THE SITUATION OF DUMPS AND DEGRADED LANDS OF BERBEŞTI MINING BASIN

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Abstract: *In the Berbeşti mining basin was a continues concern of land reclamation into the economic circuit which were used as sterile dumps. The reclamation works executed, generally have achieved the goal for which they were executed, except for some small areas. The land which inclination prevents the achievement of mechanized agriculture and which are prone to erosion or landslides have been reused, so far being successfully planted Acacia species only.*
Key words: *dumping, stability, accumulated material, cohesion, passive resistance.*

1. Introduction

Berbeşti mining basin is located in the structural unit of Dacian Depression, in the extreme East of the Oltenia lignite deposit. Of the four coal pits with technology of excavation, transport and dumping in continuous flow, Ruget, Oltet, Berbeşti and Panga in over 30 years of activity were exploited 85 million tonnes of coal that have necessitated a stripping of 513 million m^3 sterile [7].

2. Dumping of sterile rocks

Sterile rocks belonging to the Pliocenului and Quaternary, heterogeneous and with wide particle size, resulting from ripping of useful minerals, are transported and stored in dumps. At all the coal pits in the basin, in the opening phase but also in the exploitation phase of ore at great depths, were used the outer dumps which were located in lowland areas or on slopes with gradients of less than 15 °, aiming to use degraded lands or less productive [5].

Only when the situation required it, were affected lands with a high agricultural potential, such as those located in Olteț meadow (Jigăi dump), or partly in the Tărâiei meadow (for outer dumps Panga North and Panga South) which are located on very little horizontal land or inclined. The transport distance of rocks over 7 km away, as is the case of outer dump of Oltet coal pit, where for excavation, transport and dumping of sterile is used a specific electricity consumption of more than 4,5 kW/m³, and the need for additional occupation of large areas of land, leading to the conclusion that these are uneconomic, but absolutely necessary to ensure the transition to the dumping conditions within this coal pit.

The inner dumps are most economical, due to short circuits transport of sterile and the use of land already affected by the extraction of coal pit activities. It is ensured the maximum productivity and is the simplest of the organizational point of view. The dumping should provide a number of requirements needed for the effective activities namely: storage of the entire volume of sterile excavated, complete security of work for staff, equipment and surrounding attractions, low costs, high productivity, etc. [6]

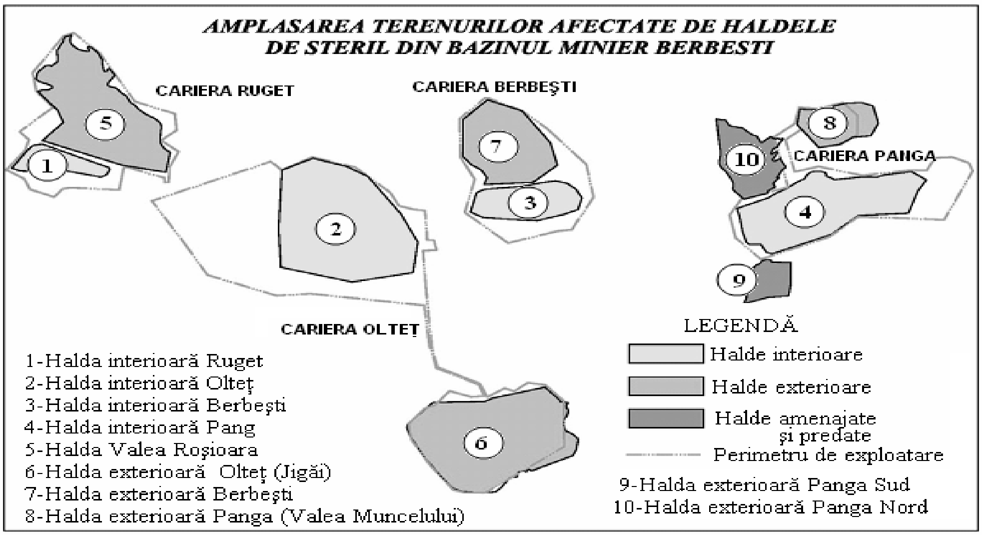

Figure 1 *Location of sterile dumps from Berbeşti mining basin*

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3. Location of sterile dumps

Every coal pit from the mining basin have used one or more external dumps and open up to the possibilities of creating the dumping possibilities within them. Location of the dumps from the Berbeşti mining basin is shown in Fig. 1.

