OPEN PIT EXPLOITATION OF COAL DEPOSITS FROM BERBEŞTI MINING BASIN

Dumitru FODOR, Nicolae DICAN***

Abstract : Sporadic exploitation of coal by underground mining works in the Berbeşti mining basin, is attested since 1902, [5], in the Eastern side of the deposit, at the Cuceşti mine in Oteşani village. The obtained yields with negative economic results most of the time, have not provided the necessary energy for the power stations in the area.

Development of high production, which contributes to achieving a major goal of the Romanian economy, before 1989, to obtain the energy independence energy, could not be satisfied only by the underground mining, appearing as an necessity of open pit exploitation, first in small coal pits and then in modern coal pits fitted with complex excavation, transport and storage.

Key words: dragline excavator, excavation complex, continuous sheet flow, excavation block.

1. Open pit exploitation by discontinuous flow

Because of the numerous advantages of open pit exploitation compared with underground exploitation [3], since 1979, the year in which it is open the first small coal pit from Berbeşti mining basin, we assisted to a fast development of coal exploitation industry. In this way, the coal layers with a thickness of less than 2 meters, but considerable in numbers and reserves, which were not subject to underground exploitation with coal faces fitted with mechanized complex due to the failure of coal layers exploitation, are capitalized now. Exploitation losses are reduced substantially, dropping below 15%, labor productivity increases and economic results are favorable.

The maximum capacity of development is achieved after 1982 when a few small open pits are opened at Panga, Oteşani, Armăşeşti, Cernişoara Copăceni, Valea Mare, Berbeşti and Seciuri West, positioned as shown in Figure 1.

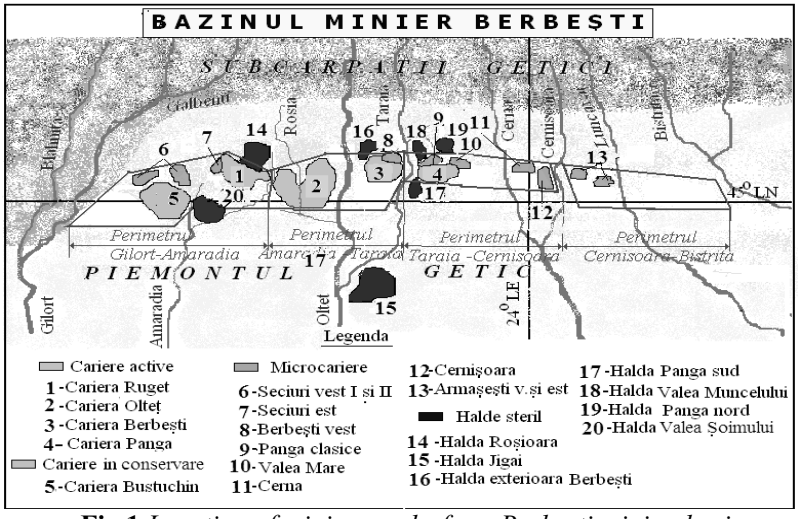

Fig 1 *Location of mining works from Berbeşti mining basin*

The exploited coal layers, separated by interlayers are made by clays, sand, according to Protodiakonov rocks classification, included in category VII of soft rocks, with a strength coefficient f=0,8÷2, [8]. In this way, for cutting and loading the usefull rocks, were used the Promex 1202, 3602, Unex, excavators and at

Seciuri West coal pit was used a dragline excavator „ESA 10/70" type. It was a russian dragline excavator with a bucket capacity of 10 m³ and a lenght of the arm of 70 m, was cutting, loading the sterile and transporting it to the interior dump. The sterile transportation was made by a dumper type „Raba MAN 2156 HCM", which could transport 16 tones. The technology used for excavation and dumping is shown in Figure 2.

