RESEARCH ON THE POSSIBILITY OF THE DEVELOPMENT AND WATER FILLING OF THE REMAINING HOLE OF URDARI OPEN PIT

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Abstract:

The restructuring process of the mining sector in Romania, started in the mid '90, involved closing or moving into conservation of some mining objectives, either because of depletion of their reserves or due to their economic non viability.

In the Oltenia mining basin several coal pits were closed, without taking redevelopment measures for being reintroduced in the economic cycle or being reintegrated in the natural environment.

The present paper work proposes to analyze the design of such works, more precisely the water filling of the remaining hole of Urdari open pit, by presenting the results of a study carried out in terms of creating a stable configuration of the future lake.

These studies refer to: ensuring the stability of the open pit's slopes, remodeling them, determining the volume of material to be conveyed and determining the volume of water required for raising the lake's level from the current elevation to a projected one.

Opportunities that arise from applying this method of ecological rehabilitation are related to the reintegration of Urdari open pit in the natural environment, ensuring the conditions for biodiversity development in the area and the increase of the terrain value.

Keywords: stability, rehabilitation, remaining hole, water filling

1. Characterization of the studied area in order to establish the reuse variant

Exploitation area of Urdari open pit is located in the southern part of Rovinari coal basin, village Urdari, Gorj county, 40 km south of Tg. Jiu municipality, respectively 15 km west of Țicleni town, in the hilly area west of the Jiu river and was defined as follows:

- north: the area reintroduced in the forestry circuit on the left side of Mănăstirii Valley (Monastery Valley), near the operation perimeter of Urdari mine;
- south: by Graurului Valley (Starling's Valley);
- east: by Urdari locality and county road DJ 674;
- west: a hilly area with very rugged terrain.

To highlight the climate of the area were analyzed and interpreted values of meteorological parameters taken from the closest weather stations, namely Tg. Jiu and Apa Neagră (Black Water).

The monthly averages of air temperature at the two meteorological stations in the studied area shows that the coldest month of the year is January (average temperature is -2.5°C at both meteorological stations). The hottest month is July (average values between 20.6°C - 21.4°C).

It should be noted that the average temperatures in December are positive, and the mean annual temperature ranges between 9.7°C and 10.6°C.

Generally the highest monthly precipitation amounts are recorded in the months from late spring or early summer (May and June) or autumn, in October, and the annual average rainfall is 762.81 l/m^2.

Predominant vegetation in the area of Urdari open pit is the specific to the hilly area of Oltenia and includes deciduous forests. As tree species present in the area are mentioned beech (Fagus silvatica), evergreen oak (Qurcus petraea, Quercus dalechampii, Qurcus polycarpa) penduculat oak (Quercus robur), sky (Quercus cerris) and flasks (Quercus frainetto).

Forest areas alternate with meadows and farmlands. Representative crops in the area are corn, grasses, potatoes, etc. On small areas there are orchards and vine plantations.

Remaining holes of former open pits can be filled with water, thus taking different functions, from the industrial ones to recreation, or they can be used for storing industrial or household waste.

Several ways to redevelop the remaining holes can be identified:

- *ponds for fish farming;*
- *ponds for water retention and storage;*
- *ponds for industrial water and irrigations;*
- *lakes for recreational purposes;*
- *landfills.* [3]

From the possible reuse options for remaining holes, naturalistic rehabilitation is chosen by forming a natural lake, which is within the area's landscape, by raising the water level from the current elevation of 157.3 m to 162 m, remodeling the open pit through slope stabilization, covering

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the operating platforms with topsoil, and planting vegetation specific to the ecosystem.

Since the open pit is surrounded by woods, for future lake shores forestry recultivation was chosen, which is less costly and has beneficial results. The species that are recommended for this kind of work in the area where is located the remaining hole is acacia.

2. The current situation of the remaining hole of Urdari open pit

The remaining hole is located in the exploitation area of Urdari open pit (fig. 1 and 2) in the southern part of Rovinari coal basin.