It will be made a brief presentation of dumps, from West to East, highlighting in particular the areas showing the importance of reclamation in the economic circuit, volume and geometric elements.

Valea Roşioara outer dump is located in the vicinity of Ruget coal pit, in the northern part of it in a valley area, which name it bears. External dump is built in five benches, with maximum heights of 15 m, jointed with the natural terrain on the right slope of the valley, to the final rate of + 470m, the height of it dropping to 40 m in the final results of the eastern area located in the middle of the valley. In general, the designed geometry have been breached, the slopes (1:2), equivalent to a slope angle $\alpha = 26$ °, and a width of at least 90 m, and the front berm also has a height of 15 m. The amount deposited in the landfill is 82 million m3 and the area of occupied land and not given to the economic circuit is 217 ha.

Ruget inner dump is located in the vicinity of the coal pit, being at present actually assisted in the final slope of the coal pit, as can be seen in Figure 2. Due to the height of the front bench of the dump of over 35 m , the rock flow software [2]. The storage ability of the Ruget inner dump is over 30 million m^3 and the further inside dumping works is possible either by exploiting the Bustuchin perimeter either in the North Oltet expanded perimeter. The surface of the land reclamation of Ruget inner dump is 56 hectares.

Figure 2. *Sterile dumping in the inner dump of Ruget coal pit assisted in the final slope*

Exterior dump of Olteț coal pit (Jigăi dump) is located at a distance of 7 km South-East from the coal pit, in the area of confluence of the Oltet river and Tărâia. Choice of location from a so far distance, was conditioned by the fact that there is a high density construction near the coal pit and expropriation thereof would have produced an impact too heavily on the local community. Being the greatest distance transportation from the Mining Division Branch, plus the great share of sterile posted in the exterior dump vs. inner dump, the specific electricity consumption exceeds 4,5 kW/m^3 excavation sterile, loaded, transported and stored in the exterior dump, representing the great disadvantage with direct implications for the price of production.

Morphological point of view, the dump is located on a relatively level plateau (lowland area), made up of the alluvial deposits that are part of the lower terrace of the Oltet river.

The volume of sterile dumped into the outer dump is 101 million m^3 in an area of 250 hectares, and to the finish of dumping the total volume put away will be 140 million m^3, occupying a total area of 303,5 hectares.

Olteț inner dump is located in the northern part of Oltet coal pit, with the shape and dimensions of the coal pit's floor. From tectonic point of view takes the form of a system of steps with the E-W direction and tilt N-S between 4°-5°, although it is made up of one, maximum two, Figure 3.

The volume of sterile deposited in inner dump on 01 January 2012 is 47.5 million m^3 on an area of 200 hectares, and the exploitation of coal in the total volume of stored will be 210 million m^3, occupying a total area of 490,5 ha.

Berbeşti outer dump is located on the West, Northwest side of the Berbeşti coal pit and is geographically located within the Berbeşti and Alunu localities. Its foundation is made up of weak cohesive rocks arranged in a slope that tilts East-West with 6-8 °, over which the waste rock has been made from E-2 and E-01 excavators located on the 1st and 2nd bench of the coal pit. The surface of the outer dump is 127 hectares and contains a volume of 64.3 million m^3, and upon completion of filing, its surface will be 139 hectares, with a total volume of sterile storage of 68,5 million m^3.

Berbeşti inner dump is located in the northern part of the coal pit, having a horizontal footprint identical to the excavations carried out by the excavator situated on the floor of the coal pit. Has a stable foundation of grey clays with coal inclusions, with a slope of 4-5 ° from North to South. The occupied area is 129 ha and the amount deposited is 46 million m^3. The depletion of the reserve, the total area of inner dump will be 188 hectares with a total volume of deposited sterile of 76.8 million m^3.

