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STABILITY OF WASTE DUMPS, ISSUE OF MINE CLOSURE MONITORING PLAN FROM JIU VALLEY COAL BASIN

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ABSTRACT: Modifying and depleting the soils by mining works and dumps of mineral waste as a result of coal mining and tailing is one of the important aspects in mining area Jiu Valley. The paper's aim is to analyze which are minerals and resources policies of our government and to adopt measures for sustainable development in the coal mining in this region. The measures to reduce the instability risk for the mining works and waste dumps, which could affect the underground mining constructions or the related surface areas, were consider. The estimation of waste dump stability must be doing to reduce impact of the negative environmental factors.

МОНИТОРЕН ПЛАН ЗА УСТОЙЧИВОСТ НА ОТПАДЪЧНО НАСИПИЩЕ ВЪВ ВЪГЛЕДОБИВНИЯ БАСЕЙН В ДОЛИНАТА НА Р. ЖИЛ

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РЕЗЮМЕ: Един от основните проблеми в резултат на минните работи в долината на р.Жил е неустойчивостта на почвата и образуването на отпадъчни насипища. В доклада се анализират правителствената политика и мерките за осигуряване на устойчиво развитие във въгледобива в региона. Дискутират се мерките за намаляване на рисковете и се отчита необходимостта от обективна оценка на устойчивостта на минните работи и насипищата, с цел намаляване вредното им влияние върху околната среда.

General aspects

In the last decade, the mining sector restructuring has represented one of the major goals of the industry and resources ministry, considering that the national energetical policy should maintain the general framework of sustainable development, which in the globalisation context represents a political and economical strategy issue. Coal mines closure in Jiu Valley and in other basins was performed basically for political/social reasons, and less care was given to economical/technical considerations, directed to the aim of sustainable development of this sector, which supplies energy resources for the country.

Mineral resources extraction activity is a temporary one, even if his environmental impact is long lasting, acting a certain time after activity cessation. To provide a sustainable development after mine closure for mining areas, strategies must be developed to restructure the mining sector, including both objectives for increased activity efficiency and for ecological reclamation and rehabilitation of affected areas, economical and social development.

The macroeconomic reorganisation initiated by the Romanian Government in 1997 determined the reduction for coal mining demand with approximately 3500-3600 millions tones/year, 3000-3200 being energetic coal, this fact generating the necessity of a restructuring process, began in the Jiu Valley with a personnel reduction of about 50%. This is the reason why at the beginning of 1999 it has been initiated a rigorous program of reducing the losses in the mining activity at the National Company of Hard Coal Petrosani, respectively CNH- Petrosani.

During the stage 1992 – 2002 there have been elaborated strategy studies concerning the hard coal mining and processing, studies that have been periodically putted up to date according to macro – economical and financial changes Romania passed through. Now, the national energetic zone has to face the main challenges which are put in an internal level and a global one: the energy filling safety, the increase of the economic competitive action and the environment impact decrease. Under these circumstances, the role of the coal, and especially the lignite in the national energetic balance, raises.

The mining zone needs to take the following measures:

- Production focusing in the most profitable area;
- Closure of non-profitable exploitations, the changing of labor force and cleaning of affected areas;

The necessary of investments for the 2006-2009 season, evaluates at about 500 millions Euros, from which 20% represent mines closures and cleaning of affected areas. The

evolution of primary energy production on coal in the period between 2005-2009 years is about 24%.

Environmental aspects related to the coal mining from the Jiu Valley Basin

The mining activity performed in Romania until the year 1989 was focused mainly onto reaching high production levels, fact which has lead to neglect ecological issue and that has resulted in accumulation in time of very serious damages for the environment. Rehabilitation of mining wastes represents a constant concern of all specialists in the field of mining, biology and sylviculture, who have cooperated along the years with very good results.

The strategy concerning environment protection in Romanian involves the development of an unitary program concerning the technological implementation in the field of clearing of mining wastes out from affected areas. This program is supported by a legislative frame resulted from Low 137/1995 regarding environment protection, issues by the Ministry of Water, Forests and Environment Protection.

Jiu Valley represents one of the most important mining areas in Romania and its industrial development has generated a high level of pollution in this area. During the time, is result of Jiu Valley coal mining and processing activity, important quantities of wastes storied in waste dumps occupying a total surface of over 200 ha have been accumulated, of which 60 % are inactive. Present situation of the waste dumps from mining perimeter of Jiu Valley is presented Table 1.

