ISSN 1454-9174

ANNALS
OF THE
UNIVERSITY OF PETROSANI

MINING ENGINEERING

vol. 15 (XLII)

UNIVERSITAS PUBLISHING HOUSE
Petroşani – ROMÂNIA, 2014

ISSN 1454-9174

Editorial office address: University of Petroșani, 20 University Street, 332006, Petroșani, Romania, Phone: (40) 254/54.29.94, 54.25.80, 54.25.81, 54.25.82, 54.97.49, Fax. (40) 254/54.34.91, 54.62.38, www.upet.ro, E-mail: ibol@upet.ro

CONTENTS

GOLD MINING AT APUSENI MOUNTAINS IN ATIQUITY

IOAN-LUCIAN BOLUNDUŢ*

Abstract: *Gold Dacia was the main cause of its conquest by the Romans, to save the Empire from bankruptcy. Gold and silver deposits Dacian were stationed in the Golden Quadrilateral of the Apuseni Mountains. It seems that when the Romans sacked 165.5 tons of gold and 331 tons of silver, and 165 years of occupation have mined 500 tons of gold and 950 tons of silver. The Romans were not satisfied with just taking over the mines and miners in the Apuseni Mountains, but also brought the technique used when the main mining centers of Hispania and Britannia Empire and skilled miners in Illyria. Archaeological research undertaken gives evidence on the mining organization and technology applied here in antiquity in order to obtain gold. This paper presents the organization of the ancient mining, mining methods used, ore transport, groundwater discharge, ventilation and illumination of the mines*

Key words: *gold mining in antiquity, mining organization, mining technology.*

1. INTRODUCTION

Extraction and processing of useful minerals appears together with the history of mankind in order to produce weapons and tools. The first rock to be employed was flint, but later on, in the Neolithic, gold and copper came to be utilized. In the second millennium B.C., bronze was discovered by amalgamating copper with tin or lead. Bronze tools and weapons were far better than those made of copper, as they had a superior hardness and were easier processed during molding. Such objects were discovered all over Romania, but more frequently in Transylvania where there were also found several non-ferrous ore deposits. Still here were discovered many treasures and gold items, with the assumption that those found at the East and South of the Carpathian Mountains – dating from the Bronze Age and the first stage of the Iron Age – were also made of gold that had been extracted and processed in Transylvania.

Probably, gold mining in the Apuseni Mountains (i.e. the Occidental Carpathians) started somewhere during the 7th century B.C., when some of the Greeks that had left their country for Caucasus in search of the *Golden Fleece* turned towards us, where they could also obviously find such a *fleece*. Otherwise cannot be explained the multitude of coins, household and art objects and of tools used at the extraction and processing of gold, all of Greek origin, which were discovered here and dated from this period. Some sources say that the Phoenicians would have been delving, as well, into this richness. By the 6th century B.C., some Scythian shepherds, who had already known how to get the gold from the river sand, as they were passing their sheep across the Carpathians, discovered the precious metal in the rocks of the mountains and settled themselves down on the Mureş River Valley to become outstanding gold producers. About another branch of the Scythians – the Agathyrsi – there is also written evidence from several ancient authors starting with Herodotus. As he describes the war of 514

* *Prof. Ph.D. University of Petroşani, ibol1947@gmail.com*

B.C. of the great Persian King, Darius, against the Scythians at the north of Danube, he mentions that Agathyrsi used to live in the Apuseni Mountains area and that they mastered the art of mining and of processing golden jewelry.

The art of extracting and processing of gold and silver was taken over from the Agatyrsi by the Dacians, who did not neglect the use of iron in the making of weapons either. Starting from the assertions of our great historian and archaeologist Vasile Pârvan in his *Getica,* it was believed for a long time that all the Dacian gold captured by the Romans would have been obtained only from the river silt. But, between 1999 and 2006, a team of French archaeologists and researchers from Centre National de Recherche Scientifique (CNRS) and from Unité Toulousaine d'Archéologie et d'Histoire (UTAH) together with geologists from Cluj-Napoca and München executed researches in the field of mining archaeology in some very old mining works at Roşia Montană. On this occasion, there were also discovered some wooden structures of mine sustaining elements. The dating of the samples of this wood, done by help of C_{14}, goes back somewhere between 295 and 90 B.C. that is, among 200 and 400 years before the Roman occupation!

2. MINING ORGANIZATION

The riches of gold and silver available in the Apuseni Mountains were definitely known to the Romans as well. The only significant gold deposits in the empire found in the Iberian Peninsula had already been exhausted, so that, the single rescue from bankruptcy of the proud empire could be the Dacian gold. Trajan already knew this very well so he couldn't leave anything happen by chance, but prepared himself thoroughly for the conquest of Dacia – the result of the two military campaigns of 101–102 and of 105–106, carried out by him. Having defeated the Dacians, Trajan remained here for another couple of months in order to organize the new province and especially the gold mining in the Apuseni Mountains. On the grounds of a *Lex Provinciae* the borders of the new province and its juridical basis were established, as well as the imperial domains and the capital at Sarmizegetusa. The main imperial domain was the gold-bearing area, directly subordinated to the imperial administration. Its headquarters were in Ampelum and it was run by a *procurator aurariarum* who exercised his duties by means of an administrative apparatus made out of technicians and clerks and which disposed of a limited number of soldiers to ensure the military guard of the gold-bearing area. The procurator was in charge of mining efficiency and he used to receive all the direct and indirect incomes of the domain. There was also the possibility of renting some of these mines by little entrepreneurs, the usual renting interval being up to 5 years without renewal. The renting fee was established by the procurator and it had the average value of 4,000 sestreti per year (1 sestret = 1 gram of silver) so, this was not too big. Among the most important mines worked by the Romans in the Apuseni Mountains are to be mentioned those at Bucium, Roșia Montană, Baia de Arieş and Zlatna, as well as those around the town of Brad. Initially, the hand labor employed by the Romans consisted of local inhabitants transformed into slaves. They were not allowed to move to a different place and could be sold or rented by their masters. In order to increase the amount of the extracted gold and silver, the Romans brought here colonists from Dalmatia and other areas having a tradition in working in mine deposits, to labor alongside natives. Dalmatians were settled down at Bucium in establishments called *vicus* and *castellum* in quite a large number, so that they organized themselves in a separate corporation run by Celesenius Constans to whom Opellius, the governor of Sarmizegetusa, raised a tombstone at Ampelum, the place where he died [*Corpus Inscriptionum Latinarum, III, 1322*]. A consequence of the employment of both native and colonist miners at gold mining in the Apuseni Mountains was a period of flourishing until the autumn of 167 which marked the beginning of the Macromanic War (167–175). Macromans were one of the Germanic tribes related to Suebians and Longobards; they carried out two wars against the Roman Empire (167–175 and 178–180). In the autumn of 167 they reached up to Ampelum and Alburnus Maior, destroyed the whole mining area and pilfered all the gold and silver they found. The disaster was so great, that other colonists had to be brought here to work in the mines. The Macromans were defeated by Marcus Claudius Fronto, the governor of Dacia and of Superior Moesia (168–170), to whom the citizens of Sarmizegetusa raised a statue bearing an inscription in which they praised his bravery [*Corpus Inscriptionum Latinarum, III, 1457*]. The great German historian and archaeologist Theodor Mommsen (1817–1903), an expert in the history of the Roman Empire and coordinator of the monumental work in 12 volumes, *Corpus Inscriptionum Latinarum,* believes that the inhabitants of Roşia Montană and Bucium had hidden most of their riches from the eyes of the Macroman invaders in places known only to them. Mommsen is right as the same inhabitants will act in the same way along the next thousand years during the Barbarian invasions.

Many of the written information on the mining organization in the Apuseni Mountains come from a series of *waxed tablets* discovered at Roşia Montană in the old Roman mine galleries between 1786 and 1855. These are small wooden boards bound in sets of two (diptychs) or three (triptychs) pieces together and coated with bee wax on which different texts could be written. The total amount of discovered tablets was 40, of which only 25 have been preserved, four of them being complete triptychs. They come from the time of the Roman emperors Antoninus Pius (138–161) and Marcus Aurelius (161–180) and one of them from the time of Hadrianus (117–138). These texts contain contracts regarding the renting of the mines by individuals, or different associations done in order to run the mining process, contracts of sale and purchase of slaves, bills, an act regarding the dissolution of a funeral college, and a menu with all the dishes of a party organized by a college of artisans. As a matter of fact, at this party held on the eve of the calends of May, that is, on the 30th of April, the total amount of wine to be consumed exceeded by far, half of the entire expenditure! This demonstrates the everlasting validity of the saying: *„Food is swagger, drinking's the foundation!"*

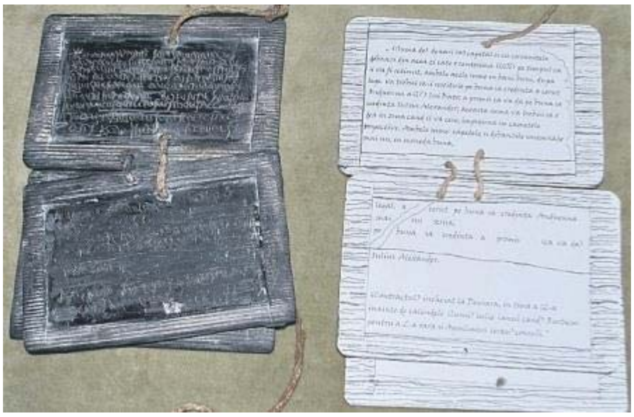


Figure 1 Triptychs of waxed tablets, resembling books

3. MINING TECHNOLOGY

Dacian mining technology could not be restored in the absence of relevant archaeological evidence. Certainly, they obtained the alluvial gold by the same procedures that had been used until the Middle Ages, and even later. The golden veins found in the mountain areas were washed by waters and the little parts of ore detached from the vein were taken down to great distances and crumbled into pieces. Those looking for the alluvial gold nuggets used to have simple tools. With the help of a hoe and of a container, the golden sand was taken out of the river bed and downloaded on the superior side of an inclined surface made of wooden boards and covered with a raveled woolen fabric. With a wooden dipper, water was taken out of the river and poured over the sand placed on the slanted board, in order to make it move downwards onto the woolen fabric. To help the sand move, there was also used a scraper. As the fleece retained the gold nuggets, this was washed out into a two-handled water tub and then, the resulting gold was separated from the remaining sand by help of a buddle.

It is hard to believe that the huge amount of gold gathered by the Dacians resulted only from river silt. Going upstream they discovered the outcrops of the gold-veins and started mining, initially at the surface, and then in the depth of the ground. Dacian mines were not such elaborated as those found in the Iberian Peninsula or Britannia, being probably just narrow coast galleries of short length or shallow wells dug into the veins. As already mentioned, it was scientifically proved that Dacians had already practiced underground mining several centuries prior to the Roman arrival.

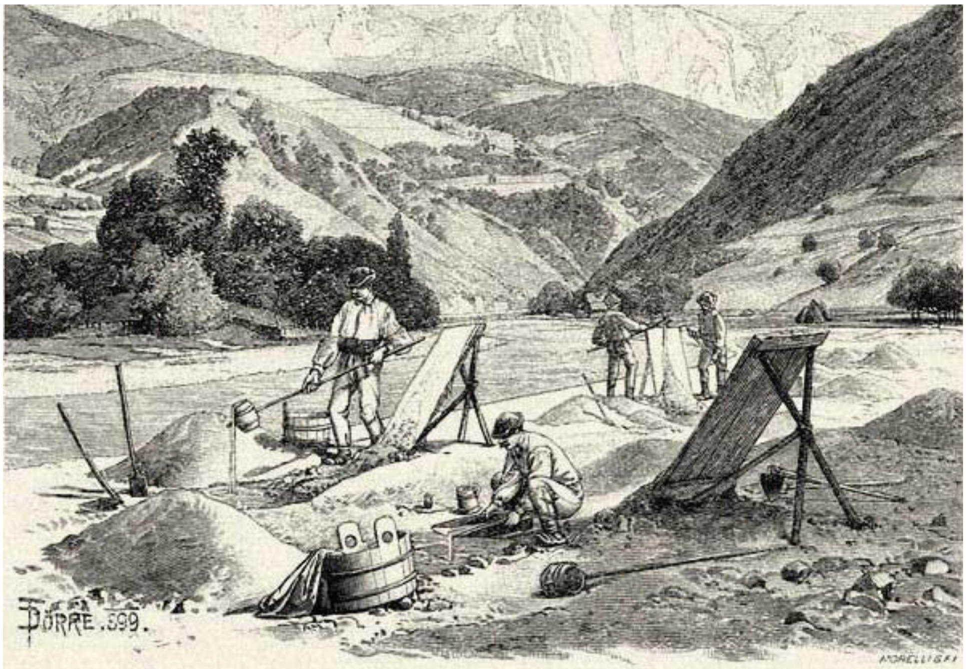


Figure 2. Extraction of alluvial gold

The conquest of Dacia by the Romans also represented the improvement of both gold extraction and gold processing technologies. They were not satisfied with simply taking over the mines and miners in the Apuseni Mountains, but also brought along with them the technique of those days, used in the major mining centers of the empire, as well as skilled miners. The most interesting vestige of the Roman surface mining at Bucium is a trench called *Ieruga* , dug into the southern slope of *Corabia* (i.e. *The Ship*) into the outcrop of the gold-vein with the same name, and very rich in gold. It has a length of 500 m and an average depth between 20 m at the top, and 30 m at the bottom. The width of its basis is of 15 m at the top, and 20 m at its bottom. This work is a faithful copy of the Spanish *Corrugates* as seen and described by Pliny the Elder (23–79 A.D.) in his *Naturalis Historiae.* Exactly like in Spain, at the foot of this mine work there was arranged a lake of 120 x 120 m, corresponding to the lake of 200 x 200 steps described by Pliny, its water being necessary to separate the gold that resulted from the ore crushed in the mills. It's been estimated that the Romans had extracted only from this place, about 4 tones of pure gold. Nowadays, this area is forested, but in a picture made around 1900, the old Roman mining work is obviously seen.

By the end of the 19th century, in the area of the old lake at the foot of the Roman trench, there were discovered a grinding mortar made of amphibolic andesite and a stone of quartzy conglomerate used at crushing the golden ore. Further on, the crushed ore was ground in stone mills. The gathering of gold was done gravitationally, by help of the water in the pond which caused the moving of the grinded product onto the slanted plane, as already mentioned. The barren tailings were washed and taken away by water, while gold, heavier than that, remained onto the sheepskin or shaggy fabric on the slanted board. In order to avoid material flowing to the sides of the inclined plane, this had to be bordered. The gathered particles of gold were then melted in crucibles made of fireclay and placed into the ember of an open hearth. The melted content was actually an alloy of gold and silver, which also contained other impurities. To obtain pure gold, they introduced salt (NaCl) into this mixture and so, separated gold from silver, as described by the Roman historian of Greek origin Diodorus of Sicily in the 1st century B.C. In this way, they obtained pure gold and silver chloride. The silver chloride was mingled with the lead oxide of which, silver was separated by cupellation.

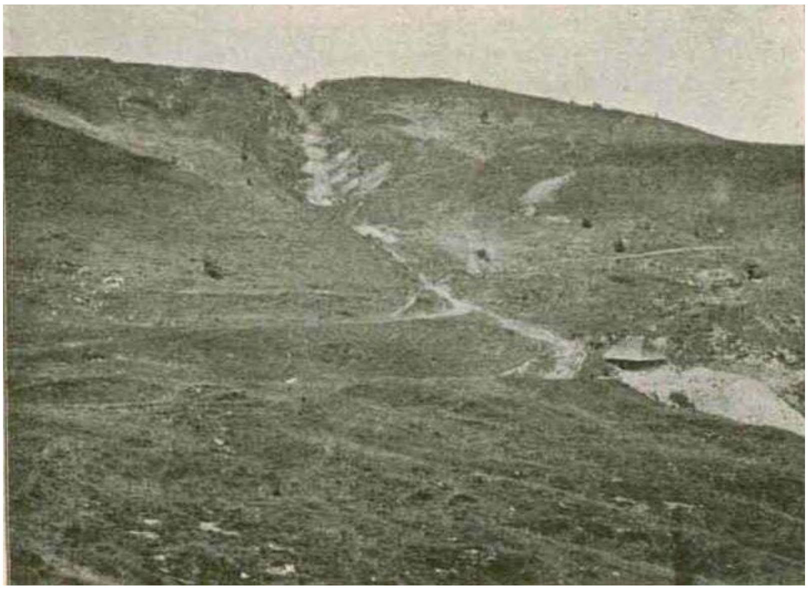


Figure 3. Ieruga dug by the Romans on the southern slope of Corabia

For the underground mining, the opening of mines was done by drifts dug from the surface. In the area of the ore deposit, works were then continued either by directional galleries, mined along the vein, or by cross-heading ones. Galleries (*cuniculi*) were opened as far as possible, in hard and compact rocks and digging was done by help of chisel and hammer. Directional galleries were between 2.1 and 2.7 m high, depending on the size of the vein, while the cross-heading ones were between 1.5 and 1.8 m high and between 0.6 and 0.65 m wide.

Where the rocks were firm, galleries were not reinforced, but given a vaulted ceiling for a better distribution of pressure onto the side walls (fig. 5. a). In the case of an inadequate ceiling, reinforcement was done only with wooden beams tightened with wedges and lined with boards (fig. 5. b.), but if the walls we not strong enough they had to be reinforced either with half (fig. 5. c), or with complete wooden frames (fig. 5. d).

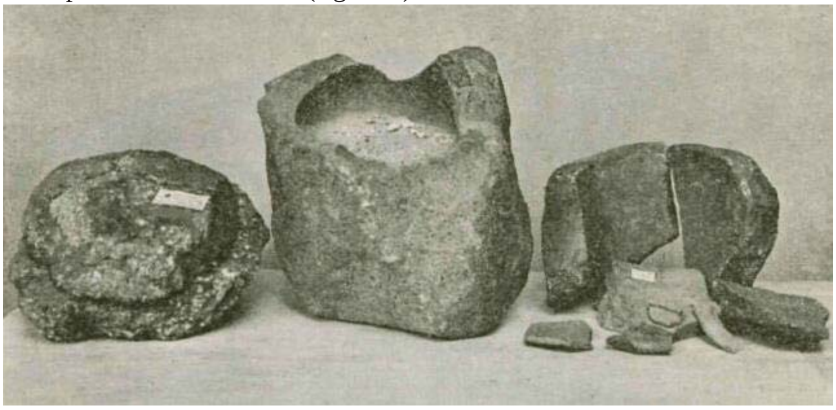


Figure 4. Roman mortar used at crushing golden ore, discovered at Vulcoi
Museum of Geology in Budapest, Hungary

The work in the heading galleries – in case of a hard rock – was done by cutting a square groove of 20 x 20 cm with a depth of 5–7 cm at the centre of the cross section of the drift; then, the groove was enlarged to 40 x 50 cm and then to 70 x 90 cm. In the end, the entire outline of the gallery was achieved and the wall was smooth, without cracks. This explains why such galleries as those at *Saints Peter and Paul* have been preserved in such a good condition for almost 2 thousand years. When the rock was very tough, *the method of fire and water* was used. The first written evidence on this ancient technique belongs to the Greek historian and geographer Agatharchides (2^{nd} century B.C.) and later, this is described by Diodorus of Sicily. First, the rock was heated by help of fire in order to produce its expansion, and then, it was cooled down by sprinkling of water upon it, to cause a sudden contraction and thereby, to make it crack or break into pieces. This is how the endless areas of sand in the desert came into being, with great heats during the day and very cold nights. In the writings of the ancient authors it is said that sometimes, water was replaced by vinegar, as the latter has a greater destructive power, due to its higher contraction value.

Among the *gold mining methods* applied by the Romans on the veins at Bucium, are to be mentioned:

a **–** *Mining in ascending directional strips, with the filling of the mined space;* this was practiced in those places where the rock was not too hard, and the material was dislocated by help of the chisel and hammer. The amount of backfill was small and this could be produced even in the working face drift, by cuttings done into the walls next to the vein.

b **–** *Mining in descending directional strips, without the backfilling of the mined space;* this was used in the diggings of Ieruga-Scursura, were the rock was hard and very hard. In this case, the vein was left aside in one of the working walls while the sterile, more fragile, was removed. The vein was then extracted with the chisel and hammer, by execution of grooves disposed perpendicularly, in a way that created squares of various dimensions which were then cut out. To avoid accidents, mined spaces were reinforced with wood.

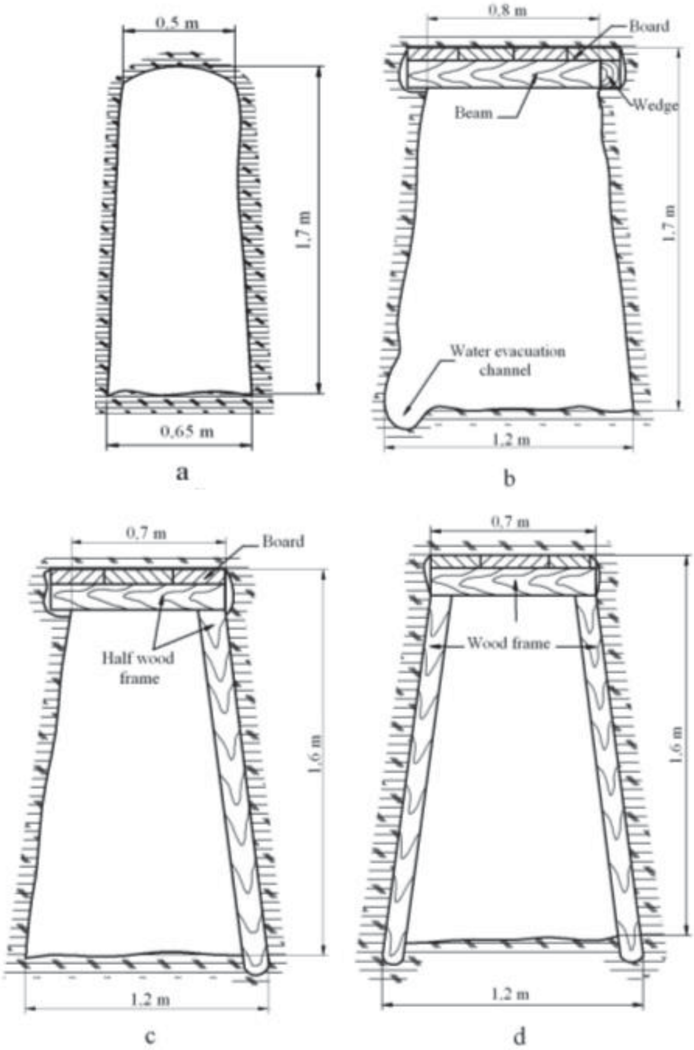


Figure 5. Types of Roman galleries

c – *Operating by subsidence* was used in the areas with a dense network of thin veins. Advancing in the direction of the veins was done through overlapped galleries, separated vertically by safety floors. By subsequent collapsing of these floors, there resulted some huge empty spaces called *Corands,* such as the one at Dealul Frasinului (i.e. Ash Tree Hill) situated between Șasa and Muntari.

Ore transport to the surface was done manually, by means of wattled baskets fastened onto the shoulders. In the working face drift, an initial separation of sterile and useful ore was done, and only the latter was taken to the processing place. To evacuate the ore excavated in the very narrow directional galleries they used a sort of trough, that is, a vessel made by hollowing a wooden trunk of 1.4–1.5 m length and 0.4–0.5 m width. This was pulled out by help of a rope connected to a handle at its end. The uploading of the material was done with a wooden bowl. Both these objects have been found in a Roman gallery in the mine of *Saints Peter and Paul*, the bowl being made of ash tree wood.

Evacuation of water was one of the most difficult problems to work out with the technical equipment of the time but, starting with the first century A.D., the Romans made use of two such devices to evacuate water on the vertical: *Archimedes' screw* and the *Hydraulic wheel*. The first device had been invented by the great ancient scholar Archimedes (287–212 B.C.) as a military implement, afterwards being also used to evacuate waters from the gold mines of Egypt and the Iberian Peninsula. This was built of a wooden cylinder in which a spiral snail with the propeller made of wood or copper, was made to revolve. The screw was revolved manually, by means of a crank. Such a device, discovered in the Roman gold mines of the Iberian Peninsula, was about 3–5 m long, with an inner diameter of 20–30 cm, and able to evacuate 35–40 l of water/min and had an efficiency of 40–50 %.

The hydraulic wheel, similar to that of a water mill, was built of a shaft with spokes and an exterior rim having a diameter of 4–6 m, on which 20–24 cups were fixed and made watertight with resin and wax. The cups raised the water from a lower tank and discharged it into a superior basin through an adjacent pipe. This operation was repeated on the vertical, up to one of the drifts which was provided with a drain. The wheel was moved manually, by help of some handles fixed on the exterior side of the rim or by treading by one or two persons on a particular frame placed at the superior part of the wheel. The height at which water was lifted was of ¾ of the wheel diameter and the water discharge reached up to 70–80 l /min. The one who described these hydraulic wheels was the Roman architect Vitruvius (1st century B.C.) and several specimens were found in the Iberian Peninsula, Great Britain, and in Romania at Roşia Montană and Brad (fig. 7). At Rio Tinto, in Spain, 8 such wheels connected into a system that was projected to evacuate waters by taking them to a height of 30 m, have been discovered.

Mine ventilation was achieved by convection, that is, by taking advantage of the vertical movement of the air, due to the lower density of the warm air inside the mine, compared to the higher density of the cold air, outside. Ventilation was absolutely necessary in those places where fire and water were used, in order to evacuate smoke and steam. This was realized by digging above the main gallery, at a distance of 4–5 m, of another gallery and by joining them together through ventilation wells. Clean air entered through the main shaft, while vitiated air went out through a secondary one; at its end they used to make a fire in order to enhance depression. The ventilation wells were dug at about 10 m distance from one another.

As soon as the new ventilation well was dug, the previous ones were backfilled in order to avoid evacuation of the fresh air through the ventilation well, but lead it towards the working place. Such works have been described by several ancient authors (Lucretius, Vitruvius, Strabo and Pliny the Elder), and subsequently discovered *in situ* (i.e. in the site) at Rio Tinto in Spain. Ventilation wells and galleries had quite small sections of about 1 sq. m. According to Pliny's description, the quality of ventilation used to be checked by help of a lamp; in case the lamp failed to light, workers were evacuated and measures to improve ventilation had to be taken.

Mine illuminating was achieved by lighting lamps (*lucernae*). The lamp was made of burnt clay and it illuminated by means of a wick which was introduced into a container filled with tallow, lard or oil. The tank could be either open, or closed. In the latter case, the tank was endowed with one hole for the fuel and with 1–3 orifices for the wick. At Vulcoi, there was discovered a lighting lamp bearing the brand of *FORTIS.* The brand was always applied on the lower side of the tank and it displayed the name of the manufacturer. In order to be carried, the lamps were provided with a handle. Usually, they were placed in some niches carved in this respect, into the walls of the galleries. Pliny the Elder believes that the oil lamps were also used to measure the working time, probably a day, or a shift of 8 or 10 hours.

Figure 6. Archimedes' screw

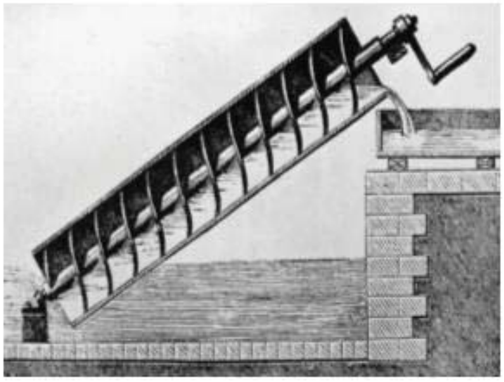


Figure 7. Hydraulic wheel

Traffic in the wells and between levels was done by wooden stairs made of trunks in which steps were carved at a distance of 0.4–0.5 m. Such stairs have also been discovered in the Roman mines at Vulcoi.

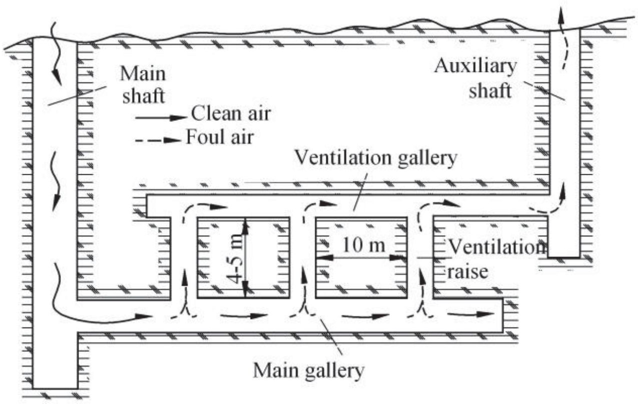


Figure 8. Ventilation in a Roman mine

Figure 9. Mining lamps

4. CONCLUSIONS

As already mentioned, the Romans had captured from the Dacians 165.5 tons of gold, and 331 tons of silver, and during the 165 years of occupation they extracted another 500 tons of gold and 950 tons of silver. Following the Roman withdrawal from Dacia, the entire course of the socio-economic life got a rural character. Economy turned back to grazing and extensive agriculture and the crafts declined, receiving a predominantly domestic character. Mining made no exception. After the Roman withdrawal, mining activity of the natives was reduced to the use of metals for making agricultural tools, weapons and household utensils. Gold mining in the Apuseni Mountains was probably reduced to the alluvial mining in the river beds, and mining in some of the poorer gold veins found near the surface, which had no relevance to the Romans. Yet, it's hard to believe that miners remaining here after the Roman administration withdrawal abandoned their job and started grazing animals – as agriculture seems impossible in the area. Gold and silver represented, for sure, a strong currency even in those troublesome times of which we know very little.

Roman mining technology was so advanced that in the next 1.500 years it remained unchanged not only in our country, but in the whole Europe, as well. On the land of our ancestors, the barbarian invasions erased the Roman–Dacian culture and civilization for the next thousand years and so, there followed the so-called *dark millennium.*

REFERENCES

[1]. **Baron, M.** – *Istoria mineritului în România,* Litografia Universităţii din Petroşani, 1999.

[2]. **Bauer, G. –** *A rudai 12 apostol bányatársulat aranybányászyta,* Bányászati és Kohászati Lapok, XXXVII/1904/2k, pp.289–338, Budapest, 1904.

[3]. **Croce, G. –** *Breve storia delle lampade da minatore,* Tipografia Nero su Bianco, Agordo, 2006.

[4]. **Faller, G. (**coordonator general**)** – *A magyar bányászat évezredes története,* Országos Magyar Bányászati és Kohászati Egyesűlet, Budapest, 1997.

[5]. **Fodor, D. –** *Pagini din istoria mineritului,* Editura INFOMIN, Deva, 2005.

[6]. **Maghiar, N., Olteanu, Şt. –** *Din istoria mineritului în România,* Editura Ştiinţifică, Bucureşti, 1970.

[7]. **Nichitean, C., Jianu, C. M. –** *Din istoria extragerii aurului aluvionar,* www.anu-arulsargetia.ro/din-istoria**-extragerii-aurului-aluvionar.**

[8]. **Pârvan, V. –** *Getica, o protoistorie a Daciei,* Cultura Naţională, Bucureşti, 1926, http://www.scribd.com/doc/16740477/Vasile-Parvan-Getica-O-proto-istorie-a-Daciei.

[9]. **Roman, B., Sîntimbrean, A., Wollmann, V. –** *Aurarii din Munţii Apuseni,* Editura Sport-Turism, Bucureşti, 1982.

[10]. **Rusu-Abrudeanu, I. –** *Aurul românesc ● Istoria lui din vechime până azi,* Editura Cartea Românească, Bucureşti, 1933.

[11]. **Téglás, G. –** *A dácziai bányászat lámpabélyegei,* Bányászati és Kohászati Lapok, XLII/1909, pp. 484–488, Budapest, 1909.

[12]. **Téglás, G. –** *Római bányámécsesek a Zalatna–Bucsum közti Korábia bányászatából,* Bányászati és Kohászati Lapok, XLV/1912, pp. 204–205, Budapest, 1912.

[13]. **Xenopol, A. D. –** *Istoria românilor din Dacia Traiană* (Ediţia a IV-a), Editura Ştiinţifică şi Enciclopedică, Bucureşti, 1985.

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

CALCULATION MODEL OF THE ALTITUDE MODIFICATION AS A RESPONSE OF THE GEOMORPHOLOGIC SYSTEM FOLLOWING ANTHROPOGENIC ACTIVITIES OF MINERAL RESOURCES EXPLOITATION

GRIGORE BUIA*
CIPRIAN NIMARĂ**

Abstract: *Geomorphologic system response is primarily dependent on the intensity and frequency of anthropogenic exploitation activities held on a geomorphologic resources, and secondly, by the geological, meteorological and soil variables. The most important environmental variables are: quantity of precipitation, wind intensity, type of rock, soil erosion etc. Using the proposed calculation method, we want to quantify the result of the exploitation of mineral resources on the relief. The end result, expressed in value, being in fact the geomorphological system response to these human-induced disturbances.*

Keywords: *geomorphological system, human activity, calculation model*

1. INTRODUCTION

The need to address the problem of extreme phenomena in systemic perspective is appropriate for itself if we consider the fact that in the genesis and manifestation of the risks, a determining role it holds on condition of "causal interface". This condition involves extreme phenomena within the potentialisation of a set of factors and alike, through diversification of their considerable upgrade, in terms of "target" effects. As a result, the attributes as well as systemic complexity, completeness, unity, functionality is deeply involved in the expression of the non-linear evolutionary systems.

Human modeling differs from the natural one, by the degree of intensity, the manifestation, the complexity and design of the products, by printing an irreversible trend to the territory. Thus, areas with positive forms of relief, subject to anthropogenic modeling, were transformed from its original form to a flat form, and flat surfaces have been uplifted with tens of meters. As a result of the feedback it generates a new spatial size and territorial planning, resulting in the occurrence of inversions final relief and critical environments.

* *Prof. PhD. Eng., University of Petroşani*
** *Assist. PhD., University of Petroşani*

Critical environments, seen as a product of the ambient system malfunction caused by human intervention, in the form of threshold, characterized by phenomena of information and energy disruption which detracts from or do disappear entirely the internal capacity of the system to be autoregla and to ensure a dynamic equilibrium [5].

Unpredictability, uncertainty, the apparent indeterminacy and surprising character building and the succession of status, representing all of the traits of a system at risk. They are undecided character paths for energy imbalances that occur on the evolutionary trajectory of the system.

Natural geomorphological modeling processes are represented by fluvial modeling system, glacial, marine, wind or oceanic, as well as the tectonic. Anthropogenic processes that have a modeling effect on relief by printing a certain touch to the landscape are: agricultural techniques and processes, construction (buildings, roads), the processes of extraction and processing of minerals, military actions, and others [1].

We can affirm that human activity is like the weather, is manifested every day is widespread and is found in an ever-changing, affecting both the natural and the human society through its manifestations.

The evolution of the socio-economic causes of acceleration-induced environmental components, and the answer it is apparent by highlighting the conflicting relations on the ground. As technological development and spatial extent of anthropic compound was an amplification of the conflicting relationships with the natural environment.

Through the activities of minerals extraction and processing, spaces which are at a relatively steady, changes the dynamics in a backward acceleration, generating other landscapes which function in an advanced degree of entropy. Geomorphological elements are changed; it creates new superficial formations and accelerates their physical-chemical processes of hipergen.

2. PRESENTATION OF THE CALCULATION MODEL

In designing this model of calculation has started from the premise that any anthropogenic change of the landscape will ultimately result in a contrasting image within the natural landscape, even though it will be subsequently rehabilitated.

It has been taken into acount the relative elevation of the anthropic surface, the original elevation, the newly created form of relief, the tendency of subsidence (sinking rate), the erosion feature of the material that forms the new form of relief and the average quantity of precipitation.

So we have proposed the following formula for calculation:

$$\mathbf{H_f = (H_i - R_s) \cdot C_e \cdot P} \qquad \textbf{[1]}$$

Where:

H_f – relative elevation of the anthropic surface;
H_i – the original elevation;
R_s – the tendency of subsidence (sinking rate);
C_e – the erosion feature of the material;
P – the average quantity of precipitation;
S – surface (1 km^2);

Taking into account that we determine the changing rate of altitude per year respectively per surface area is considered to be constant i.e. does not affect the result. We put a set of parameters, however, because this is right. The Formula is applied per year (by admitting that the given values are the respective constants). Of course it is possible each year to be different values. It is Important to demonstrate how to apply in an year. After that it may change depending on the new values.

Using problem-solving as a way of expressing those exposed earlier, then we could make by way of example the following problem or situation:

- If in 2004, the initial relief had an altitude of 650 m, and in 2014 the relief has an altitude of 675 m, bearing in mind that the rate of sinking basin is 4 mm/year and erosion coefficient of the constituent material is 0.03, a quantity of 120 mm precipitation/year, can you calculate which was the average rate of change of the relief on the surface (1 km^2), over a year.

Solution:

Definition of parameters set:

H_i = the original elevation (650 m)
H_f = relative elevation of the anthropic surface (675 m)
S = surface (1 km^2)
R_s = the tendency of subsidence (sinking rate 4 mm/an)
Ce = the erosion feature of the material (0,03 - 0,04)
$P|_{an}$ = the average quantity of precipitation (120 mm/an)

For a start it has to be made all transformations in meters (we work with meters and as a result the final outcome will represent a quantity in m/year, Figure 1).

H_i = 650 m
R_s = 4 mm/year = 0.004 m/year
C_e = 0.03
$P|_{an}$ = 120 mm/year = 0.12 m/year

Then $\mathbf{H_f = (H_i - R_s) \cdot C_e \cdot P}$
= (650-0.004)*0.03*0.12
= 649.996*0.03*0.12 =
= (649 996 *3*12)/10 000 000 =
= 2,339 ~ 2,34

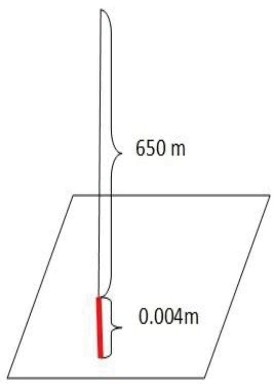


Figure 1 Graphic elevation

Observation:

The rate of altitude change in one year depends on the variables and that is Hf (Figure 1). If we are talking about an area that has a negative erosion coefficient, then we have a decrease of its initial data.

3. CONCLUSIONS

One component of the concept of "sustainable development" is the impacts management of socio-economic activities on the environment. Keeping the control assumes knowledge of the impact of the phenomenon, which presumes the stages of identification, estimation, evaluation, etc.

It should be mentioned that generally distinguishes dynamism and a trend of improvement in the rules on the identification of the relationship between a particular activity or product, with the environment and minimize eventual negative environmental impact.

It is well known that any human activity has a wide range of implications that can be felt in the most diverse fields. In general, you should take into account the whole spectrum of implications of indirect effects, in some cases exceeding, the importance of direct ones.

In a brief definition, anthropic impact assessment seeks the scientific investigation of geomorphological complex effects resulting from the impact of anthropogenic activities on the structure and original morphology land.

By estimating the induced effects of human impact on the morphology of the terrain means the quantitative assessment and/or quality of geomorphological processes or phenomena. Often, given the novelty of the issues, lack of previous or similar data, extremely diverse nature of the effects, the uncertainty and the multitude of interactions with other environmental factors, predicting in qualitative terms may be the only solution, and may require the use of quantitative estimation of mathematical and physical models, to provide a basis for the interpretation of the obtained results [2, 4].

On the base of effects estimation is the size, being determined by the level of indicators characterising the effects. The size of the effects, as assessed through indicators always relate to the reference level, to certain standards, at intervals of admissibility.

The main advantage of quantification is the precision more akin to phenomenon, especially where comparisons over time and space. Numerical estimation can be used where the terms are ambiguous [3].

The aim of creation and subsequent use of this model is to be able to monitor in time and otherwise to present graphics in a soft the dynamic geomorphological system's evolution from a territory, depending on the type of human impact. In this way, having set the parameters on the basis of statistical data, one can have a clear picture of the "evolution" of the new created landforms.

REFERENCES

[1]. **Buia, G., Rădulescu, Monica -** *Geologia mediului înconjurător*, Editura Focus, Petroşani, 2002;

[2]. **Canter, L.W. -** *Environmental Impact Assessment*, McGraw-Hill, New York, 1996;

[3]. **Lazăr, Maria, Dumitrescu, I. -** *Impactul antropic asupra mediului*, Editura Universitas, Petroşani, 2006;

[4]. **Mac, I. -** *Ştiinţa mediului*, Editura Europontic, Cluj-Napoca, 2003;

[5]. **Nimară C. -** *Cercetări privind reintegrarea peisagistică a arealelor afectate antropic din cadrul Bazinului Minier Petroșani,* Teză de doctorat, Facultatea de Mine, Universitatea din Petroșani, 2011.

Scientific Reviewers:
Roland Iosif MORARU

ROLE OF JIU VALLEY HARD COAL DEPOSITS BETWEEN EASTERN AND WESTERN EUROPEAN ENERGETIC CONSTRAINTS

**GRIGORE BUIA*
CSABA LORINŢ**
CIPRIAN NIMARĂ***
RADU LUPULEAC******

Abstract: *As a result of being part of European organizations, Romania took responsibility to produce until 2020 about 24% of its energy from renewable sources. Energy wise nowadays, hard coal gives 5-7% of the electrical energy produced in Romania. Based on this fact, but given the context of East-European conflict which can rewrite local and regional energy scenario, this paper analysis the opportunities of coal valorization, framed by the wider perspective of mineral production technologies, energy factors and geological reserves.*

Keywords: *energy balance, Jiu Valley, hard coal deposit, geological reserves*

1. INTRODUCTION

The motivation of this paper appeared in the new geo-economic context created by the geopolitical changes in Europe and in particular in South-East Europe, Romania as well. In connection with this, we can highlight the following issues: the contribution of natural gas in the energy balance of the region in question is quite uncertain, due to the policy of Russia. Other sources, Turkmenistan, Iran, Iraq, which represent the replacement of one of the main supplier from this region (Russia) are in part difficult to become viable, due to the lack of

* *Professor Ph.D. eng., at University of Petrosani, Mining Faculty, Management, Environmental Engineering and Geology Department, Universitatii Street, No. 20, 32006, Petrosani, Romania, grigbuia@yahoo.com*
** *Lecturer Ph.D. eng., at University of Petrosani, Mining Faculty, Management, Environmental Engineering and Geology Department, Universitatii Street, No. 20, 332006, Petrosani, Romania, csabigeo@yahoo.com*
*** *Assistant PhD, at University of Petrosani, Mining Faculty, Management, Environmental Engineering and Geology Department, Universitatii Street, No. 20, 332006, Petrosani, Romania, cikgeogra@yahoo.com*
**** *PhD Student, University of Petrosani, l.radu.f@gmail.com*

transport infrastructure, and socio-political situation in the region and on the other hand, the policy of protectionist and intimidation promoted by Gazprom and Rosneft. In the same context, we noted that for the near future, the exploitation of shale gas in Southeastern Europe may not be a certainty. Taking into account the stated role of hard coal, even at that rate of 5-7%, it becomes important and a viable alternative in any geopolitical and more as geo-economic circumstances.