* *Prof. eng. Ph.D University of Petroşani*
** *Eng. Ph.D E.M.C. Berbeşti*

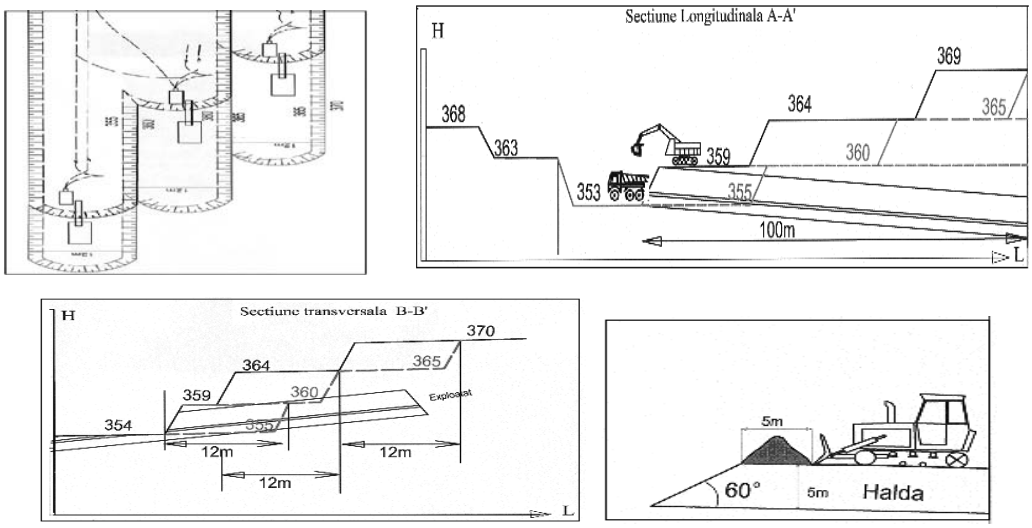

Fig. 2 *Excavation and dumping technology used in the small coal pits of the basin*

The equipment used in the construction of dumps were the bulldozers of 80 and 250 HP. 3,769 million tons of lignite was extracted from these coal pits, 1987 was the year with the maximum output of 469 thousand tonns. Although the mining fields next to these coal pits have benefited from the most favorable geological and mining conditions, a gravimetrically ratio of stripping up to 4 m3/tonne, the results have not been up to expectations. The major causes of small productions were the following:

- the bad weather conditions have diminished or totally obstructed the sterile transport on the exploitation benches and to the dumps due to clay or sand;
- the low reliability of the excavation equipment and the low productivity of 100-120 m3 sterile/hour and much smaller of obtained coal, (it should be noted that at the Oteşani coal pit, to exploit the coal layer I is completed after drilling and blasting);
- specific high fuel consumption at excavation and transportation equipment, as well as for dumping and storage with direct influence on economic outcomes;
- presence of rocks with low carrying capacity has made difficult the movement of dragline excavator to Seciuri West coal pit..

All of these shortcomings have been eliminated or substantially reduced, with the implementation of continuous flow technology, technology that has allowed the growth of coal production. From then and till now, was made a total production of lignite of 82.885 million tons, with the maximum production in 1989, the year in which it was exploited 4.711 million tons.

In the same year, was realised the maximum production of 6.08 millions tons by underground mining works and open pits. The whole amount of exploited coal from Berbeşti mining basin since 1977 until now (2012) is 103.895 million tons.

In figure 3 is shown the total coal production of Berbeşti mining basin since the open of exploitation until now, by using the continuous flow (coal pits) and discontinuous (small coal pits), and as well from underground exploitation.

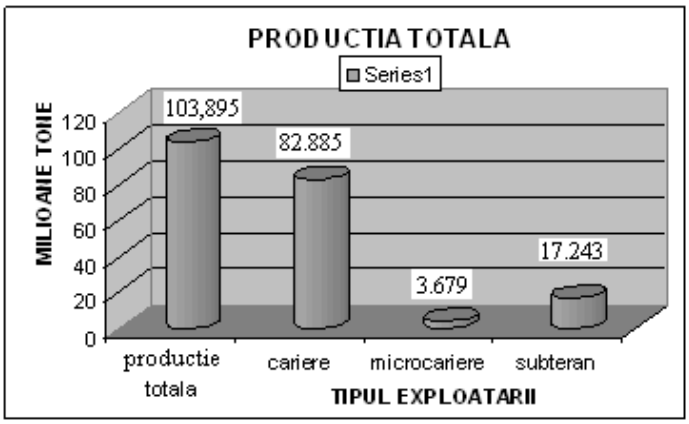

Fig. 3 *Total coal production*

Table 1. *High capacity equipment from Berbeşti mining basin*

Coal pit	Excavators			Dumpers			Storing machines				Conveyors	
	EsRc 470	EsRc 1400	Total	MH 4400.60	MH 6500.90	Total	Mixt	to put in	to take out	Total	No. of belts	Km of belt
Olteț	2	2	**4**		2	**2**		2	2	4	30	18
Berbeşti	3		**3**		1	**1**		2	2	4	17	5,6
Panga		3	**3**		2	**2**					18	6,7
Ruget	1	2	**3**	1	1	**2**	1	1	1	3	31	12
Total	**6**	**7**	**13**	**1**	**6**	**7**	**1**	**5**	**5**	**11**	**78**	**43,3**

