-88
Maximal admissible concentrations CMA	2000	60	6.5-8.5	3	25

We can see that most of the indicators are over the limits (up to 14 times for the ammonium), 2,5 times for the suspensions, 4 times for the dissolved oxygen, affecting the quality of the water. The quality classes are D, E (poor and very poor).

2.2. The characteristics of the technological waters generated by other economic activities

They are usually represented by the car wash business, five of the in the eastern side of the district and seven in the western side. The waste water generated by these businesses is evacuated in the sewerage system and from here into the emissary.

The analysis regarding the quality of the waters show that the following admissible concentrations are exceeded: phosphor (2.5-4 times), phenols (2-3.5 times), anionic detergents (over 9 times), hydrogen sulphide (2.5 times) and, respectively, active foam. The analysis shows that the concentrations for oil products are two times higher than the maximal admitted concentration (5mg/dm^3).

2.3. The characteristics of the domestic waste water generated by the urban and rural systems as well as by the economic activities

The waste waters generated by urban system and by the economic activities are about 750,000-1,200,000 m^3/year, evacuated in the sewerage system and then in the emissary, either directly or after being treated in the waste water treatment plants (Danutoni and, respectively, Uricani). The analysis shows that the admissible concentrations are exceeded as follows: for the phosphates up to 3 times, for the anionic detergents up to 8 times, for the phenols up to 2 times, for the ammonium up to 3 times, for the organic substances up to 3 times.

The rural system, represented by the villages Cimpa, Campu lui Neag, Valea de Brazi, Dealul Babii has not an sewerage system, the waste waters being evacuated directly into the sources of water, causing high values of concentration for the phosphates, synthetic detergents, phenols, ammonium, organic materials.

3. CONCLUSIONS

The analysis of the sources of pollution of the surface hydrographical system and the underground waters in the Jiu Valley district shows the following:

- there are three main sources of pollution, respectively: the mines, other economic activities and the urban and rural systems;
- the main polluter in the waters are the solid suspensions, the concentration growing as the water crosses more industrial zones;
- the degree of pollution is different for the East Jiu and the West Jiu, due to the presence of more mines in the western side;
- the analysis shows that the degree of pollution is increased due to all the sources of pollution identified, causing values over the admitted limits for ammonium, phosphates, organic materials, hydrogen sulphide etc;
- the index of global pollution for the East Jiu is placed in the class II of quality and is in the process of natural regeneration;

- the waters of the West Jiu are more polluted than in the eastern side of the district, being placed in the class IV of quality and measures must be taken to collect and treat the technological and domestic waste waters.

REFERENCES

[1]. Arad V. s.a. – *Some aspects of ecological impact produced by hard coal mining in coal basin Pketrosani and the perspective of pollution reducing of Jiu River"*, Balkena, Roterdam, 1998.
[2]. Caramete A. – *Stabilirea impactului produs de activitatea miniera asupra raului Jiu*. Teză de doctorat 2008.
[3]. Dumitrescu I. – *Poluarea mediului*, Ed. Focus 2002.
[4]. Fodor D., Baican G. – *Impactul industriei miniere asupra mediului*, Ed. Infomin, 2001.
[5]. Traista E. – *Ingineria mediului - igiena aerului si a apei*, Ed Universitas, 2000.

Scientific Reviewers:
Prof. Ph.D. Eng. Romulus-Iosif SÂRBU

STUDY ON ECOSYSTEM RESTORATION ON DEGRADED TERRAINS BY COAL MINING IN CÂMPU LUI NEAG QUARRY - E AREA

REBECA- VASTI VINTER (ZAHARIA)[*]
CONSTANTIN ZAHARIA[**]

Abstract: *The activity that was conducted in the mining area of Câmpu lui Neag quarry - E area, had as objective the exploitation of energetic pit coal located in layers 3, 5 and 17/18, up to 760 and 710 horizons and lead to the degradation of surrounding terrains, with devastating effects on flora and fauna causing drastic changes of landforms and hydrological elements. With the cessation of mining exploitation in Câmpu lui Neag quarry - E area a series of ecological rehabilitation works were executed on the degraded terrains, which meant just planting seedlings of acacia, trying to stabilize them and their integration in the surrounding landscape. Stability studies on the former quarry slopes were never conducted and there was no intervention in order to reshape the final quarry steps and slopes. The paper presents a complex study to design land reclamation and restoration of ecosystems in terms of ensuring environmental and economic benefits to local communities in the area.*

Key words: *mining, quarry, slopes, stability, recovery, ecosystem restoration*

1. LOCATION AND NATURAL SURROUNDINGS

From the administrative point of view, the mining area belongs to Uricani town, Câmpu lui Neag village, Hunedoara County. From the physico-geographical poin of viewit is located on the southern frame of Petrosani basin, north of the West Jiu, at altitudes of 650-750 m

The quarry is located in the eastern edge of Câmpu lui Neag mining field (Fig. 1) in the vicinity of West Jiu and in the west is bordered by the perimeters of the micro quarries A and B areas. In the southeastern extremity the E area borders with the accumulation lake's Valea de Pești (Fish Valley).

The landscape is predominantly mountainous; Uricani town is bounded in the north by Retezat Mountains and in the south by Vâlcan Mountains. Hydrographic network of the area is tributary to West Jiu which gathers the waters that flow perpendicular to its direction. The depressionary character favours the accumulation

[*] *Eng. Inspector S.S.M. at Zaharia Rebeca Vasti P.F.A., e-mail zahariarebeca@yahoo.com*
[**] *Cheif Eng. at S.C. Apa Serv Valea Jiului S.A.*

and stagnation of cold air, which causes frequent temperature inversions even between relief units with low altitudes.

During summer the warming are stronger due to reduced circulation, so that annual and daily thermal amplitudes will be differentiated from other regions.

Fig. 1. Câmpu lui Neag quarry- E area (satellite view)

The climate is moderate continental, with average annual temperatures of mountain climate type, with annual average temperatures ranging around 7°C. Lowest average temperatures are recorded in January (-15°C) and the highest in July (20°C). The average amount of rainfall is 693.7 mm/year at Petroșani the meteorological station [9].

Soils in Jiu Valley have a number of features related to the pedogenetic conditions and landscape features. Overall, they have a regional character, determined by altitude and therefore bioclimatic conditions.

The protected flora from Uricani area consists of 1050 plant species, woody species are included in protected areas or natural monuments. Around the town prevails, both on the southern and northern slopes, forests of beech, which in some places, vegetate with other species like: spruce, pine, larch, mountain maple, ash, hornbeam, birch forming clumps that spreads at the bottom of the beech forest. Specific to mountain forest are: grouse, mountain hen, blackbird, rock collar thrush, black woodpecker, raven, deer, lynx, brown bear, pine marten.

2. THE CURRENT SITUATION OF THE QUARRY

2.1. Location and geometry

The area of the former quarry Câmpu lui Neag-E area, is located near DN 66A, and the base of the quarry is at an altitude of 816 m in the SW (entrance area) and 846 m in the NE, at contact with the natural terrain (Fig. 1). At the top, at the contact with the natural terrain the altitude ranges from 840 m to the SW, to 855 m in the central area and 869 m in the NE. The total area occupied by the quarry is approximately 3.64 ha (currently represented by its slopes) [8].

The height of the steps was about 10 m, mining works were performed with mechanical shovel excavators. Excavated rocks were then loaded into dump trucks and transported either to the dumps (Poiana Mare and Șesul Șerbanilor) or to coal deposit.

The length of the quarry on a NE-SW direction is 511.5 m in the middle, and the width varies from 95 m to the left and center to 53 m to the right extremity.

Some of the sterile initially deposited in Poiana Mare waste dump was reexcavated and deposited and the exploited area of the quarry E area, parallel to the quarry's slopes. In this way an artificial valley was formed at the contact between the embankment and waste dump that collects rainwater drained from the slopes. During periods of heavy rainfall torrents of mud are forming (water mixed with loose material from the slopes), which created problems in the past to residents who have farms located downstream of the quarry.

2.2. The nature and origin of the material from the quarry, E Area

Area E is geologically located in south of Jiu fault, along which the lower basal horizon formations and the sedimentary complex that contains the 3 and 5 layers that reach the surface.

The synthetic column of the quarry's E area may be described as follows: 0.5 - 1.0 m alluvial terrace (boulders, gravels and sands). It may be a shallow aquifer level that depends on rainfall; 0.5 -1.0 m sandstone; 1.0 -2.0 m, clay; 3.7 m carbonaceous complex (0.7 m coal + 0.5 m clay + 2.5 m coal); 1.0 m clay; 1.5 m sandstone; 0.6 m clay; 2.0 m sandstone; 5.0 m carbonaceous complex, layer 3 (2.0 m coal + 3.0 m coal-clay with coal intercalations); 2.0 m sandstone, bed of the 3rd layer.

2.3. Characteristics of rocks

The rocks have a medium-coarse texture, high content of minerals and low content in nutrients. From the mineralogo-petrographic point f view, this sterile waste is represented by clays, clayey sandstone, marls, microconglomerates and carbonaceous shales with a varied granulometry.

The geomechanical characteristics of the rocks from the quarry's slopes have been determined by laboratory investigation, the values measured are shown in Table 1. The physico-mechanical characteristics, allowed the determination of their variation limits and determination of necessary geomechanical indexes [6].

From the study the following conclusions were drawn:

- the topsoil, present on top of the quarry, is a powdery loamy sand with a psamito-pelt structure in which occur fragments of gravel;

- from the point of view of the compressibility of the rocks, they exhibit moderate to heavy compaction. Parameters expressing the compressibility of rocks were determined for a lithostatic load between 1.0 ÷ 2.0 daN/cm^2;

- there is a very sharp variation of cohesion and internal friction angle depending on humidity.

Table 1. ***Characteristics of the rocks from Câmpu lui Neag quarry – E area***

Crt. no	Specification	MU	Variation limits
1.	Granulometry - clay (under 0.005 mm) - dust (0.000 – 0.05 mm) - sand (0.05 – 2.0 mm) - gravel (2.0 – 20 mm) - boulder (over 20 mm)	 % % % % %	 0÷2.3 2.4÷4.1 18.5÷50.7 20.3÷43.9 5.3÷18.40
2.	Specific weight	g/cm^3	2.67÷2.77
3.	Volumetric weigh	g/cm^3	1.81÷1.94
4.	Natural Humidity	%	11.87÷14.38
5.	Porosity	%	30.83÷37.23
6.	Pore index	-	0.59÷0.61
7.	Saturation coefficient	-	0.46÷0.58
8.	Cohesion	daN/cm^2	0.34÷0.41
9.	Friction angle	°	19÷23
10.	Compressibility coefficient	cm^2/daN	0.9
11.	Deformation module	daN/cm^2	97
12.	Specific compaction	daN/cm^2	5.9

To characterize in terms of the chemical composition the rocks from the quarry's slopes samples were collected and subjected to laboratory analysis, the results of these analyzes are presented in Table 2.

Table 2. ***Chemical composition of the rocks from Câmpu lui Neag quarry – E area***

Rock type	Parameter								
	pH	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	MgO %	CaO %	Na_2O %	K_2O %	Volatile %
Topsoil	6.96	60.37	8.12	4.90	0.62	0.78	0.82	1.60	19.70
Rocks from the slopes	7.11	61.81	10.21	4.73	0.81	0.69	0.89	1.34	20.67

Fertility characteristics were determined on samples collected at the top of the slope and the flat areas of the quarry (20 cm deep), the values determined are shown in Table 3.

These data indicate that the pH of the rocks from the quarry slops is similar to the natural soil in adjacent areas and has an almost neutral value, eliminating the need for amendments or neutralizing interventions. Macronutrient content is middle, and from this point of view allows installation of spontaneous species, species that are present in the adjacent areas and are unpretentious to soil quality (especially birch and shrub species like: wild rose, hazel , hawthorn and so on and herbaceous species) [7].

Table 3. ***Fertility characteristics***

Nr. crt.	Parameter	MU	Value			
			P1	P2	P3	P4
1	pH	Unit. pH	7.15	7.13	6.85	6.63
2	Humidity	%	19.01	18.51	18.13	17.90
3	Humus	%	7.11	7.17	8.20	9.05
4	N	mg %	0.35	0.37	0.41	0.49
5	P	mg %	4.2	4.6	5.3	4.8
6	K	mg %	7.6	7.7	7.8	8.0

2.4. Considerations regarding the technical condition

The final slopes of the quarry, which in fact were working slopes were not arranged in advance (by reshaping, terracing, leveling, etc.). When designing the work slopes the value of the safety coefficient is lower than the safety coefficients adopted for the final slope of a quarry that should ensure their stability for long periods of time [3, 5].

Under these conditions appeared stability problems that consist of edge breaks, shallow and deep erosion, superficial landslides and plastic flows of rocks on the slopes (Fig. 2). These plastic flows moved and planted seedlings, so they were transported to the base of the quarry.

Fig. 2. Plastic flows on the quarry's slopes

The factors that negatively influenced the stability of the slope depend on the rocks nature dump, the geometry of the steps and rainfall regime in the area. Another factor that adversely affects slope stability is the absence of herbaceous vegetation on much of the slope. Lack of herbaceous vegetation favores the superficial runoff of rainfall which dislocates rocks from the slope and forms torrents of mud.

Because of the many problems created by these mud leaks to local inhabitants, in the years 2012-2013 a concrete guard channel a spillway ware made whose role is to collect torrents and direct them toward West Jiu river.

Summarizing those presented above we can say that, except the area reforested with acacia, the quarry's slopes suffered deformation phenomena that can be reactivated during periods of heavy rainfall or in snowmelt period, and that may threaten the overall slope stability (producing deep landslides).

Given the current poor technical condition of the Câmpu lui Neag- E area quarry's slopes, prior to execution of the ecosystem restoration works there should be carried out development works and preparation of the land and the stability of the slopes must be verified after making these works.

For the current situation conducting stability analysis is superfluous since negative geo mining phenomena occurring on the slope are obvious.

3. IDENTIFICATION OF TERRAINS REUSABILITY POSSIBILITIES

3.1. Need for land restoration

Ecological restoration of degraded lands and require special attention in terms of legislative and regulatory framework to allow greater flexibility in the forecast and the possibility of changing the destination of land and take account of the attractions and characteristics of the territory based on a complex analysis of landscape built on the most modern work methods.

The need for recovery of land (ecological, naturalistic, productive or for any other purpose) can not be more obvious than in an area like Jiu Valley, area that has developed over a relatively narrow strip of land plain terrain, guarded from all four directions by high mountains. The fact that currently the degraded land by the quarry has not a specific function and there is a significant reactivation risk of plastic flow or landslide (which would endanger farms in the area downstream of the quarry) emphasizes the need to identify opportunities to capitalize its value on medium and long term.

3.2. Possible variants for the recovery of land

In theory there are multiple possibilities for the recovery of a degraded land, possibilities listed next: naturalistic recovery, recovery for recreation and leisure, productive recovery, residential recoveries, cultural recovery, recovery for productive and technological installations, other types of recovery [2, 3].

In choosing the recovery variant of degraded land we must keep in mind the fundamental principles of ecological planning: the principle of globality or intercasuality, principle of ambient autonomy, minimal sizing and reversibility principle, the principle of economy, the principle of respect for tradition, the principle of transparency and democracy, the principle of respect for the demands of the population.

Discussions with former owners of the degraded land by mining activity at Câmpu lui Neag focused on two main directions:

- naturalistic recovery;

- productive recovery.

Finally the idea that was supported basically combines the two options, which implies lower cost and lower risk, the establishment of a hazel culture.

This culture (grafted and selected varieties) can bring substantial revenue to the community and at the same time provides a integrations of the area in the surrounding landscape (wild hazel is a common species on neighboring hills).

Today's desolate landscape in the former quarry area would be tonic and refreshing, and would provide jobs and income to ensure a decent living standard for local residents. In the last 15-20 years, in domestic conditions there have been tried and found valuable varieties of hazel from world selections that could be grown successfully in the area of Câmpu lui Neag- E area quarry [7].

3.3. Level of intervention

As noted above, the current situation of the land is a serious one, lack of vegetation on greater part of the quarry's slops, plastic flows and erosion, slope edges breaks, which requires several types of interventions.

First, before speaking of ecological restoration, a series of specific works to redevelop the land must be carried out. Works to restore the slopes and flat parts of the quarry's steps, leveling works, planning and extension of existing guard channels in order to steer water from rainfall. This works must be done urgently to eliminate current plastic flows that threaten the overall stability of the slopes (and therefore represents a risk factor for households in the area of influence).

A second category of works to be carried out refers to revegetation of slopes and flat areas of the quarry's steps. Initially applying fertilizers and grassing of land, followed by a second phase (executed in autumn) which will consist of planting hazel seedlings, by a well defined formula, in accordance with the recommendations of the experts.

3.4. The purpose and objectives of recovery

Any recovery project of degraded terrains mainly aims to improve the quality of the degraded land, minimum returning the terrains to their initial capacity, to ensure future use.

Therefore, the aim of this paper is to transform an unproductive area or rather an area without a specific function, strongly affected by negative geo-mining phenomena, but also worthless, in a landscaped area with a well-established functionality capable of generating income for the resident population, while ensuring the integration of the portion of land affected by coal exploitation in the surrounding landscape.

So the purpose of this paper is to design the works needed to be carried out in order to reintroduce the degraded terrains in the economic circuit, while restoring the landscape.

The objectives to be achieved are: redevelopment of slopes and flat areas, development and extension of guard channels, ensuring the slopes stability, monitoring the technical conditions after redevelopment; grassing the land, planting hazel seedlings, monitoring the established culture, estimate costs and revenues, identifying financing sources [7].

4. REMODELING AND PREPARATION WORKSFOR THE TERRAINS

4.1. Works to reshape the slopes and the quarry's steps

These works should ensure a proper geometry of the quarry's steps, so that they provide good stability and allow the works from the stage of ecosystem restoration to be carried out.

Given the current morphology of the terrain these works will be carried out in a different manner for the 4 zones of the quarry (in zone 2 this type of works are not necessary).

For zone 1 it is considered the execution of safe flat areas (Fig. 3a). For the slope in zone 1 a falt belt will be executed, with a width of 20 m. This work will be done with a bulldozer, being somewhat similar with slope reshaping works from top to down.

The amount of material from the slopes to be moved is 16380 m^3, requiring 4 days for the construction of the flat belt on the entire length of the slope.

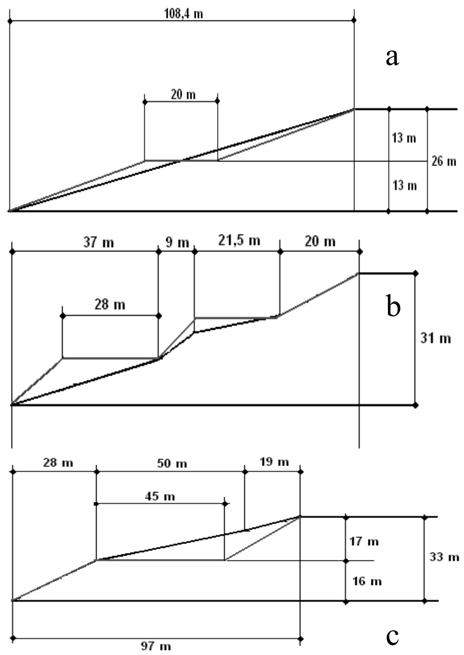


Fig. 3. Sections S1, S3 and S4 after reconstruction

In zone 3 the aim is to restore the three initial steps of the quarry (Fig. 3b). This requires a volume of 31822 m^3 of backfill that will result from the execution of works in zone 4.

To execute this works we use a bulldozer and excavator gear for the restoration works and uploading the material and dumper for moving it from zone 4 to zone 3.

This works will takes 9 days of work performed by the bulldozer, 12 days of excavating, loading and transporting by excavators and dumpers.

In zone 4 works will be perform in order to reconstruct the upper flat part of the first step (Fig. 3c).

After reconstruction works, the terrains which are the object of this paper work will have the configuration shown in Figure 4.

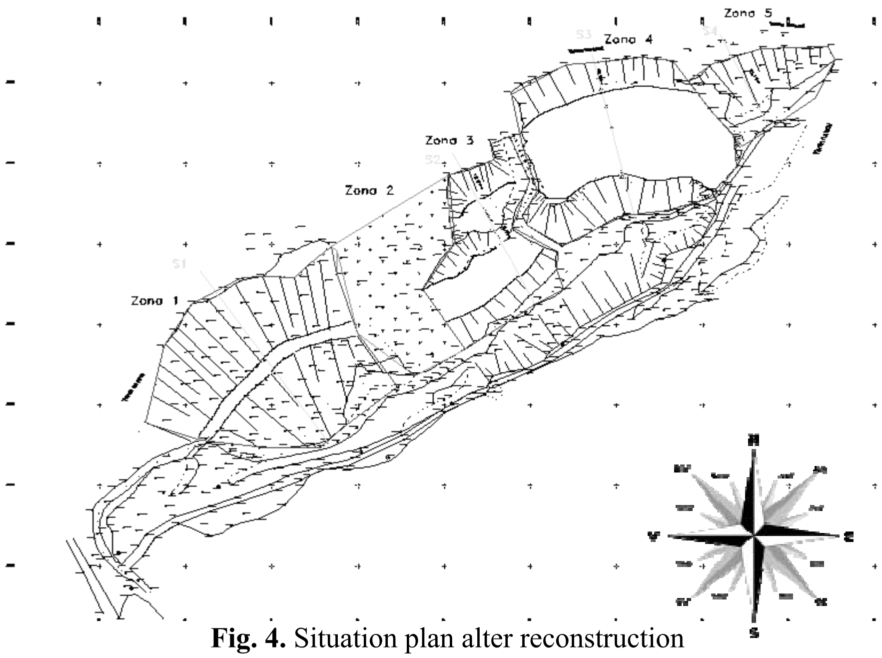


Fig. 4. Situation plan alter reconstruction

Reshaping the two steps of the slope will require the excavation and loading in a dumper of a volume of 90100 m^3 material (cut) which will be partially used to reconfigure zone 3. The remaining 58000 m^3 of material will be transported and stored in the waste dump belonging to ME Uricani.

Leveling works will begin immediately after the reconstruction works. Leveling works will be performed by bulldozers and they start from the limit of the upper step to the edge of the slope. For water drainage the leveled areas will ensure slopes of 2-3% (up 5%) to marginal drains and slope angles from 1:1.25 to 1:4. The total volume of material required to be moved for leveling works will be 14340 m^3.

4.2. Ameliorative and fertilization works

In order to provide the necessary conditions for the first stage of the ecosystems restoration, namely the grassing, taking into account the characteristics of fertility, presented above, is necessary to apply a quantity of fertilizer (complex N:P:K) nitrogen (N): - 55 kg/ha , phosphorus pentoxide (P_2O_5) - 35 kg/ha, potassium oxide (K_2O) - 55 kg/ha. The total area that will spread evenly with fertilizers is 3092 m^2, about 3.1 ha, resulting in a total of 449.5 (450) kg [8].

4.3. Stability analyses of the objective

As stated, the stability analysis is performed only for the slopes resulting from reconstruction works because now the situation is clear in this regard (slope instability phenomena are present along the entire length of the quarry, except zone 2) .

Factors influencing the stability of slopes can be grouped as follows: geological and hydrogeological factors, mechanical natural and geomechanics factors, anthropogenic factors (technogenic) hydro-meteorological and seismic factors, biotic factors [3, 5].

Landslides can have different mechanisms and may be characterized by a well defined sliding surface. The most common forms of sliding surfaces, which can be analyzed by limit equilibrium method are plane, circular and polygonal. Regarding the sliding surface, there are two issues of particular importance, namely: the depth of the sliding surface and the geometrical shape of the sliding surface [4].

For stability analyzes, studying literature, were chosen three commonly used methods: of Fellenius, Janbu and Bishop.

Slope stability analysis for the slopes of Câmpu lui Neag quarry was performed using a geotechnical specialized software, Slide. The values used in the analysis of stability, volumetric weight, cohesion and angle of internal friction are shown in Table 4.

Table 4. ***Physico-mechanical characteristics uset in the stability analyses***

Rock type	**Volumetric weight γ_{nat}, (kN/m^3)**	**Cohesion c, (kN/m^2)**	**Angle of internal friction φ (degree)**
Mixture of rocks from the quarry's slopes	18.10	34.00	19.00

In order to determine the stability reserve of the slopes, their geometry was reproduced using the mentioned software, being calculated for each considered slope the stability factor. It is noted that stability analyzes did not take into account the pore water pressure. The test results are shown in Table 5.

Stability analysis showed that the reconstructed slopes of Câmpu lui Neag quarry-E area, are stable, the stability coefficient values above the 1.3, value recommended by standards for final slopes [5, 6].

In conclusion it can be said that the objective, after completion of remodeling works has a good stability and allow the next steps (ecosystem restoration) to be performed safely.

Table 5. ***Stability analyses results***

Section	**Slope/step**	**Sability analyses for reconstructed slopes**		
		Fellenius	**Bishop**	**Janbu**
S1	superior	2.43	2.51	2.45
S1	inferior	3.11	3.20	3.13
S2	step 3	1.77	1.82	1.78
S2	step 2	1.93	2.02	1.96
S2	step 1	2.16	2.19	2.17
S3	superior	1.53	1.62	1.55
S3	inferior	1.85	1.97	1.87
S4		2.26	2.30	2.29

4.4. Vegetal soil

Being a culture of shrubs is not necessary to make a uniform layer of soil all over the quarry's surface.

Planting of the seedlings will be made in individual holes with loan soil. The hole's dimensions are 40x40x50 cm, the volume of soil needed for a single hole is 0.08 m^3. Depending on the planting scheme, in the next paragraph the total amount of soil will be calculated and in the last paragraph the acquisition costs will be estimated.

4.5. Monitoring the technical conditions of slopes

For this purpose, the simplest and cheapest method is represented by regular surveying. To perform these measurements alignments will be established at each step of the quarry and fixed landmarks placed on natural terrain outside the perimeter of the quarry. Surveying will be performed with total stations.

Another option to achieve topographic measurements on geometry compliance and updating designed situation plans is represented by GPS measurements. GPS measurements can be made both in the case where there is a GPS network and in the case where there is no such a network. To achieve measurements coordinates will be used for GPS points in WGS 84 system. For determination will use one control station and GPS receivers mobile rovers.

Measurements on compliance with designed geometry for Campu lui Neag-E area quarry's steps will be correlated with the works execution rhythm.

5. ECOSYSTEM RESTORATION

For Câmpu lui Neag-E area quarry, as a variant of terrain recovery, was proposed the establishment of a hazel culture. This variant was chosen because it has two main advantages, ensures the restoration of the landscape in the region and brings economic benefits through marketing the peanuts production.

Hazel is not a popular culture in Romania, although the quality and economic importance determined many countries to cultivate hazel on large surfaces. Italy grows, for example, about 40000 hectares and Cyprus, a country with a surface comparable with Constanta County, hazelnuts are grown on 3000 hectares. In Romania, Timiș County is the largest grove of nut trees in Europe over an area of 850 ha which will be extended up to 1,500 ha [10].

Other important cultures: Sibiu on 50 ha, Alba establish a culture 40 ha, but there are many other plantings on smaller surfaces.

5.1. Establishing the planting scheme

Hazel seedlings are planted at a distance of 4 m between them (in other words each hazelnut has a land area of 4 m^2). Planting takes place in spring or autumn (preferably autumn) in the holes at a depth of 40-50 cm, which is then filled with soil (preferably forest soil that favors their adaptation). In the first 2-3 years the culture do not require cutting or cleaning, only then it can be cleaned by trimming branches that form the skeleton. Hazel bear fruit in year 3 or 4 of life.

For seedlings the planting scheme from Figure 5 was chosen.

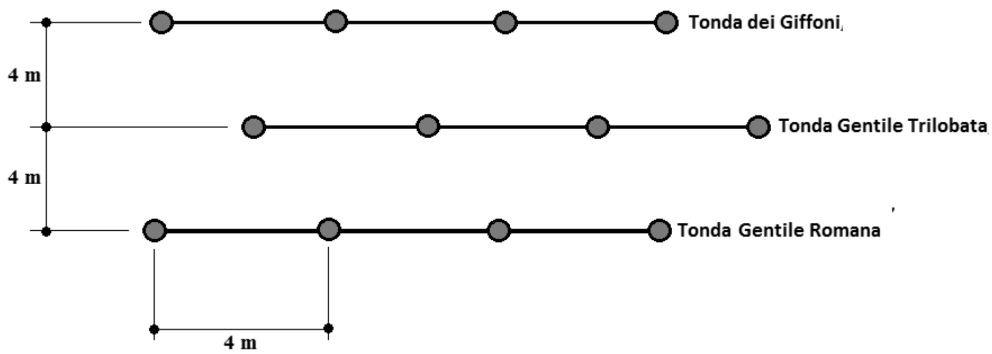


Fig. 5. Seedlings planting scheme

As can be seen from Figure 5, the planting scheme implies planting the seedlings in rows, at a distance of 4 m between them, and 4 m between seedlings. To ensure accessibility to light conditions and water the seedlings will be willing alternating (on rows) and each row will be planted with seedlings from one of three species of hazel that will be purchased.

5.2. Purchase of necessary biotic elements

To restore the degraded terrains from Câmpu lui Neag-E area quarry two distinct phases will be followed:

- *Grassing the quarry's slopes and flat areas*

These works will be carried out in the spring, as soon as the terrain was remodeled. Grassing aims to prevent surface flows and the rapid integration of the area in the surrounding landscape until fall when the hazel seedlings will be planted. The surface of the 4 zones will initialy be grassed on an area of 3.092 hectares (relating to zones 1, 3, 4, 5 in Figure 3). This will grass seed purchased domestically. For grassing a quantity of 464 kg of grass seed will be purchased needed at a specific dose of 15 g/m^2.

- *Purchase of hazel seedlings*

Hazel seedlings will be purchased from nurseries in the country (particularly from Timiş County). There will be purchase three species, namely: Tonda dei Giffoni, Tonda Gentile Trilobata, Tonda Gentile Romana, in equal numbers.

The combination of the three species is recommended for efficient pollination. Also for this purpose, is assessed as positive the presence of acacia trees in zone 2, species that during the flowering attracts many bees.

For planting the whole area of about 3.093 ha (zone 1 - 11525.79 m^2 , zone 3 - 5633.07 m^2 , zone 4 - 10696.26 m^2 and zone 5 - 3065.27 m^2) established according to the plantation scheme, it is necessary a total of 7750 seedlings. The seedlings are supplied in growing pots at the age of two years (Fig. 6).