Currently, the mining activities in the Jiu Valley are carried out under the coordination of “Societatea Naţionala de Închideri Mine Valea Jiului” (the National Society of Mining Decomissioning Jiu Valley), within the perimeters of the mining sectors Petrila, Paroşeni and Uricani and also under the coordination of the entity known as “Complexul Energetic Hunedoara S.A” (Energy Complex Hunedoara). “Complexul Energetic Hunedoara S.A” was created by the unification of several commercial entities, namely “Electrocentrala Deva S.A.”, “Electrocentrala Paroşeni S.A.” and “Societatea Naţională a Huilei S.A.”; its main role consists of electricity generation using hard coal sourced from the mining perimeters Lonea, Livezeni, Vulcan and Lupeni, Figure 1. (CEH Portal, 2014)

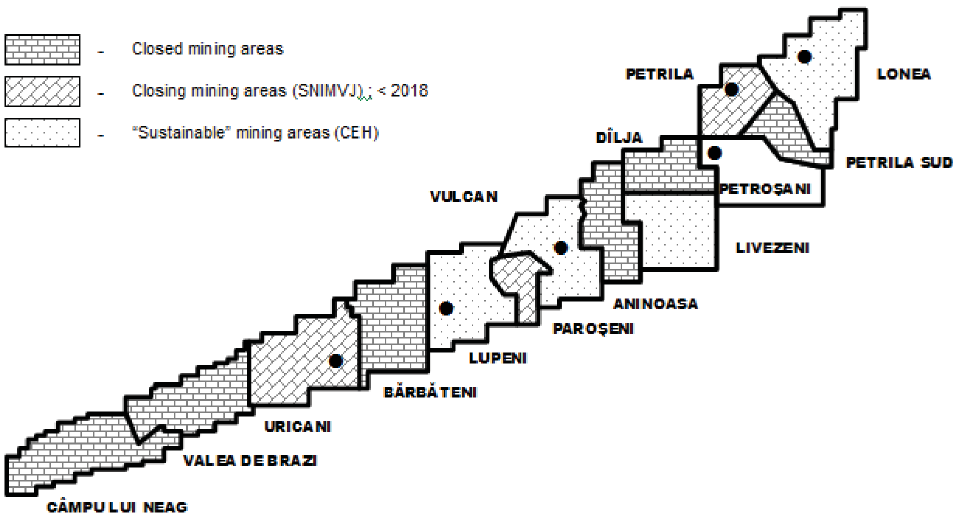


Figure 1. Spatial distribution and status of mining perimeters in the Jiu Valley

2. GEOLOGY OF THE STUDY AREA

The Jiu Valley (Valea Jiului) / Petroşani basin (Figure 2) is an asymmetrical synclinal structure formed during the Alpine orogeny, and sliced by transverse faults (Figure 2). The Jiu Valley basin, with a SW–NE orientation, is 48-km long and 10-km wide on the eastern side and 2-km wide on the western side; the coal mines are distributed along the center of the valley, following the western and eastern tributaries of the Jiu River (Figure 2).

The Jiu Valley basin (Figure 2) is underlain by a crystalline basement, filled with molasse sedimentary deposits. On the basin rims, rocks of Danubian and Getic ages crop out; these rocks are represented by Neoproterozoic, Paleozoic, and Mesozoic sedimentary, volcanic and magmatic formations, presenting different degrees of metamorphism (Burchfiel, 1976; Pop, 1993; Preda, 1994; Petrescu et al., 1987; Iancu et al., 2005). The Getic crystalline rocks crop out in the north-eastern side of the basin and partially on the southern rim, consisting of gneisses, mica-schists, quartzites, and amphibolites. The overlying sedimentary deposits are of Jurassic, Cretaceous, Paleogene, and Neogene age, mostly covered by Quaternary formations. The oldest sedimentary rocks in the basin are Cretaceous, consisting mostly of flysch deposits, located on the northern and southern rims. The Cretaceous deposits are represented by conglomerates, green-grey sandstones, red marls, and minor limestones. From an economic perspective, the Oligocene deposits are the most important, as these formations contain all the coal layers, of Rupelian and Chattian ages. The Rupelian overlying the metamorphic sediments of the bedrock and the Cretaceous deposits crops out as discontinuous layers on both rims of the basin. The Rupelian deposits, 200 m to 600 m thick, consist of sandstones and green and red conglomerates with ferruginous and limestone clasts. Dîlja–Uricani Formation, of Chattian-age, also known as the „productive horizon", contains coal seams and crops out on the southern rim of the basin, as well as in the northeastern, central, and western rims (Figure 2). The thickness of these paralic deposits ranges from 270-m to west to 350-m to east (Baron, 1998). Twenty-two layers of coal have been identified in the Chattian-age rocks, numbered as beds 0 to 21, from the bottom to the top. Beds 3, 4, 5, 7, 8/9, 12, 13, 14, 15, and 17/18 are economically feasible for extraction, bed 3 being the most productive. The thickness of these beds varies from several meters up to several tens of meters (bed 3); the estimated percentage of the Jiu Valley reserves are as follows: bed 3-48 percent, bed 5-16 percent; bed 13-10 percent; beds 4, 6, 7, 8, 9, 12, 15, 17, and 18 are thin, discontinuous and each contributes about 1-3 percent; beds 1, 2, 10, 11, 14, 16, 19, and 20 are very thin, representing a small fraction of the reserves (Pop, 1993; Preda, 1994; Petrescu et al., 1987; Fodor et al., 2000; Fodor and Plesa, 2006; Belkin et al., 2010; Buia and Lorinţ, 2010). The Miocene deposits are between 300 m and 550 m thick, formed of grey sandstones, marls, clays, sands, and coarse conglomerate. The Quaternary consists of alluvial and pro-luvial deposits.

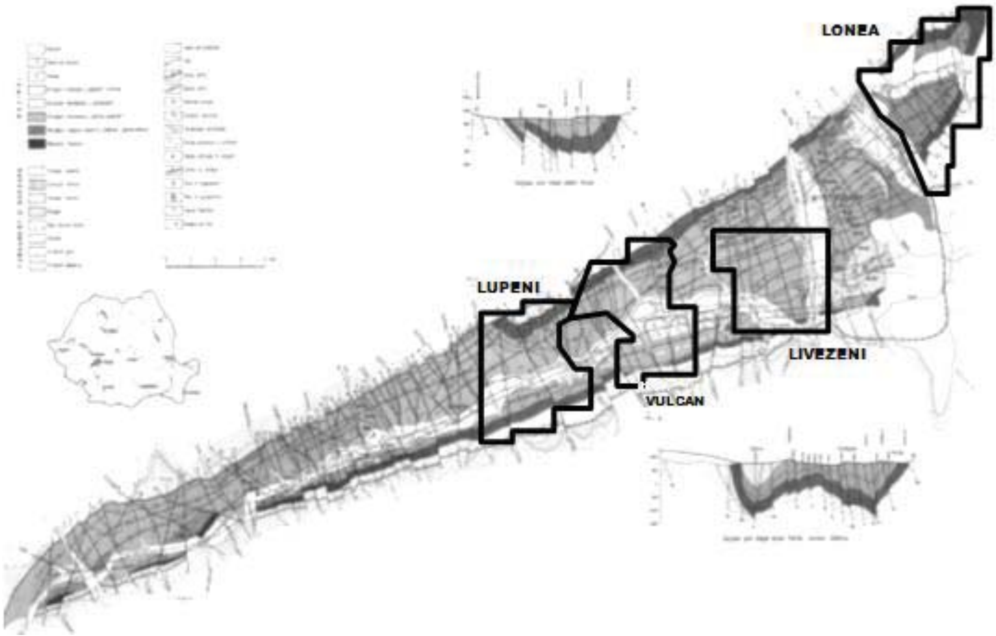


Figure 2. Geo-tectonic map of Jiu Valley / Petroşani basin study area showing the regional geology, the major synclinal axis, tectonic units and few sections in major point of interest Modified from Pop E.I. (1988)

3. TECHNICAL PROPERTIES AND STATISTICS OF HARD COAL RESERVES IN THE JIU VALLEY

This section describes the main characteristics of the hard coal in the Jiu Valley. From a valorization potential perspective, the classification falls into three categories, depending on the current state of the mining perimeters, as follows; Closed (decommissioned) mining Perimeters (Table 1), Closing mining perimeters (Tables 2 and 4) and Sustainable mining perimeters (Tables 3 and 4).

Table 1. Statistics of the reserves pertaining to the closed mining perimeters (thousands of tonnes at the closing date)

Group/Category	Lonea Pilier	Petrila Sud	Dâlja	Aninoasa	Valea de Brazi	Câmpul lui Neag
Ab	0	269	746	90	710	54
Bb	0	769	0	72	393	0
C1b	52,660	48,484	56,710	0	59,128	716
C2b	0	10,332	2,657	0	9,766	0
Total recoverable, (proven) geological reserves	**52,660**	**59,854**	**60,113**	**162**	**69,997**	**770**
Aaf.b	0	98	5	461	232	0
Baf.b	0	0	0	632	209	0
C1af.b	41,693	17,783	14,869	75,109	12,270	199
C2af.b	0	9,328	9,380	23,485	5,644	779
Total probable geological reserves	**41,693**	**27,209**	**24,254**	**99,678**	**18,355**	**978**
Total geological reserves/perimeter	**94,353**	**87,063**	**84,367**	**99,849**	**88,352**	**1,748**
Total geological reserves Closed perimeters	**455,732**					
Heating value/perimeter Q (kal/kg)	**5,788**	**5,566**	**5,434**	**5,539**	**5,343**	**4,776**
Average heat content Q (kal/kg)	**5,535**					

Table 2. Reserves Statistics - Closing mining perimeters (thousands of tonnes)

Group/Category	Petrila		Paroşeni		Uricani		TOTAL	
	Quantity	Aanh (%)	Quantity	Aanh (%)	Quantity	Aanh (%)	Quantity	Aanh (%)
Ab	337	22.05	538	19.74	48	24.43	**923**	**20.83**
Bb	810	22.73	0	0.00	406	30.25	**1,216**	**25.24**
Ab+Bb	1,147	22.53	538	19.74	454	29.63	**2,139**	**23.34**
C1b	16,109	19.42	20,683	21.77	38,980	24.76	**75,772**	**22.81**
A+B+C1	**17,256**	**19.63**	**21,221**	**21.72**	**39,434**	**24.82**	**77,911**	**22.82**
C2b	1,481	32.56	1,213	24.88	8,411	23.37	**11,105**	**24.76**
Total recoverable (proven) geological reserves	**18,737**	**20.65**	**22,434**	**21.89**	**47,845**	**24.56**	**89,016**	**23.06**
Aaf.b	343	22.72	315	23.60	354	26.46	**1,012**	**24.30**
Baf.b	81	29.00	83	20.66	595	30.92	**759**	**29.59**
C1af.b	55,761	18.64	13,216	21.95	50,589	21.47	**119,566**	**20.20**
C2af.b	13,535	18.18	5,425	23.14	11,386	21.74	**30,346**	**20.40**
Total probable geological reserves	**69,720**	**18.58**	**19,039**	**22.31**	**62,924**	**21.64**	**151,683**	**20.32**
Total geological reserves Closing perimeters	**88,457**	**19.02**	**41,473**	**22.08**	**110,769**	**22.90**	**240,699**	**21.33**

Table 3. Reserves statistics – Sustainable mining perimeters (thousands of tonnes)

Group/ Category	Lonea		Livezeni		Vulcan		Lupeni		TOTAL	
	Quant.	Aanh (%)	Quant.	Aanh (%)	Quant.	Aanh (%)	Quant.	Aanh (%)	Quant.	Aanh (%)
Ab	785	19.23	113	22.47	251	24.75	1,117	27.82	**2,266**	**24.24**
Bb	362	18.25	1,246	29.78	308	27.26	1180	26.87	**3,096**	**27.07**
Ab+Bb	1,147	18.92	1,359	29.17	559	26.13	2,297	27.33	**5,362**	**25.87**
C1b	21,501	18.79	70,176	23.74	22,997	21.36	29,379	24.48	**144,053**	**22.77**
A+B+C1	**22,648**	**18.80**	**71,535**	**23.84**	**23,556**	**21.47**	**31,676**	**24.69**	**149,415**	**22.88**
C2b	0	0.00	4949	20.18	13	26.47	0	0.00	**4962**	**20.20**
Total recoverable (proven) geological reserves	**22,648**	**18.80**	**76,484**	**23.61**	**23,569**	**21.48**	**31,676**	**24.69**	**154,377**	**22.80**
Aaf.b	59	15.00	1,390	27.08	288	29.61	471	30.41	**2,208**	**27.80**
Baf.b	317	13.81	1,710	29.72	288	17.73	756	26.27	**3,071**	**26.10**
C1af.b	39,769	17.16	53,225	20.81	24,389	21.42	34,304	22.05	**151,687**	**20.23**
C2af.b	4,280	19.12	36,875	22.74	8605	20.66	16	27.40	**49,776**	**22.07**
Total probable geological reserves	**44,425**	**17.32**	**93,200**	**21.83**	**33,570**	**21.26**	**35,547**	**22.25**	**206,742**	**20.84**
Total geological reserves Sustainable perimeters	**67,073**	**17.82**	**169,684**	**22.63**	**57,139**	**21.35**	**67,223**	**23.40**	**361,119**	**21.68**

Based on the data presented in Tables 1, 2 and 3, the reserves of hard coal are as follows: **455.732** millions of tonnes in the closed mining perimeters Lonea Pilier, Petrila Sud, Dâlja, Aninoasa, Valea de Brazi, Câmpul lui Neag, **240.699** millions of tonnes in the closing mining perimeters Petrila, Paroşeni, Uricani and **361.119** millions of tonnes in the sustainable mining perimeters Livezeni, Vulcan, Lupeni –leading to a total of **1,057.550** million tonnes.

Of the total reserves, only the recoverable (proven) reserves are available for valorization, as follows: **243.556** million tonnes in the closed mining perimeters, **89.016** million tonnes in the closing mining perimeters and **154.377** million tonnes in the Sustainable perimeters, totaling to **486.949** million tonnes. To note that within the closed mining perimeters, the recoverable (proven) reserves belong over 90 percent to category C1 of reserves.

As it can be observed from table 4, the reserves from the active mining perimeters, including the closing and sustainable perimeters, amount to **94.189** million tonnes which are currently available.

Table 4. Statistics of proven and probable reserves in the active mining perimeters (thousands of tonnes)

Mining Perimeter	Coal Bed	Characteristics of the coal bed	Proven			Probable			Total		
			Quantity	Aanh (%)	Q (kal/kg)	Quantity	Aanh (%)	Q (kal/kg)	Quantity	Aanh (%)	Q (kal/kg)
Lonea	3	block II - III level 200, block VII, level 380	1,389	40.40	3,861	12,042	41.90	3,739	13,431	41.74	3,752
	5	block II - III level100	127	27.80	4,881	344	32.60	4,492	471	31.31	4,597
	Total		**1,516**	**39.34**	**3,946**	**12,386**	**41.64**	**3,760**	**13,902**	**41.39**	**3,781**
Petrila	3	block II level -300, eastern side block II -200 - 250	1,352	40.25	3,922	7,194	45.10	3,537	8,546	44.33	3,598
	Total		**1,352**	**40.25**	**3,922**	**7,194**	**45.10**	**3,537**	**8,546**	**44.33**	**3,598**
Livezeni	3	block VI, VIA, III, VII and VIII to level 150	1,563	47.21	3,332	12,085	50.30	3,088	13,648	49.95	3,116
	5	block VII				3,159	39.07	3,974	3,159	39.07	3,974
	13	block X-VIII Iscroni, between level 50 and 200	197	40.16	3,888	1,121	23.24	5,223	1,318	25.77	5,023
	Total		**1,760**	**46.42**	**3,394**	**16,365**	**46.28**	**3,405**	**18,125**	**46.29**	**3,404**
Vulcan	3	block VI, VII, VIII and IX to level 260	656	44.7	3,837	5,412	36.31	4,532	6,068	37.22	4,457
	5	block VII to level 250, block VIII-IX	55	49.52	3,437	1,247	45.78	3,747	1,302	45.94	3,734
	Total		**711**	**45.07**	**3,806**	**6,659**	**38.1**	**4,385**	**7,370**	**38.76**	**4,329**
Paroşeni	3	block 0 - VI between 350 and 200			7,545	11,032	47.68	3,590	11,032	47.68	3,590
	5	block 0, I and II between level 200 and 400	763	42.95	3,982	1,356	39.94	4,232	2,119	41.02	4,142
	Total		**763**	**42.95**	**3,982**	**12,388**	**46.83**	**3,660**	**13,151**	**46.61**	**3,679**
Lupeni	3	block II to 200, block II N, IV,V and VI	2,881	44.12	3,957	13,032	45.10	3,876	15,913	44.92	3,890
	5	block VI level 300-350				744	49.32	3,524	744	49.32	3,524
	Total		**2,881**	**44.12**	**3,957**	**13,776**	**45.33**	**3,857**	**16,657**	**45.12**	**3,874**

Uricani	3	block IIIN, IV, V and VI between level 350 and 250	545	46.61	3,778	13,454	46.92	3,753	13,999	46.91	3,754
	5	block IIIN, IV, V and VI between level 400 and 250	57	38.02	4,483	2,382	33.45	4,859	2,439	33.56	4,850
	Total		**602**	**45.80**	3845	**15,836**	**44.89**	**3,919**	**16,438**	**44.93**	**3,916**
TOTAL	**3**		**8,386**	**43.66**	**3,798**	**74,251**	**45.50**	**3,676**	**82,637**	**45.31**	**3,688**
	5		**1,002**	**41.11**	**4,095**	**9,232**	**39.24**	**4,193**	**10,234**	**39.42**	**4,183**
	13		**197**	**40.16**	**3,888**	**1,121**	**23.24**	**5,223**	**1,318**	**25.77**	**5,023**
	Total		**9,585**	**43.32**	**3,831**	**84,604**	**44.52**	**3,753**	**94,189**	**44.40**	**3,761**

- closing mining perimeters

4. CONCLUSION

Based on the current organizational structure of the coal system, the 2013 coal production from the active mining perimeters, respectively closing perimeters Petrila, Paroşeni and Uricani and sustainable perimeters Lonea, Livezeni, Vulcan and Lupeni amounted to 1.5 million tonnes (0.4 million tonnes, respectively 1.1 million tonnes), with a heating value of 3,600 kal/kg; this resulted in 2,700 GWh/year, for combustion factors representative of the current technology of 3.6 Gkal/t hard coal of Jiu Valley and 2 Gkal/Mw), representing about 5-7 percent of the electric energy produced in Romania, this being 54,358 GWh/year.

Given the energy balance, 94 million tonnes of hard coal from the currently proven reserves in the active mining perimeters can sustain the coal consumption for the next 60 years.

The recoverable reserves from the closed and closing mining perimeter can also be valorized through alternative methods, such as internal combustion.

REFERENCES

[1]. **Buia Gr., Lorinţ C.,** 2010. Hard *Coal Deposits in Romania/Depozite de huilă din România*. Mining Revue/Revista Minelor, vol. 16, No. 3, 9-14.

[2]. **Burchfiel, B.C.**, 1976. *Geology of Romania*. Geological Society of America Special Paper 158, 82.

[3]. **Iancu, V., Berza, T., Seghedi, A., Maruntiu, M.**, 2005. *Palaeozoic rock assemblages incorporated in the south Carpathian Alpine thrust belt (Romania and Serbia): a review*. Geologica Belgica 8, 48–68.

[4]. **Baron, M.,** 1998. *Cărbune şi societate în Valea Jiului. Perioada interbelică*, Editura Universitas, Petroşani 109–130. (in Romanian).

[5]. **Fodor, D., Plesa, V.,** 2006. *Present situation of underground coal mining in Valea Jiului-Romania*. Journal of Mines, Metals & Fuels 54, 266–273.

[6]. **Fodor, D., Baican, G., Pasarin, C., Bonci, G.,** 2000. *Coal mining in Romania at the beginning of the 21st century.* In: Ghose, A.K., Dhar, B.B. (Eds.), Mining: Challenges of the 21st Century. A.P.H. Publishing Corp, New Dehli, pp. 117–135.

[7]. **Harvey E. Belkin , Susan J. Tewalt, James C. Hower, J.D. Stucker, Jennifer M.K. O'Keefe, Calin A. Tatu, Grigore Buia**, 2010. *Petrography and geochemistry of Oligocene bituminous coal from the Jiu Valley, Petroşani basin (southern Carpathian Mountains), Romania.* International Journal of Coal Geology 82 (2010) 68–80.

[8]. **Petrescu I., Nicorici E., Biţoianu C., Ţicleanu N., Trodos C., Ionescu M., Mărgarit Gh., Nicorici M., Duşa A., Pătruţoiu I., Munteanu A., Buda,** 1987. *Geologia zăcămintelor de cărbuni* (vol. II – Zăcăminte din România), Ed. Tehnică, Bucureşti. (in Romanian).

[9]. **Pop, E.I.,** 1993. *Monografia geologică a Bazinului Petroşani,* Ed. Academiei Române, Bucureşti. (in Romanian).

[10]. **Preda I., Bădăluţă A., Turculeţ I., Barus T., Androhovici A.,** 1994. *Geologia zăcămintelor de cărbuni* (vol. II), Ed. Universităţii din Bucureşti. (in Romanian).

[11]. CEH Portal, 2014. *Mineritul în Valea Jiului - Repere Istorice. Date de referinţă pentru mineritul din Valea Jiului.* (in Romanian) http://www.sdm-cenhd.ro/istoric.aspx

[12]. Transelectrica Portal. https://www.transelectrica.ro/web/tel/productie

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

ANALYSIS OF MECHANIZED MINING TECHNOLOGIES FOR THE ROMANIAN ROCK SALT DEPOSITS

ILIE ONICA*
EUGEN COZMA*

Abstract: *In the present, for the Romanian rock salt deposits mining are used some rock blasting mining methods and technologies. The goal of this paper is to analyse the possibilities of mechanized extraction of the rock salt by using the road headers and to design the appropriate mining methods in these geo-mining conditions.*

Keywords: *rock salt deposit, mining method, rooms and pillars, mechanized technology, roadheader*

1. ROADHEADER SELECTION FOR THE TECHNICAL AND GEO-MINING CONDITIONS

The roadheader is a self-propelled unit mining machine that ensures the cutting and loading of the rocks inside horizontal or inclined underground workings (galleries or inclined opening and preparatory workings, tunnels, short mining faces, etc.).

The main technical and geo-mining conditions requested of the road header are the following [5], [6], [7]:

-To be able to excavate a transversal section profile of the mining rooms at the designed section;

-To be able to achieve the average annually production capacity of the saline;

- It should be a roadheader with successful world experimentation, in the similar mining conditions of the rock salt or other evaporate rocks;

- It should have very good reliability, be very easy to maintain and operate and should ensure the best conditions of underground health and safety;

The main technical and geo-mining selection criteria of roadheaders should be based on the following requirements:

-To cover the transversal section sizes of the working;

-Correlation of the strike and transversal dips of the mining workings with the technical possibilities of the roadheader;

-Penetration of the roadheader tracks in the underground working floor;

-The main performances of the roadheader (instantaneous cutting rate and specific cutting picks consumption [1], [8]).

- The consumption of cutting picks needs to be as low as possible [1], [8];

- It should be possible to use an electrical power supply, in the conditions of the existent energetic system of the saline;

∗ *Prof. Ph. Dr., at the University of Petrosani*

- It should be a roadheader with successful world experimentation, in the similar mining conditions of the rock salt or other evaporate rocks;

- It should have very good reliability, be very easy to maintain and operate and should ensure the best conditions of underground health and safety;

The main technical and geo-mining selection criteria of roadheaders should be based on the following requirements:

-To cover the transversal section sizes of the working;

-Correlation of the strike and transversal dips of the mining workings with the technical possibilities of the roadheader;

-Penetration of the roadheader tracks in the underground working floor;

-The main performances of the roadheader (instantaneous cutting rate and specific cutting picks consumption [1], [8]).

2. MINING TECHNOLOGY BY USING THE ROADHEADER

2.1. Mining method description

At the Romanian rock salt deposits, in the most saline, are used the mining method with rooms and square pillars, with the plain ceiling [2], [3], [4]. The characteristic parameters of these methods are:

-the roof (crown) pillar of the rock salt deposit has a minimum thickness of 30m;

-the floor pillar has a minimum thickness of 25 m;

-the marginal pillars have a minimum thickness of 8 m;

-the mining pillars, between rooms, are a square shape with sizes of 14x14 m, until 18x18 m, depending on the overburden, and the height of 8m;

-the mining rooms have a plain ceiling, with the width ranging from12 m until 16 m, depending on the overburden of the mining level, and the height of 8 m.

2.2. Establishment of the mining technologies and the face equipments

As a result of the research carried out by the paper authors, for the mining method with rooms and square pillars, the mining face technology recommended involve the Sandvik MR-520 roadheader (Fig.1) and the loading with the roadheader in the Renault Kerax 420/42 trucks [6], [7].

Fig.1. Sandvik MR-520 Roadheader

The rooms with the sizes of 8 x 12 m will be mined in two slices with 4m thickness, and every slice is extracted in two strips with the width of 6 m until 8 m. At beginning, is mined the upper slice, in advance with a room, after that is mined the lower slice.

The main stages of the salt mining process are the followings:

a) the driving of the preparatory gallery on the upper slice of the mining panel of the level;

b) the cutting and the loading with Sandvink MR-520 roadheader in the Renault Kerax 420/42 trucks;

c) the checking and the excavation jowling of the face.

2.3. The cutting with the Sandvik MR 520 roadheader

The Sandvik MR 520 roadheader is a ripping or transversal roadheader (with the rotational axe of the cutting heads parallel with the working face). The cutting arm revolves after the horizontal plane, along the entire face. When the cutting heads penetrated the face, is regulated the cutting depth ”X”. Before the every horizontal cutting, the cutting head is regulated for the cutting thickness ”Y”, penetrating the rock salt face on a supplementary depth. The cutting depth and the cutting thickness are calculated in function of the rock salt physical and mechanical characteristics.

The rock salt face penetration is achieved by the road header arm adjustment or the roadheader motion, whereas the cutting arm revolves in horizontal way.

The loading table, in the cutting operation, must be set on the floor for loading the rock salt during the roadheader advancement. After the initial rock salt face penetration, by the arm motion, is cut a floor kirve along the entire cutting width and is regulated the cutting depth ”Y” and is revolved horizontally the arm. The cutting is made in shuttle way, on entire rock salt surface.

The rock salt extraction from the rooms, between the square pillars, is achieved in conformity with the stages shown in the Fig. 2 and 3.

The rock salt mining is provided into a two successive slices (first slice and second slice) with height of 4 m, into an established order. Every slice with 4 m of height, from every room (with total height of 8 m and the width of 12 m until 16 m) is mined in two strips with the width of 6 – 8 m. From the technical characteristics of the Sandvik MR 520 roadheader, results that maximum sizes of the transversal profile, possible to be extracted with the roadheader, situated into a single position are: the maximum height of 5.2 m and the maximum width of 8.32 m (the covering values for a strip with height of 4 m and the width of 6-8 m).

In the case of the width of rooms of 12 m, the road header cut the rock salt working face, from a single position, in the arc of a circle with the length of 6.3 m, and the rotation angle, left-right, in the horizontal plane, of the cutting booms is about 31.5^o (Fig.2 and Fig.3).

The technological process of a slice mining, from the total of four slices, corresponding with the transversal section of a room, involves the following cutting stages:

Stage 1: From the stationary position of the roadheader, focused on the strip axis with the sizes of 6 m x 4 m (section of 24 m^2), the cutting crown penetrate the rock salt massive at the on of the strip extremity, on the width of 2.38 m (with of the cutting head) and a depth of 0.625 m (half of the crown diameter) and a height of 1.25 m or 1.3 m following the vertical curvature of the face (the rock salt detached volume is about 1.58 m^3);

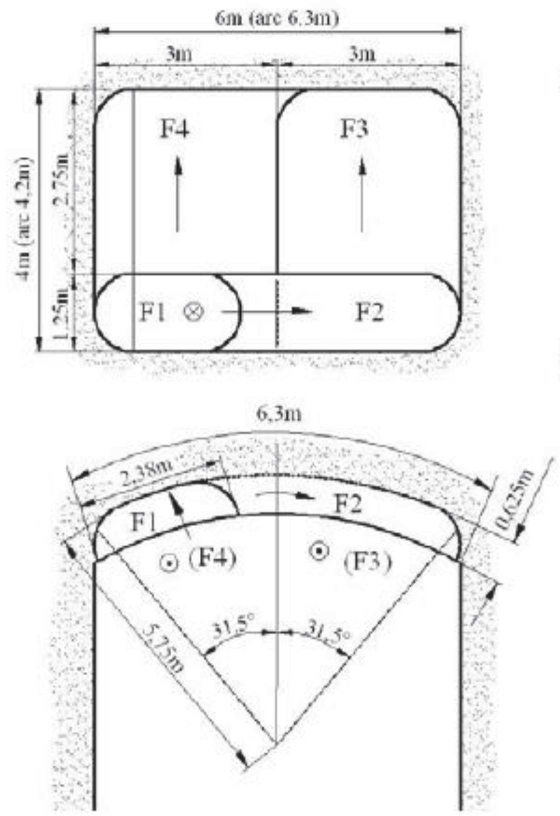


Fig.2. Representation of the roadheader main cutting stages of the first strip

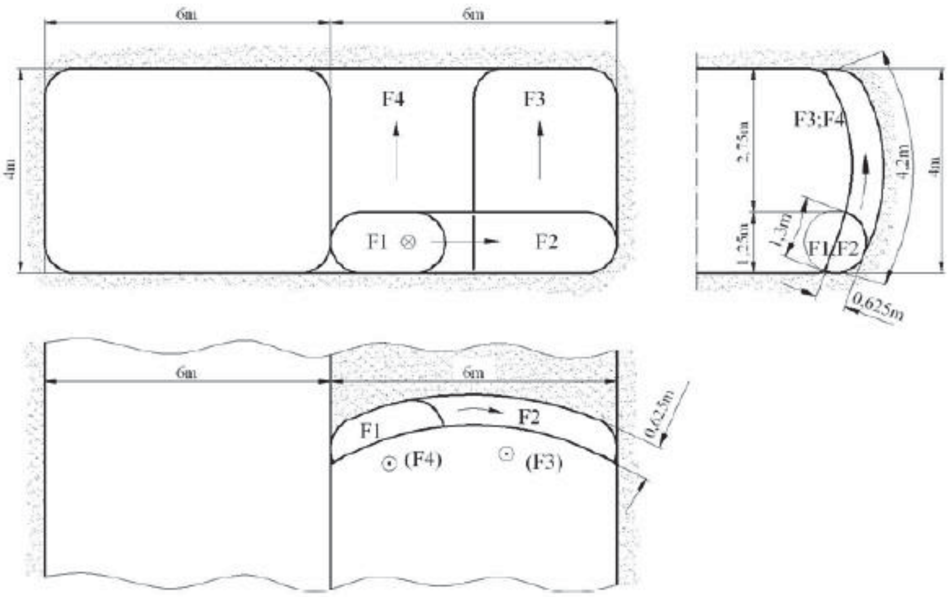


Fig.3. Mining with the roadheader of the second strip, slice I

Stage 2: The cutting of horizontal kirve continues with the displacement of the cutting crown in a horizontal plane, until the right extremity of the face, achieving a floor kirve, following the entire arc of 6.3 m (the excavated rock salt volume is 2.6 m3);

Stage 3 and 4: After a strip floor extraction of 1.25 m, is continued the rock salt extraction, following the vertical plane, of a width face portion of 3.0 m (or 3.15 m, following the arc length), by the vertical displacement of the crown, with 20-30 cm left-right motions, which leads to ascendant cutting of a rock salt volume about 5.7 m3 (excavated sizes of the rock salt being: cutting step of 0.625 m, height of 2.9 m and the width of 3.15 m).

The stages 1, 2, 3 and 4 are repeated, also at the second strip from the first slice, after that in the second slice, for to reach the designed sizes of the mining rooms.

After the achievement of the step of 0.625 m, the roadheader is retreated, is put on the center, and the cycle is repeated, until it is extracted the first strip on the 15 m length, after that the roadheader is retreated in the back with 15 m and is cut the second on a length of 30 m. The previous stages shown in the Fig.2 and 3 are repeated along the entire rooms' length at the second strip and after that, in the others strips of the second slice.

3. TECHNOLOGICAL STAGES OF THE ROOMS MINING

The technological stages involved by the process of the rock salt mining using the road header, in the case of rooms and square pillars mining method [6], [7] are shown in the Fig.4-11.

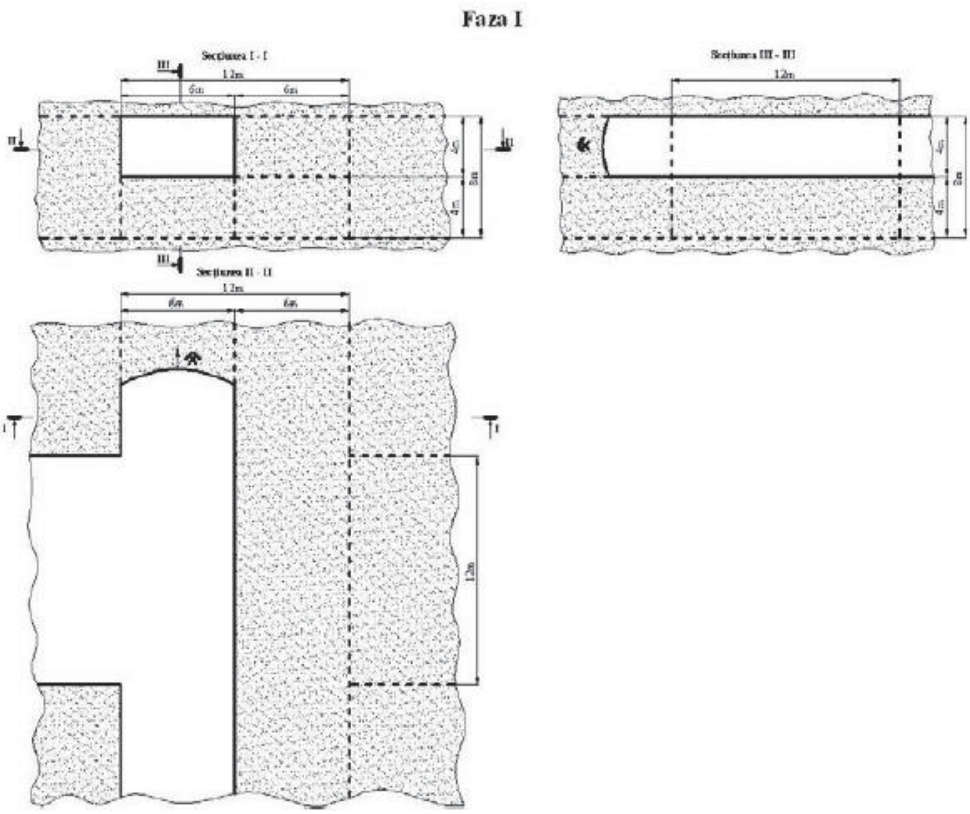


Fig.4. Scheme of the strip 1, slice I mining

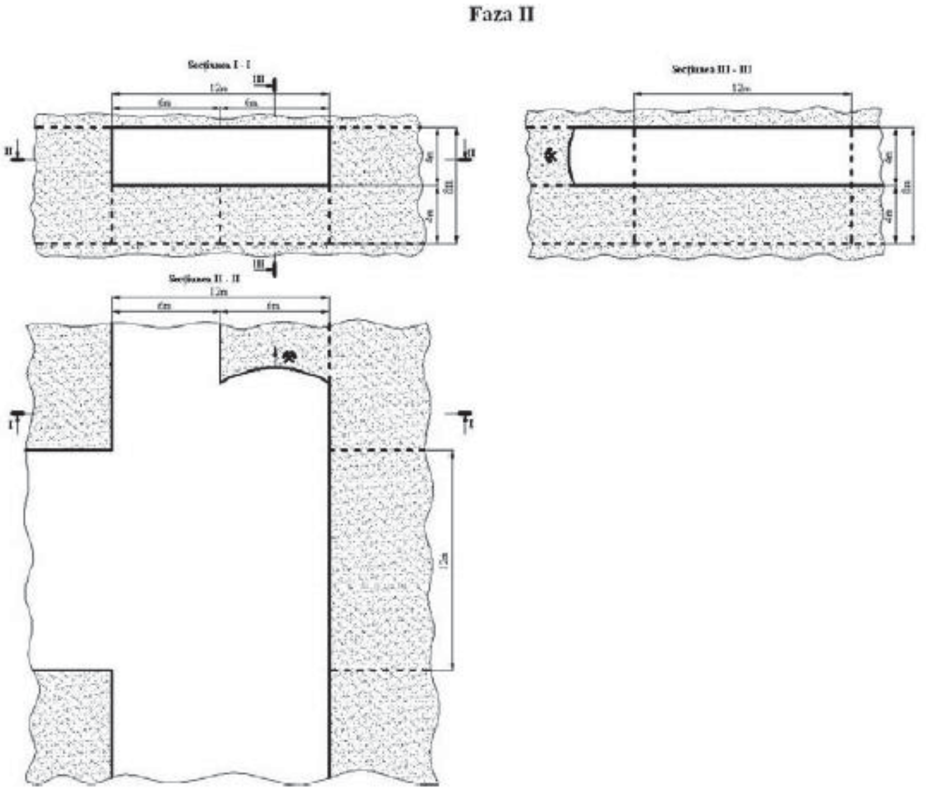


Fig.5. Scheme of the strip 2, slice I mining

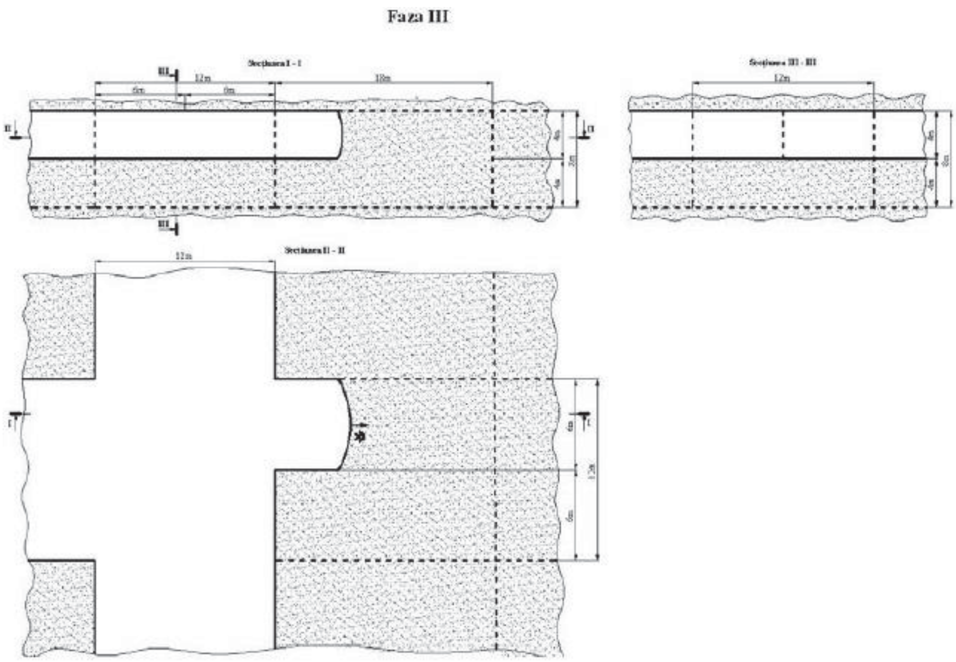


Fig.6. Scheme of the strip 1, slice I mining

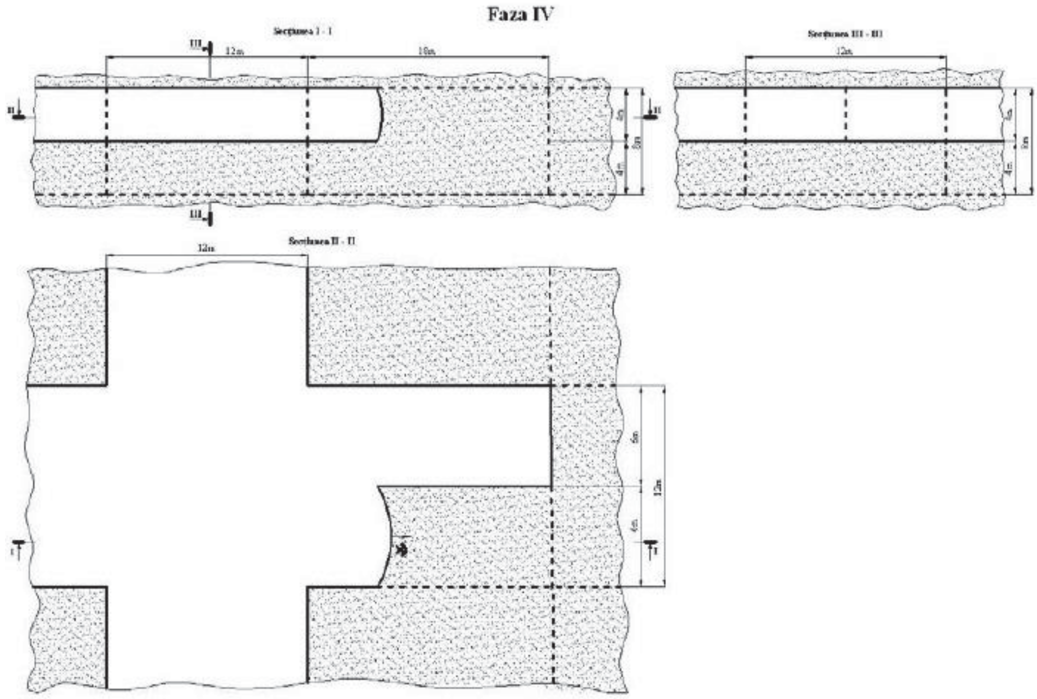


Fig.7. Scheme of the strip 2, slice I mining

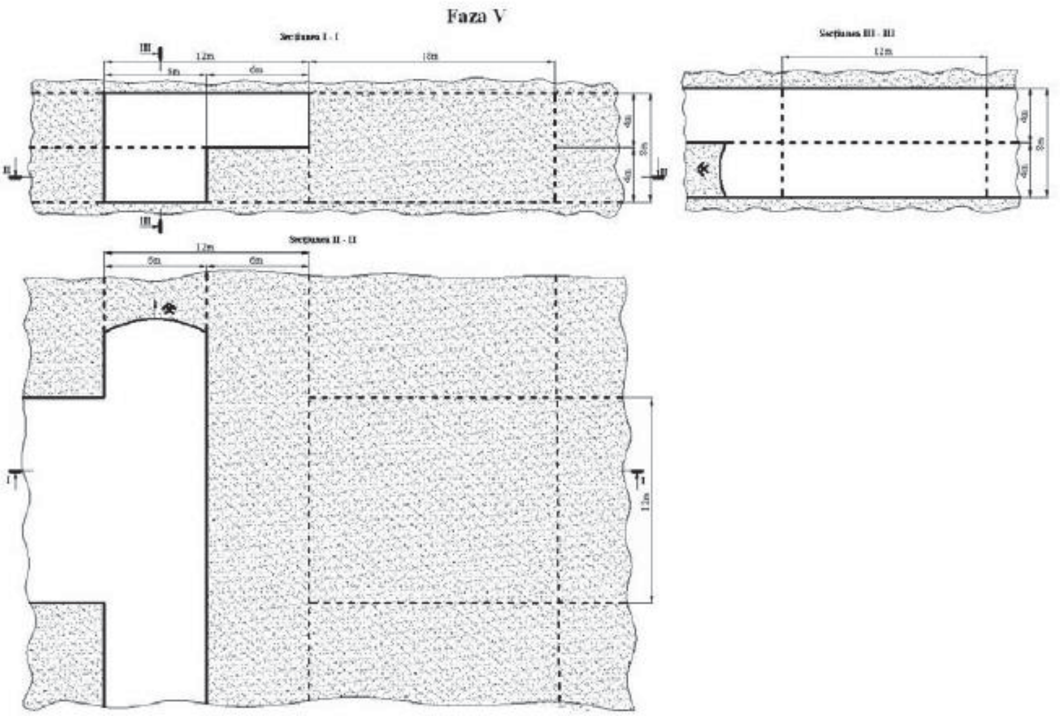


Fig.8. Scheme of the strip 1, slice II mining

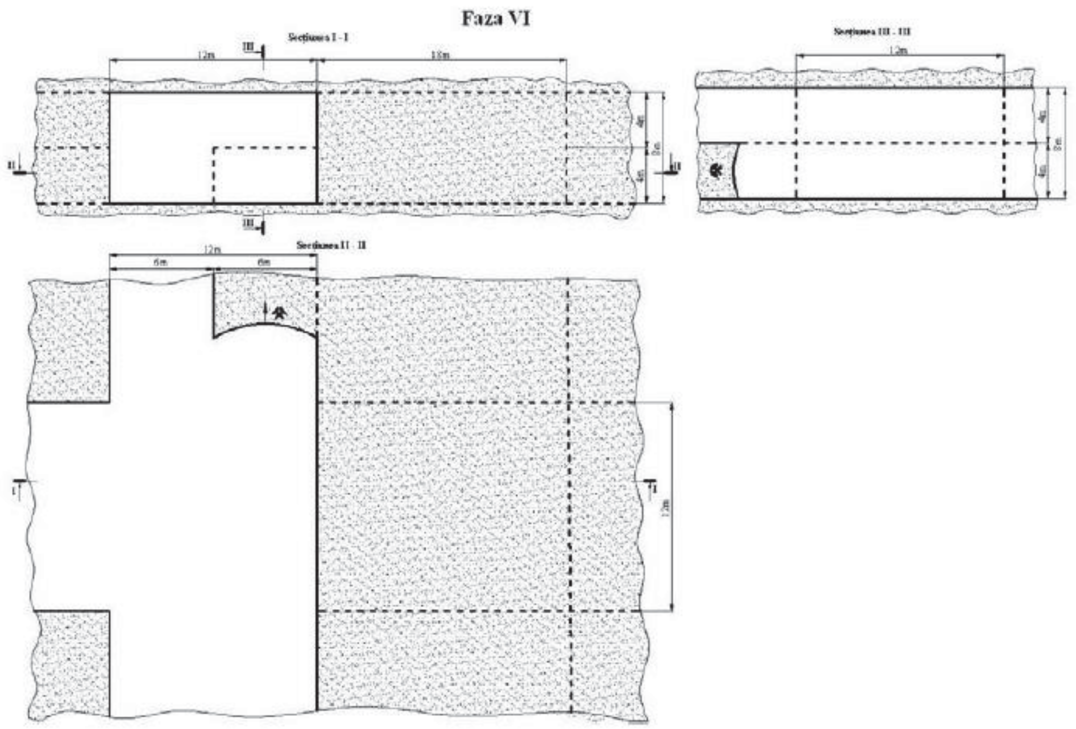


Fig.9. Scheme of the strip 2, slice II mining

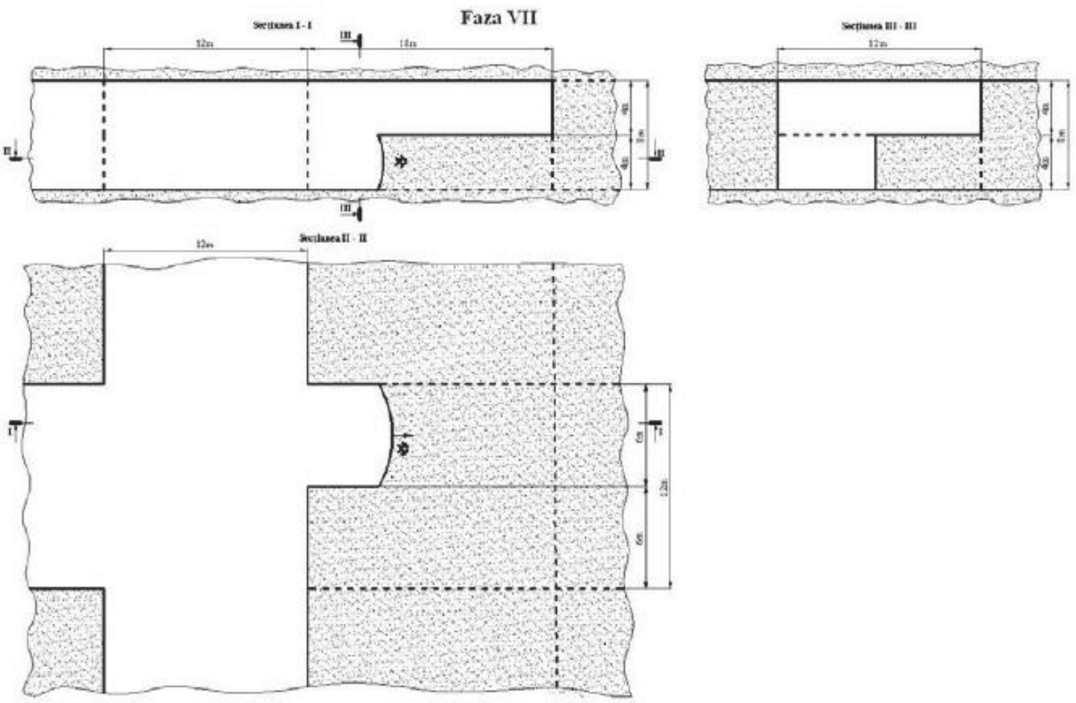


Fig.10. Scheme of the strip 1, slice II mining

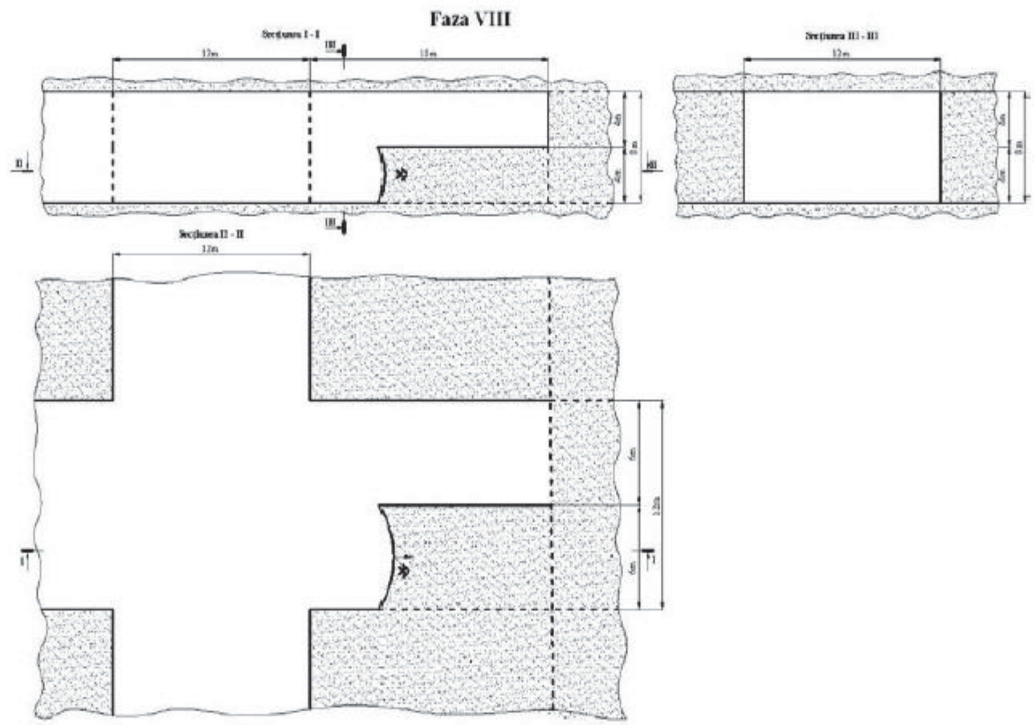


Fig.11. Scheme of the strip 2, slice II mining

4. CONCLUSIONS:

- Sandvik MR-520 roadheader accomplished all the technical, constructive, operating and reliability requirements by report to the technical and geo-mining conditions, imposed by the Romanian saline, for an efficient mining of the rock salt deposits, from of economical and technical point of view.