2. Open pit exploitation by using the continuous flow

Since 1984 have been put into service the first excavators with bucket-wheel type ERc-1400-30/7 at Alunu coal pit, followed by those from Panga, Ruget and Bustuchin coal pit. Also, it came into operation the first bucket wheel excavator type SRc-451 15/3.5 in Berbeşti coal pit, followed by Alunu and Seciuri coal pits. In the table No. 1 is presented the situation of existing high capacity equipment in the Berbeşti mining basin nowadays.

In this amount is not included the coal production exploited from Cuceşti and Armăşeşti mine before 1977 when they belonged to I.M. Campulung or Horezu Local Industry.

1997 is the turnaround year in the mining industry, when it is made a conversion from the extensive production of coal to the production based on the requirements of market, economic efficiency and concentrating production in viable centers whose useful mineral reserves provides the indigenous economy needs for several decades. In this sense have been closed all mines and small coal pits from the entire mining basin, the staff have been lay off, concentrating the production in four coal pits equipped with high-capacity machines, positioned from West to East as follows: Ruget coal pit (Seciuri), Olteț coal pit (Alunu), Berbeşti coal pit (West) and Panga coal pit.

At Bustuchin coal pit, which had two excavators type ERc-1400-30/7 and a dumper, type MH 6500 – 90/50, the activity was shut down in 1997 because of the uncertain land used for excavation and dumping. An excavator was transfered inside the society and the other equipment are preserved.

The following is a brief overview of coal pits from the basin, where is still an economic activity.

2.1 Ruget coal pit

Ruget coal pit is located in the Western part of the Gorj County in the vicinity of Vâlcea County, in an area with high hills, which borders the coal pit's advance towards the South and the Northern limit is the crop. The open pit is geographically located between the Roşioara and Amaradia Valley belonged to Prigoria Mining Branch, part of the Energy Complex Craiova until the year 2012. With the establishment of Oltenia Energy Complex it re-entered to the Berbeşti Mining Exploitation. Ruget coal pit, spanning the range of the Roşia de Amaradia, Seciuri and Prigoria locality.

The development documentation of Ruget open pit was the ”Execution Project” made by ICSITPML Craiova and approved by Decree No. 403/1985 and HCM no. 36/1986. The mining development started in 1986 by making a ditch to the coal layer I, with a length of 1630 m, width of 30 m and a slope angle of 9º, for a production capacity of 1.000 thousand tons per year, at a stripping ratio of 7.46 m^3/t. The designed production capacity has been reached and exceeded in 1989 after only three years after the opening, [11]. Situation of production and stripping from the beginning until now (2012) is shown in the Table 2 and the evolution of production and staff is presented in Figure 4.

The technical rigging of the coal pit:

- two bucket wheel excavator, type ERc-1400-30/7;
- one bucket wheel excavator, type SRc-470 15/3,5;
- one dumper, type MH 4500x50;
- one dumper, type IHS 6500/50x90;
- one machine for taking out the coal, type T 2846;
- one truck with belts;
- one combined machine, type ASG 6500.40;
- 31 belt conveyors with a width of mat between 1400 and 1800 mm and a total length of 12 km.

Table 2 *Table for production and stipping of active coal pits from Berbeşti mining basin*