In the closing mine activity two types of wastes are present in mining area: old and new waste.
The main sources of soil pollution and degradation are:

1. household waste deposited on the soil;
2. tailing deposited on the soil;
3. buildings occupying the soil.

The main sources of soil pollution and degradation are:
a) Soil being occupied by continuously degrading buildings;
b) Different types of wastes improperly stored, like scrap-iron, piles of sterile mass etc.;

c) Water (coming from the mine water drainage that belongs to RAAVJ Petroşani), which lays on a sloppy ground in the northern area of the preparation facility, as well as the rain water, which is not drained through the sewage system and is covering the sloppy zone in the northern area of the preparation facility, when rainy.

Table 1 Situation of waste dumps in accordance with the sources of waste deposits afferent to mining activities

Provenance of storied deposit	*Storage surface (ha)*		*Total (ha)*
	Active	*Passive /In conservation*	
From underground works	23.64	93.08	116.72
From coal processing plants	45.62	44.91	90.53
Total (ha)	69.26	137.99	207.25

The environment pollution sources ceased to exist since the processing activity has been suppressed. At present, washing and filtering processes have been stopped; there is no more need for supplying industrial water, and for the drainage of the residual one. The rainwater is taken away by the sewage system from inside the preparation facility.

At present, there are no more air pollution sources within the curtilage, both in terms of gas and sound pollution.

The issues of monitoring plan in post closing are presented in Table 2. The waste dumps are generally located on mountain slopes or along valleys with or without hydrologic condition. Waste depositions in valleys or rainfalls have led to the formation of lakes in the riverbeds or from. The occurrence of such lakes is geo-mechanically unfavorable.

Table 2 Issues of monitoring plan during post closure mine period

Issue	*Where is parameter to be monitored*
i. vegetation - vegetation density - vegetation	Cultivated and planted surfaces on curtilage, waste tips
ii. stability of waste tips or impoundments - settlement - erosion	Stabilised or deposition areas

The water seeps causes the phenomenon of suffusion modifies the physical- mechanical properties of the rocks in the waste dumps and in the soil, being about landslides or plastic flows eventually.

Analyses of soil pollution sources and assessment of impact to the environment

The mining perimeter is located on both banks of the Jiu River. The relief of the mining field is developed on soft rocks, clay and sands; it is hilly, with level differences and relatively steep slopes. The land is largely deforested and it is used as hayfields. The forests, covering limited areas, are mainly beech forests.

The climate is continental temperate with slight influences of the Mediterranean currents and the average annual temperature of 6-8°C, among the lowest in the country. Generally, winters are frostier than in other parts of the country and summers are very short and colder. Another characteristic of the climate is late and cold springs, sometimes with snowfalls and frosts in May.

Hard coal mining and processing has a significant influence to the environment, due to the fact these processes leads to damage of sylviculture, agriculture and landscape fund in Jiu Valley.

The soil polluting sources are the followings:

- mineral waters dumps
- industrial wastes
- household wastes.

The effects of all these polluting sources to the soil are following: they occupy large areas of agricultural a sylviculture land, land damage due to infiltration of lubricants and other substances into the soil in the case of inadequate storage of industrial wastes. As result of vegetation lack if occurs the erosion of the dump due to the fine material carried by the weather factors. The waste dumps represented the most important soil polluting sources in Jiu Valley, resulted from the mining activity. From geological point of view, these deposits consist of the following types of rocks: shale, marly – shales, marls, marls – limestone, slimes, cinder, etc.

Common characteristics are following:

- non – uniform geometry and location auto steep land areas ;
- before their settlement no land arrangement works have been carried out, such as : removal of vegetal soil, performing of crossing steps, drainage of streams or water springs in the area ;
- due to the fact that not all over locations there have been carried out waste dumps leveling works and catching of site water springs, this have often lean to local water accumulations.
- In the case of waste dumps afferent to coal processing plants, main problems consist in water included info the material resulting from the press filters that is storied into these waste dumps, especially during cold period of the year.
- In many cases the material storied auto dumps present self ignition phenomena due to coal fines in it.

In accordance to the rules regarding the design execution and passing info conservation of waste dumps these are classified as presented below:

- ❖ According to the types of storied rocks: rock hardness inflammability (dumps with flammable substances);
- ❖ According to the waste dumps geometry: nr of steps; height; surface lands shape;
- ❖ According to the environment polluting possibilities influence of powders and water;
- ❖ According to the technology used for setting the waste dumps: dry transportation system.