- By the mechanized mining of the rock salt, the rooms could be with 1-2m larger then in the case of the drilling-blasting cutting system, increasing the recovery rate.

- At the mechanized extraction of the rock salt, are reduced the cost of the rock salt tonne and also the risks.

REFERENCES

[1]. Balci, C., Demircin, M.A., Copur, H. and Tuncdemir, H., *Estimation of optimum specific energy based on rock properties for assessment of roadheader performance, The Journal of The South African Institute of Mining and Metallurgy,* December 2004, pp.633-641.

[2]. Covaci, Şt., Oncioiu, Gh., Cozma, E,ş.a., *Exploatări miniere vol.2,* Ed. Corvin, Deva, 1999.

[3]. Cozma, E., Goldan, T., *Proiectarea minelor, vol. I,* Ed. Focus, Petroşani 2005.

[4]. Deak, G., Hirian., C. ş.a., *Exploatarea sării geme din România în secolul 21 pe principii Ecomining,* Ed. ESTFALIA 2005.

[5]. Onica, I., Cozma, E. ş.a., *Exploatarea sării cu combina la Salina Praid,* Contract nr.19/12.12.2011.

[6]. Onica, I., Cozma, E. ş.a., *Proiect tehnic: Exploatarea sării cu combina la Salina Ocna Dej,* Contract nr.40/21.06.2012.

[7]. Onica, I., Cozma, E. ş.a., *Proiect tehnic: Exploatarea sării cu combina la Salina Slănic Prahova,* Contract nr. 7858/10.07.2012.

[8]. Thuro, K. and Plinninger, R.J., Roadheader *excavation performance -geological and geotechnical influences, The 9th ISRM Congress, Theme 3: Rock dynamics and tectonophysics / Rock cutting and drilling,* Paris, 25 August, 1999, pp. 1241–1244.

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

TECHNICAL-ECONOMIC INDICATORS FOR THE ASSESSMENT OF TECHNOLOGICAL SCHEMES OF MINES

INGA ROSIORU[*]
NICOLAE ILIAS[**]

Abstract: *In order to assess mining technological systems, the following three operational indicators are suggested: level of mining technology, level of concentration of workings and level of mine workings intensity. These technical-economic indicators allow both to evaluate the scheme and the technical solutions chosen for the exploitation. The main characteristics of a mine are the production capacity and the duration of service of a mine. In order to determine the production capacity, an algorithm is proposed that allows different technological variants and solutions to be analyzed, based on recommended technical – economic indicators.*

1. MAIN CHARACTERISTICS OF A MINE

The main characteristics of a mine are production capacity and duration of service. Production capacity of a mine is called characteristic, showing the quantity of useful mineral substance extracted in a time unit (24 hours, year).

Production capacity determines the quantity parameters of the entire complex and the main technical-economic indicators of mine functioning.

The service duration of a mine is equal to the period in which the industrial reserves of a seam within the mining field are exploited.

There is a correlation between the annual production capacity of a mine Aa, its duration of service Ts and the magnitude of the mining fields' industrial reserves Zind :

$$T_s = \frac{Z_{ind}}{A_a} \qquad (1)$$

The total duration of service of a mine Tt will be a little larger than Ts, since the time required to achieve the mine production capacity and restriction of activity towards the end of the reserve exploitation is added to the calculated duration:

$$T_t = T_s + t_1 + t_2 \qquad (2)$$

Where:

t1 - time the mine's designed production capacity is reached;

* *Ph.D Student, University of Petrosani*
** *Prof.Ph.D., University of Petrosani*

t2 - time the activity is restricted towards the end of the reserves exploitation.

When the mine's annual production capacity and the existence are established, there usually are two cases: seam reserves are limited; seam reserves are unlimited.

In the second case, to reach the mine's probable production capacity, statistic method or the variant of placing workers in technological processes and operations are recommended.

Determination of production capacity of a functioning mine. As basic methodical document to determine the production capacity of a functioning mine, "Calculation instructions for bituminous coal mines production capacity" should be developed, which should provide the following assertion: "The production capacity of a functioning mine is determined as being the smallest resulted from the transfer capacities of the leading technological processes(links), namely: mine working faces, underground transport, extraction(hoist), technological complex at the surface and ventilation."

Calculation of the mine production capacity is a laborious problem requiring algorithms and programs to be developed, allowing determination of mine production capacity for any conditions(with various face equipments, with any underground transportation scheme etc.).

Unit 3 determines the transfer capacity of the transportation with conveyers along the passage "face – loading point on the principal transportation gallery", which is determined by the minimal transfer capacity of the transportation means, along each route.

Unit 4 determines the transfer capacity of the principal transportation gallery along the route "loading point in the sector – shaft ramp". The calculation can be made both when engines are used in the principal gallery and in case of conveyers.

Units 5 determines the transfer capacity of the shaft ramp as being the smallest of the transfer capacity of the shaft ramp as being the smallest of the transfer capacities of the workings of the shaft ramp(in case of engine transportation).

Unit 7 determines the transfer capacity of the extraction (hoist).

Unit 8 makes calculations for the technical possibilities for ventilation conditions for which the air flow required to be brought to the mine is determined. Afterwards, the production determined from the mine workings faces being known, the air flow passing through the fan determines the technical possibility of the mine according to ventilation conditions.

Unit 9 determines transfer capacity of the surface technological complex for which the transfer capacities of the "collecting silos - loading in railway cars" and "collecting silos – emergency deposit" are assessed.

Unit 10 determines the mine production capacity as the smallest of the leading technological processes (links) transfer capacity.

Unit 11 prints the calculations. Besides the mine's production capacity, the transfer capacities of the leading technological processes, and the nominalization of the least productive equipment("narrow spaces") in each leading technological process are pointed out.

In the design of coal mines, the parameters and characteristics of the enterprise are also founded, therefore with the passage of time makes it more progressive and efficient.

In order to carry out completely and objectively the adopted technological solutions and the chosen technological schemes of the mine, technical-economic indicators should be used, which could be structured in 3 groups: technical-productive indicators, economic indicators and geological-mining characteristics.

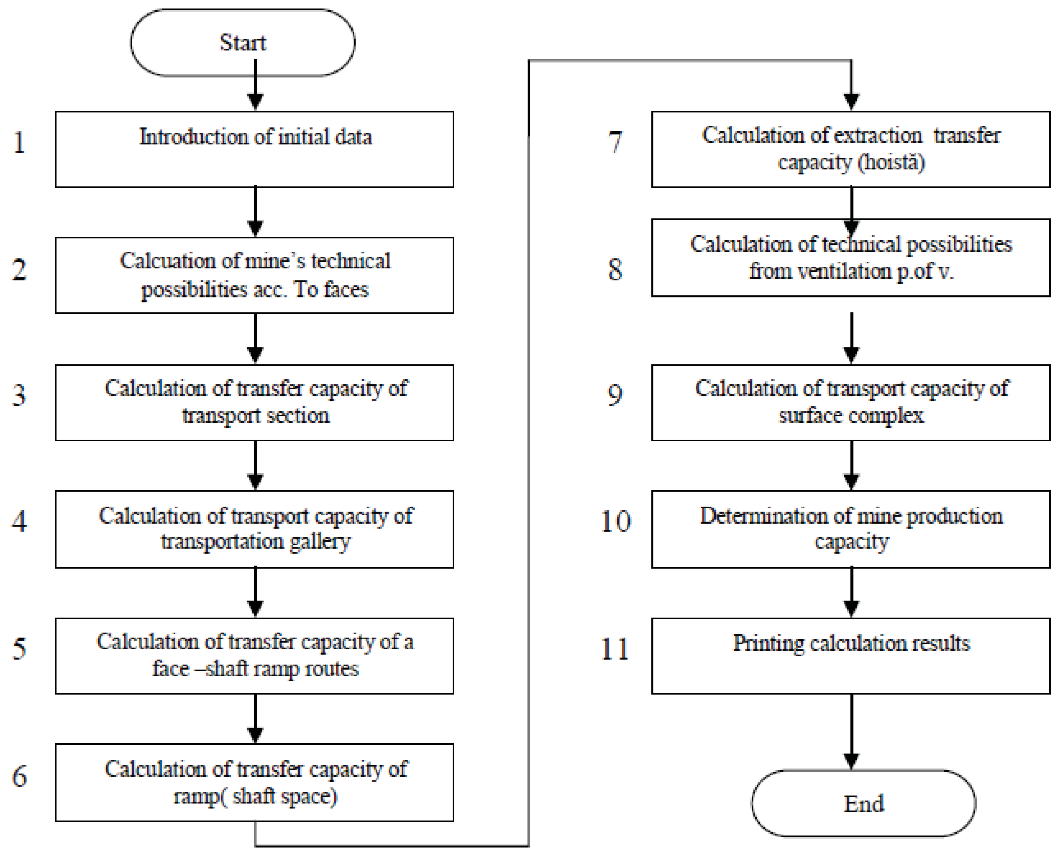


Fig. 1. Algorithm diagram of determination of production capacity of an active mine

2. ELEMENTS FOR THE ASSESSMENT OF THE MINE'S TECHNOLOGICAL SCHEME

To assess the technological scheme of a mine, with a sufficient depth of prognosis and truthfulness of technical solutions chosen, it is considered that the following indicators and parameters should be adopted:

• *Work productivity of the worker in the mine production, t/shift(t/month);*

• *Work consumption for 1000 t average production of the mine, year-shift/1000 t;*

• *Indicator of the mine technological level, expressed by the number of jobs of workers in production, for 1000 m2 exploited area of seams in 24 hours, jobs/1000 m2;*

• *Mine production capacity, t/shift(mil. t/year) determining the concentration level of production;*

• *Face capacity, t/day;*

• *Indicator of the mining working concentration levels, expressed by the magnitude of the exploited area of the seams an average per hour, for an active face m2/h;*

• *Parameters of the opening, preparation, and exploitation system of the mining field;*

• *Indicator of the mining workings level of intensity, calculated in m2/day or m2/hour exploited seam area, for an active face*:

a) Length and volume of opening and preparation workings, which is done during the entire service duration of a mine for 1000 exploited strata area in the mining field, actually determining the technical level of the opening and preparation systems of the mining field;

b) Length and volume of mining workings for the opening and preparation of the mining field;

c) Length and volume of opening and preparation workings for the mining field, done for the entire service duration of a mine, for 1000 t industrial reserve of the mining field, on which the work volume and the time of mine construction, the investment costs and amortization costs depend.

d) Length and volume of mining workings for 1000 t annual production capacity of a mine, which are adopted in the designing stage of a mine and determining the work consumption, construction or reconstruction time and the specific capital expenses.;

e) Length of mine workings to be maintained for the average daily mine production(km/1000 t), determining the number of workers for mine workings maintenance and in some degree for transportation and therefore the work consumption and the cost of those workings during exploitation;

• *Indicators for preparation and exploitation systems of production sectors*, namely:

a) Length and volume of preparation workings for 1000 t industrial reserve of production sector on which the expenses for their execution within the coal price depend;

b) Number of preparation workings simultaneously executed in a production sector;

c) Length and volume of preparation workings and faces executed in a mine in 24 hours for 1000 t capacity of daily production of a mine, on which the work consumption and the execution cost for 1 m working, and therefore the share of expenses for this kind of consumptions in the coal price depend(along with the previous indicator);

d) Number of workings that should be maintained before the faces, for 1000 t of the daily production capacity of a mine;

e) Number of workings that should be maintained from the side of the exploited space of the faces, for 1000 t of the mine’s daily production capacity;

f) Length and volume of preparation workings of production sectors that should be maintained, for 1000 t of the mine’s daily production capacity, on which the work consumption and the cost of maintenance for these workings and in some degree for transportation within the production sector entirely depend, along with the two precious indicators.

3. INDICATORS FOR THE TECHNICAL-ECONOMIC ASSESSMENT OF THE COAL MINES’ TECHNOLOGICAL SCHEMES

To assess the mining technological systems, the following three operational indicators are considered the most important: indicator of the mine’s technological level, indicator of the workings concentration and indicator of the mine workings intensity.

3.1. Indicator of the mine’s technological level

The technical level indicator is meant to assess the share of each technological process of a mine, in the general level of technology in the mine.

From this point of view, the most preferable indicator of the technological level of a mine is work consumption for 1000 t of the daily production of a mine.

The expression to determine the technological level of a mine Nm has the following form:

$$N_m = \frac{1000P_m}{S_m} = \frac{1000P_m m\gamma}{A} \qquad (3)$$

Where :

Pm – number of jobs in extraction in 24 hours;
Sm – area of exploited strata in 24 hours, m2;
A – daily production capacity of a mine, t;
m – stratum's average thickness, m;
γ – volumetric mass of coal, t/m3.

3.2. Indicator of the concentration level of the workings

The notion of concentration of working in mining industry is made up of two principal elements: production concentration and mining working concentration.

The main indicator, with the help of which the production concentration level is determined, is the production capacity of a mine. If the production concentration level is expressed by the size of the mine's production capacity, then as its main indicator, the total level of faces for 1000 t of daily average production of a mine is considered.

The indicator of the concentration level of the mining workings $K_{c.l.}$ is determined with the formula:

$$K_{c.l.} = \frac{1000n_{t.a.}}{A} \qquad (4)$$

Where:

nta – total number of mine faces;
A – daily average production of a mine, t.

Thus, the adopted indicator of the working concentration Kcl is expressed by the relationship of the total number of faces related to 100 t daily production of a mine.

The concentration of the workings in a mine is a notion determining the degree of concentration workings in the mining field. Its level depends on several factors: total number of faces and preparation faces in a mine, number of panels, blocks, strata and levels that are simultaneously exploited in the mining field, the length of the mining workings.

The principal factor determining the concentration level of the mining workings is the total number of the faces in a mine, ensuring its production. The fewer the faces or their specific indicator (total number of faces rot 100 t daily production of a mine), the fewer the panels, blocks, strata and levels that are exploited simultaneously. This, in its turn leads to lessening of the specific extent of the mining workings in a mine.

With the increase of the concentration level of the mining workings, the specific capital costs and basic funds for mining workings are reduced, the costs with work consumption and means for mining working maintenance and in some degree for transportation are reduced, leading to a cut down of the final balance of work expenses and expenses for this kind of workings (in the cost of coal, etc.).

The increase of the concentration level of the mining workings leads to the decrease of the basic funds, of the exploitation consumption and increase of work productivity, therefore leading to a cut down of the coal price and related costs, increase of economic efficiency and production.

The considerable reduction of the number of faces providing a mine's production capacity, that is increasing the concentration of mining workings, is only possible based on the increase of production at the face.

Therefore, the face production is the principal determining factor, ensuring production increase in panels, blocks, strata, levels, improving thus a mine's technical-economic indicators.

The achievements in the field of underground exploitation technology and method opened ways to considerable increase the face's production capacity, which in its turn contributed to the subsequent increase of both the concentration level of the workings, and the production capacity of a mine – the main indicator of production concentration.

3.3. Indicator of the mining working intensity

As indicator of the mining working intensity Il.m., the size of the strata exploited in average per hour (day) for an active face is adopted.

The formula to determine Il.m. has the following form:

$$I_{l.m.} = \frac{A}{24 n_{a.a.} m \gamma} \tag{5}$$

Where:

na.a. - number of active stopes;

m - the average thickness of the strata, m;

γ - volumetric mass of coal, t/m^3.

When comparing the versions of technological schemes or the technologies of performing stope works, for the same intensity geological and mining conditions of mining works it can assess the speed of advancement of the workings or or the average amount of coal extracted from the stope in 24 hours.

In order to lay a foundation for the technical level indicator of the opening and preparation workings, the mining field is analyzed, its dimensions by direction are noted with Sc.m., by inclination with H, and the total extent and volume of the opening and preparation workings of the mining field, effected during the entire period of mine service, by L and V. Thus, the specific length and volume (Vs)of these workings for 1000 t industrial reserves can be determined with the formulae:

$$L_s = \frac{1000L}{HS_{cm} m \gamma c} \tag{6}$$

$$V_s = \frac{1000V}{HS_{cm} m \gamma c} \tag{7}$$

Where:

c – extraction coefficient of the reserve.

If in the formulae (3.4.) and (3.5.) L, V, H, Sc.m. – are constant, then the magnitudes Ls and Vs will depend on the values of m and γ, that is for the same dimension of the mining field, strata depth, technical solutions and parameters of the opening and preparation system, specific values of the extent and volume of the mining workings for 1000 t industrial reserves will depend on the thickness and volumetric mass of coal strata.

Thus, as indicator of the technical level of the opening and preparation of the mining field, the specific length and volume of opening and preparation workings of mining fields for 1000 m2exploited area of the strata are considered.

The adopted indicators allow both the mine's technological scheme, and the technical solutions selected for exploitation to be assessed.

The mine's technological schemes applied in determined geological-mining conditions with optimum values of the above mentioned indicators, provide not only minimal work consumption, but also minimal costs.

4. CONCLUSIONS

Restructuring coal industry, its being made efficient require a systemic combination between technological, economic, environmental and social aspects

The technological scheme of a mine can be considered a system including basic and auxiliary technological schemes, and the totality of mining workings of opening, preparation and extraction, as well as mechanisation and automation means of the basic and auxiliary processes, allowing the extraction of useful mineral substances by a determined work organization.

The objective function of a mining system is assessed by efficiency; therefore the technical and economic indicators should be analyzed.

The main characteristics of a mine are its production capacity and its duration of service.

In order to determine the production capacity, an algorithm is proposed allowing the analysis of various variants and technological solutions based on technical –economic indicators.

A mine's efficient operation requires a rational structure for the technological scheme of the mine to be established, where conditions are created for a quasi-continuous activity of the faces.

REFERENCES

[1]. Astahov, A.C. ş.a., *Economicescoe i pravovoe osnovâ prirodopolzovania.* MGGU – Moscova 2002.

[2]. Gâf – Deac, I., Iliaş, N., Surulescu, D., *Directions towards performance in technology, Mining Revue*, no. 9/2006.

[3]. Ilias, L., *Performance assessment of mining technology systems,* Universitas Publishing House, 2009.

[4]. Iliaş, L., Andraş, I., Cioara, I., Nicolae, F., *Assesment of mining technological systems based on operational metrics,* International Conference, Science and Technology in the Context of Sustainable Development, Ploiesti, 6 – 7 Noiembrie, 2008.

[5]. Iliaş, L., Andraş, I., Cioara, I., Nicolae, F., *Technical evaluation in the mining system using operational indicators,* Scientific Bulletin of Petroleum - Gas University of Ploiesti, 2009.

[6]. Surulescu, D.L., Popescu, C., *Restructuring of coal mining in Romania,* FOCUS Publishing House, 2008.

[7]. Rosioru-Cioara, I., *Technical assessment of economic, social and ecological systems of mining technology. Project to Promotion of Scientific Research Program,* 2013.

[8]. Ilias, N., Andras, I., Radu, S.M., Gruneantu, I., Mârza, F., Mija, E., Rosioru-Cioara, I.*, Energy scenarios based on the Jiu Valley coal,* FOREN 2014,22-26.0602014, Bucuresti.

[9]. Radu. S.M., Candrea, T., Mititica T., Ionitescu N., Roşioru - Cioara Inga, Universitatea din Petroşani, România.- *The issue of changing in Romanian exploitation systems for the efficient protection of the environment,* International Conference on Performance in a competitive economy, IMI-NOVA, Chisinau,25-26.04.2014.

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

CALCULUS OF SUPPORTING CAPACITY OF THE PILARS AND FLOORS NETWORK FROM ROSIA MONTANA CETATE QUARRY

MIHAELA TODERAŞ*

Abstract: *Full exploitation of the Cetate quarry massive from EM Rosia Montana was made in the conditions of existence the underground voids networks under the platforms quarry; these goals resulted from old mining exploitations. Some of these voids can not be defined precisely because of their chaotic development and their removing step by step, as the quarry level descent, based on special programs adapted along the way to the realities of the land. Another part of the underground cavities, namely those resulting from the previous exploitation by rooms and pillars method is contoured on the maps of exploitation allowing the access of peoples inside them, for any controls and inspections. The platform quarry reached the level of upper bottoms of the breccia and will proceed to exploitation those contained in pillars and floors. In the dacite area of massif, the quarry would have in exploitation one bench up to reach of the level of bottoms opposed unlike the "Coranda" cavities whose removal impose drawing out this perimeter of the proper quarry and considering a protection berm and filling progressively the cavities with the dislocated ore from western of quarry without prior filling the existent cavities. In this regard, the work bench of quarry would take a height corresponding to level difference between two successive bottoms and the equipments existent on the platform to work practically under the intermediate floors between bottoms. Given that this working mode assumed that the quarrying take place directly over network overlay cavities of underground, it follows that the security working depends directly of the stability of the pillars and floors below, which must resist both to the loads caused by equipments on the platform and the dynamic loads resulting on blasting.*

Key words: *quarry, stability, resistance, floor, pillars, floors, bearing*

1. GEOMETRICAL CHARACTERISTICS OF ROOMS, PILARS AND FLOORS NETWORKS IN BOTTOMS ZONE

The dimensional characteristics of the resistance network on the bottoms perimeters which are proposed to exploit, can be conditioned by the fact that [1], [3], [4]:

a) Each horizon exploited (bottom) has a different extension in plan, but there are enough large areas where all bottoms are overlapping; in the breccia zone there are eight bottoms; in the dacite zone, above the + 873 m level we find only four overlapping bottoms, and the others four are immediately below the respective level. Taking into account the interaction of them, we consider that in the dacite zone there are eight overlapping bottoms too;

* *Assoc. Prof. Ph.D. Eng. at the University of Petrosani, toderasmihaela@yahoo.com*

b) In the overlap zone of bottoms, the pillars were not positioned over each other which create a more disadvantage load;

c) The pillars dimensions are variable and in calculus will consider the work height as 3.5 m (figure 1);

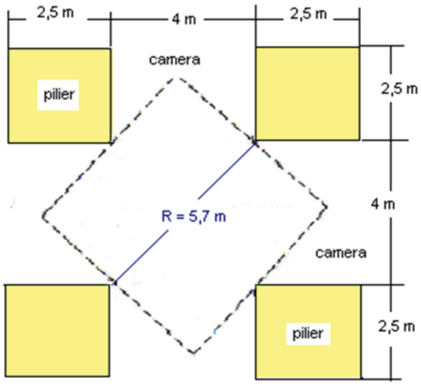


Fig.1. Maximum opening of the floor

d) opening rooms range from minimum 2 to 2.5 m and maximum 4.5 to 5 m. considering that the openings greater than 4 m are sporadically and that they are in the edge areas where are recorded only overlap of most 2 or 3 of the existing bottoms, we considered that an opening of 4 m is lower and sufficiently to be generalized as parameter of calculus;

e) Thickness load bearing of the floors is smaller than the real one, standing at more 2 m in the breccia zone and 3 m in dacite zone. We mentioned that in the voids network located in dacite, the real thickness of the floors is about 5 m, but due of the fissuration we will consider that only 3 of this real thickness are supporting.

The different opening of rooms (minimum 2 to 2.5 m and maximum 4.5 to 5 m) has not imposed further measures, given that the openings greater than 4 m have met only sporadically and just in the edge zones where were registry only overlap of no more 2 or 3 of existing bottoms, see Table 1.

Table 1. Geometrical calculus parameters of pillars – floors network stability

No.	Calculus parameter		U.M.	Value
1.	Thickness of floors between the bottoms (h)	- network of breccia - network of dacite	m	2,0
2.	Width of rooms (l_1)		m	4,0
3.	Maximum opening of floors considered on the diagonal intersection between two rooms (l)		m	5,7
4.	Height of the pillars (H)		m	3,5
5.	Load bearing section of pillars (S)		m	2,5 x 2,4
6.	Slenderness ratio of pillars $\alpha = \frac{3,5}{H}$		-	0,7

Concerning the floors, we mention that the bearing thickness was less than the real, standing at more than 2 m in the breccia area and 3 m in the dacite area (see table 1). In the voids network located in dacite, the real thickness of the floors was about 5 m, but due to brittle in the calculus of stability we considered that only 3 m of this real thickness is load bearing [6].

2. ROCK COMPONENTES CHARACTERISTICS OF PILLARS – FLOORS NETWORK

The bottoms of Cetate massif from Rosia - Montana mine are located in breccia and dacite. The analysis of the geological fractions taken from in side of bottom showed that most of them fall into the following varieties: silicified mixed breccia; poorly fractured dacite, table 2. In term of physical – mechanical and strength characteristics (instantaneous and in time), these varieties were analyzed in detail in [3].

Table 2. The calculus values for the strength parameters of rocks

No.	SPECIFICATION	U.M.	BRECCIA	DACITE
1.	Bulk density, γ	$N/m^3 \cdot 10^4$	2.5	2.6
2.	Compressive strength, σ_c	$N/m^2 \cdot 10^5$	550	210
3.	Tensile strength, σ_t	N/m^2	86.4	58.8
4.	Shear strength, σ_f	N/m^2	127	227
5.	Cohesion, C	$N/m^2 \cdot 10^5$	21	15
6.	Angle of internal friction, φ	grade	38	36
7.	Elastic modulus, E	$N/m^2 \cdot 10^4$	201950	245500
8.	Poisson’s coefficient, μ	-	0.126	0.304
9.	Limit degree of load, Δ	-	0.6	0.7
10.	Admitted velocity of the vibration	m/s	0.05	0.04

3. WORK SYSTEM PREDICTED TO REMOVAL THE BOTTOMS

From the work schema, it resulted that during of 6 successive benches the quarry’ platform itself will consist practically of a floor of 2 m thickness in the breccia, respectively 5 m in dacite, the floor that initially has 33 m in breccia area and 54 m in dacite and which in turn is based on a complex system of pillars and intermediate floors extended in depth. In order that the quarrying be carried out properly is necessary to ensure both the stability of the upper floor which is actually the bottom of quarry as well the stability of all resistance structures placed below that support this floor.

In the existing pillars and intermediate floors network, any loss of stability exercised to one of the elements founded at lower levels can lead a falls’ chain transmission up to the quarry’ level. Until now, the stability structure has not suffered during the 40 years of existence, and at the first sight the situation doesn’t seem to change worthless, if it’s considered that with the descent of quarry the charges that weigh on the system was considerably diminished. But, if by descending quarry the static charge on the whole system continuously decreased, at the same time began to visibly increase the dynamic loads due to the current quarry’ activities. Thus, near the working front will soon reach that the quarry equipments (excavators, dumpers, bulldozers, drilling machines) work on a floor with a thickness capacity that has not been seen so far, then blasting operations will be even close to that floor, fig.2.

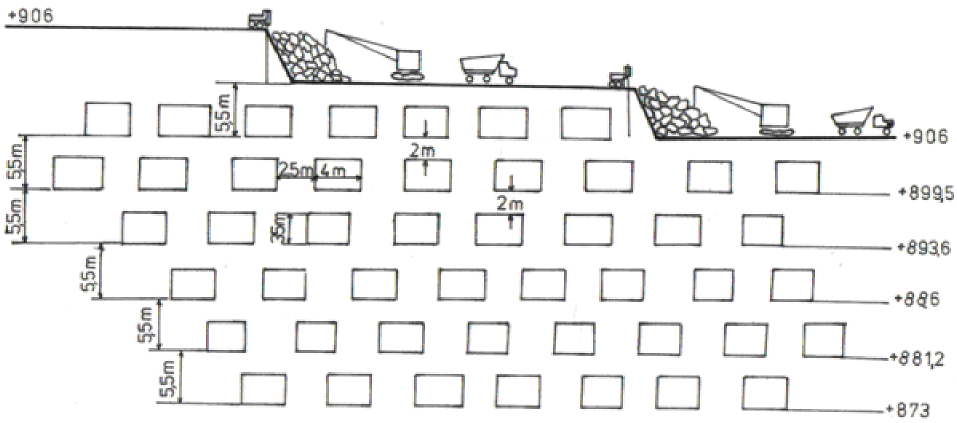


Fig.2. Work schema to removal the bottoms.

Initially, this system was extended to a depth of 33 m in the breccia zone and respectively 54 m in dacite. In order that quarry exploitation to be conducted adequately it was necessary to ensure the stability both of the upper floor representing in fact the bottom of quarry, and the equilibrium of entire resistance system located under the bottom of quarry. In the existent pillars and intermediate floors network, any loss of stability appeared at one of these elements situated at lower levels, can generate the chain transmission of cave-ins up to the quarry. It should be noted that throughout the period of over 55 years of exploiting of the deposit for Rosia Montana mining perimeter, the equilibrium of the resistance structure was preserved, although with considerable lowering of quarry and reducing the loads that acted the system, increased the dynamic loads from current activities of quarry.

In order to apply in complete safety of this working system, it was taken into account on the one hand of course the bearing strength of pillars - floors network under loads conditions generated by equipment used in quarry and minimum dimensions of the resistance elements, and on the other hand the maximum explosive admitted quantities and actually all blasting parameters according to the reserve of bearing strength. Verifying the possibilities of applying in complete safety of the predicted work system includes two stages, namely:

a) Determine the actual bearing strength of pillars – floors network under loads conditions generated by the equipment proposed to work in quarry and minimum dimensions of the resistance elements;

b) Establish the maximum explosive admitted quantities and the other parameters of blasting depending on the reserve of bearing strength resulted from the previous.

If, during the first stage of verification will appear that the pillars and floors between bottoms have not actually a reserve of bearing strength or this reserve is too small to support the dynamic effect of blasting, it means that the proposed technology can not warrant the complete security and will be replaced. If will require a reserve of bearing higher than this one resulting from the use of heavy equipment, they will be replaced with lower weight.

4. ACTUAL BEARING STRENGTH OF PILLARS – FLOORS SYSTEM

The security work in quarry is conditioned by the equilibrium of the all assembly of pillars and floors, extended to a depth of 33 m in breccia zone and respectively 54 m in dacite area. The danger of a major accident occurring both in the event of breaking the floor where the machines work directly and in case of breaking a floor or pillar in depth that can lead to a chain collapse of the entire upper structure until to the level quarry. Consequently, verification of the bearing strength will expand the full depth of the bottoms; that can be do for all the real cases of position of pillars and floors network, but only for the case to be considered the most disadvantageous in term of loading. For shaping this limiting case, you must set the following: which is the horizon most loading; which is the maximum load that supports the pillars and floors located within the most loading horizon. After these principal elements are established, we make the calculus of bearing strength to determine the effective bearing reserve in the most loading horizon. In the aspect of this, is clearly that this horizon is the lowermost; his structure supports both the weight of upper bottoms and the machines of quarry too.

As we move above the load decreases, reaching the upper floor of the network to support only the weight machines running on it. The maximum charge on the horizontally structures depends on the positioning of the pillars and floors towards above the element consider. The pillars of bottoms are not perfectly overlapped, contrary, every bottom was independent developed; the pillars were outlined without any coordination with those of the upper and lower bottoms. Thus, there appeared infinite mutual positioning between the pillars of each horizon, impossible to represent in a reciprocal calculus schema. For this reason, in the following calculus we chose an hypothetical schema unidentified practically in situ, but that which will constitute the worst case of all the possibilities theoretically possible. This schema, fully enclosure, was differentiated between the particular situation of pillars and floors respectively [1], [2], [5]. She corresponds to the following positions: for pillars, continuous multilayer pillars column until the level of quarry, with the heaviest equipment stationed above; for floors, identically column of pillars like the previous case, positioned on the middle of opening floor.

In the case of these positions, the pillars and floors of the last horizon must resist to the following static loads: own weight; weight of overlying rock; weight of the great equipment of quarry or of the blasting rock. It should be note that the pillars are quite closer and than they can take either a weight of blasting rock, either the excavator weight of 75 tf that is the bigger on bottoms, or the loads transmitted by the running dumper trucks or other equipment easier. Since the loads of quarry can not be cumulated, the maximum individual load will be considered. Determination of the maximum load is further determined by comparing the individual values.

4.1. Weight of blast rock

Rock weight is determined by the relation:

$$Q_R = \gamma_a \, h \quad [N/m^2] \tag{1}$$

where:

γ_a – bulk density of rock; h - height of bench.

	$\gamma_a \cdot 10^4$ N/m^2	h [m]	Q_R [N/m^2]
Breccia	2,5	5,5	$13{,}75 \cdot 10^4$
Dacite	2,6	8,5	$22{,}1 \cdot 10^4$

4.2. Load develop by SC 3602 excavators and dumper trucks of 16 tf

The pressure on the soil of the excavator is $12.2\,tf/m^2$. The seating surface is greater than the surface of pillar, but it is retransmits entirely to the pillar. Taking into account that the excavator is moving equipment, the total load will be about 10 % higher than the static pressure on the soil.

$$Q_E = 1{,}1 \cdot 12{,}2 \cdot 10^4 \quad N/m^2$$
$$Q_E = 13{,}42 \quad N/m^2$$

The total weight of dumper trucks is 26 tf, which major with the dynamic coefficients will send to a single pillar:

$$Q_A = \frac{26}{S_p} \cdot \beta_1 \cdot \beta_2 \cdot 10^3 \quad [N]$$

where:

S_p – bearing surface of a pillar: S_p = 2,5 · 2,5 = 6,25 m^2; β_1 – stress concentration coefficient, β_1 = 2,5; β_2 – increase coefficient of static load: β_2 = 1,25.

$$Q_A = \frac{26}{6{,}25} \cdot 2{,}5 \cdot 1{,}25 \cdot 10^3 \quad [N]$$

The maximum loads from quarry due to the blasting rock and rich to the values:

$$Q_{max} = 13{,}75 \cdot 10^4 \quad N/m^2$$ - in breccia zone

$$Q_{max} = 22{,}1 \cdot 10^4 \quad N/m^2$$ - in dacite zone

4.3. The bearing strength reserve of actual pillars

This reserve can be established from the general relation:

$$P_s = \sigma_{lim} - (\sigma_0 + \sigma_s) \cdot \beta \quad [N/m^2] \qquad (2)$$

where:

σ_{lim} – bearing strength of pillar; σ_0 – own weight of pillar; σ_s – additional load that consists in weight of overlying rock in the limit state hypothesis to which is added the quarry's loads; β - – increase coefficient of static load: for pillars β = 1,1.

The bearing strength of pillars is determined by the relation:

$$\sigma_{lim} = \frac{K\,D}{\alpha}\left[2 + F(\alpha, f)\right] \quad [N/m^2]$$

where:

K – cohesion of material of pillars; D – load degree limit admissible of pillars; α - fineness coefficient of pillars: α = width / height; F – mathematical auxiliary function depending of fineness coefficient and angle of internal friction of rock on pillar: F = 6,5 for breccia and respectively, F = 4,5 for dacite.

We will have:

- in breccia areas:

$$\sigma_{\lim} = \frac{210 \cdot 0{,}6}{0{,}714} \cdot (2 + 6{,}5) \cdot 10^4 \cong 1500 \cdot 10^4 \quad N/m^2$$

- in dacite area:

$$\sigma_{\lim} = \frac{150 \cdot 0{,}7}{0{,}714} \cdot (2 + 4{,}5) \cdot 10^4 \cong 955 \cdot 10^4 \quad N/m^2$$

4.4. Specific Own weight of a pillar. Additional load (σ_s)

These parameters will be established taking into account the rock type, the geometry and respectively the number of existent upper bottoms considering each pillar and floor located overhead one bottom. Thus, the specific own weight of pillar, is:

$\sigma_0 = 17{,}5 \cdot 10^4 \quad N/m^2$ - for the pillars in breccia

$\sigma_0 = 18{,}2 \cdot 10^4 \quad N/m^2$ - for the pillars in dacite

Additional load (σ_s) is composed of weight of overlying rock to which is added the maximum load provided from quarry Q_R = 13,75 · 10^4 N/m^2, respectively 22,1 · 10^4 N/m^2. The overlying rock consists (in the adopted hypothesis) in the floor overlying immediately and the 5 upper bottoms, each of them comprising one pillar and the floor above it. Totally, they are 6 floors and 5 pillars, whose total specific weight reported to the pillar support surface will be:

- for the breccia zone:

$$\sigma_{sl} = \frac{6 \cdot 4^2 \cdot 2 \cdot 2{,}5 + 5 \cdot 2{,}5^2 \cdot 3{,}5 \cdot 2{,}5 \cdot 10^4}{2{,}5^2} = 120{,}6 \cdot 10^4 \quad N/m^2$$

$$\sigma_s = (120{,}6 + 13{,}75) \cdot 10^4 \cong 134{,}35 \cdot 10^4 \quad N/m^2$$

- for the dacite zone:

$$\sigma_{sl} = \frac{6 \cdot 4^2 \cdot 5 \cdot 2{,}6 + 5 \cdot 2{,}5^2 \cdot 3{,}5 \cdot 2{,}7 \cdot 10^4}{2{,}5^2} = 245{,}2 \cdot 10^4 \quad N/m^2$$

$$\sigma_s = (245{,}2 + 22{,}1) \cdot 10^4 = 267{,}3 \cdot 10^4 \quad N/m^2$$

Returning to the basic relationship (1), finally we determine the bearing strength reserve of pillars from the last horizon and the safety coefficient, c:

a) for the breccia zone:

$$P_s = \left[1500 - (8{,}75 + 134{,}35) \cdot 1{,}1\right] \cdot 10^4$$

$$P_s = 1343 \cdot 10^4 \quad N/m^2$$

$$c = \frac{1500}{157} \quad \Rightarrow \quad c = 9{,}55$$

b) for the dacite zone:

$$P_s = \left[955 - (9{,}1 + 267{,}3) \cdot 1{,}1\right] \cdot 10^4$$

$$P_s = 651 \cdot 10^4 \quad N/m^2$$

$$c = \frac{955}{304} \quad \Rightarrow \quad c = 3{,}14$$

Therefore, it appears that in the worst case of load the pillars have a sufficiently reserve of bearing enabling to carry out blasting in quarry.