YEAR	OPEN PIT							
	RUGET		OLTEŢ		BERBEŞTI		PANGA	
	Production (tons)	Stripping (thousand m³)	Production (tons)	Stripping (thousand m³)	Production (tons)	Stripping (thousand m³)	Production (tons)	Stripping (thousand m³)
1977					0	94		
1978					0	284.8		
1979					0	732.3		
1980					99.6	1667.7		
1981					585.6	1397.2	135	445.5
1982					484.7	1458.4	349	1430.9
1983					706.9	1904.5	486	1944.0
1984			9.12	1594	888.7	1894.1	456	1824.0
1985			65.97	1786	921.6	2758	537	1611.0
1986			261.8	2282	1105.6	3873.7	727	2617.2
1987	520	2993	671.07	3507	773	3666.8	721	5551.7
1988	830	1912	1301.53	4642	745.7	4322.6	461	6670.7
1989	1051	4371	1595.86	5400	879.3	4498.9	794	7066.6
1990	718	5431	1180	2894	683.3	3114.8	544	5548.8
1991	577	3998	799.78	2195	439.7	2147.1	361	4007.1
1992	701	5464	1258	3618	626.6	2824.4	584	5956.8
1993	928	4621	1216.6	4264	708.3	3153.3	531	5262.2
1994	880	5022	1308.4	4582	483.7	3614	532	4819.9
1995	892	7676	1261	4213	679	3706	296	3285.6
1996	689	8136	1186	5500	615.5	4154	265	5379.5
1997	750	4780	963	4950	421.1	3809	650	7280.0
1998	272	3210	736	4500	404.7	1615	245.8	4557.1
1999	275	3308	542	3951	288.3	1647	254.7	3331.5
2000	500	3411	972	5982	522.1	1956	338.1	5392.7
2001	642	4847	1075	5755	555.2	2718	643.8	6161.2
2002	568	5048	1150	7200	705.65	3257.5	687	6526.5
2003	685	5470	1120	5627	433	2656	500	5000.0
2004	650	4985	1110	6493	313	2759	877.5	8511.8
2005	560	4290	1150	6615	228.5	1187	539.5	5610.8
2006	694	5100	1100	6750	150	245	1103	9596.1
2007	690	5270	1352	8427	100.5	4158	1329.5	9897
2008	662	5123	1383	8008	287.5	3618	1179.5	8513
2009	705	4956	1113	5350	121	1506	1036	6300
2010	705	3760	1022	4975	118	1474	801	5470
2011	713	4410	1160	6180	104	298	971	6233
2012*	450	2020	1200	6500	350	1240	850	6050
TOTAL	**17307**	**119612**	**29263.13**	**143740**	**16529.35**	**85410.1**	**19785.4**	**167852.1**

TOTAL PRODUCTION - 82884,8 thousand tons

TOTAL STRIPPING - 516614,2 thousand m^3

Fig. 4 *Production and staff evolution at Ruget coal pit*

The coal layers are East-West with a decline of 3-5º North–South. The benches are excavated on the layers, and the coal pit's advance is carried out on their incline. In the exploitation perimeter of Ruget coal pit an economic importance have the layers I and II, which by the way is on exploitation. The geological profile of Ruget coal pit [5] is shown in Figure 5, and hydrogeological characteristics are shown in Table 3.

Fig. 5 *Geological profile at Ruget coal pit*

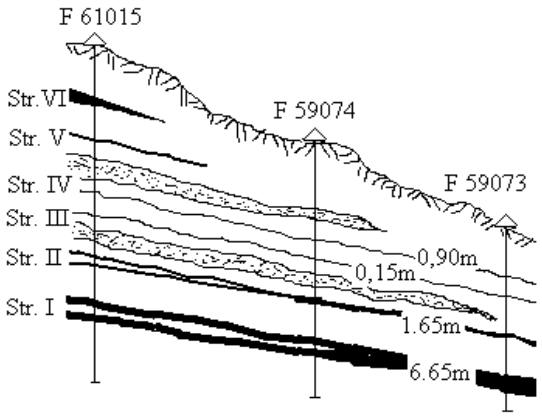

Table 3. Hidrological and geological features the deposit from Ruget mining perimeter

Petrography	Depth (m)	Stratigraphy	Hidrogeology
Deposit of terrce	10-20,0	Quaternary	Aquifer
Clay and sand	5,0-10,0	Romanian	Deep aquifer ee levels
Layer VIII	0,1-0,5		
Clay	3,0-9,0		
Layer VII	0,15-1,5		
Adobe	5,0-13		
Layer VI	0,1-0,5		
Clay and sand	3,0-20,0		
Layer V	0,15-0,9		
Clay and sand	3,0-15,0		
Layer IV	0,55-1,5		
Clay and sand	3,0-20,0		
Layer III	0,1-1,0	Dacian	Deep aquifer with ascensional feature
Clay and sand	4,0-25,0		
Layer II	0,5-5,5		
Grey clay	1,0-7,0		
Layer I sup	3,0-7,0		
Marl	0-2,0		
Layer I-a	0,15		
Marl	5,0-10		

Fig. 6 *Sterile dumping in the interior dump by leaning on the final slope of the coal pit*

Because of the excavator E 02 type SRc-470 15/3,5 which reached to the South of the area where was no stripping made by clasical machines, this was stopped and parked untill a solution will be found for the activity in Bustuchin or Olteț coal pits. The excavators E-01 and E-03 are digging in the last excavation blocks and will be stopped and taken out from the coal faces during this year.

