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EVOLUTION OF LIGNITE EXPLOITATION IN THE COAL PITS OF ROVINARI COAL BASIN

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Abstract

Rovinari Coal Basin represents a very important mining entity for Romania's economy. In 60 years of continuous activity, it has been extracted and capitalized over 430 mil. tons of lignite.

Today, into the coal basin are highlighted the industrial reserved by leased of approximately 180 million tones, accounting for the continuation of the activity, at the current capacity of 6 million tons/year, for a period of at least 30 years. Balta Unchiaşului coal pit was the first coal pit opened in the basin, then followed by Beterega and Cicani coal pits and Urdari coal pit was the last one, which was put in service in 1987.

Currently, in the Rovinari Coal Basin works the following coal pits: Gârla, Rovinari, Tismana I, Tismana II, Pinoasa, Roşia de Jiu, Peşteana South and Peşteana North. Balta Unchiaşului, Cicani and Beterega coal pit, were closed because they have exhausted the reserves, and Urdari coal pit has been closed because the unfavorable economical and technical results.

1. Introduction

The beginnings of exploitation and capitalization of lignite deposits from Gorj County, dates back to the period from 1916 to 1917, when it was removed manually from the crop of lignite layers from Rovinari Coal Basin, about 1000 tons of coal. In 1924 the first underground mine was opened for lignite exploitation from Rovinari Basin, during the years 1924-1929 was a production of almost 3,200 tons of lignite. After this period due to the economic crisis and the events that followed, including the World War II, the activity is interrupted and it will be resumed in 1950. Geological investigations undertaken beginning in this year, highlighted the existence of important reserves of lignite both in Rovinari Mining Basin and in surrounding areas as well. At that time, were highlighted the particularly advantageous conditions of surface mining of lignite reserves in the Jiu, Jaleş and Tismana meadow.

As a result, parallel to the underground exploitation is to exploit the lignite deposits from Rovinari Mining Basin. At the beginning, the exploitation was done in small coal pits having discontinued technology flow, after which it moved on to larger coal pits equipped with continuous technology flow with modern high-capacity machines and increased productivity.

Prospecting activity continued throughout Oltenia, highlighting the new coal reserves in Motru, Jilt, Husnicioara and Berbeşti-Alunu, within have been designed and put into service new mines and coal pits.

Of the 12 coal pits designed and put into operation in Rovinari Coal Basin, so far have been exploited and flat-out the Balta Unchiaşului, Cicani and Beterega coal pits, Urdari coal pit has been closed and still in operation: Gârla, Rovinari East, Tismana I, Tismana II, Pinoasa, Roşia de Jiu, Peşteana South, Peşteana North, located in the north-western part of the mining basin adjacent to the Rogojelu power station and extended to the South to the Turceni power station (figure 1).

Geological speaking, the lignite deposits from Rovinari Basin, belongs to the Pliocene stratum (Romanian, Dacian, and Pleistocene) and consist of 17 lignite layers, from which are entirely exploited the layers V, VI and VII and from VIII to XII are locally exploitable in areas where the thickness exceeds 1.0 m.

Layers I to IV are not exploitable because of the aquifer sands from the bed and layers XIII-XVII insular appear being mostly flat-out.

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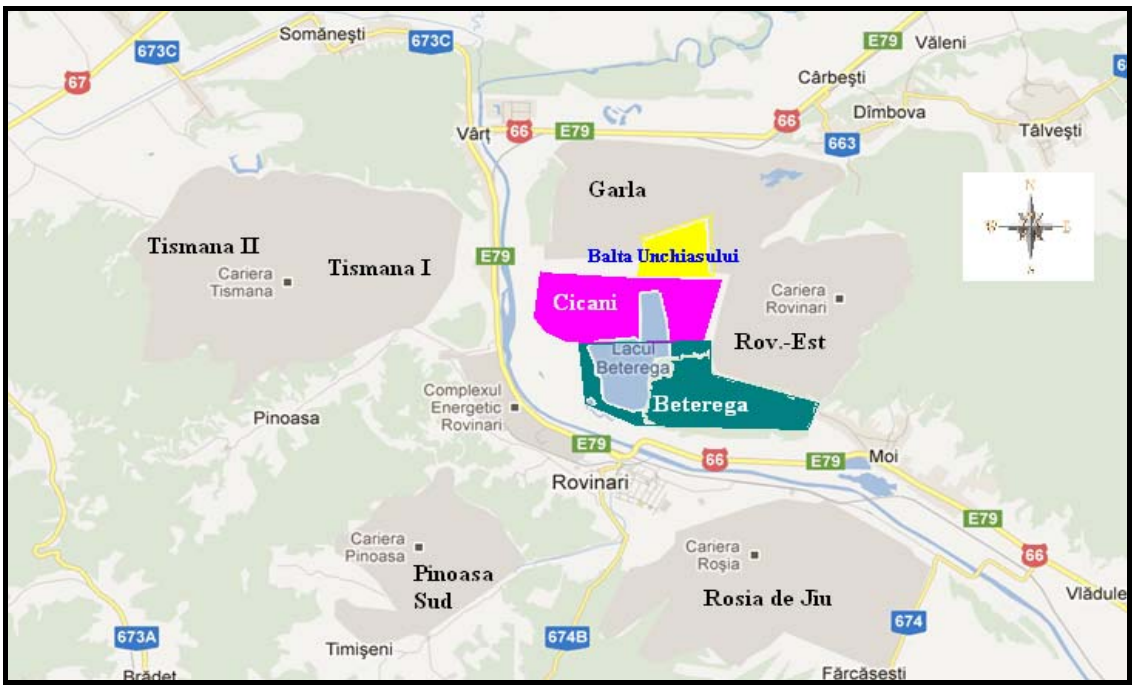

Fig. 1 *Coal pits location in Rovinari Coal Basin*

The average thickness of a layer varies between 4 and 8.0 m, and the coal complex, in the case of many layers, the thickness is 100-120 m, in the hilly areas and 20-40 m in meadow areas (figure 2).

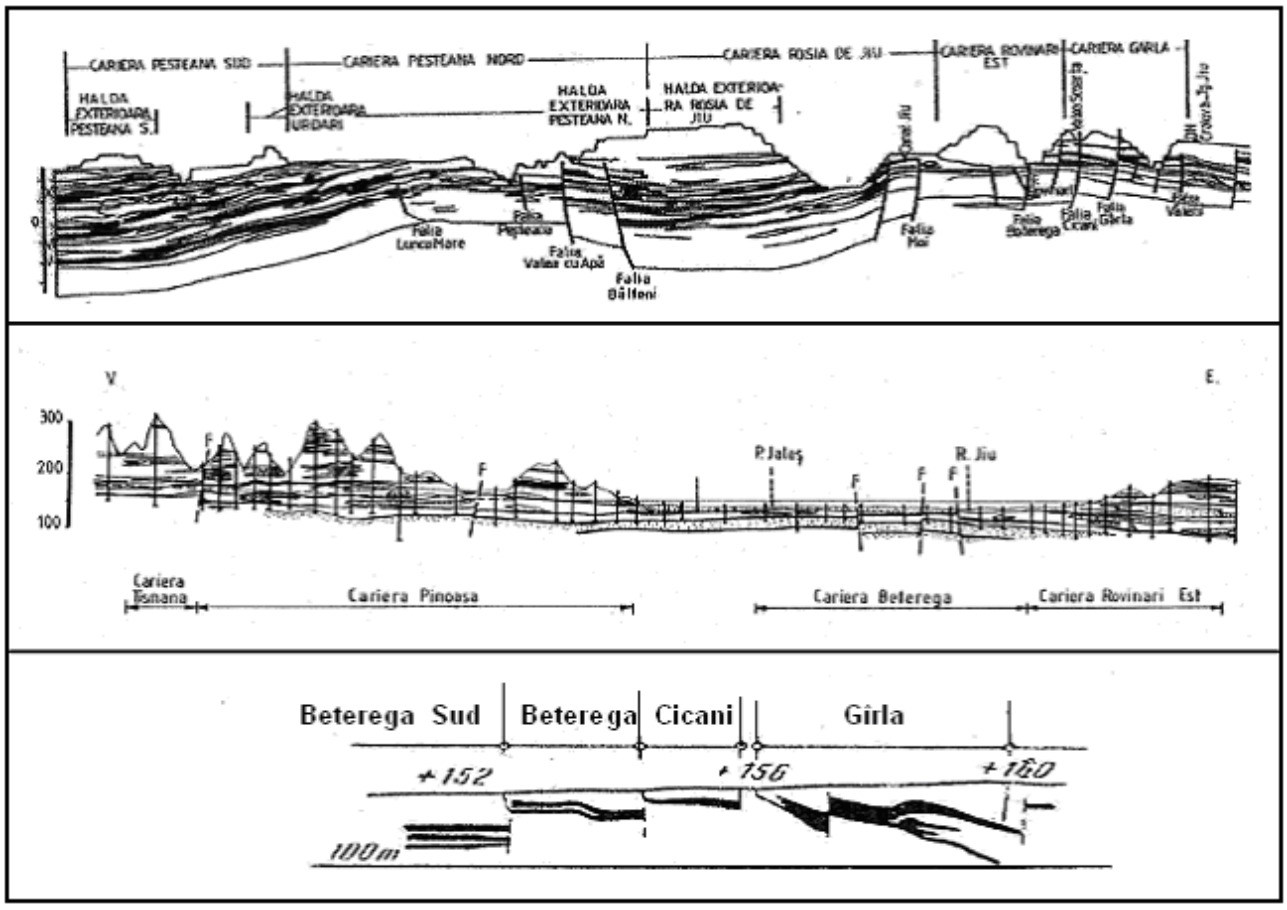

Fig. 2 *Geological sections through Rovinari Mining Basin*

Rocks from the bed and roof of lignite layers are generally poorly consolidated and made up of vegetable soil consisting of 5-20%, clays and marl, 50-70% and sans 5-20%.