The ecological reconstruction actions amount the necessary actions for the improvement and re-use of the degraded soil: applying fertilizers, the sowing seeds actions and the rain water harvesting actions.

The old waste has a 107.0 ha surface and approx 54,000,000 m^3 volume, being naturally stabilised, the new waste a 82,000 m^2 surface and approx 360.600 m^3 volume, and it will be ecologies.

Works to prevent soil erosion and the stabilization of damps were made like in Figure 1.

Fig. 1. Work to prevent soil erosion and to drain the dripping waters

Evaluation of waste damps stability by numerical methods

Numerous methods of analyzing stability can be classified according to different criteria; nevertheless they can be classified into two large categories:

- Methods of static equilibrium
- Methods of deformation, based on the stress- strain relation, or
- Mixed methods (Manea, 1998).

In the second category, the determination of the Stress State in the rock - mass, which is compared, is done by several techniques.

In the paper, the determination of the Stress State was carried out using the finite element method (Salvadori et. al.1972). The method divides the analysed environment into small domains, on which a simple distribution of stresses and strains is considered, while the stresses are average on a finite volume in the rock mass. The "a priori" knowledge of the position of break surface, by applying the finite element method indicates the areas with stress concentration and their evolution with the load state, the areas with tensile stress and the displacements before slope break (Arad et al. 2000).

In the case of a waste dump, which can become unstable owing to weather phenomena the analysis method of the Stress and Strain State by the finite element method has been applied.

Adequate software by finite element analysis, QuickField has been used by which a finite domain in the rock mass is modeled through a 199 knot mesh. First of all the general problem parameters are described, in a planar model type. The data for the materials, loads and boundary conditions was provided. The part labels and the mash for the model were given in the detailed description of the geometry (Arad, 2002).

We obtained the solution by numerical modeling for Ileana 1 waste dump from Lupeni mining area. The Ileana 1 waste dump lies on an area of 14.26 ha, having 21 m average height and a volume of 4 283 656 m^3.

From the laboratory tests and the material characteristics it is known that: the elasticity module, E = 200x10^6N/m^2; Poisson coefficient μ = 0.3; inner friction coefficient φ = 34°; apparent specific gravity γ = 2.2x10^4 N/m^3; Volumetric weight γ = 2.31 x 10^4 N/m^3 (Arad, 2000).

Results and comments

The displacement on the contour of the slope and Stress tensor has been plotted in Figures 2 where is presented the state of displacements δ on the block of the slope. In Table 3, are given the values of the parameters characterizing the stress state calculated in the point at the side bottom, the side top and the critical point to right extremity of the geometric model. The model of the slope waste dump is rendered in Figures 3.

Table 3.The parameters of the stress state for the geometric model

Parameter (UM)	*At the slope top*	*At the slope bottom*	*In the critical point*
		Value	
δ_x (m)*	1.00	-0.89	0.79
δ_y (m)*	-0.71	-0.52	1.00
σ_{Tr}(10^9 N/m^2)**	4.14	2.07	6.21
σ_{Mi}(10^9 N/m^2)**	1.89	3.11	4.9
σ_x(10^9 N/m^2)***	-2.96	0.916	4.8
σ_y(10^9 N/m^2)***	-2.8	1.69	-3.55
τ_{xy}(10^9 N/m^2)***	1.82	-0.85	2.59

* Displacement,
** Tresca and von Mises Stress,
***Stress tensor.

In conclusion: (i) from the analysis of the results obtained we find out that the stresses occurring in the waste dump slope are higher than the corresponding mechanical resistances (σ_{rc} = 5x10^6 N/m^2; σ_{rt} = 1x10^6 N/m^2; τ_{rf} = 3.41x10^6 N/m^2) determined in the laboratory, therefore the slope is unstable; (ii) regarding displacements, it is found out that these have maximum values on the vertical, which does not, however, affect waste dump stability.

Conclusions

Corroboration of the results obtained by numerical methods, of slope modeling, and the statistical processing of the large number of instability phenomena by long term observations on them imposes making out prevision charts of instability phenomena. The prediction on slope stability, and in general on that of sides, is a requirement due to the negative impact the instability phenomenon has on the environment.

During the design, construction, and abandon of the tailing dam, the stability must be assured during all its lifetime.