It is defined as follows:

- north: the open pit's internal waste dump;
- south: Poduri Valley and Bujorului Glade (Bridges Valley and Peony's Glade);
- east: Săscuia Valley;
- west: a hilly area with very rugged terrain.

The remaining hole covers about 14 hectares and the base is located between the elevations 145 to 152 m. It has a length of 950 m, a width of 220 m and the depth is between 13 to 16 m. [4]

Fig. 1 *Urdari open pit (satelite image)*

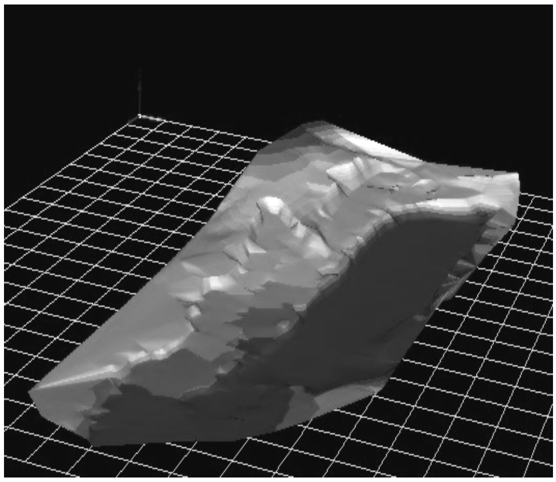

Fig. 2 *Urdari open pit (3D model seen from the east side)*

Analyzing the current situation in the field, the main categories of deformation are the erosion and shallow and/or profound landslides on the final slopes of the open pit.

Erosions are represented by ravines and actual erosion. Ravines appear on the western and south western slopes and are caused by the absence of a drainage system for runoff water. Shallow landslides are present on the southern lower slope, and the profound ones are found on the second step whose height is 40 m and slope angle exceeds 50°.

Marginal slope stability is one of the major problems in the rehabilitation of the remaining hole. Stability analysis for the remaining hole's slopes of Urdari open pit was performed using the specialized geotechnical software Slope. Values used in stability analysis for volumetric weight, cohesion and internal friction angle are presented in table 1.

Table 1. *Physico-mechanical characteristics used in the stability analysis*

Type of rock	Volumetric weight γ_{nat}, (kN/m^3)	Cohesion c, (kN/m^2)	Internal friction angle φ (grade)
Mixture of rocks from the open pit's slopes	18,98	19,80	17,00

Taking into account the geometric configuration of the open pit and nature of rocks, a stability analysis was performed considering that the slip occurs most likely after circular contour surfaces. For determining the stability reserve the slopes geometry was reproduced the mentioned software, the stability coefficient being calculated for each slope taken into account. The stability analysis did not take into account the pore water pressure, because the material is granular and has a high permeability which allows the possibility of a rapid gravitational drainage and after the filling of the remaining hole with water to the projected height, the pressure generated by the lake on the slopes increases the normal unit effort and thus increases the friction on the sliding surface.

Stability analysis was performed using three of the most popular computational methods, namely the methods of Fellenius, Bishop respectively Janbu and had analyzed slopes with heights between 20.21 and 40 meters with slope angles between 43 and 53 degrees, located on the southern and western sides.

Three sections were analyzed (two cross sections and one longitudinal section), made on the original plan of situation, namely the upper and the lower slopes.

Stability analyses results revealed that for one of the cross sections the stability coefficient has a subunit value (0.66 respectively 0.86 after Fellenius) meaning that both the upper and lower slopes are unstable. [1]

For the other sections analyzed the stability coefficient has values higher than one, values which lie just above 1.3 (after Janbu), recommended by the technical requirements for design, construction and preservation of the final pit slopes.

In figures 3 and 4 are presented the analyzed profiles and the critical slip surfaces (for which the values of the stability coefficient are below one after Fellenius), for the lower and upper slopes of one of the cross sections.