In terms of quality, the lignite from deposits has a calorific power of 2.000-2.200 kcal/kg. Through the excavation process there is a dilution, as a result of the addition of sterile, which leads to obtain a lignite with a calorific power of 1.500 – 1.800 kcal/kg.

The deposit has an angle up to 50 with undulation on many directions and being interrupted by a series of major faults on East-West direction.

2. Presentation and case analysis of coal pits from Rovinari coal basin

2.1. Coal pits with discontinuous technological flow

Balta Unchiaşului coal pit

The first coal pit put into service in Rovinari Mining Basin and in Romania as well, was Balta Unchiaşului coal pit. This coal pit was opened in 1955 in the meadow of the Jiu river, in the most favorable conditions from the point of view of stripping ratio. Until completion of the technological process of Balta Unchiaşului coal pit, was need to experiment more kinds of excavation, transportation and dumping machines which impress an experimental character to the coal pit. In the coal pit activity are distinguished two stages:

- **Stage I** is characterized by making the stripping with a dragline excavator type Markwart E200 (Figure 3) with lignite transport with a belt conveyor band to the exterior dump, from where the sterile material is conducted throughout the Jiu river bed by a monitor working at a pressure of approx. 10 atmospheres, on a dumping bridge, adapted to a stepping dragline.

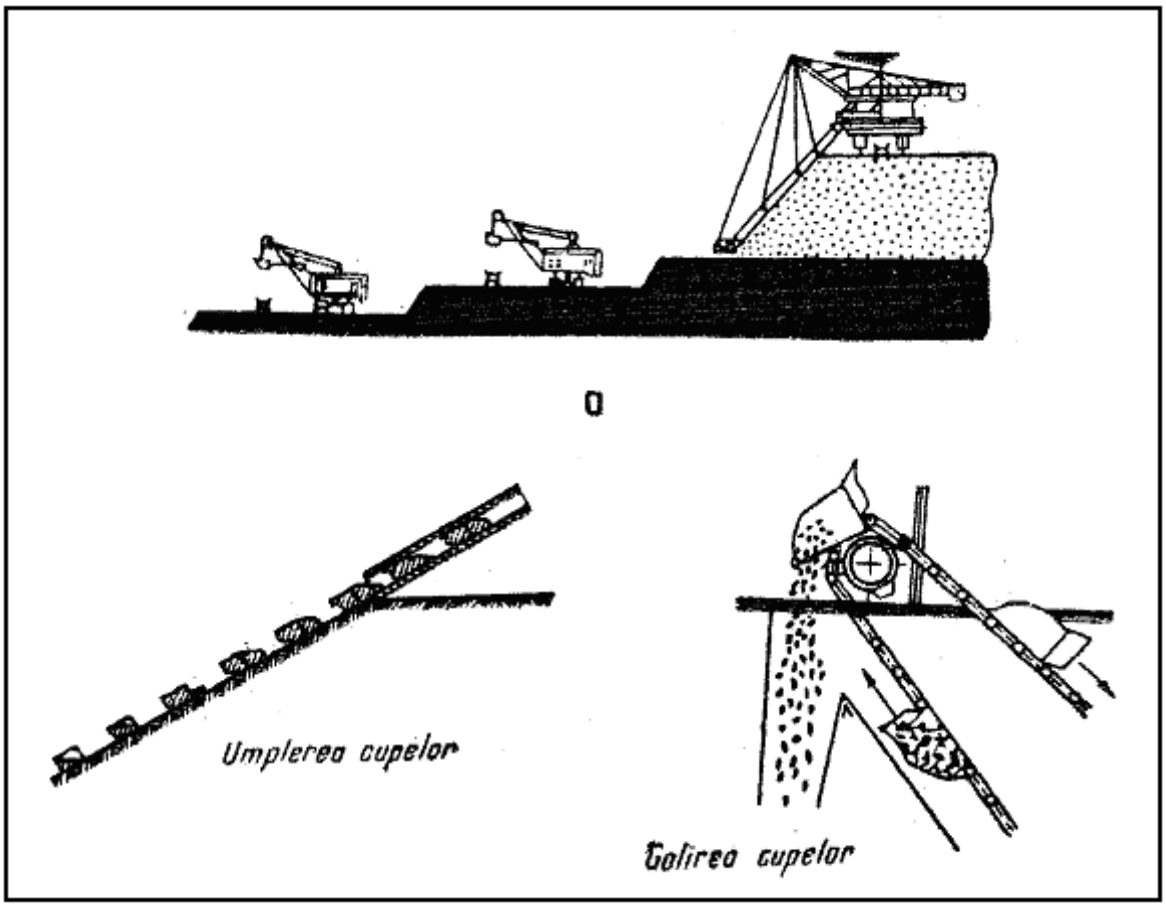

Fig. 3 *Stage I of exploitation for Balta Unchiaşului coal pit stripping by a Markwart E-200 type bucket-chain excavator*

In 1959, it gave up of using the bucket-chain excavator because the cutting effort used for clay and marl rocks was superior to the cutting force of excavator's cups, of which, the excavation capacity was significantly reduced and the wear of cutting equipment was high.

- **Stage II** represents the completion of the technological process from Balta Unchiaşului coal pit. This stage is characterized by making the stripping with discontinuous action excavators and sterile transport with dumpers to the interior dump, (figure 4).

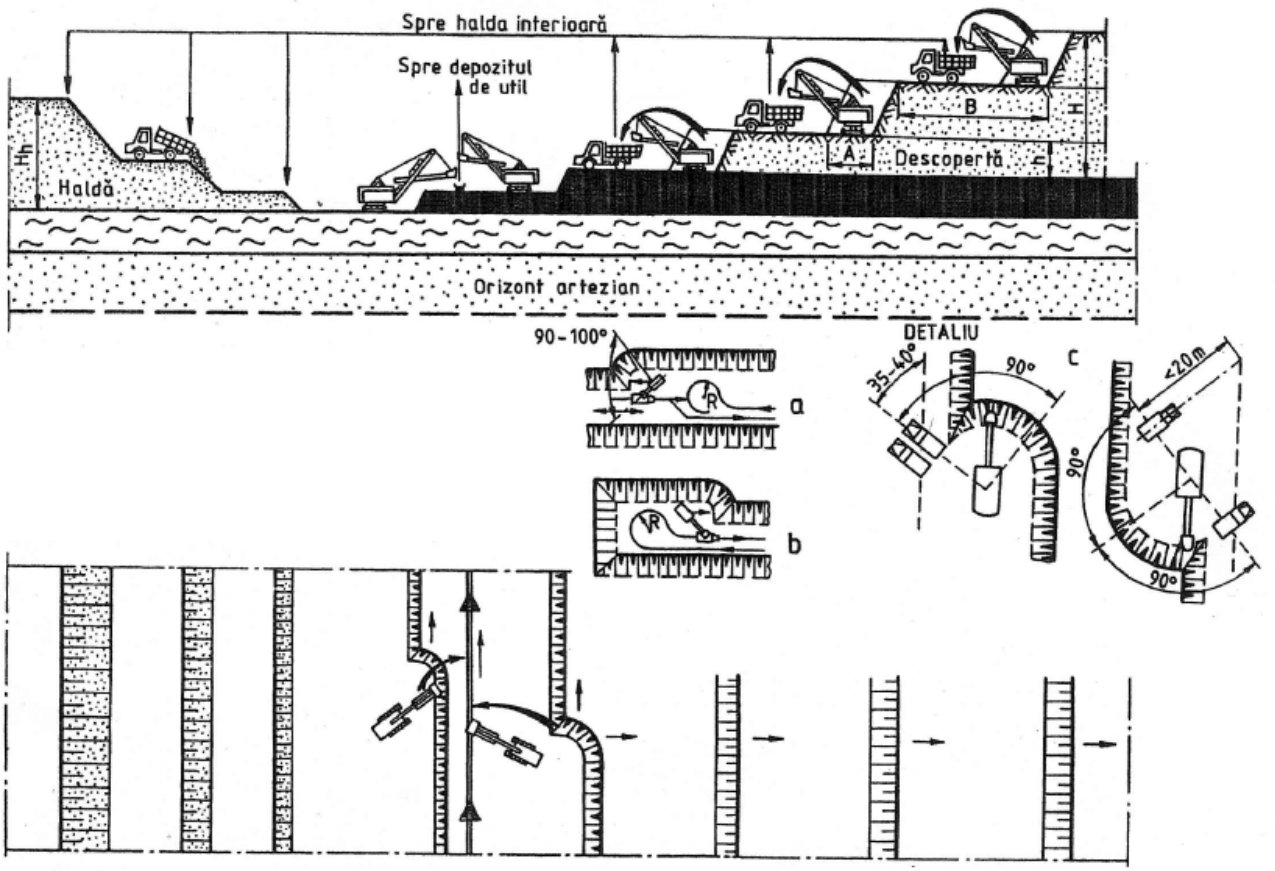

Fig. 4 *Design of exploitation method from Balta Unchiaşului coal pit – Rovinari, in stage II of activity*