Fig. 6. Hazel seedlings in growing pots

Their plantation is recommended to be carried out in autumn, when the percentage of fixing is about 90 % as compared to 75-80 % for planting carried out in the spring.

5.3. Grassing and planting works

Seeding works (grassing) will be executed in the spring after the terrain was reconstructed (reshaped, leveled and fertilized).

These works can be performed manually or mechanically where the terrain permits access for machines.

The plantation of hazel seedlings will be carried out during fall under the supervision of specialized personnel of the Forestry Authority and a representative of the company that supplies the seedlings. For planting, in the first phase the terrain will be picketed (planting will done on the quarry's slopes and flat areas), after that, the contracted personnel will dig planting holes and plant the seedlings. After plantation works are finished the perimeter will be surrounded by a protective fence so that animals do not destroy the seedlings.

5.4. Monitoring the culture

Hazel culture monitoring will be conducted by specialists (agronomists, researchers from land reclamation institutes etc.) and they will observe the growth rate of plants, the number of mature plants, the coverage of the recovered surface by mature plants etc.

Monitoring will also be made on the production of peanuts/hazel tree, which in principle should be in the normal range of variation: at the age of 4-5 years, the production of peanuts/plant should be of 2.5 to 3 kg, at the age of 6-7 years, the production of peanuts/plant should be of 7-8 kg. At 10 years the peanut production can reach 20-30 kg/plant in optimal conditions of culture. The profitable duration of a hazelnut plantation is around 40 years [10, 11].

Monitoring the productions obtained will be seasonal - runs every year from September 1 to October 31. There will be used control surfaces placed after planting and will be carried out under the technical guidance for annual inspection of regeneration [1].

Percentage of completions can reach up to 10 % in the second year after planting, and 5% in the third year after planting.

6. ECONOMIC CONSIDERATIONS

Costs related to the restoration of ecosystems from the degraded terrains by Câmpu lui Neag-E area quarry are related to the reconstruction of the slopes, fertilization, revegetation and the establishment of a hazelnut culture.

Estimated total costs for ecosystem restoration in the area of Câmpu lui Neag-E area quarry are of **89643** Euros (about **90000** Euros).

To make an assessment of the time needed to recover the investment is, will review the prices of peanuts on the world market in 2013 and the production of peanuts by the age of the plant.

On August 3, 2013 the price of peanuts on the international market, displayed on the website www.nocciolare.it starts from 3 to 7.5 euro/kg for shelled peanuts.

Debarked peanuts - prices vary between 20 and 24 $/kg. And the prices for hazelnut oil is even higher, starts from 46 – 79 $/kg, and reaches 131 - 168 $/kg [11].

If you do a simple calculation, taking into account the averages, the investment could be covered in a few years (practically from the first year when the hazel trees bear fruits, in the 4th year a profit can be obtained at a production of 2.5 kg nuts/plant) and for a period of 40 years (as the culture is considered viable) only from selling shelled peanuts an income of **755625** Euros can be obtained each year, for 40 years, amount of money that can provide a decent living standard for any private investor in Jiu Valley [7].

Financing sources for compiling the technical and economic documentation, for revegetation of the degraded terrains and those related to the rehabilitation, improvement, maintenance until reaching the massive state: land improvement fund constituted under the Land Law No. 18/1991, as amended and supplemented; allocations from the state budget, local budget allocations; sponsorships; external financial sources; external grants or long term loans; conservation and regeneration of forests fund constituted under Article 63 of the Forestry Code. The possibility of a private investment should not be neglected, by leasing the terrain for a period of 50 years or by purchasing it from the Uricani Public Administration.

CONCLUSIONS

In retrospect, before 1980, the terrains degraded by Câmpu lui Neag-E area quarry were owned by locals from Câmpu lui Neag. On this terrains were located either farms, pastures or forests before they entered in the the administration CNH-SA Petroșani and then in the public domain of Uricani town, in the administration of the Local Council, which are the competent authorities to establish the final use of these terrains.

Variants of recovery and capitalization of the degraded terrains have focused on two main actions: naturalistic and productive recovery. The orientation to the two directions is mainly based on detailed analyzes of terrains and ecosystems in the area and based on economic value criteria.

In this paper work the production version was analyzed, which refers to the establishment of a hazel culture, which can bring substantial revenue to the community and at the same time provides a integration of the terrains in the surrounding landscape (wild hazel is a common species in the neighboring hills) .

Before carrying out the ecosystem restoration works, there have been identified and designed engineering works and preparation of slopes and flat areas, subsequently imposing a study on the stability of the slopes and monitoring works until the revegetation works by applying fertilizers and grassing of the terrains are carried out. It aimed at preventing recurrence of superficial flows and the integration of the area in the surrounding landscape until autumn when the hazel seedlings will be planted. This project is one that fits in the surrounding landscape of the area and is able to provide high and stable income on a long-term (by selling peanuts unprocessed or processed) for the local community.

Estimated total costs for ecosystem restoration in the area of Câmpu lui Neag-E area quarry are of 89643 Euros (about 90000 Euros). For this project is necessary to access European funds allocated for Romania during 2014-2020.

The investment could be covered in a few years (practically from the first year when the hazel trees bear fruits, in the 4^{th} year a profit can be obtained at a production of 2.5 kg nuts/plant) and for a period of 40 years (as the culture is considered viable) only by selling peanuts in shell would get a total of: 30.225 million Euros, or in other words an income of 755625 Euros each year.

REFERENCES

[1]. Iacobescu O., Bârnoaiea I., Cenușă R. L., *Ghid de bune practici pentru identificarea și cartarea terenurilor degradate*, Editura Universității "Ștefan cel Mare", Suceava, 2010.
[2]. Lazăr M., *Reabilitarea terenurilor degradate*, Editura Universitas, Petroşani, 2010.
[3]. Lazar M., *Ingineria naturalistică - instrument de reabilitare ecologică a haldelor de steril din Valea Jiului*, Revista Minelor, nr. 11-12/2008, ISSN 1220-2053, Editura Infomin, Deva, 2008.
[4]. Lazăr M., Faur F., Dunca E., Ciolea D., *Landslides occurred in Bujorascu Valley dump and stability improvement solutions* - Environmental Engineering and Management Journal, ISSN 1582-9596, Vol. 11, Nr.7/2012, 7, pag. 1361-1366, Iași, 2012.
[5]. Rotunjanu I., *Stabilitatea versanților şi taluzurilor*, Editura Infomin, 351 p., Deva, 2005.
[6]. Rotunjanu I.,. Voin V., Lazăr M., Fodor D., Boyte A., Dumitrescu I., Florea A., Duca E., *Studiul stabilității haldei active de la E.M.Paroşeni*, Universitatea din Petroşani şi Compania Națională a Huilei Petroşani, 2005.
[7]. Vinter (Zaharia) Rebeca-Vasti, *Studiu privind restaurarea ecosistemului pe terenurile degradate de exploatarea a cărbunelui în cariera Câmpu lui Neag – Zona E*, Lucrare de dizertație, Petroșani, 2013.
[8]. S.C. CONVERSMIN S.A. București, *Caiet de sarcini Câmpu lui Neag*, partea I+II, București, 2004.
[9]. http://www.orasuluricani.ro/, *Planul Strategic de Dezvoltare Socio-Economică al Orașului Uricani 2009 – 2014*, Uricani, 2009.
[10]. http://www.cultivareatrufelor.eu/alunul_in_romania
[11]. http://www.iltartufoalba.ro/alunul

Scientific Reviewers:
Prof. Ph.D. Eng. Maria LAZĂR

RECOVERY AND CAPITALIZATION SOLUTIONS FOR THE LAND FROM POIANA MARE, ŞESUL ŞERBANILOR AND GALBENA WASTE DUMPS, FROM CÂMPU LUI NEAG AREA

CONSTANTIN ZAHARIA[*]
REBECA - VASTI VINTER (ZAHARIA)[*]

Abstract: *One of the problems characteristic to mining is the appearance of waste dumps that occupy and diverts large areas of land from their initial use. In Jiu Valley there are 49 waste dumps that occupy a total area of over 270 ha and the volume of waste material stored exceeds 40 million* m^3*. Recovery in one way or another of the land occupied by these engineering constructions is one of the major environmental problems in Jiu Valley. The waste dumps subject of the present study, Poiana Mare, Şesul Şerbanilor and Galbena, belonged to the Mining Exploitation (ME) Câmpu lui Neag, being in conservation since 1998, at the same time with the closure of the mine. Based on the current situation, and after discussions with members of City Council several options for recovery and capitalization of this land were considered, one of which appears to be the most interesting and also the most ambitious, the transformation of the land occupied by the dumps (and some of the surroundings) in a sports facility, namely a biathlon circuit. Therefore, this paper aims to present the steps needed to be taken in order to transform waste dumps Poiana Mare, Şesul Şerbanilor and Galbena into a european level sports facility.*

Key words: *mining, waste dump, recovery, capitalization, sports facility, biathlon*

1. LOCATION AND NATURAL SURROUNDINGS

The studied area is located in the western end of the Petroşani basin, respectively Câmpu lui Neag area. Geographically, the waste dumps are located on the lower course of Western Jiu, in a depression that has functioned as a settling and formation basin of humic superior coals (pit coal).

The location of Câmpu lui Neag mining area (the waste dumps and the micro quarries Galbena and A-E zones) is surrounded to the north by Retezat Mountains (Tulişa Peak) and to the south Vâlcan Mountains [6].

The evolution of air temperature during the year is determined by the annual variation of solar radiation and atmospheric circulation regime with a maximum of 14.5°C in July and a minimum of -5.2°C in January.

[*] *Cheif Eng. at S.C. Apa Serv Valea Jiului S.A.*
[*] *Eng. Inspector S.S.M. at Zaharia Rebeca Vasti P.F.A., e-mail zahariarebeca@yahoo.com*

In the regime of annual relative air humidity the maximum value is registered in December (93%) when the air temperature is low and minimum value is recorded mainly in March-April (77%). The total medium amount of the precipitation in Petroşani Depression is 822.6 mm. In Petroşani Depression winds have a low intensity.

Morphologically, the waste dumps are located on the main floodplain (alluvial terrace) of Western Jiu, at an average height of 830 m. The terrain is flat on the two sides of Western Jiu (on width between 50 and 150 m). Site area is crossed by Western Jiu and has as tributaries on the left side Lazarus Valley, Paroşeni Valley and Ursească Valley that spring from atop northern Retezat Mountains. On the right side, Western Jiu receives seasonal tributaries or streams of water of which the most important are Răstovanu Creek, Galbena Creek and The Big Creek [6].

Forests cover about 60 % of the basin and there can be differentiate several vegetation floors that are succeeding vertically.

Jiu Valley still has a rich fauna, whose spread is facilitated by the presence of forests. However, human intervention - the exploitation of forests and deforestation in order to extend grasslands and cultivated areas, forestry roads construction, mining exploitations location, waste deposits, building of cottages and vacation homes etc. - caused, in part, the reduction of habitat for some species.

Câmpu lui Neag Village is the gateway into the Retezat Mountains. From here tourists can go either to Cheile Buții touristic complex, Retezat Chalet, at Valea de Pești (Fish Valley) motel or other lodges in the area, or to get in the unique Retezat Natural Reservation, with beautiful glacial lakes and special flora and fauna [9].

Near the location of the waste dumps is an artificial lake, created in the remaining hole of Câmpu lui Neag micro quarry area A + C, where water sports and fishing can be practice (the lake is populated with trout and grayling). Also those seeking rest can stay at one of the many private lodges and guesthouses in the Câmpu lui Neag area.

2. CURRENT SITUATION OF THE WASTE DUMPS

Waste dumps Poiana Mare, Șesul Șerbanilor and Galbena (Fig. 1) resulted from storage of sterile rocks resulting from coal mining in micro quarries Galbena and Câmpu lui Neag (areas A - E) and they and are located on the right side of the main riverbed of Western Jiu and on both sides of DN 66A Petroșani - Câmpu lui Neag [5].

Construction of waste dumps was performed by transport and deposition of material by tippers and leveling it with bulldozers, so that now the upper platforms of the dumps don't have major bumps.

The waste dumps have an elongated shape, being arranged on a general W-E direction.

Following the outbreak of negative geo-mining phenomena (landslides) due in particular to large amounts of rainfall in 2002 and 2004 (maximum of 130 l/m^2), there have been performed a number of works completed in 2006, which modified the occupied surfaces of land, the waste volumes stored and the geometry of the dumps so that the situation is as follows: Poiana Mare waste dump: area occupied 6.5 ha, volume 920000 m^3; Șesul Șerbanilor+Galbena: area occupied 9.3 ha, volume 1558000 m^3. During these works the slopes were reshaped on the northern and western sides of Șesul Șerbanilor waste dump and on the southern side of Poiana Mare waste dump, works that were intended to reduce the slope angle from initial values between 36 and 47 degrees to values between 26 and 35 degrees [4].

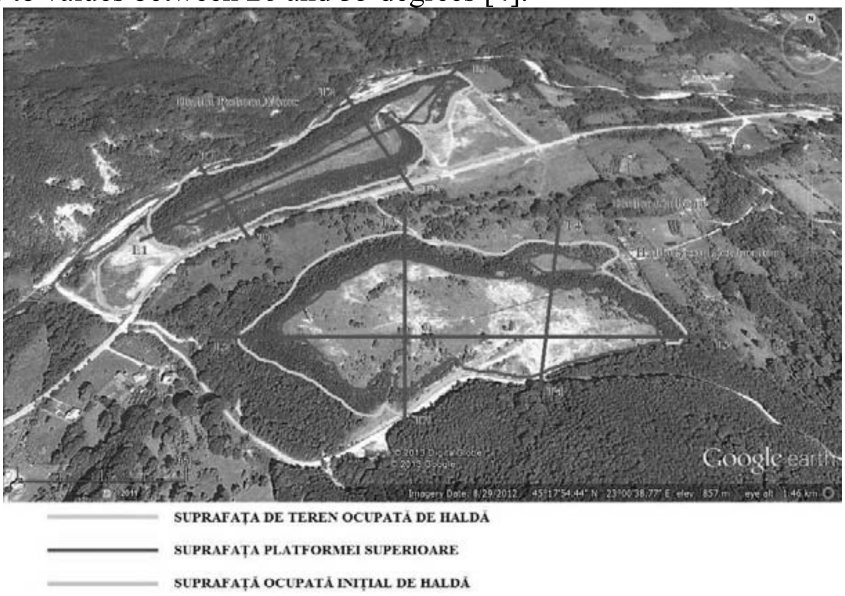


Fig. 1. Situation plan

The natural terrain where Poiana Mare waste dump is located has altitudes between 838 and 840 m on the southern side. For Șesul Șerbanilor and Galbena waste dumps the base terrain lies at altitudes between 850 and 853 m on the northern side and between 874 and 876 on the southern side. The upper platform of Poiana Mare waste dumps is at altitudes between 844 and 846 m, for Șesul Șerbanilor waste dump at altitudes between 870 and 873 m and for Galbena waste dump at 855 m.

In terms of geometry the waste dumps situation is as follows:

- Poiana Mare waste dump has a height of between 4 and 9 m (minimum height is at the western extremity), the length on W-E direction is 460 m and width of 80 m in the west and 120 m to the east;

- Șesul Șerbanilor waste dump has a height between 17 and 23 m on the northern side, on the western side an average of 15 m, on the eastern side 10 m and on the southern side the dump doesn't have a height itself (the twinning area between the natural terrain and the waste dump). The length of the waste dump on W-E direction is 488.5 m, an average width of 216 m in the western half of the dump and of 176 m in the eastern half;

- Galbena waste dump has a height between 4 and 6 m on the north side, on the south side being united with Șesul Șerbanilor waste dump. The length of the dump is 92 m, and an average width of 50 m;

- the upper platform of Poiana Mare waste dump has an area of 31268 m^2 (3.13 ha), a length of 402 m in the W-E direction of and widths between 55 m in western half and central part of the dump and 102 m in the eastern half;

- the upper platform of Șesul Șerbanilor waste dump has an area of 57665 m^2 (5.77 ha), a length of 420 m in the W-E direction of and average widths of 199 m in the western half and 120 m in the eastern half;

- the upper platform of Galbena waste dump has an area of 2744.7 m^2 (0.27 hectares), a length of 69 m in the W-E direction and an average width of 40 m.

As a result of mining pit coal in micro quarries from Câmpu lui Neag mining perimeter resulted in a significant amount of waste material which was deposited in the waste dumps covered by this study. Stockpiled material consists of a heterogeneous mixture of soft rocks such as clay or shale and hard rocks, as sandstone, with a pronounced non-uniformity of particle size and physical-mechanical properties.

It was found that the sterile rocks from Poiana Mare, Șesul Șerbanilor and Galbena dumps is highly complex, being deposited a mixtures of rocks in loose form, heterogeneous and non homogeneous in terms of the mineral - petrographic composition and particle size. In terms of mineral – petrographic composition, this mixture is represented by clays, sandy clays, clayey sandstone, marls, microconglomerates and carbonaceous shale with a varied particle size.

The limits of variation of the physical-mechanical characteristics are shown in Table 1.

Table 1. ***Limits for granulometry and physical-mechanical proprieties of the sterile rocks***

Crt. no	Specification	MU	Variation limits		
			Sterile rocks		
			Poiana Mare waste dump	Șesul Șerbanilor waste dump	Galbena waste dump
1.	Granulometry - clay (under 0.005 mm) - dust (0.000 – 0.05 mm) - sand (0.05 – 2.0 mm) - gravel (2.0 – 20 mm) - boulder (over 20 mm)	 % % % % %	 0÷3.2 2.4÷10.1 20.1÷60.7 17.3÷40.9 4.4÷16.60	 0÷1.7 2.1÷10.1 15.6÷67.2 14.80÷43.4 6.2÷14.80	 0÷2.6 3.5÷8.2 25.2÷57.4 21.50÷30.1 9.5÷17.80
2.	Specific weight	g/cm^3	2.53÷2.61	2.56	2.63
3.	Volumetric weigh	g/cm^3	1.76÷1.805	1.755	1.69
4.	Natural Humidity	%	13.87÷16.88	17.40÷23.03	20.47÷27.39
5.	Porosity	%	40.83÷41.23	31.44	35.74
6.	Pore index	-	0.69÷0.70	0.45	0.55
7.	Saturation coefficient	-	0.50÷0.64	0.62÷0.70	0.74÷0.84
8.	Cohesion	daN/cm^2	0.32÷0.38	0.18÷0.29	0.12÷15
9.	Friction angle	°	19÷21	14÷22	12÷15
10.	Compressibility coefficient	cm^2/daN	1	1.90	1.50
11.	Deformation module	daN/cm^2	100	66.5	52
12.	Specific compaction	daN/cm^2	6.9	8.2	7.5

By studying the data, the following conclusions can be drawn:

− the soil is represented by a clayey-dusty sand with gravel fragments, with θ = 2 to 20 mm. The presence of fine particles (dust and clay) in the soil structure leads to water retention capacity greater than the sterile rocks;

− the non homogenous character of the waste rocks from the dumps leads to a stronger variation of geotechnical characteristics;

− shear resistance characteristics are influenced by the mineral-petrographic composition of the rocks and their moisture content. There is a very sharp variation of cohesion and internal friction angle depending on humidity.

Table 2 shows the chemical composition of rocks landfill three deposits.

Table 2. ***Chemical composition of the rocks deposited in Poiana Mare, Șesul Șerbanilor and Galbena waste dumps***

Waste dump	**Parameter**								
	pH	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	MgO %	CaO %	Na_2O %	K_2O %	Volatile %
Poiana Mare	7.21	62.27	9.12	4.40	0.81	0.80	0.90	1.49	18.70
Șesul Șerbanilor	7.22	63.84	10.51	4.63	0.84	0.75	0.96	1.55	15.67
Galbena	7.35	67.21	10.66	4.38	0.82	0.76	1.00	1.59	15.48

Chemical analyzes show a pH value close to neutral, indicating the absence of elements that could affect human health or which would not allow the development of vegetation.

The outbreak of negative geo-mining phenomena in 2002 and later in 2004 (landslides on Șesul Șerbanilor dump and plastic flow on Poiana Mare dump) were clearly favored by large amounts of rainfall that occurred in a very short period of time (high relative intensity of rainfall).

After the outbreak of these negative geo-g phenomena it was issued a new specification in 2004 and works were performed at the three dumps that included: releasing the land of foreign objects: 18000 m^2 on Șesul Șerbanilor waste dump and 24,000 m^2 on Poiana Mare waste dump. leveling an area of 8.9 ha representing the upper platforms of Poiana Mare and Șesul Șerbanilor waste dumps; desilting the existing guard channel: 409 m^3; redevelopment of the northern slope of Șesul Șerbanilor dump by decreasing the slope angle to a value of 35 degrees and uniting it with Galbena waste dump; release a land area of 3.1 ha initially occupied by Poiana Mare dump (the sterile rocks being stored in the micro quarry Campu lui Neag E area, on the base); reducing the height and slope angle (southern slope) for Poiana Mare waste dump (resulted material being deposited as a earth dam in the Campu lui Neag micro quarry – the area across of the quarry final slope, subsequently planted with seedlings of acacia); acacia seedlings planting in areas where the slopes where reshaped : 250 pcs. on Șesul Șerbanilor waste dump, respectively 312 pcs. on Poiana Mare waste dump [5].

Currently the three dumps are in a good condition, meaning that during the observations made in the field were not identified negative phenomena such erosion or landslides on slopes, uneven subsidence or areas of rainfall accumulation on the upper platforms.

Southern slope of Poiana Mare dump is covered with acacia plantation, aged between 7 and 10 years. On the eastern slope reforestation was done spontaneously, the dominant species is beech. The northern slope is very close to the Western Jiu riverbed and is naturally revegetated especially with alder (moisture-loving species). On all slopes of Poiana Mare waste dump the forest vegetation coverage is over 85%.

The top platform is covered with herbaceous and shrub vegetation spontaneously installed. Coverage ranges from 50 % in the eastern end of the dump to 80-85 % elsewhere. Sporadically on the upper platform of the dump appear isolated specimens of spruce (Fig. 2a).

The western and northern slopes of Șesul Șerbanilor waste dump to the twinning area with Galbena waste dump are covered with acacia plantations. Age of seedlings is between 7 years in areas where works were carried out in 2004-2006 (the northern slope) and 13 years on the western slope.

The rest of the northern slope, on the eastern and on the northern slope of Galbena waste dump the forestry vegetation is spontaneously installed.

Unlike Poiana Mare waste dump, where we can speak of dominant species spontaneously installed, the vegetation spontaneously installed on Șesul Șerbanilor and Galbena waste dumps slopes presents a unique mixture of species (sycamore, birch and spruce, sporadically appear acacias and especially at the base of slopes and along the guard channel the predominant species are shrubs such as wild rose and herbaceous species).

The upper platform of Galbena waste dump is covered with herbaceous vegetation in 90%, that of Șesul Șerbanilor waste dump at a rate of 50-60%, sporadically occurring shrubs, especially wild rose (Fig. 2.b).

a b

Fig. 2. Upper platforms of Poiana Mare and Șesul Șerbanilor waste dumps

Except the guard channel found at the contact between DN 66A and Poiana Mare dump at the base of the northern slope of Galbena waste dump which are in good condition, the remaining guard channels are clogged and is necessary their restoration.

3. IDENTIFICATION O RECOVERY POSIBILITIES OF THE TERRAINS

The terrain occupied by Poiana Mare waste dump was originally occupied by private houses, and the terrain occupied by Șesul Șerbanilor and Galbena dumps was originally covered with beech forests mixed with spruce and birch as main species plus a number of shrubs (wild rose, hazel, hawthorn etc.) alternating with areas for grazing (areas where forestry vegetation and shrub vegetation was removed by locals)

Ecological restoration of waste dumps requires special attention in terms of legislative and regulatory framework, allowing greater flexibility in the forecast and the possibility of changing the destination of land and take into account the attractions and characteristics of the territory based on a complex analysis of the built landscape, by applying the most modern methods of work [2, 3]. The fact that the land currently occupied by the three waste dumps doesn't have a specific function emphasizes the need to identify possibilities to capitalize it on medium and long term.

For Poiana Mare, Șesul Șerbanilor and Galbena dumps the recovery options for the terrains occupied by them that were discussed were proposed either by members of the Uricani City Council, either by private individuals (potential investors).

The main discussion focused on four main direction of recovery: naturalistic recovery, productive recovery, recovery for recreation and leisure, creating a sports facility (biathlon circuit).

A fourth option under discussion is the most ambitious, both from the point of view of the intervention but also in terms of investment volume needed. It is about transforming he waste dumps into a sports facility on a european level, namely achieving an arena to host biathlon competitions. Arguments underlying such a proposal start with favorable climate characteristics (biathlon is a winter sport), excellent location in terms of accessibility and opportunity to develop businesses by local residents and the administration in the Jiu Valley (in particular on accommodation and hotel services) [4].

Compared to other types of recoveries of land occupied by the three dumps (naturalistic. productive or recreational/leisure) that did not involve any intervention or small interventions in terms of work volume and costs involved, the alternative o convert the terrain into a sports facility (at International Biathlon Union IBU standards) requires a much higher level of intervention (in volume and complexity of work, standard that must be achieved and therefore costs for implementation). It is not a simple adaptation of the current situation to the specific needs, but a total transformation of the area, as utility and aesthetic point of view.

To this work adds some smaller scale such as grassing certain areas or vegetation removal (where needed) along the cross-country ski trails or where it can affect visibility of spectators or organizers and officials.

Reconstruction and rehabilitation of land degraded by human activities must be conducted in accordance with the political and economic objectives of a country (Jiu's Valley development strategy is based on tourism potential, this project satisfying this condition) [1, 2]. Therefore, the purpose of the present project is the transformation of a non-productive area, or rather environmentally and economically unsustainable in a landscaped area, with well defined functionality, able to attract tourists and with high potential to bring revenue to local budgets of cities in Jiu Valley.

4. CONSTRUCTION OF THE SPORTS FACILITY

Biathlon (Latin bi 'two' and Greek athlon "contest") is a term designating a sporting event consisting of two disciplines. Usually the term refers to a winter sport that combines freestyle cross-country skiing and shooting. Nowadays, biathlon is governed by IBU that organizes major competitions [7, 8].

Athletes go through circuits of different lengths, between them are inserted shooting sessions fitted in a specially designed space (shooting range), each session with five targets to be shoot down.

For the sports facility from Câmpu lui Neag is envisaged the possibility of organizing summer competitions. Cross-country and shooting with low caliber gun is a form of summer biathlon, deployment rules are similar to those of winter biathlon, the difference being that there is no snow and skis. In principle the IBU rules of competition are applicable.

Cross-country ski course - the course is the network of tracks used in competition. It must be chosen so that it show continuous variations and alternating portions of varied landscape, respectively straight, ascent and descent surfaces. Maximum altitude of any portion of the curse must not exceed 1800 m. The competing lanes must have a minimum width of 6 m and arranged on trodden snow. If necessary, their width may be even greater in the points considered to be demanding such as uphill portions for example. The minimum width allowed is 4 m in sections totaling a length of 50 m. The actual length of the course should not differ by more than 5% of the specified length for the competition [7, 8].

At Câmpul lui Neag two courses will be arranged (actually one with a length of 2.5 km that can be shortened to 2 km for female competitions) fully paved (to be able to organize summer competitions). The lanes (lanes or tracks) of a course can be covered several times during a competition if their width, as specified, is at least 6 meters. The profile designed for the construction of the lanes is shown in Figure 3.

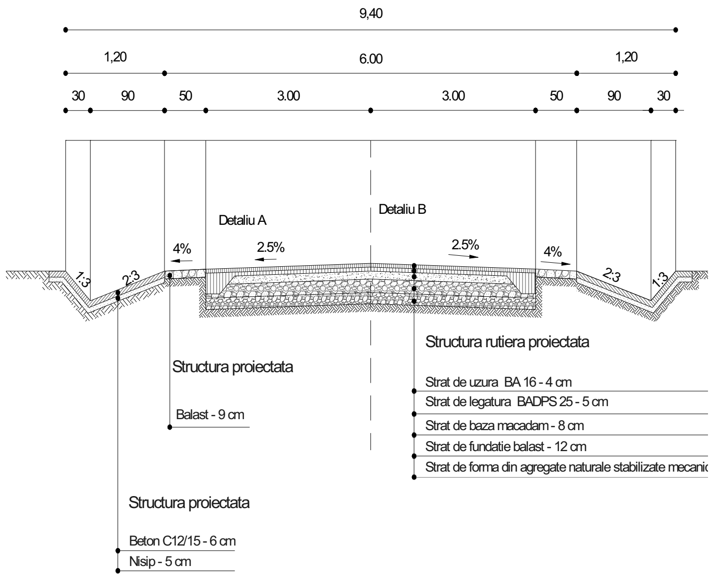


Fig. 3. Transversal profile designed for the lanes

A test area for ski slip will also be constructed. Its location will be outside the main arena, on a slightly sloping land that is large enough to encompass all of the competitors. The test slope must be of 8-12º inclination and be at least 30 meters long. This area should be prepared as well as the competition track.

The heating track will be right next to the arena and it must have a length of at least 600 m and be prepared as well as the official route for the contest. This heating track will not be part of the competition course.

The course was chosen so as to not require massive deforestation, 80% of the track will be constructed on existing forestry roads, located to the south and east of Șesul Șerbanilor waste dump.

Main Arena - will be fitted on the top platform of Șesul Șerbanilor waste dump and will include: start and finish area (part of the cross-country ski course), the penalty area (in addition to the 2.5 km of track), the shooting range, tribunes for spectators (area A and B), space for media and competition office, first aid point.

Penalty area - a circular or oval track, 5 m wide and 150 m long (plus-minus 5 m), measured on the inner perimeter of the tour.

Shooting range – the shooting range is where all the shooting takes place during a biathlon competition. It will be located in the center of the arena so that, both targets and shooting stands to be in sight of most spectators.

The distance between the ramp front edge and the targets line must be of 50 m (+/- 1 m). The shooting ramp surface and the surface where the targets are set must be if possible at the same level.

On the polygon contour are located concrete L shape profiles (100 x 50 x 15 cm) to support the excavated area. On the firing ramps and targets support areas, behind the concrete L-profile, on the entire length of the ramp and over a width of 2 m asphalt will be poured.

The polygon will have 30 firing lines.

In order to construct the polygon an amount of material from the waste dump will be the excavated:

Length of ramp: L1 = 30 x 2.75 + (2 x 3) = 88.5 m;

Firing line length (the distance between ramps): L2 = 50 m;

The difference in level between the base of the polygon and ramp: D = 0.5 m;

Excavated volume: V1 = L1 x L2 x D = 2212.5 m^3.