Outer dumps from Panga coal pit, in number three, have been used successively in order of presentation, from opening until the achievement of a sufficient space in inner dump, for putting away all of the remaining excavated volume from the coal reserve. These conditions were created in 2009, a year in which it was brought into the inner the A-01 dumper and its associated transport circuit. Panga South outer dump, with an area of 46 hectares and a volume of sterile of 18 million m³ and the North outer dump, with an area of 92 hectares and a volume of 52 million m³, have a common feature in terms of the nature of the land, being located on hillsides located on the left side of the Tărâiadownstream, upstream, respectively. Both dumps have been reclaimed in the economic circuit and given to the local communities, Figure 4.

Figure 3. *Olteț inner dump*

Figure 4.*Wheat crop from the reclaimed land of Panga South dump*

Figure 5. *Crops of wheat, maze and alfalfa on the West slope of Panga inner dump*

Muncelului Valley outer dump is located in the north-eastern part of Panga coal pit within Mateeşti and Berbeşti localities. The occupied land is 95 ha and the sterile volume of 44.2 million m³ is dumped in a relatively flat valley lying between two hillsides that is coming to the South, has facilitated the construction of a stable deposit. With the completion of sterile dumping, in 2009, have begun the forestry works for re-use.

Panga inner dump is located to the left of Tărâia brook and is bordered in the South by the end slope of the coal pit and to the North of the outcrop of coal layer I. At the present time, the 53,5 million m³of sterile occupies an area of 99.5 hectares, at the completion of the work, the area of occupied land will reach 171 hectares and the volume of sterile deposited at 95.5 million m³. Still in construction phase of dump, after the release of technological tasks of land located on the West end, the slope was re-shaped and arranged for reclamation in the agricultural circuit, being handed over to the local community, figure 5.

In table 1 is given the situation in the occupied areas and the volumes of stored sterile in every dump in the present day and at the completion of dumping works.

Table 1. *Current situation of sterile dumps from the basin and from the copletion of works*

Coal pit	**Dump**	**Ocuppied area [ha]**		**Volume of dump [mil.m³]**		**Current situation**
		Current	Final	Current	final	
Olteț	Inner dump	198	490,5	47.5	210	Under construction
	Outer dump	248	303,5	101	140	Under construction
Berbeşti	Inner dump	129	188	21.1	76,8	Under construction
	Outer dump	127	139	64,3	68,5	Under construction
Panga	Inner dump	99,5	171	53.5	95,5	Under construction
	Panga North dump	92	92	52.0	52.0	Restore
	Panga South dump	46	46	18.0	18.0	Restore
	Valea Muncel dump	95	95	44.3	44.3	Partial restore
Ruget	Inner dump	15	56	29,9	50	Under construction
	Outer dump	240,5	240,5	82	82	Partial restore
Total Berbeşti basin		**1290**	**1821.5**	**513.6**	**837.1**	

The stored volumes in dumps of the tens of millions of cubic meters, or more than 100 million m³ in case of Oltet outer dump, have imposed the construction of sterile deposits with great height between 30 and 75 m, with classification index (2.2.2.), consisting of two or more benches with a height between 10-15 m each, corresponding to an index (2.1.2.) for the classification of dumps [8], as shown in table 2. In terms of surface topography on which were built the outer dumps, they were located on slopes with gradients of less than 20° (2.3.2), except Jigăi dump which is located on the flat ground or slightly inclined (2.3.1.).

Table 2 *Dumps classification after their geometry*

Classification criteria		**Index**	**Classification groups**
			Characterization
1	2	3	4
After dump's geometry	2.1.Number of benches	2.1.1.	One bench dumps
		2.1.2.	Dumps withe more benches
	2.2. Height of dump	2.2.1.	Dumps with small height (<30m)
		2.2.2.	Dumps with big height (30÷100m)
		2.2.3.	Dumps with very big height (>100m)
	2.3.Land topography	2.3.1.	Dumps on flat land
		2.3.2.	Dumps on incline land ($<20^0$)
		2.3.3.	Dumps on incline land ($>20^0$)

4.Technical condition of dumps

The field observations and analyses conducted at each dump in part, highlighted a few general conclusions and others with particular character.