4.5. The reserve of bearing strength of floors

The basic relationship is:

$$P_s = \sigma_{\lim} - (\sigma_0 + \sigma_s) \cdot \beta \cdot 10^4 \quad [N/m^2]$$

The bearing strength of floors is calculated according to the relation:

$$\sigma_{\lim} = \frac{\sigma_c \, D}{1{,}2} \left(\frac{b^2}{l^2} - 0{,}002 - \frac{h}{l} \right) \cdot 10^4 \quad [N/m^2]$$

where:

σ_c compressive strength of rock in floor; D - load degree limit admissible; h – bearing thickness of floor; l – maximum opening of floor.

Adopting the appropriate values, obtain:

- for the floors in breccia:

$$\sigma_{\lim} = \frac{5500 \cdot 0{,}6}{1{,}2} \left(\frac{2^2}{5{,}7^2} - 0{,}02 - \frac{2}{5{,}7} \right) \cdot 10^4$$

$$\sigma_{\lim} = 319 \quad N/m^2$$

- for the floors in dacite:

$$\sigma_{\lim} = \frac{2100 \cdot 0{,}7}{1{,}2} \left(\frac{3^2}{5{,}7^2} - 0{,}02 - \frac{3}{5{,}7} \right) \cdot 10^4$$

$$\sigma_{\lim} = 326 \quad N/m^2$$

The own weight of one floor, will be:

- floor in breccia:

$$\sigma_0 = 2{,}5 \cdot 2 \cdot 10^4$$

$$\sigma_0 = 5 \cdot 10^4 \quad N/m^2$$

- floor in dacite:

$$\sigma_0 = 2{,}6 \cdot 5 \cdot 10^4$$

$$\sigma_0 = 13 \cdot 10^4 \quad N/m^2$$

The additional load consists from 5 pillars and 5 floors and the maximum load of quarry, namely $13{,}75 \cdot 10^4$ N/m^2 and respectively, $22{,}1 \cdot 10^4$ N/m^2. It follows that:

- for the floors in breccia:

$$\sigma_q = 5 \left(2{,}5^2 \cdot 3{,}5 \cdot 2{,}5 + 5{,}7^2 \cdot 2 \cdot 2{,}5 \right) \cdot 10^4 \quad \Rightarrow \quad \sigma_q = 1086 \cdot 10^4 \quad N/m^2$$

$$\sigma_l = \frac{1086}{5{,}7^2} \cdot 2 \cdot 10^4 \quad \Rightarrow \quad \sigma_l = 66{,}85 \cdot 10^4 \quad N/m^2$$

$$\sigma_s = (66{,}85 + 13{,}75) \cdot 10^4 \quad \Rightarrow \quad \sigma_s = 80{,}6 \cdot 10^4 \quad N/m^2$$

- for the floors in dacite:

$$\sigma_q = 5\left(2{,}5^2 \cdot 3{,}5 \cdot 2{,}6 + 5{,}7^2 \cdot 2 \cdot 2{,}6\right) \cdot 10^4 \quad \Rightarrow \quad \sigma_q = 1129 \cdot 10^4 \quad N/m^2$$

$$\sigma_l = \frac{2393}{5{,}7^2} \cdot 2 \cdot 10^4 \quad \Rightarrow \quad \sigma_l = 69{,}5 \cdot 10^4 \quad N/m^2$$

$$\sigma_s = (69{,}5 + 22{,}1) \cdot 10^4 \quad \Rightarrow \quad \sigma_s = 91{,}6 \cdot 10^4 \quad N/m^2$$

Finally, we establish the reserve of bearing strength of floors from the last horizon:

a) For breccia zone:

$$P_s = \left[319 - (5 + 80{,}6) \cdot 1{,}25\right] \cdot 10^4 \quad \Rightarrow \quad P_s = 212 \cdot 10^4 \quad N/m^2$$

$$c = \frac{319}{107} \quad \Rightarrow \quad c = 2{,}98$$

b) For dacite zone:

$$P_s = \left[326 - (13 + 169{,}6) \cdot 1{,}25\right] \cdot 10^4 \quad \Rightarrow \quad P_s = 98 \cdot 10^4 \quad N/m^2$$

$$c = \frac{326}{228} \quad \Rightarrow \quad c = 1{,}43$$

Table 3. The reserve of bearing strength in actual bottoms networks from Cetate massif:

The element of resistance	Rock	Total bearing strength [N/m^2] · 10^4	Actual statically load [N/m^2] · 10^4	Safety factor to statically load	The available bearing strength	
					[N/m^2]· 10^4	[%]
Pillars	Breccia	1500	157	9,55	1343	89,5
	Dacite	955	304	3,14	651	68
Floors	Breccia	319	107	2,98	212	66
	Dacite	326	228	1,43	98	30

5. CONCLUSIONS

Full quarrying of the Cetate massif from Rosia Montana was made in the conditions of existence under the quarry' platforms of networks of underground cavities resulted from the old exploitations and from rooms and pillars exploitation method.

To pass to the exploitation of pillars and floors reserves, it was suggested a scheme where the working bench of quarry would have a height appropriately level difference between two successive bottoms and equipment on the platform to work practically on intermediate floors between bottoms. Therefore, safety of the work in quarry is directly conditioned to the stability of the pillars and floors below system, which must be resist both to the loads caused by the machines on the platform, as well as dynamic loads resulting from the blasting. In the existing pillars and intermediate floors network, any loss of stability exercised to one of the elements founded at lower levels can lead a falls' chain transmission up to the quarry' level. Due to this fact, was imposed an analysis of the bearing strength of pillars and floors made in the two rock types in which they are achieved and implicitly their safety degree.

By descent the quarry, the static load on the entire system decreased continuously and simultaneously began to increase visibly the dynamic loads from the current activities of the quarry.

Analyzing the results obtain from calculus it is found that in both structures – pillars and floors, the elements most loaded are the floors; the bottoms structure located in breccia is more resistant, the bearing strength reserve of them is high and thus will allow blasting a greater quantity of explosives. For the most unfavorable load acting on the pillars, they have a reserve of bearing sufficiently high as to enable safely blasting works in quarry.

REFERENCES:

[1]. Glodeanu, E., *Studiu privind exploatarea prin carieră a pilierilor şi planşeelor conturate anterior prin exploatarea în subteran, la E.M. Roşia - Montană, între cotele +906m şi +873m*.

[2]. Stamatiu, M., *Rock Mechanics*. Didactical and Pedagogical Publishing House (in Romanian), Bucharest, 1962.

[3]. Toderaş, M., *Rock characteristics of Cetate quarry perimeter from Rosia Montana*. Annals of the University of Petroşani, Mining engineering. Petroşani, vol. 14 (XXXXI), Universitas Publishing House, pag.31-40, Petroşani, 2013, ISSN 1454-9174.

[4] Toderaş, S., *Reabilitarea ecologică a zonelor afectate de activitatea minieră de la Roşia Montană.* Teză de doctorat. Petroşani, 2009.

[5] *,** *Technical and geological documentation from Roşia Montană*.

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

LANDFILL CAPACITY ASSESMENT AT WASTE DUMP VALEA ARSULUI - VULCAN COLLIERY

ADRIAN FLOREA*
MARIA LAZĂR**
CSABA LORINŢ***

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 modelling, heap capacity assessment, mining waste dump, Jiu Valley colliery*

1. 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).

* *Assoc. Prof. Ph.D., University of Petroşani*
** *Prof. Ph.D., University of Petroşani*
*** *Lecturer. Ph.D., University of Petroşani*

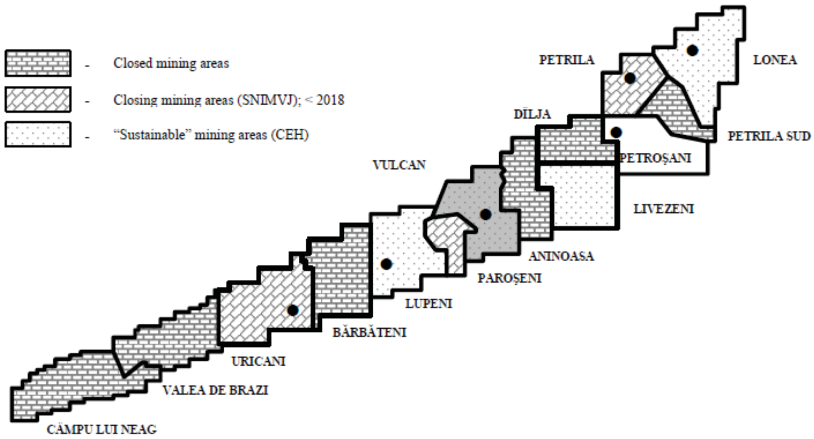


Fig.1. Location of Vulcan colliery in Jiu Valley hard coal basin

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 180. The inclination of the valley bottom in the heap area is about 5o (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).

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.

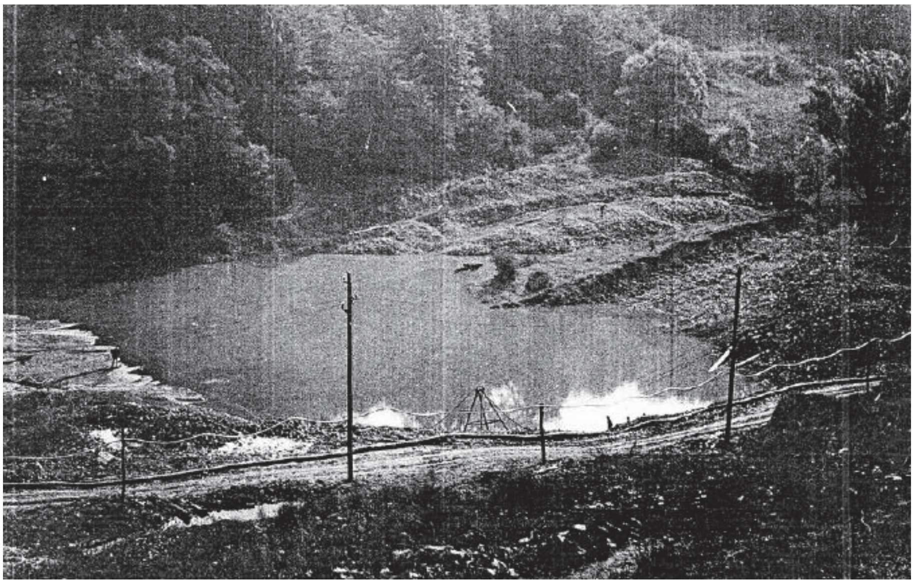


Fig. 3. Small lake generate by Arsului creek water accumulation in the subsidence trough - 1981

2. 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).

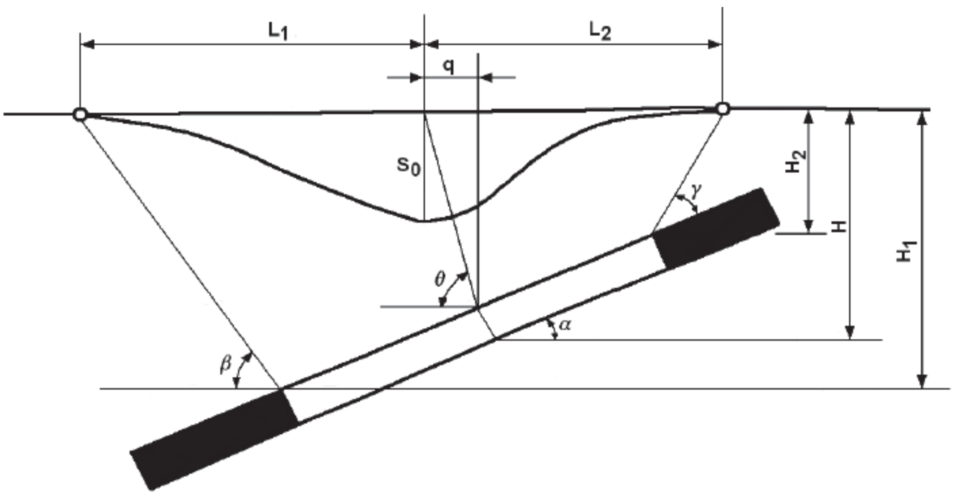


Fig. 4. The trough diving generated at extraction of a dip seam deposit

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

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

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; $\alpha = 39°$

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:

$$S_0 = a \cdot m \cdot f \cdot z \tag{2}$$

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 S0 = 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.

3. 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).

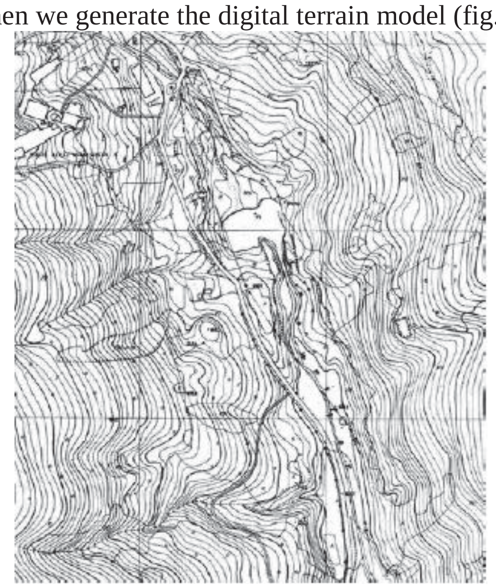


Fig. 7. Aerial survey made in 1981 in Valea Arsului

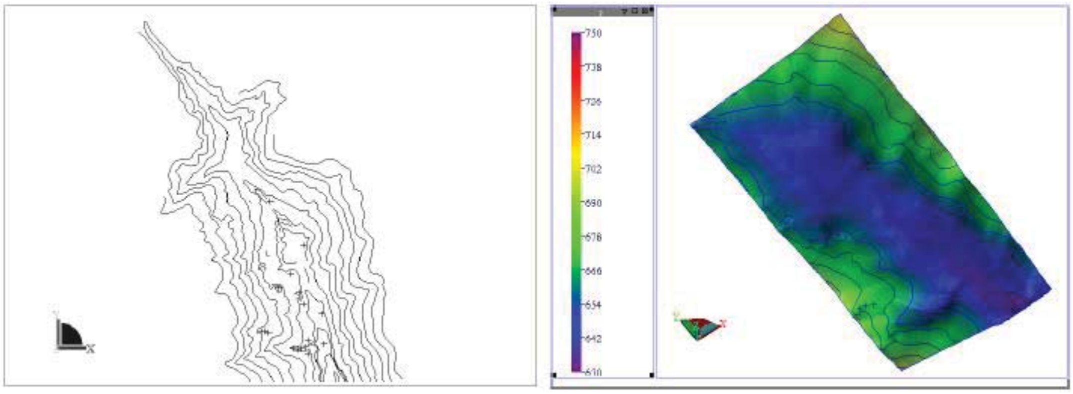


Fig. 8. Digitized level curves from aerial survey made in 1981 in Valea Arsului (left) and digital terrain model of Valea Arsului with sinking phenomenon (right)

4. 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 22o. 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.

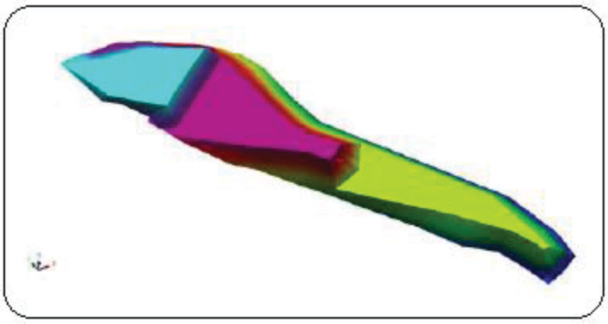


Fig. 9. Final geometry of the Valea Arsului heap

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).

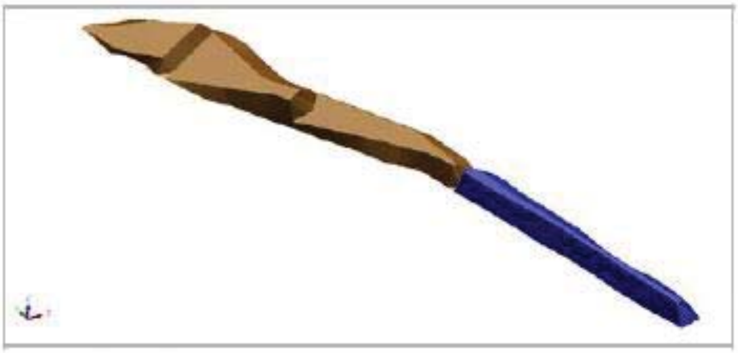


Fig. 10. Final geometry of the heap with the expanded perimeter towards south (blue body)

5. 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”.

REFERENCES

[1]. Băncilă I., *Geological Engineering*, Vol. I şi II, (in Romanian), Technical Publishing House, Bucharest, 19981;

[2]. CEH Portal, http://www.cenhd.ro/, 2014;

[3]. Dima N., Padure I., Herbei O., *Mining Surveying*, (in Romanian), Corvin Publishing House, Deva, 1996;

[4]. Florea A., Lazar M., Lorinţ C., *Subsidence Modeling at Valea Arsului - Vulcan Colliery*, Conference Proceedings of *14th International Multidisciplinary Scientific GeoConferences SGEM2014,* Volume 3*,* Section: Exploration and Mining/Mineral Processing, 2014;

[5]. Florea M. N., *Landslides*, (in Romanian), Technical Publishing House, Bucharest, 1979;

[6]. Lazăr M., Voin V., Boyte A., Dumitrescu I., Florea A., Dunca E., Lorinţ C., Postolache M., Stability study of Valea Arsului heap, Research Contract No. 69 ASL/15.09.2005, for National Hard Coal Company, Vulcan Colliery, 2005;

[7]. Lorinţ C., Edelhauser E., Lazăr M., Florea A., Danciu C., Cilibia L., Rada C., Stability study of Valea Arsului heap - EM Vulcan - Waste Management Plan according with HG 856/2008, Research Contract, No. CD 2130 of 17.10.2013. for Hunedoara Energy Complex, Mining Division, (in Romanian), 2013;

[8]. Pop E.I., *Geological Monography of Petrosani Basin*, (in Romanian), Romanian Academy Publishing House, Bucharest, 1993;

[9]. SNIMVJ Portal, http://www.snimvj.ro/, 2014

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

NECESSITY OF SUBSIDENCE PHENOMENON MONITORING IN THE CASE OF SUSTAINABLE DEVELOPMENT OF JIU VALLEY COAL BASIN CONDITIONS

**FLOAREA DACIAN*
ILIE ONICA**
EUGEN COZMA**
DACIAN-PAUL MARIAN*****

Abstract: *Ground surface deformation as consequence of underground mining operations has always been a phenomenon which can cause significant damage even after mining operations have ended in the concerned area. The constant observation of ground surface deformation within the limits of closed underground mining areas is, nowadays, of little interest for local authorities. This paper presents the effects on the environment, thus proving the necessity of constant observation of this phenomenon after the closure of the mines. Also, legal solutions concerning the observation of this phenomenon are presented with the purpose of creating a tool which can be used in land management policies.*

Key words: *subsidence, monitoring, legislation, coal, underground mining*

1. INTRODUCTION

Underground mining of mineral resources causes numerous problems related to the effects upon ground surface. There are two main causes: the dumping on the surface of underground rocks resulted from extraction (the operation of dumping waste material) and surface deformation as result of underground mining operation (the land subsidence phenomenon). In the case of dumping waste rocks on the surface the negative effect of this activity ends once the mining operations have ended and the piles of waste rock have been reconstructed ecologically. When it comes to the land subsidence phenomenon, the underground mining operations can have negative effects upon the ground surface, upon buildings and industrial facilities, long after the closure of the mines. Such phenomena have been recorded within the territory of Romania in the case of mining operations in the Jiu Valley coal mining basin and in the case of other mining operations related to the mining of other useful minerals. These activities have caused destruction and significant damage, both financially and in terms of negative effects upon the environment.

* *Min. Eng. Ph.D. Student - University of Petroşani*
** *Prof., Min. Eng. Ph.D. - University of Petroşani*
*** *Lecturer, Min. Eng. Ph.D. - University of Petroşani*

Surface movements due to underground mining of paramount importance especially when it comes to total mining of coal seams, thick seams respectively or a package of seams, in consequence in areas of industrial and civil construction cracks and crannies in which can lead to their destruction to agricultural land Gavan formed where water accumulates precipitation, ways of communication infrastructure and water and gas pipes appear cracks and fissures etc. sinking land often occurs instantly and can lead to imbalance and genuine disaster layers.

As in „Mine Closure and Completion Guide”, there is no reference to the necessity of determining the areas which can be affected by the land subsidence phenomenon once a mine has been closed, the purpose of this article is both to outline the importance of constant observation of the land subsidence phenomenon after the closure of a mine, and to put forward some legal solutions which can serve as tools to be used within land management policies.

2. THE JIU VALLEY COAL BASIN

The Jiu Valley coal mining basin, also known as the Petroşani coal mining basin, is situated in the South of the Hunedoara county, in the South-West of Transylvania - 45^{o}25’ North Latitude and 23^{o}22’ East Longitude in a depression in the Southern Romanian Carpathians called the Petroșani Depression or Jiu Valley Depression. Average altitude throughout the Jiu Valley Depression is 600m above Black Sea Level [1].

Depending on the geomorphology of the region, the major tectonics, the results of geological exploration activities, the ways of access and the possibilities of operating works of mine opening and coal mining, the Jiu Valley Coal Mining Basin was divided into 17 mining fields. The boundaries between mining fields correspond to some natural dividing features such as safety pillars or great amplitude faults [1].

From East to West the mining fields are: Lonea, Lonea-Pilier, Petrila-Sud, Petrila, Livezeni, Sălătruc, Dâlja, Iscroni, Aninoasa, Vulcan, Paroşeni, Lupeni, Lupeni-Sud, Bărbăteni, Uricani, Valea de Brazi şi Câmpul lui Neag (Figure 1).

Beginning with the year 1991 coal mining in Jiu Valley has undergone a process of restructuring the activities which will have as final result the end of mining operations by closing some mines (year 1994 - Lonea Pilier, 1999 - Câmpu lui Neag and Petrila Sud, 2003 - Dâlja and Bărbăteni, 2004 - Valea de Brazi, 2006 - Aninoasa).

3. THE LAND SUBSIDENCE PHENOMENON – GENERAL ASPECTS

After the seams of useful materials have been mined in underground mines, voids are created. These voids tend to be occupied by the covering rock layers and a shift of the covering rocks is produced. When the movement reaches the surface a subsidence depression is created.

A very short, concise and easy to understand description of the phenomenon is this: in underground mines, after the extraction of useful minerals from a seam, the stresses inside the massif change which leads to the destruction of the stability of the surrounding rocks. After the stresses inside the surrounding rocks are redistributed, the rocks are set in motion and occupy the space created after the mining. In some cases the shifting of the rocks conglomerate takes place within certain limits, without affecting the integrity of the surface. Most of the times, though, the movement is transmitted to the surface, affecting it and, consequently, degrading civilian and industrial facilities situated within the mining area.

Fig. 1. The Jiu Valley Coal Basin

In order to monitor the shifting and the deformation of the surface monitoring stations are created. They are composed of mobile landmarks situated on the line of subsidence and fixed landmarks situated outside the area of influence of the mining.

The quantification and assessment of the shifting process is made by using certain parameters called parameters of the terrain shifting-deformation process. These parameters are [3]: the subsidence angles (β_s downstream, γ_s upstream, δ_s on the coal seam strike); the breaking angles ($\beta_r, \gamma_r, \delta_r$); vertical displacement (W) mm; horizontal displacement (U) mm; horizontal strain (ε) mm/m; tilt (T) mm/m; curvature (K) mm/m^2.

The size of surface degradation and the way rocks shift are influenced by numerous factors: the size of void created through mining, the depth of the mining, the thickness and the inclination of the layer, the method and the technology used for mining, the way pressure was directed, the geo-mechanic characteristics of the rocks, the seam tectonics, the duration of the mining [3].

4. THE EFFECTS OF THE LAND SUBSIDENCE PHENOMENON IN THE JIU VALLEY

The Jiu Valley coal mining basin contains the most important pit coal deposits in Romania. These deposits have been known and exploited since 1788, the times of the Austro-Hungarian Empire. The extensive coal mining of this deposit began after World War 2 at the same with the industrialization of the country. In the 1980s the production reached 9-10 million tons of coal a year.

As a consequence the surface terrain was affected by the underground mining operations, by the land subsidence phenomenon. In the Petroşani mining basin area over 20 ha of terrain can't be used anymore for constructions or agriculture because, due to the collapse of the surface terrain, the underground water level was lowered which caused desertification and the disappearance of the local flora and fauna.

The fractured and unstable terrain affected almost 70 individual village households (fig.2) and in certain caused the destruction of a large number of houses and of the Dâlja Mare community center.

There were also other incidents: the shift of the entrance point and of the tower above auxiliary shaft no.1 at E.M. Livezeni which led to its abandonment; the partial destruction of the ventilation shaft no.2 Petrila which led to its decommission; the presence in the area of influence of the mine of the metal pillars of the Valea Arsului (E.M.Lonea) cableway which led to the abandonment of the project; the presence in the area of influence of the mine of the "80 de case"(80 houses) area after which several houses had to be demolished.

Figure 2. Effects of the land subsidence phenomenon

Depending on the geological and mining conditions, the coal mining operations in Valea Jiului has led to surface land subsidence (vertical displacements) to levels which vary between 1 meter (in the case of coal seams with low thickness and inclination) and tens of meters (in the case of thick and very inclined coal seams – as it is the case of E.M. Lonea – figure 3).

5. NECESSITY OF CONSTANT AND CONTINUOUS OBSERVATION OF GROUND SURFACE DEFORMATION IN JIU VALLEY AREA

As the Jiu Valley Coal Mining Basin is known for being a mono-industrial area (pit coal mining) it is necessary that a shift be made from the underground coal mining activities to a more diverse range of activities developed above ground once the mines have been closed. In order to develop above ground industrial activities a stable terrain is needed but an important part of the surface terrain has been affected by the mining operations.

The need to monitor the phenomenon of subsidence land monitoring results from the effects and consequences that groundwater exploitation prints them from the land surface and the desire authority development in the area.

The effects of underground mining operations involve both destruction of the fields and of the constructions within the area of influence of the mine (figures 2 a, b, c, d) and other consequences related to the land subsidence phenomenon. The negative effects of the underground mining operations can be divided into four categories:

(a) Physical – destruction of fields, constructions, ways of access, supply lines (water, electricity, natural gas), etc;

(b) Economical/Financial – spending generated by the destruction and reconstruction of the facilities affected by the underground mining operations;

(c) Social – generated by the displacement of the people whose properties were affected by the underground mining operations – the psychological impact upon these people;

(d) Political and related to the mass-media – this final category refers to the political debate that can be generated by the land subsidence phenomenon and to the fact that this phenomenon can be exploited by the media in the search for a sensational story. The social consequences can be amplified as the authorities might seem incapable to deal with such situations.

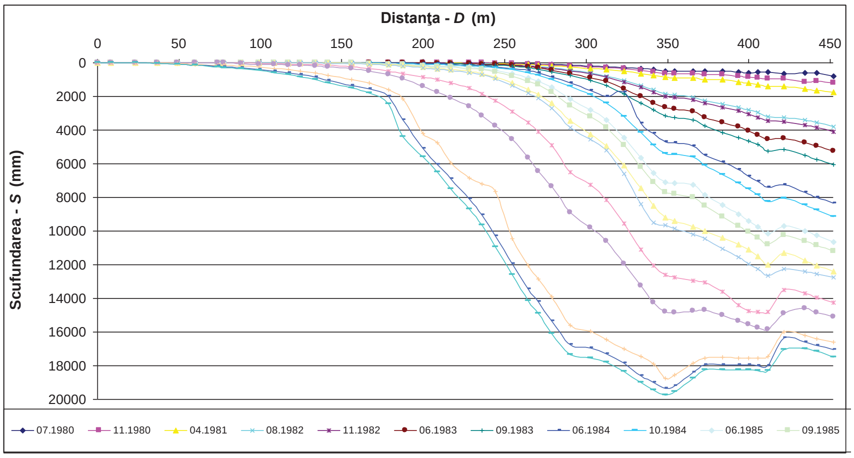


Figure 3. Subsidence profiles at the Lonea Mine

All these aspects should be considered when deciding upon the necessity of preparing for this phenomenon before closing the mine and before post-closure observation.

6. SUSTAINABLE DEVELOPMENT IN JIU VALLEY

The standard definition of sustainable development "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" was for the first time formulated in the Report of the World Commission on Environment and Development of the United Nations Organisation - *Our common future.*

The concept through which a sustainable development is possible in the Jiu Valley has at its core the common and unified administration of the area. The process of economic, social and environmental rehabilitation of the area can be administered unitarily (idea presented by the Hunedoara county prefect). According to this concept the local administrations currently existing in Jiu Valley become administration subunits (neighbourhoods) of a single city – Jiu Valley. Within this concept are also presented the main development directions in the area:

Tourism is considered the fundamental starting point **-** it can outline the exceptional scenic beauty of the area, it can bring out the cultural richness of the area (history, ethnology, architecture, arts);

Agriculture, especially livestock rearing, is one of the directions of development. The mountainous relief favours the existence of pastures and meadows which represent the main supply of food for livestock. It can also supply raw materials for manufacturing;

Manufacturing and traditional craft and arts may function as a bridge between agriculture and tourism.

7. DESCRIPTION OF THE CURRENT LEGISLATION

The negotiations regarding the integration of Romania into the European Union begun on February 15th 2000 had as main objective the acceptance and the integration of the community acquis into the national legislation. As a result Romania is undergoing an extensive process of restructuring in the field of coal mining, process which consists of closing the so-called unprofitable mines and of environmental rehabilitation through ecological reconstruction of the areas affected by the mining operations.

Through bills and laws issued for this purpose it is established that the ecological reconstruction of these areas is o be made based upon a formal application accompanied by a plan of cessation of trading/activities which includes: the reason for the cessation of trading, the technical plan for mine closure and the plan for the post-closure monitoring of the environment.

The plan for rebuilding the environment contains – the measures taken for environmental rebuilding and rehabilitation in the area of mining operation in accordance to the options of the local communities regarding the use of the area in the post-closure stage and - the technical plan of putting the measures into practice [4]. The Minister of Economy and Commerce, in accordance to the law, has developed a Mine Closure and Completion Handbook in order to provide „a unified framework of procedures applicable in the process of mine closure" [5]. According to this handbook mine closure is made in several stages:

a) Stage I: Planning - The Plan of Cessation of Trading/Activities, The Technical Plan for Mine Closure;

b) Stage II: Cessation of mining activities;

c) Stage III: Contract for the Execution of Works;

d) Stage IV: Implementation of the contract and monitoring activities;

e) Stage V: Terrain transfer;

f) Sage VI: Post closure monitoring.

Each of the stages is presented in detail in an addendum to this manual [5].

Regarding the post-closure monitoring , one of its objectives (as formulated in the annex 4 of the Mine Closure and Completion Handbook) is" *to demonstrate for a longer period of time, the effect of mine closure*". It is also stated that " *Where the underground mining operations have taken place close to the surface, the terrain may be affected by the land subsidence phenomenon, with effects upon de above ground constructions such as buildings and roads. In order to enhance the quality of visual inspections, surveying measurements might be necessary*".

It is also stated the fact that" *In the areas where the land subsidence phenomenon is forecast surveillance networks with fixed positions connected to the monitoring network are to be installed. The density of the measurement points and the frequency of the measurements must be established depending on the risk presented for the surface of the terrain by the underground operations*".

8. CONCLUSIONS

After careful study of these bills and legal regulations the following conclusions have been reached:

In the Mine Closure and Completion Handbook the notion of ” underground mining operations performed close to the surface” isn’t clearly explained – namely ,which are the minimum and maximum depths for which underground mining operations are considered underground mining operations performed close to the surface according to the Minister of Economy and Commerce.

Taking into consideration only this Mine Closure and Completion Handbook the phenomenon of land subsidence generated by the exploitation of coal at depths greater than 300m using room and pillar methods are not the subject of post-closure monitoring.

At the moment of mine closure the ground surface may not have undergone noticeable shifting or sinking according to the „visual inspections” an, in consequence, it is decided that monitoring the terrain stability should be done for a relatively short period of time. The land subsidence phenomenon may develop over time and cause important damage after 10-20 years from the mine closure.

According to research studies performed by several specialists during one year the rocks shift and move vertically approximately 100m. Therefore, in the case of deep level underground mining operations, the movement at the surface will be felt only after many years since the beginning of the operations.

The same Mine Closure and Completion Handbook states the fact that the observation networks for monitoring the land subsidence phenomenon will be built only in the areas for which the occurrence of this phenomenon is forecast. It is not specified who has the obligation to make this forecast and which are the elements which need to be taken into consideration when making such a forecast.

The density of the measurement points within the monitoring station must be in accordance to the depth of the coal seam, the subsidence angle, the tolerance margin in determining the subsidence angle, according to the field literature and not by considering the risk presented to the terrain surface by the underground operations.

9. SUGGESTIONS

As underground mining of useful mineral substances can have unpleasant effects, even after the operations have ended, and because current legislation has certain holes, a number of suggestions meant to prevent unwanted events will be presented:

As in Romania topographic maps and plans representing underground mining operations are considered professional secrets (access to such documents is restricted), it is necessary to create risk maps associated to the land subsidence phenomenon. That is, using prognosis methods described in the technical literature [2], [3] specialists must determine which are the parameters that define the subsidence area and must create risk maps; At the end of the mine closure stage and after the ecological reconstruction of the area the risk map of the area should be delivered to the local authorities so that future works could be made taking into account the forecast dangers;

In order not to deteriorate the data collected during the measurements done by the monitoring stations it is important that the measurements be done by specialists;

As the plan for environmental rehabilitation takes into consideration the options of the local communities regarding the use of the area, the data regarding the shifting and sinking of the area which covers the underground mine should be made accessible to the local authorities;

Charts of ground subsidence phenomenon measured over time (post-closure) should be made. Together with the risk maps of the area they should be included in the documentation necessary for the development of the General City Plan.

REFERENCES

[1] Marian D.P. – *Influenţa factorilor geologo-minieri asupra parametrilor de deformare a terenului de la suprafaţă în urma exploatării stratelor de cărbune din Valea Jiului*, Referat de doctorat, Universitatea din Petroşani, 2009.

[2] Onica, I. – *Impactul exploatării zăcămintelor de s.m.u. asupra mediului*, Editura Universitas, Petroşani, 2001.

[3] Onica, I., Marian, D.P. - *Ground surface subsidence as effect of underground mining of the thick coal seams in the Jiu Valley Basin*, Archives of Mining Sciences, Vol. 57, nr. 3, Polonia 2012.

[4] Ortelecan, M. – *Studiul deplasării suprafeţei sub influenţa exploatării subterane a zăcămintelor din Valea Jiului, zona estică,* Teză de doctorat, Universitatea din Petroşani, 1997.

[5] Vereş I., Farcaş R., Ştefan N. – *Study On The Surface Instability of The Coal Exploitation Area in Livezeni* International Multidisciplinary Scientific Geo-Conference & EXPO - SGEM , Vol. II, Sofia, Bulgaria, 2013.

[6] *** **-** Legea Minelor nr. 85/2003.

[7] *** **-** Ordinul 273/2001 pentru aprobarea Manualului de Închidere a Minelor.

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

SOCON CAVERN'S STABILITY ANALYSIS BY USING FINITE ELEMENT NUMERICAL MODELLING

DACIAN-PAUL MARIAN[*]
ILIE ONICA[**]
EUGEN COZMA[**]
SORIN MIHUŢ[***]

Abstract: *Extracting salt from Ocnele Mari has been done since ancient times, in this area numerous mining tools have been discovered from the Neolithic Age, Brazen Age and Iron Age. A strong community developed in this area, since antiquity, due to salt extraction. Since 1959 and up to the present Ocnele Mari rock salt deposit is mined by two methods of operation, namely: through a humid method by kinetics dissolution and through a dry method (at Coceneşti Mine on +226m and +210m level, through a mining method with small rooms and square pillars). Ocnele Mari rock salt deposit was mined through dissolving wells in several surface drilled wells fields, the brine extracted representing the raw material for soda products and chemical products manufactured on the industrial platform Govora. The abandoned fields of dissolving wells represent a real danger, because of the uncontrolled dissolving process that can lead to the development of large caverns, with safety floors which have a thickness that does not correspond in terms of lifting power.*

Keywords: *rock salt, kinetics dissolution, numeric modelling, stability analysis, finite element*

1. INTRODUCTION

In our country the mining of rock salt deposits has been made until the end of the XVIIIth century through a dry method. Only now, at Cacica, it has begun the rock salt mining in solution by evaporation of the brine from the salt springs in the area. After nearly a century it has begun the rock salt mining by dissolution in three circular basins with a diameter of 100 m, set-up in underground workings.

Ocnele Mari salt deposit was mined by dissolving wells in several drilled wells fields, the brine extracted representing the raw material for soda products and chemical products manufactured on the industrial platform Govora.

Extracting rock salt through wells as a solution represents a simple method with certain advantages than that of rock salt extraction, in solid state, through mining workings. The effectiveness of this process consists of low production prices, minimum transportation costs, the opportunity to mining the rock salt deposits with rocks inclusions and deep mining depth.

---

[*] *Lecturer, Min. Eng. Ph.D. at the University of Petroşani*
[**] *Prof., Min. Eng. Ph.D. at the University of Petroşani*
[***] *Min. Eng. Ph.D. Student at the University of Petroşani*

However, insufficient knowledge of the problems regarding the rock salt mining by dissolution can lead to loss of control over the dissolution and the destruction of the pillars among the dissolving chambers (Mihuţ, 2012).

2. ROCK SALT MINING WITH THE HELP OF SOLUTION AT OCNELE MARI DEPOSIT

2.1. Set-up of dissolving wells and applied mining methods

Once Govora plant was set in motion the need for salt in solution increased from 850 000 tons / year to 2 450 000 million tons / year.

To meet this need, 4 well fields have been put into operation since 1960 located in the central part of the salt deposit (fig. 1).

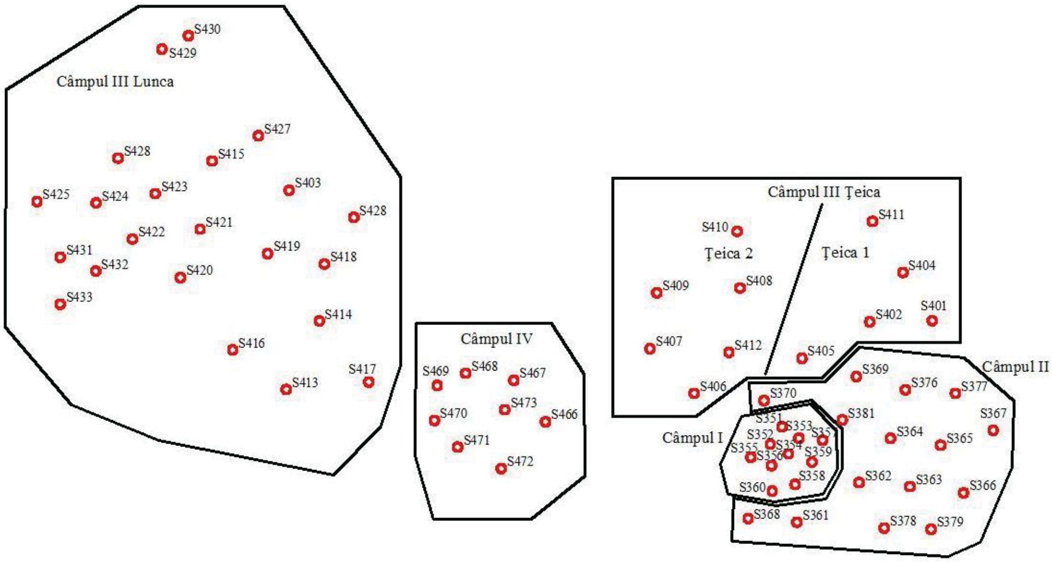


Fig.1. Set-up of wells fields from Ocnele Mari

These well fields are as followings:

a) **Field I -** comprises a total of 10 individual wells, S351 - S360, set-up on Urzicaru Hill. These wells have been exploited during 1960 - 1973 through a mining method with lifts in small scales (stages).

b) **Field II -** comprises a total of 15 individual wells, S361 - S370, S376 - S379 and S381 set-up around Field I, extending eastward in Ţeica district. These wells have been exploited during 1968 - 1991 through a mining method with lifts in big scales (stages).

c) **Field III -** comprises a total of 33 wells, namely:

- a total of 28 individual wells exploited through a mining method with lifts in big scales (stages), divided according to the area where they were set-up and according to the place of connection to the technological installations that serve them as follows:

- *Ţeica Area I* - comprising 5 wells (S401, S402, S404, S405 and S411) set-up on Ţeica Hill, north of the wells that form Fields I and II, connected to the control room of Field II;
- *Ţeica Area II* - with a total of 6 wells (S406 - S410 and S412) set-up on the right side of Ţeica Valley, which were initially connected to a temporary primer station and then to the control room of Field III of wells set-up in Lunca district;
- *Lunca-Goruniş Area* - comprising a total of 17 wells (S403, S413 - S428) set-up in the districts with the same name, connected to the control room of Field III Lunca.

- a total of 5 experimental wells set-up as follows:
  - 2 wells (S429 and S430) set-up in Lunca district on the left side of Sărat Brook, located in an isolated area than the individual wells. In regards to these wells, a battery mining method was applied. These two wells were stopped in 2001, having exhausted their reserves.
  - 3 wells with channel exploitation (S431, S432 and S433) set-up on Goruniş Hill, south-west of the individual wells, in an isolated area.

d) **Field IV** - which comprises a total of eight wells (S466 - S473) set-up on the perimeter of the former salt mine at Ocniţa, mine partially collapsed, around the lake formed on the old brine pit. The exploitation in this field was done in order to mining the salt reserves abandoned under the old mines and it begun in 1992, as it followings: S466-S472 wells; S470-S471 wells; S467-S468-S469 wells, indicating that the S467 well was maintained suspended because the connecting channel between S467 well and S466-S472 wells was executed at another insertion.

2.2. The effects of salt in solution extraction

Due to dissolving chambers that emerged because of the rock salt mining through the kinetics dissolving wells method, certain peculiar problems appeared regarding the stability of massive rocks. By creating dissolving cavities the initial state of stress of the massive rocks changes, occurring a redistribution of stresses around the created cavity, which leads to the appearance of several stress concentrators. These have the maximum value in the horizontal extremities of the cavity, which could lead to cracking or rock fall from the ceiling or from the dissolving cavity walls.

To maintain the balance of massive rocks, both during and after the exploitation, the mining technology must be properly selected according to local geo-mining properties. It is therefore necessary to properly establish the dissolving chambers' size and position in the plan. Therefore, if the sizes of the dissolving chambers and the safety pillars among these chambers are designed properly, it can ensure the stability of the excavations over a long period of time (Bendea, 2000).

The main negative effects that may result from the exploitation through kinetics dissolution of the rock salt deposits are the following:

- the dissolution of the pillars among the dissolving chambers, the joining of the dissolving chambers could lead to the appearance of several large underground caverns;
- uncontrolled surface embedding, with the emergence of large caving cones;
- degradation of surfaces and, as well as, of the civil and industrial objectives in that area;

- local saturation of the surface with brine and diesel (or even environmental disasters) due to tightness loss of certain dissolving wells or due to accidental leakage flows.

2.3. Problems encountered in Ocnele Mari Field II of wells

3. SOCON CAVERN'S STABILITY ANALYSIS BY 2D NUMERICAL MODELLING

For achieving calculation models with finite elements in plane deformation and in the elastic, isotropic and linear behaviour hypothesis, the CESAR-LCPC 2D software was used.

With the help of this software finite element models were accomplished keeping, as much as possible, the geo-mining conditions found in Ocnele Mari rock salt deposit.

3.1. Achievement of numeric models

For a more precise analysis, two numeric models with finite element were made (fig. 3-4) corresponding to sections 3-3` and 6-6` (fig. 2).

