LANDFILL CAPACITY ASSESMENT AT WASTE DUMP VALEA ARSULUI - VULCAN COLLIERY

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ABSTRACT: *Vulcan is one of the few active remaining collieries from Jiu Valley, in the Meridional Carpathian Mountains. The paper deals with the stages involved in the process of computerized design in order to evaluate the remaining discharge capacity and the various over passed obstacles in order to gain all the necessary information available from different sources. The solutions of the problem conclude the paper.*

KEYWORDS: subsidence modeling, heap capacity assessment, mining waste dump, Jiu Valley colliery

INTRODUCTION

In 1989, the hard coal production exceeded eight mil. tons and over 60000 people were involved in this mining sector. Since 1997 the Romanian mining industry confronted with a massive restructuring process and as result many collieries from Jiu Valley (Dâlja, Aninoasa, Petrila Sud, Lonea Pilier, Valea de Brazi, Bărbăteni) was closed or are in closing procedure (Petrila, Paroseni, Uricani).

Vulcan is one of the few active remaining collieries from Jiu Valley, a hard coal mining basin located in south west of Romania, in the Meridional Carpathians Mountains.

The Vulcan colliery is situated in the central part of Jiu Valley hard coal mining basin. Currently, the mining activities in the Jiu Valley are carried out under the coordination of "Societatea Naţionala de Închideri Mine Valea Jiului" within the mining perimeters of Petrila, Paroşeni and Uricani and under the coordination of the entity known as "Complexul Energetic Hunedoara S.A", created by the unification of several commercial entities, namely "Electrocentrala Deva S.A.", "Electrocentrala Paroşeni S.A." and "Societatea Naţională a Huilei S.A."; with purpose of electricity production using hard coal sourced from the mining perimeters Lonea, Livezeni, Vulcan and Lupeni, (fig.1). (CEH Portal, 2014; SNIMVJ Portal, 2014).

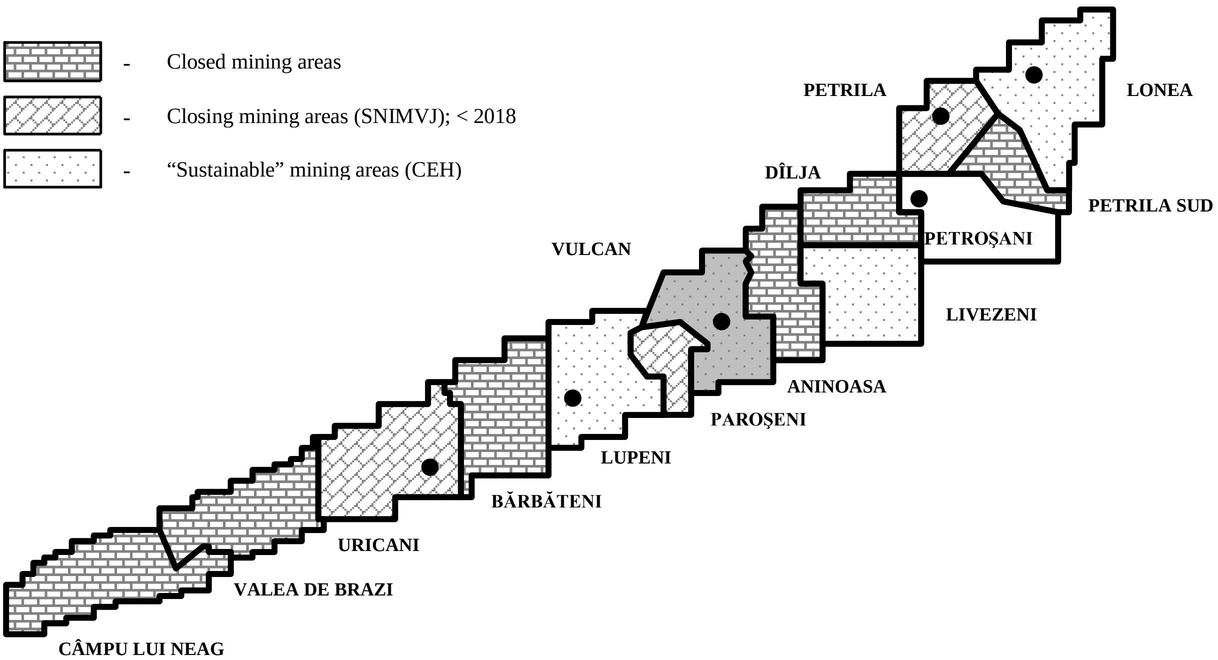

Fig.1. Location of Vulcan colliery in Jiu Valley hard coal basin

The Valea Arsului landfill location is in the valley of the Arsului creek, in the northern side of Vulcan town (fig.2). The inclination of eastern and western slopes of the valley in cross section is between 7 and 18^0. The inclination of the valley bottom in the heap area is about 5^o (Florea et al., 2014).