In Berbeşti mining basin was a continues concern for reclamation of land awarded by technological tasks which were used for dumping. At the present time, the outer dumps Panga South, Panga North, Muncelului Valley were rendered entirely in forestry or agricultural circuit and given to the local communities or Romsilva.

Also, to the dumps: inner Panga, outer Berbeşti, outer Olteț and outer Ruget, on small surfaces, work was done to the economic circuit, others being a work in progress.

The reclamation works executed on these land, generally have achieved the goal for which they were executed, except for some small areas, where subsequently occurred landslides which have affected the access road from the South Panga, or the houses at the bottom of the Panga North dump, figure 6.

Figure 6 *Landslide near Panga North dump*

The dumps with technological tasks have geometry contained in the admitted limits to the design of the building, there is a tendency to maintain the slope angle of the individual steps at the maximum permissible limit, and on the small stage lengths there is definitive undersized berms. In their great majority, the upper rungs have a poor or non-existent, leveling that allows rainwater infiltration into their body. All the dumps there are manifestations of mining negative phenomena, such as: abnormal bulging local subsidence, pressing of slope or terrain, superficial landslides and erosions or clough. The presence of accumulations of water dumps is found on surfaces inside the Panga inner dump and Helen outer dump. The small size of the zones in which manifests itself occasionally these phenomena, they are not affecting the stability of the overall system of the dumps.

A large landslide took place in the inner dump of Oltet coal pit in the year 2005 and has affected the bench system on the base [10], which had spread over an area of 60 hectares, and the material has been leaning on the excavation bench slope of the coal pit floor.

After lansliding and restoring balance in the new conditions, with the excavation of the block on the coal pit's floor along with a part of waste rock that is supported by it, the first bench was reconstructed in terms of stability, thus forcing the greater caution, but the and the adoption of additional measures to increase the reserve stability.

Analyzing the causes that have led to the loss of system stability, we determined the stability factor in the hypothesis of slipping on a polygonal surface, based on the theory of active resistance and knockback liabilities [4,8].

Fs1 stability factor was calculated under the conditions existing at the time of the landslide, in which the rocks were deposited directly into a floor constructed by excavating with the inverse buckets, with an angle β = 4 ° towards the outside of the dump, using the formula:

$$F_{s1} = \frac{\gamma_a \cdot h_1^2 \cdot \lambda_p \cdot \cos\beta + 4 \cdot c \cdot h_1 \cdot \sqrt{\lambda_p} \cdot \cos\beta + \gamma_a \cdot (h_2^2 - h_1^2) ctg\alpha \cdot \cos\beta \cdot tg\varphi_c}{\gamma_a \cdot h_2^2 \cdot \lambda_a \cdot \cos\beta - 4 \cdot c \cdot h_2 \cdot \sqrt{\lambda_a} \cdot \cos\beta + \gamma_a \cdot (h_2^2 - h_1^2) ctg\alpha \cdot \sin\beta} + \frac{2 \cdot c_c \cdot \dfrac{(h_2 - h_1) ctg\alpha}{\cos\beta}}{\gamma_a \cdot h_2^2 \cdot \lambda_a \cdot \cos\beta - 4 \cdot c \cdot h_2 \cdot \sqrt{\lambda_a} \cdot \cos\beta + \gamma_a \cdot (h_2^2 - h_1^2) ctg\alpha \cdot \sin\beta} \quad (1)$$

where:

α – slope angle unghiul of the individual dump (α=25 º);
h_1- height of the forward bench of dump (h_1=11 m);
h_2- total height of the system of two dump benches (h_2=26 m) ;
γ_a- volumetric weight of the dumped rocks (γ_a =19,2 kN/m^3);
φ- the angle of internal friction of the dumped rocks (φ=18 º);
φ_c- the angle of internal friction on the contact surface (φ_c=23 º);
c- cohesion of dumped rocks (c=24 kN/ m^2);
c_c- cohesion of rocks on the contact surface with the floor (c_c=33 kN/m^2);
λa=tg^2(45- φ /2) coefficient of the active pushing (λa=0,52);
λp = tg^2(45+ φ /2) passive resistance coefficient (λp =1,89);

$$Fs_1 = \frac{19{,}2\cdot 121\cdot 1{,}89\cos 4^{o} + 4\cdot 24\cdot 11\cdot\sqrt{1{,}89}\cdot\cos 4^{o} + 19{,}2\cdot(676-121)ctg25^{o}\cdot\cos 4^{o}\cdot tg23^{o} + 2\cdot 33\frac{(26-11)\cdot ctg25^{o}}{\cos 4^{o}}}{19{,}2\cdot 676\cdot 0{,}52\cos 4^{o} - 4\cdot 24\cdot 26\sqrt{0.52}\cdot\cos 4^{o} + 19{,}2\cdot(676-121)ctg25^{o}\cdot\sin 4^{o}} \qquad (2)$$

Fs_1= 2.60, the stability factor is below the minimum limit specified by this theory.

It is mentioned that the stability factor Fs > 3, is a necessary condition to ensure the stability of the bench system when the stability analyses are carried out on the basis of this theory.

The made excavation on the coal pit's floor with a slight inclination towards the dump (ß1 = 0.5 °), as can be seen from Figure 7, perfectly possible with the right cups due to the lack of an important aquifer in the coal layer is bunk what would generate the risk of fragmentation of the screen protector and flooding her career, contribute to increasing stability factor of the speed of the dump. For the same humidity conditions, and friction angle, cohesion of dumped rocks, the same geometry of the treads of the landfill, an increase in stability factor of at Fs_1=2,60, to **Fs_2=3,18** [2].

The Fs_2 stability factor was calculated for those conditions, using the formula:

$$F_{s2} = \frac{\gamma_a\cdot h_1^2\cdot\lambda_p\cdot\cos\beta_1 + 4\cdot c\cdot h_1\cdot\sqrt{\lambda_p}\cos\beta_1 + \gamma_a\cdot(h_2^2-h_1^2)(\cdot\cos\beta_1\cdot tg\varphi_c + \sin\beta_1)ctg\alpha}{\gamma_a\cdot h_2^2\cdot\lambda_a\cdot\cos\beta - 4\cdot c\cdot h_2\cdot\sqrt{\lambda_a}\cos\beta} +$$

$$+\frac{2\cdot c_c\cdot\dfrac{(h_2-h_1)ctg\alpha}{\cos\beta_1}}{\gamma_a\cdot h_2^2\cdot\lambda_a\cdot\cos\beta_1 - 4\cdot c\cdot h_2\cdot\sqrt{\lambda_a}\cdot\cos\beta_1} \qquad (3)$$