Of the excavated material, protection embankments will be constructed on the sides and in front of the firing lines. They will trapezoidal, with the following dimensions:

Side embankments: B = 4 m, b = 2 m, h = 2 m, L = 50 m;

The embankment in front of the firing line: B = 6 m, b = 3 m, h = 2.5 m, L = 90 m;

As a result, the total volume of material will be 1612.5 m^3.

These embankments will be made of material excavated to achieve the level difference between firing lines and ramps. The difference will be a volume V3 of 600 m^3 of material ant it will be used as addition material to achieve the designed ski track. The base of the polygon will be leveled and planted with grass.

Tribunes - these will be located in two areas. A area behind the firing lines (view perpendicular to the polygon) and B area near the penalty circuit, right side view to polygon. The stands are built on steel structure, paved with wood and seats numbered individualy. Capacity is projected to be 3,000 seats.

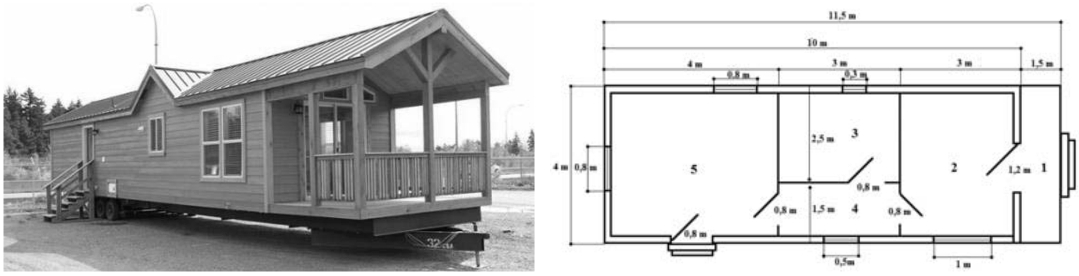
Media and competition office building - this building will house sports commentators, the announcer and race officials.

Point of first aid - will be located in the eastern end of the Șesul Șerbanilor waste dump and will not be permanent. It can use a tent over the duration of the competition.

Technical teams spaces - for the construction of technical teams spaces will be used the top platform of Poiana Mare waste dump. They will be located on the northern and southern sides of the dump. A number of 50 modular construction - chalets will be purchased (Fig. 4a and b), that will be connected to the sewerage, drinking water and electricity networks. Heating and melting wax installations used (stove) will run on electricity, the gas network is not expanded in the area. These buildings will be permanent and accommodation can be rented for periods between competitions.

On Poiana Mare waste dump, between the two rows of cottages a paved footpath will be constructed, like the one for public access to main arena. There will also be lighting columns and installations.

As can be seen from Figure 4 such a modular house is divided into five areas with different utilities: 1. Porch, 2. Kitchen 3. Bathroom, 4. Aisle, 5. Room.



a b

Fig. 4. Modular houses for technical teams

The overall dimensions of such a construction are 11.5 x 4 m^2, which makes it possible to arrange them on two rows (across the paved footpath) on Poiana Mare waste dump even in the area where the upper platform has a minimum width of 55 m.

Parking lots and bus station – there will be arranged three parking spaces, with a total surface of 4.8 ha (48000 m^2). Teams designated parking will be arranged in the eastern part of Poiana Mare dump (area where the sterile rocks were removed) and will have an area of 1.8 ha. A second parking lot will be arranged at the western extremity of the dump (also in the area where the sterile rocks were removed), it will have an area of 1.3 ha and will target media representatives, organizers and VIPs. The public parking lot will be located on the right side of DN 66A, across the technical teams parking lot and will cover an area of 1.7 ha. The bus station will be located east of the technical teams parking lot on one way and across the street, west of the public parking lot on the other way.

Grassy areas - all grassed areas are inside the main arena. It is the area protection behind the shooting range, the inside of the penalty area, first aid area, polygon area between the firing ramps and the targets ramp and the three protective embankments.

The total area covered by grass will be St = 10502.3 m^2, consisting of:

Surface of the protection zone: S1 = (13 + 2 + 1.5) x 100 = 1650 m^2;

Inside area of the penalty course: S2 = $\pi \times r^2$ = 1987.5 m^2 (the penalty curse being a circle with a circumference of 150 m);

First aid area: S3 = 1000 m^2;

Inner area of the polygon: S4 = 88.5 x 50 = 4425 m^2;

Protection embankments: S5 = 646 + 793.8 = 1439.8 m^2.

In order to obtain a uniform and high quality lawn the recommended seeds dose by specialized companies is 30 g/m^2, which means that for the entire surface to be grassed is needed a quantity of about 316 kg of lawn seed.

Accommodation for athletes - according to the regulations of IBU the competition course should not be at a distance greater than 30 km, and 30 min. drive from where the teams are staying. This rule is respect everywhere, except that the IBU Executive Board decides otherwise.

To achieve this it is considering an arrangement with the University of Petroșani, that holds a practice training base at Câmpu lui Neag (two four-story dormitories that could be used for this purpose).

Other facilities required - for the functioning of the sports facilities are needed a few other buildings and equipments: warehouse for contest materials, booths for porters and guards, walkways, guard channels, health points, garage, restaurant.

Throughout the period of the construction works, the companies/engineering firms will be required as a specification to monitor environmental factors, and the environment authority within the Uricani City Hall will conduct periodic inspections to verify the conformity with laws and regulations in force.

The general view of the sports facilities from Câmpu Neag is shown in Figure 5 .

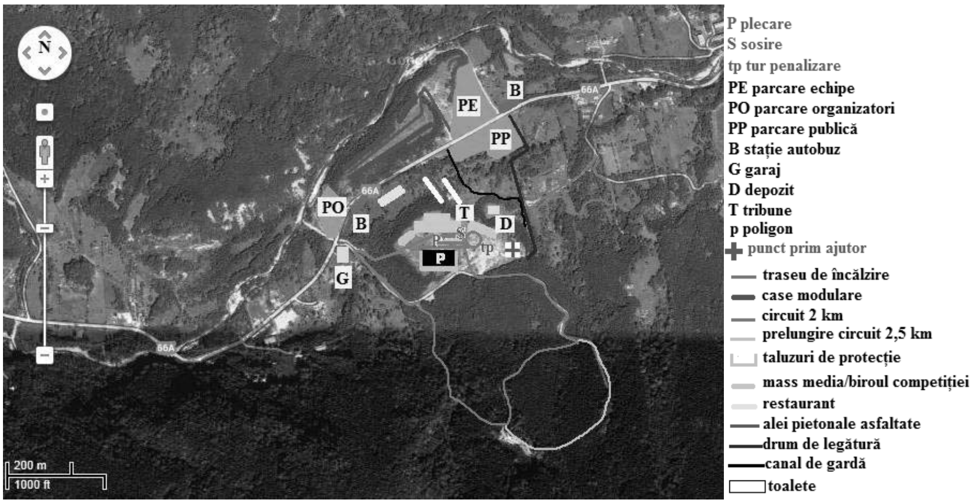


Fig. 5. General view of the sports facility

5. ECONOMIC CONSIDERATIONS

Costs were estimated in Euros, taking into account the works to be performed, prices of construction works and the exchange rate in the year 2013.

Adding the cost of land development work as intended, a total of approximately 3.7 million Euros (16.465 million lei) was obtained [4].

To materialize this project, must be analyzed the conditions for financing with EU funds that will come into appliance on January 2014, and the documentation required must be elaborated under these new conditions.

In the event that the project should be cofinanced at a rate of 30%, 1.11 million Euros, it should be considered an association between localities in the Jiu Valley (especially Uricani, Lupeni, Vulcan and Petroșani) to find this amount (leaving aside the political struggles and petty interests existing at this level) [4].

The financing of such a project can be done by the Romanian state through the Ministry of Youth and Sports, possibly with the involvement of the Ministry of Tourism. However, this option is unlikely in the short term, taking into account the economic realities in Romania today.

CONCLUSIONS

Poiana Mare. Șesul Șerbanilor and Galbena waste dumps were constructed for storage purposes of the sterile rocks resulting from coal mining operation in Câmpu lui Neag mining perimeter. These dumps were put in conservation in 1998 with the closure of ME Câmpu lui Neag under the provisions of H.G. No. 816/1998, and from 2000 to 2006 were executed a series of ecological rehabilitation works.

Currently the technical condition of the three dumps is very good. Observations have not revealed the existence of negative geo-mining phenomena (uneven subsidence, erosion or landslide), and on the reforested slopes (with acacia) the massive stage was reached.

After completion of this work, in 2006 the lands occupied by the three waste dumps were transferred to the property of Uricani City Hall and City Council, which are the competent authorities to establish the final use of these lands.

For the ecological reconstruction of the three dumps, in the meetings of the Local Administration several proposals have been made regarding the final destination of these lands, and the proposals were analyzed, being brought arguments pro and against these proposals. The variants proposed for land rehabilitation and recovery followed four main directions: naturalistic recovery, productive recovery, recovery for recreation/leisure and creating a sports facility.

In this paper work the last variant was analyzed, which is the most ambitious in terms of the complexity of the works to be performed, but also in terms of the costs involved in this phase.

The costs for the construction of a sports facility were estimated considering the average prices charged by specialized companies in the country and the European Union. In estimating costs in addition to the work described in paragraph 4, were taken into account costs for the purchase of equipments absolutely necessary for the operation of the sports facility (shooting targets, signaling flags, ratrack, asphalt washing machine etc.). The amount reached (which must be regarded as an guiding one) is approximately 3.7 million Euros. Of course a city like Uricani can not afford such an investment from its own budget, for this project is necessary to access the European funds for Romania during 2014-2020 (about 40 billion Euros).

The construction of a sports facility on lands occupied by Poiana Mare. Șesul Șerbanilor and Galbena waste dumps is an original version (at least for Romania) for recovery and capitalization of degraded terrains by mining, while being a good example of long-term planning and conscious construction of a portion of the territory, consistent with the strategy of socio- economic recovery of Jiu Valley, which can be applied in other mining areas (constructing sports facilities in mining perimeters Paroşeni, Petrila and Uricani, perimeters where extractive activities will cease until 2018).

REFERENCES

[1]. Lazăr M., *Reabilitarea ecologică*, Editura Universitas, Petroşani. 2001.
[2]. Lazăr M., *Reabilitarea terenurilor degradate*, Editura Universitas, Petroşani, 2010.
[3]. Faur F., Lazăr M., *Identification of ecological rehabilitation possibilities of Petrila mine waste dump*, Annals of the University of Petroşani. Mining Engineering. Vol. 13 (XXXX), pag. 275-283, ISSN 1454-9174, Petroşani, 2012.
[4]. Zaharia C., *Soluții de recuperare și valorificare a terenurilor de pe haldele de steril Poiana Mare. Șesul Șerbanilor și Galbena din zona Câmpu lui Neag*, Lucrare de dizertație, Petroșani, 2013.
[5]. S.C. CONVERSMIN S.A. București, *Caiet de sarcini Câmpu lui Neag*, partea I+II. București, 2004.
[6]. http://www.orasuluricani.ro/ *Planul strategic de dezvoltare socio-economică al Orașului Uricani 2009 – 2014*, Uricani, 2009.
[7]. http://www.frschibiatlon.ro/ro *Regulament Biatlon IBU.*
[8]. http://www.biathlonworld.com/en/
[9]. http://www.turisminfovaleajiului.ro/

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

RESEARCH ON POTENTIAL ACIDIFICATION OF SOILS, DUE TO ACID RAINS, IN THE INFLUENTIAL AREAS OF THE POWER PLANT PAROȘENI

VLAD VIRGIL SANDU[*]
MARIA LAZĂR[**]

Abstract. *Acid rains are precipitations that have a pH level lower than 5.6, thus having strong acidic characteristics. Usually this phenomenon takes place after a considerable amount of sulfur dioxide or nitrogen oxide reach the atmosphere, where they go through a series of transformations and are absorbed by water droplets in clouds. A means by which these gases can reach the atmosphere in significant quantities are the emissions generated by power plants. This paper is aimed at highlighting the potential acidification of soils, due to acid rains in the influential areas of the power plant Paroșeni, and includes a number of methods of sampling and testing of water and soil samples to determine the effect of acid rains in these regions.*

Key words: *power plant; acid rain, emissions, acidification, soil, labor analysis*

1. INTRODUCTION

Paroşeni thermoelectric plant is located in the center of Petroșani basin, on the right bank of the river west Jiu in town Paroşeni, county Hunedoara, is bordered to the east by the access road to the mining Paroşeni, to the west by the river Jiu, and to the north by the railroad Livezeni-Lupeni, and it's aimed at providing the necessary heat and energy, for urban consumers in cities Petroșani, Vulcan, Lupeni and Aninoasa and to supply electricity in the National Power Grid /11/.

Combustion of fossil fuels in steam boilers result in various emissions such as sulfur dioxide (SO_2), nitrogen oxides (NO_x), particulate matter (PM_{10} and $PM_{2,5}$), carbon monoxide (CO), of which hose that pose a serious risk to both human health and the environment are sulfur dioxide and nitrogen oxides, because once released into the atmosphere have the ability to produce a number of negative effects over the environment of which the most important may be their capacity to produce acid rain have a negative effect on the flora and fauna of the area affected, but also the structures present in the area /3, 7/.

[*] *Masterand, University of Petrosani, email: sandu_vlad_virgil@yahoo.com*
[**] *Prof.univ.dr.ing., University of Petrosani, email: lazar@upet.ro*

2. ESTABLISHING RESEARCH DIRECTIONS

In order to determine the potential soil acidification, in the influential areas of C.E.T Paroşeni, a series of studies are required. Studies needed include sampling and laboratory analysis of soil samples and rain water in areas where concentrations of pollutants reach maximum concentrations, and thus the probability of acid rain is greater.

Analyses will include determination of pH, salt content, nitrites, chlorides, aluminum and other substances that can accumulate in the soil due to acid rain. To establish these sampling points, dispersion maps will be used (fig. 1 and fig. 2), since these maps provide information on the direction of the movement these gases and also their concentration. To highlight a soil acidification values obtained in laboratory tests will be compared with results obtained from an adjoining area, which is not under the power plant's influence.

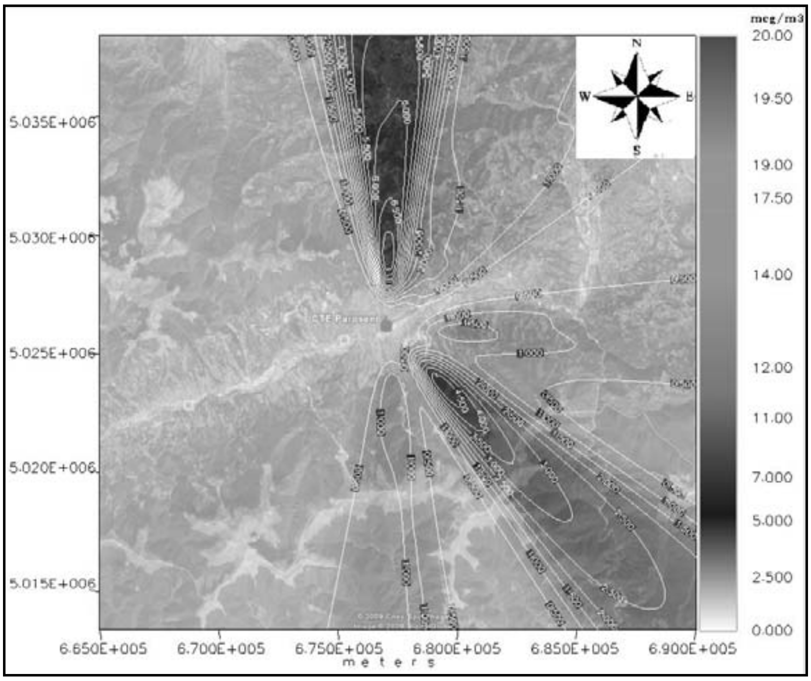


Fig. 1 Dispersion map with annual SO_2 concentration, expressed in g/m^3

2.1. Establish sampling points for the soil and water samples

Upon analyzing the dispersion maps it was determined that the pollution plume is being dispersed to the North and South-East, with SO_2 concentrations reaching a maximum of 6.5 μg/m^3 in the "Dealul Babii" area to the North and 4.5 μg/m^3 in the "cable car" area to the South-East, therefore the sampling point will be in number of two to the north in the "Dealul Babii" area an one so the South-East in the "cable car" area. The control samples will be taken from the "Valea Arsului" area to the north east, being the adjoining area, which is not under the power plant's influence (fig. 3).

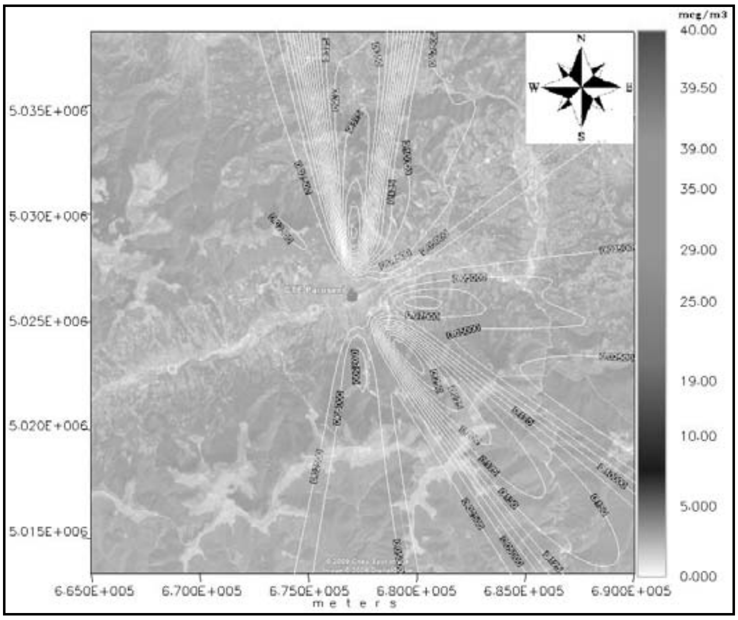


Fig. 2 Dispersion map with annual NO_x concentration, expressed in g/m^3

Fig. 3 Sampling points locations.

2.2. Water and soil sampling

For the collection of water samples, in every area containers were placed in order to collect rain water for the exception of the "Dealu Babii" area where because of the relative small distance between the points "Dealul Babii I" and "Dealul Babii II" was decided that placing a single container was sufficient. To ensure that a sufficient amount of rain water was collected, the containers were placed two days before a major rain, and were collected no later than 24 hours after the rain stopped to minimize evaporation.

Also from the “Dealu Babii” area water samples were collected from stagnant surface waters and from temporary springs caused by surface leakage.

In order to perform lab analysis, from each area soil samples were collected using the envelope method /4/, from a depth of 10 centimeters, the distance of the envelope corners being approximately 10 meters (fig. 4).

The soil samples taken from all 5 points of the envelope, that have a dimension of 20 cm^2, were placed in individual airtight plastic bags, that have been placed in black plastic bags with a note that contains data regarding the date, time and area where the sampling took place.

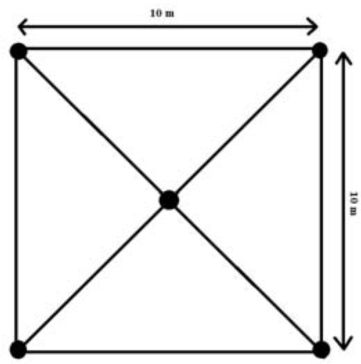


Fig. 4 Envelope method for sampling

3. CHEMICAL ANALYSIS OF SOIL AND WATER SAMPLES

3.1. Determining soil pH and conductivity

To determine the conductivity and soil pH the first step is to homogenize soil samples. After homogenization, 20 grams of soil from each area was weight using an analytical scale and mixes with 200 ml of distilled water in Erlenmeyer flasks and left for 24 for the salts to dissolve. The pH was measured with a HANNA HI 9023 pH meter and the conductivity was measured with a HANNA 1032 conductivity meter. After measuring the pH and conductivity, the solution was filtered for later use in the nitrate and chloride analysis.

3.2. Determining soil cation exchange capacity

The cation exchange capacity represents the maximum quantity of cations absorbed in colloidal complex. Cation exchange capacity values depend on the nature of the soil absorption complex and soil reaction. In general, the organic part of the adsorption complex, represented by humic acids, possesses a higher retention capacity than the mineral part /4/.

Higher cation retention also occurs when the soil pH rises, because it increases the ionization of the functional groups of humic acids and clay minerals. The most common exchangeable cations found in soils, that gives it basic properties are: $Ca2^+$, $Mg2^+$, K^+, Na^+, Al^{3+} , while the H^+ cation in large quantities will raise the soil’s pH level considerably /5/.

To determine the cation exchange capacity of hydrogen ions (SH) /6, 9/, 10 grams of soil that was dried and sifted was mixed with 100 ml of distilled water in a Erlenmeyer flask, 2-3 drops of phenolphthalein indicator will be added, and then the solution was titrated using NaOH 0,1 n solution until until the content of the flask is colored a steady pink.

The cation exchange capacity of hydrogen ions is calculated using the following relation:

$$SH = V_{NaOh} * 10 \text{ [m.echil/Kg sol]} \quad (1)$$

The process used to determine the cation exchange capacity of metal ions (SMe) is similar to the one use for the hydrogen ions with the exception that the color indicator will be methyl orange and for the titration a HCl 0,1 n solution was used until the contents of the flask was a steady orange.

The cation exchange capacity of metal ions is calculated using the following relation:

$$SMe = V_{HCl} * 10 \text{ [m.echiv/Kg sol]} \quad (2)$$

3.3. Determining the soil's nitrate content

Nitrites are naturally present in soil, water and food and regularly testing their concentrations is essential for many applications, in this case serving as an indicator since due to acid rains they can accumulate in soils in significant quantities. To establish the soil's nitrate content an AQUAQUANT Nitrit 114424 kit will be used, this kit being equipped with two test tubes, Color indicator reagent AH and a color scale.

To determine the soil's nitrate content, in both of the test tubes will be filled to the 25 ml mark with the left over solution from the pH and conductivity determination, after which in one of these test tubes was added a measure of AH reagent, and then placed in the Styrofoam stand next the test tube with no reagent. Using color scale … the two test tubes will be compared until the colors match. The nitrite content will be displayed on the right side of the color scale.

3.4. Determining the soil's chloride content

In order to establish the soil's chloride content an AQUAQUANT Cl 114401 kil will be used, this kid being equipped with two test tubes, two types of reagents Cl 1A and Cl 2A.

The testing method is similar to that used for the nitrates with the exception that the test tubes will be filled with only 2.5 ml and in one of these tubes will be added 3 drops of Cl 1A followed by 3 drops of Cl 2A reagent. Like with the nitrate determination the chloride concentration will be displayed in the right side of the color scale.

3.5. Determining the soil's aluminum content

To determine the soil's aluminum content 500 grams of soil were mixed with one liter of distilled water and left for 24 hours in order for all the salts and minerals present in the soil to dissolve. Afterwards the samples will be filtered repeatedly until all the solid particles will be removed, and the remaining solution will be placed in thermo resistant vessels which will be placed in an oven 105 degrees Celsius for 26 hours in order to evaporate.

The remaining salts will be scraped using a steel wool, weighed, and then analyzed using a spectrophotometer.

3.6. Soil spectrophotometric analysis

For the spectrophotometric analysis 20 grams of soil that were dried and sifted through a 1 mm test sieve were stored in a special aluminum containers after they were placed in plastic ones an covered with transparent foil, and are placed inside the spectrophotometer.

The samples go through an x-ray source that excites atoms, and the output rays produced pass through a prism and decompose the radiation into components and are received by a detector. Determination of elements that make up the soil samples will be based on the wavelength of the radiation components.

3.7. Chemical analysis of water samples

Water sample analysis includes pH determination, nitrite and chloride content and will be performed using the same methods as in the case of the soil samples.

4. BIOINDICATORS ANALYSIS

Plants can adapt to various conditions, but some species prefer more specific conditions, among them being the acidophilic plants, that can provide information on acid rain /1, 2/. Investigations on bioindicators and observations made in the areas of influence of the power plant that may indicate acidification of soils were found following species of flora:

Athyrium filix-femina is a species of pteridophytes from the Athyriaceae family which includes about 180 species of ferns. It is found mainly in the northern hemisphere temperate zones where it grows abundantly, being one of the most common ferns. It prefers humid environments and shaded forest. The plant prefers sandy soils, clay and heavy soils, but requires well-drained soil. It can adapt to acidic, neutral and alkaline soils but prefers an acidic soil with a pH of 5.5 - 6.5.

Genistella sagittalis is a genus of flowering plants in the legume family Fabaceae. The stem is a cladodie with yellow flowers, presenting flattened arch, and reduced leafs. It’s commonly found in temperate climates in Europe and grows in areas with hayfields, pastures and bushes. This plant prefers a soil with a pH of 4.0-4.5.

Petasites ablus (White Butterbur) is a perennial herb belonging to the family Asteraceae genus Petasites. The petals of this plant are white and elongated and the flowers are grouped on top of the stem. White Butterbur is a plant native to Europe and Southwest Asia thriving in hilly areas and mountain forests with relatively high moisture or areas close to flowing or standing water sources. This species of plants prefers a slightly acidic soil with a pH between 6.0-6.8.

Leucanthemum waldsteinii (daisy) is a plant of the family Asteraceae, genus Leucanthemum, which includes about 70 species. They are herbaceous plants with a specific type of inflorescence called calathidium. Though the chalatidium is made up of many flowers, the inflorescence is like a single flower. The flowers that make this type of inflorescence often have tubular or ligulate shaped petals. They are found in Europe, Northern Africa and the temperate regions of Asia. This plant grows in a weakly acidic type of soil with a pH value of 6.0-6.8.

Serpyllum Thymus (field thyme) is a species of angiosperms belonging to the Lamiaceae family. The stems are cylindrical, hairy, with a reddish-green color, on top of which are piles of flowers. The leaves are small, oval, and sometimes bent down. The filed thyme is an herb native to Europe and northern Africa, which grows even in arid areas, in soils with low fertility and low to medium humidity. Being an unpretentious plant regarding growing conditions it can adapt to almost any soil with proper drainage but it thrives in a soil with a pH value of 5.5-7.0.

Vaccinium myrtillus (blueberry bush) is a shrub of the genus Vaccinium species belonging to the family Ericaceae. It prefers moderate temperatures but in winter can lasts up to maximum of -20° C. Behaves well in areas with average annual rainfall ranging from 800-1000 mm. Grows on, well structured, with a high humus content acidic soils (pH values between 4.5 - 6.5). The species is native to Europe, northern Asia, Canada and the United States.

5. THE RESULTS OF ANALYZES

Laboratory tests conducted on soil samples taken from the areas of influence near power plant have obtained a series of values. These values are shown in tables 1, 2, 3.

Table 1 Soil chemical analysis

Sampling area / **Chemical Characteristics**	Dealul Babii I	Dealul Babii II	Cable car	Valea Arsului
pH	7.15	7.05	6.85	6.94
Nitrites [mg/kg]	4	5	3	3
Chlorides [mg/kg]	750	550	400	400
Conductivity [µs]	111.5	79.4	85.9	75.4
Aluminum (Al^{3+}) [mg/kg]	8.97	6.36	11.25	1.57

Table 2 Cation exchange capacity

Sampling area / **Exchange capacity**	**Dealul Babii I**	**Dealul Babii II**	**Cable car**	**Valea Arsului**
Hydrogen ions [m.echiv]	82	70	95	48
Metal ions [m.echiv]	210	190	170	310

Analyzing data obtained from measurements made in the laboratory, included in table 1, can be observed that a higher concentration of nitrates and chlorides is higher in sampling points “Dealul Babii I” and “Dealul Babii II” then in the control point “Valea Arsului” what may indicate their accumulation due to acid rains, these chemicals being released into the atmosphere from the processes carried out at the power plant. Aluminum also can give us indications of soil acidification, it being more soluble under acidic conditions, and as the results show, in all three sampling points the numbers are higher than the control point. Conductivity can also provide information regarding the activity of acid rains in the region, due to the potential of acid rains to dissolve most salts and minerals, therefore the lower values of the conductivity in the control point could point out a certain soil acidification due to acid rains.

As it can be seen in table 2 exchange capacity of hydrogen ions is higher in the “Dealul Babii I”, “Dealul Babii II” and “cable car” areas compared to the control area “Valea Arsului”, which could indicate a soil acidification in those areas. Also the exchange capacity of metal ions is higher in the control point (the most common cations found in soils are $Ca2^+$, Mg_2^+, K^+, Na^+, Al_3^+) , giving the soil alkaline characteristics.

Table 3 Spectrophotometric analysis

Sampling area / Chemical Characteristics	Dealu Babii I	Dealu Babii II	Cable car	Valea Arsului
Na_2O [g/kg]	1.48	1.08	0	0
MgO [g/kg]	3.82	3.49	3.32	3.87
SiO_2 [g/kg]	412.3	418.6	532.3	427.1
P_2O_5 [g/kg]	4.68	4.34	0	2.23
SO_3 [g/kg]	3.89	5	3.85	4.46
Cl [g/kg]	0.94	0.7	0.5	0.5
K_2O [g/kg]	48.1	49.8	23.6	27
Al_2O_3 [g/kg]	121.5	120	74.9	99.7
CaO [g/kg]	31.74	15.97	11.87	18.98
TiO_2 [g/kg]	21.3	16.66	26.89	22.98
V_2O_5 [g/kg]	0.3	0	0	0
Cr_2O_3 [g/kg]	2.1	0.6	4.19	4.55
MnO [g/kg]	4.26	4.89	3.61	5.08
Fe_2O_3 [g/kg]	177.9	197.82	159.4	194.64
Co_2O_3 [g/kg]	0	0	0.6	0
NiO [g/kg]	0.78	0.66	0.42	0.54

CuO [g/kg]	0.72	0	0	0
Ga_2O_3 [g/kg]	0	0	0.42	0
GeO_2 [g/kg]	0	0	0	0.39
As_2O_3 [g/kg]	0.92	0.87	0.13	0
SeO_2 [g/kg]	0	0.39	0	0
Rb_2O [g/kg]	1.5	1.72	0.53	2.08
SrO [g/kg]	0.55	0.76	0.58	0.74
ZrO_2 [g/kg]	2	1.81	0.21	0
Nb_2O_5 [g/kg]	0	0	0	0.2
BaO [g/kg]	6.15	7.74	0	3.96
$CaCO_3$ [g/kg]	56.6	28.43	21.2	32.71
Humus [g/kg]	88.7	111.47	119.79	139.89

Following the analysis of water samples made in the laboratory, the following data was obtained:

Table 4 Chemical analysis of rain and surface water

Sampling area / **Chemical Characteristics**	**Dealul Babii**			**Cable car**	**Valea Arsului**
	Rain water	**Surface water**	**Temporary spring**	**Rain water**	**Rain water**
pH	5.97	5.91	6.14	5.94	6.17
Nitrites [mg/l]	0.3	0.3	0.4	0.3	0.2
Chlorides [mg/l]	20	15	15	15	10
Conductivity [μS]	67.7	55	77.6	59.1	46.9

As in the case of soil samples, a difference can be observed between the values of the results from the two sampling areas “Dealul Babii I” and “Cable car”, compared to the ones obtained from the control area “Valea Arsului”. The presence of nitrates and chlorides in water samples taken indicate the existence of these compounds in the atmosphere as a result of processes performed at C.T.E Paroşeni which even in relatively small amounts can lead to their accumulation in the soils due to the presence of humus.