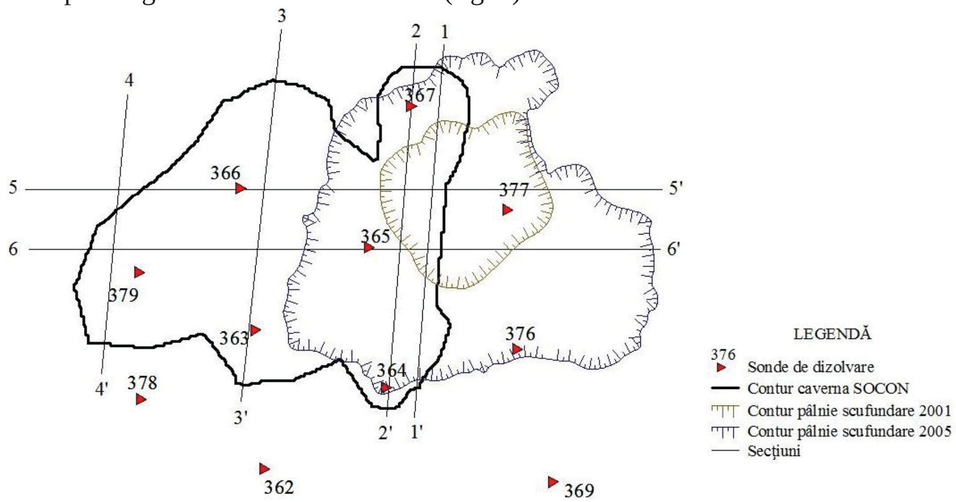


Fig. 2. Vertical section's position in the plan in regard to SOCON cavern's outline

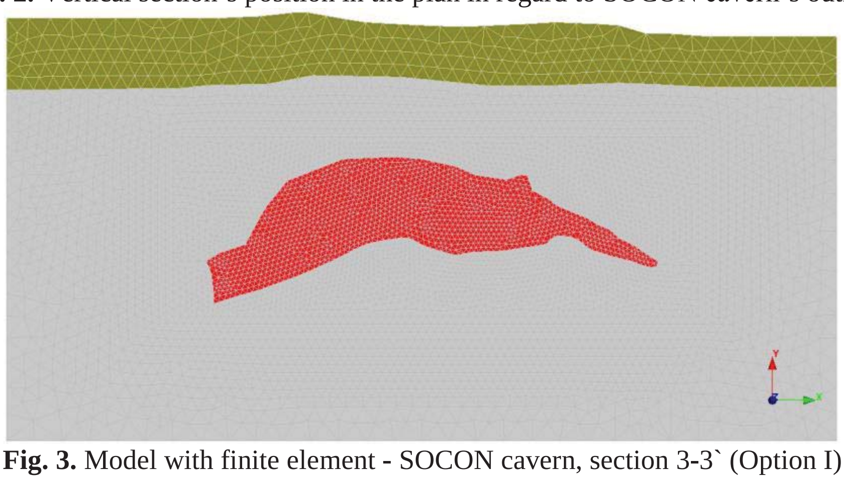


Fig. 3. Model with finite element - SOCON cavern, section 3-3` (Option I)

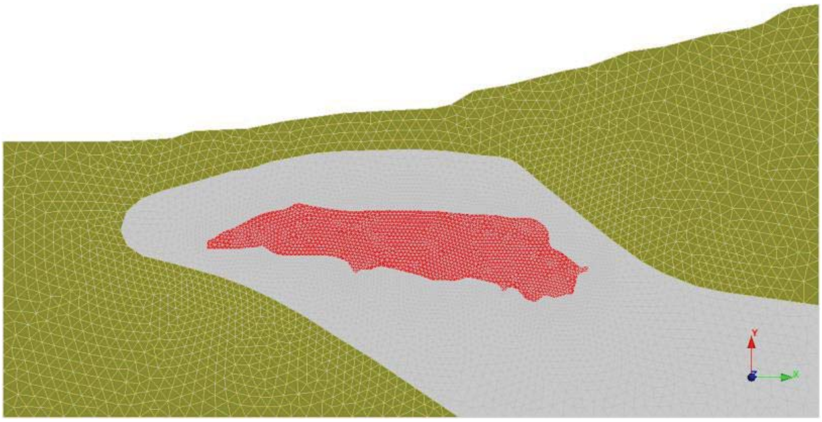


Fig. 4. Model with finite element **-** SOCON cavern, section 6-6` (Option I)

For SOCON cavern's stability analysis in plane deformation, in the case of the two executed sections, it has been taken into account four options of calculation, namely (Mihuţ, 2015):

- Option I – the cavern is completely filled with brine;
- Option II – at the top of the cavern (it is considered at a height of 10 m) there is an area with air;
- Option III – the cavern is completely filled with brine and the piezometric load in the cavern is located at an elevation of + 290 m;
- Option IV – the cavern is completely filled with brine and the piezometric load in the cavern is located at an elevation of + 295 m.

The initial load conditions of the model were considered geostatic $[\sigma_o]$, corresponding to an average disposition depth of the cavern of approximately H = 125 m, namely:

- vertical geostatic tensions $\sigma_{oy} = \rho_s \cdot g \cdot H = 24806$ kN/m^2 = 24.8MPa;
- horizontal geostatic tensions $\sigma_{ox} = \frac{\nu}{1-\nu} \cdot \sigma_{oy} = k_o \cdot \sigma_{oy} =$ 8269kN/m^2 = 8,3MPa

(where $k_o = \frac{\nu}{1-\nu} = 0.333$).

The induced tensions by the presence of excavations resulting from the extraction of salt were $[\sigma_e]$, respectively the tensions variation represented by horizontal tensions σ_{ex} = – 8,3 MPa and vertical tensions σ_{ey} = – 24,8 MPa. Finally, the loading of models was made with total stresses state (fig. 6.9): $[\sigma_T] = [\sigma_o] - [\sigma_e]$ (Onica, 2001; Onica & Marian, 2012).

For determining the third dimension, a Lambda coefficient was introduced, determined by relation 1, the value of which was: for section 3-3`: $\lambda = 0.554$; for section 6-6`: $\lambda = 0.618$.

$$\lambda(x) = \frac{1 - th\,(0.33 - x/D)}{2} \tag{1}$$

Where: *th* is the hyperbolic tangent; *D* – excavation opening; *x* – the distance from the studied section to the adit end ($\lambda > 0$ if the section is in the rear of the adit end - excavated section; $\lambda < 0$ if the section is in front of the adit end – unexcavated section).

Because inside of the cavern there is a certain amount of brine (which exerts some pressure on the cavern walls), inside the numerical models was inserted a hydrostatic pressure (opposite to that induced by the presence of the excavation) considering zero pressure at the top of the cavern, for option I, respectively 10 m below the top for option II. For options III and IV zero hydrostatic pressure was considered at an elevation + 290m respectively + 295m (fig. 5). The bulk density of the brine taken into account was of $\rho = 1300$ kg/m^3.

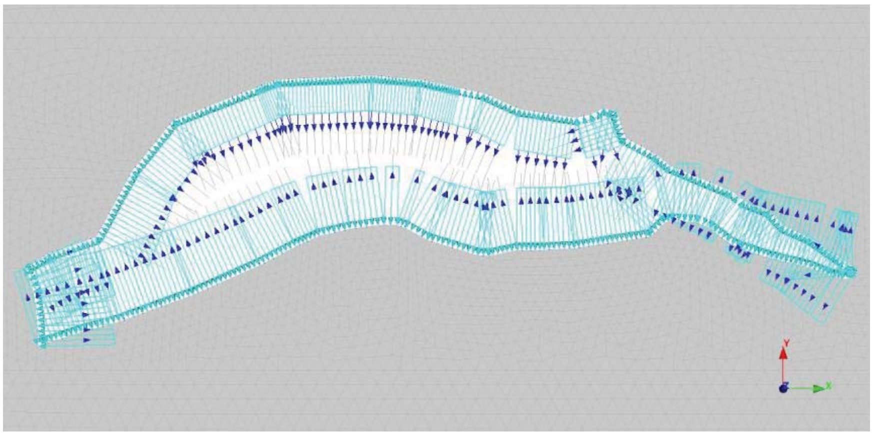


Fig. 5 The hydrostatic pressure for section 3-3` **-** Option IV

To optimize the calculations based on the accuracy of the results required by the stability analysis, calculations were made assuming a total of 60 iterations per increment and a 1% tolerance of the results, using the "initial stress method" for solving the calculations.

3.2. Analysis of results obtained by numerical modelling

After solving the calculations using the models described above, comparing the values of the obtained results (table 1and 2), it may be noted that there aren't major differences between the obtained results in options I and II (Option I – the cavern completely filled with brine; Option II – at the top of the cavern there is an area with air) or between options III and IV. However, major differences are found between options II respectively IV (that is, between option II where the cave is said to have a 10 m cavity at the top and option IV where the hydrostatic pressure in the cavern is at an elevation of + 295 m). Between these two options there is a difference of about 60%.

Table 1 The range of the main calculation parameters from the numerical models, section 3-3'

Parameter	**Range**			
	Section 3-3`			
	Option I	***Option II***	***Option III***	***Option IV***
u, [mm]	+324 ÷ -335	+331 ÷ -344	+120 ÷ -124	+108 ÷ -122
v, [mm]	+150 ÷ -1090	+150 ÷ -1110	+48 ÷ -391	+43 ÷ -350
d_{uv}, [mm]	0 ÷ 1090	0 ÷ +1110	0 ÷ +391	0 ÷ +350
σ_{xx} , [kN/m^2]	+4800 ÷ -12700	+4900 ÷ -12900	+4110 ÷ -6910	+4240 ÷ -6560

σ_{yy} , [kN/m^2]	+100 ÷ -34000	+100 ÷ -34900	+100 ÷ -14700	+100 ÷ -13500
σ_{xy} , [kN/m^2]	+8500 ÷ -10200	+8700 ÷ -10400	+3380 ÷ -4070	+3080 ÷ -3710
σ_1 , [kN/m^2]	+4990 ÷ -8120	+5090 ÷ -8210	+4310 ÷ -5270	+4420 ÷ -5100
σ_2 , [kN/m^2]	+100 ÷ -34600	+100 ÷ -35500	+100 ÷ -15100	+100 ÷ -13900
$\tau_{f\max}$, [kN/m^2]	0 ÷ +13700	0 ÷ +14100	0 ÷ +5390	0 ÷ +4900
σ_t , [kN/m^2]	0 ÷ +4990	+5080 ÷ -10	0 ÷ +4300	0 ÷ +4420
σ_c , [kN/m^2]	0 ÷ -34600	0 ÷ -35500	0 ÷ -15100	0 ÷ -13900

As it can be seen, the worst case is that where the hydrostatic pressure in the cavern is low, and where at the top of the cavern there is a cavity. Also, you can see that there are great differences between the displacement values and the stress values resulted in the two sections through the cavern, the values of the parameters resulted in section 6-6` being almost four times higher than the values resulted in section 3-3`.

Table 2 The range of the main calculation parameters from the numerical models, section 6-6'

Parameter	Range			
	Section 6-6`			
	Option I	***Option II***	***Option III***	***Option IV***
u, [mm]	+1350 ÷ -1150	+1380 ÷ -1190	+904 ÷ -765	+876 ÷ -740
v, [mm]	+420 ÷ -4430	+440 ÷ -4550	+280 ÷ -2980	+280 ÷ -2890
d_{uv}, [mm]	0 ÷ 4440	0 ÷ +4550	0 ÷ +2980	0 ÷ +2890
σ_{xx} , [kN/m^2]	+11100 ÷ -64000	+11500 ÷ -65800	+8100 ÷ -45200	+8000 ÷ -44000
σ_{yy} , [kN/m^2]	+1300 ÷ -90600	+1600 ÷ -93300	+100 ÷ -63400	+100 ÷ -61700
σ_{xy} , [kN/m^2]	+38700 ÷ -33200	+39900 ÷ -34200	+26400 ÷ -22200	+25600 ÷ -21600
σ_1 , [kN/m^2]	+11100 ÷ -31300	+11500 ÷ -32100	+8600 ÷ -23000	+8600 ÷ -22500
σ_2 , [kN/m^2]	0 ÷ -110000	0 ÷ -113000	+100 ÷ -76500	+100 ÷ -74500
$\tau_{f\max}$, [kN/m^2]	0 ÷ +40700	0 ÷ +42000	0 ÷ +27800	0 ÷ +27000
σ_t , [kN/m^2]	0 ÷ +11000	0 ÷ +11500	+8620 ÷ -10	+8540 ÷ -10
σ_c , [kN/m^2]	0 ÷ -110000	0 ÷ -113000	+100 ÷ -76500	+100 ÷ -74500

Analyzing the massive rocks' vertical displacement values (for the worst case section 6-6` Option II - fig. 6), it appears that the highest embedding is registered in the centre of the cavern, but in reality the caving of the surface area occurred at the edge of the cavern towards the upstream (fig. 7).

Fig. 6 Vertical displacement of the massive rocks in section 6-6`
scalar representation (Option II) – *v*, in mm

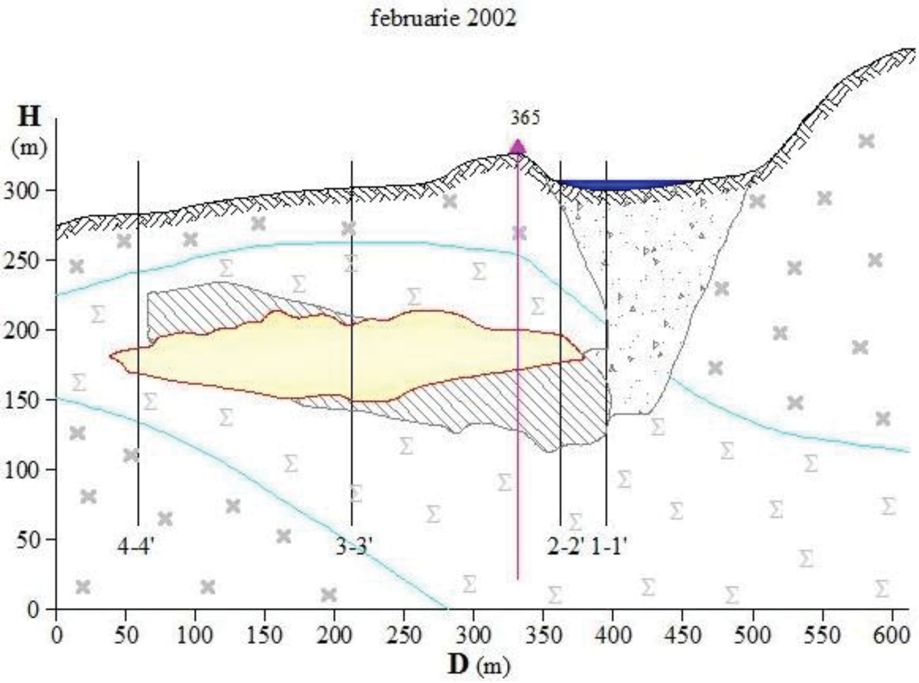


Fig. 7 Caving of the surface area in the wells field II - section 6-6`

A possible reason for the caving of the surface in this area could be a horizontal displacement, which, as can be seen in fig. 8 in that certain area it reaches a maximum value (which in the worst case it amounts to 1190 mm).

Horizontal displacement leads to the massive rocks’ cracking, thus facilitating water infiltration into the cavern and thus dissolving the salt floor.

Fig. 8 Horizontal displacements in section 6-6` scalar representation (Option II) – u, in mm

Studying the massive rocks' tensile stresses in section 6-6` (fig. 9), it can be seen that the surface maximum stresses reach a value of 3500 – 4500kN/m^2, value much above the tensile strength of rocks (approximately 500kN/m^2), these maximum values were registered towards the upstream, approximately around the area that collapsed in 2001.

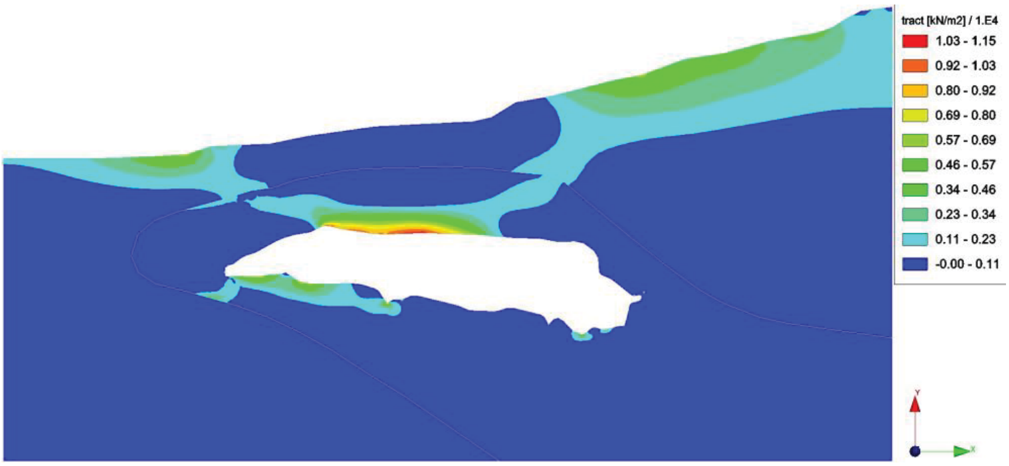


Fig. 9 Tensile stresses in section 6-6` scalar representation (Option II) - σ_t, in kN/m^2

Predefined sections were executed in accordance with the caverns' ceiling (fig. 10, 11) and the surface area (fig. 12 and 13), for a better assessment of the state of stresses, comparing the tensile and shear stress' charts with the limit values of rock salt.

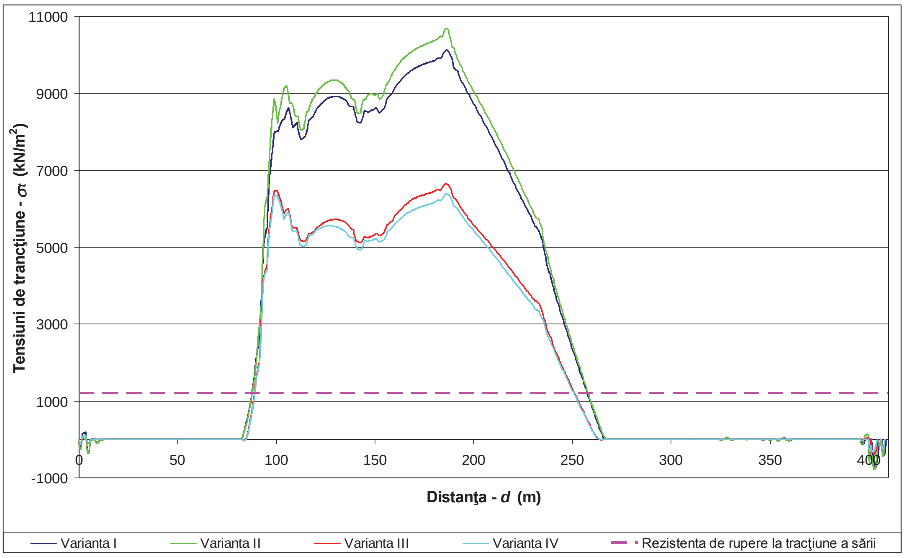


Fig. 10 Tensile stresses σ_t at the cavern's ceiling in section 6-6`

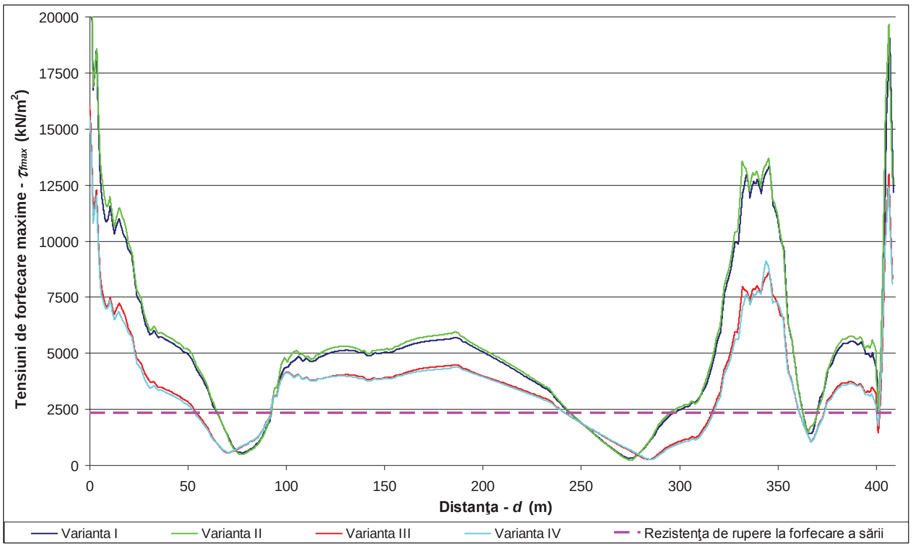


Fig. 11 Maximum shear stresses $\tau_{f_{\max}}$ at the cavern's ceiling in section 6-6`

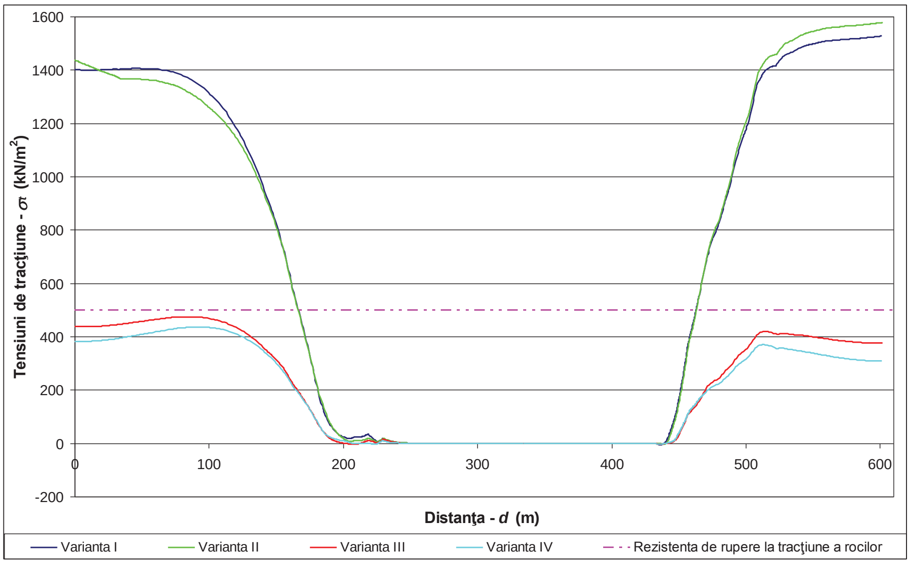


Fig. 12 Tensile stresses σ_t at the surface in section 3-3`

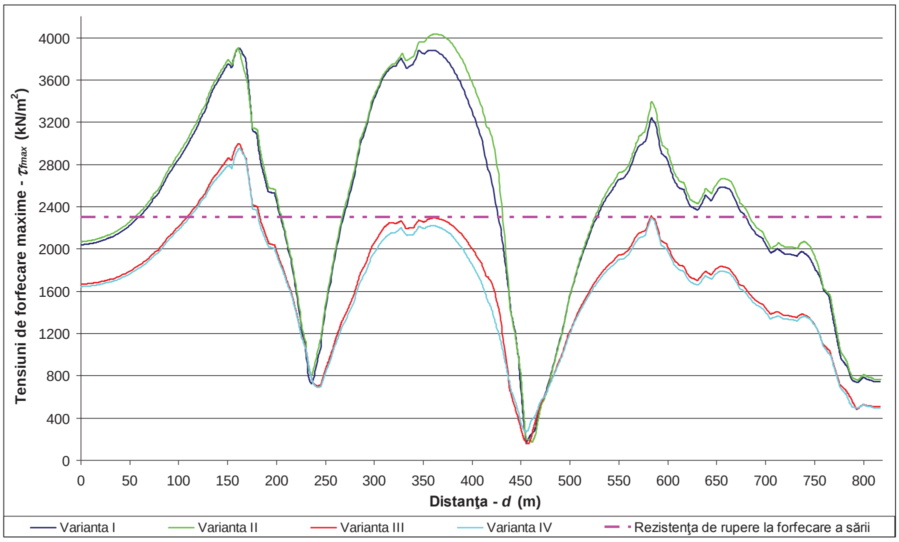


Fig. 13 Maximum shear stresses $\tau_{f_{\max}}$ at the surface in section 6-6`

4. CONCLUSIONS

Analyzing the results obtained by 2D numeric modelling it can be concluded, that because of the cavern's registered size in 1993 a collapsing of the surface was only a matter of time.

So, studying the stresses and deformations charts we can say that the collapsing of the surface occurred due to tensile and shear stresses complex phenomena.

REFERENCES

[1]. Bendea H. (2000) – *The tracing of deformations, caused by underground cavities at Ocnele Mari mining area, by topographic and calliper diameter methods*, PhD Thesis, University of Petroşani.

[2]. Mihuţ S. (2010) - *Presentation of the current state of salt extraction by dissolution in Romania*, PhD report, University of Petroşani.

[3]. Mihuţ S. (2015) - *Establishing optimal solutions for removal of risk situations from the areas affected by the exploitation by the dissolution of rock salt*, PhD report, University of Petroşani.

[4]. Onica, I. (2001) - *Introduction to numerical methods used in the mining excavations stability analysis*, „Universitas" Publishing House, Petroşani.

[5]. Onica, I., Marian, D.P. (2012)- *Ground surface subsidence effect of underground mining as thick coal seams of the Jiu Valley in the Basin*, the Archives of Mining Sciences, Vol. 57, no. 3, p. 547-577; ISSN: 0860-7001.

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

CONTRIBUTION TO SOLVING GEOMETRIC LEVELLING UNDERGROUND NETWORKS

OFELIA-LARISA FILIP[*]
NICOLAE DIMA[**]
IOEL VEREȘ[***]

Abstract: *Processing of measured size in geometric levelling underground networks to obtain their likely values, using the theory of indirect measurements and measurements conditioned. The article introduced a new method of indirect measurements respectively multiple observations.*

Keywords: *underground network, levelling, topographic, reference system*

1. THE PURPOSE AND IMPORTANCE OF THE WORK

Showcasing a deposit of useful minerals are require creation of a complex underground mining works opening, training and service provided in the project developed for this purpose.

Leadership in digging such work is possible using appropriate methods of measurement and processing (underground topographic methods).

It works by transmitting topographic reference system surface underground transmission works topographic reference system from one horizon to another, topographic works to achieve topographic base of support in underground works and tracing lifting of penetrations mining particular etc. Given the precision that is required for positioning in space mining works (as designed), topographic execution needed is an absolute priority.

Achieving this goal is achieved by performing a complex topographic high quality works among which an important role geometric levelling networks.

Superior quality is very high accuracy in obtaining determinate, which ensure the proper measurement techniques and processing methods based on the theory of least squares.

2. MAKING GEOMETRIC LEVELING UNDERGROUND NETWORK

We recognize that access to the underground at some horizon is provided by two galleries (G1 si G2), and about another skyline is made by two vertical wells (wells blind PO1 si PO2) (fig.1).

Also admits that galleries near the coast is materialized the absolute point P whose HP is known.

∗ *Lector Ph.D, University of Petrosani*
∗∗ *Prof.Ph.D., University of Petrosani*
∗∗∗ *Assoc. Prof.Ph.D., University of Petrosani*

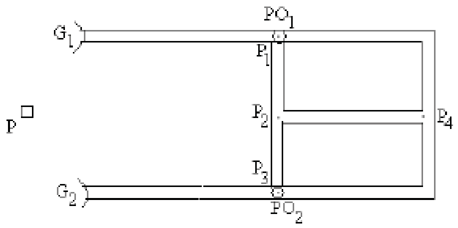


Fig.1

If the wells blind about height between horizons is achieved through mechanical transmission rates, it can be achieved using geometric leveling network nivement geometric paths in the two horizons (fig.2).

It is appreciated that the two adits routes PP1 and PP3 (upper horizon) and routes the lower horizon P1P2, P2P3, P1P4, P2P4 and P3P4.

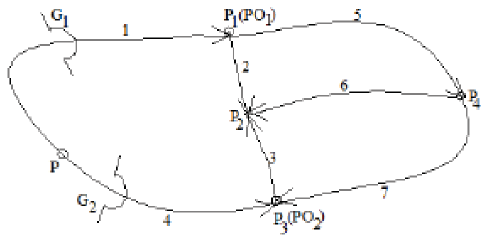


Fig.2

Levelling lines are marked, as shown in fig., with 1, 2, 3,…,7 and directions of increase or decrease in the level differences by arrows.

Level differences mentioned levelling lines is measured using the geometric levelling the middle and with this length levelling lines.

Therefore, the measured sizes are: h1, h2,…,h7 and S1, S2,…,S7. To determine the absolute quotas of points P1, P2, P3, P4, sizes that measured level differences must be processed in order to obtain their likely values.

In the following presents a processing method according to the probable values are obtained quota points P1, P2, P3, P4, and the measured level differences.

Levelling network considered in the first stage can be determined Provisional quota values pointsP1, P2 and P3 with relations:

$$H_1^0 = H_p + h_1 \text{ at upper horizon}$$
$$H_2^0 = (H_1^0) + h_2 \text{ at lower horizon:}$$
$$(H_1^0) \text{ it is } H_1^0 \text{ submitted} \qquad (1)$$
$$H_3^0 = H_p + h_4 \text{ at the upper horizon}$$

Denote corrections provisional rates x1, x2, x3. It is specified that the pointsP1 and P2 determine at the upper horizon, provisional quotas using measured level differences h1 and h4, which are transmitted to the lower horizon, using size (difference in height between horizons) and get quotas measured points P1 and P3 in underground. x1 si x3 corrections admit the same for points determined in the upper horizon of the transmitted underground (lower horizon).

If v1, v2,…,v7 are corrections to the measured level differences, their likely values are:

$$\begin{aligned} &(h_1) = h_1 + v_1 \\ &(h_2) = h_2 + v_2 \\ &\dots\dots\dots\dots \\ &(h_7) = h_7 + v_7 \end{aligned} \tag{2}$$

And probable values of shares the points P_1,

$$\begin{aligned} &H_1 = H_1^0 + x_1 \\ &H_2 = H_2^0 + x_2 \\ &\dots\dots\dots\dots \\ &H_3 = H_3^0 + x_3 \end{aligned} \tag{3}$$

With these notations we can form a system of equations consisting of six equations in which:

- four equations corresponding to the measured level differences: h1, h2, h3, h4;
- two polygons corresponding equations I and II

The shape of the system is:

$$\begin{aligned} &H_1^0 + x_1 - (H_P + h_1) = -v_1 \\ &H_2^0 + x_2 - (H_1^0 + x_1 + h_2) = -v_2 \\ &H_3^0 + x_3 - (H_2^0 + x_2 - h_3) = -v_3 \\ &H_3^0 + x_3 - (H_A + h_4) = -v_4 \\ &-(h_2) + (h_5) + (h_6) = 0 \\ &(h_3) - (h_6) + (h_7) = 0 \end{aligned} \tag{4}$$

Where in:

$$\begin{aligned} &(h_2) = h_2 + v_2 \\ &(h_3) = h_3 + v_3 \\ &(h_5) = h_5 + v_5 \\ &(h_6) = h_6 + v_6 \\ &(h_7) = h_6 + v_6 \end{aligned} \tag{5}$$

System (4) can be written

$$\begin{aligned} &+v_1 \qquad\qquad\qquad\qquad +x_1 + l_1 = 0 \\ &\quad +v_2 \qquad\qquad +x_2 - x_1 + l_2 = 0 \\ &\qquad +v_3 \qquad x_3 - x_2 \qquad + l_3 = 0 \\ &\qquad\quad +v_4 \;\; x_3 \qquad\qquad + l_4 = 0 \\ &\qquad\qquad\quad -v_2 + v_5 + v_6 + \omega_1 = 0 \\ &\qquad\qquad\quad v_3 - v_6 + v_7 + \omega_2 = 0 \end{aligned} \tag{6}$$

Where in:

$$\begin{aligned}
l_1 &= H_1^0 - (H_p + h_1) \\
l_2 &= H_2^0 - (H_1^0 + h_2) \\
l_3 &= H_3^0 - (H_2^0 - h_3) \\
l_4 &= H_3^0 - (H_A + h_4) \\
\omega_1 &= -h_2 + h_5 + h_6 \\
\omega_2 &= h_3 - h_6 + h_7
\end{aligned} \tag{7}$$

The system of equations (6) corresponds to indirect measurements of multiple observations.

Therefore, applying the method, known at this type of measurements, we obtain:

$$\begin{aligned}
& S_1K_1 + 0K_2 + 0K_3 + 0K_4 + 0K_5 + 0K_6 + x_1 + 0x_2 + 0x_3 - S_1l_1 = 0 \\
& 0K_1 + S_2K_2 + 0K_3 + 0K_4 + S_2K_5 + 0K_6 - x_1 + x_2 + 0x_3 - S_2l_2 = 0 \\
& 0K_1 + 0K_2 + S_3K_3 + 0K_4 + 0K_5 - S_3K_6 + 0x_1 - x_2 + x_3 - S_3l_3 = 0 \\
& 0K_1 + 0K_2 + 0K_3 + S_4K_4 + 0K_5 + 0K_6 + 0x_1 + 0x_2 + x_3 - S_4l_4 = 0 \\
& 0K_1 + S_2K_2 + 0K_3 + 0K_4 + S^IK_5 + S_6K_6 + 0x_1 + 0x_2 + 0x_3 - \\
& -S_2l_2 + S_5l_5 + S_6l_6 = 0 \\
& 0K_1 + 0K_2 - S_3K_3 + 0K_4 - S_6K_5 + S^{II}K_6 + 0x_1 + \\
& +0x_2 + 0x_3 + S_3l_3 - S_5l_5 + S_6l_6 = 0 \\
& K_1 - K_2 + 0K_3 + 0K_4 + 0K_5 + 0K_6 = 0 \\
& 0K_1 + K_2 - K_3 + 0K_4 + 0K_5 + 0K_6 = 0 \\
& 0K_1 + 0K_2 + K_3 + K_4 + 0K_5 + 0K_6 = 0
\end{aligned} \tag{8}$$

By solving the system (8) we obtain:

- corrections x_1, x_2, x_3
- correlates k_1, k_2,…,k_6

Correlates values are calculated corrections v_1, v_2,…,v_7 with relations:

$$v_i = S_i(a_iK_1 + b_iK_2 + \cdots + f_iK_6) \qquad i = 1, 2, \ldots, 7 \tag{9}$$

Or:

$$\begin{aligned}
v_1 &= S_1K_1 & v_4 &= S_4K_4 \\
v_2 &= S_2(K_2 - K_5) & v_5 &= S_5K_5 \\
v_3 &= S_3(K_3 + K_6) & v_6 &= S_6(K_5 - K_6) \\
v_7 &= S_7K_7
\end{aligned} \tag{10}$$

Finally we obtain:

$$\begin{aligned}
H_1 &= H_1^0 + x_1 \\
H_2 &= H_2^0 + x_2 \\
H_3 &= H_3^0 + x_3
\end{aligned} \tag{11}$$

And:

$$(h_i) = h_i + v_i \quad \text{for} \quad i = 1, 2, \ldots, 7$$

3. CONCLUSIONS

Base topographic levelling underground consists of levelling routes geometric existing open and closed horizon or several horizons.

This is a network dependent levelling a point or points known by their absolute quotas existing at the surface.

Considering the role of levelling network made underground mine workings in proper management, measurements made and their processing should lead to values with high accuracy and probably calculated.

This requirement is fulfilled considering the open or closed routes from many horizons form a network of levelling unit and measurement process is based on the theory of least squares.

As a result, such a network, considered in the paper, can be solved using the theory of indirect measurements with multiple observations. It is to determine the benefits of a number of fixed quotas to the two horizons, by their likely values at the same time accurately determining appropriate intervals.

4. REFERENCES

[1]. Dima N., s.a., *Mining topography,* Corvin Publishing House, Deva, 1998

[2]. Dima N., *The theory of errors and method of least squares,* Universitas Publishing House, Petrosani, 2001

[3]. Filip L., s.a., *Specialised mining topography,* Universitas Publishing House, Petrosani, 2014

[4]. Filip L., *The theory of errors and method of least squares,* Sample Calculation, Petrosani, 2010

Scientific Reviewers:
Prof. Ph.D. Eng. Eugen COZMA

RESEARCH REGARDING THE EXISTENCE TIME OF ORE LUMPS IN PRIMARY AUTOGENOUS GRINDING

NICOLAE CRISTEA[*]
CAMELIA BĂDULESCU[*]
DIANA MARCHIŞ [**]

Abstract: *In this paper a special laboratory method which may lead to establish the existence time of ore lumps like ore pieces grinding in industrial autogenous mills as a function of their constructive and working characteristics is reviewed. The ores grind ability and this parameter, established in this way will constitute the main elements in the selection of diameter and working regime of the primary autogenous mill in order to obtain the maximum efficiency of respective ore comminution. To reverse, when a certain mill type is imposed, it is possible to establish the feed particle size and the product particle size in order to obtain efficiency in primary autogenous grinding.*

Key words: *ore lumps, autogenous grinding, mill*

1. INTRODUCTION

Generally, the economic factor is decisive in the selection of the comminution method.

Some main advantages of autogenous grinding practice

- the stages number is significant diminished;
- the partial or total removal of the balls in mill is achieved;
- the undesirable effects of iron brought about the balls are removal;
- the produced particles are better differentiated and produce positive influence on the quality and the metal extraction.

In a sensitive process like the autogenous grinding the economic efficiency depends on the optimum maintenance in working parameters.

To satisfy the necessary of ore lumps like ore pieces grinding is very important in autogenous grinding. This necessary depends on the existence time of the lumps that must be selected in order that not be created abundant critic fraction as a result of lumps premature destruction and not determine their agglomeration in mill.

2. THEORETICAL CONSIDERATIONS

In the autogenous grinding process the lumps behavior depends on the ore type and the lumps speed in the impact moment.

∗ *Associate Professor, Eng., PhD, University of Petrosani, Romania*
∗∗ *Lecturer Dr., University of Petrosani, Romania*

In order to determine the speed at impact moment it is considered that lumps movement that abandon the mill lining has a parabolic trajectory characterized by the following equation:

$$y = x \cdot tg\alpha - \frac{x^2}{2 \cdot R \cdot cos\alpha} \qquad (1)$$

Where the variables and parameters are:
α – abandon angle;
R – radius of the mill.

In order to determine the impact speed it is necessary to know the coordinates of the impact point (M) and of the maximum point (C) of the parabola (figure 1).
For point M:

$$x_M = 4 \cdot R \cdot sin\alpha \cdot cos^2\alpha \qquad (2)$$

$$y_M = 4 \cdot R \cdot sin^2\alpha \cdot cos\alpha \qquad (3)$$

For point C:

$$x_C = \frac{x_M}{4} \qquad (4)$$

$$y_C = \frac{y_M}{8} \qquad (5)$$

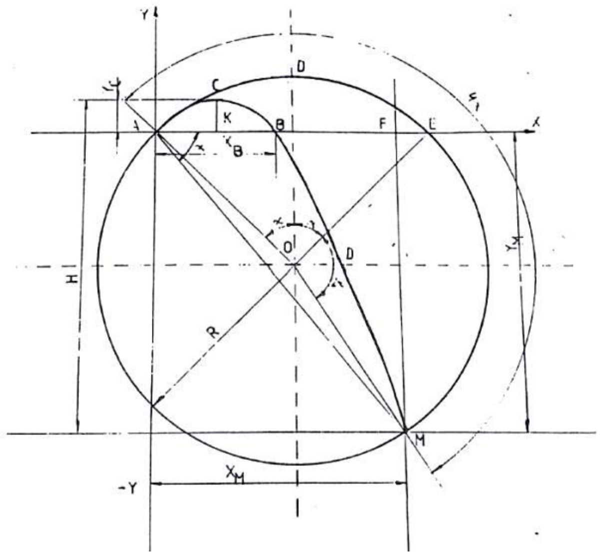


Fig. 1 Characteristic points of the parabolic trajectory of the grinding pieces in autogenous mills

The throwing speed of the lump is given by the following equation:

$$v = (R \cdot g \cdot cos\alpha)^{1/2} \quad (6)$$

If $h = y_M - y_C$the impact speed is given by the following equation:

$$v_M = 2 \cdot g \cdot h + v^2 \quad (7)$$

In order to achieve the same impact speed through free fall it is necessary to have a level difference $H = \frac{v_M^2}{2 \cdot g}$

The lump movement parameters and the equivalent height are calculated by means of the equations presented in table 1.

Table 1 **Lump movement equations**

Mill diameter, [m]	Abandon angle, grades	Throwing speed, [m/s]	Impact speed, [m/s]	Equivalent height, [m]
5.0	36.6	4.43	8.86	3.84
7.0	38.96	5.16	10.52	5.65
8.5	39.85	5.65	11.69	6.96

3. EXPERIMENTAL WORK

In order to determine the existence time of ore lumps in various working regimes of the mill it was achieved an efficient installation to simulate the lumps fall thus to have the same impact speed without of mill lumps. It consists of a metallic tower equipped with a lift capable to permit lumps fall from the wanted height. The impact compartment placed in the lower part permits the accomplishment of the impact typical conditions.

This experiment presents the most unpropitious conditions when the material comes in direct contact with the mill lining.

The evolution of the lumps degradation was established by successive weighing of fractions +50 mm that is considered to be the minimum limit of the lumps size like grinding pieces.

The variation of lumps weight in percent with the falls number is demonstrated in figure 2 for a mill with a diameter of 5 m, in figure 3 for a mill with a diameter of 7 m and in figure 4 for a mill with a diameter of 8.5 m.

In order to determinate the existence time of the lumps it was selected the time value when 95 percent of the initial weight of the lumps has size below 50 mm.

Dividing the falls number by the revolution speed, in rev/min, there can be obtained the existence time of the lumps.

In a mill with a diameter of 5 m the existence time of the lumps is 15 minutes, in the mill with a diameter of 7 m is 13.3 minutes and in the mill with a diameter of 8.5 m the time is 4.85 minutes.

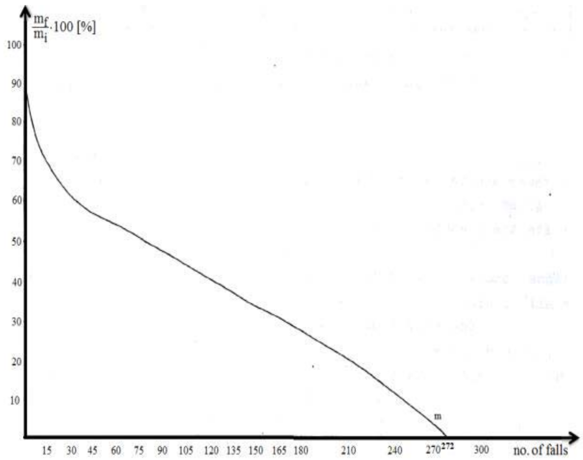


Fig. 2 The lumps weight variation depending on the number of falls for a 5 m diameter mill

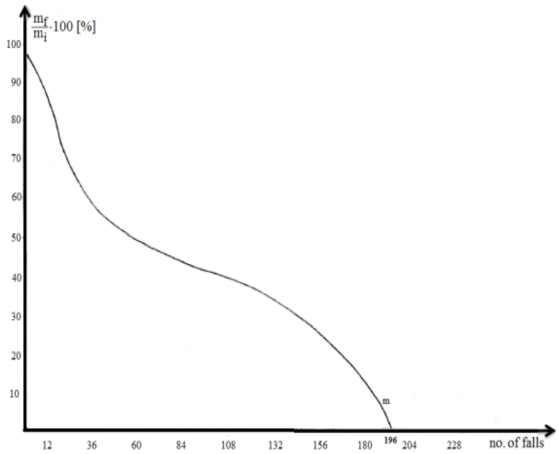


Fig. 3 The lumps weight variation depending on the number of falls for a 7 m diameter mill

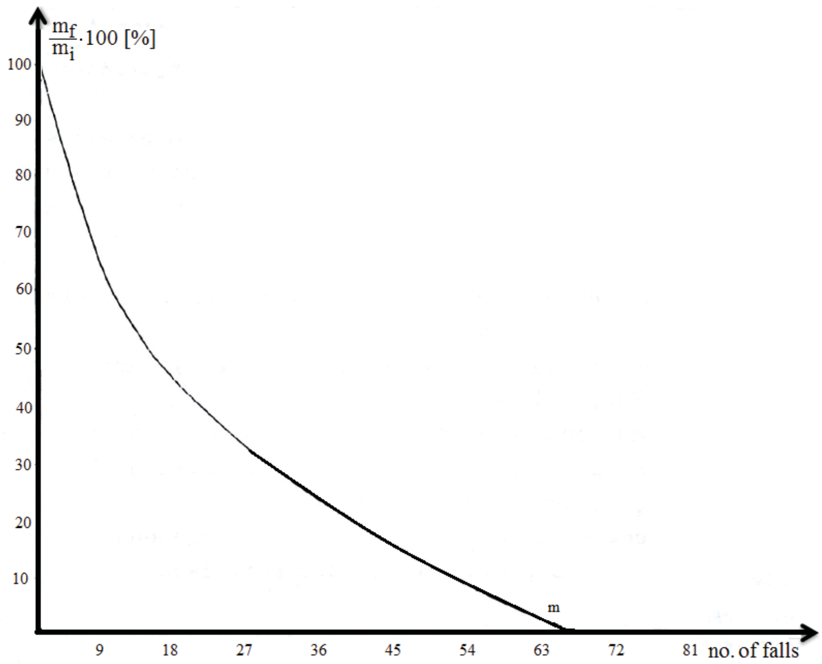


Fig. 4 The lumps weight variation depending on the number of falls for a 8.5 m diameter mill

4. CONCLUSIONS

The existence time of the lumps decreases when the diameter value increases.