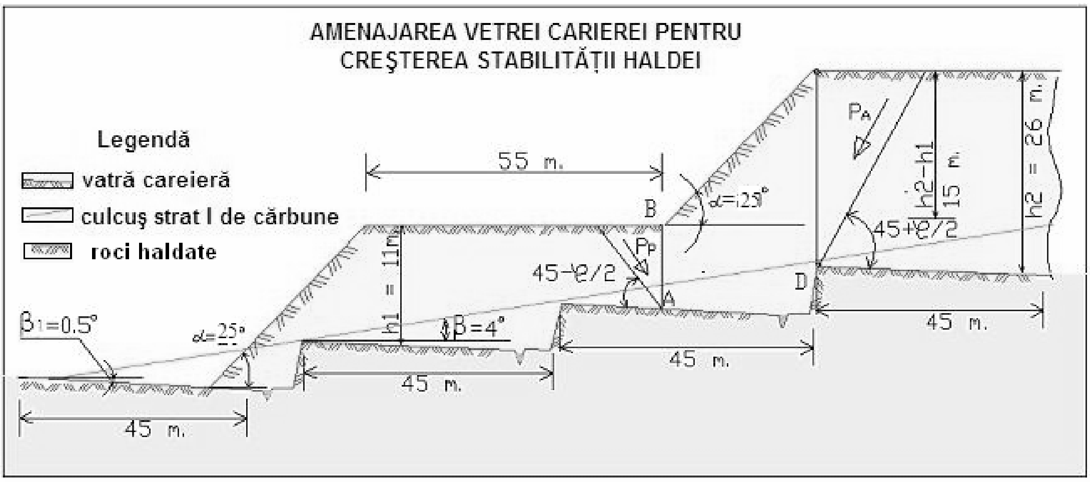

Figure 7. *Arranging the coal pit's floor from the excavation phase to ensure the stability of dump reserve*

5. Degraded land for different purposes and their characterization.

The exploitation of stratiforme lignite deposits, particularly in mining, involves the employment of large surfaces, but also qualitatively and quantitatively, of land which originally met the interests of local communities. At the end of 1989, when was made the maximum output of over 6 million tonnes, the organisation that encompassed all Horezu Mining mines and coal pits of the Gilort and up to the Bistrita had a total surface occupied by 1814 hectares of land. Further exploitation of coal in the basin and commissioning of new production capacity, it required an additional purchase of other land areas, so that in 1997 it was recorded maximum surface occupied by 2209 hectares, of which 1695 hectares farmland respectively 77% and 514 hectares of land, with a share of 23%, as shown in Figure 8.

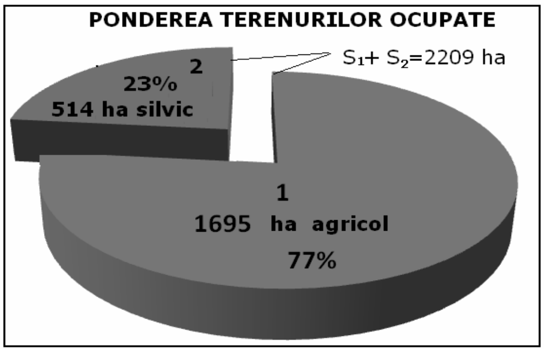

Figure 8.*Percentage of occupied land in 1997*

After 1997, went into preservation and then were closed one by one the mines from Cuceşti, Armăşeşti, Cerna, Berbeşti, Alunu, Copaceni and Albeni, small coal pits from Oteșani, Cernişoara, Cerna, Valea Mare, Panga and Seciuri. These closed mines and small coal pits in the Berbeşti mining basin have completed a list of 52 goals of national society of mining of lignite Oltenia, 550 respectively, at national level, which have been shut down in 1998-2008 through 10 successive decisions by the Government [1].

The influence of the subsidence to surface and underground works, preparation and service was trivial thanks to the great depth at which the operation took place and small thickness of overlying strata of coal and rock from the roof direct aeration during was tapped to fill the space. Thus, it was not necessary to use tools for leveling, it could have a more destructive effect as a result of the degradation of soil, crop or vegetable plantations or forests. The occupied land by the small coal pits basin were subjected to substandard facilities and after seeding with meadow and inorganic fertilization and, were handed over to local communities. On the final slope did not intervene, so that the more than 15 years since the execution of the work, these areas have partially seeded, and currently there is a natural slope as a result of environmental factors.

A special situation is the occupied lands from Bustuchin coal pit of 48 ha. In full development in 1997, with an EsRc-1400 excavator and a dumping installation into service, and other excavators of the same range almost completed in mounting platform, due to the impossibility of acquisition of land required for the continuation of the activity of extraction at the time, went into preservation.

On these lands has not stepped in to reclamation,Bustuchin coal pit being an alternative continuity of work in the western part of the basin, given the imminent closure of Ruget coal pit.

As it has been awarded by technological tasks, the outer dumps and a small portion of the inner dumps were also arranged and given in the economic circuit.

Beside the occupied lands for the dumping process, a significant area of land remains occupied by the excavation tehnlogical lines and transport.

