MINING WASTE DEPOSITS AT THE FORMER PREPARATION UNIT IN LUPENI – JIU VALLEY IN THE CONTEXT OF CIRCULAR ECONOMY

DOREL VITAN[1], MARIN SILVIU NAN[2], DĂNUȚ GRECEA[3], BOGDAN VLADU[4], DANIEL COSMIN VITAN[5]

Abstract: Mining wastes display a special condition depending on the category they represent (dangerous or non-dangerous). There are various types of mining waste treatment (mechanical, physical, biological, thermic or chemical processes or a combination of processes applied to mineral resources). Due to the amount of such types of waste and their impact on the environment, they are considered to have a high potential for being promoted in the context of circular economy.

Keywords: Mining industry, closed and abandoned mining waste deposits, environment pollution, recovery technologies, circular economy.

1. OVERVIEW·

The mines in Lupeni, Lupeni South, Victoria, Carolina and Ileana were opened in 1840 as private assets. The location of the exploitations follows the direction of the outcrop of the productive formation in the Northern - Eastern area of the perimeter.

The deposits of mining waste at the former Preparation unit in Lupeni were formed through the layering of the stuff owing to funicular equipment in a bumpy area displaying high level differences. At present, there are three branches of mining waste deposits, with angles of 15^0 between branches 1 and 2 and 40^0 between branches 2 and 3.

[1] *PhD student at the University of Petroşani, vitandorelpetrica@yahoo.com*
[2] *Professor Ph.D. at the University of Petroşani, nan.marins@gmail.com*
[3] *Ph.D. at the INSEMEX Petroşani, danutgrecea@gmail.com*
[4] *PhD student at the University of Petroşani,bogdan.vladu@yahoo.com*
[5] *Assistant Professor PhD at the University of Petroşani, vitan.daniel.cosmin@gmail.com*

The storage technology determined the formation of deposits in a single stage, whose geometrical parameters depend on the morphology of the ground's surface, on the elevations where the funicular is located and on the geotechnical characteristics of deposited rocks. During the unloading of the stuff from the transportation buckets, a certain granulometric selection occurs due to the movement of large granules at the basement of the deposit.

Bulldozer pushing and levelling determined the increase of the storage capacity of the sterile resulting in platforms located in various areas. The shape of the mining waste deposit is not regular. The active branch is branch no. 3, the other two being considered inactive and including an amount representing 800,890 m3 of stored mining waste. The height of the mining waste storage areas in the case of Branch 1 and Branch 2 is variable, ranging between 10 and 70 m, depending on the aspect of the ground level.

Fig. 1. The group of mining waste deposits at Lupeni / Branches 1 and 2

2. PHYSICAL, MECHANICAL AND PREPARATION CAPACITY CHARACTERISTICS OF MINING WASTE DEPOSITS IN THE MINING PERIMETER OF LUPENI

Researches and observations in the field showed that the sterile mass in the mining waste deposit is extremely complex including mixtures of loose rocks that are heterogeneous from a mineralogical, petrographic and granulometric point of view.

Macroscopically, the mixture of stored rocks appears as a mixture of rubble and rocks within a loamy grey mass, which, after burning, sometimes becomes grey-

reddish. The waste resulting from the technological flux of the former Preparation unit in Lupeni is a mixture of clay, shale clay, sand stone clay, coal shale, and fragments of coal. Waste burning is determined by the presence of the coal granules having reached the sterile as combustible mass losses, due to separation and concentration processes.

The slow infiltration of the water from precipitations determines the moistening of the rocks at the base of the deposit and sterile stored in its lower part and, implicitly, the decrease of their strength characteristics. Erosion phenomena, mainly located in the superficial areas where the mining waste deposit is formed, also occur.

The clays and the rock elements in the sterile deposits behave as a composite stuff displaying values of 13-30 Ohm (sometimes 100-1200 Ohm, in the case of a very dry stuff), while the rocks at the base attain values of 40-100 Ohm. This contrast is enough for separating the mining waste deposit from the initial ground. Meanwhile, sliding areas may display values between 19 and 25 Ohm, being separated from the rest of the mining waste deposit through zones exhibiting a high gradient of apparent resistivity isolations.

Several field and laboratory measurements showed that rocks and minerals are better individualized from a point of view of their resistivity rather than from the point of view of their density and propagation speed of elastic waves.

Granulometry as well as the main physical characteristics are displayed synthetically in Table no. 1.