Fig. 2. Location of Valea Arsului landfill -Vulcan colliery

First studies on subsidence phenomenon occurred in Valea Arsului was conduct in 1981 and it can be seen the Arsului creek water accumulation in the subsidence trough (fig.3).

Fig. 3. Small lake generate by Arsului creek water accumulation in the subsidence trough - 1981

After the occurrence of water accumulation in Valea Arsului, this small lake migrated to the south along the valley axes, following the subsidence phenomenon due to underground coal extraction, with an average rate of approx. 10 m/year.

Landfill activity started here at late ‘90s. The rocks from the dump consist of rocks that occur in the productive horizon, i.e. clay, marl, sandstone, argillaceous sandstone and carbonaceous shale with different degree of granulometry and alteration (Pop, 1993; Lazăr et al., 2005). The granulometric composition of the stored material is very different; from millimeters to tens of centimeters.

SUBSIDENCE ASSESMENT

Modeling was necessary because the subsidence phenomenon was not monitored and the actual shape and position of base terrain was unknown. The shape and size of trough diving were assessed using analytical methods (Dima et al.,1996), according to the geological particularities of the coal deposit (dip and dept of coal seam).

In case of horizontal or low dip seam deposit ($\alpha \leq 25°$) the maximum sinking is represented by a symmetrical curve but in the case of average or large dip seam deposit ($\alpha > 25°$) the sinking curve is an asymmetric one (fig.4).

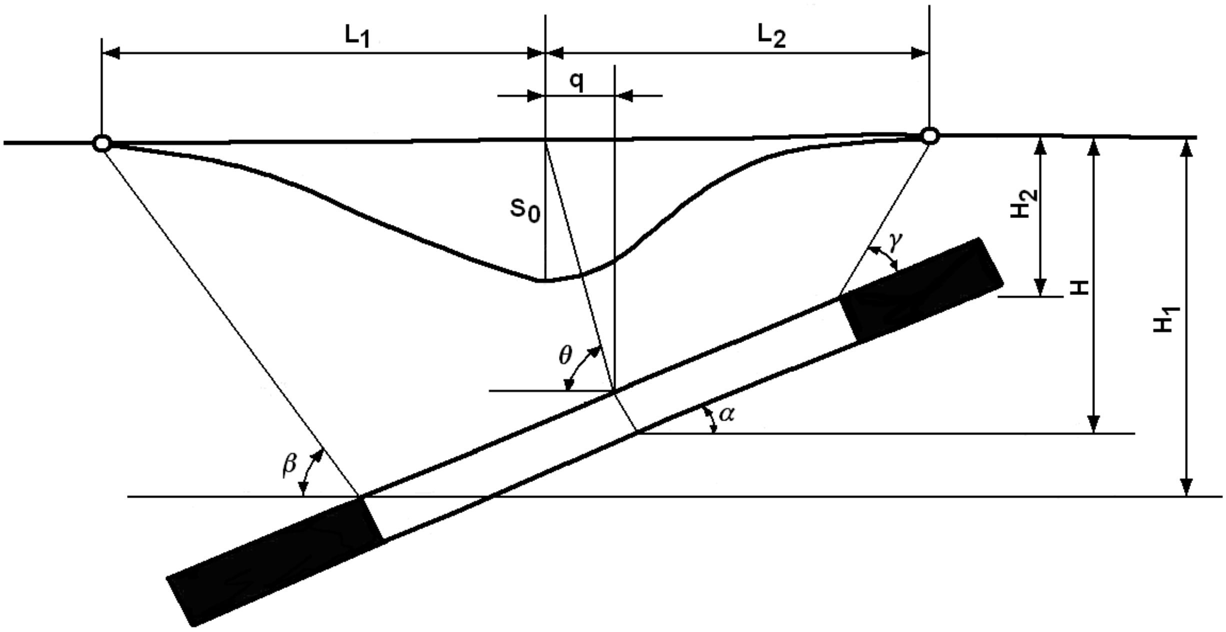

Fig. 4. The trough diving generated at extraction of a dip seam deposit

Displacement **q** from symmetry can be calculated using the equation:

$$q = \frac{H}{tg(90° - 0{,}15 \cdot \alpha)} \qquad (1)$$

where:

- $H = \frac{H_1 + H_2}{2}$ is the average depth between the minimum and maximum depth of exploitation and

- ***α*** is the dip angle of exploited seam.