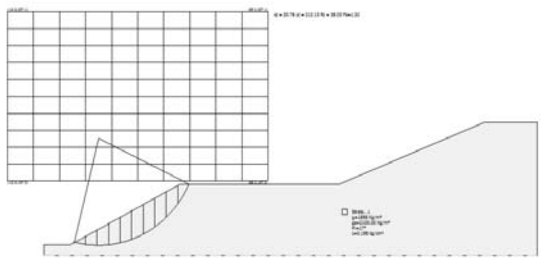

Fig. 3 *Cross section, the lower slope*

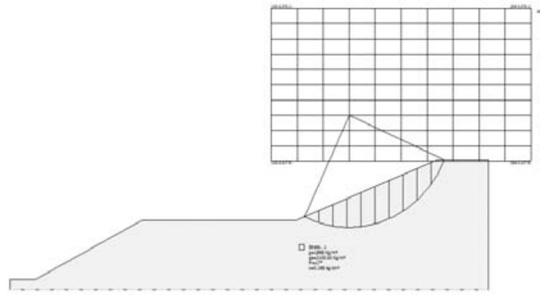

Fig. 4 *Cross section, the upper slope*

3. The design of the development works for the remaining hole

Reshaping the steps (figure 5) to increase the stability reserve and ensure the necessary conditions for the particular type of rearrangement, namely naturalistic recovery, will be made by both known methods from top to bottom and from bottom up.

For Urdari open pit the method from top to bottom will be used for the upper slope and for the lower slope which is in contact with the existing lake the bottom up method, involving the excavation and movement of material from the bottom of the slope to its top.

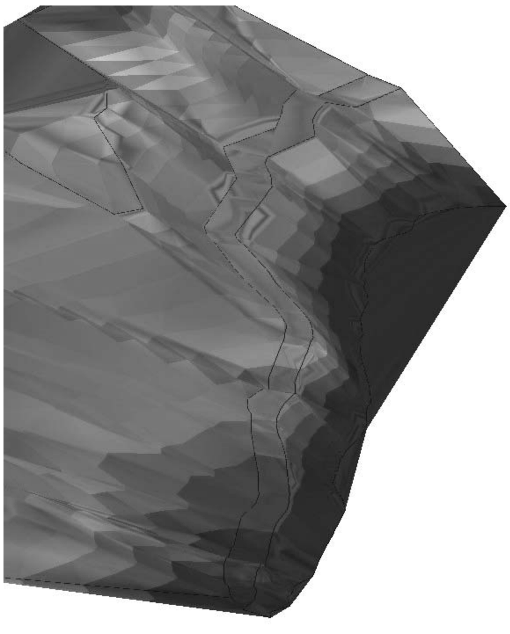

Fig. 5 *Reshaping the soutern side (wiew from the eastern side)*

Reshaping is required especially for the southern slopes of the cross section for which the values of the stability coefficient were below one.

After completion of the reshaping works, a new stability analysis was made (figure 6) for the general slope thus formed.

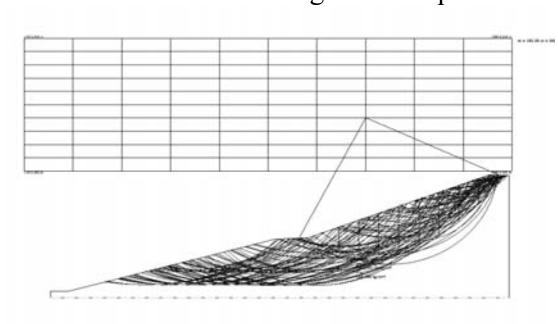

Fig. 6 *Cross section, general slope after reshape*

Stability coefficient values obtained after completion of the reshape works indicate a considerable increase from under one to 1.37 (after Janbu). This value is above 1.3 recommended by current standards, which means ensuring a sufficient stability reserve to allow a safe continuation of rearrangement works.

Reshaping works involves the movement of large volumes of material in order to achieve the projected slopes geometry (volumes of material resulting from excavation and refilling works).