Coal extraction was done in both cases in the first and the second stage, in coal pit faces of 10 m wide and up to 9 m height, with discontinuous action excavators like mechanical shovel type with bucket capacity of 1.0-1 ÷ 1.5 m^3, and transportation of useful material was done with belt conveyors with rubber mat width of 1000 mm and speed of 1.2 m/s to selection station, ensilage and shipping.

Were used excavators type SE-3 and Ry-1.5, stepping dragline type ES-1, Kirov scrapers, "Red Flag" and Molotov dumpers. The maximum production of this coal pit was 582.000 tones per year.

2.2 Coal pits with continuous technological flow

Technologies in continuous flow extraction of sterile and useful material with bucket and cutting buckets excavators and transport of excavated material using belt conveyors with high-capacity belt, were applied for the first time in Romania in 1967 in Rovinari Mining Basin, in Cicani coal pit and in 1969 in Beterega coal pit, based on technology projects drawn up by German companies.

At the beginning the lignite pits from Rovinari Basin, equipped with continuous technology was applied the operation method by transport the sterile to the interior or exterior dumps beside the available place for dumps location (figure 5).

The technology flow used for extracting the sterile was made by excavation machines, belt conveyors with specific elements of switching and dumpers.

The extracted coal from working front was transported from the coal pit to the coal yard, equipped with specific dumping machines and taking out the production for being sent to the beneficiary. So each machine from the technological has it own task to achieve the production process as a whole.

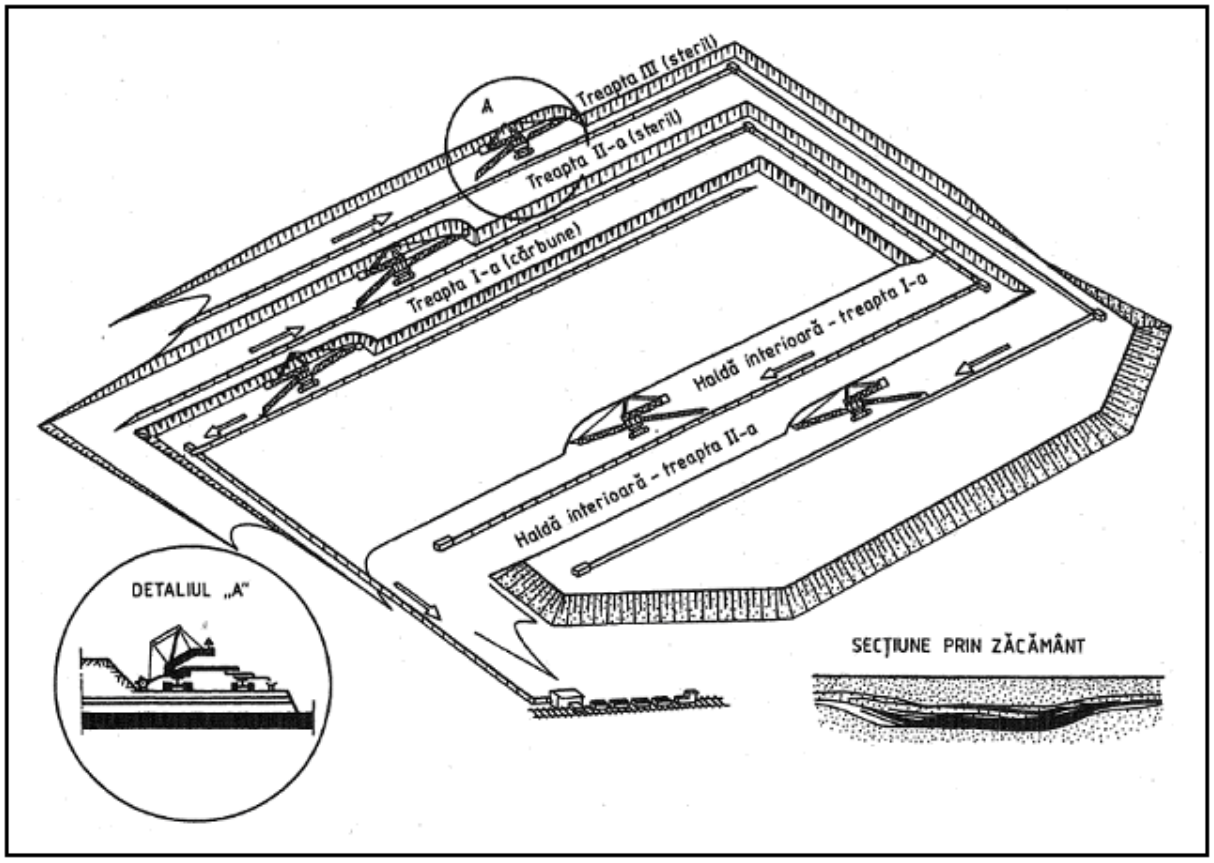

Fig. 5 *Exploitation method with continuous transport of sterile rocks in interior dumps, used in the coal pits of Rovinari Mining Basin*

Bucket excavators are responsible for the excavation of working benches within the exploitation perimeter in blocks with a width of 45 ÷ 55 m (figure 6). Vertical, the working front can be developed only in sterile or only in coal or in a mixed formation - sterile and coal. Bucket excavator and cutting buckets excavator can excavate both above and below the displacement level.

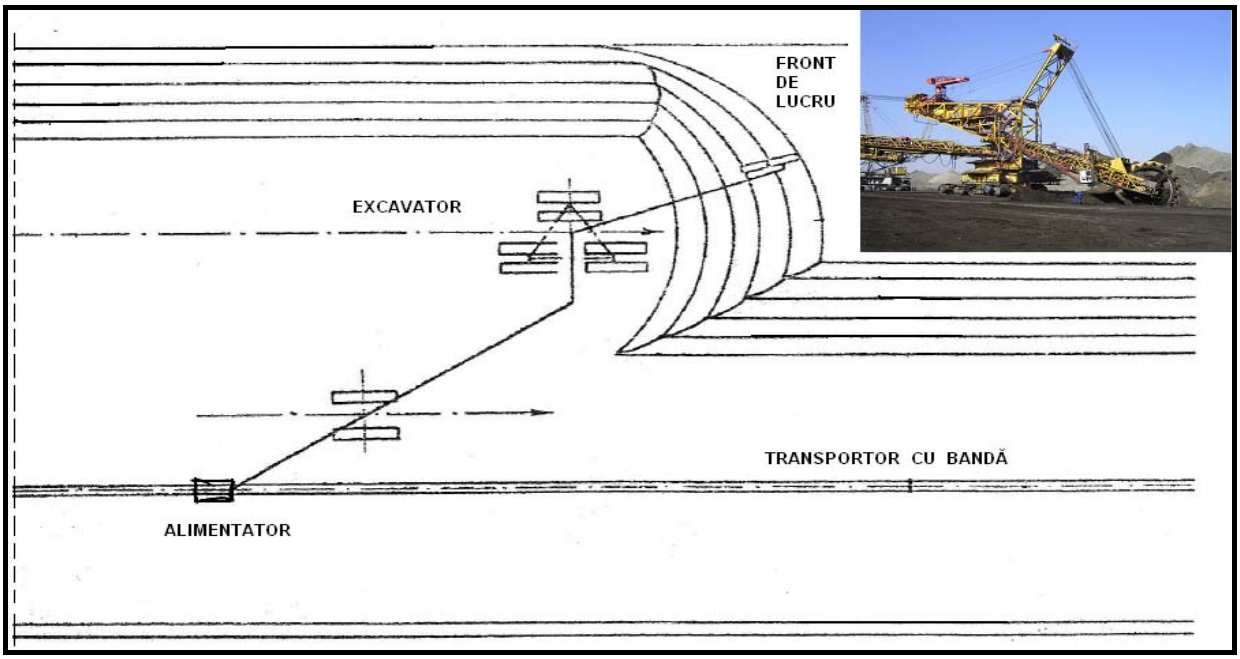

Fig. 6 *Bucket excavator type ERc – 1400* $\frac{30}{7}$ *and its location into the working front*

Excavation above the displacement level is made by straight buckets placed on rotor (+15m÷ +30m) and for excavation of a bench located under the displacement level, the excavation is made by back-acting buckets placed on rotor (-3,5m÷-7,0m), figure 7.