In this situation, for four years the sterile has been dumped in the interior dump. As the coal layer I is excavated from the coal pit's floor and the coal face conveyor gets shorten, the sterile is dumped so that it can lean on the final slope of the coal pit (figure 6).

The exploitation method used at Ruget coal pit is the „Exploitation method with sterile transportation to the dumps" from the group „Exploitation method using the belt conveyor for sterile transportation to the dump", the applyed technolgy is „continuous flow".

2.2. Olteț coal pit

The Olteț coal pit is located in Western side of Vâlcea County, following an extention to the Eastern side of Gorj County, being located in the Amaradia –Tărîia mining field on the range of Roşia de Amaradia, Alunu, Sineşti and Berbeşti locality.

The development works started in 1980, according to the documentation PE 901-03/1980, aproved by the Decree no. 310/1980 and was started by ditch in the Nortern area, where it can be found a crop. The development method was ”Development method with interior ditches comune base grouped”.

The design production capacity was 1.3 million tons per year, which was reached and overtaken in 1988 and 1989,[10].

Since the exploitation licence has been taken for the period 2001-2020, the production capacity was 1.2 millions tons per year, and the annual coal production was between 1 and 1.4 million tons. The annual coal production and stripping are shown in Table 2 and the production and staff evolution is shown in figure 7.

Fig. 7 *Production and staff evolution at Olteț coal pit*

The technical rigging of the coal pit:
- two bucket wheel excavator, type ERc-1400-30/7;
- two bucket wheel excavator, type SRc-470 15/3,5;
- two dumpers, type IHS 6500/50x90;
- two trucks with belts on tracks;
- one distribution cart, type CDS 1600.60;
- 30 belt conveyors with the mat width between 1400 and 1800 mm with a total length of 18 Km.

The coal yard, figure 8, has two piling machines type T-253[ASG] and a taking out machine, type T-2052 (KSS)

Fig. 8 *The coal yard of Olteț coal pit*

In the coal pit perimeter, the exploitable coal layers are: I, II, III and IV, but, on a small area, where the thickness of the layer can be selected, the layer VII is also exploited.

The sterile from the stripping is transported to the two dumps, 65% to the exterior dump. The ratio of sterile trensportation between the two dumps is according to:
- the benches stability of the interior dump by keeping the slope angle to ~ 9º;
- the maximum wide of 80-100 m, to ensure the production activity;
- economic efficiency of the mining activity.

The exploitation method applied to Olteț coal pit is the ,,combined method with partial transport of stripping to the interior dump, the second part to the exterior dump and partial shipping of the third part to the interior dump”.

The exploitation technology is ,,technology of excavation, transportation and dumping in continuous flow”

This method is applied to the horizontal deposits or with a slight incline, with a limited thickness, with the hard rocks of stripping, beeing chracterized by the fact that a part of sterile is

dumped in the interior dumps and the other part is dumped in the exterior dumps.

The efficiency of this method [2], is ensured when the transported sterile is minimum 30 % of all. The E-01 excavator, EsRc 1400-30/7 type located on the floor of the coal pit has the possibility to rotate the belt no. V for letting the sterile to the front conveyor, following the course to the interior/exterior dump, or to a belt truck on tracks type CBS 1400, which can directly dump the sterile on the floor making a bench of 7-8 m high. The way of dumping on the floor is shown in Figure 9.

Fig. 9 *Sterile transportation on the floor, by a belt truck on tracks, type CBS 1400*

The excavtor E-01 make 80% of the production, exploiting the layers I, II and III, and beyond the economic efficiency with a lower electricity consumption, (maximum 1.2 kW/m³), it makes possible the intensive usage of the excavator by reducing the parking time.

2.3. Berbeşti coal pit

Berbeşti coal pit is located to the West of Tărâia brook, on the range of Berbeşti-Alunu locality, being a part of Amaradia –Tărâia mining perimeter. The hilly relief is between 350-470 m. The mining activity has started in 1980, in the North side of the coal pit on an averege length of ditch of 600 m. The works on the grouped interior ditc were made by the classic machines from West to East and the extention was parallel or in a fan shape. The designed production capacity was 700 thousand tons per year, being reache between the years 1983-1989, [9]. Starting to 2007, after obtaining the exploitation licence, the production capacity was 500 thousand tons per year. The annual stripping and production ratio is shown in Table 2 and figure 10.