As a result of this experiment we are in the position to assert that the established parameters of the autogenous grinding in pilot scale cannot be used in industrial scale.

After a certain mill diameter value the existence time rapidly decreases. This value can be considered like the higher limit for the mills diameter in which the autogenous grinding can be realized. Over this value the impact stress is higher than the impact strength.

The knowledge of the existence time of lumps allows us to establish the lumps necessary in fed ore and the size distribution of the primary autogenous grinding product.

5. REFERENCES

[1]. **Haidinger Al., Ludnan T.,** *Autogenous Grinding*, ODPT, Bucurest 1972

[2]. **Digre M.,** *Progress in Autogenous Grinding*, Mines & Carrieres July 1990, vol.72P

[3]. **King R.P.,** *Comminution Research – A Succes Story That Has Not Yet Ended*, International Mineral Processing Congress, Sydney, May 1993, Vol. 1

[4]. **Cristea N., Craescu I.,** *Factors Affecting the Autogenous Mills Capacity*, U. T. Petrosani, 1994

[5]. **Cristea N., Cristea G.,** *Macinarea autogena in procesarea resurselor minerale*, Editura Universitas, Petrosani, 2000.

Scientific Reviewers:
Prof. Ph.D. Eng. Romulus-Iosif SARBU

USE INDEPENDENT PATHWAY TO TROUBLE POLYGONAL TOPOGRAPHY PIRCING MINING

OFELIA-LARISA FILIP*
NICOLAE DIMA**

Abstract: *The article reviews the possibility of using an independent topographic base to achieve mining works which have a thrusting.*

Keywords: *topographic, underground, polygonal path, mining*

1. THE PURPOSE AND IMPORTANCE OF THE WORK

It can meet the execution of underground (horizontal, vertical, inclined) when it is possible to make a polygonal path necessary and sufficient support for coordination work breakdown.

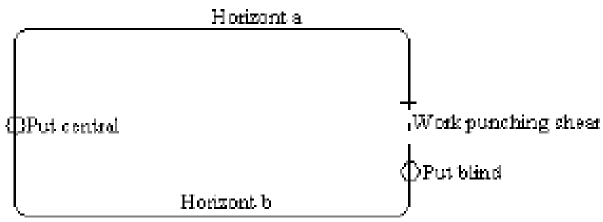


Fig.1

This route forms a topographically independent system (called polygon of breakdown), errors in measuring angles and these sides forming an independent system acting on achieving punching shear of the work. This feature requires a detailed study on the propagation of errors, their influence on achieving punching, distribution errors, etc.

2. THE WORK CONTENT

To prepare the study, separate angles errors separate sides settling their influence in polygons punching shear.

2.1. Influence of angular errors

Consider a simple polygon punching shear of 4 sides (fig.2) in which angle β_1 was measured with the error ε_1.

---

* *Lecturer, Ph.D, University of Petrosani*
** *Prof. Ph.D., University of Petrosani*

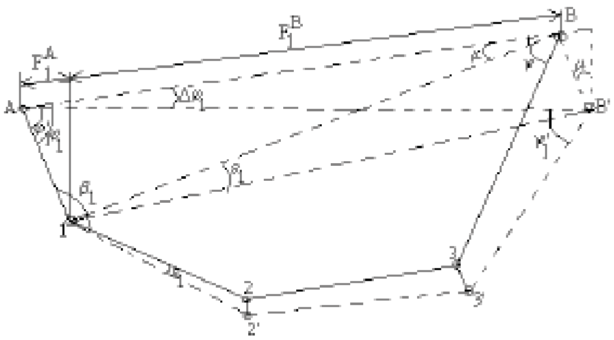


Fig.2

A1 vs. B side will move in B 'and angles φ_1' and ψ_1' have errors $\Delta\varphi_1$ and $\Delta\psi_1$ with these notations we can write:

$$\begin{aligned} \varphi_1 &= \varphi_1' + \Delta\varphi_1' \\ \Psi_1 &= \Psi_1' + \Delta\Psi_1' \end{aligned} \tag{1}$$

The figure shows:

$$\Delta\varphi_1 = \varepsilon \frac{1B\cos\mu}{AB} = \varepsilon_1 \frac{F_1^B}{S} \tag{2}$$

F_1^B – distance from point B to point projection one side AB
S – distance between points A and B
Analog, error ε_2 of the angle β_2 producing the angle φ error $\Delta\varphi_2$ date the relation:

$$\Delta\varphi_2 = \varepsilon_2 \frac{F_2^B}{S} \tag{3}$$

Continuing totaling reasoning and relations (1), (2),…. total error is obtained:

$$\Delta\varphi_t = \frac{[\varepsilon F^B]}{S} \tag{4}$$

Taking as fixed side edge of the angle 3B total error ψ angle is determined by the errors:

$$\Delta\Psi_t = \frac{[\varepsilon F^A]}{S} \tag{5}$$

Polygon A, 1, 2, 3, B using the piercing of mine works in the direction AB, provides steering angles φ_t', ψ_t' inaccurate compared to actual measurements $\Delta\varphi_t$ and $\Delta\psi_t$ given by relations (3) and (4).

This means that if two lines advancing mining work punching shear after directions AK and BK (fig.3).

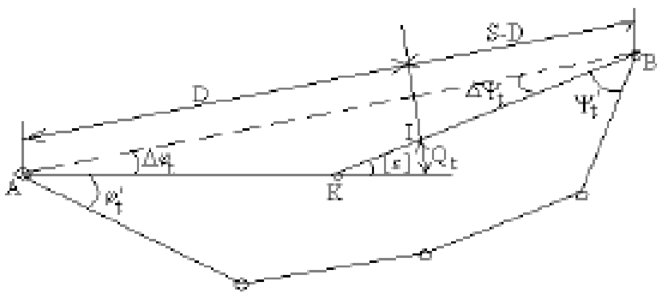


Fig.3

It follows that if K is the point of breakdown; puncture mining of the work is done without a deviation.

We consider the case when rates are advancing so that punching shear point is the point I different from point K.

In this situation, with the notations in Figure 3, the error cross Qt is given by:

$$Q_t = D\,\Delta\varphi_t - (S-D)\Delta\Psi_t \qquad (6)$$

Or the relations (3) and (4):

$$Q_t = D\,\frac{[\varepsilon F^B]}{S} - (S-D)\,\frac{[\varepsilon F^A]}{S}$$

But:

$$Q_t = D\,\frac{[\varepsilon(S-F^A)]}{S} - (S-D)\,\frac{[\varepsilon F^A]}{S}$$

And:

$$Q_t = [\varepsilon(D-F^A)] \qquad (7)$$

Denote by m_β mean squared angular error and then:

$$Q_t = \pm m_\beta\sqrt{[(D-F)^2]} \qquad (8)$$

2.2. Influence of aspect errors

We consider the analysis of representation in the next figure (fig.4):

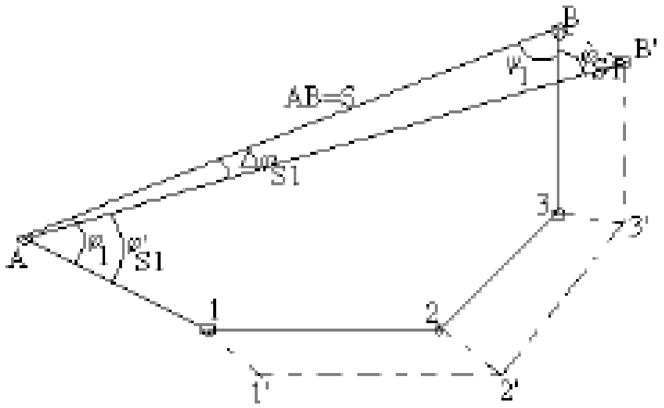


Fig.4

We admit that the side S1 is measured real with the error ε_{S1}.
This error produces a cross deviation ε_{S1} $\sin\varphi_1$.
The error on the angle φ_1 will be:

$$\Delta\varphi_{S_1} = \frac{\varepsilon_{S_1}\sin\varphi_1}{S}, \text{ total with the error:}$$

$$\Delta\varphi_t = \frac{[\varepsilon_S\sin\varphi]}{S} \qquad (9)$$

Analogous errors occur on the sides of the ψ angle error:

$$\Delta\Psi_{S_1} = -\frac{\varepsilon_{S_1}\sin\varphi}{S} = -\Delta\varphi_S, \text{ with the total error:}$$

$$\Delta\Psi_t = -\frac{[\varepsilon_S\sin\varphi]}{S} \qquad (10)$$

The two total error is equal to the absolute value means that erroneous submission directions are parallel and therefore measurement error due to transverse sides is the same, regardless of where they are determined.

Terraced is obtained average errors:

$$Q_S = \pm\sqrt{[m_S^2\sin^2\varphi]} \qquad (11)$$

From equation (10) gives:
- Influence errors sides of the sides parallel to the closing line is zero;
- In normal sides participate entire production error cross sides.

Since the transverse average error due to measurement error aspect is constant, it follows that those found on the punching shear point remains valid.

2.3. Errors cumulative punching shear in polygons

Since independently errors Qt and QS, the law of propagation of errors, cumulatively allowed, consequently:

$$Q = \pm\sqrt{m_\beta^2[(D-F)^2] + [m_S^2 sin^2\varphi]} \qquad (12)$$

2.4. Determinate minimum error point

Note that the error is a function of the average transverse size of the variable "D" so that we can determine an optimal “D_0” the transverse error is minimal

In this sense writes:

$$\frac{dQ}{dD} = \pm\frac{m_\beta}{q}\frac{2[(D-F)]}{\sqrt{[(D-F)^2]}} = 0 \qquad (13)$$

From equation (12) gives:

$$D_0 = \frac{[F]}{n} \qquad (14)$$

On the other hand, it is important to note that the highest point of submission is considered in the total error is smaller.

How real total errors can be calculated to determine the average errors of relations:

$$m_{\varphi_t} = \pm\frac{m_\beta}{S}\sqrt{[F^B F^B]}$$

And (15)

$$m_{\psi_t} = \pm\frac{m_\beta}{S}\sqrt{[F^A F^A]}$$

Or:

$$m_{\varphi_t} = \pm\frac{m_\beta}{S}\sqrt{[(S-F^A)^2]}$$

(16)

$$m_{\psi_t} = \pm\frac{m_\beta}{S}\sqrt{[F^A F^A]}$$

So if:

$$[(S-F^A)^2] < [F^A F^A] \qquad (17)$$

Then:

$$m_{\varphi_t} < m_{\psi_t} \qquad (18)$$

And the most important is the submission of A. Condition (15) can be written more simply, by developing the following:

$$\frac{[F^{A}]}{n} > \frac{S}{2} \tag{19}$$

From the above it follows that the optimal point cross found error midway AB only if symmetric polygons, the angles were measured with the same precision.

Transverse error optimal point value is determined by the relation (7) in which D is calculated by (13), respectively:

$$Q_t = m_\beta \sqrt{nD_0^2 - 2D_0[F] + [FF]} \tag{20}$$

Or:

$$Q_{t,0} = \pm m_\beta \sqrt{[FF] - \frac{[F]^2}{n}} \tag{21}$$

The conclusion is that as the distance from the optimum point is higher transverse error increases.

3. CONCLUSIONS

In mining, mining works opening and preparation are very important technical point, have permanent character as the embodiment are high-volume and represent goals that require special financial efforts.

On the other hand the implementation of the projects elaborated in this area is done with topographic methods that have special character by conditions that run and by their quality. The papers presented were studied independent routes used to establish the base topographic topographical elements that lead workings in their execution and have character punching shear.

From angular and distance error study conducted independent polygonal paths, there exists an optimal point where the punching shear is minimal transversal deviation is determined and its position.

REFERENCES

[1]. Covaci St., s.a., *Underground mining Publishing* Corvin, 1990

[2]. Dima N., *Contributions to the study of networks of underground topographic and punching shear problems* – The doctoral thesis, 1971

[3]. Dima N., s.a., *Mining topography,* Publishing Corvin, Deva, 1998

[4]. Filip L., s.a., *Specialised mining topography,* Universitas Publishing House, Petrosani, 2014.

Scientific Reviewers:
Assoc. Ph.D. Eng. Ioel VERES

POSSIBILITY OF SOLVING PROBLEMS IN CADASTRE

IOEL VERES*
NICOLAE DIMA**
OFELIA-LARISA FILIP***

Abstract: *It presents the possibility of replacing topographic methods analytical methods detaching the surfaces made of cadastre issues.*

Keywords: *topographic, polygonal,*

1. THE PURPOSE AND IMPORTANCE OF THE WORK

Preparing technical documentation that is required for the legal classification of a building can be done using measurements and processing methods specific to the cadastre. Complex issues in this area include among others works on dividing surfaces and their calculation.

Solving the many situations encountered in practice is possible using appropriate calculation methods, but with regard to finally obtain the appropriate size in terms of quality, high precision, respectively.

Following the paper uses analytical methods of calculation in place for situations commonly encountered topographic methods.

2. CONTENTS OF THE WORK

It will be analyzed two cases of division of areas:

- dividing of a surface into a triangle:

a) after passing the right through a point of the triangle

b) after a parallel to a side of the triangle

c) after a same polygonal contour from another polygonal

- dividing of a surface into a triangle by a line passing through a point of the triangle

W_e consider the surface S bounded by the sides of a triangle (fig.1), peak points (P1, P2, P3) having the known coordinates.

S1 and S2 = S – S1, after passing right through the deck P2.

Splitting problem is to determine the coordinates of P0 which shall be delimited the surfaces S1 si S2.

For the surfaces S1 and S2 equations can be written:

---

* *Assoc. Ph.D. University of Petrosani*
** *Prof. Ph.D., University of Petrosani*
*** *Lector Ph.D., University of Petrosani*

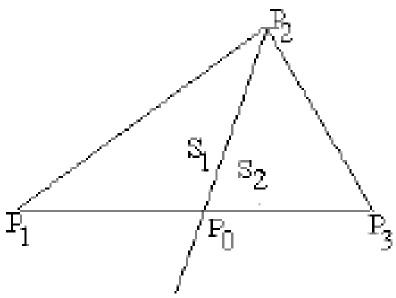


Fig. 1

$$
\begin{aligned}
x_0(y_1 - y_2) + x_1(y_2 - y_0) + x_2(y_0 - y_1) &= 2S_1 \\
x_0(y_2 - y_3) + x_2(y_3 - y_0) + x_3(y_0 - y_2) &= 2S_2
\end{aligned}
\qquad (1)
$$

Or:

$$
\begin{aligned}
x_0(y_1 - y_2) + y_0(x_2 - x_1) + x_1y_2 - x_2y_1 &= 2S_1 \\
x_0(y_2 - y_3) + y_0(x_3 - x_2) + x_2y_3 - x_3y_2 &= 2S_2
\end{aligned}
\qquad (2)
$$

By solving the system of equations is obtained:

$$
x_0 = \frac{\begin{vmatrix} x_2y_1 + x_1y_2 + 2S_1 & x_2 - x_1 \\ x_3y_2 - x_2y_3 + 2S_2 & x_3 - x_2 \end{vmatrix}}{\begin{vmatrix} y_1 - y_2 & x_2 - x_1 \\ y_2 - y_3 & x_3 - x_2 \end{vmatrix}}
$$

$$
y_0 = \frac{\begin{vmatrix} y_1 - y_2 & x_2y_1 - x_1y_2 + 2S_1 \\ y_2 - y_3 & x_3y_2 - x_2y_3 + 2S_2 \end{vmatrix}}{\begin{vmatrix} y_1 - y_2 & x_2 - x_1 \\ y_2 - y_3 & x_3 - x_2 \end{vmatrix}}
\qquad (3)
$$

By conducting relations from (3) we obtain:

$$
\begin{aligned}
x_0 &= x_2 + \frac{S_1}{S}(x_3 - x_2) + \frac{S_2}{S}(x_1 - x_2) \\
y_0 &= y_2 + \frac{S_1}{S}(y_3 - y_2) + \frac{S_2}{S}(y_1 - y_2)
\end{aligned}
\qquad (4)
$$

b) Splitting of a surface in a right triangle after a parallel to a side of the triangle We consider the triangle P1P2P3 (fig.2), for the coordinates of the peak are known.

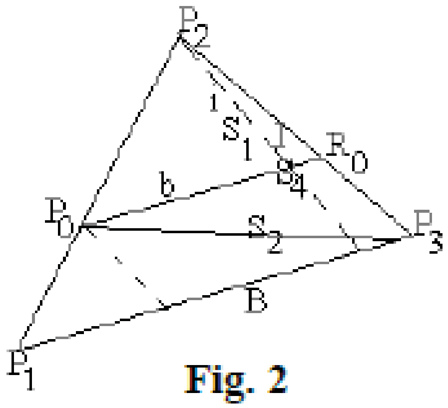


Fig. 2

In this triangle should be separated surfaceS2 (known) by right P0R0 parallel to the side P1P3.

To solve this problem is reduced to determining the coordinates (x0y0) the point P0.

If the point P3 goes a line that passes through the point P0 then the problem is reduced to the previous case

The coordinates x0, y0 the relationships are obtained:

$$x_0 = x_3 + \frac{S_3}{S}(x_2 - x_3) + \frac{S_4}{S}(x_1 - x_3) \tag{5}$$
$$y_0 = y_3 + \frac{S_3}{S}(y_2 - y_3) + \frac{S_4}{S}(y_1 - y_3)$$

In relations (5) are known:

- coordinates: x1, x2, x3 and y1, y2, y3 surface S of coordinates using the equation:

$$2S = x_1(y_2 - y_3) + x_2(y_3 - y_1) + x_3(y_1 - y_2) \tag{6}$$

In relations (5) are not known the surfaces S_3, S_4. to determine these areas proceed as follows:

With the relations from figure 2 we have:

$$\begin{aligned} 2S &= BI \\ 2S_1 &= bi \\ 2S_2 &= (B + b)(I - i) = BI + bI - iB - ib \end{aligned} \tag{7}$$

Or:

$$\begin{aligned} 2S_2 &= 2S + bI - Bi - 2S_1 \\ 2S_2 &= 2S_2 + bI - Bi \end{aligned} \tag{8}$$

And

$$bI = Bi, \quad i = \frac{b}{B} I \tag{9}$$

But:

$$\frac{bi}{BI} = \frac{S_1}{S} \quad \text{where:} \quad i = \frac{b}{B}\frac{S_1}{S} I \qquad 10)$$

from the relations (9) and (10) results:

$$\frac{b}{B} I = \frac{B}{b}\frac{S_1}{S} I$$

where:

$$\frac{b}{B} = \sqrt{\frac{S_1}{S}}$$

And:

$$i = I\sqrt{\frac{S_1}{S}} \qquad (11)$$

With:

$$I - i = \left(1 - \sqrt{\frac{S_1}{S}}\right) I \qquad (12)$$

With the relationship (12) is calculated: S3
And with it:

$$S_4 = S - S_3 \qquad (13)$$

c) Dividing by a polygonal contour surface parallel to other polygonal contour.

We recognize polygonal P1, P2, P3, P4, P5 points whose coordinates x, y known (fig.3).

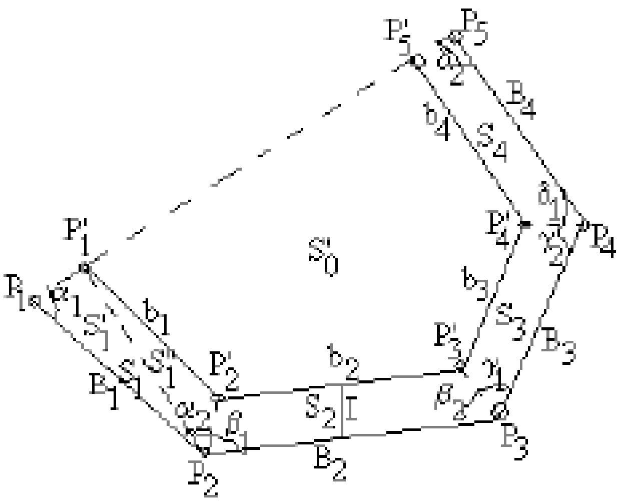


Fig. 3

Inside this contour surface S must separate an area S_0 delimited by the path P_1', P_2', …, P_5'.

Therefore, the surface "S" is known (is calculated from coordinates), and the surface "S_0" given, indicating that $S_0 < S$.

The problem is considered solved if the coordinates are obtained x_1', y_1'from the point P_1'.

Is this possible if I write equations corresponding surfaces S_1 and S_0' bounded by points $P_1P_1'P_2$ and $P_1'P_5P_4P_3P_2$.

$$x_1'(y_2 - y_1) + x_2(y_1 - y_1') + x_1(y_1' - y_2) = S_1' \qquad (14)$$

$$x_1'(y_5 - y_2) + x_5(y_4 - y_1') + x_4(y_3 - y_5) + x_3(y_2 - y_4)$$
$$+x_2(y_1' - y_3) = S_0'$$

Equations (14) form a system of two equations with two unknowns (x_1', y_1') which are obtained by solving the point coordinates P_1'.

It is specified that the surface S_1' we obtain the relationship:

$$2S_1' = B_1 I \qquad (15)$$

and S_0'with the relationship:

$$S_0' = S - S_1' \qquad (16)$$

To obtain the height "I" we write:

$$(B_1 + b_1) + (B_2 + b_2) + (B_3 + b_3) + (B_4 + b_4) = 2S_0$$

Or:

$$I([B] + [b]) = 2S_0$$

But:

$$b_1 = B_1 - (ctg\alpha_1 + ctg\alpha_2)I$$
$$b_2 = B_2 - (ctg\beta_1 + ctg\beta_2)I$$
$$b_3 = B_3 - (ctg\gamma_1 + ctg\gamma_2)I$$
$$b_4 = B_4 - (ctg\delta_1 + ctg\delta_2)I$$

And

$$[b] = [B] - [ctg\ i]I \qquad i \rightarrow \alpha, \beta, \gamma, \delta \qquad (18)$$

With the relationship (18) is calculated (17):

$$(2[B] - [ctg\ i]I)I = 2S_0$$

Or:

$$[ctg\ i]I^2 - 2[B]I - 2S_0 = 0 \qquad (19)$$

from the relation (9) results:

$$I = \frac{[B] - \sqrt{[B]^2 - 2[ctg\, i]S_0}}{[ctg\, i]} \quad \text{for } S_0 < S$$

3. CONCLUSIONS

Division's problems on surfaces are known primarily solved by trigonometric.

The methods presented above are analytical measurements used the known coordinates and surfaces calculated or data.

Even if the volume of computation is in some cases increased, the proposed methods provide superior accuracy in delimiting surfaces.

Delimitation to be separate surfaces is done by points that may appear in the inventory of known points.

Cases analyzed, show a unified solution, from simple to complex and frequently met cadastre.

REFERENCES

[1]. **Leu I.N., s.a.,** *Topography and agricultural cadastre,* Didactic and Pedagogic Bucharest, 1999

[2]. **Veres I., s.a.,** *General topography and mining surveying elements,* Publishing House Universitas, Petrosani, 2006.

Scientific Reviewers:
Prof. Ph.D. Eng. Eugen COZMA

ANALYSIS OF AERODYNAMIC PARAMETERS SPECIFY A MAIN LOCAL STATIONS

MARIUS SIMION MORAR*
DORU CIOCLEA**
ION GHERGHE***
ADRIAN MATEI*****

Abstract: *For underground extraction of coal are running a complex network mining vertical, horizontal and inclined role extraction, transportation and evacuation the surface. Associated system of mining works have the air network to ensure the oxygen necessary for workers, diluting explosive gases and/or toxic substances and preparations to evacuate heat and humidity in the underground. For air circulating on the active underground works, from the points of entry of fresh air to the point of exit of the tainted air, are using powerful fans located at the main stations of fans. The operation of the fan depends on the parameters of specific network aerodynamic, the ventilation of buildings and structure of main air stations. Knowledge of the exact parameters of the specific local networks aerodynamic leads to the optimizations of air flow distribution at the level of each branch concerned to ensure the health and safety conditions in the underground.*

Key words: *ventilation, ventilation networks, aerodynamic parameters, fans*

1. GENERAL REMARKS

For air circulation route active underground workings, from the points of entry of fresh air to the point of exit of foul air, use fans placed on the surface in the main ventilation stations. [1], [2], [3]

At the main station there is complex ventilation based mining ventilation shafts or ventilation rising. The figure is rendered complex work related to the expansion of the main stations connected to a vertical shaft, and includes the following elements:

- The vertical shaft of the expansion valve which has two segments:

* *Eng., PhD. Student, Scientific researcher 3rd degree at INCD INSEMEX Petroşani, marius.morar@insemex.ro*

** *Eng., PhD., Scientific researcher 2nd degree at INCD INSEMEX Petroşani, doru.cioclea@insemex.ro*

*** *Eng., Scientific researcher 3rd degree at INCD INSEMEX Petroşani, ion.gherghe@insemex.ro*

**** *Eng., Scientific researcher assistant at INCD INSEMEX Petroşani, adrian.matei@insemex.ro*

• the portion of the ventilation shaft to the intersection with ventilation channel;
• ventilation shaft portion of the intersection with ventilation channel to bridge surface with sealing.

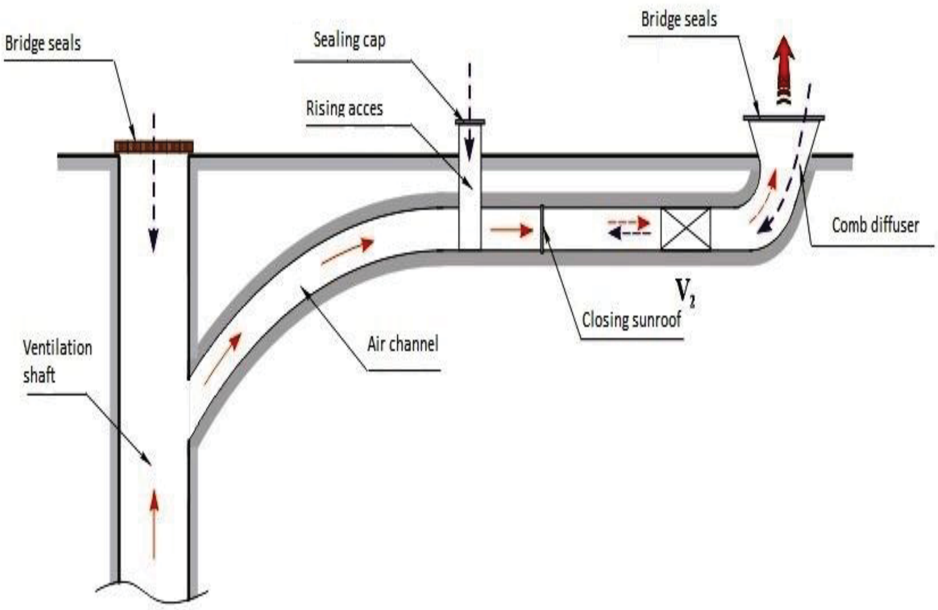


Fig. 1

- Ventilation channel which has two segments:
  - ventilation channel portion of the intersection with ventilation shaft to the intersection with gallery locks;
  - ventilation channel portion of the intersection with gallery locks up at the point of bifurcation of fan channels.
- Gallery lock access channel ventilation;
- Access of raises the ventilation channel provided with the sealing cap;
- Fan channel No 1 provided with hatch closure is normally open position during fan operation located thereon;
- Fan channel No 2 provided with hatch closure is normally closed position whilst the fan placed on it is stopped;
- Speaker with combs for the fan no 1;
- Speaker with combs for the fan no 2; [1],[2],[5]
- Sealing bridge obscures the speaker with combs that foul air is circulated. [5]

2. PARAMETERS SPECIFIC AERODYNAMIC MAIN STATION VENTILATION [5], [3], [4]

Aerodynamic parameters related complex mining are:

- Pressure loss H (Pa);
- The flow rate of air Q (m^3 / min);
- Air resistance R (NS2 / m8). [5]

To determine the aerodynamic parameters specific ventilation main station is called as direct measurements or by calculation alignment mining.

For it is considered a complex workings associated main station ventilation fig. 2, where we have the following ramifications:

- 1-3, shorting the surface characterized by Q_{sc}, R_{sc}, H_{sc};
- 2-3, mine related branch characterized by Qm, Rm, Hm;
- 6-3 channel ventilation characterized by Qc, Rc, Hc;
- 5-6 airlock ventilation access channel characterized Q_{sas}, R_{sas}, H_{sas};
- 4-6, fan route no. 2 characterized by Q_{V2}, R_{V2}, H_{V2};
- 6-7 fan route no. 1 characterized by Q_{V1}, R_{V1}, H_{V1}.

Airflows QSC, Qm, Qc, Qsas, QV2, QV1, is determined by direct measurements ramifications anemometric 2-3, 3-6, 5-6,4-6, ie 1-3 and 6-7 indirect ramifications as follows:

$$Q1\text{-}3 = Q3\text{-}6 - Q2\text{-}3 \quad (m^3/min);$$
$$Q6\text{-}7 = Q3\text{-}6 + Q5\text{-}6 + Q4\text{-}6 \ (m^3/min).$$

Pressure drop Hm, Hsc, Hc, Hsas, HV2, HV1, is determined by depresiometric measuring all branches 1-3, 2-3, 3-6, 5-6, 4-6, 6-7.

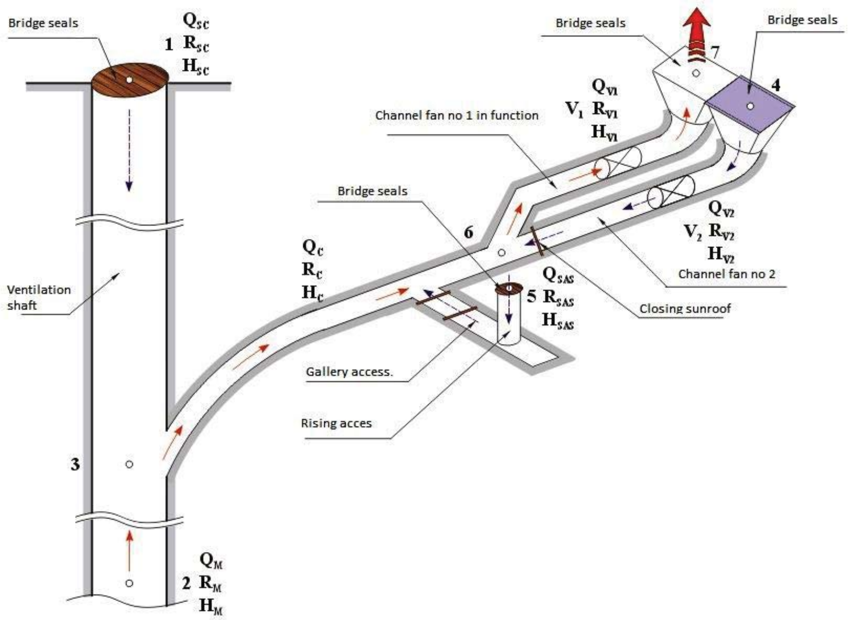


Fig. 2

The aerodynamic resistances are determined by calculation as follows:
In mode 3 have two resistors connected in parallel, namely, R2-3 or R1-2. [5]
In this equivalent resistance R3 will be:

$$\frac{1}{\sqrt{R_{e3}}}=\frac{1}{\sqrt{R_{1-3}}}+\frac{1}{\sqrt{R_{2-3}}}$$

$$\frac{1}{\sqrt{R_{e3}}}=\frac{\sqrt{R_{2-3}}+\sqrt{R_{1-3}}}{\sqrt{R_{1-3}*R_{2-3}}}$$

By the square follows:

$$\frac{1}{R_{e3}}=\frac{\left(\sqrt{R_{2-3}}+\sqrt{R_{1-3}}\right)^2}{R_{1-3}*R_{2-3}}$$

$$R_{e3}=\frac{R_{1-3}*R_{2-3}}{\left(\sqrt{R_{2-3}}+\sqrt{R_{1-3}}\right)^2}\quad (Ns^2/m^8)$$

The equivalent resistance R_{e3} is in turn connected in series with the channel resistance R3-6 ventilation.

The equivalent resistance of the two resistors is connected in series R1-6:

$$R_{1-6} = R_{e3} + R_{3-6}\quad (Ns^2/m^8)$$

$$R_{1-6}=\frac{R_{1-3}*R_{2-3}}{\left(\sqrt{R_{2-3}}+\sqrt{R_{1-3}}\right)^2}+R_{3-6}$$

$$R_{1-6}=\frac{R_{1-3}*R_{2-3}+R_{3-6}\left(\sqrt{R_{2-3}}+\sqrt{R_{1-3}}\right)^2}{\left(\sqrt{R_{2-3}}+\sqrt{R_{1-3}}\right)^2}\quad (Ns^2/m^8)$$

In node 6 have also three resistors connected in parallel, namely R_{5-6}, R_{4-6} respectively R_{1-6}.

In this respect Re6 equivalent resistance will be:

$$\frac{1}{\sqrt{R_{e6}}}=\frac{1}{\sqrt{R_{5-6}}}+\frac{1}{\sqrt{R_{4-6}}}+\frac{1}{\sqrt{R_{1-6}}}$$

$$\frac{1}{\sqrt{R_{e6}}}=\frac{\sqrt{R_{4-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{4-6}}}{\sqrt{R_{5-6}*R_{4-6}*R_{1-6}}}$$

By the square follows:

$$\frac{1}{R_{e6}}=\frac{\left(\sqrt{R_{4-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{4-6}}\right)^2}{R_{5-6}*R_{4-6}*R_{1-6}}$$

$$R_{e6}=\frac{R_{5-6}*R_{4-6}*R_{1-6}}{\left(\sqrt{R_{4-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{4-6}}\right)^2}\ (Ns^2/m^8)$$

The equivalent resistance R_r network is:

$$R_r = R_{e6} = R_{6\text{-}7}$$

$$R_r = \frac{R_{5-6}*R_{4-6}*R_{1-6}}{\left(\sqrt{R_{4-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{4-6}}\right)^2} = R_{6\text{-}7}\ (Ns2/m8)$$

Thus the 6-7 branch, which is located active fan, identify aerodynamic parameters in the main station ventilation, Q_s, H_s, R_s, as follows:

- Air flow at the main station ventilation

$$Q_s = Q_{6\text{-}7}\ \ (m^3/min)$$

- Depression exerted by the fan at the main station ventilation

$$H_s = H_{6\text{-}7}\ \ (Pa)$$

- Resistance to the main station ventilation

$$R_s = R_r = R_{6\text{-}7} = \frac{R_{5-6}*R_{4-6}*R_{1-6}}{\left(\sqrt{R_{4-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{1-6}}+\sqrt{R_{5-6}}*\sqrt{R_{4-6}}\right)^2}\ (Ns^2/m^8)$$

3. ANALYSIS OF THE SYSTEM NO SURFACE SHORTING [5]

When the fan from the main station is mounted directly on the shaft ventilation or ventilation of raises, there is shorting to the area that is:

$$R_{1\text{-}3} = 0$$

Then

$$R_{e3} = R_{2\text{-}3} \quad (Ns^2/m^8)$$

and

$$R_{1\text{-}6} = R_{e3} + R_{3\text{-}6} = R_{2\text{-}3} + R_{3\text{-}6} \quad (Ns^2/m^8)$$

So air resistance Rr network is modified accordingly as follows:

$$R_{e6} = \frac{R_{5-6} * R_{4-6} * (R_{2-3} + R_{3-6})}{\left(\sqrt{R_{4-6}} * \sqrt{(R_{2-3} + R_{3-6})} + \sqrt{R_{5-6}} * \sqrt{(R_{2-3} + R_{3-6})} + \sqrt{R_{5-6}} * \sqrt{R_{4-6}}\right)^2}$$

$= R_r = R_{6\text{-}7}$ (Ns2/m8)

4. ANALYSIS OF VARIATION OF VENTILATION PARAMETERS [5], [6]

The cases analyzed that main station specific aerodynamic parameters vary depending on the configuration ventilation structure mining complex in its composition as follows:

- Change air flow circulated;
- Change depressions;
- Variation of aerodynamic resistance.

5. ANALYSIS OF THE SYSTEM NO SURFACE SHORTING, SAS ACCESS CHANNEL VENTILATION FAN THAT CHANNEL V2 [5], [7]

When the fan from the main station is mounted directly on the shaft ventilation or ventilation rising, there is shorting the surface.

If the main station ventilation is provided with a gate valve type when there is no access cover ventilation channel.

If the main station ventilation presents a sled type or equivalent, which allows either change or motor unit fan motor in a short time, then there is no fan channel V2.

Then:

$R_{1\text{-}3} = 0$

$R_{5\text{-}6} = 0$

$R_{4\text{-}6} = 0$

$$R_{e3} = R_{2\text{-}3}$$

and

$$R_{1\text{-}6} = R_{e3} + R_{3\text{-}6} = R_{2\text{-}3} + R_{3\text{-}6} \quad (Ns^2/m^8)$$

So air resistance Rr network is modified accordingly as follows:

$$R_r = R_{1-6}$$

$$R_r = R_{2\text{-}3} + R_{3\text{-}6} = R_{e6} = R_{6\text{-}7} \quad (Ns2/m8)$$

6. CONCLUSIONS

At the main station ventilation are complex mining ventilation shafts either grafted or on ventilation rising including: ventilation shaft; ventilation duct; of raises ventilation channel access; fan duct No 1; fan duct No 2; speaker with combs.

Mine workings associated main station, a number of strategically placed ventilation construction to ensure network functionality.

The analysis presented mining specific aerodynamic parameters of the main station ventilation by using flow balance, depressions resistances revealed that, compared with other variants, where the main ventilation station is equipped with two fans located on two separate channels, a ventilation channel provided with a lid and connected to a ventilation shaft vertical to the surface of the short circuit, then:

- Entrained in the air flow of the fan is greater than the maximum flow rate of air circulated to the level of the mine;
- Depression exerted on the fan is minimal and greater than the depression exerted at mine;
- A network of ventilation air resistance is minimal and much less than the equivalent resistance of the mine.

REFERENCES

[1]. Baltaretu R., **Teodorescu C. -** *Ventilation and safety in mine*, Didactic and Pedagogic Publisher, Bucharest 1971

[2]. Covaci Șt. **-** *Underground mining*, Vol I, Didactic and Pedagogic Publishing, Bucharest, 1983

[3]. Teodorescu, C., **Gontean, Z., Neag, I.,** *Mine ventilation*, Technical Publishing House Bucharest, 1980

[4]. Matei I., **Moraru R.,** etc. **-** *Environmental Engineering and ventilation underground*, Technical Publishing House Bucharest, 2000

[5]. Cioclea D. **-** *solving ventilation network based on depresiometric measurements to determine air flow rates of depressions, the aerodynamic resistance on the job, to the commissioning of new fans stations VOD 2.1 from ventilation shaft no. 10 - Valley Arsului*, Study INSEMEX 2006

[6]. Patterson A. M. **-** *The Mine Ventilation Practitioner's DATA BOOCK,* M.V.S. of South Africa 1992

[7]. CANMET – *Mining and Minerals Sciences Laboratories Underground Mine Environment and Ventilation – User's manual – 3D program – CANVENT – 2K*

[8]. Le Roux - *Notes on Mine environmental control,* The MVS of South Africa 1990.

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

MANAGEMENT OF THE VENTILATION NETWORK AT VULCAN MINING UNIT

MARIUS SIMION MORAR*
SORIN MIHAI RADU**
DORU CIOCLEA***
ION GHERGHE****

Abstract: *Healthy and safe working conditions in the underground especially in those areas with hazard of potential atmospheres shall depend mainly on the production implementation and the management of the ventilation system. Improving the management of the ventilation system involves thorough and complex analyses of the ventilation network, i.e. a huge amount of data to be processed only by IT. This paper shows an analysis of the ventilation network at Vulcan Mining Unit, with the use of the IT to simulate certain situations that may come up in the ventilation system*

Key words: *ventilation, ventilation networks, aerodynamic parameters, fans*

1 INTRODUCTION

The best management of the ventilation network used by a mine involves the use of the IT with the view to performing relevant analyses and to successfully preventing the occurrence of hazardous situations. Expert software can simulate the occurrence of the alterations that may come up in the ventilation system considering certain possible hypotheses.

2 GENERAL REMARKS

For getting the best possible working conditions in underground, it is necessary to provide the primary protection, i.e. suitable ventilation. The purpose of this ventilation is to: [1], [3]

- provide the concentration in oxygen necessary for the personnel currently working in underground;

* *Eng. PhD. Student, Scientific researcher 3nd degree at INCD INSEMEX Petroşani, marius.morar@insemex.ro*
** Prof. PhD. *Eng. at the University of Petrosani*
*** *Eng. PhD. Scientific researcher 2rd degree at INCD INSEMEX Petroşani, doru.cioclea@insemex.ro*
**** *Eng. Scientific researcher 3nd degree at INCD INSEMEX Petroşani, io.gherghe@insemex.ro*

- dilute the explosive and/or toxic gases existing in the mine network;
- diminish the heat emitted inside mine workings, both due to human activities and to thermal gradient.

A good ventilation of each mine working involves the best possible repartition of air flows along each branch of the ventilation network. In this spirit it is necessary to settle the ventilation network of each mine. An example of complex ventilation network is the one belonging to Vulcan mine. [2]

3 OF THE VENTILATION NETWORK OF VULCAN MINE

The ventilation network of Vulcan mine was quite complex. At present it has diminished because of some accidents (such as explosions) and due to the depletion of the useful mineral deposits. Therefore, the ventilation network includes four ventilation shafts: Chorin Shaft, Prokop Shaft and X Shaft - Valea Arsului. It also includes three ventilation raises with the related ventilation stations (B'Allomas Raise, Karollus Raise and Ionaşcu Raise) and underground mine workings located on four levels (level 315; level 360; level 420; level 480). These mine workings are made of main cross sectional galleries, directional galleries, diagonal galleries, plain cross sectional galleries, inclines, working faces, connection raises.

The whole ventilation network includes 251 junctions (knots) and 300 branches. [2]

4 PROVIDING THE SOLUTION FOR THE VENTILATION NETWORK OF THE MINE [2], [4]

For providing the best solution available for such a complex ventilation network, we have used the Hardy-Cross method for successive approximation. This method represents the grounds of an expert software CANVENT designed in Canada . [4] This software helped us to provide the solution for the ventilation network as well and optimization of the air flow distribution within the ventilation branches.

The settlement of the ventilation network related to Vulcan mine made necessary to run several stages:

a) Marking the junctions of the ventilation network on the spatial diagram;
b) Determining the geodesic coordinates of the identified junctions;
c) Inputting the geodesic coordinates of junctions and the existing branches into the database of the software;
d) The carrying out of measurements in situ; these measurements include:
1. measurements of the aerodynamic parameters of mine workings;
2. measurements of the geometrical parameters of mine workings;
3. measurements of the physical parameters of the air;
e) Calculation of aerodynamic strength specific to each branch;
f) Inputting the values of parameters specific to the ventilation network into the expert software CANVENT;
g) The 2D or 3D drawing of the ventilation network;
h) Balancing the ventilation network;
i) Settling the ventilation network. Both the direction and the optimum distribution of the air flows along each branch are being identified in this stage;
j) Getting the results.

This final stage provides the data on electronic support or paper regarding the graphic settlement of the ventilation network.

5 SIMULATIONS IN THE VENTILATION NETWORK [2], [3], [4]

CANVENT software allows simulating certain changes that may come up in the ventilation network. Hence, the following situations have been simulated out the ventilation network of Vulcan Mine:

a) removal of the air outlet circuit from no. 4/3/VI towards Terezia raise (360 - 420);

Simulation no. 1 - removal of the air outlet circuit from no. 4 / 3 / VI towards Terezia raise (360 - 420).