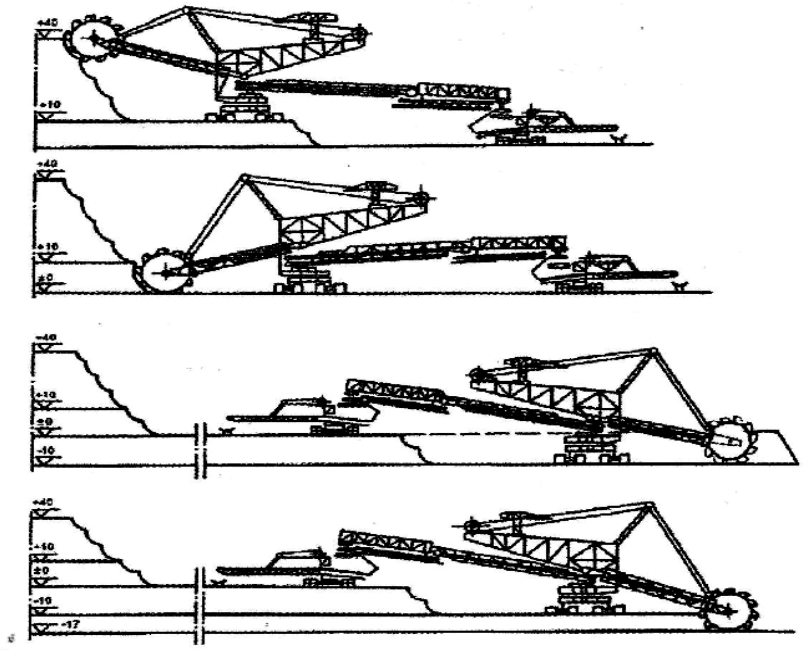

Fig. 7 *Working possibilities of Sch Rs 1400* $\frac{30}{7}$ *excavator*

The bucket excavators types currently used in Rovinari Mining Basin are: SRs 2000-30/7 type, ERc 1400-30/7 type, SRs 1300-28/3,5 type and exceptional ERc 470 -15/3,5 + CBs 1200 type. Technological flows from coal pits of Rovinari Mining Basin have 33 functional bucket excavators, which can ensure an excavation capacity of approx. 83.000 m^3/h.

High capacity belt conveyors (TMC) make the excavated material in the distribution joint, and from there to the coal yard and inside or outside dumps of the mining perimeter. Practically all the TMC make up the composition of technological flow and ensuring the transport of excavated mass and represents the moving vector into a coal pit.

TMC can be stripped when it make up the front technological flow for a bucket excavator or dumper and can be stationary when it makes up the main transport circuits to the coal yards or dumps.

The TMC may be fitted with carts on tracks (MAN) in order to achieve the switches in the distribution joint or can be special constructed with "extensible head" in order to switch into the coal yards.

The currently used types of TMC are the ones with the width of the rubber mat of 1400÷1600÷1800÷2000÷2200mm with metal insertion, or in special cases being used rubber mats with textile insertion (figure 8). The technological flows of coal pits belonging to Rovinari Mining Basin have currently in operation a total of 165 pieces of TMC with a total length of approx. 115 km.

The high capacity belt conveyors (TMC) represent a part of the technological flow where are concentrated the highest cost of electricity with rubber mat, idlers, with additional and monitoring machine, where from result their up to date and decreasing of transport length.

Fig. 8 *High capacity belt conveyor (B=1800mm)*

The knee-type dumpers ensure the deposition of sterile materials into dumps which can be internal or external. The deposition is done generally in deposition blocks with a maximum width of 45 ÷ 90 m in high-bench or under track (low bench), figure 9.

If they are located on the floor of the coal pit and are used with bucket excavators it would perform the transshipment of sterile in the dumps. The currently used types of machines are A2Rs-B 6500x90, A2Rs-B 6300x95, A2Rs-B 4400x170, A2Rs-B 12500x95 and A2Rs-B4400x60. Knowing that the stripping ratio has increased substantially over time, these machines have had and would have an increasingly annual targets.

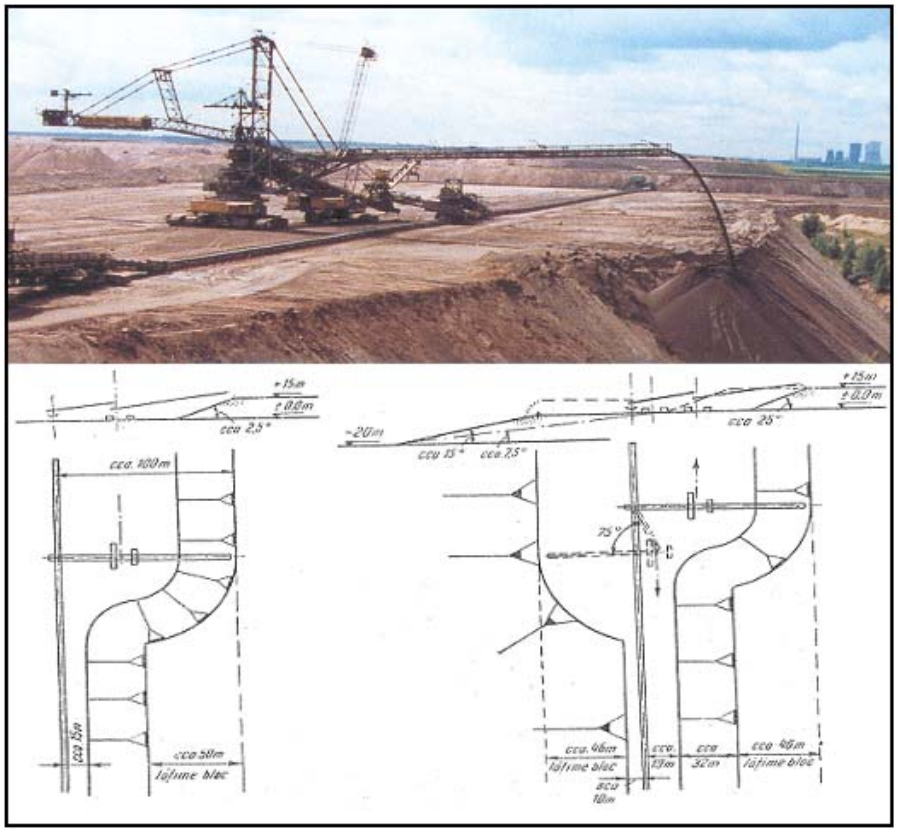

Fig. 9 *The knee-type dumper and the deposition mode of the material into the dump*

Dumping/dumping and şi taking out machines (AsG, KSS) ensure the deposition of coal into the coal yard. These machines are part of technological flows quite complicated where is ensured the deposition, taking out and transfer of coal from the coal pits to the power station or loading points into cars (figure 10).

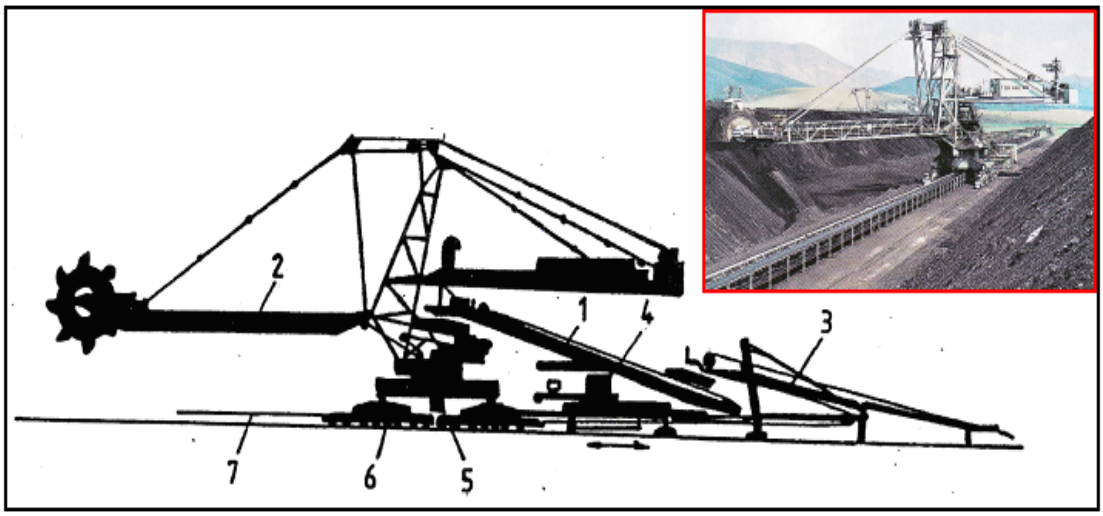

Fig. 10 *The mixed machinery of deposition and loading the coal from the coal yard*
1- input belt; 2- loading-deposition belt; 3- roller; 4- taking-over mass;
5- delivery shaft; 6-displacement system; 7- transportation belt

The technological flows of coal pits belonging to Rovinari Mining Basin have currently in operation a total of 25 pieces of knee-type dumpers and 16 pieces of dumpers, which can provide a storage capacity of approx. 150,00 m^3/h, and a coal storage capacity greater than 0.6 mil tons in stock.