The total volume of material for accomplishing the designed reshaping works is 417,593.47 m^3 (figures 7 and 8) of which 40,281.42 m^3 refilling material on the right half of the southern side of the open pit. For moving a volume (V1) of 278,396 m^3 from the total of 417,593.47 m^3 bulldozers will be used, and for the rest of 139,197.47 m^3 excavators. Bulldozers will be used for top to bottom method and excavators will be used for bottom to top method, for reshaping the lower slope in contact with water. [1]

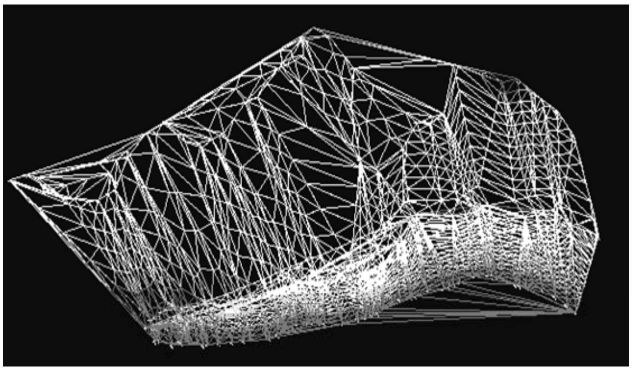

Fig. 7 *Prisms generated for calculation of the total reshaping volume*

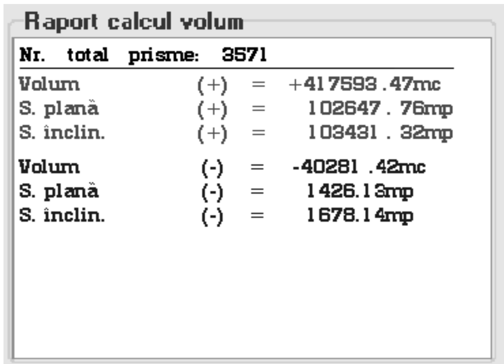

Fig. 8 *The total reshaping volume of material*

Because the type of rearrangement chosen involves the increase of the water level from the lake, from the current level of 157.3 to 162 m is necessary to elevate the eastern bank.

As a result it was calculated the volume of material necessary to build a superelavation dam on the eastern bank from 164 to 170 m, resulting a total volume of 381,453.27 m^3 of material required (figure 9).

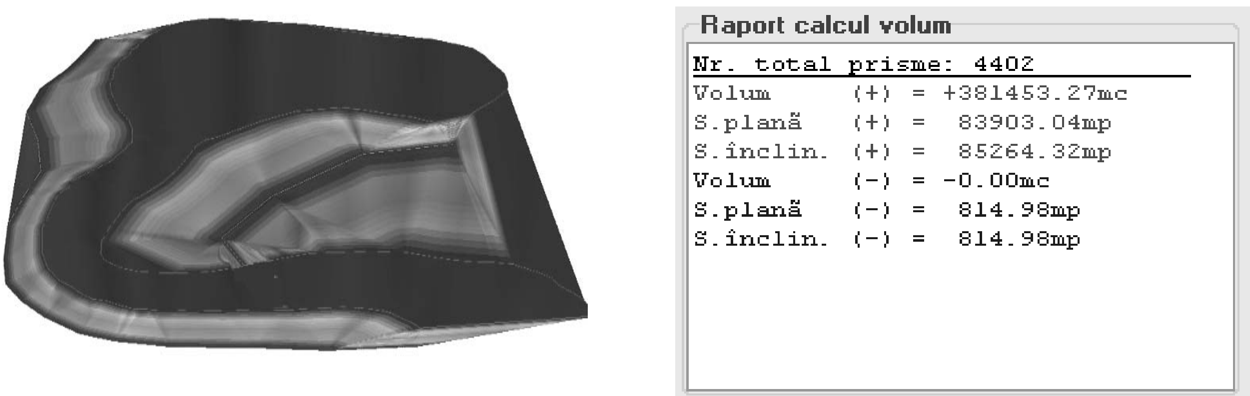

Fig. 9 *Calculating the volume of material from the superelevation dam*

Correlating the two volumes, for the dam construction and the one from the reshaping works, it can be observed that if we decrease from the total volume of material from reshaping works the volume of material needed for refilling works, the remaining volume of material is fairly similar to the one necessary for the dam construction. The remaining material, 4141.22 m^3, will be deposited on the top step of the interior waste dump (on the north side).