This simulation involves the placing of sealing structures on the connectivity gallery with the raise no. 3 bl. VI, branch 100-101 and on the raise no. 4 floor, branch 92-93.

The placing of these sealing structures removed the following branches from the ventilation system: 92-93; 93-94; 94-95; 95-96; 96-97; 97-98; 98-99; 99-100 and 100-101.

As a result of this removal and to maintain the specified flow rate at the longwall no. 2, bed 3, bl. VI, the regulating door on the transverse gallery, level 420 (branch 75-101) was eliminated.

The alteration carried out for this simulation is shown in Figure no. 1.

We have got the following results that can be compared to the present situation:

- The air flow rate along the fresh air intake at the level 360, branches 22-23; 15-24; 30-31; 193-194 increased from 33.91 m^3/s to 34.54 m^3/s (from 2035 m^3/min to 2073 m^3/min);
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn’t change significantly;
- The air flow rate along the ventilation incline 360-315 increased from 16.03 m^3/s to 16.98 m^3/s (from 962 m^3/min to 1019 m^3/min);
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI changed from 2.1 m^3/s to 2.8 m^3/s;
- The air flow rate at the longwall no. 0, bed 3, bl. VIII, level 376 m and at the longwall no. 0, bed 3, bl. VIII, level 386, didn’t change significantly;
- The air flow rate increased from 8.19 m^3/s to 8.76 m^3/s (approx. 34 m^3/min) along the air outtake related to longwall no. 2 bed 3 bl. VI (branch 181-183) level 480;
- The air flow rate diminished from 5.18 m^3/s to 4.01 m^3/s (approx. 70 m^3/min) along the air outtake related to longwall no. 4 bed 3 bl. VI (branch 90-89) level 360;
- The air flow rates didn’t change significantly along the air outtake of longwalls no. 0 bed 3 bl. VIII, level 376 m and no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153);
- Virtually, the air flow rates stayed the same in the mine (branches 240-242, 235-237).

b) the tank from the skip is empty and the door in the gallery that connects the tank with the skip (the upper part of the tank) is open and the collecting tank, level 360, is full;

Simulation no. 2 - the tank from the skip is empty and the door in the gallery that connects the tank with the skip (the upper part of the tank) is open and the collecting tank, level 360, is full.

To carry out this simulation, we take as closed the circuit between the outtake of longwall no. 4 bed 3 bl. VI, level 360 m and the transverse gallery Terezia raise level 420 m, i.e. simulation no. 2 relies on simulation no. 1.

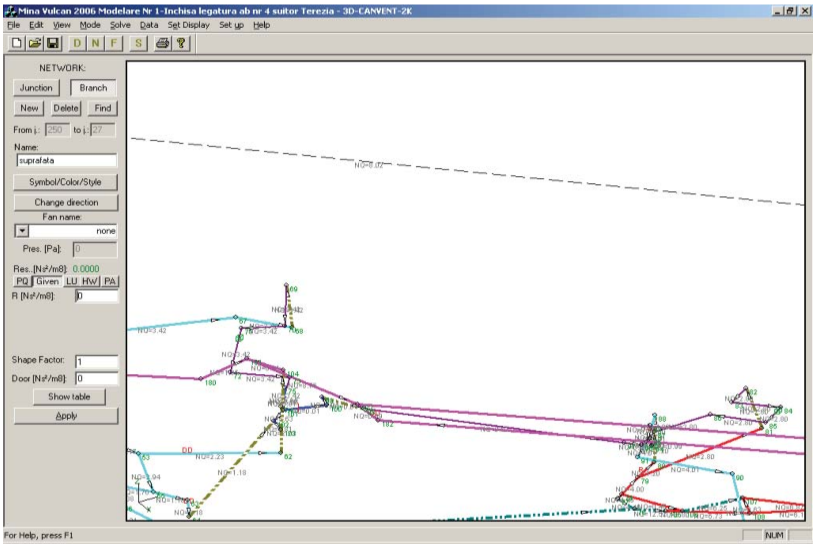


Figure no. 1 [4]

The removal of the door on the gallery that connects the skip to the upper part of the tank level 387 m (branch 8-15) removed the initial strength of 5 Ns^2/m^8 on the connecting tank, branch 14-15; thus we simulated the empty tank. Also, we increased strength on the collecting tank, level 360 m (branch 46-48) and simulated the full silo.

The alteration carried out for this simulation is shown in Figure no. 2.

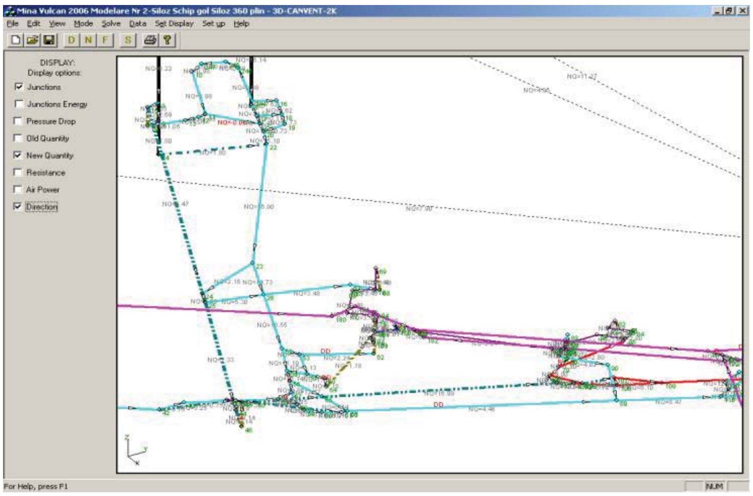


Figure no. 2 [4]

We have got the following results that can be compared to the present situation:

- The air flow rate along the fresh air intake at the level 360, branches 22-23 ; 15-24 ; 30-31 ; 193-194 increased from 33.91 m^3/s to 34,65m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the ventilation incline 360-315 increased from 16.03 m^3/s to 17 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI changed from 2.1 m^3/s to 2.8 m^3/s;
- The air flow rate at the longwall no. 0, bed 3, bl. VIII, level 376 m and at the longwall no. 0, bed 3, bl. VIII, level 386 m, didn't change significantly;
- The air flow rate increased from 8.19 m^3/s to 8.80 m^3/s along the air outtake related to longwall no. 2 bed 3 bl. VI (branch 181-183) level 480 m;
- The air flow rate diminished from 5.18 m^3/s to 4.03 m^3/s along the air outtake related to longwall no. 4 bed 3 bl. VI (branch 90-89) level 360;
- The air flow rates didn't change significantly along the air outtake of longwalls no. 0 bed 3 bl. VIII, level 376 m and no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153);
- Virtually, the air flow rates stayed the same in the mine (branches 240-242, 235-237).

c) the tank from the skip is full and the door in the gallery that connects the tank with the skip (at the upper part of the tank) is closed and the collecting tank, level 360, is empty;

Simulation no. 3 - the tank from the skip is full and the door in the gallery that connects the tank with the skip (at the upper part of the tank) is closed and the collecting tank, level 360, is empty.

To carry out this simulation, we take as closed the circuit between the outtake no. 4 bed 3 bl. VI, level 360 m and the transverse gallery Terezia raise level 420 m, i.e. simulation no. 3 relies on simulation no. 1.

We reduced the strength of the collecting tank level 360 m and thus we simulated the situation when the tank is empty. Also, we increased strength on the tank from the skip to simulate the case when the tank is full.

Figure no. 3 shows the alterations made for this simulation. [4]

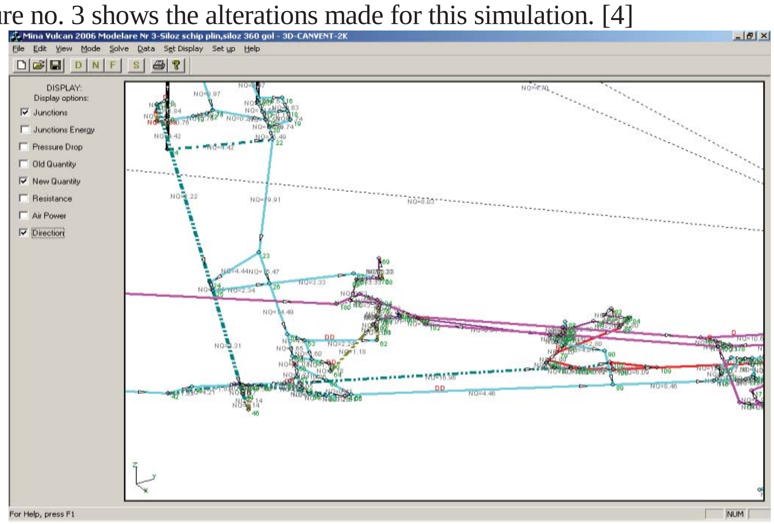


Figure no. 3 [4]

We have got the following results that can be compared to the present situation:

- The air flow rate along the fresh air intake at the level 360 m, branches 22-23; 15-24; 30-31; 193-194 increased from 33.91 m^3/s to 34,46 m^3/s;
- The air flow rate along the connecting raise (branch 25-44) increased from 1.8 m^3/s to 4.31 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the ventilation incline 360 - 315 increased from 16.03 m^3/s to 16.97 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI increased from 2.1 m^3/s to 2.8 m^3/s;
- The air flow rate at the longwall no. 0 bed 3 bl. VIII, level 376 m, ant at the longwall no. 0 bed 3 bl. VIII, level 386 m, didn't change significantly;
- The air flow rate along the air outtake of longwall no. 2 bed 3 bl. VI (branch 181-183) at the level 480 m, increased from 8.19 m^3/s to 8.72 m^3/s;
- The air flow rate along the air outtake of longwall no. 4 bed 3 bl. VI (branch 90-89) at the level 360 m, diminished from 5.18 m^3/s to 4.02 m^3/s;
- The air flow rate along the air outtake of longwall no. 0 bed 3 bl. VIII, level 376 m and of longwall no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153) didn't change significantly;
- Virtually, the air flow rates stayed the same in the mine (branches 240-242 and 235-237).

d) the tanks from the skip is empty and the door in the gallery that connects the tank with the skip is open and the connecting tank, level 360, is empty;

Simulation no. 4 - the tanks from the skip is empty and the door in the gallery that connects the tank with the skip is open and the connecting tank, level 360, is empty.

To carry out this simulation, we considered the simulation no. 1 where the connection between the outtake of longwall no. 4 bed 3 bl. VI, level 360 m and Terezia raise, level 420 m, is closed.

We reduced the strength from the raise of the skip (branch 14-15) and simulated the situation when the tank from the skip is empty. The ventilation door on the gallery that connects the skip to the upper side of the raise (branch 8-15) was eliminated. We also reduced the strength of the collecting tank level 360 m (branch 46-48) and simulated the situation when the collecting tank is empty.

Figure no. 4 shows the alterations made for this simulation.

We have got the following results that can be compared to the present situation:

- The air flow rate along the fresh air intake at the level 360 m, branches 22-23 ; 15-24 ; 30-31 ; 193-194, increased from 33.91 m^3/s to 34.85 m^3/s;
- The air flow rate along the connecting raise (branch 44-45) diminished from 1.8 m^3/s to 0.92 m^3/s;
- The air flow rate on the connecting gallery (branch 8-15) increased from 2.18 m^3/s to 3.68 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;

• The air flow rate along the ventilation incline 360 - 315 increased from 16.03 m^3/s to 17.09 m^3/s;

• The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI increased from 2.1 m^3/s to 2.8 m^3/s;

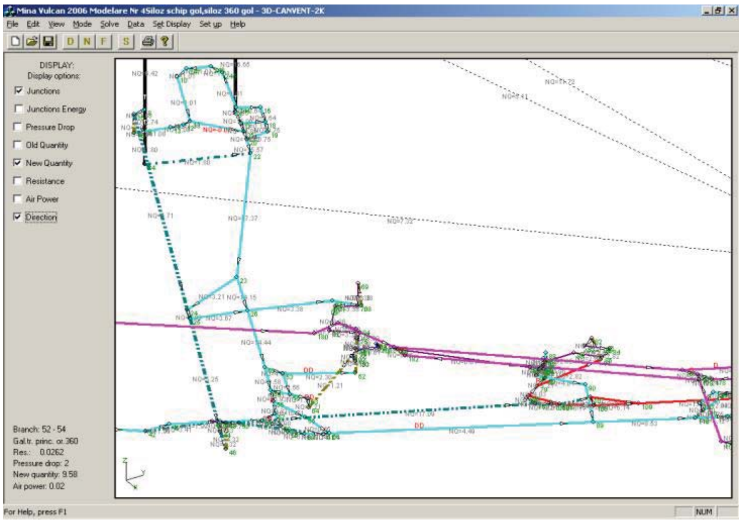


Figure no. 4 [4]

• The air flow rate at the longwall no. 2 bed 3 bl. VIII, level 376 m and at the longwall no. 0 bed 3 bl. VIII, level 386 m, didn't change significantly;

• The air flow rate along the air outtake of the longwall no. 2 bed 3 bl. VI (branch 181-183) at the level 480, increased from 8.19 m^3/s to 8.79 m^3/s;

• The air flow rate along the air outtake of the longwall no. 4 bed 3 bl. VI (branch 90-89) level 360 m, diminished from 5.18 m^3/s to 4.05 m^3/s;

• The air flow rates along the air outtake of the longwall no. 0 bed 3 bl. VIII, level 376 m, and of the longwall no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153) didn't change significantly;

• Virtually, the air flow rates stayed the same in the mine (branches 240-242 and 235-237).

e) the tank from the skip is full and the door in the gallery that connects the tank with the skip is closed and the connecting tank, level 360, is full;

Simulation no. 5 - the tank from the skip is full and the door in the gallery that connects the tank with the skip is closed and the connecting tank, level 360, is full

To carry out this simulation, we take simulation no. 1 as the starting point.

We also increased the strength: on the tank of this skip (branch 8-15) to simulate the situation when the tank of the skip is full and on the collecting tank level 360 m (branch 46-48) to simulate the situation when the collecting tank is full.

Figure 5 shows the alterations made for this simulation.

We have got the following results that can be compared to the present situation:

• The air flow rate along the fresh air intake at the level 360 m, branches 22-23; 15-24; 30-31; 193-194, increased from 33.91 m^3/s to 34.33 m^3/s;

- The air flow rate along the connecting raise (branch 44-45) increased from 1.8 m^3/s to 2.03 m^3/s;
- The air flow rate on the connecting gallery (branch 8-15) diminished from 2.18 m^3/s to 1.98 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the incline for access to the base of the shaft with skip (branch 34-22) increased from 3.19 m^3/s to 4.34 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI increased from 2.1 m^3/s to 2.79 m^3/s;
- The air flow rate at the longwall no. 0 bed 3 bl. VIII, level 376 m and at the longwall no. 0 bed 3 bl. VIII, level 386 m, didn't change significantly;
- The air flow rate along the air outtake of the longwall no. 2 bed 3 bl. VI (branch 181-183) at the level 480 m, increased from 8.19 m^3/s to 8.73 m^3/s;
- The air flow rate along the air outtake of the longwall no. 4 bed 3 bl. VI (branch 90-89) level 360 m, diminished from 5.18 m^3/s to 4.0 m^3/s;
- The air flow rates along the air outtake of the longwall no. 0 bed 3 bl. VIII, level 376 m, and of the longwall no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153) didn't change significantly;
- Virtually, the air flow rates stayed the same in the mine (branches 240-242 and 235-237).

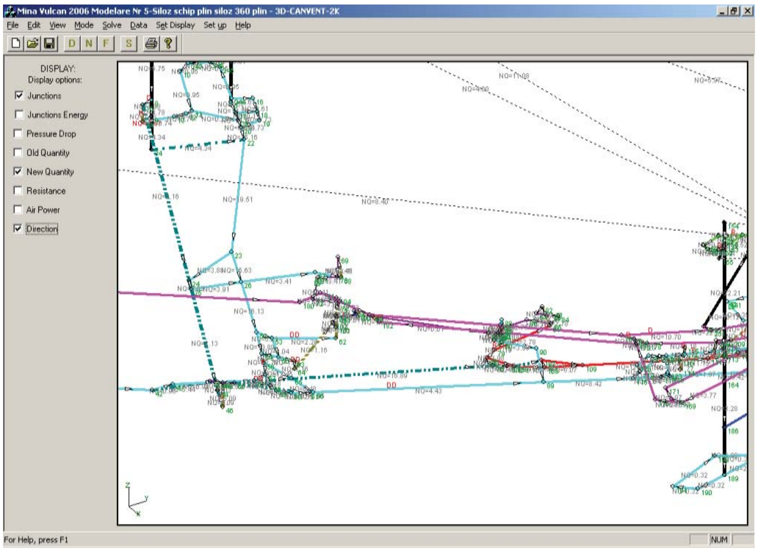


Figure no. 5[4]

f) case when the working face no. 1 / 3 / VIII level 366, is put to operation.

Simulation no. 6 - case when the working face no. 1 / 3 / VIII level 366, is put to operation. To carry out this simulation, we have taken into consideration the simulation no. 1.

We have also introduced new knots: 21, 26, 49, 139, 140, 168, 175, 177, 228, 230, and 241, based on the topographic coordinates got from the topo department of Vulcan Mining Unit. We have also introduced new branches: 12-21, 21-26, 26-49, 49-139, 139-140, 140-168, 168-175, 175-177, 177-228, 228-230, 230-241, 114-241, 241-215.

Consequently we have simulated the existence of a new longwall (no. 1 bed 3 bl. VII, level 366 m) in the current network of the mine, with the air intake on level 315 m on the transverse gallery no. 1 (branch 12-21) and the air outtake is on the raise in the floor no. 2 bed 3 bl. VIII (branch 241-115).

The presence of this new longwall unbalanced the distribution of air flow rates on the circuits related to the ventilation network of Vulcan Mine. Consequently, it was necessary to:

– remove the ventilation door in the transverse gallery no. 2 bed no. 3 bl. BII, level 360 m (branch 115-125);

– place a regulating door in the access gallery to raise no. 2 bed no. 3 bl. VII, roof of level 315 m (branch 110-114);

– place a regulating door in the directional gallery bl. VII-VIII, level 315 m (branch 113-126);

– place a sealing door in the raise no. 1 bl. VIII, level 315-360 m (branch 130-181) for balancing the ventilation network and getting a normal distribution of air flow rates, especially at longwalls.

Figure no. 6 shows the alterations made for this simulation.

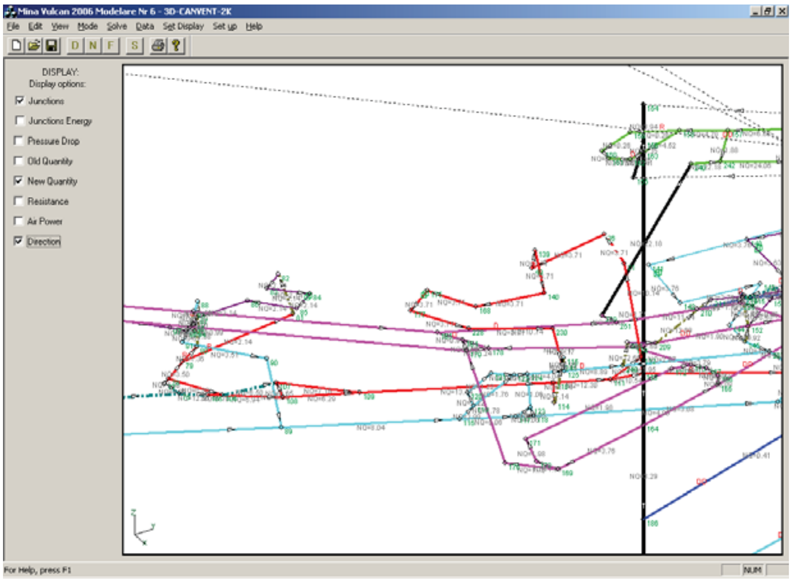


Figure no. 6 [4]

We have got the following results that can be compared to the current situation:

- The air flow rate along the fresh air intake at the level 360 m, branches 22-23; 15-24 ; 30-31 ; 193-194 increased from 33.91 m^3/s to 34.39 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the ventilation incline 360 - 315 increased from 16.03 m^3/s to 16.77 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI didn't change significantly;
- The air flow rate at the longwall no. 1 bed 3 bl. VII reached 3.67 m^3/s, i.e. the value stated in the ventilation project for this longwall;

- The air flow rate at the longwall no. 0 bed 3 bl. VIII, level 376 m and at the longwall no. 0 bed 3 bl. VIII, level 386 m, reduced insignificantly;
- The air flow rate along the air outtake of the longwall no. 2 bed no. 3 bl. VI (branch 181-183), level 480 m, increased from 8.19 m^3/s to 8.79 m^3/s;
- The air flow rate along the air outtake of the longwall no. 4 bed no. 3 bl. VI (branch 90-89), level 360 m, diminished from 5.18 m^3/s to 3.46 m^3/s;
- The air flow rate along the air outtake of the longwall no. 1 bed no. 3 bl. VI (branch 125-249), level 360 m, increased from 7.18 m^3/s to 8.80 m^3/s;
- Virtually, the air flow rates stayed approx. the same in the mine (branches 240-242 and 235-237);
- The air flow rate along the directional gallery bl. VII - VIII (branch 113-126) diminished from 10.95 m^3/s to 8.52 m^3/s;
- The air flow rate along the raise no. 1 bed no. 3 bl. VIII (branch 130 - 131) diminished from 2.75 m3/s to 1.18 m^3/s.

6. CONCLUSIONS

- Giving solutions for the ventilation networks with the help of it is a huge step forward that allows optimum ventilation and a visualization of the changes made on the network in real time.
- The ventilation network given as example belongs to Vulcan mine and includes 4 shafts, 3 ventilation raises, 4 levels and several underground workings (cross-sectional galleries, directional galleries, diagonal galleries, inclines, connection raises and working faces).
- The best solutions available for the ventilation network of Vulcan mine have been obtained with the help of the Canadian software called CANVENT. It includes the run of 10 main steps.
- We have been able to perform 6 simulations on this software that involved certain changes which might come up in the ventilation network.
- Giving solutions for the ventilation network with the help of IT allows the best possible solutions irrespective of its complexity.

REFERENCES

[1] Baltaretu, R. Teodorescu, C. - *Mine ventilation and safety (in Romanian),* Didactic and Pedagogic Publishing House, Bucharest 1971.

[2] Cioclea D., ş.a., *Solving ventilation network under depresiometric measurements to determine air flow rates, the depressions, the aerodynamic resistance, the job of the EM Vulcan (in Romanian),* INSEMEX Study, 2006.

[3] Todorescu C., Gontean Z., Neag I., *Mine ventilation (in Romanian),* Technical Publishing House Bucharest, 1980.

[4] CANVENT – *Mining and Minerals Sciences Laboratories Underground Mine Environment and Ventilation - 3D program – CANVENT – 2K..*

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

RISK ASSESSMENT POLLUTION AND ECOTOXICOLOGICAL EFFECTS IN SITES ABANDONED MINING INDUSTRY IN ROMANIA

EMILIA-CORNELIA DUNCA*
DANIELA-IONELA CIOLEA**

Abstract: *The processing and storage of waste from the extractive industry in Romania was in many cases without preventive measures, due to the lack of legal framework, risk is affecting environmental quality. Therefore, currently several of abandoned mining sites have a significant impact on human health and the environment. The main impact on the environment derived from mining tailings ponds and waste dumps and preparation plants the decommissioned. The risk of soil and groundwater consisting of a variety of pollutants, in particular the heavy metals ions, cyanide, hydrocarbons, acidity, salinity, etc. The infiltration of contaminants into the soil and groundwater and surface air emissions has also some serious risk to human quality and environmental factors. This paper proposes the risk assessment and eco-toxicological effects they may have sites abandoned the mining industry in Romania on the health of the population and the environment.*

Keywords: *abandoned site, sterile, risk, eco-toxicology, environmental factors, tailings pond, waste dumps*

1. INTRODUCTION

Mining activities are important human activities in terms of generating metal pollution sources. After mining stored in sterile environment rich in metals and their mobility is mainly by water flows and atmospheric contaminating ecological systems at large distances from the source. If mobility about hydrological main receivers is wetlands that can facilitate the dispersion of metals, being secondary sources of pollution.

The main pollution sources are: mining, farming and urban agglomerations. These activities lead to the release of pollutants into the environment. Ramada, 1989, Postolache, 2000, quoted by V. Dumitrescu, 2011 ranks pollutants into 3 major classes: physical, chemical and biological signals following classification:

a. the ionic inorganic compounds (metals and other inorganic ions);
b. organic pollutants (hydrocarbons, insecticides, herbicides, detergents, etc.);
c. organo-metallic compounds;
d. radioactive isotopes.

---

* *Assoc.Prof.Ph.D.Eng. at the University of Petroșani*
** *Lecturer Ph.D.Eng. at the University of Petroșani*

Heavy metals are considered harmful organisms are present in high concentrations (Martin, 1997 Onianwa 2001, Krishna and Govil, 2004, quoted by V. Dumitrescu, 2011). Ecological significance of heavy metals is important for toxicity, mobility and their accumulation.

These elements can enter the hydrologic cycle through groundwater by leaching, and ground waters through runoff. It can accumulate in plants and then released into the atmosphere as a gas, it can aggregate Semi-permanent in clay or organic matter in the soil or sediment accumulation may have repercussions on human health in the long term (Sæther et al., 1997, Acero et al. Krishna and Govil 2003, 2004, quoted by V. Dumitrescu, 2011).

To designate metals ecological significance take into account the factor of anthropogenic disturbance. This factor is the ratio of annual global natural inputs and inputs due to human activities in the metal. Pb, Cd, Cu and Zn were the most lift anthropogenic disturbance factors (Forstner and Wittman, 1981, Ramada, 1992 Iordache, 2009, quoted by V. Dumitrescu, 2011).

It has been found by the skilled person that the mobility of heavy metals varies according to the chemical characteristics of each metal, and thus, the chemical structure may occur. The metals are usually found in the form of complexes with organic or inorganic ligands. Depending on the preference of metal for metal ion ligands are classified as Class A (also called hard), class B (also called weak) and intermediate (Postolache, 2000 IUPAC, 2002 Iordache, 2009, quoted by V. Dumitrescu, 2011).

A metal can be Class A and Class B, depending on the oxidation state and coordinated ligands. This classification allows elucidation of metal complexes. The metals of type A are usually associated with oxygen or nitrogen ligands in the composition to form electrostatic bonds, whereas type B metals are associated with the CN ligands and sulfur in the composition, in particular to form covalent bonds (Pearson, 1973, Postolachi, 2000 quoted by V. Dumitrescu, 2011).

2 SOURCES OF METALS AND PROCEDURES FOR RELEASE

The main sources of heavy metal pollution are diverse such pollution problem arising mainly from exploiting deposits of coal and ferrous and non-ferrous metals as well as use by the human population, but also from other production (Postolache, 2000 , quoted by V. Dumitrescu, 2011). Therefore, metal pollution is not attributable exclusively mining activity, although it is prevalent in this case.

In Table 1 are some human activities that are sources of heavy metal pollution for eight common.

In conclusion, human activities increase metal flows through the overwhelming variety of activities, each having an important contribution to the disruption of these flows.

Typically, metals are dispersed into the environment through air or water flows resulting from industrial activities. Waste streams resulting from socio-economic activities are important sources of metal pollution. Mobility of water in river basins contaminated with mine tailings or waste dumps such tailings is a way of dispersing metals in environmental systems (Agarwal, 2009, quoted by V. Dumitrescu, 2011).

Metal concentration can be correlated with hydrologic flow (Ciolpan, 2005, quoted by V. Dumitrescu, 2011). Hydrological processes that determine metal mobility are (Iordache, 2011, quoted by V. Dumitrescu, 2011):

1. leaching - the process is carried metal complexes soluble in the superior to the inferior metals are transported in aquifers

Table 1: Sources of pollution for eight common heavy metals (Agarwal, 2009, quoted by V. Dumitrescu, 2011)

Source	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn
Mining and processing of metal ores	✓	✓		✓		✓		✓
Metallurgy	✓	✓	✓	✓	✓	✓	✓	✓
Chemical industry	✓	✓	✓	✓	✓	✓		✓
Industry of alloys					✓			
Paint industry		✓	✓		✓			✓
Glass industry	✓				✓	✓		
Pulp industries and paper			✓	✓	✓	✓	✓	
Tanning of hides	✓		✓			✓		✓
Textile industry	✓	✓		✓	✓	✓	✓	✓
Chemical fertilizer industry	✓	✓	✓	✓	✓	✓	✓	✓
Cl-alkali industry	✓	✓	✓		✓	✓		✓
Petroleum refineries	✓	✓	✓	✓	✓	✓	✓	
Combustion coal	✓	✓	✓	✓	✓	✓		✓

2. leaks

a. surface - can carry metal complexes soluble in water or metal mass adsorbed to soil erosion

b. underground - metal mobility can occur from leaking underground aquifers fed by percolation

Figure 2 presents the main ways of transport of heavy metals in sources of ecological systems tanks.

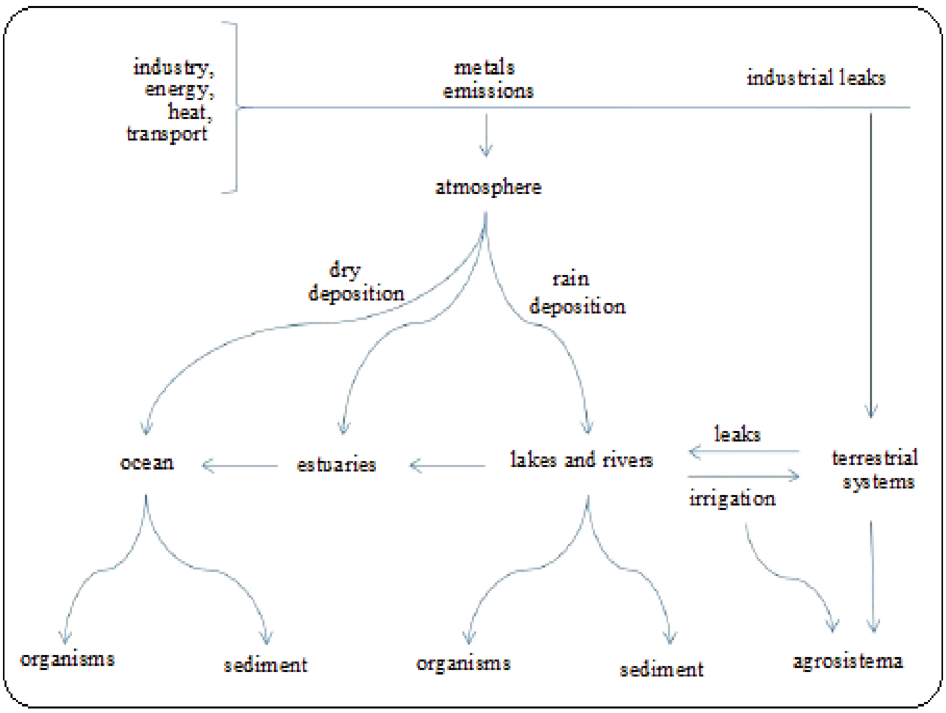


Figure 2 Dispersion of metals in the environment (adapted from Agarwal, 2009, quoted by V. Dumitrescu, 2011)

3 Ecotoxicity effects

Metals, in contrast to other contaminants that are used by organisms such micronutrients (e.g. Fe, Ca, Mg) as well as macro nutrients (e.g. Cu, Zn, Ni) (Fairbrother, 2007, cited V. Dumitrescu, 2011). Virtually any compound is toxic when it exceeds a certain threshold concentration may have disruptive effects on organisms. The degree of toxicity is quantified based on tests (Postolache, 2000, quoted by V. Dumitrescu, 2011).

If effects the heavy metal ecotoxicological are dependent on the time of action of the metal and acts in a very wide range of scales (from molecular level to complex ecosystems). Unfortunately, these effects are not directly proportional to the concentration of these metals, and for this reason are used as indicators of pollution (Iordache, 2009).

3.1. Effects at the individual

Toxicity due to high concentrations of metals exposure is difficult to understand and rarely quantified in the field (Fairbrother, 2007, quoted by V. Dumitrescu, 2011). The toxic effects of compounds dichotomy manifests depending on concentration and stress caused by toxic compound can be classified as (Postolache, 2000, quoted by V. Dumitrescu, 2011):

a. stress destructive;
b. physiological stress.

Stress is destructive specific lethal doses that result in death of the organism and physiological stress induces physiological abnormalities or loss of specific functions (Postolache, 2000, quoted by V. Dumitrescu, 2011).

Physiological stress is mainly caused by biochemical disturbances that occur at the molecular level. The metals may affect enzyme activity, alter the structure of the resulting DNA mutations reduce the fertility of the eggs (in fish), etc. (Iordache, 2009, quoted by V. Dumitrescu, 2011).

These biochemical changes can cause cellular and tissue effects. For example, biomass production is affected by the stress caused by lifting the metal concentrations.

In the case of plants the phenomenon of oxidative stress. A metal causes biochemical reactions cationic protein produced by moving centers, thereby disturbing or inhibiting enzyme activity. It is also possible to increase the concentration of highly reactive oxygen species (O_2, OH●, H_2O_2) leading to destruction of cell membranes, causing lipid peroxidation and apoptosis (programmed cell death in response to a particular gene signal) (Peralta, hollow 2009 Eraly, 2011, quoted by V. Dumitrescu, 2011). An example of a metal which promotes lipid peroxidation is Cu (Iordache, 2009, quoted by V. Dumitrescu, 2011).

Cadmium is considered one of the metals of ecotoxicological interest due to negative effects on the metabolism of plant and animal kingdom (Kabata-Pendias, 2001, quoted by V. Dumitrescu, 2011). Following toxicity tests demonstrated that nitrogen-fixing bacteria and crop toxicity grade was distributed according to the metals studied as follows:

Cd > Cu > Ni > Zn > Pb > Cr (Athar, 2001)

Phytotoxicity low for Cr and Pb was attributed to the fact that they are insoluble in most soil conditions (James and Bartlett, 1984, Athar, 2001, quoted by V. Dumitrescu, 2011), and increased toxicity of other metals is associated with their solubility in sol. In Figure 3 is shown the range of movement of the metal ions on the pH of the soil.

Heavy metals contamination of soils is often associated with low pH, and this helps to increase the acid content of fulvic acid that forms metal complexes bioavailability and highly mobile (Popa, 2005, cited Dumitrescu V., 2011).

If metals can be accumulated intracellular microorganisms associated with cell wall or immobilized extra-cellular mobilized by bacterial metabolic products or transformed and volatilized (Chen et al., 1995, Iordache, 2009, quoted by V. Dumitrescu, 2011).

Most heavy metals are mobilized in the food chain and affect both producers and consumers (Peralta, Videos, 2009, quoted by V. Dumitrescu, 2011). They are stored and sent them each level trophic relationships based on higher order consumers. For example, Cr is stored in vacuoles in plant oligochetae the digestive tract in the exoskeleton of crustaceans; Pb accumulates in the liver and bone in a mammal; Hg is fixed in the brain and liver etc. (Peralta, Videos, 2009, quoted by V. Dumitrescu, 2011).

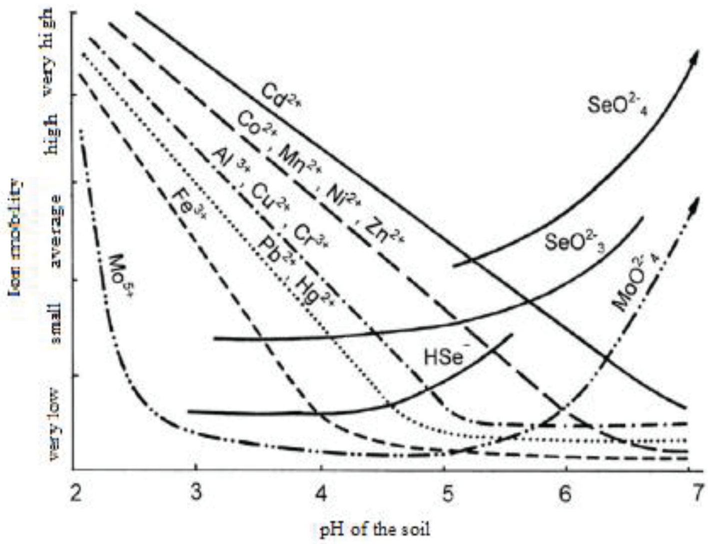


Figure 3 Mobility metal ions depending on the pH of the soil (Kabata-Pendias after 2001, quoted by V. Dumitrescu, 2011)

4 ENVIRONMENTAL RISK ASSESSMENTS

Environmental risk assessment is the process of estimating the consequences of integrated risk materializes, in combination with additional quantification of the probability of their occurrence and vulnerability to these risks.

Quantification of the three components of environmental risk assessment is to develop scales, which is associated numerical values. This assessment can be done in different ways, depending on the need for the decision maker, the ability to interpret and process awareness of the phenomenon or factor

Risk assessment is a systematic technique for organizing information and knowledge available on a level of scientific certainty, in conjunction with the data, models and assumptions necessary; technique is the facility to obtain objective conclusions on the risks, regardless of their nature.

The risk assessment was conducted in accordance with the "Order no. 184/1997 "on" Procedure for achieving environmental balance "and that the risk is the probability of an adverse effect in a specified time period.

Risks of accidents or damage which may impact on the environment and on population Brad mining area are: Outbreak of fire or explosion of explosives depot, leading to deterioration of the ecosystem in the area with harmful effects on environmental factors; Loss of stability dump; Loss of stability of the tailings Contamination of groundwater; Closure of mining in the area; Destruction of historic sites.

Risk quantification is based on a simple classification system where the probability and severity of an event is classified downward.

Classification probability	Classification of gravity
3 = high	3 = major
2 = average	2 = serious
1 = low	1 = aboard

The risk factor is calculated by multiplying the probability by a factor of gravity to obtain a comparative figure. This will allow comparisons between different risks. The result is higher, the higher the priority that will be given to controlling risk.

The main purpose of risk assessment is to help establish risk control. Risk assessment involves identifying hazards and then assesses the risk which they present, by examining the likelihood and severity of damage that may arise from such dangers.

Information on assessment of pollutants, are given in the form of a checklist or matrix. The values of degree at risk to environment components water, air and soil.

Activity taking place in the Brad is 60% dependent on the mining industry. Reduced activity in the mining industry today caused a shortage of jobs for local residents.

The quantifying a relationship between various economic, social, and cultural factors influence.

Is it possible that the defined ambient ERM exercise is necessary to carry out studies which aim to be tolerable.

Often, they appear constraints on time and resources needed for these studies.

Purpose and methods selected studies should consider addressing these constraints.

Even if the study is preliminary or final, he should always aim point.

To achieve the goal, studies must take into account particular aspects such as the interaction and interdependence between specific parts of the operations or the system to be studied and other parts of the same system and external systems. Limits will be set so that it can be taken into account these factors; the basic concern is chaining them in a flowchart.

✓ **Risk analysis**

The 5 elements of risk analysis processes are:

1 Understand and description

Stage of the analysis is the familiarity, knowledge of the system and its context and operational environment and its description.

The volume of work required of this stage is based on the approach of the staff and the level of detail required.

Familiarity with the process can be done by reconsidering documents, including drawings, maps, procedures, reports of previous studies and investigations documentation including Environmental Impact Assessment (EIA) and audit reports.

For the proposed and existing operations is essential to organize an inspection of the entire site.

System description should be thorough and complete, otherwise it is possible that all hazards are identified.

2 Hazards identification

Hazard identification should be a structured process to work systematically with the elements facilities or system being studied (as identified during familiarization / description).

For each element of the whole system or the system will be given particular attention: Possible initial events or circumstances; Consequences of these events or circumstances; Availability of technical, operational and organizational security and control; The probability of an event or circumstance; The probability of conversion in significant adverse outcomes, in terms of surveillance and control.

The hazard identification should include:

a) all aspects of the potential dangers that may affect the environment, including, but not limited to: Surface water and groundwater; Settlements; Forests, farmland, pastures, along with related animals and their crops; Soil (contamination, erosion, degradation); Geological structures;

b) All types of hazards, including fires, explosions, toxic or polluting materials, changes precipitation regime or water courses, introducing exotic plant or animal species or pathogen damage tailings.

c) The entire life cycle of the mine, including exploration and recovery (impact: acid mine water, tailings, may cause long-term);

d) All potentially affected area or system;

e) All relevant operations as defined;

f) Emissions continue, not just the accidental;

g) All types of causative factors, including natural factors;

h) Hazards charged and controversial issues;

i) Waste and the semi-products and mining materials and equipment used in operations associated.

A typical environmental hazard caused by mining operations is shown in the list below: Destruction of vegetation (loss of rare species or habitat); Effect of soil (erosion caused by wind, water, dust); Acidification of soil sulfur; Damage (explosions, dust and vibration); Crushed rocks / rock and sludge (instability, acid water and dust); Subsidence (impact on cultural relics and natural); Sterile radioactive; Potential toxic tailings (acid water, heavy metal ions, salts); Salts and other contaminants to waters from mining operations; Contamination of rainwater; Storage, handling and transportation of petroleum products or chemicals (spillage, fire, explosion); Effect of surface watercourses and groundwater; Storage and handling of explosives (explosion unintentional); The introduction of alien plants or animals or pathogens; Sources of ignition; Processing, storage, handling and transport of the mining and processing; Continuous emissions to air and water; Contaminants from activities associated (ponds, water storage tanks, pipes and conveyors); Safety inappropriate, sabotage, etc. (mechanical failure, human error, accidents, etc.).

This representative list is not exhaustive and can not be used as a checklist, as factors can change from one site to another.

In general hazard identification process can practice more entries. These should include: An inspection - type audit; Sessions meetings with relevant parties in the process of hazard identification; reconsideration of issues that concern the community of licenses and permits, the conditions to be complied with incidents, procedures and emergency maintenance, audits and previous studies.

3 Analysis of consequences

Consequence analysis includes both final results and the steps that led to these results.

For example, the effect of a storm on a pond, consequence analysis may cover: Consequences of the storm on the volume of water received TMF expansion possibilities spill and damage; Consequences of contaminants that can be released and their concentrations / duration receiving water after a leak or spill; The consequences of these concentrations / duration on the aquatic ecosystem.

For each element to consider several key issues. These may include the magnitude, extent, severity, duration, etc. For this part of the analysis is typical understanding of the effects of the initial event. Consequence analysis is always a mix of quality and quantity.

By their nature, risk analyzes are multidisciplinary. Disciplines that can contribute to these analyzes are construction engineering, chemistry, hydrology, geology, toxicology, ecology, ecotoxicology etc.

4 Analysis of probability

Analysis of probability means the probability of each step in the entire event. These probabilities include: The frequency of initiating event; Probabilities specific safety measures required; The probability that an event causing primary damage and cause significant damage, affecting safety; The probability that events coincide and cause each different problems; The probability of human error and appropriate and inappropriate responses; Probability of dangerous weather events; Calamities

✓ ***Quantifying risk indicators and weights***

Rigorous quantification of risk requires determining the probability of occurrence of damage causing uncontrolled loss of TMF content.

In Romania is used empirical risk assessment process developed (Stematiu, Constantinescu and Asman, 1998).

✓ ***Quantifying the consequences of breaking***

- Rapid and uncontrolled loss of the contents of a pond can have the following types of consequences:

- Fatalities (PVO);
- Effects on biological and physical environment (EM);
- Damage caused to third parties in the affected area (PMT);
- Damage of the Holder (PMD);
- Effects on Society Image (EI).

The risk analysis is sometimes used a global assessment of the extent and severity of the consequences, by assigning a value within 5 ... 10 steps stairs.

✓ ***Quantifying the likelihood of breaking events on tree***

The probability of fracture is determined from the summation of probabilities partial probabilistic tree adverse events related events. It starts from the base of the tree to the top. At each level the next higher probability of the event is given by: sum of the probabilities of events when they are independent and are connected by logical OR operator; the product of probabilities of events when they are conditioned and are linked by AND operator.

Typically risk measure is given by the annual rate risk and therefore is probable are annual probabilities of realization of events.

Quantification is conditional probability definition of primary events.

If contour dams on lowland ponds in assessing probabilities come as a separate item and length, guard, beach, sufficiency of drainage, slope downstream slope, geo-mechanical characteristics of the filler can be different from one section to another, in especially when the dam evolves with deposition.

Annual probability of such an event is determined from the relationship Initial:

$$P[dig] = 1- (P[segment])n \qquad (1)$$

Where:

n - is the ratio of breakwater length and segment length basis;

P [dig] - annual probability of occurrence of a primary event initiating the whole dam;

P [segment] - annual probability of occurrence of an event based Initial segment.