Cicani coal pit

The Cicani mining perimeter is located on the left bank of river Jiu, between the mining perimeters Gârla North and Beterega South. It has been exploited the layers V,VI and VII from the 17 th lignite layers of the basin. The layers have the width of 1,5 ÷ 5m, angles up to 5º, having undulation on many directions, being interrupted by a few faults. The industrial reserves from this perimeter were approx. 15 mil. tons from which have been exploited 14.133.656 tons of lignite.

In terms of quality, the lignite from this deposit has a calorific power of 1800-2200 kcal/kg. By exploitation process there is a dilution, because it's not possible to separate the interlayer under 0.4 m, which conduct to a calorific power of 1750÷1820 kcal/kg.

The evolution of coal production and the sterile from the stripping ratio is shown in Figure 11. The average stripping ratio was 1,61/1(m^3/t). In Cicani coal pit has been applied the *method of transport the sterile rocks to the interior dump.*

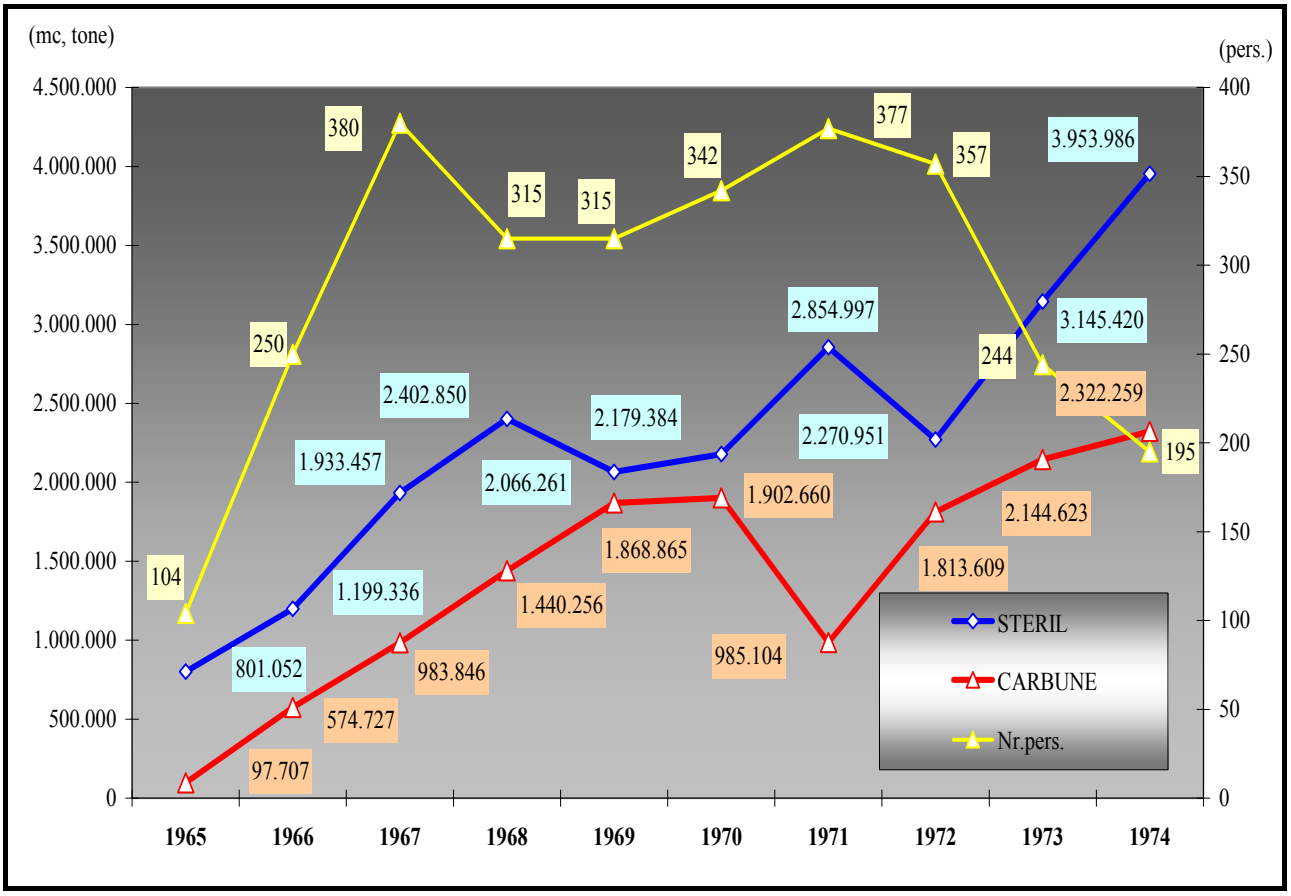

Fig. 11 *The evolution of coal production in Cicani coal pit*

The technical equipment was: bucket excavators, 2 pieces of SRs 470 type, a knee-type dumper ARsB2500x50, a CBs 1200, 8 pieces of TMC 1200 type, with a total length of approx. 7.5 km. The technological flow presented in figure 12 dumps the excavated sterile in the interior dump and the coal is transported into a coal yard with a capacity of approx.1500 tons from a loading point.

The Cicani coal pit was closed in 1974 because the coal deposit went flat. The hole of the coal pit was used in the first phase for dumping the sterile from Beterega coal pit, after which it was used to dump the ash from Rogojelu power station of Rovinari Energy Complex. In a few years the dump of Cicani coal pit was arranged and integrated to agricultural circuit.

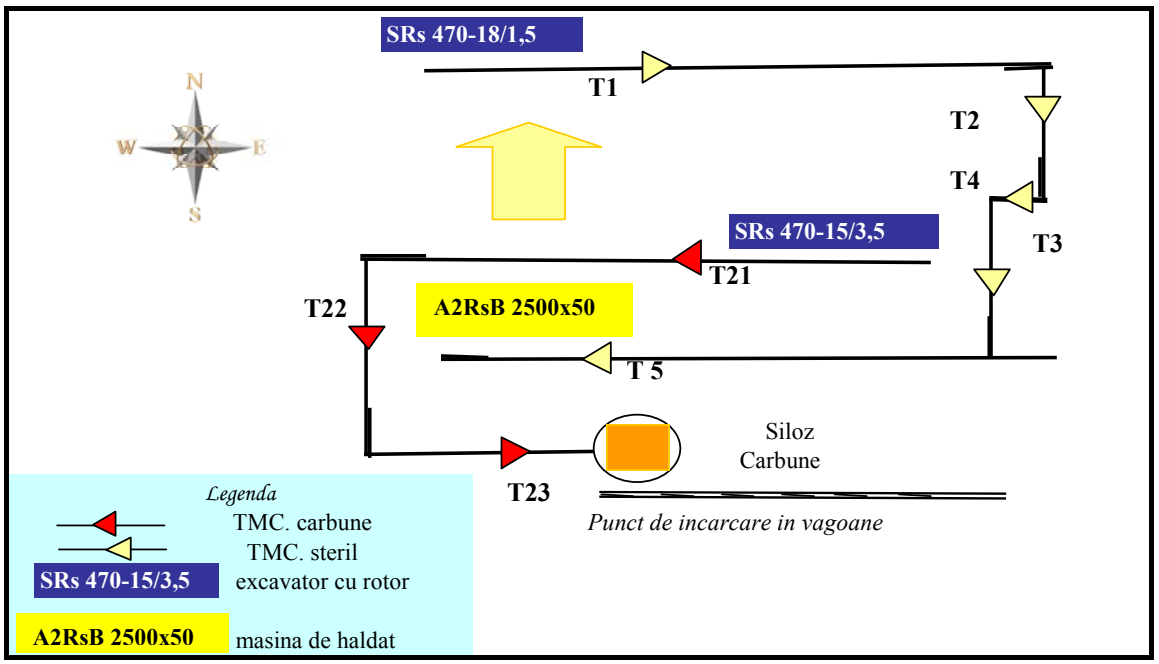

Fig. 12 *Technological flow from Cicani coal pit*

Beterega coal pit

The Beterega mining perimeter was located in the meadow area of Rovinari Basin, to the South of Cicani coal pit. The industrial reserves were approx. 20 mil. tons from which 19.566.742 tons of lignite were extracted, with an average stripping ratio of 1,78:1 (m^3/t). The layer V had a width of approx. 5,5m.