The numerical methods for the simulation of the Stress State in the waste dump block were examined to assess their use in prediction sliding of the slope.

Aiming this, the environmental monitoring of the pollution sources are most important- risk assessment and reconsidering terms regarding environmental quality.

Another priority is the environmental policy, according to the specific legislation and the governmental policy. In the Jiu Valley this is done the CNH- Petrosani Enterprise.

Dumps' rehabilitation and reduction of the waste generation realize the improvement of the washed coal quality parameters and also the mining works reliability during the coal life cycle. The estimation of waste dump stability must be doing to reduce impact of the negative environmental factors.

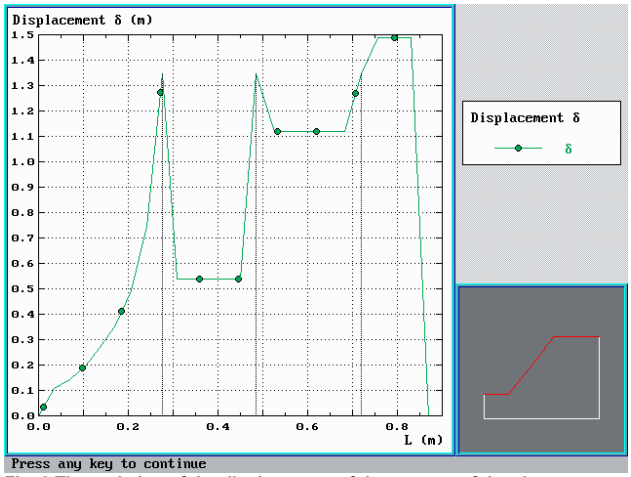

Fig. 2 The variation of the displacement of the contour of the slope

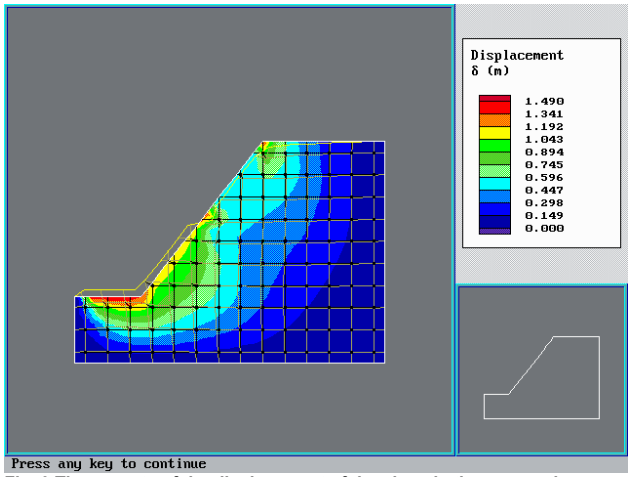

Fig. 3 The aspects of the displacement of the slope in the geometric model

REFERENCES

Arad, S., Arad, V., et.al. 1999. The economic and ecologic priorities regarding the exploitation and processing in the coal industry in Jiu Valley. *Proc. of 5th Conference on Environment and Mineral Processing*. VSB-TU Ostrava, ISBN 80-7978-671-x ,1999, pg. 313-317

Arad, S., Arad, V. & Chindris, Gh.2000 a. *Environmental Geoechnics,* Deva Polidava Press, ISBN 973-99458-0-5, (in romanian).

Arad V., Arad S., 2005. Environmental aspects of continuous mining in Jiu Valley, Romania, *Proc. SDIMI 2005*, Aachen, Germany, pg 293-297

Arad, V., Arad, S., & Cosma, D, 2002, Evaluation of side stability risk degree for environmental preservation. *Proc. of AACMSM17,* Gold Coast, Queensland, Australia, A.A. Balkema Publishers: Rotterdam, NL, pg.439-443, ISBN 90 5809 386 7

Manea, S., 1998. *Side slope stability risk degree evaluation*. Bucuresti: Conspress (in romanian).

Marinescu, C. 1988. *The Slopes and the Embankments stability assurance*. Bucuresti: Technical Press (in romanian).

Salvadori, M. & Baron, M. 1972. *Numerical Methods in Engineering*. Bucuresti; Technical Press (in romanian)

http://www.quickfield.com, Students' QuickField

http://www.minind.ro/domenii_sectoare/Pachet_de_masuri_energie_CE_ian_2007/Producerea_de_energie_durabila_din_combustibili_fosili.pdf

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