6. CONCLUSIONS

From gaseous pollutants discharged into the atmosphere by power plant Paroseni, the significant negative influence on soil acidification potential are sulfur dioxide and nitrogen oxides. These gases have synergistic effects on local and regional scale, and their quantity depends on the quality of the used fuel and of the characteristics of burning process.

After chemical analyzing the data obtained in the laboratory and observations made on bioindicators in the areas of influence of the power plant, it has been established that there is a slight acidification of soils due to the activities undertaken at C.T.E Paroşeni.

Therefore, further research is recommended by a pedological study of the affected soils in areas to determine the ability of buffering and neutralizing of the acidic soil by humic acids. Also, these studies can provide information on the accumulation of nitrates in the soil. It is proposed sampling of the lichens and their spectrophotometric analysis, which can provide information's on pollution from affected areas by their property to absorb harmful substances.

REFERENCES

[1]. Ciolea Daniela-Ionela, Dunca Emilia-Cornelia – *Biologie.* Editura Universitas Petrosani 2011.
[2]. Chirițoiu Magdalena - *Revista de educație ecologica și ocrotire a naturii.* ECOS 19/2007
[3]. Dumitrescu Ioan - *Poluarea mediului.* Editura Focus 2002.
[4]. Dunca Emilia, Biro Carol – *Pedologie.* Editura Universitas Petroșani 2006.
[5]. Enache Răzvan-Dănuț - *PhD Thesis "Quantitative determination of ecological indicators used in forest site evaluation of hill-area sessile, beech and mixed stands (FD3) from the Ialomița Subcarpathians".* Brasov 2012
[6]. Ionescu Clement, Traistă Eugen, Matei Aronel - *Lucrări practice de chimie generală.* Universitatea Tehnică Petroșani 2000.
[7]. Lazăr Maria, Dumitrescu Ioan - *Impactul antropic asupra mediului.* Editura Universitas, Petrosani, 2006.
[8]. Lazăr Maria, Faur Florin - *Identificarea și evaluarea impactului antropic asupra mediului.* Editura Universitas, Petroșani, 2011.
[9]. Matei Aronel, Edelhauser Carmen, Ionescu Clement, Traistă Eugen - *Lucrări practice de chimie anorganică.* Litografia Universității Petroșani, 1995.
[10]. Autorizație integrata de mediu, S.E Paroșeni 2007
[11]. INCD – ECOIND - *Raport de Amplasament S.E Paroseni*, Bucuresti, 2010.

Scientific Reviewers:
Prof. Ph.D. Eng. Ioan DUMITRESCU

USING FBC TECHNOLOGY TO STUDY THE SO_2 EMISSIONS RESULTING FROM COMBUSTION OF JIU VALLEY COAL

CLEMENTINA SABINA MOLDOVAN*
CLEMENT IONESCU**
LIANA SIMONA SBIRNA***

Abstract: *This paper reports the results obtained for the emissions of SO_2 from a large coal under staged combustion without any additive. The experiments were carried out at fluidizing velocities of 1 and 2 m/s, bed temperatures of 1000-1100 K, 20% and 40% excess air, at a primary air staging of 70:30 and a secondary air staging of 60:40, by using bed particle sizes of 0.2 and 0.7 mm. The effect of each of these work parameters on SO_2 emissions was investigated, in order to draw the conclusions of the study.*

Key words: *Jiu Valley coal, sulfur dioxide emissions, FBC technology*

1. INTRODUCTION

Coal, which is primarily used for the generation of electricity, is one of the largest domestic contributors to sulfur dioxide emissions. The public has become more concerned about global warming which has led to new legislation.

The coal industry has responded by running advertising touting clean coal in an effort to counter negative perceptions.

Fluidized bed combustion (FBC) is a combustion technology that is based on suspended solid fuels in upward-blowing jets of air during the combustion process. The result is a turbulent mixing of gas and solids [5].

The mixing action of the fluidized bed brings the flue gases into contact with a sulfur-absorbing chemical, such as limestone or dolomite.

More than 95% of the sulfur pollutants in the fuel can be captured inside the boiler by the sorbent. The sorbent also captures some heavy metals, though not as effectively as do the much cooler wet scrubbers on conventional units.

The literature reports that FBC technology involves either two beds in series with two distributors or a simple air staging technique.

In the staged operation mode, the combustion air is separated into a primary air stream.

* *Lecturer Ph.D. Chem., at the University of Petrosani*
** *Assoc. Prof. PhD .Eng. at the University of Petrosani*
*** *Ph.D., University of Craiova*

This constitutes the fluidizing air supply to the bed and a secondary air stream that is injected higher up in the bed or freeboard [3].

Combustion is then completed following the introduction of secondary air. However, overall excess air conditions are maintained in a similar way as in conventional operation.

Air-staging is a proven technique to reduce NO_x emissions, but is known to increase in SO_2 emissions.

This increment is due to the presence of secondary air in the freeboard that allows further combustion (it seems that at high staging this increment is caused by the carryover of unburned fuel sulfur into the freeboard).

The objective of this study is to determine the effects of different work parameters on SO_2 emissions.

One can compare the efficiency of SO_2 reduction with the one obtained if a sorbent is added to the bed (as previously mentioned, a sorbent denotes here a sulfur-absorbing chemical, such as limestone or dolomite).

Bed temperature exhibits a significant effect on SO_2 emissions which indicates that the rate of formation of SO_2 in the freeboard is affected by staging and changes in the temperature profile of the freeboard [1].

In this study, the simple air staging technique was adopted where most part of the total air is injected through the distributor and the remainder is injected in the freeboard of the fluidized combustor.

2. EXPERIMENTAL

A stainless steel combustor, 0.3x0.3 m in cross section and 2 m high was used.

Fluidizing air was supplied through a multi-hole distributor. An adjustable secondary air injector was used along the vertical axis of the combustor to introduce secondary air in the freeboard.

Investigations were carried out at 20% and 40% of total air injected in the freeboard above the bed, at a primary air staging of 70:30 and a secondary air staging (primary/secondary air) of 60:40, whereas the fluidizing velocities were of 1 and 2 m/s, bed temperatures of 1000 and 1100 K. The bed particle sizes were of 0.2 and 0.4 mm [2].

The fluidized bed was preheated by a propane burner, fixed above the bed, and the fluidizing air flow rate was set at the lowest level to minimize the heating time.

The secondary air was injected through a secondary air injector consisting of a stainless steel pipe with a 15 mm inside diameter, containing twelve holes of 3 mm diameter. This injector was located on the vertical axis of the combustor and its position above the bed or in the freeboard was adjustable. The bed temperature was maintained by using an adjustable cooling coil [4].

Coal sampled from Jiu Valley was used in the experiments.

3. RESULTS AND DISCUSSION

Coal feeding started when the bed temperature reached 1000 K.
The proximate and ultimate analyses of coal are given in Tables 1 and 2.

Table 1. Proximate analysis of coal used

Proximate analysis (dry basis)	Weight (%)	
Ash	6.23	6.22
Volatile matter	33	33.00
Fixed carbon	60	60.78

Table 2. Proximate analysis of coal used

Ultimate analysis (dry basis)	Weight %	
Carbon	70	77.51
Hydrogen	5	4.8
Oxygen	8	8.5
Nitrogen	1	1 .43
Sulfur	11	1 5
Moisture	5	5.0

Values of SO_2 emissions were continuously recorded.

More specifically, the SO_2 in the flue and the axial concentration profiles of SO_2 through the combustor were measured for a fluidizing velocity of 1 and 2 m/s; the bed material was sand, of about 0.2 and 0.7 mm size respectively, staging 70:30 and 60:40, excess air 20 and 40%, at bed temperatures between 1000 and 1100 K (the Ca:S molar ratio was found to be approximately 3:1).

The results (*i.e.*, the values of SO_2 emissions – measured in ppm) are summarized in Tables 3 and 4 for the two particle types that were used. As is obviously that the particle size does not practically affect the results, one may reduce the study to the one involving the particles of 0.7 mm.

Table 3. The values of SO_2 emissions (ppm) for the case of 0.2 diameter sand particles in fluidized bed

	70:30	60:40	70:30	60:40	
1 m/s	627	670	653	700	40%
1 m/s	689	719	703	823	20%
2 m/s	731	781	833	904	40%
2 m/s	818	885	1020	1204	20%
	1000 K	1000 K	1100 K	1100 K	

Table 3. The values of SO_2 emissions (ppm) for the case of 0.7 diameter sand particles in fluidized bed

	70:30	60:40	70:30	60:40	
1 m/s	628	670	653	700	40%
1 m/s	690	720	703	823	20%
2 m/s	732	780	834	905	40%
2 m/s	818	885	1020	1205	20%
	1000 K	1000 K	1100 K	1100 K	

4. EFFECT OF DIFFERENT WORK PARAMETERS ON SO_2 EMISSIONS

It shows that the SO_2 emissions decreased when the amount of the secondary air was increased and the fluidizing velocity decreased. One may notice that the SO_2 emissions are sensitive to bed temperature, increasing as it increases.

The SO_2 emissions at different secondary air ratios appear to be affected by combustion efficiency.

They exhibit higher values at higher secondary air (which equals to lower air staging) are due to increased combustion of sulfur in the bed and freeboard.

Figures 1-4 illustrate the two charts representing SO_2 emissions as functions of bed temperature at a particular air staging (either 70:30 or 60:40) for a fixed fluidizing velocity (either 1 or 2 m/s) and also for a fixed excess air (either 20% or 40%).

The results demonstrate that the extent of SO_2 emission during staged combustion is influenced by the amount of secondary air and by the bed temperature. More specifically, it increases as bed temperature increases and the primary/secondary air increases (*i.e.*, at higher secondary air).

One can observe that the trends obtained are alike for these charts.

The primary air to coal ratio (air/fuel ratio) is defined as the ratio of primary air supplied to the stoichiometric air required, calculated from the coal composition (at 40% staging, an excess air level of 40% resulted in a primary air to coal ratio of 0.8, and 20% excess air resulted in a primary air to coal ratio of 7:10, *etc*.).

At a low primary air to coal ratio, an increase in carryover of unburned fuel sulfur species into the freeboard where it subsequently oxidizes also increase SO_2 emissions.

This indicates that oxidation of some of the sulfur bearing compounds to SO_2 cannot be ignored in the second stage (above the bed).

The air: fuel ratio has significant influence on the rate of sulfur release from the coal and on the ratio of H_2S formed during fuel-rich combustion.

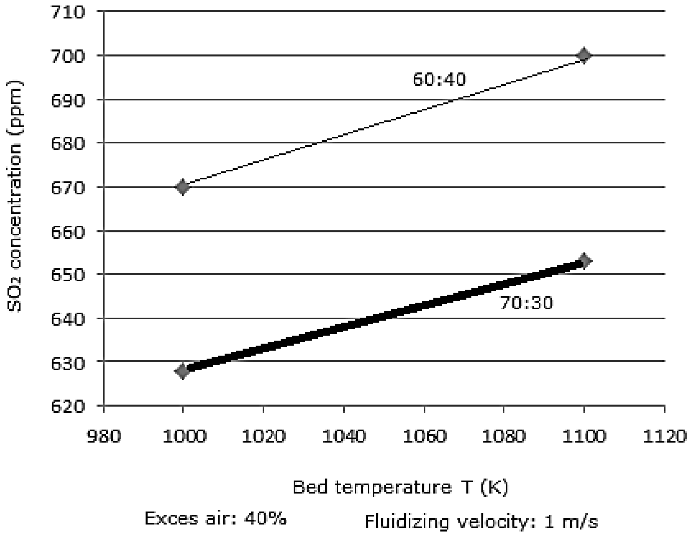


Figure 1. SO_2 emissions as functions of bed temperature at two particular air staging levels (the fluidizing velocity is fixed at 1 m/s, whereas the excess air is fixed at 40%)

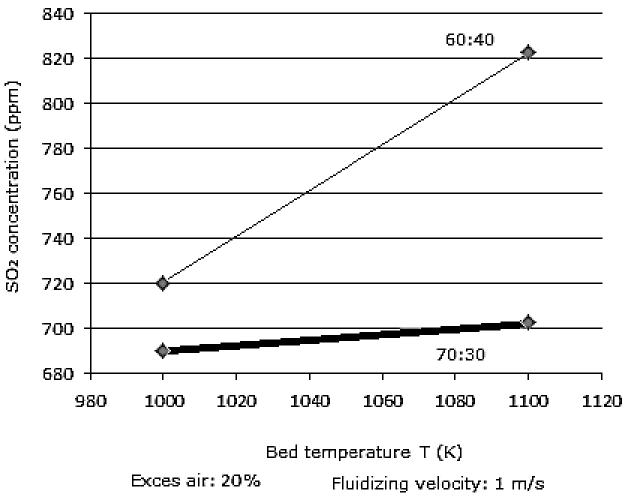


Figure 2. SO_2 emissions as functions of bed temperature at two particular air staging levels (the fluidizing velocity is fixed at 1 m/s, and the excess air is fixed at 20%).

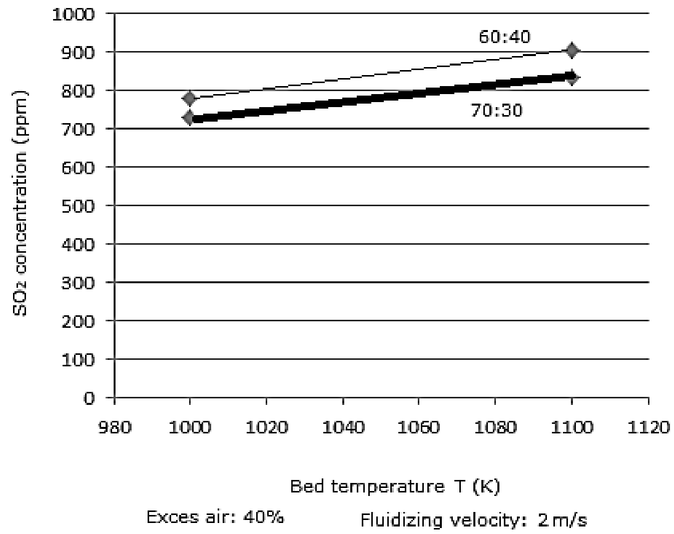


Figure 3. SO_2 emissions as functions of bed temperature at two particular air staging levels (the fluidizing velocity is fixed at 2 m/s, whereas the excess air is fixed at 40%)

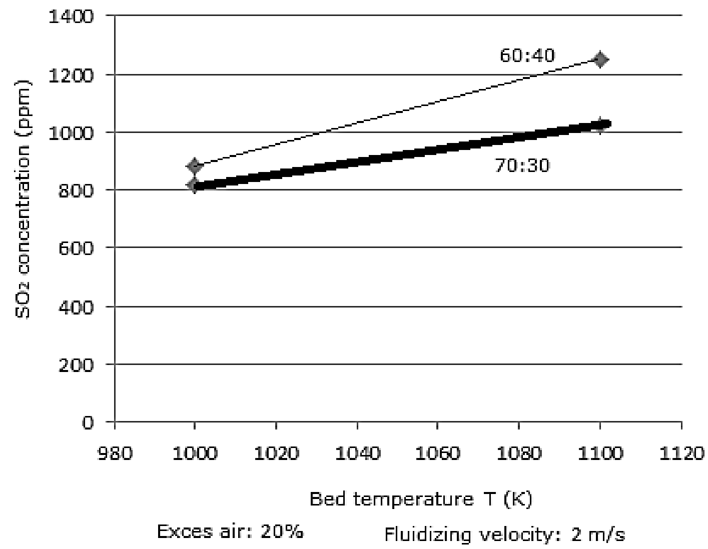


Figure 4. SO_2 emissions as functions of bed temperature at two particular air staging levels (the fluidizing velocity is fixed at 2 m/s, whereas the excess air is fixed at 20%)

5. CONCLUSION

The results indicate that SO_2 emissions increase with a rise in bed temperature. The extent of SO_2 emission during staged combustion is strongly influenced by the amount of secondary air and bed temperature.

For a given bed temperature and excess air level, increasing the level of air staging or lowering the primary air to coal ratio causes an increase in SO_2 emissions.

An increase in SO_2 emissions as excess air is reduced was observed at both fluidizing velocities and at all secondary air ratios.

REFERENCES

[1]. Modrak, T. M., Tang, J. T., Auliso, C. J., *Fuel*, 2007
[2]. Tatebayashi, J., Okada, Y., Yano, K., Ikeda, S., *Fuel*, 2007
[3]. Tomita, M., Hiramo, T. Adachi, T., Yamaguchi, H., Horio, M., *International Conference on Fluidized Bed Combustion*, Atlanta, Georgia, USA, ASME, 2000
[4]. Valk, M., Bramer, E. A., Toissant, H. H. J., *Conference on Fluidized Bed Combustion*, Montreal, Canada, ASME, 2002
[5]. www.netl.doe.gov

Scientific Reviewers:
Prof. Ph.D. Eng. Sanda KRAUSZ

THE SEPARATION OF COAL PARTICLES IN STERILE FLOTATION DEPOSITS IN COAL TAILING PONDS THOURGH THE USE OF HYDROCYCLONATION

**CĂTĂLIN VRÂNCEANU*
DIANA MARCHIŞ**
LAURENȚIU DOBREI***
ROMULUS SÂRBU******

Abstract: *As a result of coal preparation though hydrogravitational and floatation methods, significant quantities of coal slurry, containing solid particles with diameters mostly under 1 mm, of which approximately 20% are coal fines, have been generated over the past years. They have been deposited in coal tailing ponds, and can therefore be extracted and used as a secondary source of solid energetic fuel. The technology used for the recovery of the coal fines in the gross slurries impounded in the two tailing ponds, belonging to the Coroiesti Valea Jiului Preparation Plant, which are used as combustion fuel in thermal power plants or any other combustion installations, consists of the combining of attrition-separation processes, primary centrifugal field concentration performed by a coarse hydrocyclones unit, connected at its overflow compartment with a fine hydrocyclones unit, whose underflow product is passed through a dehydration sieve, while its overflow residue, containing a high quantity of fine clay particles is deposited in a sedimentation compartment of the pond under exploitation. The resulting waste waters are completely recycled throughout their course through the installation, while technological water is used for the achieving of the necessary working dilution, spraying on the sieves and cooling of the equipment. The clay fines are transported to authorized storage facilities. This technology allows for the emptying of the tailing ponds, which will make them reusable for the same purposes they have been created for in the near future on one hand, and for adding economic value to this secondary source of energetic fuel on the other.*

1. DESCRIPTION

Taking into account that the $+63x10^{-3}$ mm coal fraction represents 23,49 %, a successful BAT technology for the separation of coal and clay particles would be an installation that can perform the application of centrifugal field separation through hydrocyclonation, which can achieve a minimum acceleration factor of 10g.

Separation through hydrocyclonation is a method that has been proven to be highly lucrative for the processing of the presently exploited materials; however it has

* *student PhD. Eng. - LCC - Coal Company Reşița*
** *PhD. Eng. - LCC - Coal Company Reşița*
*** *student PhD. Eng. at the University of Petroșani*
**** *Prof. PhD. Eng. at the University of Petroșani*

also shown a number of restrictions, especially in relation to the feeding conditions of the used technology:

- feed dilution (liquid/solid percentages) with a minimum value of 3 and maximum of 5;
- volumetric concentration of the solid phase of about 275g/dm^3;
- maintaining the quality of the raw material within semi-constant limits in relation to the percentages of useful particles and refuse;

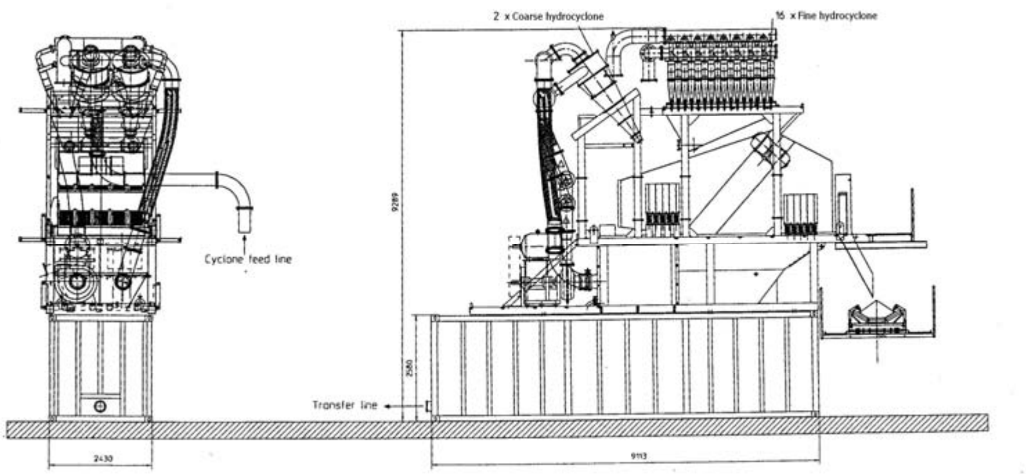
At this rate, at the present level of exploitation works and quality of the vertically deposited slurries, it is necessary to ensure the simultaneous extraction of the materials from both tailing ponds, to keep the aforementioned percentages at the desired rates.

Should the quality of the raw slurry change substantially inside the extraction areas, it will lead to the adjustment of these percentages, to better suit the newly created conditions.

Following is a description of a technology and installation used for the preparation of coal slurries, with a variable content of coal fractions, impounded in coal tailing ponds, with millions of cubic meters of slurry stretching on a vast territory of tens of hectares, thorough centrifugal field processing of these materials and two-stage hydrocyclonation, which is performed at first stage with the use of 700 mm coarse hydrocyclones for the separation of the particles with sizes ranging between 4 ÷ 0,25 mm, whose overflow is connected to a 125 mm fine hydrocyclones unit, for the separation of the finer coal particles of 0,25 ÷ 0,063 mm. The resulting product has characteristics that allow its combustions in thermal power plants or other combustion installations, while the refuse of the second stage of the hydrocyclonation process, with sizes below 0,063 mm consists mainly of clay us residue.

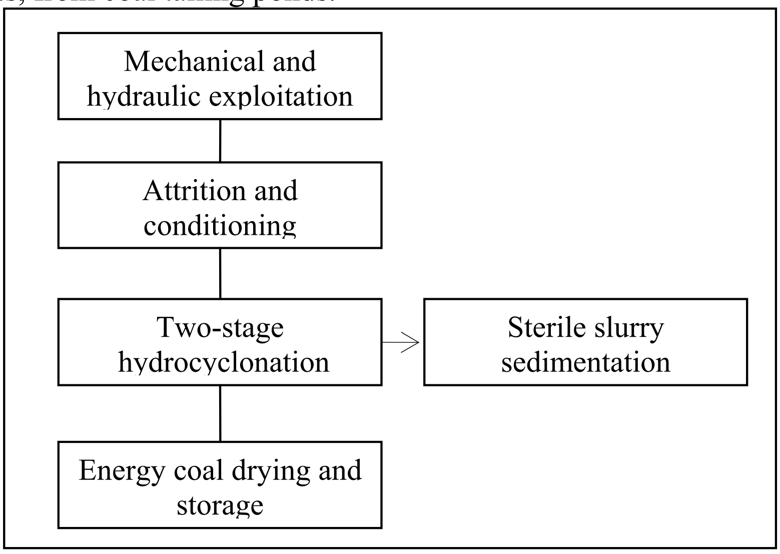
The suggested technological solution is characterized by the fact that the raw slurries, impounded in the coal tailing ponds, are extracted thorough mechanical and hydraulic methods and conveyed to a mixing tank where the dilution of minimum 3 m^3/t is achieved, as well as the attrition through agitation, that releases the float-able clay fines. From the mixing tank, a centrifuge pump carries out the feeding of a 2-level sieve with openings of 14 and 4 mm, that ensure the removal of the foreign bodies in and the sterile particles originating in the wells of the tailing ponds. The passed material is fed under pressure to the coarse hydrocyclones that perform the separation of the particles with sizes above 0.25 mm. The overflow of these cyclones represents the material that is fed during the second stage of the process, to the fine hydrocyclones unit, where the usable particles with sizes above 0,063 mm are separated from the float-able clay fines, with sizes under the aforementioned value, that constitute the final residue of the operations. This residue is deposited in a pond created for this very purpose. The resulting water is recirculated though the separation installation.

The solids obtained during the two-stage hydrocyclonation process are the coal fractions that are subsequently passed through dewatering screens with reverse angles. The final materials are loaded into rail freight coaches and sent to the beneficiaries.



Insert n° 1. Two-stage hydrocyclonation installation

Insert no 2 has been included to show the processing framework of the technological flow of the raw slurries, which is worked over through mechanical and hydraulic methods, from coal tailing ponds.



Insert n° 2 Processing framework of technological flow

The technological parameters obtained by this technology are shown in Table 1.

Table 1. Technological parameters

Mass flow rate A, [t/h]	Volumetric flow rate Q, [m^3/h]	Ash content [%]			Calorific power, [kcal/kg]			Coal recovery rate, [%]	Water recirculation degree, [%]
		Raw	Coal	Refuse	Raw	Coal	Refuse		
150	450	58,13	27,70	72,52	1720	4100	780	57,86	85

2. CONCLUSIONS

The technology we have presented is adaptable to all sterile deposits that contain coal fractions, usually with sizes under 3 mm, impounded in tailing ponds or found in alluvial deposits.

It is a well known fact that when the finer coal particles of fewer than 63 microns represent a high percentage of the raw product, the gravitational separation methods available can prove inefficient, which is why it is necessary to involve significantly increased force rates of 10-100g. These forces can be obtained only through the use of centrifugal field applications.

The technology presented here is innovative at least at national level and is based on the process of centrifugal field coal particle separation, through two-stage hydrocyclonation:

- a coarse stage for the separation of the particles of over 250 microns, within a coarse hydrocyclone unit;
- a fine separation stage with the recovery of particles above 63 microns, within regular size hydrocyclones.

As a general rule, the particles with sizes above 63 microns consist mostly of coal fractions, which are merchantable, while the particles with sizes below the above mentioned value, is compiled of float-able clay particles that represent the final refuse of the process.

Due to a high degree of water re-circulation through the installation, without any discharges into the environment, we see the aforely described technology as clean and safe for the environment.

This technology is adjustable, depending on the characteristics of the raw material that is processed through the installation, offering a viable technical solution for the requirements of modern mineral and environmentally-friendly engineering.

BIBLIOGRAPHY

[1]. Sârbu R.I. - *Gravitational preparation – Gravitational concentration methods***,** Lit. Univ. Tehn. Petroşani 1993.

[2]. Vranceanu C, Marchis D, Sarbu R. - *Improving the sizing efficiency by using hydrocyclones with additional water current*, 13th International Multidisciplinary Scientific Geoconference SGEM 2013, Energy and Clean Technologies – Conference proceedings, Albena, Bulgaria.

[3]. Sârbu R.I. - *Desing of centrifugal hydraulic classifiers based on hydrodynamic similitude*. Annals of the University of Petrosani - Mining Engineering Vol. 7 / 2006.

[4]. * * *- *Data sheet and declaration Emptying works of Coroesti Coal Preparation Plant tailing ponds 1 and 2*, 2013.

Scientific Reviewers:
Prof. Ph.D. Eng. Mihaela PODARIU

ASPECTS OF THE ANALYSIS OF THE MINING INDUSTRY PRODUCTION PROCESS

IOAN NICOLAE TIUZBAIAN*

Abstract: *In order to solve management and engineering problems, beginning with the simplest ones, such as the movements of a worker during the working process, and ending with the most complex ones, such as the management of the various economic activities specific to large companies, analyses of the production process are drawn out.*

Key words: *resources, mining industry, management, complex of operation, production process, movement.*

1. BASICS

In order to solve management and engineering problems, beginning with the simplest ones, such as the movements of a worker during the working process, and ending with the most complex ones, such as the management of the various economic activities specific to large companies, analyses of the production process are drawn out.

Nowadays, there is no unitary approach of such analyses or a unitary consideration of the problems they arise; each problem category according to their level of complexity still employs its own notional system of principles and criteria.

A single category of problems, namely the one regarding work quoting, is approached owing to a standard analysis system. This analysis system, in the case of the mining industry had as a basis the already existent standard analysis system of the machine building industry. Within the extractive industry such a standard is extremely difficult to be used; there are even instances when it cannot be employed for certain production processes.

Consequently, a few decades ago, that is between 1955 and 1960, they set forth and published a conception of analysis of the mining industry production processes according to a proper system of notions and principles.

This system has been proposed by Professor M. Al. Luca and set forth by a scientific work at Prague in 1962.

The basic idea of the production process analysis model proposed by Professor Luca is the passage from simple to complex, passage that is underlined by qualitative leaps of the work object that undergoes the changes. Accordingly, everything starts

* *Lecturer Eng. PhD. at the University of Petrosani, tiuzbaian@yahoo.com*

from the simplest work acts of a worker finally reaching processes of a great complexity at the branch level.

Three levels of complexity can accordingly be established:

- Inferior work and technological stages;
- Medium work and technological stages;
- Superior work and technological stages.

There are certain criteria according to which the integration within certain levels can be done, such as:

- The time during which the work act develops;
- The space within which the work act develops;
- Integration is done from simple to complex.

2. INFERIOR WORK AND TECHNOLOGICAL STAGES

These stages begin with the simplest work acts of the worker, namely the movements of parts of the human body, and end at the moment when the first changes of the work object can be identified and, even quantified.

According to their complexity, the inferior stages are the following:

- Movement (m);
- The complex of movements (cm);
- Handling (H);
- The complex of handlings (CH).