The calorific power of extracted coal was 1785-1855 kcal/kg. The evolution of coal production, sterile and employees is shown in figure 13.

In Beterega coal pit was applied the *method of transport the sterile rocks to the exterior dump.*

The technical equipment was: 3 bucket excavators type SchRs 400 12,8/5, a knee-type dumper A2Rs B4400x60, 3 CBs 1200, 7 TMC type 1200, 1400 with a total length of approx. 8,95 km, 2 pieces of slope bridge with 50 m length with a belt conveyor with a width of 1600mm. The technological flow shown in Figure 14 deposit the excavated sterile into the exterior dump of Cicani and the coal was transported into the coal yard of Rogojelu.

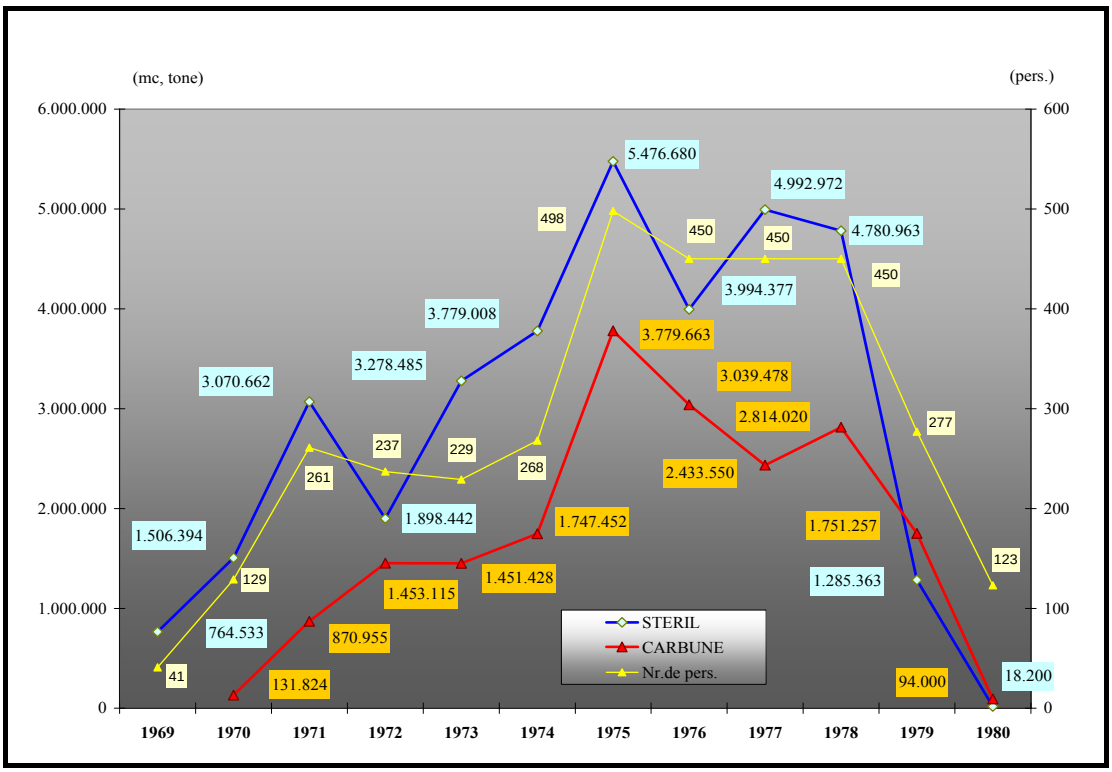

Fig. 13 *The evolution of coal production in Beterega coal pit*

The Beterega mining perimeter was closed in 1980 because the coal deposit went flat.. Continuing the exploitation to the East of Beterega coal pit represented actually the opening of Rovinari East coal pit. The hole of Beterega coal pit is used today to dump the ash from Rogojelu power station.

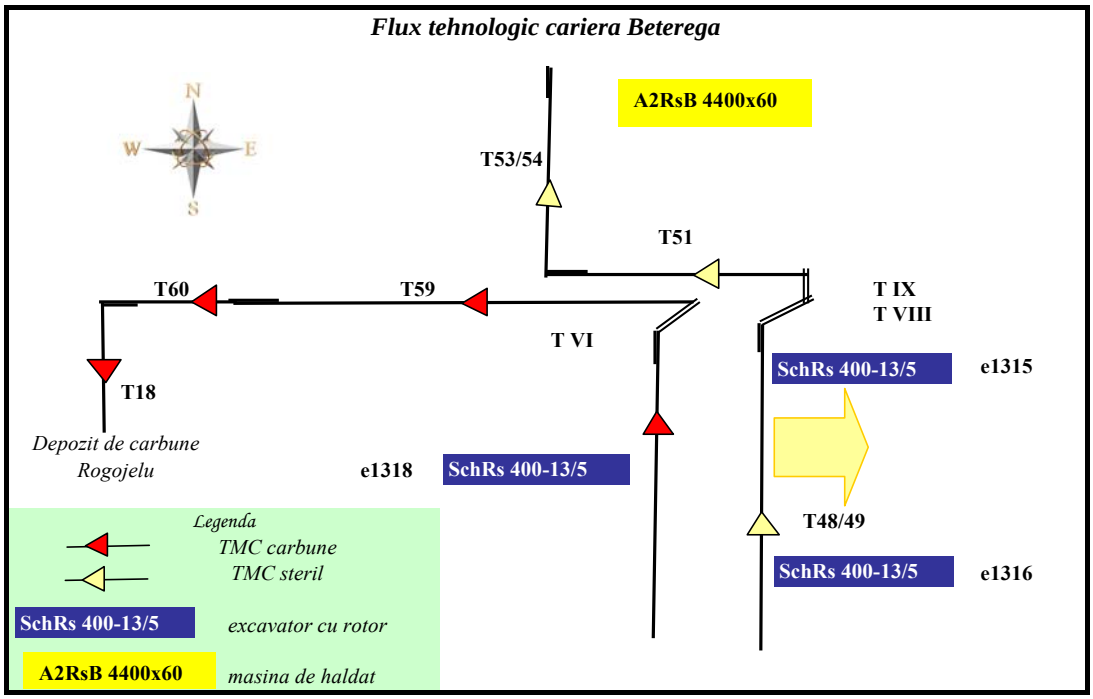

Fig. 14 *Technological flow in Beterega coal pit*

1967 is the year base for the Romanian coal pits, because of the start of the first modern technological line with a *bucket excavator* (SRs 470), *belt conveyors* with textile insertion with B=1200mm and a *knee-type dumper* (ARsB2500x50) at Cicani coal pit. Development of these working technologies in lignite extraction, has guided for a long time the Romanian energy strategy, thus in Rovinari Mining Basin have been opened new coal pits (Figure 15): Gârla, Tismana I, Roşia de Jiu etc.

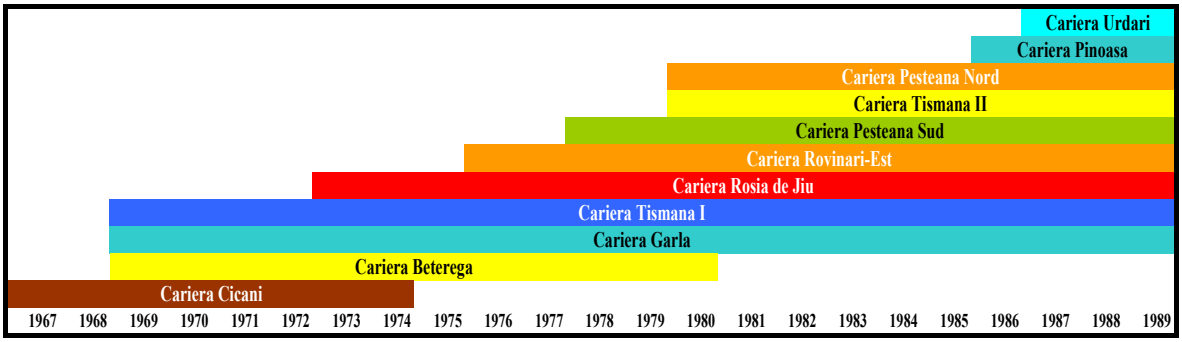

Fig. 15 *The coal pits from Rovinari Mining Basin*

If the designed production capacity of the first coal pits with continuous technological flow were small, respectively for Cicani and Beterega were 1.350 thousand tons/year, according to the existing technical equipment like bucket excavator type SchRs 400 12,8/5, transport circuits made of TMC with textile insertion belt with a 1.200-1.400 mm width, today, the production capacities have increased, so that Pinoasa and Roşia de Jiu coal pits have a production capacity of 3.500 thousand tons/year respectively 4.400 thousand tons/year.