This can be seen as an advantage in designing the redevelopment works for degraded terrains by the fact that the material is not transported over long distances, for construction of projected elements or to be stored (if surplus material results from reshaping works), thus eliminating the problem of occupancy of new areas of natural tarrain.

4. Water filling of the remaining hole

The water filling of the remaining hole aims to increase the level of the existing lake from 157.3 m to a projected level of 162 m. To provide the necessary conditions to achieve the projected level it was proposed the construction of a dam on the eastern side, which leads to an elevation of the terrain from 164 m to 170 m.

Because there is no permanent water course near the open pit, and costs to build a feed pipe are very high, to ensure the volume of water required to raise the water level up to 162 m, respectively 316,294.76 m^3 (Figure 10) it was chosen to fill the remaining hole in a natural way (by intake of water from rainfall).

For this purpose it was considered as retention surface only the surface of the new formed lake (at 162 m) without considering the contribution of runoff water from the surrounding slopes. Also in the calculations evapotranspiration and infiltration were taken into account.

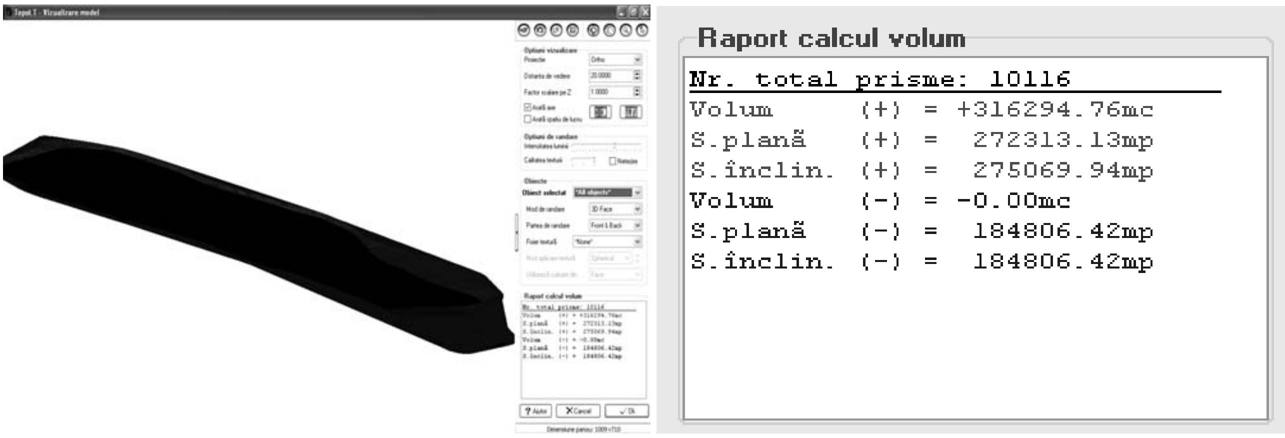

Fig. 10 *Volume of water required to increase the lake's level from 157.3 to 162 m*

The total retention area calculated is about 140,000 m^2, which means that for an annual average effectively rainfall of 377 l/m^2 requires approx. 6 years to achieve the projected water level by filling the remaining hole in a natural way.

According to analysis, water quality is in the second category, suitable for instalation of flora and fauna characteristic to the bioclimatic floor.

Reshaping volumes, the dam volume and the required volume of water were calculated using the specialized software Topo LT.

The designed works and the configuration of the area can be seen on the situation plan in fig. 11.