These stages are also similar to the standard specifications of the machine building industry.

2.1. Movement

The defining marks are the human body and its condition at a certain moment of the working process.

A movement is the change of the position of a part of the human body as compared to the previous condition. A movement is the simplest work act of a worker.

2.2. The complex of movements

The defining mark for a complex of movements is, this time, a material object of the production process (e.g. materials, tools, machines, a place within space) and human body.

A complex of movements is a group of movements specifically combined (overlapped or successive) that finally lead from a certain position of the human body as compared to the material mark to another position as compared to the same material mark.

The complexes of movements can be complexes of movements of changing the place (changing the place towards the pick-hammer), complexes of movements of engaging (seizing the hammer), complexes of movements of disengaging (setting free the hammer) and complexes of movements of relaxation in order to recover owing to a micro-break. The complexes of movements determine several types of movements.

2.3. Handling

In order to define handling we introduce as a mark a first position change of one of the material elements of the working process.

Handling is a technological group of complex movements or of movements only that finally change the position of the material elements taken into consideration. An example of handling is the switching on of a bulb from the switch.

2.4. The complex of handlings

The complex of handlings has as a defining mark either a single material object that successively moves through several positions in order to reach a qualitative different position as compared to the intermediary positions or several material objects that undergo handlings (simultaneously or successively) in order to determine a different configuration from the previous position.

As examples we can notice the complex of handlings of loading wood on a truck or the complex of handlings of starting a drill rig.

The identification of these work stages within the production process and their correct definition is necessary in order to explicitly set forth beginning and ending marks mainly with a view of measuring time. Such analyses of production processes are drawn out for planning studies of working methods as well as for time study and its measurement.

3. MEDIUM WORK AND TECHNOLOGICAL STAGES

The qualitative leap from the inferior stages to the medium ones is marked by the elementary changes (the first change of the work object), and the ending of medium stages is marked by reaching the final form of the changes of work objects when they are already taken or given either to other workers or in order to be received and paid (even if they are taken by the same worker in order to be changed again). The medium stages are the following:

- The operation (o);
- The complex of operations (co);
- The phase of simple process (psp);
- The simple process (sp).

As regards the medium stages there is no equivalence between the standard terminology and the terminology proposed for the mining industry due to the complexity of the mining production processes.

3.1. Operation

An operation can be defined when its technological elements are well established, that is the changes of work objects that take place during the operation, when the work object is correctly defined (especially those changes for which a worker is quantified and paid).

An operation is a group of complexes of handlings and/or handlings and passages and, possibly, machine phases that have as a result a first (elementary) change of the work object already defined, a change that can be quantified and for which a worker having a certain qualification is quoted and paid.

The defining elements of an operation require maintaining unchanged its material elements (tool, machine, material) as well as of those of the worker. The change of these material elements specifies another operation. Examples of operations: preparing a drill for drilling, drilling, elevation of the beams on the console, ripping the sections, loading the resulted material with the loading machine, trucks maneuver at ramification.

3.2 The complex of operations

There is a work object at the level of the complex of operations that is usually the result of one of the operations that are part of the complex of operations or of several operations that are considered to be the main ones of the complex of operations. The change of the work object is superior to any operation having a higher degree of finishing. At the same time, beside the operations that are considered to be the main ones there are other secondary operations that only help the well performing of the main operations.

Some of the secondary operations have, as a rule, a beginning or a ending character with no time connection with the duration of the whole complex of operations or with the volume of change achieved within the complex of operations.

As a result, within a complex of operations, both repeatable operations can appear considering the proportionality of work consumption to the volume of changes to be achieved, and unrepeatable operations that consume work that does not depend upon the quantity of changes of the work object.

The complex of operations is a group of main and secondary operations, repeatable and unrepeatable connecting each other and overlapping according to certain technological rules having as a result changes of work objects superior to any of the component operations. As an example, the drilling of a mining with a view of achieving a leap is a complex of operations due to the fact that starting with the moment the drilling begins until the moment the mining can be taken in order to load the holes several operations should be done in the sense previously defined. Accordingly, the following operations may take place:

- Proper drilling – main and unrepeatable;
- Passage from one hole to another – secondary and repeatable;
- Cleaning the hole – secondary and repeatable;

- Preparing the drill – secondary and unrepeatable;
- Fixing the holes – secondary and unrepeatable;
- Removing the drill – secondary and unrepeatable.

3.3. The phase of simple process

The works of Professor M. Al. C. Luca contain certain ambiguities regarding the way a simple process is defined, a fact that determines the necessity of including another stage between the complex of operations and the simple process. This contribution to the analysis of the mining work processes has been done by Professor Aurelian Simionescu, D.E. who noticed that several simple production processes are, in fact, made of several process phases. As an example, in order to build a drift the following process phases are to be considered:

- Digging and sustain;
- Enlarging and concrete filling;
- Railway building.

Process phases may be assigned to different working teams. Such process phases are quoted and paid differently even though they are achieved by the same working team. Process phases are done during different periods of time and, consequently, different agreement contracts are to be concluded, the phases being received and paid separately.

A process phase has as a result only a part of the entire work; yet, it is a finite one from the point of view of those who execute it. There are simple processes that have a single process phase, but there are also simple processes that have several process phases.

3.4. The simple process

A simple process is a group of complex operations and/or process phases within a defined technology but different from the one of the complex of operations and only owing to the combining of such complexes of operations and/or process phases that result in a work, a product or a service that, from the point of view of their destination, are already finite.

A simple process may be the execution of a mining work (drift, shaft, ladder shaft, incline) or the extraction from the mining of useful ore. A simple process, as we have already seen, may include several process phases.

The simple process has been defined as resulting in a finite work (drifts, inclines, shafts, ladder shafts) or finite products (extracted coal or ore).

4. SUPERIOR WORK AND TECHNOLOGICAL STAGES

4.1. The complex process

Complex processes are organized at the sector or unit (quarry) level and include all the simple processes of the main and auxiliary activities of the unit.

At the level of the complex process only exchanges of delivering and receiving between independent workers take place.

The analysis of the complex process according to the component simple processes and their process phases is the object of the engineering of production processes at sector and unit level. Currently, they materialize under the nomination of production programming, production organizing, and production supervising being accomplished by the programming, organizing, quoting, and remuneration department specific to each mining unit.

4.2. The integrated process

The integrated process structures the complex processes of various units having a mining profile (mines, quarries) with other units that deploy complex processes of preparation or even processing auxiliary products, general services, that is activities having a different character from the mining one.

Integrated processes are to be encountered at the level of autonomous administrations or mining branch.

REFERENCES:

[1]. Simionescu A.*, Organizing and Administrating Mining Activities*, Technical Publishing House, Bucharest, 1985.

[2]. Tiuzbaian I. N., *Researches with a View of Elaborating a New System of Quoting the Work within the Mines of the Jiu Valley Having as a Basis the Engineerig of Working Methods*, doctorate thesis, Petrosani, 2003.

Scientific Reviewers:
Prof. Ph.D. Eng. Petru HODOR

SELECTION METHODS OF ELASTIC WAVES ARRIAL AT SURFACE EMPLOYED IN SEISMIC PROSPECTING

VIOREL VOIN*

Abstract: *This paper the is presenting selection methods of elastic waves arial at surface employed is seismic prospecting*

1. INTRODUCTION

In the seismic prospecting technique, the main operations consists of elastic waves generation and, then, the registration of waves arrival at geophones, after the waves were deviated the subsurface separation limits.

In order to achieve a selection when registering the pulses on a seismographic record it is important to clearly register the signals induced by longitudinal elastic waves, which are having the highest propagation velocity.

To selected the most appropriate registering method of elastic waves arrival at surface, it is necessary to take into account the differences existing between the main physical characteristics and parameters of elastic waves in the researched from which we will mention:

a. Seismic wave dependence on source's type and magnitude employed (explosion, blasting, mechanical shock etc.).

b. Arrival time of elastic wave to the geophones will repressed a function of the depth were the subsurface separation limits is located.

c. Elastic waves propagation velocity.

d. Shape and specificity of specie-time holograph.

e. Different spectral composition for various seismic wave categories.

f. Different arriving directions of wave front for various types of seismic waves.

2. METHODS USED IN SEISMIC PROSPECTING FOR RECORDING OBSERVATION DATA

Et main technique applied in seismic prospecting in view to improve the elastic wave registration at geophones is the addition.

Actually, the addition of observations data employed in seismic prospecting, can be achieved by the following procedures:

- the use of several goofiness for reception of elastic waves generated by only

---

* *Prof. PhD. Eng at the University of Petroşani*

one seismic source (fig. 1a);

- production of elastic waves in several generation points and reception of these waves in a unique location (fig. 1b);
- multiple coverage(fig.1c);
- individual wave fronts compositions (fig. 1d).

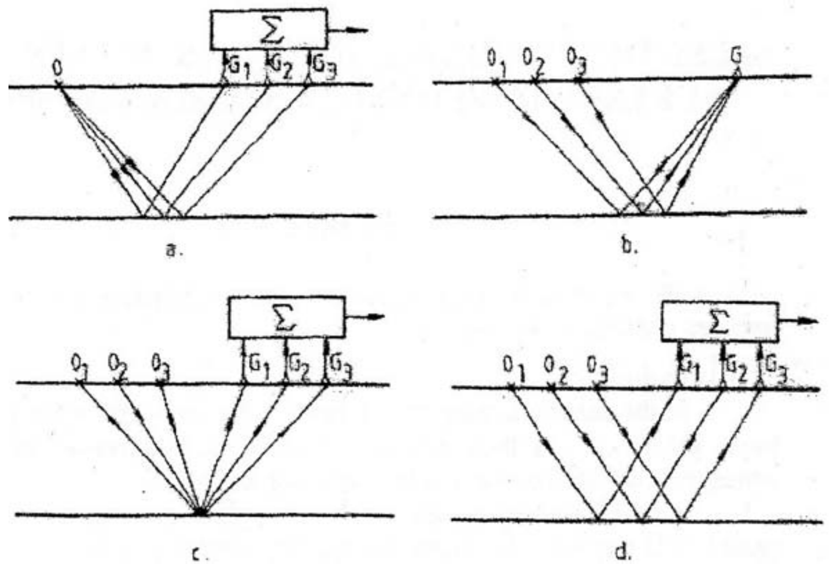


Figure nr. 1

With the scope of dearly register on a seismographic record the pulses given by useful waves (longitudinal), having the highest propagation velocity, and to mitigate the disturbing waves propagation (surface waves) which are having lower propagation velocities, the following methods can be applied: filtration in wave number, frequency filtration and filtration in apparent velocity.

From the above-mentioned methods, the most often is employed the filtration in wave number. This technique is based on the feature of seismic waves to arrive at ground level with apparent velocities v_a and apparent wavelengths λ_a which differs from one to another.

In this manner, the useful (longitudinal) waves are characterized by high value apparent velocities v_a, arriving at surface almost in the same time with the disturbing (surface level) waves. This leads to their addition and allows emphasizing a much higher value signal that the individual signals are.

3. THE GEOPHONES CONTINUING GROUP

It follows that filtration in wave number has the property to act differently, as a function of elastic waves arrival directions at the surface. In order to asses the basic parameters of a geophone group at surface, which monitors and registers the arrival of useful (longitudinal) wave data required in seismic prospecting, a continuous linear geophones group is considered, having an infinite length and a distribution of geophones sensitivity denoted by g(x).

If in a point x = 0, a F(t) signal arrives, having a frequency spectrum S(w) (fig.2), then in a point x = xi located in the group's center will arrive an elastic wave

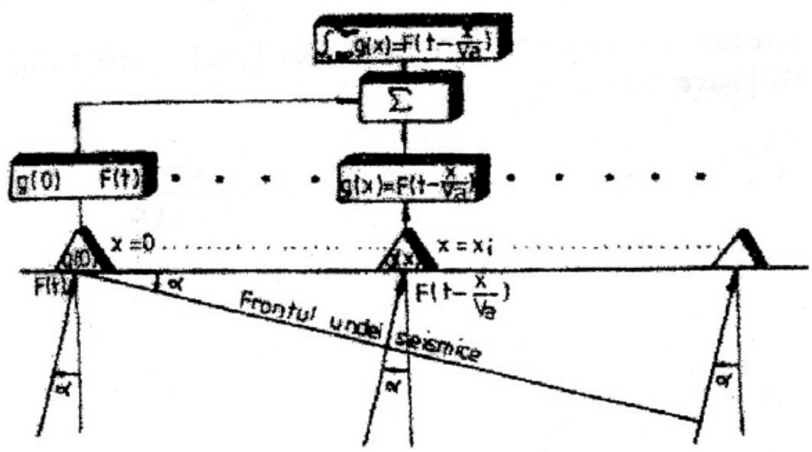


Figure nr. 2

having a signal $F\left(t-\frac{x}{v_a}\right)$ and a frequency spectrum $S(w)\cdot e^{\frac{-i\cdot w\cdot x}{v_a}}$.

If al the geophones entering in the analyzed group are taken into consideration, the following relationships can be obtained:

$$F_{\alpha i}(t) = \int_{-\infty}^{+\infty} g(x)\cdot F\left(t-\frac{x}{v_a}\right)\cdot dx \tag{1}$$

$$S_{x_i}(w) = S(w)\int_{-\infty}^{+\infty} g(x)\cdot e^{\frac{-i\cdot w\cdot x}{v_a}}\cdot dx = S(w)\cdot G\left(\frac{w}{v_a}\right) \tag{2}$$

Where $G\left(\frac{w}{v_a}\right) = \int_{-\infty}^{+\infty} g(x)\cdot e^{\frac{-i\cdot w\cdot x}{v_a}}\cdot dx$, represents the transfer function specific to the continuous geophones group.

If the wave number is noted as:

$$k = \frac{1}{\lambda} = \frac{1}{v_a\cdot T} = \frac{f}{v_a} \tag{3}$$

Than the transfer function of the continuous geophones group, while have following expression:

$$G(k)=\int_{-\infty}^{+\infty} g(x)\cdot e^{\frac{-i\cdot w\cdot x}{v_a}}\cdot dx \qquad (4)$$

If a finite length $-\frac{B}{2}\le x\le\frac{B}{2}$ geophones group is chosen, with a uniform sensitivity distribution of geophones $[g(n)=g(0)]$ (fig.3), than the transfer function will have the shape:

$$G(k)=B\cdot g_0\frac{\sin\pi\cdot k\cdot B}{\pi\cdot k\cdot B} \qquad (5)$$

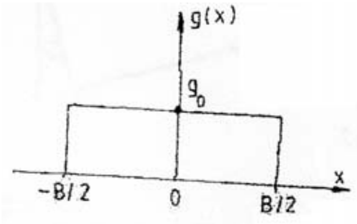


Figure nr. 3

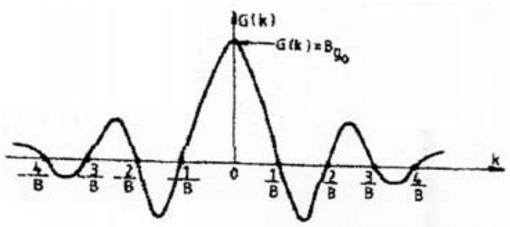


Figure nr. 4

Analyzing the relationship (5) it can be remarked that the transfer function of a finite length geophones group, having equal sensitivities has the shape of a harmonic curve (fig.4). It can be seen that the function has a main maximal value and several secondary maximal values, which attenuates on the k abscissa.

Et transfer function becomes null in the points defined by the relationship:

$\sin\pi\cdot k\cdot B=0$, $\pi\cdot k\cdot B=p\cdot\pi$ namely $k=\frac{p}{B}$, where p = 0, 1, 2, 3.... and B - represents the base of the geophones group, that is the distance between the first geophones in the group and the last one.

Taking into account the above considerations, the full following parameters are defined for a group of geophones:

- the geophones group base:

$$B_G=\frac{1}{k_1}=\lambda_1=\frac{v_{ap}}{f_1+f_2} \qquad (6)$$

Where: v_{ap} is the apparent propagation velocity of disturbing (surface) wave, which has to be attenuated.

f1 - inferior limit frequency of the seismic channel.

- the distance between two geophones whiting the group, δ_{xG}:

$$k_0=\frac{1}{\delta_{xG}};\ \delta_{xG}=\frac{1}{k_0}=\frac{v_{ap}}{f_0}=\frac{v_{ap}}{f_1+f_2} \qquad (7)$$

Where: f2 the superior frequency of the seismic channel.

- number of geophones within a group, n:

$$B = (n-1) \cdot \delta_x \text{, resulting } n = \frac{B}{\delta_x} + 1 \qquad (8)$$

4. CONCLUSIONS

It results that the geophones group should be employed only when the frequency of surface wave $S_s(f)$ and of useful (longitudinal) wave $S_u(f)$ are the same: $S_s(f) = S_u(f)$ and, consequently, the frequency filtration can not act.

Lately, in seismic prospecting appeared seismic stations in which processing in an analogical station allows obtaining the location of separation levels (old refraction or reflexion) in the subsoil.

The choice of geophones group parameters must be done such as the transfer function bandwidth includes the signal and the reflection bandwidth includes the noise.

REFERENCES

[1]. Botezatu R., *Prospectarea geofizică a zăcămintelor de minereuri.* 1976, Editura Tehnică Bucureşti.

[2], Chapel P., *Géophysique appliquée.* 1980, Paris.

[3]. Enescu D., Orban T., *Prospecţiuni seismice.* 1983, Litografia Universităţii Bucureşti.

[4]. Hoower G., *Influenţa amplasării geofonilor asupra datelor seismice din teren.* 1980, Revista Geophysics vol.45.

[5] Voin V., *Prospectarea şi evaluarea rezervelor de substanţe utile.* 2013, Editura Universitas.

Scientific Reviewers:
Prof. Ph.D. Eng. Constantin SEMEN

RESEARCH ON THE OBTAINING AND DISPOSAL SLUDGE IN THE JIU VALLEY

DANIELA IONELA CIOLEA*

Abstract: *In the Jiu Valley, sewage sludge comes from two stations waste water treatment. The stations waste water treatment are located in Petrosani (WWTP Danutoni) and Uricani. Dehydrating sludge by means natural, upon beds of drying at WWTP Danutoni; but quantities of sludge are currently uncertain. Dry Sludge is be exhausted in waste deposits local official, be discharged to sources of surface water, without authorization. Do not use sludge in agriculture; in the past few years, there has been no case of spread of sludge on soils.*

Key words: *waste water, sludge, sewage, environment, ecology*

1. THE LEGISLATIVE FRAMEWORK

The legislative framework of the European Union on waste-water treatment, management and disposal sludge, have been introduced over the years several major amendments. For example, the discharge in sludge and oceans once is prohibited after the issue cleaning European directive on urban waste water (91/271/EEC).

Next change in the field of eliminating represented a European directive on the disposal of waste (1999/31/EC). Thus, in many Member States of the European Union, almost as it is prohibited in municipal sludge disposal waste deposits. Therefore, operators are currently alternative means of disposal in large part of Europe. Also, it is expected changes in the legislation on the reuse municipal sludge in agriculture. [4]

The project of the future Directive on sewage sludge already limit values should be more stringent for pollutants contained in sludge. Legislative developments should be pursued with caution.

Normally, the methodology European legislation relating to the environment provides that the European Union defines several objectives. They are binding on all Member States. Each Member State must then define the national legislation in order to achieve these objectives. But the implementation usually differ from one Member State to another.

EU Directive on sewage sludge (Council Directive on the protection of the environment and in particular of the soil when using sludge from sewage plants in agriculture 86/278/EEC) regulate the use of sewage sludge in agriculture in such a way as to prevent harmful effects on soil, vegetation, animals and man, while encouraging

* *Lecturer Eng. PhD. at the University of Petrosani, cioleadaniela@gmail.com*

proper use of them. For this purpose, it shall be prohibited to use untreated sludge on the land if they are not injected or incorporated into the soil. Sludge treatment are defined as sludge's to be subjected to a "biological, chemical or heat, long-term storage or any other appropriate process, with a view to significant reduction in capacity fermentability and health risk resulting from their use. [1]

To protect against any animal health risks caused by residual pathogens shall be prohibited from applying sludge on ground intended for the cultivation of fruit and vegetables for a period of at least 10 months before the harvest and during harvest. Animals shall be prohibited from grazing on grassland or fodder crops for a period of at least three weeks from sludge application. Also, the Directive imposes an obligation to take into account the use sludge, of the nutrient needs of the plants, so that it will not be compromised quality of the soil and of surface water or groundwater.

Directive lays down limit values for concentrations of heavy metals in soils (Annex I A to Directive on sewage sludge), in sludges (Annex I B to Directive on sewage sludge) and the maximum annual quantities of heavy metals which may be introduced into soil (Annex I C to the Directive on sewage sludge). Also, the Directive specifies rules for sampling and analysis of sludge and soil. Establishes rules for detailed record of the quantities of sludge produced, of the quantities used in the agricultural sector, the composition and characteristics of sludge, the type of treatment carried out and of the places for the use of sludge. Limit values for concentrations of heavy metals in sewage sludge intended for use in agriculture and in soils treated. [2]

But think the Romanian EU Directive 86/278 is Order No 344/708 16.08.2004 of the Minister of Environment and Water Administration and Ministry of Agriculture, Forests and Rural Development for the approval technical rules relating to the protection of the environment and in particular of the soil when using sewage sludge in agriculture. It should be noted that the limit values and the restrictions laid down in the national legislation are much more stringent than those required by the Directive. This is due to the fact that European Directive will be modified in the near future. The text national is implemented on the basis of the third draft of European Directive concerning sludge in 2000.

2. THE SLUDGE DISPOSAL AT PRESENT IN THE JIU VALLEY

Sludge disposal in the Jiu Valley is carried out at present as follows: in the Jiu Valley, sewage sludge comes from two stations waste water treatment. The stations waste water treatment are located in Petrosani (WWTP Danutoni) and Uricani. The biological station at Uricani has been given in operation for several years, while the base station to Danutoni, supplemented with the step of biological treatment, entered into service recently, in July 2009, after the implementation of the investment program ISPA. Sludge management in the Jiu Valley, as it is practiced at present, it is not satisfactory. The quantity of sludge generated by the stations waste water treatment is low, and route for the disposal of sludge is by carrying it with the truck to the nearest waste depot, located at approximately to 7 km WWTP Danutoni.

For that sewage sludge can be removed from the warehouse of waste, add lime in sewage sludge dried and reinforced in order to reach a solid content of 35 %.

Sludge dehydration and storage facilities are located on the perimeter of the workstation waste water treatment Danutoni, and hardened sludge from the treatment plant waste water Uricani is transported by trucks to Danutoni WWTP, as outlined in figure 1.

In the figure 1 is illustrate the route activated sludge treatment plants and sewage Uricani Danutoni. [5]

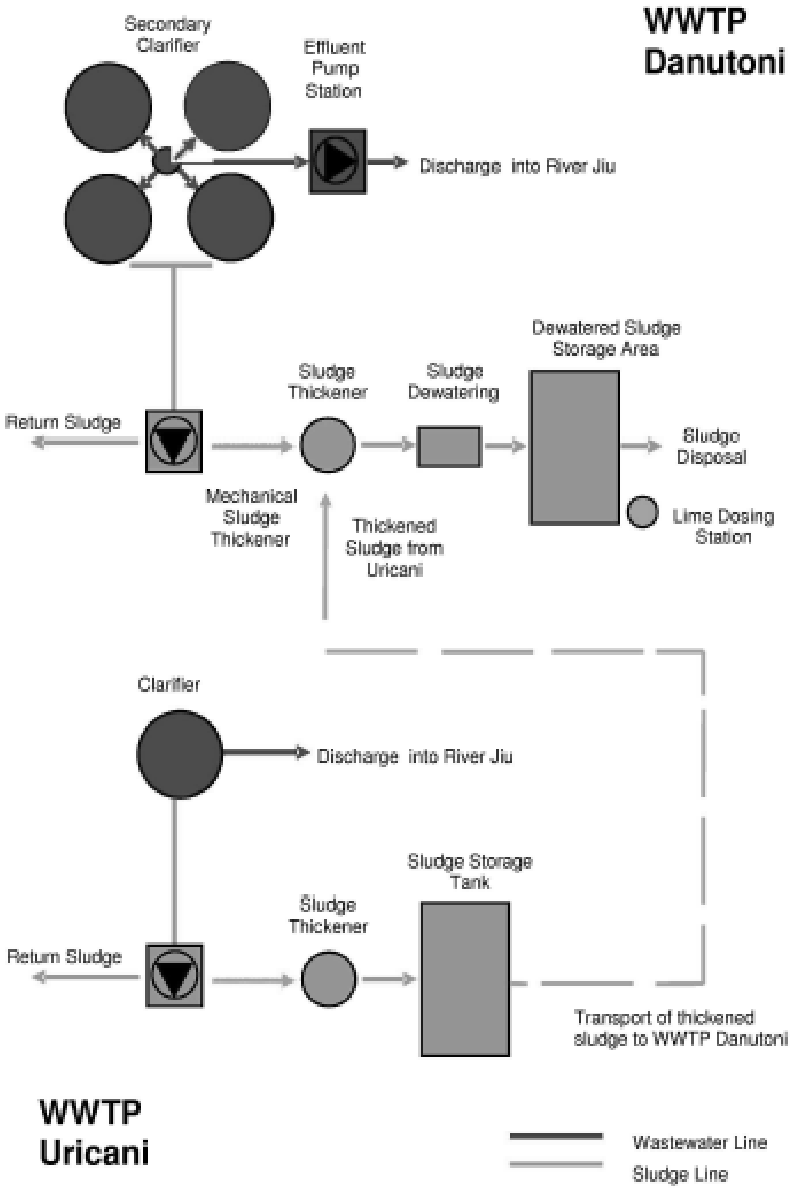


Figure 1. The current route of sludge from WWTP Uricani and Danutoni

Current problems of the disposal sludge, as is done at present, are the following:

- the absence of a benefit on the possible use of natural nutrients contained in sludge;
- risk to the environment;
- failure to comply with national and European legislation in force.

3. THE VOLUME OF SLUDGE AND SLUDGE QUALITY

Official information on sewage sludge from the treatment plants waste water in the cities of the coal miners in the Jiu Valley, between the years 2005-2009, have been presented in such [5]:

Table 1: Existing WWTP in the Jiu Valley with disposal of sludge

Year	**2005**	**2006**	**2007**	**2008**	**2009**
UM	**[tonsDS]**	**[tonsDS]**	**[tonsDS]**	**[tonsDS]**	**[tonsDS]**
WWTP Uricani	143	149	142	150	150
WWTP Danutoni	329	326	310	303	207

Dehydrating sludge by means natural, upon beds of drying at WWTP Danutoni; but in Master Plan concludes as follows:

- quantities of sludge are currently uncertain;
- is not to be used sludge in agriculture; in the past few years, there has been no case of spread of sludge on soils;
- dry sludge is be exhausted in waste deposits local official, be discharged to sources of surface water, without authorization.

In Table 2 - existing stations waste water treatment with sludge disposal in the Jiu Valley below are listed stations waste water treatment, with current methods for the treatment of sludge, final potential destinations of activated sludge and current production of sludge:

Table 2. The existing stations waste water treatment with sludge disposal in the Jiu Valley

The station	**The current method for the treatment of sludge**	**Route the final disposal**	**The current production of sludge**
Uricani	Transport to Danutoni (3%DS)	Waste Deposit	150 t DS/year
Danutoni	Pre-hardener sludge gravitational Press Filter (20%DS) Metering lime (35% DS)	Waste Deposit	207 t DS/year

For WWTP Danutoni was carried out quality analysis sludge before the beginning investment in expansion. In accordance with these analyzes, the concentration of sludge shall be located within the limits laid down in EU directives.

Table 3. The concentration of heavy metals in sludge which will be used in agriculture

The current limits		**The values analyzed**
Directive 86/278 EEC (mg/kg DS)		**Danutoni 15.06.2009**
Heavy Metals (mg/kg DS)		
Cadmium	20-40	
Copper	1000-1750	180
Mercury	16-25	-
Nickel	300-400	52
Lead	750-1200	295
Zinc	2500-4000	1293
Chromium	-	72
Cobalt	-	24
Arsenic	-	12
Organic compounds (mg/kg DS)		
AOX	-	315
PAH	-	-
PCB	-	0.0184

Table 4. The future production of sludge in the Jiu Valley

Agglo-meration	**PE_{de}**	**The quantity of waste**							
		2009		**2015**		**2018**		**2037**	
		[m^3/an]		**[m^3/an]**		**[m^3/an]**		**[m^3/an]**	
		The content of DS							
		[m^3/an]	[m^3/an]	[m^3/an]	[m^3/an]	[m^3/an]	[m^3/an]	[m^3/an]	[m^3/an]
Uricani	10000	750	428	1077	610	1080	612	923	523
Petrosani	129000	1035	591	10104	5770	12000	6852	10323	5894
Total	**133000**	**1785**	**1019**	**11182**	**6380**	**13080**	**7464**	**11245**	**6417**

4. THE RE-USE SLUDGE IN AGRICULTURE

In principle using sludge, originating in may, in the farming sector as a matter of principle, the ideal solution for ultimate disposal of sewage sludge in the Jiu Valley. In accordance with the analysis activated sludge, the parameters with regard to the quality sludge (with the exception of concentration of arsenic) complies with the requirements of Directive on sewage sludge [3]. However, potentially in agriculture in the Jiu Valley is extremely unlikely because farms are situated in mountainous areas and sewage sludge from may not be used for cultivation in such land. Sewage Sludge was to be transported to farmers, at a further distance from the base station waste water treatment Danutoni. [4, 5]

Because of reduced capacity of agricultural land to incorporate sewage sludge, because no one has showed no interest from the owners of land for reuse sludge in agriculture, it has not been possible to date signing the pre-contracts with farmers.

So this optioned will be a long-term goal and will be sought for a sustainable use solution sludge in agriculture, which will mean, making samples of activated sludge and wearing a marketing campaigns of long duration, and that in other parity of Europe, even so, land owners will be reluctant when using sludge on agricultural land. [5]

5. CONCLUSIONS

Sludge management in the Jiu Valley, as it is practiced at present, it is not satisfactory. The quantity of sludge generated in wastewater waste water treatment is low, and route for the disposal of sludge is by carrying it with the truck to the nearest waste depot, located at approximately 7 km from WWTP Danutoni.

For that sewage sludge can be removed from the warehouse of waste, add lime in sewage sludge dried and reinforced in order to reach a solid content of 35 %.