The technical supply from the coal pits of Rovinari Basin has bucket excavators like ERc1400$\frac{30}{7}$ type, SRs1300$\frac{26}{3,5}$ type and SRs 2000$\frac{30}{7}$ type, high capacity belt conveyors with a metallic insertion in the rubber mat, having a width of 1.400-2.200 mm, knee-type dumpers with deposition capacity of Q = 4.400-12.500 m^3/h and the length of L = 60-170 m. The evolution of Rovinari Mining Exploitation from 1967-2011, being considered a standard for Romanian coal pits is shown in figure 16. The mining perimeters from

that time were: Cicani, Beterega, Gârla, Tismana I, Tismana II, Rovinari East and Pinoasa from 2002.

It has to be highlighted the continuous growth of the coal production from 1989 when Rovinari Mining Exploitation has extracted 12.24 mil. tons, and the stripping sterile was 44,48 mil. m^3. After 1990 the coal production has decreased because of the major changes of the society, having a minimum in 1999 of 3.32 mil. tons with 23.86 mil. m^3 of sterile, and also because of the workers dismissing in 1997. Today, the coal production is approx. 6.5 mil. tons of extracted coal with a stripping ratio of approx. 7.0:1 (m^3/t).

It is obvious the increase of stripping ratio, which was 3:1(m^3/t) in 1981 and after 30 years has become 6.65:1(m^3/t) in 2011, in conditions of developing the coal pits to the final limit (Gârla, Rovinari East) and others have moved to the hilly area (Tismana I and Tismana II).

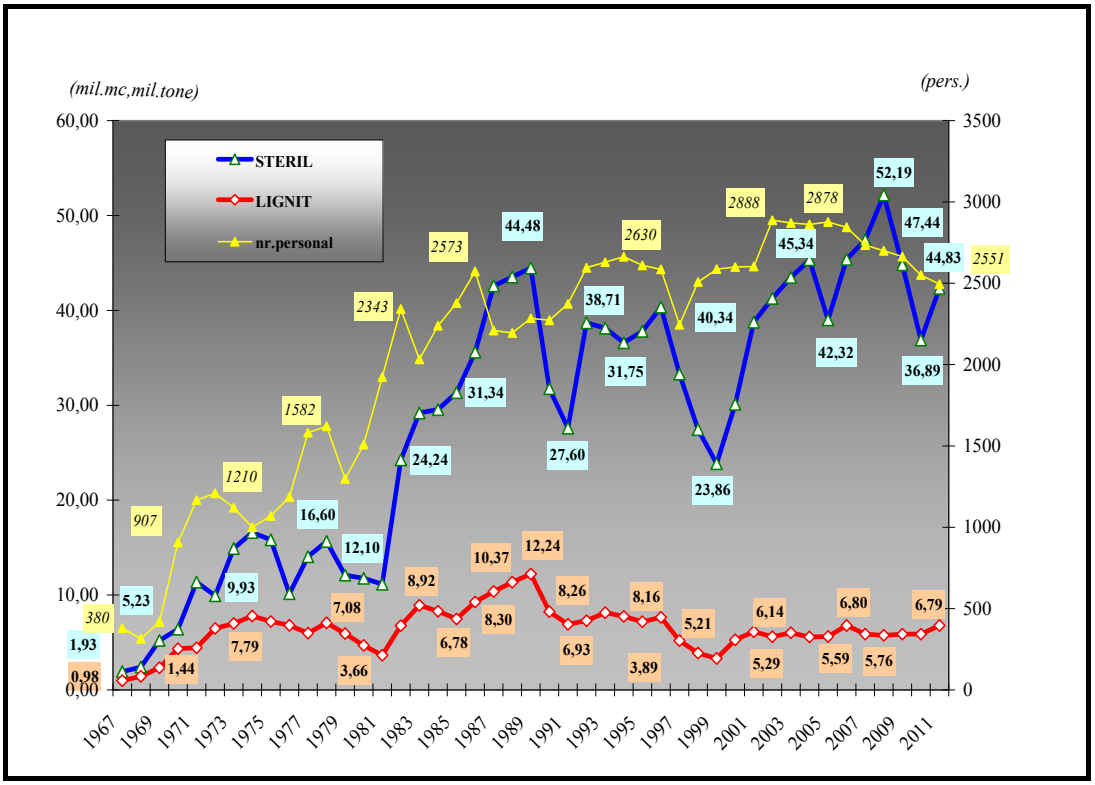

Fig. 16 *Evolution of coal production at Rovinari Mining Exploitation*

Nowadays, the most representative coal pits from Rovinari Mining Basin are: Tismana, Rovinari and Pinoasa coal pits which have the technological flows presented in figures 17, 18 and 19 and in table 1 are shown their economic results from 2011.

Today, the extraction of coal from Oltenia Mining Basin is made by SNL Oltenia Târgu-Jiu SA, SC Rovinari Energy Complex SA, SC Turceni Energy Complex SA and SC Craiova Energy Complex SA from the leased perimeters, which ensure the lignite demand from Romania.

Table 1 *Economic results of the coal pits from Rovinari Mining Exploitation*

Specificatie	U/M	***Tismana***	***Rovinari***	***Pinoasa***
PRODUCŢIA FIZICĂ	mii to	3.114,32	1.967,61	1.709,85
DESCOPERTA	mii mc	19.756,87	12.326,63	10.234,77
CHELTUIELI TOTALE	lei	112.300.887,31	79.755.238,76	82.372.257,03
CHELTUIELI DE EXPLOATARE	lei	112.300.887,31	79.755.238,76	82.372.257,03
Număr personal	pers	672,00	528,00	532,00
Câştigul mediu lunar	lei/pers/luna	3.703,06	3.640,75	3.607,86
COST UNITAR	lei/tona	*36,06*	*40,53*	*48,18*
PRODUCTIVITATEA FIZICA A MUNCII	tone/pers	4.634,40	3.726,53	3.214,00
	(tone+mc)/pers	34.034,51	27.072,42	22.452,29
CHELTUIELI ACTIVITATI AUXILIARE	lei	24.941.806,00	16.710.086,50	11.903.671,47
CHELTUIELI DE ADMINISTRATIE	lei	12.910.537,00	9.928.896,07	10.238.457,74
CHELTUIELI TOTALE	lei	150.153.230,31	106.394.221,33	104.514.386,24
COST UNITAR TOTAL	lei/tona	**48,21**	**54,07**	**61,12**