Fig. 10 *The stripping and production evolution at Berbeşti coal pit*

Berbeşti coal pit is equiped with:
- three bucket wheel excavators ESRc-470 15/3,5;
- one dumper IHS 1800/50+80 +27;
- four belt trucks on tracks;
- 10 belt conveyors with a mat width of 1400 and 1600 mm.

Each excavator is located on a working bench, digging one, two or three benches with a hight of 10 m, 5 m, respectively 3 m. Most of the bench I of the dump, has been built by a directly dumping of the sterile resulted from the stripping of coal layers I and II by two CBS which are located on the bench three of the coal pit, which is excavated by excavator E-03.

The exploitation method is the „combined exploitation method by transport the sterile to the exterior and interior dump" and the excavation technology used is the „technology of excavating, transport and dumping in continuous flow".

At the Berbeşti coal pit, the layer I of 5.4 m average thickness and layer II of 3.42 m are separated by a thin interlayer of sterile and that is why many of the areas are exploitated in a complex. The coal is transpoted in the

intermadiate coal yard with a capacity of 20000 tons, being located in the premises of the coal pit and from here is loaded into the trucks and transported to Govora thermal power station.

2.4 Panga coal pit

The Panga coal pit is located on the Western part of Vâlcea county, on the left bank of Tărâia brook, being located on the locality range of Berbeşti, Copăceni and Mateeşti. The hilly area has a hight between 350 and 460 m and has allowed the coal exploitation in the Tărâia-Cernişoara mining perimeter.

The development of Panga coal pit has been made by the PE 902-14 documentation from 1982 and aproved by the Decree no. 16/17 01 1985. The development works have been made by clasical machines by digging a ditch of 600 m in the Western side of the coal pit and then in parallel [12]. Nowadays, at Panga coal pit are ensured the dumping conditions of sterile in the interior dump by two sunt asigurate condiţiile de depozitare a sterilului în totalitate în halda interioară prin intermediul celor două dumpers and two separate transport circuits for sterile (but also with a posibility of switching the technological lines).

Panga coal pit is equiped with:
- three bucket wheel excavators ESRc-1400-30/7;
- two dumpers IHS 1800x27/50x90;
- one truck with belts on tracks;
- two distribution carts CDS 1600.60;
- 18 belt conveyors with a mat width of 1400 and 1800 mm with a total length of 18 Km.

The three ESRc 1400-30/7 excavators are located on each working bench directed North-South on the coal layers incline.

The E-02 excavator is located on the floor (mostly on the entire productive horizon) and carves 40 m of a bench, by dividing it in three.

This fact is also realised by a CBS-1400. The coal pit advance is done from West to East on the layers direction, being the only coal pit from the basin which is doing this, with a main disandvantage on a 5º of coal layers, where the coal is not continuous and can not ensure a continuous production on each machinery, Figure 11. As an advantage is that the benches don't have the floor declivity to the excavation benches. They incline to the final South slope, leaning on it and giving a high stability to the benches system.

Fig. 11 *Panga coal pit. The advance of the coal pit on the coal layers direction*

Fig. 12 *Mining mass evolution at Panga coal pit*

The designed production capacity was 1.1 millions tons of coal per year and the exploitable coal layers are I, II and III, the most important is the layer I with a thickness of 5 m. The coal production and stripping per year, made from the beginning till the present day is shown in Table 2 and the production and stripping evolution along the time is shown in figure 12.

The exploitation method applied to Panga coal pit is the method of sterile transportation to the interior dumps by circuits of belt conveyors. This method ensure a minimum cost which can make possible the exploitation to a higher stripping ratio (over 8 m³/ton of coal). The three exterior dumps: Panga South; Panga North and Valea Muncelului, have been used from the development untill 2009, when it was brought into the interior dump the machine A-01 and the transport circuit.