Table 1. **Characteristics of the waste within the mining waste deposit at Branch 1 Lupeni**

Laboratory trials	**UM**	**Results**
Granulometry under 0.005 mm	%	3 – 9
0.005 – 0.05 mm	%	5 –29
0.05 – 2 mm	%	16 – 45
2 – 20 mm	%	8 – 50
+20 mm	%	25 – 60
Work humidity	%	5 – 18
Absolute specific weight	g/cm^3	2.01 – 2.65
Volumetric weight	g/cm^3	1.45 – 2.10

The largest share is detained by the gross granulometric fraction with particles higher than 20 mm (30 - 60 %)

In the case of the waste stored at Branch 1 Lupeni, class + 80 mm is mainly sterile, which makes possible an inverse picking for retrieving pieces of coal and breaking them.

The humidity of the stuff is pretty low, a fact that shows a good drainage of the waters through the deposit. The lower volumetric weights of certain samples may be correlated with a relatively high content of combustible mass, stores in those areas.

These primary data represent the calculation basis for tracing Henry – Reinhardt (HR) curves used for settling the main parameters and the theoretical preparation indices.

The shape of the curves confirms the presence, in large amounts, of associated granules, even in the case of a class + 40 mm breaking operation and, consequently, confirms a behaviour that makes preparation difficult; this behaviour may be improved owing to a higher mincing degree or to concentration along several technological stages, as in the case of gross coal preparation.

Choosing the technological concentration variant involves the financial resources available for such an investment, while considering the amount of coal that may be capitalized and the quality levels.

When considering direct production of a type energetically marketable, displaying a caloric power of 3600 kcal/kg, in the case of the mining waste deposit at Lupeni – Branch 1, HR curves show the data synthetized in Table no. 2.

Table 2. **General characteristics of coal**

Granulation [mm]	**Share [%]**	**Ashes [%]**	**Caloric power [Kcal/kg]**
+40	31.23	76.0	1220
-40	68.77	70.0	1440
Total or average	100.0	71.88	1370

These preliminary data show that it is possible to retrieve an energetic fuel whose calorific power is estimated at around 2100 – 2900 kcal/kg, while also considering the humidity content of a product displaying decreased granulometry and a high percentage of clayish stuff, finely dispersed on the surface of the coal and within the mass of the concentrate obtained.

3. STABILITY ISSUES OF THE MINING WASTE DEPOSIT AT LUPENI – BRANCH 1 AND THE NEED FOR ECOLOGICAL REHABILITATION

The morphology of the ground and the lithology of the covering formations determine local accumulations such as lakes, slops, and swamps in the area of the mining waste deposits at Branch 1 and 2.

Topographic maps displaying the morphology of the ground previous to the mining sterile deposits show the presence of lakes and slops within Boncii-Ferejele

hydrographical basin.

The formation of mining sterile deposits determined the accumulation of waters from the surface drainage into the various lakes located among the three mining sterile deposits; on two alignments directed towards the Western – Eastern part, in the Northern part of R2 mining waste deposit, a continual lake is shaped at present, which displays a surface of 2 ha and a water level bench mark of +804, with depths that probably surpass 3 m; a second lake is shaped behind R1 + R2 common body, exhibiting water level bench marks of +784m.

Between R1 and R2 there are a series of slops that represent about 1 ha, with depths of about 3 m.

Water accumulations are not being used. At present, local works are carried out for draining these water accumulations that decrease the stability of mining waste deposits through increasing water pressure within the pores of the stored stuff.

Water bench marks in these accumulations show the lack of an active hydraulic communication. It appears that the clay stuff clogged the pores of the stuff within the mining waste deposit and reduced the coefficient of hydraulic conductivity. Besides, the basic rock on which mining waste deposits are located does not host aquifers that are able to allow water drainage in depth. Local phreatic aquifers only appear in the deluvial stuff accumulated in discontinued areas. Such a situation determines improper conditions for the stability of mining waste deposits due to the high pressure of water in the pores of the stored stuff.

Fig. 2. Group of slops formed among the mining waste deposits

In the area of the mining waste deposits, there no captures for drinking or industrial water providing. The only hydro-technical works are carried out for:

a). The hydro-technical gallery that allows Boncii stream to undercross branches R1 and R2;

Fig. 3. Deteriorated hydro-technical gallery for sub-crossing Boncii Valley

b). Water drainage gutter from the lake in the Northern part of R2 mining waste deposit, towards the junction of Ferejele stream and Boncii stream.