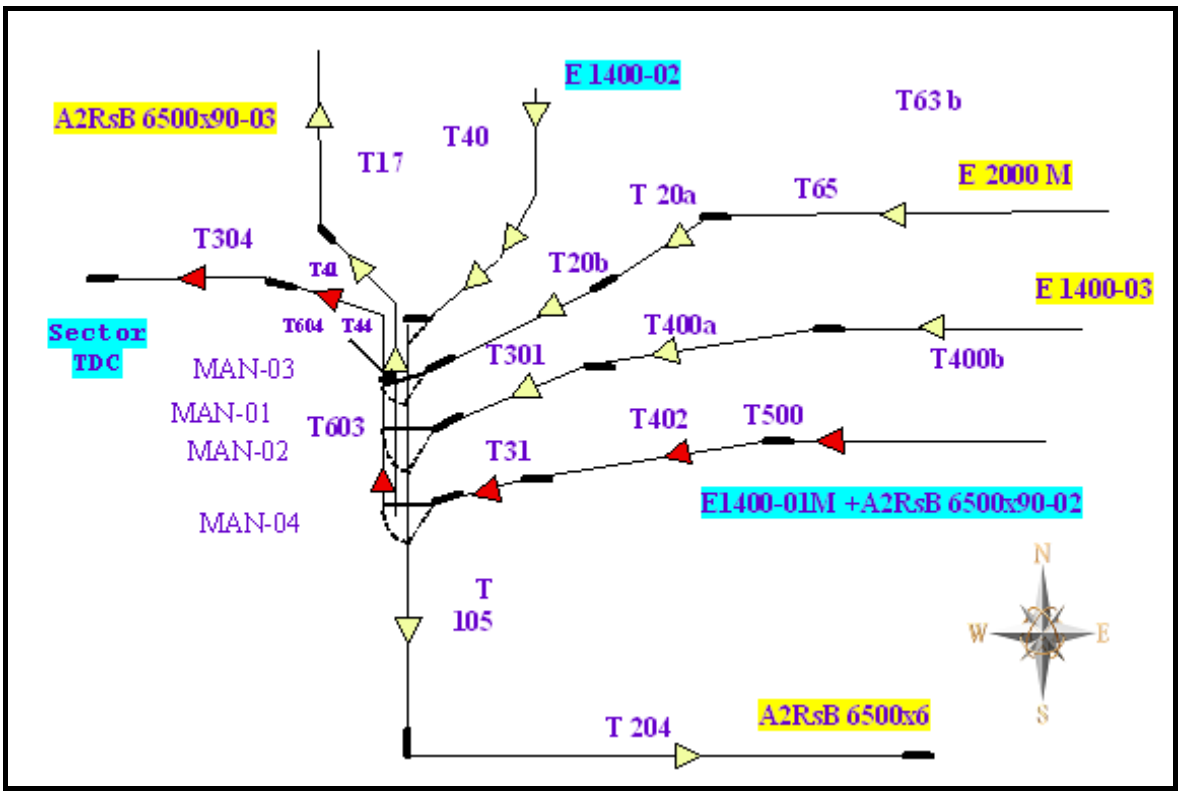

Fig. 17 *Technological flow in Rovinari coal pit*

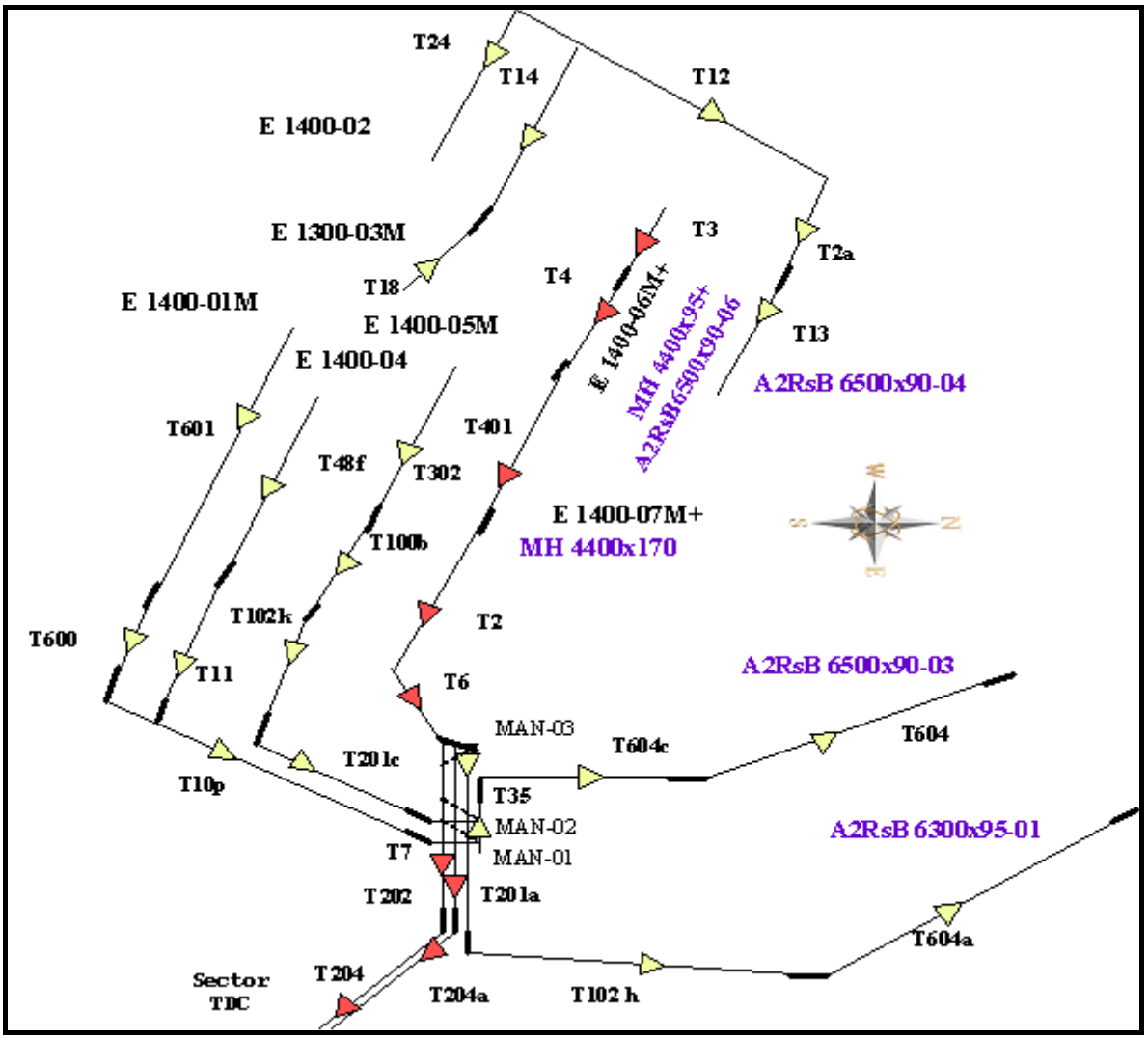

Fig. 18 *Technological flow in Tismana coal pit*

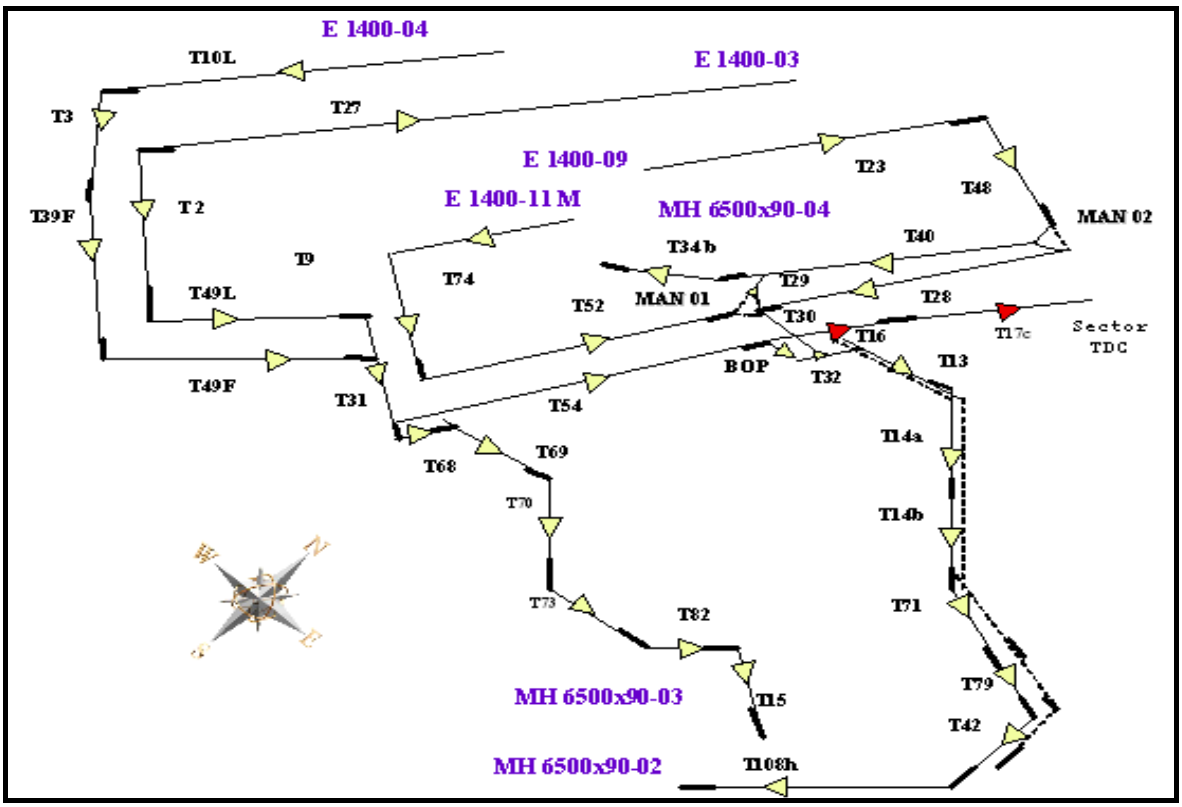

Fig. 19 *Technological flow in Pinoasa coal pit*

3. Conclusions

The first coal pit opened in Romania was Balta Unchiaşului from Rovinari Mining Basin, which from 1955 has practiced different extraction methods.

The continuous and discontinuous technology flow of sterile and lignite extraction with bucket excavators and cutting buckets and transportation by high capacity belt conveyors of excavated material, have been applied for the first time in Romania in 1967 in Cicani coal pit and in 1969 in Beterega coal pit, using German technological projects.

Exponential development of lignite extraction in the coal pits of Rovinari Mining Basin and the lately progress are a result of an update of transport systems and equipment from the technological flows.

To satisfy the demand in 2013-2030 must highlight the existing perimeters and satisfy the research for capitalizing the new perimeters. Therewith the expropriation procedures have to be improved for a better efficiency of lignite extraction.

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