In this case H_1 = 294 m; H_2 = 41 m; α = 39°

For the Valea Arsului condition we have he average depth of exploitation H = 167.5 m and the displacement from symmetry q = 17.16 m

The value of the maximum sinking can be calculated using the equation:

$$S_0 = a \cdot m \cdot f \cdot z \qquad (2)$$

where:

a – is the sinking factor (for pressure routing methods through total collapse a=0.85);

m – seam thickness;

f – superficiality factor;

z – time factor (if the movement not yet stopped z=1)

For the Valea Arsului condition we have the maximum sinking value S_0 = 23.8m and the location of maximum sinking point at middle distance between pillar 15 and 16 of electric power grid. The lateral limits of the subsidence trough are visible on the eastern and western slopes that borders the heap (fig.5, 6).

Fig. 5. Breaking phenomenon caused by sinking of the land on the slope from eastern part of the heap

Fig. 6. Breaking phenomenon caused by sinking of the land on the slope from western part of the heap

Based on subsidence phenomenon assessment, we proceeded to current land surface modeling under the heap Valea Arsului.

SURFACE MODELING

As starting point we had an aerial survey from 1981 (fig.7) which was made before landfill process started and the sinking phenomenon was in an early stage.

In the first stage, we digitized the level curves from this aerial survey (fig.8 - left). In the second stage, we applied correction to this level curves, taking into account the results of the sinking assessment and then we generate the digital terrain model (fig. 8 - right).

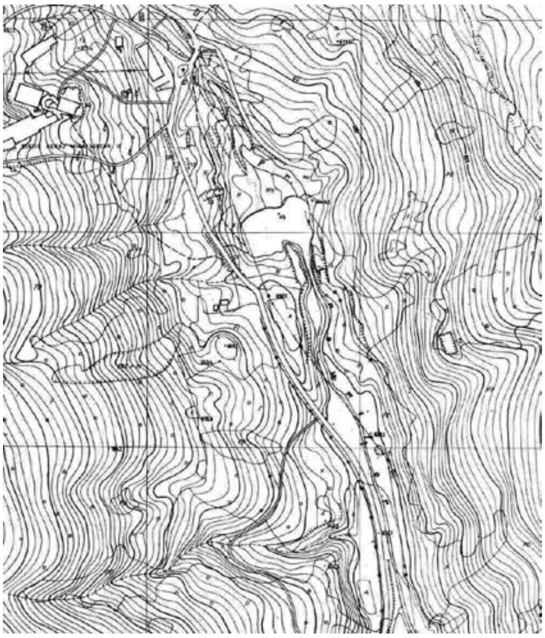

Fig. 7. Aerial survey made in 1981 in Valea Arsului

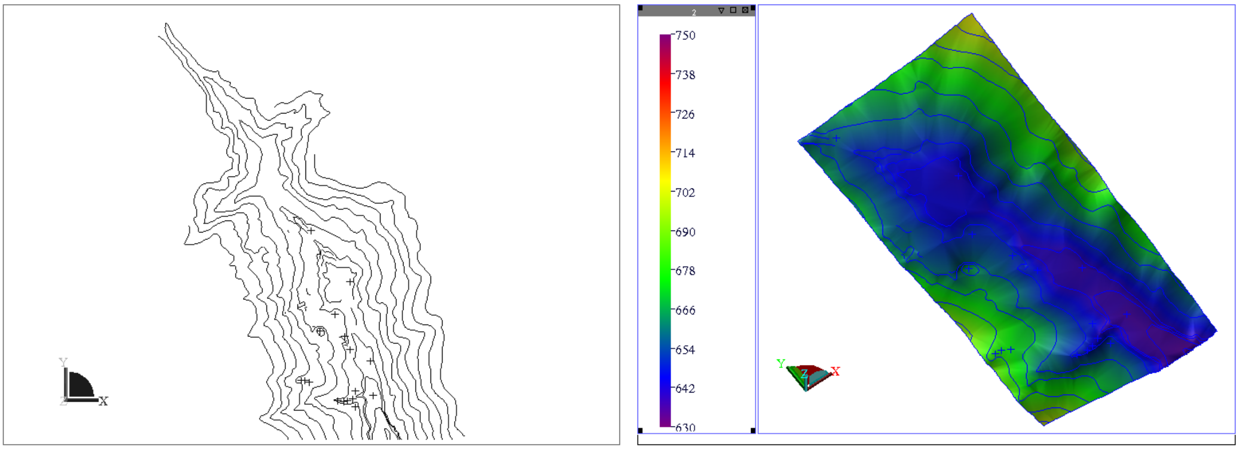

Fig. 8. Digitized level curves from aerial survey made in 1981 in Valea Arsului (left) and digital terrain model of Valea Arsului with sinking phenomenon (right)

RESIZING AND DESIGN OF THE GEOMETRIC ELEMENTS OF THE HEAP

Given the stability analysis results and the consequences of a possible landslide, it is necessary to resize the geometric elements of the heap, so to have a minimum 30% stability reserve, even under the most unfavorable geotechnical conditions.To establish the geometric elements of the heap under slope stability conditions, can be used different graphic-analytical methods as E. Hoek, which proved its valability in many cases, including fot the many heaps in the Jiu Valley (Băncilă I., 1981; Florea M. N., 1979).