Fig. 4. The lake formed in the Northern part of the mining waste deposit at Branch 2

Due to the deterioration of the hydro-technic system within the body of the mining waste deposit, a series of phenomena of suffusion occur, which represent a serious danger for the stability of the deposit.

Fig. 5. Dangerous phenomena appearing within the body of the mining waste deposit

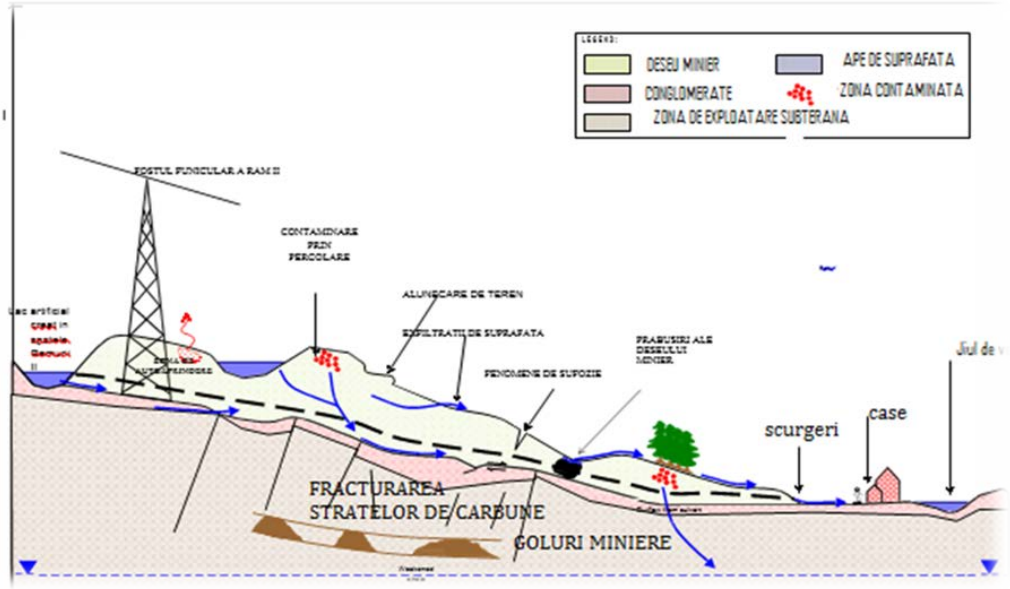

Fig. 6. Modelling of the flow of underground waters and of the transfer of contaminants within the analysed area (the perimeter of Lupeni)

With a view to get a general image of contamination in the area of the mining waste deposits, it was necessary to design the modelling of the flow of underground waters; such an enterprise allows the correct evaluation of the stability of the mining waste deposits and of the transfer of contaminants in the analysed area and towards its Southern part (the perimeter of Lupeni).

4. RETRIEVAL AND CAPITALIZATION OF THE USEFUL STUFF IN THE CASE OF R1 MINING WASTE DEPOSIT IN THE CONTEXT OF CIRCULAR ECONOMY

In the case we consider as acceptable the incomes estimated to be obtained from capitalizing the combustible mass within the mining waste deposit in Lupeni, we might also consider investments in the domain of coal retrieval from Lupeni mining waste deposit. Works of ecological rehabilitation of the area may be carried out through processing the sterile. The researches carried out show that the best solution for the ecological rehabilitation of the area is the replacement of the present hydro-technic system by open drainage channels that allow their maintenance and the obtaining of a large amount of water in case of important precipitations. Nonetheless, such works can only be done when the mining waste deposit will be restructured and the entire amount of the stored stuff is circulated.

Fig. 7. Spectrophotometric analysis of the mining waste stored at Branch 1

The designing of a mobile station would be required with a view to processing mining waste and its storage in accordance with ecological criteria that allow the

rehabilitation of the environment. A transportation alternative is the use of funicular buckets that still work at Branch 3.

Besides the activity of retrieving the combustible stuff (coal) from the mining waste deposit, other mineral substances may also be retrieved.

The analysed sterile stuff shows a high percentage of SiO_2 and Al_2O_3 and a relatively small amount of other macro elements.

CONCLUSIONS

The thorough researches carried out on the site where the mining waste deposits at Lupeni Branch 1 are located show that, besides the issues concerning environment protection, it is necessary to pay attention to ecological reconstruction and to the opportunities the retrieval and capitalizing of the useful mineral substances may offer.

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