Reuse sludge originating from the cleaning waste water in agriculture is not a suitable solution in the Jiu Valley is not deemed viable in the short and medium term. In the medium and long term it is considered possible to use sludge in agriculture only after performing the quality tests, samples of chemical sludge and wearing a strategy of marketing efficiency and long-lasting.

Sludge dehydration and storage facilities are located on the perimeter of the workstation waste water treatment Danutoni, and hardened sludge from the treatment plant waste water Uricani is transported by trucks to Danutoni WWTP.

REFERENCES

[1] Bercu Ioana - *Studii si cercetări privind tehnologia si valorificarea nămolurilor din stałiile de epurare orăsănesti*, Rezumat Teza de Doctorat, Bucuresti 2011

[2] Gligor Emil-Traian - *Contribuții la optimizarea energetică a instalațiilor şi echipamentelor din cadrul stațiilor de epurare a apelor uzate*, Rezumat Teza de Doctorat, Oradea 2011

[3] Stoicescu A. - *Tratarea şi eliminarea nămolurilor provenite de la stațiile de epurare*, Universitatea Politehnică Bucureşti, Ecoterra, no. 28, 2011

[4] *.** *Optiuni de gestionare a namolului si cele mai bune practice,* 2011

[5] *.** *Pliant valorificare namoluri- Valea Jiului,* 2012.

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

ANALYSE DE L'OPPORTUNITE D'UTILISATION DES METHODES QUANTITATIVES D'ANALYSE DES RISQUES DANS LE SECTEUR MINIER DE ROUMANIE

**ROLAND IOSIF MORARU*
JANUSZ GRABARA**
JOANNA TABOR***
MIHAI POPESCU STELEA******

Abstract: *The field of risk assessment and risk management is becoming increasingly more complex. Risk assessment is a powerful tool that provides a rational framework for designing and managing an OHSP at institutions that use nonhuman primates. The process of risk assessment requires a factual base to define the likelihood of adverse health effects of workplace-associated injuries and exposures, and it attempts to balance scientific knowledge with concerns of staff, investigators and administration. Practical guidance should be provided for Romanian mining companies get started and make progress in the risk assessment process. The article offers guidance on how to most effectively introduce the quantitative risk assessment process in mining industry, and has as main goal to highlight that the most valuable resource remains the practical experience gained by effectively performing the process.*

Keywords: *risk, quantitative analysis, database, reliability, human error.*

1. INTRODUCTION

Actuellement, les exploitations minières en Roumanie n'utilisé pas couramment des méthodes quantitatives pour analyser les dangers et les risques, dont beaucoup sont considérés comme des risques catastrophiques. En dépit de leur large utilisation, les méthodes d'analyse qualitative des risques souffrent d'un certain nombre de limitation. Par exemple, en utilisant un langage qualitatif pour décrire des dangers et des risques crée un biais inhérent des évaluations. L'issue incertaine combinée avec la variabilité naturelle ou information statistique disponible souvent insuffisante, ce qui complique encore les prédictions, les scénarios et les comparaisons, surtout en relation avec les événements catastrophiques, qui dans la société sont si souvent associés à l'exploitation minière. Le manque d'expérience des gens, les perceptions et les hypothèses en particulier dans les périodes de pénurie de personnel qualifié et de haute font également partie du dilemme associé.

* *Assoc.Prof.PhD.Eng. at the University of Petroşani*
** *Dr . h.c. eng. PhD at Czestochowa University of Technology, Poland*
*** *Dr inż. PhD at Czestochowa University of Technology, Poland*
**** *Ph.D.Student at the University of Petroşani*

Alors que d'autres industries à haut risque ont réussi à établir un certain nombre de bases de données pour l'analyse quantitative du risque (AQR), fermement ancrée dans la gestion des risques et compétents dans leur répertoire des compétences, l'industrie minière ne dispose pas de tels instruments. Compte tenu de la nature de l'industrie minière à haut risque et coût, nous apprécions que adoptant davantage de données axée sur une gestion systématique pourraient bénéficier de nombreuses fonctions de gestion minière.

2. L'ANALYSE QUANTITATIVE DU RISQUE

Différentes méthodes d'analyse qualitative du risque (comme AST, WRAC, HAZOP et FMEA) peuvent être appliquées facilement à diverses questions, y compris l'analyse du risque sur toute les industries. Cependant, étant basée sur l'utilisation des mots et langage pour formuler le problème qualitatif, leur efficacité repose sur les connaissances et l'expertise de l'équipe d'investigation. La subjectivité humaine résultant et la variabilité et l'incertitude des hypothèses implicites signifie que ces méthodes sont souvent insuffisantes pour compléter et modéliser avec précision les relations critiques, les dépendances et les complexités qui conduisent à des risques du système et les risques catastrophiques possibles.

Les méthodes semi-quantitatives permettent que certaines comparaisons soit faites au regard du risque relatif numérique mais également elles ne offres pas la possibilité de fournir une évaluation complète et détaillée de la sécurité fonctionnelle d'un système. En outre, les méthodes qualitatives et / ou semi-quantitative sont incapables de modéliser et évaluer les effets de deux ou plusieurs modes de défaillance dans le même temps, les défaillances de cause commune et des erreurs qui peuvent affecter plusieurs parties du système ou les avantages que les redondances peuvent apporter. Un de leurs inconvénients est l'incapacité-clé d'être utilisé efficacement dans la modélisation et la prédiction de la faible fréquence d'occurrence des événements avec des conséquences graves.

Exemples de méthodes d'analyse quantitative des risques inclues: Analyse par l'Arbre de Défaillances (AAD), Analyse par l'Arbre des Evénements Arbre, méthodologie LOPA, la méthode a de Fiabilité de Premier Ordre(FOIM), la simulation de Monte Carlo et d'autres méthodes mathématiques. Les évaluations quantitatives dépassent de nombreuses lacunes des celles qualitatives et sont adaptés à des situations où des données suffisantes existent lors de la conception, l'exploitation, l'entretien ou modification d'un système technique ou travaux connexes. Les résultats de l'analyse quantitative peuvent être utilisés dans les études coût - bénéfice afin de démontrer que les risques pour les employés, l'industrie, la société et l'environnement sont si bas qu'il est raisonnablement possible (ALARP), en particulier quand l'évaluation se réfère à des risques catastrophiques évitable que par l'analyse quantitative. Les avantages des approches quantitatives par rapport aux méthodes qualitatives sont qu'elles peuvent être adaptés pour des applications spécifiques et sont capables de réfléchir même les fines nuances de l'enquête, permettant ainsi la gestion avec moins de paramètres décision.

En utilisant les données de performance on peut 'évaluer objectivement et comparer les systèmes technologiques complexes, les tests et l'évaluation des changements de la capacité d'adaptation dans la conception, l'exploitation et la maintenance. Cette approche est adaptée pour identifier les vulnérabilités et les stratégies d'atténuation pour réduire l'exposition au risque. Modélisé correctement et efficacement, les changements peuvent être simulés avant d'être mis en pratique. Les évaluations quantitatives sont enracinées dans les industries à haut risque tels que la pétrochimie, le nucléaire et l'aviation et comprennent de nombreuses méthodes d'ingénierie basée sur la fiabilité. Elles sont également utilisées dans des nombreuses autres méthodes, comme l'ingénierie de l'explosion et du feu, les études épidémiologiques ou autres sciences qui utilise des modèles mathématiques pour étudier les dangers et les risques associés. En vue de l'objective de cet article, nous représentons la place et le rôle de l'analyse quantitative des risques dans le secteur minier dans le schéma du Figure 1.

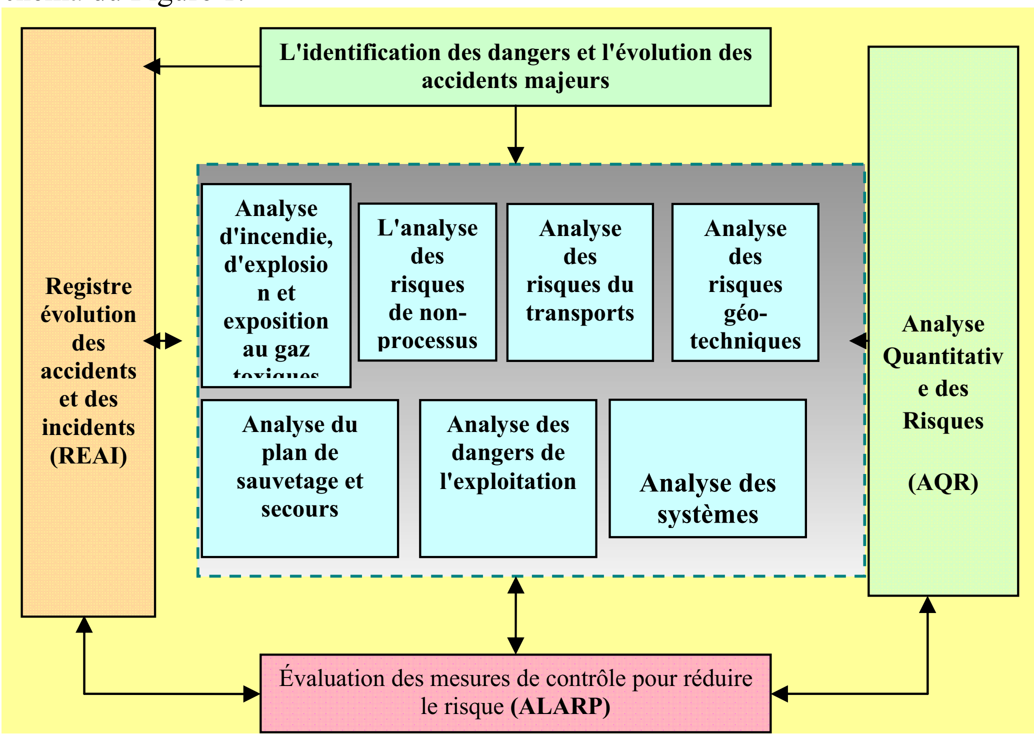


Fig. 1. Place et rôle de l'analyse quantitative des risques dans le secteur minier

Si initialement l'objectif principal était d'analyser les systèmes techniques, certains secteurs comme l'énergie nucléaire et l'aviation ont détaillé aussi l'analyse de la sécurité humaine qui, avec la fiabilité technique et les données de performance, sont capables de modéliser la performance d'un système homme- machine. Les méthodes exclusivement probabilistes telles que «la méthode de fiabilité du premier ordre"

(FOIM) sont le type le plus complexe, étant utilisé pour l'analyse quantitative des risques. L'avantage de FOIM à toute autre méthode est la possibilité de faire face avec succès à l'incertitude statistique des données. Les résultats obtenus par la méthode FOIM fournit des informations sur la vulnérabilité en fonction de la variabilité de la donnée d'entrée. La méthode peut également synthétiser des données erronée base de données technique en adaptant les calculs de conception, qui peuvent ensuite être utilisés pour soutenir l'application d'autres techniques telles que l'AAD. L'analyse par simulation Monte Carlo est plus fréquent que FOIM en raison de son approche intuitive et a trouvé une large application dans de nombreux domaines tels que l'ingénierie et de la finance. Cependant, le manque de leviers dans la méthode de simulation Monte Carlo directe, auxquels la méthode FOIM propose des solutions d'ingénierie.

3. ANALYSE DE LA TAXONOMIE ET DEFIS DE CONSTRUCTION DES BASES DE DONNEES POUR LES APPLICATIONS DE L'AQR

Bien que l'AQR ne puisse pas fournir des indicateurs de sécurité absolue, le principal avantage de l'analyse quantitative est de comparer deux ou plusieurs modèles de risque relatifs entre eux. Pour ce faire, les ingénieurs de sécurité et santé au travail ont besoin d'une combinaison de fréquences et des résultats des gravité correspondant à des entrées dans le système de modèle (de sécurité).

En d'autres termes, ils sont tenus deux types de données d'entrée clés, à savoir:

- **la fréquence** des "événements", ou descripteur numérique équivalent tels que le temps moyen de défaillance (MTTF), la probabilité d'échec ou le taux d'échec, et
- **les conséquences** des estimations crédibles décrivant les résultats liés d'événements ou défaillance d'un composant ou d'un système.

Compte tenu de l'importance de la participation humaine dans nombreux systèmes, l'estimation de l'erreur humaine devrait également être disponible et utilisé dans la modélisation. Malgré sa taille, l'industrie minière n'a pas de telles données, ce qui limitait l'utilisation des approches AQR. Parce que même les systèmes simples peuvent comprendre plusieurs milliers d'éléments, toutes les bases de données utilisent généralement un système hiérarchique, appelé *taxonomie* pour créer de l'ordre et de la logique parmi ses éléments constitutifs. La taxonomie est destiné à faciliter la collecte, l'analyse et le stockage ultérieur des données. Il s'ensuit que la qualité des données détermine la qualité de l'analyse des risques.

Un des éléments clés de la taxonomie est une définition claire de l'équipement, ou d'un système lié au travail. Cela signifie que toutes les interfaces externes doivent être identifiées. Si cela est fait, les échecs et les conséquences du périmètre peuvent être expliqués. L'intention ici est l'un d'une résolution, allant de "*une partie de l'ensemble*" représentée, par exemple, d'un ressort ou un joint torique, un pneu, jusqu'à un système entier, ce qui est une collection de composants multiples disposées en couches à exécuter une fonction spécifique, tel qu'un système de ventilation, le frein de véhicule, une pelle à benne traînante, un réservoir de carburant ou un système de pompage.

Nous devons préciser que l'effort et le coût de l'entretien nécessaire pour maintenir une base de données détaillée peuvent générer des coûts d'entretien importants. Il faudra des décisions judicieuses afin de maximiser l'amortissement des bases de données génériques, qui sont moins adaptés pour des applications en dehors du domaine pour lequel ils ont été créés. Les difficultés résident dans l'application d'accéder aux données pour les scénarios «étrangers» (par exemple, du nucléaire à l'exploitation minière). Les problèmes sont également générés par l'incertitude et la variabilité associée aux données disponibles. Si tous les fournisseurs de bases de données ne 'appliquent pas la même taxonomie stricte et la même rigueur, l'incertitude se propage dans la base de données cumulative résultant, qui ensuite va affecter négativement l'étude de sécurité ou de fiabilité.

4. POSSIBILITES DE DEVELOPPER UNE BASE DE DONNEES DE SECURITE/FIABILITE DANS LE SECTEUR MINIER ROUMAIN

Actuellement, il n'existe pas de base de données accessible au public qui peut être utilisé pour l'analyse quantitative des risques (AQR) dans le secteur minier roumain. Pour faire une évaluation quantitative des risques pour une exploitation minière le personnel pourrait utiliser de données des systèmes ou les indications du fabricant de l'équipement, lorsqu'il est disponible, afin de déterminer un modèle réaliste des ces systèmes, leur fiabilité ou sécurité (OECD, N.E.A, 1989). Ces données peuvent être stockées dans le de système de gestion de l'entretien et de du programmation de l'équipement, mais si il n'a pas été utilisé une taxonomie stricte, les données pourraient nécessiter un traitement de préalable avant qu'il puisse être analysé et utilisé dans une application AQR.

Autres sources de données dans le secteur minier sont le système d'évidence des incidents / accidents et, le cas échéant, le « registre des risques», mis en œuvre par les mines dans le monde, et aussi le système de ressources humaines qui vise le nombre d'heures travaillées. En combinaison, ils peuvent être en mesure de fournir des informations sur de fréquentes, mais sont probablement mieux utilisée pour déterminer les conséquences probables d'un événement.

Pour créer une application fiable et complète de l'AQR dans le secteur minier roumain, nous recommandons une approche similaire à celle appliquée dans l'industrie pétrochimique. Le système de base de données doit répondre aux exigences suivantes:

- être la principale source d'information pour la sécurité de l'équipement et sécurité humaine de l'industrie minière;
- fournir une estimation fiable des défaillances de l'équipement généré indépendamment, des données sur les incidents et leurs conséquences, y compris les systèmes données de sécurité critiques pour toutes les applications minières;

• fournir un registre central de toutes les enquêtes sur les incidents et les accidents comme une source précieuse de données, ainsi que de fournir des modèles de causalité d'incidents et les accidents, ainsi que d'un outil de formation en gestion des risques.

La collecte de données clé doit se baser sur une taxonomie flexible qui peut être mis en œuvre a toute activité minière, indépendamment des systèmes locaux utilisés. Un schéma de principe du système proposé, avec les entrées, le processus et les sorties est représenté sur la figure 2.

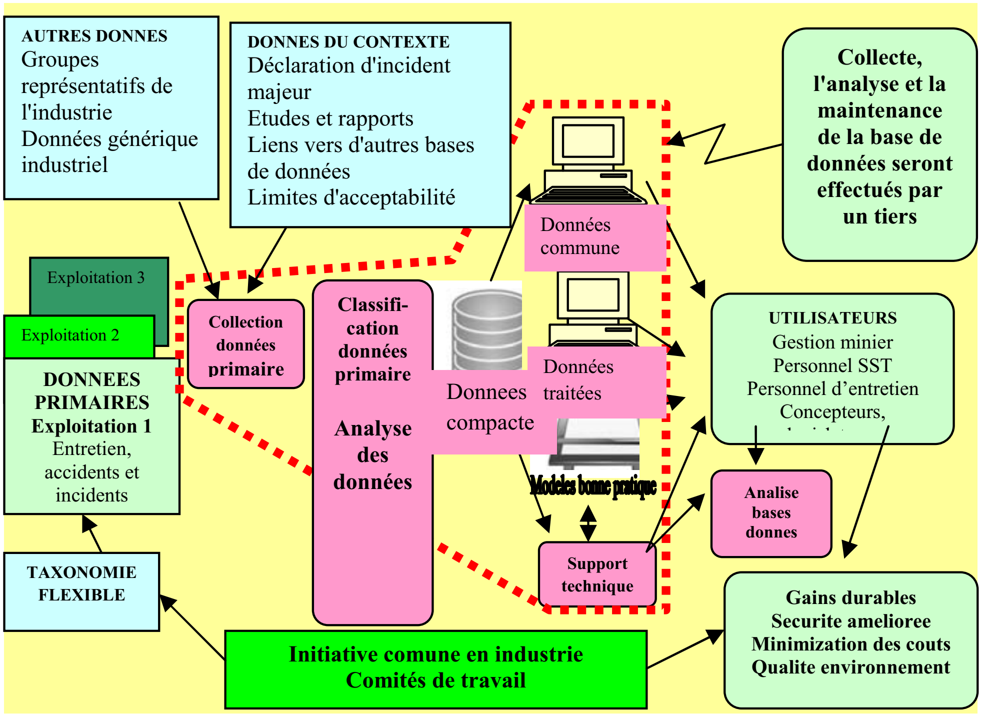


Fig. 2- Structure conceptuelle d'une base de données de défaillances, de sécurité des équipements et de travail dans le secteur minier

Établir une base de données fiable dans l'industrie minière offre également la possibilité de créer un ensemble de meilleures pratiques, des modèles et documents formalisés pour faciliter l'adoption rapide de l'analyse quantitative des risques. Ces documents formalisés pourraient également aider les fabricants d'équipement dans le développement de modèles plus efficaces dans un court laps de temps. L'analyse quantitative des risques devrait également tenir compte des informations sur l'erreur humaine, comme autre source d'information technique, afin d'obtenir une solution de conception optimale. En raison de la proportion relativement élevée d'événements indésirables liés à des erreurs humaines, prise en compte appropriée des actions et des comportements humains peut apporter les plus grandes améliorations dans le de la sécurité du travail. Grâce à sa capacité à modéliser efficacement les dépendances

(Homme Machine Interface), ce peut être mieux réalisé par l'AQR. Présentation de l'analyse quantitative, la création de bases de données, des modèles formalisés, etc doit également inclure la fourniture d'une éducation adéquate et le développement de la culture de sécurité pour l'industrie à participer et à diriger cette nouvelle branche passionnante de l'analyse risques et la gestion des opérations. L'éducation devrait couvrir à la fois l'erreur humaine et une défaillance technique, y compris certains aspects de nature statistique.

Le défaut de soutenir les exigences de formation va retarder l'introduction de l'AQR et se traduira par la meilleure performance à un coût réduit et une meilleure qualité de l'environnement. Dans le pire des cas, ça va conduire à des modèles peu fiables qui sont potentiellement dangereux.

5. CONCLUSIONS

L'analyse des risques est un outil essentiel pour la politique de sécurité d'une entreprise et son but principal est d'éliminer le risque de blessure ou de dommage dans une procédure de production (comme dans l'industrie de l'extraction du charbon). La diversité des procédures d'analyse de risque est tel qu'il existe plusieurs techniques appropriées pour toutes les occasions. L'estimation du risque est peut-être la partie la plus importante de l'ensemble des procédures d'évaluation des risques de travail, et en particulier dans les mines souterraines, où les conditions de travail sont instables (feux endogène, méthane poussière explosif de charbon, etc.). Nous estimons le risque comme une quantité qui peut être mesurée et exprimée comme une relation mathématique, en utilisant les données recueillies à partir des accidents réels.

Bien que des améliorations considérables ont été accomplis en matière de sécurité dans les mines par la législation fondée sur les risques et la gestion proactive des dangers et les risques qui en découlent, l'exploitation minière n'est pas vraiment impliqué dans l'analyse quantitative des risques, comme il le fait dans d'autres secteurs à haut risque. Utilisation de l'analyse quantitative des risques, ces industries ont réussi à améliorer la performance de la sécurité grâce à une meilleure connaissance de l'aléa spécifique. L'analyse quantitative systématiquement appliquée, donne par rapport à une approche qualitative l'avantage unique que la sécurité du système et la performance opérationnelle peuvent être conçues pour évaluer spécifiquement et de manière objective. La réticence du secteur minier à adopter une analyse quantitative minière est surprenante pour deux raisons.

Tout d'abord, l'industrie minière, de par sa nature dynamique, a un certain nombre au moins égal à ou plus grand des dangers et les risques que les autres industries comparables. Certains d'entre eux sont traités dans la législation actuelle comme "risques majeurs" et de par leur nature se prêtent à une analyse plus rigoureuse des risques et d'enquêter sur l'efficacité du contrôle. Une approche similaire rigoureuse pourrait être appliquée à d'autres dangers. En outre, de nombreuses recommandations du fabricant sur l'utilisation et l'entretien du matériel est basé sur les caractéristiques générales de l'utilisateur. L'utilisation des données de l'exploitation comme base pour l'amélioration des coûts élevés seraient extrêmement bénéfique. La possibilité d'approche quantitative des risques basée sur la collecte des donnes fournit à l'industrie des indicateurs de performance "en temps quasi réel" et des outils prédictifs plus appropriés que les moyens qualitatifs actuellement utilisés. La possibilité d'une approche quantitative des risques, qui est basée sur la collecte de données pourrait fournir à l'industrie indicateurs de performance " presque en temps réel " et des outils de prédiction plus approprié que les moyens qualitatifs en usage aujourd'hui.

Deuxièmement, l'exploitation minière dépend lourdement de technologies complexes le long du processus de production, géneralement dans des endroits isolés et environnements hostiles. Ils offrent une occasion unique pour la collecte des données relatives à l'entretien qui, à leur tour, pourraient être analysées et utilisées pour aider de façon proactive améliorer les performances de l'équipement surveillé. Les données, recueillies de façon appropriée en utilisant une approche taxonomique, serait en mesure de fournir une image directe de la santé humaine, technique et de la performance économique. Mise en œuvre de l'analyse quantitative du risque pourrait être considérée comme une stratégie de résistance dans le monde des affaires et de la conversion des données en actions de la gestion, comme un concept novateur qui pourrait améliorer sensiblement la sécurité, la performance environnementale et le contrôle opérationnel de l'industrie minière.

BIBLIOGRAPHIE:

[1]. CEE, *Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work.*

[2]. Darabont A., Pece Ş., Dăscălescu, A. - "*Occupational Health and Safety Management*", (vol. I and II), AGIR Publishing House, Bucharest, 2002, Romania.

[3]. HSE, *Principles and guidelines to assist HSE in its judgements that duty-holders have reduced risk as low as reasonably practicable*. Health and Safety Executive, 2002, Available at http://www.hse.gov.uk/dst/alarp1.htm. Accessed: 08.11.2013.

[4]. Less, F.P., *Loss Prevention in Process Industries* (vol. I, II), Butterworths, London, U.K., 1980.

[5]. Moraru, R., *Occupational Health and Safety: University Handbook (in Romanian),* Universitas Publishng House, Petroşani, 2013

[6]. Moraru, R.I., Băbuţ, G.B. - "*Participative risk assessment and management: a practical guide*" (in Romanian), ISBN 978-973-677-206-1, Focus Publishing House, Petroşani, 2010, Romania.

[7]. OECD/NEA, *Emergency Planning in Case of Nuclear Accident - Technical Aspects*, Proceedings of a Joint NEA/CEC Workshop, OECD/NEA, 1989.

[8]. * * *, *Guidance on risk assessment at work*, European Commission, Luxembourg, Office for Official Publications of the European Communities, 1996.

Scientific Reviewers:
Prof. Ph.D. Eng. Nicolae BĂNCILĂ

STUDIES ON THE WASTEWATER SLUDGE FROM THE WESTERN PART OF ROMANIA

DANIELA IONELA CIOLEA*

Abstract: *About 80% of Romania's towns have a combined system of the sewage (waste water housekeeper, drencher). Industrial Landings will also have a considerable part to play in final flows which arrive at shall; therefore it is possible that industrial waste water discharges to considerably influence sludge quality. The western part of Romania, which is taken in the study in musicology, includes 4 (four) counties, namely: Arad, Timiş, Caraş-Severin and Hunedoara.*

Key words: *wastewater, sludge, environment, ecology*

1. INTRODUCTION

Currently, in Romania, sewage sludge is stored within the framework shall (91%), discharged from the warehouse of waste (9%), used in agriculture (0.2%). Incineration is not currently practical because, in Romania, there are no incinerators for solid waste and sludge in service at municipal level. Sludge production is a continuous process which involves finding solutions flexible and safe evacuation.

The main management options (elimination) activated sludge shall include: the application on land, incineration, co-incineration, disposal of waste and store application on the basis of areas and forest land that may have been damaged.

When using sludge in agriculture or recycling with energy recovery from the warehouse of waste, etc. are prohibited, alternative options such as use on the basis of areas of plantation forestry or for the recovery of land that may have been damaged can prove to be particularly important.

Fundamental principle adopted in the development of management strategies for sludge at national and regional level is to ensure, as far as possible, that sewage sludge is used with beneficial effects that organic fertiliser or as a source of energy recovered.

Eco-friendly storage in storage of waste shall be considered as a last resort when there is no other way viable from the point of view of the environment and economy. It is accepted, however, that temporary storage may be required for a transitional period until the operators of water and sewage system to the beneficial use of sludge.

* *Lecturer Eng. PhD. at the University of Petrosani, cioleadaniela@gmail.com*

Managers Council Directive 86/278/EEC of 12 June 1986 for environmental protection and in particular of the soil, when sewage sludge is used in agriculture. [7]

2. THE TECHNOLOGICAL FLOW

Technological scheme of a wastewater treatment plant comprises two technological lines:

- ➢technological waste water line, which is aimed at compliance with effluent quality conditions prior to their evacuation in natural receptors (NTPA 001/2005);
- ➢technological line of sludge, which has as its objectives:
  - ✓ reducing sludge quantities;
  - ✓ the least hazardous sludge to environmental factors;
  - ✓ obtaining formuli economic substance (agriculture, energy, construction materials, etc.) As an essential natural resource for all biological processes, water has a special importance for the existence of life and accomplishment of all human activities.

In this context, the present study aims to make a contribution in the field of environment protection in order to improve the preservation of the environment "because the water is not a commercial product like any other but a heritage that must be preserved, protected and treated as such" (framework directive 200/60 of the European Union). [3]

The wastewater through sewage treatment plants:

- purified water;
- sludges.

Sludge arising from waste water treatment are complex colloidal systems, gelatinous-looking, with a heterogeneous composition, containing:

- ✓ colloidal particles(d< 1 μm);
- ✓ dispersed particles (d<1-100 μm);
- ✓ materials in suspension;
- ✓ organic polymers of biological origin;
- ✓ water.

Furthermore, the national strategy for managing wastewater treatment sludge is very useful if it takes into account the existing situation of sludge treatment plant managers in Romania but also in specific situations with which it is possible that the operators of existing wastewater treatment plants to deal in future with continuous sludge production.

Estimation of wastewater treatment sludge production is based on the following assumptions: until 31 December 2018, Romania will be in full accordance with EC Directive 91/271/EEC, which means that all congestion with a population greater than 2000 p.e. will be served by wastewater treatment plant, sludge will occur.

The amount of sludge produced in the present situation and advances the completion of investment projects underway or planned, had formed the basis for the data provided in the Master Plan and feasibility study. According to Ordinance No.

344/2004 MMPA sludge is defined as sludges from treatment plants effluents from settlements from other stations of the wastewater treatment plant with a composition similar to municipal waste water and septic tanks.

Sources of sludge from waste water treatment plants, wastewater treatment plants:

- mechanical-chemical primary and tertiary;
- wastewater treatment plants, the mechanical-biological.

Development of a national policy for managing sewage sludge appeared as a necessity due to some major investments made to date and will continue to perform in the construction and rehabilitation of existing wastewater treatment plants, as Romania to respect the terms of the Treaty of accession. This will result in an estimated increase of five times of mud production in the coming years.

Few operators of wastewater treatment stations have at their disposal options for recovery of sludge, 90% of the quantity of sludge produced is basically stored in the treatment plants and the lack of interest in solving methods of benefic of mud is manifested, in particular, due to the necessary additional costs, difficulty to establish new ways of removing mud and low qualities due to this product.

3. CLASSIFICATION OF SLUDGE

After sludge composition, they are classified into two categories:

- ✓ organic sludge, containing more than 50% of volatile substances (expressed as dry matter) coming from the mechanical-biological treatment;
- ✓ mineral sludge, which contain more than 50% of inorganic substances (expressed as dry matter) coming from mechanical-chemical treatment.

After origin wastewater, sludge are classified into [1]:

- ✓ sludge from urban waste water treatment;
- ✓ sludges from waste water treatment industry. Classification of sludge: according to processes of wastewater treatment plants: sludge from primary-gear mechanical cleaning;
- ✓ secondary sludge-cleaning gear from biological;
- ✓ mixed sludge-sludge mixture of primary and secondary after decantation;
- ✓ mud precipitation (Chemistry)-the physico-chemical treatment with the addition of neutralizing agents, precipitation, coagulation-flocculation.