Intrinsic operational activity in the Berbeşti mining basin, conducted to a production of 2.2 million t/year, in terms of productivity of a thickness of 8-10 t/m², lead to additional annual occupation of an area of minimum 30 ha/year, to which must be added and the necessary expansion of the dump of Oltet coal pit.

And location of the main premises, roads and coal and materials deposits, where the transport is carried out mostly by rail, it required removal of set-aside land with a good productive potential. Last but not least it should be stressed that the installation of mining mass transportation network, electricity supply, mounting platforms, fuel filling stations, pools of water and others, contribute a significant proportion of the sum of the areas of land that are taken out of the forest, set aside or for a longer time.

The situation of the occupied lands by the mining activity, and the order in which they are used is shown in table 3 [3].

By the end of the mining works of Berbeşti mining basin, will be affected another 809 ha of land with different types of use, as shown in the table 4.

It is revealed that both the expansion and agricultural productive potential, Oltet coal pit produce the maximum impact of anthropogenic impacts on the environment.

This is due to both the size of the coal pit, as well as placing the dump in an area outside of the meadow, situated at the confluence of the Tărâia and Oltet brooks what changes the landscape giving it a good appearance.

Table 5 it is shown the situation in the occupied lands in the present Oltet coal pit, the purposes for which they are used and the initial categories of use.

Table 3. *Waste land made by the mining activity according to the licence exploitation*

Name of coal pit	Bad land areas [ha]					Area from licence perimeter [ha]
	Total day [ha]	Where				
		Excavations	Dumps	Buildings and premises	Roads and railways	
Olteț	548	62	443	34	9	1099
Berbeşti	351	62	256	29	4	480
Panga	385.5	48	332.5	5	5	430
Ruget	404	112.5	255.5	28	8	536
Bustuchin	48					*
Total	1736.5	284.5	1287	96	26	2545

*- waiting for the final solution

Table 4. *Type of land use for waste land*

Type of use	Area [ha]	Percentage in the use type [%]
Arable	278,23	8,06
Orcharding	10,19	1,64
Vineyard	1,46	4,8
Meadow	67,02	5,39
Forestry	123,13	1,81
Yards, constructions	24,04	5,14
Waters	0,19	0,12
Roads	9,91	3,58
Unproductive	23,87	2,67
Total area	809	

Table 5. *The main use of the lands and their purpose*

Olteț coal pit	Land use category [ha]						Total area[ha]
	Arable	Orchard	Meadow	Yards	Unprod.	Forests	
Outer dump	245						245
Inner dump	36,1	4,8	134,7	2,2	15.4	4,8	198
Coal pit	12,2	2,6	33,7	1,8	9,5	2,2	62
Coal yard	4,4	0,6					5
Dump flow	13,8	1				0,2	15
Premises etc	13,7	1,5	6 ,4	0,4	2,6	1,4	26
Total area	324,2	10,5	174,8	4,4	27,5	8,6	548

Conclusions

- The development of mining recorded in the past 30 years needed an occupation of over 2200 ha of land which had served prior to obtain agricultural products or forestry;
- Restricting the mining activity started in 1997 left free of large technological tasks expanses of land that together with heaps of external surfaces, they could also be given in the economic productive circuit;
- Landslides from Oltet and Panga coal pit, even many years after the completion of the works getting into the economic circuit, as a result of human factors, have drawn attention to the risk of significant damage to property, embodied by the adoption of additional measures to increase the stability reserve;
- As a result of the fact that the average of 1975 m²/inhabitant of the affected area is much lower than the national average of 4,500 m² and taking into account the request of the local communities is a priority for re-use of degraded lands of the mining activity, the specialists concerns were highlighted by the attainment of this objective on the grounds of horizontal surfaces and on incline lands resulted from the re-shape of the first bench of the inner dump of Panga coal pit;
- The land which inclination prevents the achievement of mechanized agriculture and which are prone to erosion or landslides have been reused, so far being successfully planted Acacia species only;

The reduction or depletion of coal reserves inmany coal fields in the basin requires the enhancement ofreclamations in the productive economy circuit.

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