Conclusions

- The open pit exploitation in Berbeşti mining basin has ensured a continuous mining activity, started long time ago in mines;
- 516,614 million m³ of sterile has been carved, transported and dumped; it's distribution is shown in Figure 13;
- 82,885 million tons of coal has been given by the four coal pits from the development till now, with a heat output of 1800 kcal/kg; the share of each coal pit is shown in Figure 14;
- The evolution of excavated mining mass, shown in Figure 15, increased from 1989, with a fluctuation caused by the less energy consumption of coal, regard to high demand of water energy;

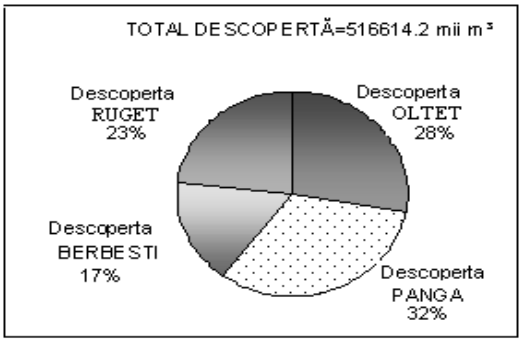

Fig. 13 *Stripping ratio per coal pits from development till present*

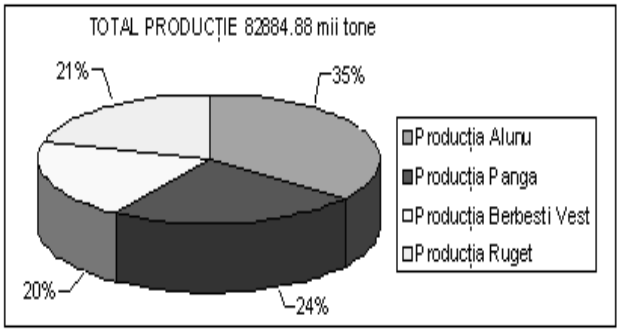

Fig. 14 *Total production of coal per each coal pit*

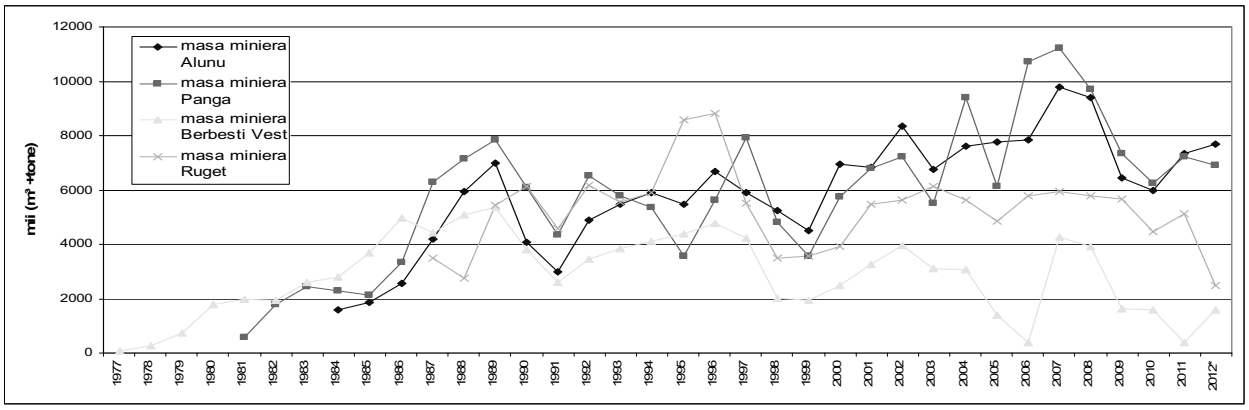

Fig. 15 *The share of excavated mining mass for every open pit*

- The existance of oversized production capacitys for avarage annual consumption of coal for the costumers: CET Govora and CET Craiova, can satisfy the additional demand caused by the dryness which directly affect the water energy production;
- The low industrial coal reserves of the coal pits from the mining basin, except of Olteț coal pit, generates on shrt and very short term issues for maintaining the present production capacity and the number of staff as well;

The attention for solving this problems is:

- the necessity of asking for the extention of licence perimeters acording to the stripping ratio and hydro-geological parameters;
- the adjustment of production costs by adjusting the transportation cost for mining mass, for balancing the sterile volume;
- production concentration in Olteț perimeter after the end of the reserve of Ruget coal pit, or provision of exploitation in Bustuchin perimeter;
- bad lands integration into the productive economic circuit, with a direct impact on costs, for satisfying the local community interests and acording the law, as well;
- maintaining the competitivity on market, for keepig the continuous exploitation in Berbeşti mining basin.

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