According to their stage in the processing of sludge management, they can be categorized in the following groups:

- ✓ mud raw (unprocessed);
- ✓ stabilized sludge (aerobic or anaerobic);
- ✓ dehydrated sludge (natural or artificial);
- ✓ sanitary sludge (pasteurization, chemical treatment or composting);
- ✓ fixes through mud solidification in order to restrain toxic compounds;
- ✓ the incineration ash-sludge.

4. PHYSICOCHEMICAL CHARACTERISTICS OF SLUDGE

Characterization is based on sludge:

- general indicators (moisture, specific gravity, pH, mineral-volatile report, calorific value, etc.);

- specific indicators (fertilizers, detergents, chemicals, heavy metals, oils and fats, etc.)

Color an scent:

- fresh sludge aerators decrease primaries have:
  - ✓color greyish or yellowish light;
  - ✓smell almost imperceptible;

- to active sludge after aeration basins are: the color to yellow-brown, grey-brown to dark brown depending on the predominant bacterial species; smell faintly of mold;

- precipitar sludges: sloppy appearance, color and smell varies according to the type of coagulant used;

- sludge an aerobically fermented: bottle to black; tar smell and look grainy.

The quantity of sludge generated by wastewater treatment plants are according to:

- the population connected to sewerage system;
- industrial water intake collected through the sewage system;
- technologies applied to wastewater treatment (primary or secondary treatment plants) and the yields obtained in the operation.

The main options for management (deletion) include: applying sludge on agricultural areas, incineration, co-incineration plants, disposal at the landfill site and application of forest areas and degraded lands.

5. THE APPROACH USED TO ESTIMATE THE AMOUNT OF SLUDGE

The amount of sludge produced in the present situation and advances the completion of investment projects underway or planned, had formed the basis for the data provided in the Master Plan and feasibility study.

On the estimation method used for future quantities of sludge produced is presented in part I of the strategy and includes: the main factors influencing market production of sewage sludge are:

➢data on population as reflected in previous census and EUROSTAT projections have been investigated and it was found a decrease in population in all regions, until 2030.

➢in the period 2030-2040 it is assumed that the population will remain constant.

➢forecasts have been made at the regional level, on the basis of information existing at the county level.

Estimation of wastewater treatment sludge production is based on the following assumptions: until 31 December 2018, Romania will be in full accordance with EC Directive 91/271/EEC, which means that all congestion with a population greater than 2000 p.e. will be served by wastewater treatment plant, sludge will occur.

Estimation of wastewater treatment sludge production based on calculations performed for each scenario for each region of the country:

➢the actual production of untreated sludge (e.g. before anaerobic fermentation process or other processes of sludge treatment) conducted by depuration plants existing in 2010 is around 97,000 t DS per annum and is expected to grow to over 247.000 t d.w. per annum until 2014;

➢major investments in progress in the field of wastewater through the Cohesion Fund will lead to an increase in the importance of mud production in the coming years (an increase of 5 times the amount during the period 2010-2018 for scenarios 1, 2 and 3 and a little later in the scenario 1B and 1 C);

➢Once all congestion will comply with the requirements of 100% in 2018, the tendency of growth will be negative, caused mainly by the decrease in population;

➢At the national level, differences between the proposed scenarios are not enough to have a significant impact on the choice of one of the national management strategies of mud. Scenario 1, which reflect the targets under the Treaty of accession, as well as detailed information from other studies carried out specific projects for the Cohesion Fund, can be considered as the starting point for estimating the cost of implementing the national strategy on sludge Management.

➢Estimated quantities of untreated sludge for 2010 are lower than the estimates made by NEPA in 2007 namely 138.000 t.DS/an.

6. REGIONAL DISTRIBUTION OF THE CONCENTRATIONS OF HEAVY METALS IN EXCESS AND THE AREA pH

In 2004, 344/MAN Romania has chosen a limit pH value more restrictive than in the other countries of the EU and as a result the mud can be applied only on soils with a pH value of at least 6.5. The EU directive allows the application of mud on soils with a pH $\geq$ 5.5 provided adjust accordingly the maximum permitted concentrations of heavy metals.

The data presents a significant variation from region to region, the share of land which meets the condition of pH $\geq$ 6.5. The availability of land for the application of sludge as a function of pH is lowest in the Northwest region, where only 27 per cent of the arable land has a pH according to the standards. Regions in the West, Southwest, West, and Center are also significantly affected. In these regions, the area of land with pH $\geq$ 6.0 is almost twice as high as those with pH $\geq$ 6.5. [5]

In the figure 1 is presented pH values for land in Romania.

Industries which are in operation and waste management operations have the legal obligation to restore the land when activities cease.

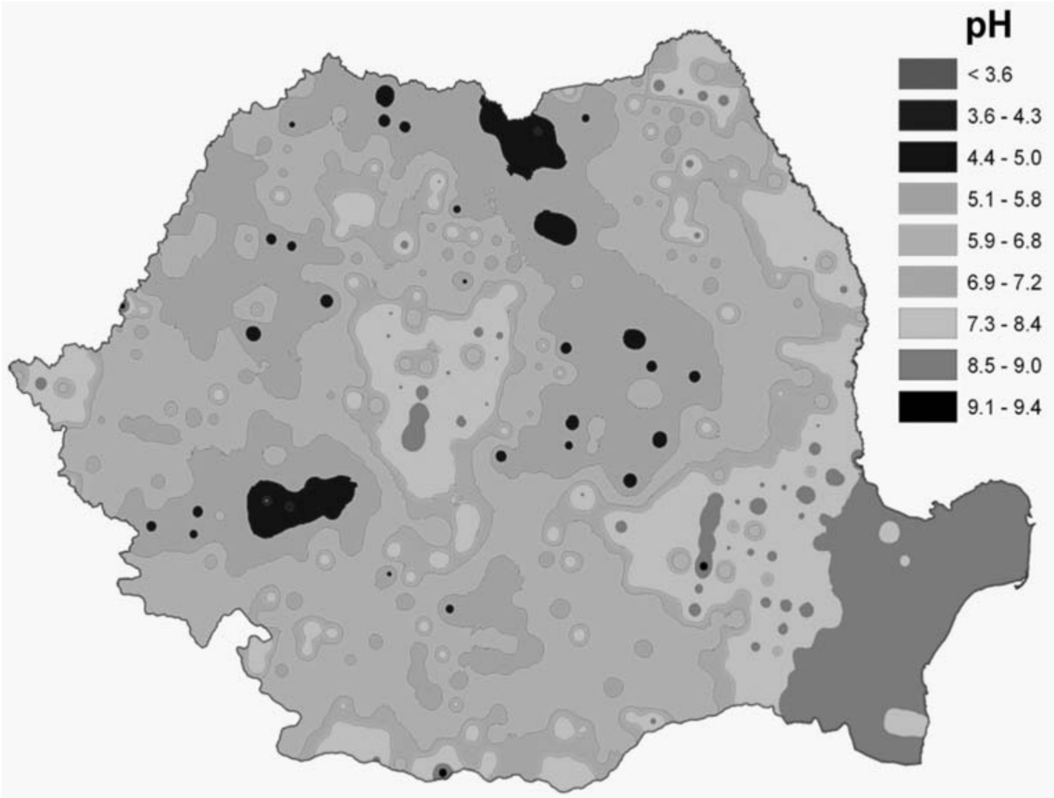


Fig. 1. pH values for land in Romania [4]

Share of arable land with a soil pH greater than 6.5 for Romania is presented in Table 1.1, which is especially marked in the West. [6]

Table 1.1. Share of arable land with a soil pH greater than 6.5

Region	**Total area (ha)**	**Arable land (ha)**	**Arable land with pH> 6.5**		**Arable land with pH> 6.0**	
			(ha)	**(%)**	**(ha)**	**(%)**
North-East	3.685.282	1.219.868	811.535	66,5	1.046.681	85,8
South-East	3.576.047	1.967.166	1.856.851	94,4	1.910.422	97,1
South	3.446.639	2.034.674	1.374.892	67,6	1.769.352	87,0
South-West	2.921.483	1.191.866	551.415	46,3	881.115	73,9
West	**3.203.416**	**1.010.940**	**328.281**	**32,5**	**602.120**	**59,6**
North-West	3.416.182	829.800	222.714	26,8	360.327	43,4
Center	3.408.703	580.550	307.038	52,9	357.454	61,6
Bucharest-Ilfov	180.528	103.855	5.456	5,3	89.085	85,8
Total	**23.838.281**	**8.938.719**	**5.458.181**	**61,1**	**7.016.555**	**78,5**

The land application of sludge suitable potential regions is shown numerically in Table 1.2. [6]

Table 1.2. The land application of sludge on areas potentially suitable

Region	Arable land - total (ha)	Land slope <5% and pH> 6.5		Land slope <10% and pH> 6.5		Tern slope <10% and pH> 6.0	
		ha	% of total arable land	ha	% of total arable land	ha	% of total arable land
North-East	1.219.868	54.053	4,4	228.909	18,8	291.204	23,9
South-East	1.967.166	399.681	20,3	694.368	35,3	712.728	36,2
South	2.034.674	557.529	27,4	696.077	34,2	846.589	41,6
South-West	1.191.866	122.566	10,3	146.191	12,3	225.445	18,9
West	**1.010.940**	**99.213**	**9,8**	**110.009**	**10,9**	**194.142**	**19,2**
North-West	829.800	6.543	0,8	25.702	3,1	50.418	6,1
Center	580.550	17.166	3	57.818	10	68.489	11,8
Bucharest-Ilfov	103.855	1.883	1,8	2.270	2,2	86.997	83,8
Romania	**8.938.719**	**2.517.267**	**28,2**	**3.922.690**	**43,9**	**4.952.027**	**55,4**

CONCLUSIONS

With the restructuring of the mining industry (H. 615/2004), S.C. CONVERSMIN S.A. became the contracting authority for the rehabilitation of the majority of mines that have been closed. Many of them have left as inheritance polluted areas. Limited funds are intended to ensure the safety of tailing ponds (77 identified), especially those which may cause transboundary pollution (requirement of the Treaty of accession to the EU) as well as treatment of high mining spills polluted. Quality land rehabilitation benefits of using sludge in the rehabilitation of abandoned lands and depraved quality are known and massive application of sludge are necessary in order to achieve a sustainable growth on such zones, characterized by a lack of superficial soil layer. This domain has a strategic potential for SEAU in Romania because many stocks have important historical SEAU of sludge that may be removed in a short period in the areas of rehabilitation of the land quality.

Types of land whose quality must be rehabilitated are usually: the former industrial areas, landfills, and mining and quarries closed landfills. In Romania there are plenty of such areas of past industrial inheritance, areas to be rehabilitated in order to control pollution and to restore the quality of the natural environment.

These sites represent a significant potential for rheumatisms. If the entire area occupied by mining waste landfills would be rehabilitated through application to 50 t/ha of mud SU, the required amount of sludge would be equal to annual production of sludge in Romania. However, the use of this potential depends on the funds that were earmarked for the rehabilitation of the lands in question. Also use this sludge is an opportunity which appears once and involves the use of large quantities of sludge accumulated in those SEAU which are located at a distance of transport.

REFERENCES

[1] Ciolea D.I., Dumitrecu I. – *Poluarea si protecția mediului - îndrumător de laborator si lucrări practice,* Editura Universitas, Petroşani, 2011
[2] Stoicescu A. - *Tratarea şi eliminarea nămolurilor provenite de la stațiile de epurare*, Universitatea Politehnică Bucureşti, Ecoterra, no. 28, 2011
[3] * * *Opțiuni de gestionare a nămolului si cele mai bune practice*, 2011
[4] * * *Raport de mediu-strategia nămolurilor*, 2011
[5] * * *Master Plan Arad*, 2010
[6] * * *Strategia națională de gestionare a nămolurilor de epurare*, 2012
[7] *** *Directiva 86/278 privind protecția mediului, în special a solurilor, atunci când se utilizează nămoluri de epurare în agricultură*

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

IDENTIFYING THE POLLUTION SOURCES IN PEŞTEANA QUARRY AND ASSESSING THE IMPACT ON THE ENVIRONMENT

GABRIEL NANU [*]
DIANA MARCHIS [**]

Abstract: *Exploitation activity of lignite in Peşteana mining area is contributing to the degradation of all the environmental components. The sources of pollution in this area are the following: operations of excavation transport and stockpiling of coal and tailings from the two quarries and dumps resulted from these activities. This paper aims to identify all sources of pollution and assess the impact on the environment generated by Peşteana mining perimeter.*

Key words: *pollution, environment assessment, mining activity, quarry*

1. INTRODUCTION

The major factors that favored the environmental degradation of soil, water and air in the mining area are anthropic and consist of: excavation operations, transport and stockpiling of coal and tailings, chemical pollution from oil products (oil, lubricants etc..), but other factors that lead to instability of the areas affected by erosion, landslides, etc.., whose influence is closely related to one another.

In the work carried out for the lignite exploitation in Peşteana mining perimeter all environmental factors from surrounding areas are polluted by emissions of pollutants in air and water and by the complete degradation of soil within the perimeters of excavation and natural. Quarrying lead to the removal, at least during the operation of most of the plant and animal species.

2. ENVIRONMENTAL POLLUTION SOURCES

2.1. Water pollution sources

The main sources of pollution of surface waters are:

• industrial water used for wetting the material in the technological flow;
• waste rainwater washing the ore deposit and the quarry platform;
• domestic waste water.

The paper presents in detail the sources of pollution of the surface waters.

---

[*] *Candidate for PhD, eng. at the University of Petrosani*
[**] *PhD, ecologyst at the University of Petrosani*

Industrial waste water

Industrial waste water resulting from the activity in Peşteana quarries originates from wetting the material in the technological flow and contains only suspensions from lignite and sterile transport.

Waste rainwater

In terms of pollutants that could be carried by rainwater washing the premises quarries and thus affecting the quality of surface waters, it can be said that rainwater can be loaded with:

- suspension from the stairs and slopes of the quarry;
- oil products.

Table 1. Indicators of river Jiu water quality 2013

Quality indicator	M.U.	Determined values		NTPA 002/2005	Method of analysis
		Jiu river upstream	Jiu river downstream		
A. Physical indicators					
Temperature	^oC	17	20	35	
B. Chemical indicators					
pH	pH unities	6,74	5,9	6,5-8,5	SR ISO 10523-97
Suspended particulate matter (MS)[2)]	mg/dm^3	18	56	60,0	STAS 6953-81
Biochemical Oxygen Demand (BOD5)[2)]	mgO_2/dm^3	20,8	24	25,0	SR EN 1899-2/2002
Chemical Oxygen Demand (COD_{Cr}^-)[2]	mgO_2/dm^3	11,06	27	125,0	SR ISO 6060-96
Ammonia nitrogen (NH_4^+)[6)]	mg/dm^3	1,0	1,007	2,0(3,0)	SR ISO 5664:2001 SR ISO 7150-1/2001
Nitrites (NO_2^-)[6)]	mg/dm^3	0,2	0,74	1 (2,0)	STAS 12754-89
Sulfates (SO_4^{2-})	mg/dm^3	211	327	600,0	STAS 8601-70
Phenols trained with water vapors (C_6H_5OH)	mg/dm^3	0,0049	0,05	0,3	SR ISO 6439:2001; SR ISO 8165/1/00
Synthetic detergents	mg/dm^3	0,1	0,36	0,5	SR EN 903:2003 SR ISO 7875/2-1996
Chloride (Cl^-)	mg/dm^3	12,4	167	500,0	STAS 8663-70
Filtered residue at 105°C	mg/dm^3	690	879	2000,0	STAS 9187-84;
Calcium (Ca^{2+})	mg/dm^3	114,4	127,1	300,0	STAS 3662-90 SR ISO 7980-97
Total ionic iron (Fe^{2+}, Fe^{3+})	mg/dm^3	0,26	0,89	5,0	SR ISO 6332-96
Magnesium (Mg^{2+})	mg/dm^3	35,81	65,2	100,6	STAS 6674-77 SR ISO 7980-97

Although suspensions driven by the rainwater are not of polluting nature, being composed of particles of rock and material from stripping, they can influence through their quantity, the quality of surface waters.

2.2. Air pollution sources

In Peşteana mining perimeter there were identified the following sources of air pollution:

♣ emissions of particulate matter in suspension and settled particles in the early stages of excavation activity, from belt carriers, stockpiling tailings, coal stockpiling and handling, having strictly local effects around the points of activity and limited in time for the periods of actual activity (Fig. 2.1.)

♣ emissions from combustion gases and settled particles in the air, due to the functioning of mining machinery and vehicles with internal combustion owned or rented;

♣ emissions of volatile hydrocarbons by natural breathing at the fuel depot, or by evaporation when handling fuel;

♣ acoustic emission of different origins, fixed or mobile, produced by technological equipment or means of transport, with local effects limited to distances of a few hundred meters from the source, and limited in time for the period of their functioning.

Machines operating in the quarry are equipped with diesel engines, the exhaust originating the following pollutants: nitrogen oxides (NOx); carbon monoxides (CO); oxides of sulfur (SOx); volatile organic compounds (VOCs) and particulates.

Table 2. Indicators of water quality in Peşteana mining area 2013

Quality indicator	M.U.	Determined values		NTPA 002/2005	Method of analysis
		quarry precinct wastewater	water from dewatering drills		
A. Physical indicators					
Temperature	ºC	18	15	35	
B. Chemical indicators					
pH	pH unities	6,4	7,09	6,5-8,5	SR ISO 10523-97
Suspended particulate matter (MS)[2)]	mg/dm^3	29	14	35,0 (60,0)	STAS 6953-81
Biochemical Oxygen Demand (BOD5)[2)]	mgO_2/dm^3	12,10	-	25,0	SR EN 1899-2/2002
Chemical Oxygen Demand (COD_{Cr^-})[2]	mgO_2/dm^3	22,03	2,91	125,0	SR ISO 6060-96
Ammonia nitrogen (NH_4^+)[6)]	mg/dm^3	0,24	0,1	2,0(3,0)	SR ISO 5664:2001 SR ISO 7150-1/2001
Nitrites (NO_2^-)[6)]	mg/dm^3	2,1	-	1 (2,0)	STAS 12754-89
Sulfates (SO_4^{2-})	mg/dm^3	123	-	600,0	STAS 8601-70
Phenols trained with water vapors (C_6H_5OH)	mg/dm^3	-	0,0001	0,3	SR ISO 6439:2001; SR ISO 8165/1/00
Synthetic detergents	mg/dm^3	0,2	-	0,5	SR EN 903:2003 SR ISO 7875/2-1996
Chloride (Cl^-)	mg/dm^3	-	11,27	500,0	STAS 8663-70
Filtered residue at 105°C	mg/dm^3	191	205	2.000,0	STAS 9187-84;
Calcium (Ca^{2+})	mg/dm^3	-	96	300,0	STAS 3662-90 SR ISO 7980-97
Total ionic iron (Fe^{2+}, Fe^{3+})	mg/dm^3	-	0,57	5,0	SR ISO 6332-96
Magnesium (Mg^{2+})	mg/dm^3	-	57	100,6	STAS 6674-77 SR ISO 7980-97

The amounts of dust released into the atmosphere depend upon: engine power; operating conditions of the engine; operating time of the engine; characteristics of the fuel used.

Tests carried out by the Environmental Protection Inspectorate Gorj at the workplaces (according to Law no. 104/2011 ambient air quality) revealed exceedances of the limits for particulate matter, during the specific operations in quarries as well as during transporting and loading lignite in wagons.

Measurements of settled particles carried out by the Inspectorate of Environmental Protection Gorj (according to STAS 12576/87) showed that especially in dry periods there are important exceedances of 17 g/m2/month in inhabited areas. These exceedances are mainly due to the points of wagon loading operation which are situated at short distances from domestic settlements.

Figure 1. Points of measuring the concentration of particulate matter and gases from coal loading

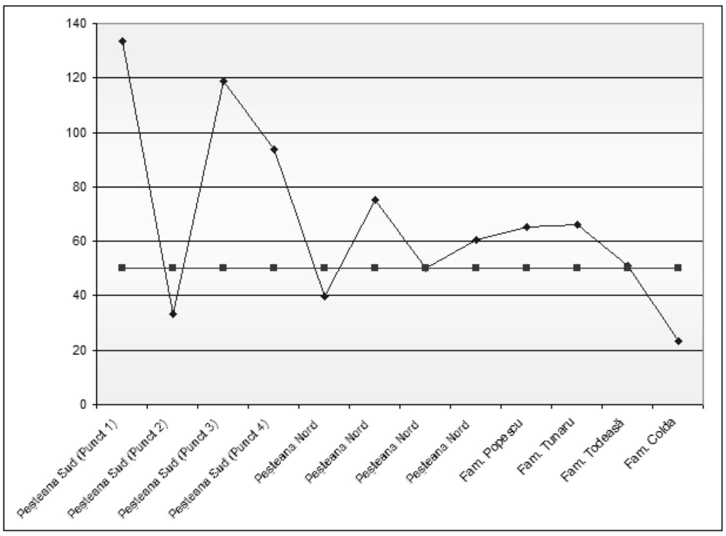


Figure 2. Variation of particulate matter in the measurement points - 2013

Based on calculations and determinations made by EPA Gorj it can be appreciated that the impact of loading and transport in Peşteana North and South, on the residential zone, is significant.

Measurements of particulate matter and sediments were also conducted by INSEMEX Petrosani.

Tests of suspended particulate matter

From analyzing the samples results that inhabited area in Peşteana Jiu (near highway) at 100m from the point of loading wagons Peşteana North, the concentration of particulate matter exceeded 2 times (Table 3).

Table 3. Determinations of suspended particulate matter in Peşteana quarry area

Sampling point	Period (min)	Concentration of particulate matter(mg/m^3)		CMA of imisions accord. STAS 12574/87 (mg/m^3)	Overcome of CMA	Microclimate Conditions
		In samples	E_{Med}			
30m from the point of loading in wagons, Peşteana South towards the inhabited - Peşteana Jiu	30	3	3		-	-relative air humidity 88%: - air velocity is negligible; - coal humidity 25%; - air temperature 3.6 ˚ C
		3				
100m from the point of loading in wagons, Peşteana South towards the inhabited - Peşteana Jiu		1	1	0,5	2	
		1				

Processing the data from Table 3, results an estimation of the distances of dispersion of particulate matter (shown in Table 4.), respectively a zonation of the areas in which there are necessary to be taken immediate measures (intervention areas) and areas that are required to be kept under observation (in alert zone).

Table 4 Estimation of the distances of dispersion of suspended particulate matter Peşteana mining area

The dispersion zone (influence) of suspended particulate matter from the point of loading (Peşteana deposit) to nearby inhabited area (Peşteana Jiu) (m)	1 1100	1 5150	200
Estimated concentration of particulate matter (mg/m^3)	11	0,5*	0,35**

Note: * Maximum permissible particulate concentration for a short term - limited intervention

** Concentration of particulates (alert limit)

It follows that the area exceeding the permissible limit of intervention extends from the source to 150 m to the inhabited area and the ones between 150 and 200m exceed the alert value.

Measurement of settleable particlates

To determine settleable particlates INSEMEX has placed a sedimentation tank in the yard no. 154 (Todeasa family) in Peşteana Jiu area, and EPA Gorj determinations were performed in five points respectively in Peşteana North, Peşteana South and the courtyards of the families Popescu, Tunaru and Colda.

Settleable particlates sampled by INSEMEX in 2013 are shown in Fig.3.

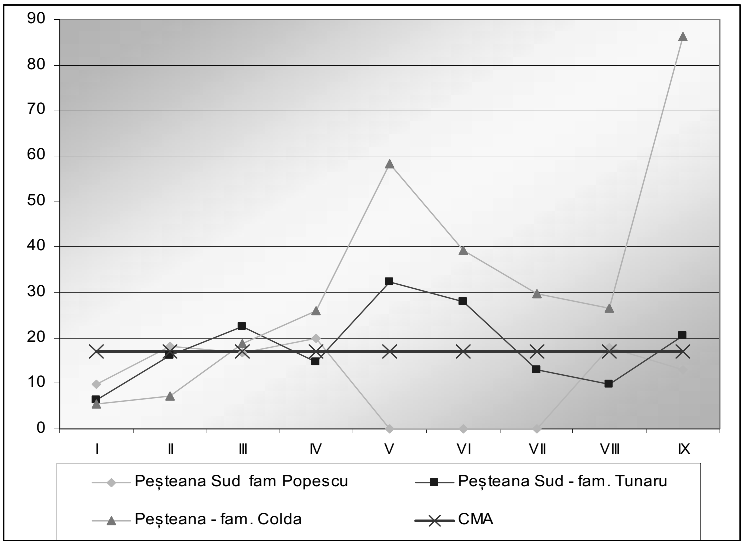


Figure 3 Variation of settleable particlates in the measuring points in 2013

2.6. Soil and underground pollution sources

A source of pollution of the soil and disruption of physical-chemical equilibrium, are all the complementary operation of coal exploitation, especially the surface ones:

Figure 4 Influence on the soil of the belt carrier activity when transporting tailings into dumps

- prospecting and exploration activities;
- land preparation activities such as deforestation of vegetation, change of watercourses, making roadways, roads and railways, parking lots;
- waste, spare parts, machinery and coal storage activities;
- excavation construction

activities of any kind, sewerage, water supply, electricity networks;

- conveyor belts planning routes and distribution of access roads, tparking;
- the regularization of watercourses, construction of dikes, dams, dewatering, draining guard channels;
- out repair of machinery and mining equipment;
- transport activity;
- activity of storage and handling fuels and lubricants.

Human activities (housing) or industrially related, arising from mining, in mining or surrounding areas, have negative effects on the soil in the area (construction and social housing, roads, sewers, storage, maintenance - repair and others).

Figure 5 **Sampling points for water, air, soil, flora, and fauna**

3. NEGATIVE EFFECTS GENERATED BY MINING ON THE ENVIRONMENT IN PEŞTEANA PERIMETER

Effects of lignite exploitation on the environment in Peşteana are local and regional, temporary and long-term.

In the course of existing activities within the mining area in Peşteana, result pollutants affecting all environmental factors: air, water, soil, flora, fauna, and health and human settlements.

To continually track the quality of environment factors there were collected and analyzed samples both upstream and downstream of pollution sources.

3.1. Impact on water

The manner in which the activity of mining in Peşteana affects the environmental factor water does not consist primarily in the emission of pollutants in water, as in radical intervention on permanent watercourses and torrential waters, changing topography, phreatic quotas, depression of artesian water, creating an adequate drainage system according to “the state" of work fronts and as a result, creating an influx of surface water from drainage that are driven to the nearest final emissary, the river Jiu.

Hydro technical works carried out are not properly managed; many were destroyed by the vegetation so that the water from rain can not be drained by them.

3.2. Impact on air

In Peşteana mining area it has been noted an increase, in certain points of the quarry perimeter, in the concentration of particulate matter, gases and smoke from vehicles and equipment used in quarry, measurements of pollution in the settled particles being smaller than the allowable limit (17mg/m^2/month).

3.3. Impact on soil

In the case of quarry mining, the impact on the ground was very hard, determined by the process of stripping or stockpiling soil, the latter disappearing either by mixing it with tailings inseparable, whether stripping it separately. By the disappearance of soil one must understand the disappearance of a "living body" formed over time with all attributes - first fertility - which give a favorable environment for plant growth. (Figure 6)

Figure 6 Quarry exploitation activity’s impact on soil

If most of the times these anthropogenic protosoils provide useful edaphic volume sufficient for the development of the crop root system in return those are lifeless without specific essential feature of developed land - namely fertility.

4. OVERALL ASSESSMENT OF THE ENVIRONMENTAL IMPACT OF MINING IN PEŞTEANA AREA

Overall assessment of the environmental impact of coal mining activities in Peşteana North and South was made using an impact assessment matrix, adapted to the specific activity of quarry coal mining.

Table 5. External dump soil analysis report

Parameter	M U	Determined value	Set points	
			Alert	Intervention
Total Cadmium	mg/kg	1,8	5	10
Total lead	mg/kg	3,2	250	1000
Fluorine	mg/kg	0	500	1000
Free cyanide	mg/kg	0	10	20
Phenols	mg/kg	0	10	40
Sulphates	mg/kg	-	5000	50000
Polycyclic aromatic hydrocarbons	mg/kg	0	25	150
Petroleum Hydrocarbons	mg/kg	0	1000	2000
Copper	mg/kg	6,5	250	500
Nickel	mg/kg	2,1	200	500
Zinc	mg/kg	9,3	700	1500
Manganese	mg/kg	14,6	2000	4000
Chromium	mg/kg	1,35	300	600

4.1. Impact Assessment Matrix

In the matrix of impact for Peşteana North and South quarries the excavation and stockpiling activities were considered as specific and most important in the whole operation and preparing, stripping, geological investigations, industrial support activities for water discharge, soil recovery, etc were considered related activities.

In the matrix, the impact of each activity was assessed based on qualitative criteria on a rating scale ranging from +3 to -5. (Table 6)

Table 6. Impact Assessment Matrix of Peşteana mining area

Factori de mediu	Activități																	
	Investigații geologice şi hidro-geologice		Pregătire teren (defrişări, descopertare sol)		Excavare masă minieră		Transport masă minieră		Haldare steril		Activități industriale conexe		Acțiuni de protecția mediului		Refacere ecologică		Modificări socio-economice ale colectivității	
	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Ape de suprafață			2		5				4		2					2	2	
Ape subterane	1				3				3									
Sol	1		4		5		3		5		2			2		2	2	
Aer			1		2		2		2		2							
Zgomot şi vibrații			1		2		2		2		1							
Peisaj			4		5		3		5		1			3		3	1	
Vegetație			4		4		3		4		1			4		4		
Faună			4		4		2		2		2			3		3		
Colectivități			1		3		1		3		1							
Total	**- 2**		**- 21**		**- 33**		**- 16**		**-30**		**-12**			**+12**		**+14**	**-5**	

Legend: ± *1 pozitive impact (+) şi negative (-) minimum,* ± *2 pozitive impact (+) şi negative (-) moderate,* ± *3 pozitive impact (+) şi negative (-) strog,* ± *4 very strong negative impact, - 5 degraded environment close to ecological disaster.*

By analyzing the matrix there are easily noted the magnitude and the negative effects of exploitation on all environmental factors including local residents.

Each of these factors suffers, more or less, from one or more activities in the mining area.

4.2. Global impact assessment method

Environmental assessment of an area, at a certain time can be done by: air quality; water quality; soil quality; health of the population; deficiency of recorded plant species.

Each of these factors is characterized by the representative quality indicators for the assessment of pollution for which there are set admissible limits. Depending on the entry in the normate limits, grades of reliability are granted.