The method use a graphic to find the adequately value for the slope angle, depending on the slope height and on the geo-mechanical characteristics of the rocks. The obtained results of calculations are presented in the following table.

TABLE 1 *Resizing of the geometric elements*

H, [m]	φ, [grads]	
	S =	
	1.3	**1,5**
5	56	47
10	41.5	35
15	34	29
20	30.5	26
25	28	24
30	26.5	22

After resizing calculation results that to have a geometry that satisfies the requirements of stability, even in the presence of water in the heap body and/or in the case of the occurrence of seismic shocks, it is preferable to construct and maintain the height of the slope of 10 m and a maximum slope angle of 30^o.

For a total heap height of 30 m, the general slope angle is recommended to be 22^o. Therefore, it is proposed to construct the heap in three benches by providing a protective berm of 5 m by Valea Arsului side (fig.9). Heap geometry control, subsidence and displacements caused by direct ground land deformations will be done through the monitoring with topographic landmarks. Landmarks position, number and distance between them are determined by the geologist and surveyor from field observations.

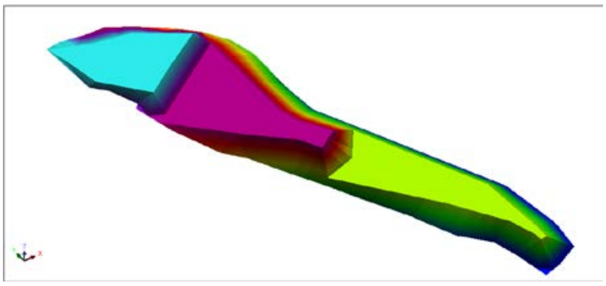

Fig. 9. Final geometry of the Valea Arsului heap

The land sinking phenomenon generated by underground exploitation of coal seam no.3 lead to a water accumulation on the southern part of the heaping area. For its removal is recommended to deposit in this area about 10,000 m^3 of sterile in order to counterbalance the sinking phenomenon and the expansion of the land perimeter towards south, both in the 4,800 m^2 area which is already affected by sinking and in the area which will be further affected by this phenomenon. Therefore the heap lower bench could be expanded which will allow the storage in the Valea Arsului heap of an additional quantity of 120,000 m^3 compared to the already stored quantity (fig. 10).

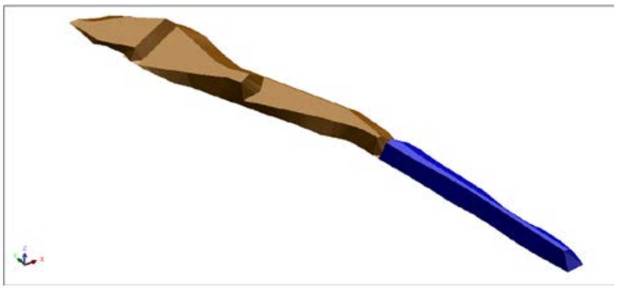

Fig. 10. Final geometry of the heap with the expanded perimeter towards south (blue body)

CONCLUSIONS:

In order to proceed with stability analysis was necessary to create a model of the heap Valea Arsului - Vulcan colliery. The main challenge was to create an actual model of the base surface affected by the subsidence phenomenon due to underground coal extraction because of lack of information and the location of this surface beneath the waste dump body.

We used as starting point an aerial survey made in 1981, before landfill process begun and the surface sinking process was in an incipient stage and we assessed the sinking process in the area, according to the specific geological and mining conditions.

After digitizing the level contours from 1981 and applying the results of surface sinking assessment, we generate the digital terrain model of actual position of the base surface.

Based on survey data from 2013 we generate the model of waste dump Valea Arsului. In order to evaluate the quality of the model, we made an estimation of waste dump volume. We compared this value with the total landfill volume from the Vulcan colliery records and the difference was below 5%. In conclusion, we assumed that the model is right and we use it for stability analysis.

Any model could be improved because, as stated the famous statistician George E.P. Box in 1987, “all models are wrong, but some are useful”.

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