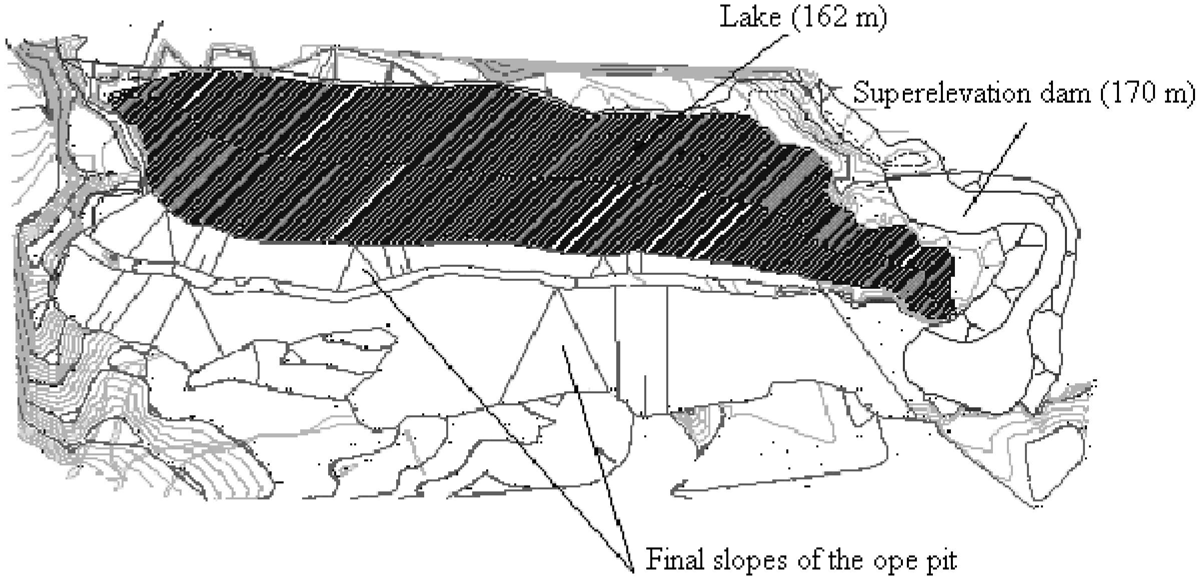

Fig. 11. *Urdari open pit situation plan after redevelopment*

5. Conclusions

The reconstruction of areas affected by mining in Oltenia, beside being an obligation of the current legislation, is a necessity given the large areas of land affected in this region.

The case study presented in this paper considered an advantageous type of redevelopment and rehabilitation (ecologicaly and economicaly) for the remanining hole of Urdari open pit, namely its reintegration into the natural environment.

Thus, by reshaping the final slopes a reserve of stabiliyi in acordance with the current requirements is ensured and the construction of the superelevatin dam ensures the conditions necessary for incaresing the water level from the lake formed in the remaining hole up to 162 m.

The redevelopment works were designed so that the excess material resulting from reshaping works to be fully used for the construction of the superelevation dam, thus avoiding the occupancy of new areas of natural terrain necessary for storage of this material. The additional volum of material needed for the construction of the dam is minimal, this volume will be deposited in the interior waste dump (minimum costs of transportation).

By creating a lake with naturalistic functions in the remaining hole, the impact generated by the emergence of a negative landform in the area is almost completely eliminated on one had, and on the other an aquatic habitate is created that contribute to improving the biodiversity.

Populating the lake with local species of fish (characteristic to the bioclimatic floor) is able to atract species of birds, which contributes to the development of a new ecosystem in the area of a higher quality then the one currently existing. The reforestation of adjacent areas will help to repopulate the area with characteristic fauna species, ensuring an even grater improvement of biodiversity.

By transforming an area heavily affected by mining, characterized by anthropogenic landforms (excessive geometrization of slopes of the open pit and internal waste dump), in an area that fits easily in the natural environment is able to increase terrain valu, providing multiple opportunies for its future use.

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