The grades of reliability obtained for the four factors have led to a chart, as a method for simulating synergistic effect. was used to For simulating the synergistic effect of pollutants in Peşteana mining area, Rojanschi illustrative method was used The ideal state is represented graphically by a regular polygon with 10 units of reliability diagonal (Fig. 7.).

The index of global pollution of the studied ecosystem is:

$$IPG = \frac{S_i}{S_r} = \frac{200}{103,78} = 1,98$$

Therefore 1 <IPG <2, which corresponds to an environment subjected to the effect of human activities, causing discomfort for life forms.

Environmental factor	Water	Air	Soil	Flora and fauna
Grades of reability	7,16	7,08	8,71	6
Regular polygon area (Si)	200			
Irregular polygon area (Sr)	103,78			
Global pollution index (IP.G)	1,98			

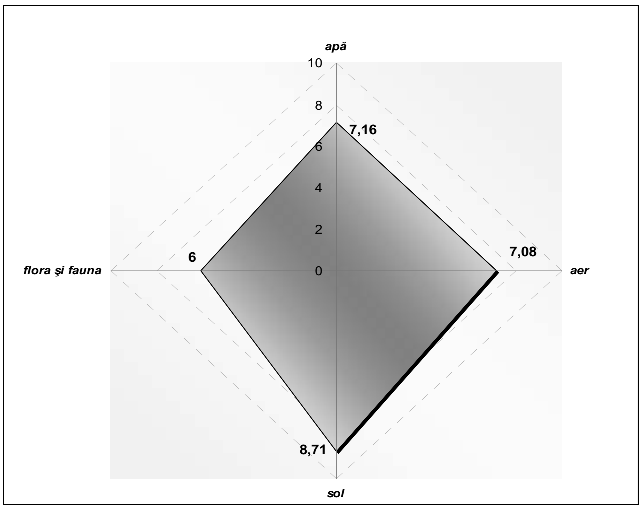


Figure 7. Graphical representation of global pollution index in Peşteana mining area

5. CONCLUSIONS

- Global assessment of pollution was carried out through a comprehensive pollution index calculation based on grades of reliability;
- Calculation of reliability grades was based on reliability scales and on the concentration of the indicators analyzed in the laboratory;
- There was performed a global pollution index calculation for all Peşteana mining area which revealed that it is subjected to human activity within acceptable limits;
- Quantifying qualitative environmental impact of Peşteana mining area was performed by the impact matrix that also analyzes all environmental factors.

Overall assessment of the environmental impact led to the appreciation of environmental quality in the studied area.

REFERENCES

[1]. Dumitrescu I. - "*Environmental Pollution*". Universitas Publishing Petrosani, 2002.
[2]. Fodor D., Baican G - "*Impact of mining on the environment*." Publisher INFOMIN Deva, 2001
[3]. Lazar M. - "*The impact of anthropogenic activity on the environment*." Universitas Publishing House, Petrosani, 2006.
[4]. Nanu G. – "*Identifying sources of pollution in Peşteana quarry and impact assessment on the environment*", Scientific research report 2. University of Petrosani, 2013.
[5]. Rojanschi V., Bran Florina., Diaconu G. - "*Protection and environmental engineering*." Economic Publishing House, 1997.
[6]. Rojanschi V. - "*Impact assessment and environmental strategies*." Ecological University of Bucharest, 1994.

Scientific Reviewers:
Prof. Ph.D. Eng. Romulus Iosif SÂRBU

ADSORPTION OF URANIUM FROM WASTE WATER USING ACTIVATED CARBON WITH NANO-IRON IMPREGNATED

EUGENIA PANTURU[*]
ANTONETA FILCENCO – OLTEANU[**]
OANA DOBRE[***]
CARMEN NICOLAE[****]

Abstract: *This paper described the equilibrium and the kinetic of uranium adsorption from waste water using activated carbon without/with nano-iron impregnated, applying batch method. Adsorption isotherms of uranium equilibrium are analyzed with Freundlich isotherms which reveal high affinity to activated carbon impregnated with nano-iron compared to non impregnate. Kinetic study showed that the decisive step of the uranium adsorption process rate is the intraparticle diffusion.*

Key words: *adsorption isotherms, uranium, activated carbon, nano-iron, diffusion*

1. INTRODUCTION

A wide range of methods are available for removal of heavy metal ions from aqueous solutions. These include ion exchange, solvent extraction, reverse osmosis, precipitation, filtration, electrochemical treatment, adsorption, etc. The most studied and applied method was the adsorption process. A number of researchers have used a variety of adsorbents to remove heavy metal ions from aqueous solutions such as activated carbon, bentonites, zeolites, iron oxides, clays etc. [1-12].

Research on the radioactive pollutants removal from the wastewater by adsorption processes using nano-iron or nano-iron impregnated solid support, gain a more general interest.

In the early 1990s, the reducing capabilities of metallic substances, such as zero-valent iron, began to be examined for their ability to treat a wide range of

[*] *Eng., Ph.D. at R&D National Institute for Metals and Radioactive Resources – ICPMRR Bucharest, eugenia.panturu@icpmrr.ro*
[**] *Eng., Ph.D. at R&D National Institute for Metals and Radioactive Resources – ICPMRR Bucharest, tonyfil2002@yahoo.com*
[***] *Eng. At R&D National Institute for Metals and Radioactive Resources – ICPMRR Bucharest, spirache_oana@yahoo.com*
[****] *R&D National Institute for Metals and Radioactive Resources – ICPMRR Bucharest, carmen_m1970@yahoo.com*

contaminants in hazardous waste water. The small particle size and high surface area to mass ratio make iron nanoparticles highly reactive and extremely versatile. The high surface area and surface reactivity compared with granular forms enable the nanoparticles to remediate more material at a higher rate and with a lower generation of hazardous by-products [13]. The ability of the nanoparticles to act as strong reducers also enables the remediation of an extremely wide range of contaminants. It proved to be particularly suitable for the decontamination of halogenated organic compounds, but subsequent studies have confirmed the possibility of using zero-valent iron in aim to the reduction of: nitrate, bromated, chlorate, nitro aromatics compounds, brominates pesticides. Zero-valent iron proved to be effective in removing arsenic, lead, and uranium and hexavalent chromium. [14-23].

In 1997 Wang [24] first produced the nanoscale iron particles in the laboratory using the method of sodium borohydride reduction. By mixing sodium borohydride ($NaBH_4$) with ferric chloride ($FeCl_3 \cdot 6H_2O$), Fe (III) is reduced according to the reaction scheme below (1):

$$Fe(H_2O)_6^{3+} + 3BH_4 + 3H_2O \rightarrow 3Fe^0 + 3B(OH)_3 + 10.5H_2 \tag{1}$$

On the laboratory scale production of nanoscale zero-valent iron, they achieved a particle size distribution of less than 100 nm for 90%of the particles produced. This work aimed to study equilibrium and kinetics of adsorption of uranium from wastewater, using as adsorbent material simple activated carbon Purolite AG 20 G and impregnated with nano- iron.

2. EXPERIMENTAL

2.1. Materials and methods - Characterization of activated carbon

Physical characteristics of activated carbon Purolite type AG 20 G (from Purolite Company, Romania), are presented in the Table 1.

Synthesis of activated carbon Purolite type AG 20 G impregnated with nano-iron was done by the method of reduction of iron ions (III) by sodium borohydride in the presence of sodium hydroxide, resulting in a coal with a nano-iron content of 5.99%.

Scanning Electron Microscopy method made with electron microscope Quanta Inspect F and particle size analysis performed with Zetasizer Nano ZS ZEN device 3600, have highlighted the absence and presence of iron nano-particles (average size of 211.5 nm) on to activated carbon [25].

2.2. Experimental methodology

To study the equilibrium of the U(VI) ions adsorption process, well-defined quantity of activated carbon Purolite type 20G AG without/with impregnated nano-iron was put in contact with solutions, in the glass bottles containing uranium with varying initial concentration, C (g U L^{-1}), a solid : liquid ratio of 1:10 (wt.). The solutions pH, determined with a pH meter InoLab was adjusted to 8 ± 0.2 value. Samples were kept under stirring at constant temperature 25 ± 1^0 C in a thermostat type bath shaker to achieve balance. The two phases were separated by filtration.

Table 1. Physical characteristics of activated carbon Purolite type AG 20 G

Characteristics	Values
Physic form	Black cylindrical pellets
Moisture content	Max 2%
Total area (N_2 method, B.E.T.)	900 – 1000 m^2 g^{-1} dry products
Grain Actual size	0.6 – 2.4 mm 0.9 – 1.10 mm
Coefficient of uniformity	1.7 – 1.8
Density, after loosening the filling water drained	480 g L^{-1}

For kinetic study of the adsorption process, parallel samples of solutions containing studied U(VI) ions with the similar initial concentration, C (gUL^{-1}), were put in the contact with the same amounts of activated carbon Purolite AG 20 G and activated carbon impregnated with nano-Fe^o a solid : liquid ratio of 1:10 (wt.). Agitation was performed in a thermostatic bath shaker type at constant temperature 25 ± 1 ºC. To well-defined periods of time, the phases were separated by filtration. Resulting solutions were analyzed after filtration. Uranium concentration in solution was determined colorimetrically (Cecil CE1101 photocolorimeter) at 670 nm, using the method with arsenazo (III).

3. RESULTS AND DISCUSSIONS

3.1. Adsorption Isotherms

Freundlich isotherm [26], which describes processes detention of U(VI) ions on adsorbent materials, used for this study, is described by the Eq. (2):

$$q_e = K_f \cdot C_e^{1/n} \qquad (2)$$

where q_e (g U kg^{-1}) is the amount of adsorbed material retained on adsorbent unit, C_e (gUL^{-1}) is the equilibrium concentration of the contaminant in aqueous solution and K_f and n are Freundlich constants which correspond to adsorption capacity.

For interpretation of the balance (Figure 1) was used Freundlich isotherm in the linear form Eq. (3):

$$\log q_e = \log K_f + \left(\frac{1}{n}\right)\log C_e \tag{3}$$

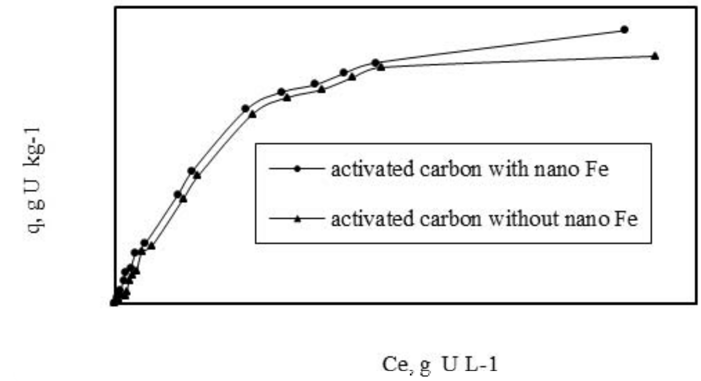


Fig. 1. Isotherms for the uranium adsorption on activated carbon Purolite type AC 20 G without/with nano-Fe° impregnated (solid : liquid ratio of 1: 10 (wt.); 300 rpm; contact time 30 minute followed by filtration and contact with the solution of higher concentration; C = 0.3-18.86 g U L^{-1})

The Figure 2 and Figure 3 show the Freundlich isotherms for uranium adsorption on activated carbon Purolite AC 20 G without respectively with nano-Fe^{o} impregnated.

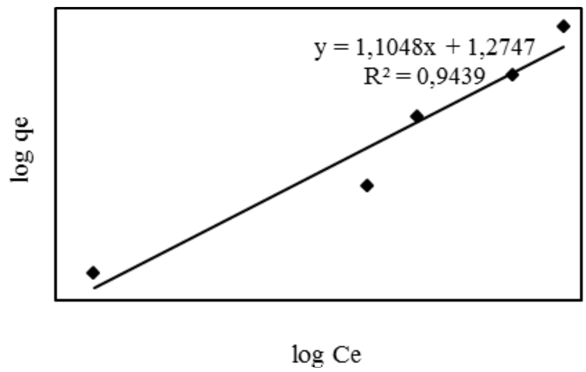


Fig. 2. Freundlich isotherm for the adsorption of uranium on activated carbon Purolite AC 20 G non impregnated with nano-Fe°

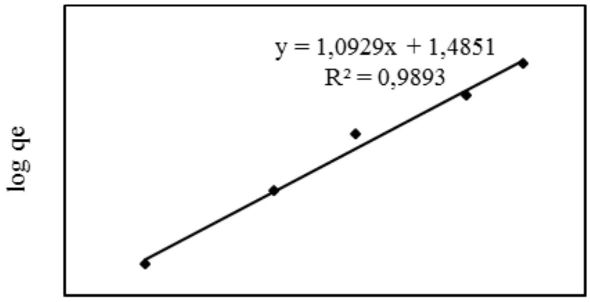


Fig. 3. Freundlich isotherm for the adsorption of uranium on activated carbon Purolite AC 20 G impregnated with nano-Fe°

The slope (1/n) and K_f intercepts of the two isotherms (log q_e versus log C_e) are determined.

After determining the constants K_f and n, Freundlich equations for the two cases are given in Eq. (4) and Eq. (5):

- activated carbon non impregnated with nano-Fe°

$$\log q_e = 1.2747 + 1.01048 \log C_e \quad (4)$$

- activated carbon impregnated with nano-Fe°

$$\log q_e = 1.4851 + 1.0929 \log C_e \quad (5)$$

R^2 correlation coefficients of 0.9439 and respectively 0.9893 and constant values show that both isothermal experimental data fit well.

3.2. Thermodynamic parameters

The Gibb's free energy (ΔG °) is calculated to evaluate the thermodynamic feasibility of the process [27]. The standard free energy can by calculated using Eq. (6):

$$\Delta G^0 = -R \cdot T \cdot \ln K_d \quad (6)$$

where *R* (J mol^{-1} K^{-1}) is the universal gas constant, *T* (K) is the absolut solution temperature and K_d is the distribution coefficient, calculated by Eq. (7):

$$K_d = \frac{q_e}{C_e} \quad (7)$$

The negative value of ΔG° (-7.734 kJmol^{-1} for non impregnated activated carbon with nano-Fe°, respectively -8.294 Kjmol^{-1} for impregnated activated carbon with nano-Fe°) establish the feasibility of the sorption process and the spontaneous nature of the adsorption with a high preference of uranium on the activated carbon impregnated with nano-Fe°.

3.3 Intraparticle diffusion

Experimental data obtained from kinetic studies for the two materials (Figure 4) were processed by applying the Shell Progressive Model for establishing the rate decisive step of the adsorption process.

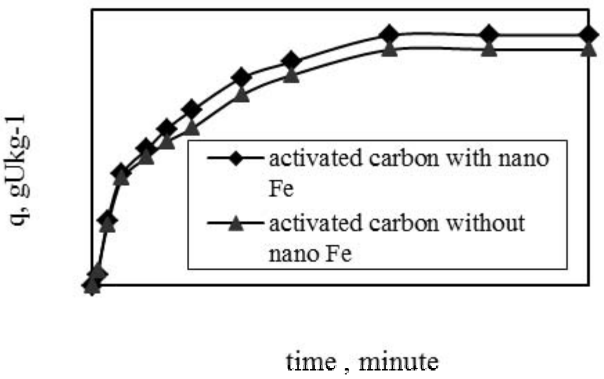


Fig. 4. Kinetic curves for the adsorption of uranium on activated carbon Purolite AC 20 G without/with nano-Fe° impregnated (solid : liquid ratio of 1: 10 (wt.); 300 rpm; contact time 1-100 minute; C = 0.6 g U L^{-1})

According to the model, the process rate decisive steps are:

- external diffusion, Eq. (8):

$$G(X) = \frac{t}{t_0} \tag{8}$$

- internal diffusion, Eq. (9):

$$G(X) = 1 - 3(1 - X)^{\frac{2}{3}} + 2(1 - X) = \frac{t}{t_0} \tag{9}$$

- chemical reaction,Eq. (10):

$$G(X) = 1 - (1 - X)^{\frac{1}{3}} = \frac{t}{t_0} \tag{10}$$

where *t* (s) is the time, t_o (s) is the time needed for the reaction to be complete and *X (%)* is the conversion of activated carbon (progressive achievement of adsorption equilibrium; ratio of adsorption capacity at time, t and maximum adsorption capacity).

In Figure 5 and Figure 6 are showed the kinetic equations test results for the three rate decisive steps corresponding of the two types of materials.

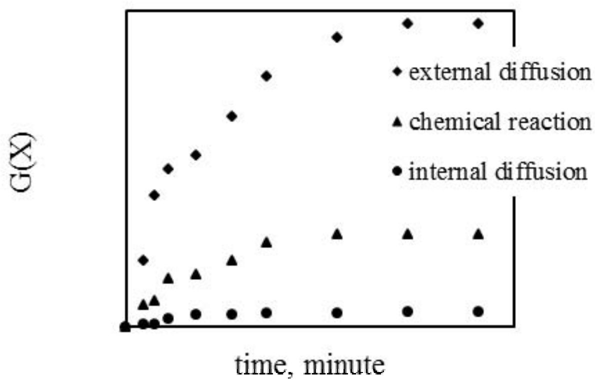


Fig. 5. Kinetics of adsorption of uranium and testing of model equations for Shell progressive model for activated carbon Purolite AC 20 G non impregnated with nano-Fe^{o}

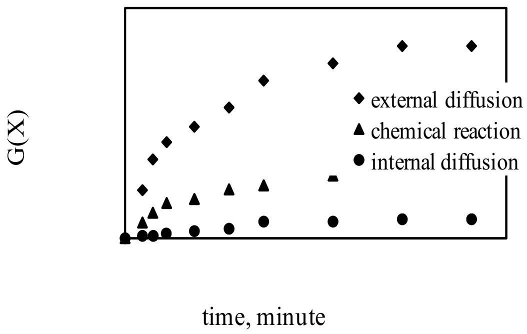


Fig. 6. Kinetics of adsorption of uranium and testing of model equations for Shell progressive model for activated carbon Purolite AC 20 G impregnated with nano-Fe^{o}

In both cases, the chemical reaction and the diffusion through the outer liquid film of the grain are excluded as process rate limiting steps, because their graphic representation is not a straight line for any of the studied coal type. Linear regression results for the two cases are presented in Table 2. Intersection values, slope and linear correlation were determined by Mathcad program.

Linear regression results for internal diffusion, as the rate limiting step of the process, shows a high correlation. *Ω* functions, adequate of each rate decisive equations represent the standard deviation of experimental values toward the calculated values. The equation for the minimum of the *Ω* function is the equation which fit best with experimental data, so is the equation which describing kinetic of process. Notice that for the external diffusion and chemical reaction, the deviations are much higher (of order 10^{-4} and 10^{-5}) towards the deviations for the internal diffusion which are of order 10^{-7} or 10^{-8}.

Table 2. Linear regression values for the batch experiment

Experiment	Applied function	Intersection	Slope	Criteria value Gauss, Ω
AC20G Purolite	X	3.1×10^{-2}	1.176×10^{-3}	3.716×10^{-4}
	$1 - (1 - X)^{1/3}$	10^{-2}	4.089×10^{-4}	4.294×10^{-5}
	$1 - 3(1 - X)^{2/3} + 2(1 - X)$	4.157×10^{-4}	4.981×10^{-5}	1.799×10^{-7}
AC 20G Purolite with nano-Fe°	X	2.612×10^{-2}	1.08079×10^{-3}	2.72023×10^{-4}
	$1 - (1 - X)^{1/3}$	8.805×10^{-3}	3.74092×10^{-4}	3.11364×10^{-5}
	$1 - 3(1 - X)^{2/3} + 2(1 - X)$	2.797×10^{-4}	4.10146×10^{-5}	7.28861×10^{-8}

The slope values were used to calculate diffusion coefficients using the equation for controlling intraparticle diffusion process.

The calculating values of diffusion coefficients are presented in Table 3.

Table 3. The calculated values of diffusion coefficients

Type activated carbon	Diffusion coefficient, m^2s^{-1}
Activated carbon Purolite AC 20 G non impregnated	1.61×10^{-12}
Activated carbon Purolite AC 20 G impregnated with nano-Fe°	1.75×10^{-12}

These values have size grades in accordance with data presented by other authors referring to cations retention on different supports [28, 29].

4. CONCLUSIONS

This paper described the equilibrium and the kinetic of uranium adsorption from waste water (from the uranium industry), using activated carbon without/with nano-Fe° impregnated, applying batch method. For the interpretation of experimental results was used Freundlich model. Calculated values of Freundlich isotherm constants and correlation coefficients R^2 0.9439 for activated carbon Purolite AC 20 G non impregnated and respectively 0.9893 for activated carbon Purolite AC 20 G impregnated with nano-Fe° prove the favorable adsorption of uranium on the two solid supports. The negative standard Gibbs energy calculated using distribution coefficient of uranium and spontaneous adsorption establish that the impregnation of iron increase the selectivity of activated carbon for uranium and therefore its retention capacity. Kinetic study (applying the Shell progressive model) showed that intraparticle diffusion is the rate decisive step for uranium adsorption process. The diffusion coefficient value for activated carbon Purolite AC 20 G impregnated with nano-Fe° is greater than for activated carbon non impregnate, so in the first case, mass transfer resistance is lower and the adsorption process arise more easy.

REFERENCES

[1]. Meena, K., Removal of heavy metal ions from aqueous solutions using carbon aerogel as an adsorbent, *J. Hazard. Mater.,* **2005**, *122,* 161-170.
[2]. Hu, X., Wang, J., Liu, Y., Adsorption of chromium (VI) by ethylenediamine-modified cross-linked magnetic chitosan resin: Isotherms, kinetics and thermodynamics, *J. Hazard. Mater.,* **2011**, *185,* 306-314.
[3]. Srivastava, S. K.,Tygai, R., Pant, N., Adsorption of heavy metal ions on carbonaceous material developed from the waste slurry generated in local fertilizer plants, *Wat. Res.,* **1989**, *23,* 1161-1165.
[4]. Curcovik, S., Metal ion exchange by natural and modified zeolites, *Wat. Res.,* **1997,** *31,* 1379-1382**.**
[5]. Akperov, E., Maharramov, A., Akperov, O., Synthesis and uranyl ion adsorption study of cross-linked allyl propionate-maleic anhydride-styrene terpolymer, *Turk. J. Chem.,* **2010**, *34,* 99– 108.
[6]. Mas Haris, M. R. H., Abdul Wahab, N. A., Reng, C. W., Azahari, B., Sathasivam, K., The sorption of cadmium(II) ions on mercerized rice husk and activated carbon, *Turk. J. Chem,.* **2011**, *35,* 936-950.
[7]. Panturu, E., Filcenco-Olteanu, A., Groza, N., Jinescu, G., Panturu, R. I., In situ decontamination of the underground water from uranium mining activities, *Rev. Chim.,* **2009**, *60,* 12, 1318-1324.
[8]. Erust, C., Sahin, M., Tuncuk, A., Akcil, A., Deveci, H., Metal Recovery from Waste by Biological Processes in Urban Mining, *Recycling Industry,* **2014**, *78*,3,74-78.
[9]. Tuncuk, A., Stazi, V., Akcil, A., Yazici, E.Y., Deveci, H ., Aqueous metal recovery techniques from e-scrap: Hydrometallurgy in recycling, *Minerals Engineering* , **2012**, *25*, 11, 28-37.
[10]. Alic, C., Manea, L.M.,Vasiu, T., Dobrei, Gh., Environmental impact due touse of coal in Mintia thermal power plant, *Revista Minelor,* **2013 ,** *19*,1, 2-8.
[11]. Bratkova, S., Angelov, A., Loukanov, A., Nikolova, K., Plokev,S., Ivanov,R., Biotechnogical removal of heavy metals from mining wastewaters by dissimilative sulphatereduction, *Revista Minelor* , **2013**,*19*,3,22-28.
[12]. Dumitrescu , I., Stanoi, C., Kando, N., Study of nikel on steel cathode used for water electrolysis, *Revista Minelor* , **2011**, *17,*2,10-13.
[13]. Zhang, X., Nanoscale iron particles for environmental remediation, Journal of Nanoparticle Research, **2003**, *5,* 323-327.

[14]. Alvarado, J. S., Rose, C., Laferniere, L, Degradation of carbon tetrachloride in the presence of zero-valent iron, *J. Environ. Monit.* **2010**, *12,* 1524-1528.
[**15]. Gheju, M.,** Hexavalent Chromium Reduction with Zero-Valent Iron (ZVI) in Aquatic Systems, Water Air Soil Poll. **2011**, *222,* 103-107.
[16]. Noubactep, C., Contaminant reduction at the surface of elemental iron: the end of a myth, *Wasser, Luft und Boden.,* **2006**, *50,* 11-12.
[17]. Noubactep, C., Schoner, A., Dienemann, H., Investigating the release of co-precipitated uranium from iron oxides, *J. Radioanal. Nucl. Chem*., **2006**, *267,* 21-25.
[18]. Dickinson, M.; Scott T. B., The application of zero-valent iron nanoparticles for the remediation of a uranium-contaminated waste effluent, *J. Hazard. Mater.,* **2010**, *178,* 171-179.
[19]. Morrison, S. J., Metzler, D. R., Dwyer, B. P., Removal of As, Mn, Mo, Se, U, V and Zn from groundwater by zero-valent iron in a passive treatment cell: reaction progress modeling, *J. Contam. Hydr.,* **2002**, *56,* 99-116.
[20]. Morrison, S. J., Mushovic, P. S., Niesen, P. I., Early breakthrough of molybdenum and uranium in a permeable reactive barrier, *Environ. Sci. Technol.,* **2006**, *40,* 2018-2024.
[21]. Panturu, R. I., Jinescu, G.,Panturu, E., Filcenco-Olteanu, A., Radu, D., ARSEN-X ^{np} Purolite resin used for the depollution of uranium contaminated waters*, Rev. Chim.* **2011**, *62,8,* 814-817.
[22]. Mamadou, D., Duncan, J. S., Savage, N., Street, A., Sustich, R. C., Nanotechnology Applications for Clean Water, *Journal of Nuclear Materials,* **2013**, *443*,1-3, 250-255.
[23]. MacFarlane, J.W., Payton, O.D., Keatley, A.C., Scott, G.P.T., Pullin, H., Crane, R.A., Smilion, M., Popescu, I., Curlea, V., Scott, T.B., Lightweight aerial vehicles for monitoring, assessment and mapping of radiation anomalies, *Journal of Environmental Radioactivity*, **2014**,*136* ,1,127–130.
[24]. Wang, C. B., Zhang, W. X., Synthesizing Nanoscale Iron Particles for Rapid and Complete Dechlorination of TCE and PCBs, *Environ. Sci. Technol.,* **1987**, *31,* 2154-2158.
[25]. Panturu, R. I., Jinescu, G., Panturu, E., Filcenco-Olteanu, A., Radulescu, R., Synthesis zerovalent iron used for the radioactive contaminated water treatment, *U.P.B Sci. Bull. Series B,* **2010**, *72,* 207-219.
[26]. Khan, A. S. A., Theory of adsorption equilibria analysis based on general equilibrium constant expression, *Turk. J. Chem.,* **2012,** *36,* 219-231.
[27]. Bhattacharya, A. K., Adsorption of Zn(II) from aqueous solution by using different adsorbents, *Chem. Eng. J.,* **2006**, *123*, 43-51.
[28]. Sj, A., Mckay, G., Khy, K., Intraparticle diffusion of basic dye during adsorption onto Sphagnum Peat *J. Environ. Pollut.,* **1989**, *50,* 39-50.
[29]. Weber, W.; Morris, J., Kinetics Of Adsorption on Carbon from solutions., *J. Sanit. Div. Am. Soc. Civ. Eng.,* **1963**, *89,* 319.

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea Georgescu

INDEX OF AUTHORS

INSTRUCTIONS FOR AUTHORS[1]

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 number, *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 and the number of pages must be even between 4 and 16. 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

[1] *Professor Eng., Ph.D. at the University of Petroşani, adresa email*

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.

<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.

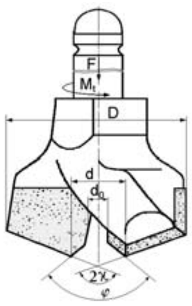


Fig. 1. Detachable bit

· (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>

$$X^2 + Y^2 = Z^2 \qquad (1)$$

· (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)

REFERENCES (will be written according to the model, Times New Roman 10 points).

· (10 points)

[1]. Marian I., *Mecanizarea în minerit,* Editura Tehnică, Bucureşti, 1969.

SCIENTIFIC REVIEWERS

Commission reviewers for article in the journal ***„Annals of the University of Petroșani Mining Engineering"***

FIELDS OF COMPETENCE

✓ **MINING ENGINEERING:**
Prof. Ph.D. Eng. Dumitru FODOR – University of Petroșani
Prof. Ph.D. Eng. Eugen COZMA - University of Petroșani

✓ **MINING SURVEYING:**
Prof. Ph.D. Eng. Nicolae DIMA - University of Petroșani
Assocc.Prof. Ph.D. Eng. Ioel VEREȘ - University of Petroșani

✓ **MANAGEMENT IN MINING**
Prof. Ph.D. Eng. Florian BUȘE - University of Petroșani
Prof. Ph.D. Eng. Petru HODOR - University of Petroșani

✓ **ENGINEERING AN ENVIRONMENTAL PROTECTION:**
Prof. Ph.D. Eng. Mircea GEORGESCU - University of Petroșani
Prof. Ph.D. Eng. Romulus SÂRBU - University of Petroșani
Prof. Ph.D. Eng. Maria LAZĂR - University of Petroșani

✓ **MINE CONSTRUCTION:**
Prof. Ph.D. Eng. Constantin SEMEN - University of Petroșani
Prof. Ph.D. Eng. Ilie ONICA - University of Petroșani

✓ **VENTILATION AN MINE SAFETY:**
Prof. Ph.D. Eng. Nicolae BĂNCILĂ - University of Petroșani
Assocc.Prof. Ph.D. Eng. Roland MORARU - University of Petroșani

✓ **PROCESSING OF MINERAL RESOURCES:**
Prof. Ph.D. Eng. Sanda KRAUSZ - University of Petroșani
Prof. Ph.D. Eng. Mihaela PODARIU – North University of Baia Mare

✓ **MINING GEOLOGY**
Assocc.Prof.Ph.D. Laura COMĂNESCU – Universitatea din București
Prof. Ph.D.Eng. Grigore BUIA - University of Petroșani

✓ **ROCK ENGINEERING**
Prof. Ph.D.Eng. Victor ARAD - University of Petroșani
Prof. Ph.D.Eng. Ioan BUD - University of Petroșani