If the tailings pond upstream rises through the construction of dams on the beach the previous stage booster, core segment and report separately for each phase is treated separately booster.

As a general rule, bear in mind that judgment and then quantifying engineering are more properly applied as the primary events are better defined.

Classification system in Romania tailings categories of importance:

A - of exceptional importance;

B - of particular importance;

C - normal importance;

D - of minor importance.

Risk classification criterion is expressed by an index of risk associated with pond called RB.

The hazard is defined based on the general formulation.

$$RB = PC \times CA \qquad (2)$$

Where:

PC - annual probability of breaking

CA - consequences of breaking

Depending on the risk index to determine the category of importance as follows (NTLH-021):

RB > 0.8 - pond category;

0.8 – RB > 0,015 - pond B;

0,015 - RB> 0.05 - pond of category C;

RB - 0.05 - pond of category D.

The consequences of belonging to a certain category of importance.

Framing tailings dams and importance categories served in accordance with dam safety law (Law no.466 / 2001) to: determining the type of follow-up dams and tailings dams (special or current); prioritizing tailings dams and to establish assessment programs safe operating condition to their approval; establishing the list of high-risk dams; setting tasks of verification and control dams and tailings dams; establishing the obligations of owners of dams and other legal entities and individuals, the safe operation of these types of works and taking appropriate measures to reduce the risk.

5 CONCLUSIONS

In conclusion, the inputs of heavy metals in environmental systems are augmented by anthropogenic activities, resulting in the accumulation of metals in terrestrial and aquatic systems from biotic and abiotic processes of transport.

A major role of government is to promote law norms and standards in the field and control the observance of them in order to ensure sustainable development.

Environmental risk management is a component of all activities currently and any action presents a potential exposure.

In the application of environmental risk management is considered and layout optimization of resources in that business, which must have the effect of directly protecting the environment.

Environmental risk management include: the systematic application of policies, procedures and practices of hazard identification; anticipating hazards; Possible consequences of hazards; estimate risk levels (quantitative or qualitative); developing criteria for prioritizing risk levels based on objective criteria and relevant; decisions to minimize the risks identified.

Environmental risk management should be based on the principles of practice: creating a structure to deal with these issues; composition of a team working with appropriate training; cover all operations in their lifetime; Periodic risk assessments rigorous and comprehensive; integrating environmental risk management in other risk management systems; regular reassessment of risk management environment.

Environmental risk management should be applied to all phases of the mining cycle and mining operations all parties.

In accordance with generally accepted definition, risk is expressed as the product of the probability of an adverse event and the size of the consequences that appear when the event occurs. Consequences of breaking may be loss of human life, accidental pollution major ecological effects, human health and environmental damage, economic losses in the affected areas, cost recovery and rehabilitation of the tailings and the affected areas, damage to company image etc.

REFERENCE

[1]. **Audry, S., Grosbois, C., Bril, H., Schäfer, J., Kierczak, J., Blanc, G.,** 2010 - *Post-depositional redistribution of trace metals in reservoir sediments of mining/smelting-impacted watershed (the Lot River, SW France)*, Applied Geochemistry, 25: 778-794;

[2]. **Băbuţ, G., Moraru, R.,** 2010 - *Risk management programme for the mining industry*. Annals of the University of Petroşani – Mining Engineering, vol. 4 (XXVI), p. 106-113. Petroşani: UNIVERSITAS Pubblishing House,.

[3]. **Ciolpan, O.,** 2005 - *Integrated environmental monitoring systems*, Ars Docendi Publishing, Bucharest, p. 70-75;

[4]. **Cutter L.**, 2001 - *American hazardscapes. the regionalisation of hazards and disaster*. Washington: Joseph Henry Press. 211 p.

[5]. **Eraly, D., Hendrickx, F., Backeljau, T., Bervoets, L., Lens, L.,** 2011 - *Direct and indirect effects of metal stress on physiology and life history variation in field populations of a lycosid spider*, Ecotoxicology and Environmental Safety, doi: 10.1016 /j. ecoenv. 2011. 04. 014;

[6]. Jianu, D., Iordache, V., Soare, B, Petrescu, L., Neagoe, A., 2011 - *The Role of Mineralogy in Hazard Potential of Mining Areas*, in Kothe E, Varma A (Editor) Biogeointeractions in contaminated soils, Springer.
[7]. Popa, M., 2005 - *Modern methods and techniques for determining environmental pollution with heavy metals - Analysis and case studies in the Zlatna* House Book of Science, Cluj-Napoca, p. 11-20.
[8]. Postolache, C., Postolache, C., 2000 - *Introduction to Ecotoxicology* Publishing Ars Docendi Bucharest, p. 5-11, 20-40, 151-220;

Scientific Reviewers:
Prof. Ph.D. Eng. Romulus-Iosif SARBU

PRIOR ESTABLISHMENT OF WORK ENVIRONMENT CHARACTERISTICS IN CASE OF THE OCCURRENCE OF AN UNDERGROUND EXPLOSION

DORU CIOCLEA*
ION GHERGHE**
FLORIN RĂDOI**
CORNELIU BOANTĂ***
CRISTIAN TOMESCU**
MARIUS CORNEL ŞUVAR***
NICOLAE IOAN VLASIN***
VLAD MIHAI PĂSCULESCU**

Abstract: *Changes occurring after the development of an explosion-type phenomenon at the level of underground works or coal faces endanger the entire working staff and may lead to the occurrence of similar phenomena. The change of operational parameters of main ventilation fans after an explosion leads to a different post-event natural repartition of air flows at branch level and the underground atmosphere in the coal face changes leading to the increase of the potential risk of a new underground explosion occurrence. Prior establishment of post-event work environment is performed through simulations on a ventilation network using the Australian VENTSIM VISUAL ADVANCED software.*

Key words: *ventilation network, explosion, work environment, VENTSIM modelling software*

1. REGIME OF METHANE RELEASES FROM FRONT COALFACES

Methane release within a coalface is a complex phenomenon depending in value and intensity on a series of natural-geological and technological factors [2]. Of the geological factors there can be mentioned: gas content of the coal bed in exploitation and of the

* *Senior Researcher II Ph.D. Eng. - Head of Laboratory - Security Laboratory, mining and industrial ventilation, National Institute for Research and Development in Mine Safety and Protection to Explosion – INSEMEX Petrosani,* Doru.Cioclea@insemex.ro
** *Senior Researcher III PhD. Eng.- Security Laboratory, mining and industrial ventilation, National Institute for Research and Development in Mine Safety and Protection* to *Explosion – INSEMEX Petrosani,* Ion.Gherghe@insemex.ro, Florin.Rădoi@insemex.ro, Cristian.Tomescu@insemex.ro
*** *Senior Researcher Eng.- Security Laboratory, mining and industrial ventilation, National Institute for Research and Development in Mine Safety and Protection* to *Explosion – INSEMEX Petrosani,* Corneliu.Boanta@insemex.ro

surrounding rocks, presence of accompanying coal beds, physico-mechanical properties of coal and surrounding rocks, geometric parameters of coal beds, tectonics of the deposit, exploitation depth etc., and of the technological exploitation factors there is highlighted the applied exploitation method, volume of achieved production, advancing speed of the coalface, direction of exploitation, manner of directing the surrounding rocks pressure.

Methane releases generally have an uniform character, however existing situations in which methane concentrations increase sharply up to values higher than average values, sometimes exceeding the values allowed by the OHSR. These sharp increases are due to several causes, the most frequent ones being disturbances within the general and partial ventilation and methane migration from the goaf.

1.1 Regime of methane releases from front coalfaces

Repartition of methane concentrations in the goaf depends on the advancing manner of the coalface and of their ventilation manner, presented in Fig 1. a) and b).

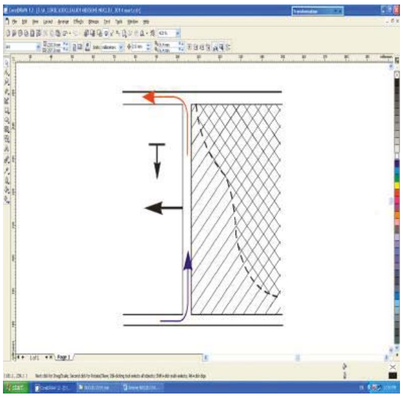


Fig. 1. a) Retreating coalface with U type ventilation

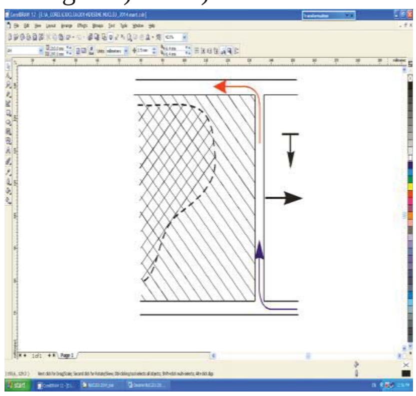


Fig. 1. b) Retreating coalface with Z type ventilation

In exploitation methods with long poles on the direction, methane arising from the goaf has a smaller share within the total methane balance of the coalface.

This is due to initial degassing of the coal bed following the shaping of the exploitation pole through preparation workings and due to a higher aerodynamic resistance of the goaf generated by the compaction of rocks as results of the mining pressure redistribution. The compaction process of rocks within the goaf ends at a distance of 80-100 m behind the edge of the coalface (Fig.2). At this distance, the movement of rocks from the roof and their fissuring decreases, having as a result the decrease of goaf permeability level, fact which hinders the migration of methane.

1.2 Regime of methane releases from undermined coalfaces

The undermined coal bed exploitation method has several characteristics related to methane releases, as follows:

- methane release arises both from the coal bed in exploitation (basic release), as well as from surrounding coal beds from the roof an floor of the one in exploitation (additional release);

- rocks movements occurring during the operation of the coalface generate crushing or shearing phenomena which have as effect the change of coal structure, releasing adsorbed and absorbed gas.

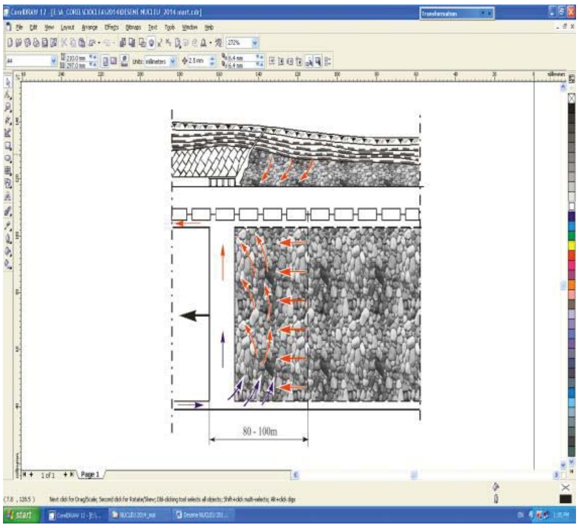


Fig. 2 Methane migration through goafs

Depending of the production extracted from the coalface during its' exploitation, gas emission rises up to the double of the initial value. Due to the fact that the width of the undermined coal bed is high, the height of the crushed and fractured area increases, case in which the methane emission from neighbouring coal beds increases significantly. Gas accumulation takes place in the upper part of the supporting and nearby the coal discharge window, so that the concentration of methane may reach 3-5 % vol. and sometimes even 25-85% vol.

Another factor which has to be taken into account for the actual appreciation of gas-dynamic regime is represented by the methane concentration within the air exhaust current, depending on time Fig. 3.

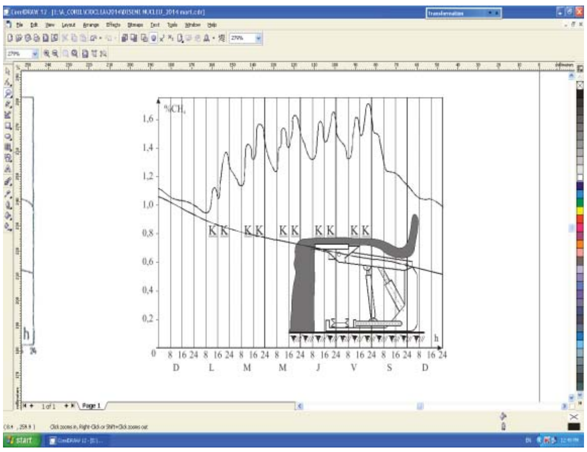


Fig. 3 Variation of methane concentration from a coalface depending in time; K – productive activity

2. WORK ENVIRONMENT CHANGES ESTABLISHMENT

In normal energetic coal exploitation in underground occur different types of gases in variable concentrations in the work environment. The most representative and the most hazardous for work staff are methane, carbon monoxide and carbon dioxide.

Larger quantities of gas are usually releases in active coalfaces during technological processes and during coal spontaneous combustion processes.

2.1 Establishing gas concentrations before the event

In order to establish gas concentrations at the level of a coal face, there are performed specific measurements during a one week period. Maximum concentration is recorded during actual exploitation works, and minimum values are registered during the resting period at the end of the week.

After the occurrence of an explosion type phenomenon, the level of air concentrations is close or identically to the one registered in the resting period of the week.

2.2 Establishing gas concentrations after the event

Q_1 circulated air flow at the level of the coalface is considered, then:

$$Q_1 = \frac{q_a \cdot 100}{c_1}, \ (m^3/min) \qquad (1)$$

in which:

q_a – absolute gas flow (methane or carbon dioxide) specific to the coalface (m^3/min);

c_1 – average concentration of methane or carbon dioxide during rest days from the end of the week (%);

After the event, the circulated air flow at the level of the coalface is Q_2, obtained by simulation using VENTSIM VISUAL ADVANCED software (m^3/min).

$$Q_2 = \frac{q_a \cdot 100}{c_x}, \ (m^3/min) \qquad (2)$$

in which:

q_a - absolute gas flow (methane or carbon dioxide) specific to the coalface (m^3/min);

c_x – average concentration of methane or carbon dioxide after the event (%);

There can be written the following relation:

$$c_x c_1 \qquad (\%) \qquad (3)$$

3. ESTABLISHING THE CHANGES IN THE WORK ENVIRONMENT AFTER THE OCCURRENCE OF AN UNDERGROUND EXPLOSION

Relevant for establishing the work environment after the occurrence of an explosion are information regarding the change of gas concentrations (CO_2, CH_4, CO) and of air flow [1], [3], [4], [5], [6], [7].

In this regard, for establishing environmental conditions after the occurrence of an explosion there is required to perform several steps:

- Simulation of explosive and or toxic gas dispersion, in normal exploitation conditions;
- Establishing the structure of the ventilation network after the occurrence of an explosion;
- Simulation of explosive or toxic gas dispersion after the occurrence of an explosion.

3.1 Simulation of explosive and or toxic gas dispersion, in normal exploitation conditions

For performing simulations, there must be chosen a ventilation network, in this case Vulcan mining unit ventilation network, and it has to be modelled and solved using a specialized software such as CANVENT 3D, VENTSIM Visual Advanced, VENTPRI, etc.

For carrying out the simulation in order to establish explosive or toxic gas dispersion, the following steps have to be performed:

- Simulation of CH_4 dispersion at ventilation network level;
- Simulation of CO_2 dispersion at ventilation network level;
- Simulation of CO dispersion at ventilation network level.

3.2 Simulation of CH_4 dispersion at ventilation network level

For achieving required simulations, VENTSIM Visual Advanced software has been used Fig.4, Fig.5, Fig.6.

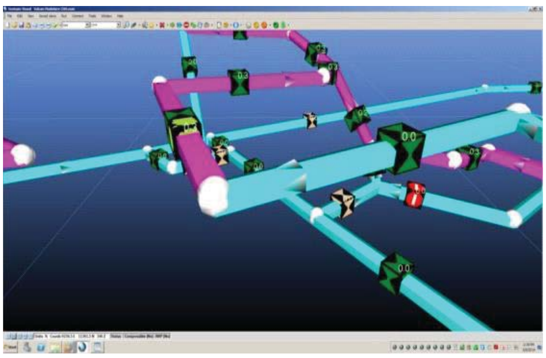


Fig. 4 Simulation of CH_4 dispersion at ventilation network level

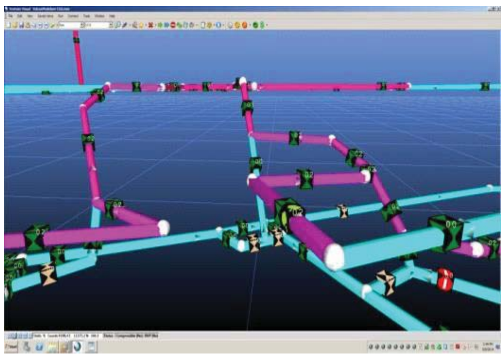


Fig. 5 Simulation of CO_2 dispersion at ventilation network level

Results of the dispersion of methane, carbon dioxide and carbon monoxide in normal exploitation conditions are the following:

- CH_4 presence in coalfaces, having an average concentration of 0.3% vol.;
- CO_2 presence in coalfaces, having average concentrations of 0.2 – 0.6 % vol.;
- CO presence in one coalface, having an average concentration of 220 ppm.

3.3 Establishing the structure of the ventilation network after the occurrence of an explosion

In order to establish the structure of the ventilation network after the occurrence of an explosion, the following steps shall be performed:

- Establishing the influence of the explosion type phenomenon upon the ventilation network;
- Ventilation network solving with regard to the changes produced by the explosion.

3.4 Simulation of explosive or toxic gas dispersion after the occurrence of an explosion

For achieving the simulation in order to establish the dispersion of explosive and or toxic gases after the occurrence of an explosion type phenomenon, the following steps shall be performed:

- Simulation of CH_4 dispersion at ventilation network level;
- Simulation of CO_2 dispersion at ventilation network level;
- Simulation of CO dispersion at ventilation network level;

Change in ventilation network structure brings along the change of airflows at branch level and as a consequence occur major changes of gas concentrations in areas of influence: Fig. 7, Fig. 8, Fig. 9.

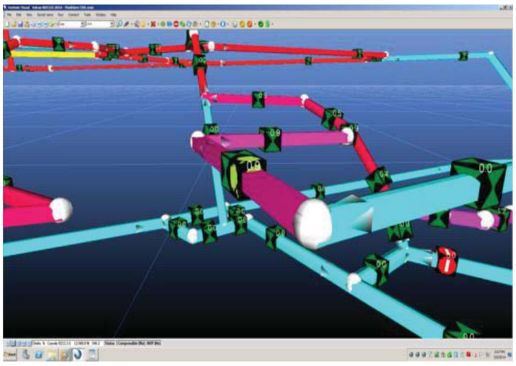


Fig. 7 Simulation of CH_4 dispersion at ventilation network level

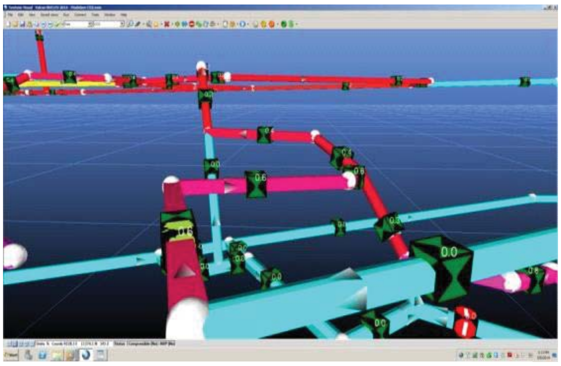


Fig. 8 Simulation of CO_2 dispersion at ventilation network level

Results on the dispersion of methane, carbon dioxide and carbon monoxide after the occurrence of an explosion are presented below:

- CH_4 presence in coalfaces, having average concentrations of 0.3%-1.2% vol.;
- CO_2 presence in coalfaces, having average concentrations of 0.2 – 1.1 % vol.;
- CO presence in one coalface, having an average concentration of 416.8 ppm.

4. CONCLUSIONS

- Methane release within a coalface is a complex phenomenon depending in value and intensity on a series of natural-geological and technological factors

- For establishing the concentrations of methane, carbon dioxide and carbon monoxide after the event, the absolute gas flow method has been used.

- In order to identify the environmental conditions after the occurrence of an explosion, the following steps shall be performed:

- Simulation of explosive and or toxic gas dispersion, in normal exploitation conditions;

- Establishing the structure of the ventilation network after the occurrence of an explosion;
- Simulation of explosive or toxic gas dispersion after the occurrence of an explosion.

- In order to establish the explosive or toxic gas dispersion, in normal exploitation conditions or after the occurrence of an explosion, there have to be performed the following simulations at the level of Vulcan mining unit ventilation network:

- Simulation of CH_4 dispersion;
- Simulation of CO_2 dispersion;
- Simulation of CO dispersion.

REFERENCES

[1]. Cioclea, D., *Methodology for establishing changes in the underground work environment after the occurrence of an explosion, in order to protect the workers*, (in Romanian), INSEMEX Research Study, 2014.

[2]. Crăciunescu I., *Establishing the methane balance in coalfaces with mechanized cutting of coal and development of technical solutions for preventing and fighting against methane accumulations*, (in Romanian), CCSM Petroșani Research Study, 1984.

[3]. Gherghe, I., *Raţionalizarea reţelelor de aeraj ale minelor din Valea Jiului în condiţiile restructurării acestora ca urmare a închiderii unor zone inactive*, (in Romanian), INSEMEX Research Study, 2004.

[4]. Patterson A. M., *The Mine Ventilation Practitioner's DATA BOOK*, M.V.S. of South Africa 1992.

[5] Teodorescu, C., Gontean, Z., Neag, I., *Mining Ventilation*, (in Romanian), Technical Publishing house Bucharest, 1980.

[6]. VENTSIM VISUAL ADVANCED – *User Manual*

[7]. Le Roux - *Notes on Mine environmental control*, The MVS of South Africa 1990.

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

ENSURING THE SAFETY AND PRESERVATION OF THE HEALTH OF THE WORKERS BY THE USE OF PERSONAL PROTECTIVE EQUIPMENT (PPE) IN THE MINING INDUSTRY

NICOLETA CRĂCIUN*

Abstract: *Being a multidisciplinary industry, the mining is based on many professions and occupations in which workers are exposed to various risks of specific activities they carry out. Given the risks to which they are exposed, the article aims to address the proper importance in selecting and using appropriate personal protective equipment to ensure the health and safety of workers.*

Keywords*: mine, dangers, protection, personal protective equipment*

1. INTRODUCTION

From ancient times, the mining industry in Romania has provided a wide range of mineral products such as coal, oil shale, salt, ferrous, non-ferrous, aluminum and aluminous rocks, noble metals, radioactive, rare earth, precious and semiprecious stones, peat, used as is or as raw materials, paving the way to civilization, actively supporting the economic development of the country.

Even the Romanian economy is restructuring and diminished the overall consumption of resources, latest statistical surveys show that in Romania there are currently 14 mining areas, being considered the seventh country in the European Union (EU) according to the value added created by mining and quarrying and second in terms of labor working in this sector.

Traditionally classified in surface mining and underground, mining is a multi-disciplinary industry based on many professions and occupations in which workers are exposed to various hazards specific to the activities they carry out. Thus, in the activities related to:

• geodesy / topography of the land, workers are exposed to hazards due to the presence of land / soil uneven and / or slippery, jobs at height, objects falling from height, stored energy that can be released quickly and can cause injury (e.g. shock by dropping off vehicles) harmful energy sources such as powerful optical radiation (solar); ambient conditions which can cause hypothermia or heat stress;

• cleansing the land to site preparation - activity which includes cutting down the trees, demolition of the buildings and removal of the upper layers of soil - main hazards related are cut falling trees hitting workers, hitting pieces of material resulting from the demolition of

* *Scientific Researcher III, The National Research and Development Institute of Occupational Safety (INCDPM) - "Alexandru Darabont"*

buildings, damaging energy sources such as strong optical radiation (solar), the electricity, the strong noise, the vibration, the temperature conditions from environment which can lead to hypothermia or stress due to the heat, fire and explosions, burns from the contact with equipment or objects with very high or very low temperature, manual handling, sources of sharp objects, sharp, rough (work equipment, work object) which parts of the body may come into contact; repetitive work; inadequate workspace; ergonomics unadvised;

- Construction of roads and buildings - the dangers are due to the presence of overhead electricity, working at heights and various machinery in motion;
- For drilling the main hazards are those related to:
  - the working at height when workers are at the risk of falling over the edge of the drill,
  - the presence of hazardous chemicals used at work or degradation of hazardous chemicals apparently by improper storage, contact between incompatible substances, accidental ignition, inhalation of vapors, gases or aggressive/caustic or toxic particles, contact with vapors, gases or aggressive/caustic or toxic particles, ingestion of vapors, gases or aggressive/caustic or toxic particles;
  - presence of dust created during drilling operations,
  - noise,
  - involvement or hit by a moving part of the drilling equipment.

If in the surface mining hazards are easily identified, for underground mining things are complicated by the emergence of new risk factors such as:

- working in enclosed space,
- danger due to low oxygen content and the presence of gas accumulations in mine (natural gas or carbon dioxide) which are potentially explosive;
- work orientation in space, which can be horizontal - gallery, stope, inclined - inclined plane, rolling, vertical or highly inclined - pit, upward way (works on very inclined lower section, which provides communication between the two levels).

Since mining is a sector where workers are exposed to various risks (work in enclosed spaces, lack of oxygen, soil instability and layers, explosions, floods, the presence of dust and other gases, etc..) and improper architectural and organizational solutions and or poor planning work can negatively impact human, financial and economic level, over time has been granted attention to measures that prevents and maintains health and safety of workers. Thus, improving the safety and health of the workers at work it is not only important to cut human suffering of workers, but also a way to ensure the success and sustainability of businesses by a better development of economic for long-term.

On the national scale the law that establishes measures to promote improvements in the safety and health of workers is Law no. 319/2006 - Occupational Safety and Health (national transposing the Framework Directive 89/391/CEE). This establishes that the risk assessment in the workplace, which means identifying all hazards acting together and /or cumulatively, while imposing and implementing a policy for the risk management at work and adopting decisions regarding protective measures to be taken including, if appropriate, the protective equipment to be used.

Personal protective equipment (here in after abbreviated as PPE) should be the last measure of protection, which applies only where a risk assessment has demonstrated that the use of other, safer work equipment or workplace reorganization to eliminate the risk is not possible and the work can be performed safely only by using PPE. According to Article 3 (1) of

HG 1048/2006 "The PPE shall mean any device designed to be worn or held by the worker to protect against one or more risks which could endanger the safety and health at work and any additional item or accessory designed for this purpose. "

Considering the potential risks of mining to the workers, the proper PPE selection and use of them has a particular importance in ensuring the health and safety of workers. However, selection of the appropriate PPE to ensure a high level of protection against the existing risks at the work are done only after making a proper assessment, considering:

a) the analyzing and assessing the risks that can not be avoided by using the other means;

b) the defining of the characteristics required to personal protective equipment to be effective where it provide protection against the risks considering any risks that the equipment itself may create;

c) comparing the characteristics of the personal protective equipment available with the characteristics of the workplace."[5]

d) the presence of conformity mark "CE" accompanied by the standard / standards whose requirements it meets (being used to protect the health and safety of workers at work, designing, manufacturing and marketing of a PPE are regulated by Directive EU 89/686/EEC (implemented at national level by HG 115/2004 with subsequent amendments).

Because the directive/HG defines only the basic requirements to be met by personal protective equipment in order to present a proof of compliance with these basic requirements, it is essential to use the harmonized European standards, which gives to these products a presumption of conformity with the referred essential requirements.

Also, a special attention should be given to indoor jobs where the gases, dusts, vapors of flammable liquid or powders, mixed with the air or other oxidizing agent could be ignited by static electricity. The ease with which they can be ignited depends by a number of factors such as dissolved oxygen, temperature and pressure. Sources of potential ignition include electrical discharge generated by static electricity present in people, clothing, used equipment, materials, produced or processed products.

The risk associated with the electrostatic discharge arising from the PPE depends by the presence and sensitivity to ignition of explosive atmospheres. For the air containing hydrocarbons the range is between about 1% and 15% by volume. Combustible substances, for example, hydrogen, acetylene and carbon disulfide, are particularly dangerous. Electrostatic charges may be produced by rubbing two parts of the same EIP (friction between sleeve and clothes, rubbing one leg of the other) or friction between two PPE (friction between clothes and PPE used to protect against falls from height).

2. PERSONAL PROTECTIVE EQUIPMENT THAT CAN BE USED IN MINING

Starting from the existing main risks at the work further will be presented the types of PPE that can be selected to provide protection of workers in the mining sector considering the hazards present in the workplace and the anatomical area exposed to the risk of injury.

a. Head protectors

PPE designed specifically to protect the top of your head against the risk of injury by falling objects are helmets.

Selection of appropriate helmet is made only after evaluating the risks from work, considering:

- the nature and the intensity of the risk (injury of scalp by hitting his head against hard objects; injury with objects falling from above (vertical direction), medium risk (general) injury from objects that are thrown (in the vertical direction, only to the head and side of body) - high risk level; injury from impact with hard objects during specific activities;
- Environmental conditions;
- The existence of additional risks (risk of electrocution);
- Other complementary risks (molten metal thrown, radiant heat, compression, in case of entering to tight spaces).

So, when in the workplace there are hazards:

- mechanical (falling objects, shocks, lateral crushing, bolts mounting), thermal (splashes of molten metal) and electrical for a maximum power voltage of 440 V, helmets are used with features (such as shock absorbing capacity , puncture resistance, lateral rigidity, flame resistance, electrical insulation) that meet the requirements of EN 397:2012+A1:2012 - "Industrial safety helmets" and EN 14052:2012+A1:2012 - "High performance industrial helmets ";
- Electric (work on or near the energized systems up to 1000V AC or 1500 V DC) using helmets that prevents the passage of dangerous electrical current through the body when used with other electrical PPE. Helmets must meet both electrical requirements of EN 397:2012+A1:2012 and EN 14052:2012+A1:2012 regarding the ability of shock absorption, puncture resistance, lateral rigidity and related features mentioned for electrical resistance in EN 50365:2002- " Electrically insulating helmets for use on low voltage installations").

To increase visibility, color for helmets can be chosen depending by the day time of the activities so signaling colors which enhance the visibility during the day are fluorescent red, fluorescent yellow and fluorescent orange-red; for night time, helmet visibility can be increased when applying beam headlight using retro reflective tape.

Regarding underground mining in mines susceptible to firedamp can be used industrial helmets and high performance helmets for industry since for normal use they are not subject to friction, so it cannot be loaded with the electric charges to generate an explosion. Therefore, in workplaces with potentially explosive atmospheres helmet was planned to not be removed from the head because rubbing the hair electrostatic discharge can generate an explosion.

b. Eye and face protectors

Whenever there are risk of injury to the eyes and face by shock characterized by varying degrees of severity (flying objects or particles), optical radiation, splashes of molten metal and hot solids, liquid chemical splashes, dust, gas, electric arc from short-circuit, or from any combination of these risks, there are used PPE for eye and face protection such as safety glasses with or without side shields, goggles, visors / face shields of different sizes with or without filters for welding.

Thus, during cutting operations, grinding, cutting, masonry works, drilling, chiseling, riveting, grinding, depending by the energy of impact flying objects or particles (determined in the step for risk assessment) may be used:

- Glasses with arms, goggles, face shield - when the impact energy is low (F);
- Goggles, face shield - when the impact energy is medium (B);
- Face shields - when the impact energy is high (A);

Protectors intended to provide protection against molten metal and hot solids are mask-glasses or face shield; mask-glasses and facial displays are designed to provide protection against optical radiation and must provide at least the same level of protection against optical radiation as that conferred by a filter for ultraviolet, infrared or solar. Protectors intended to protect against drops and liquid splashes are mask-glasses (to protect against drops) or face shield (to protect against liquid splashes); Eye protection against short-circuit arc is only provided by face shields, whose metal parts must be covered.

PPE of face and eye provides adequate protection if it has CE marking and the number of standard whose requirements are fulfilled:

- EN 166: 2001 „Personal eye-protection - Specifications“
- EN 14458:2004 “ Personal eye-equipment - Faceshields and visors for use by firefighters' and high performance industrial safety helmets used by firefighters, ambulance and emergency services“ and one of the following standards specific to protection filters:
- EN 169:2002 „Personal eye-protection - Filters for welding and related techniques - Transmittance requirements and recommended use”,
- EN 170:2002“ Personal eye-protection - Ultraviolet filters - Transmittance requirements and recommended use”,
- EN 171:2002 “ Personal eye-protection - Infrared filters - Transmittance requirements and recommended use”,
- EN 175:1997 “ Personal protection - Equipment for eye and face protection during welding and allied processes”,
- EN 379:2003+A1:2009 „Personal eye-protection - Automatic welding filters”,
- Personal eye protection - Mesh eye and face protectors “Personal eye protection - Mesh eye and face protectors”.

In areas where there is danger of explosion, must be eliminated any action to PPE (cleaning finder, remove EIP) due to friction that could lead to a static loading, unloading could cause an explosion.

c. Hearing protectors

When the risk assessment found that workers may be exposed to a noise level that exceeds 85 dB (A), it is mandatory to provide them PPE against noise. To ensure adequate protection, users should consider the noise frequency in the workplace and the level of exposure to the noise. Protection against noise can be achieved by earplugs (which are inserted directly into the ear, usually disposable), earmuffs - (shells, earmuffs) mounted on flexible mountings or spring, which can be installed directly on the head, ear mounted on a helmet, industrial helmet soundproofed.

For ear muffs mounted on helmet attenuation is different from a helmet to another and therefore such PPE should be used only with those specified by the manufacturer industrial headphones and not other models. We must also consider the fact that any antiphon reduce any sound and affect language communication. Jobs where this would lead to increased risks for workers, it may be necessary to use level-dependent attenuation earplugs or audio communication.

In areas where there is danger of explosion (underground mining), earplugs that fit inside the ear are too small to be considered an electrostatic hazard and there are not required precautions against static electricity. However for ear muffs clamping plate must be made of an insulating material whose maximum size depends on the ability of gases and vapors ignition (expressed by representative groups I, IIA, IIB, IIC (IEC 60079 - 20-1)), or dust representative group III (IEC 60079-0) and the classification of the hazardous area.

d. Respiratory protectors

Due to their work in the mining sector workers are frequently exposed to the risk of occupational disease because of the presence of different powders or lack of oxygen in the workplace.

Respirators are generally used only for short periods of time (limited duration); they are not intended to replace possible technical solutions.

Since absorption of harmful substances in the body can lead to lung disease (pneumoconiosis , silicosis , etc.) because of the inhalation the coal dust and other particulates present in the work environment, in addition to proper ventilation , the main measure for personal protective existing for workers against dust in the workplace is the use of half masks for particles filtering (FFP1, FFP2 and FFP3) according to EN 149:2001+A1:2009 „Respiratory protective devices - Filtering half masks to protect against particles - Requirements, testing, marking”. In their selection should be considered both the particle size and the characteristics of clogging for the filter, following in the same time manufacturer’s instructions.

If Gassy mines, where the danger of explosion is imminent it is necessary to equip workers with respiratory protective equipment independent with closed circuit, with oxygen chemically generated , according to EN 13794:2002 “EN 13794:2002 Respiratory protective devices - Self-contained closed-circuit breathing apparatus for escape - Requirements, testing, marking”.

e. Hand protectors

If the risk assessment will prove that during activities at the workstation hands of the workers may be exposed to various risks due to rough handling objects with sharp edges, sharp, hot, handling chemical containers, welding operations, activities at low temperature activities in electrical installations, activities in areas with potentially explosive atmosphere, causing the risk of injury must be given suitable protective gloves. When selecting gloves should consider both the specific activities of the workstation and the work environment. Thus, the use of rotary work equipment (drills, screw machine powered) protective gloves should be selected to have a low resistance to tearing, thus preventing the risk of injury as a result of catching the glove by machine parts moving.

When work is carried out in potentially explosive areas, gloves must be selected to provide also protection against the electrostatic discharge. Gloves designed to be worn in such areas should be made of conductive or dissipative materials. The use of such gloves is only effective when the carrier is connected to ground through a low resistance of $10^8\ \Omega$ (e.g., by wearing the proper shoes such as safety shoes that meet the requirements of EN ISO 20345:2011 „Personal protective equipment - Safety footwear (ISO 20345:2011)” and protective clothing to satisfy the requirements of EN 1149-5:2008 „Protective clothing - Electrostatic properties - Part 5: Material performance and design requirements”. Uses of gloves made of insulating materials are not recommended in areas with potentially explosive atmosphere because they do not allow dissipation of electrostatic charges accumulated through handheld objects.

f. Leg protectors

Personal protective equipment designed to protect the feet against risks in the mining industry is security footwear. Considering the existing risk factors in the workplace the recommended safety shoes are made entirely of rubber or polymer fully equipped with insertion for antiperforation with different electrical properties, due to their specific hazards. Thus, when handling explosives and an electrical shock hazard of a voltage equipment has been removed, is recommended as soon as possible the use of conductive footwear (whose resistance is 100 kΩ) whose role is to minimize accumulation of electrostatic charge.

If gassy mines, antistatic footwear is recommended in conjunction with conductive or dissipative flooring as a means of dissipating static electricity of the user , thus avoiding the risk of ignition of vapors or flammable substances. In general, resistance to earth through antistatic footwear and conductive flooring should be between 100 kΩ and 1000 MΩ, and if shoes will not provide user properly grounded should be used additional devices (bracelets grounded).

Whenever there is a risk of electric shock from involuntarily contact with damaged electrical the insulated footwear is recommended.

g. Protective clothing

Personal protective equipment that covers or replaces personal clothing is designed to protect against one or more hazards considering the anticipated duration of use, environmental conditions, user movements and positions during his work or when he engage in other activity. Because miners can be exposed to explosion, selected clothing must be both dissipative electrostatic (to satisfy the requirements of EN 1149-5:2008) and must provide protection against heat and flame (to satisfy the requirements of EN ISO 11612:2008 „Protective clothing - Clothing to protect against heat and flame (ISO 11612:2008)") and has to be able to signal the user's visual presence to be easy detected in dangerous conditions (to meet the requirements of EN ISO 20471:2013 „High visibility clothing - Test methods and requirements (ISO 20471:2013, Corrected version 2013-06-01)").

h. PPE for working at height

PPE for work at height is used:

- every time when working at a height greater than 2 m, measured from the worker feet to the ground (base) or any other artificial baseline, base to which there is a danger of falling into the gap and

- a risk assessment has demonstrated that the work can be performed as safely as possible during the use of PPE and using other equipment is not possible to be safer and worker and a sufficient number of available workers have received adequate training specific to the operations envisaged, including rescue procedures.

Proper selection of PPE for work at height involves both a wide range of criteria that must be considered to ensure the highest degree of safety for worker, as well as theoretical and practical training of users.

PPE for work at height is used in both surface mining during maintenance of heavy transport vehicles such as loaders, trucks, etc., as well as underground mining.

Depending on your workplace systems can be used to limit the fall (consisting of waist belt / complex + connection pieces + contact mode + anchorage point) or to fall arrest systems (consisting of safety harness + connection piece + sliding fall arrester on flexible anchorage line + anchorage point).

If gassy mines, personal protective equipment exposed to shock of, namely those which are likely to be subjected to impact during use (fall stop) should not be made of aluminum, magnesium , titanium or other alloys contain quantities of these materials where in case of shock the friction could spark and is likely to ignite combustible gas mixtures.

REFERENCES

[1]. Document CEN/TC 161 N 797 - *Selection, use, care and maintenance of personal protective equipment for preventing electrostatic risks in hazardous areas (explosive atmospheres)*.

[2]. Dr. eng. Virginia Henţulescu, drd. eng. Florentina Poruschi, dr. eng. Dobrescu Emilia, eng. Nicoleta Crăciun, *Application Guide Government Decision no. 1048 / 09.08.2006 concerning the minimum safety and health for the use of personal protective equipment at work, http://www.inpm.ro/files/publicatii/2013-05.02-ghid.pdf , 2013*.

[3]. IEC 60079-32-1/TS/Ed1: Explosive atmospheres **-** Part 32-1: Electrostatic hazards, Guidance .

[4]. *Guidance for carrying out risk assessment at surface mining operations - http://www.hse.gov.uk/quarries/q-risk.pdf* .

[5]. *Government Decision nr. 1048 of 9 august 2006.*

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

MINE RESCUE TRAINING IN UNITED STATES OF AMERICA AND ROMANIA

CRISTIAN COSTA*
CRISTIAN ILIONI*

Abstract: *In our paper we have presented the rescue training facilities from United States of America and Romania. For the 170 underground United States coal mine there are many rescue teams registered in the United States. There are thirteen facilities that focus on mine rescue training, offer some real-life training activities or have a unique training feature that could enhance current coal mine rescue training. Highly specialized and all-inclusive training centres exist in countries where mining is an important economic activity, South Africa, Australia, China, India, United Kingdom, Germany and Eastern Europe (Russia, Poland and the Ukraine). In Romania, the mining activity develops within 5 companies and 2 national society that have under their subordination several mine branches and mining units with rescue stations. Accordingly, there exists 11 first range rescue stations, 7 second range rescue stations and 26 third range rescue stations, with 800 rescuers, 35 personnel involved in control operations and 55 mechanics for the maintenance of the rescue apparatus.*

Key words: *mine rescue training, rescue station, rescue facility*

1. INTRODUCTION

When lives are in danger, mine emergency response systems must function rapidly and competently. The hierarchy of response actions begins with self-escape and then first responders and/or fire brigades and finally mine rescue teams. If there is a breakdown in self-escape and first responders are not successful, then the deployment of mine rescue teams, under control of incident command centers, is necessary for a safe rescue to be accomplished. Emergency situations requiring mine rescue teams are high-consequence, low-probability events. Although the mining industry's goal has always been to reduce this probability with advanced technology, coal mine legislation and proactive injury prevention techniques, the probability may never be reduced to zero at every coal mine. Therefore, to minimize risk, it is essential that these teams and incident command staff are fully equipped with state-of-the-art technology, are professionally trained at keeping team safety as the number-one priority and receive guidance from only the best available mine emergency response experts.

The Mine Safety and Health Administration (MSHA) developed the Mine Emergency Response Development Drill (MERD) program to improve command center performance during mine emergency situations [Mott and Snyder, 1993]. In the 1990s, MERD exercises were conducted frequently at MSHA's Mine Simulation Lab, as well as offered by coal companies and state mining agencies. They most often included the participation of mine rescue

∗ *PhD. Eng. Student – Assistant Professor - University of Petroșani*

team members, but over the years, these MERDs have become less frequent. However, this powerful training tool is starting to gain popularity once again, with more MERDs being scheduled for 2009 and 2010. The National Institute for Occupational Safety and Health (NIOSH) has also developed, over the past 10 years, some effective methods of simulated emergency response training that have received positive responses from mine rescue and fire brigade team members. However, these exercises require mine-like environments to be effective [Conti et al., 1998].

2. COAL MINE RESCUE TRAINING FACILITIES IN UNITED STATES

S.B. Bealko, D.W. Alexander and L.L. Chasko from the National Institute for Occupational Safety and Health, Pittsburgh, Pennsylvania, and R.L. Grayson from Pennsylvania State University, State College, Pennsylvania made a review of the most important US rescue training facilities. In their 2009 year paper called "Mine rescue training facility inventory – compendium of ideas to improve" they have presented the most important thirteen facilities that focus on mine rescue training. There are in US mine rescue stations for the 170 underground coal mine rescue teams registered in the United States (Mine Safety Technology and Training Commission, 2006). There are thirteen facilities that focus on mine rescue training, offer some real-life training activities or have a unique training feature that could enhance current coal mine rescue training (as of December 2008). There are some academic and government facilities that primarily service metal/nonmetal mine rescue teams, including the New Mexico Tech's Waldo Mine, University of Arizona's San Xavier Mine and the Waste Isolation Pilot Plant in Nevada. Finally, a few coal companies have built their own facilities in active or idle mines or buildings.

Only eight of twelve (67%) training facilities are readily-available public facilities; the others are either exclusively for government or academic research or are privately-owned resources. This shortage of local facilities causes many teams to travel long distances, which consumes valuable training time and resources. Furthermore, teams might not even be able to receive training at the closer facilities, because of limited availably in the facility schedule.

Table 1 show whether or not eleven selected features and training capabilities are provided at each investigated facility. For training centers that are in a planning or construction phase, expected start dates are given. Table 1 shows also that out of the eight public facilities, four of them are currently under construction and should be in full operation by late 2009 or 2010. MSHA's Mine Simulation Lab is the oldest and most heavily utilized facility. A new facility that provides real-life and wider-ranging training opportunities is the SWVCTC Academy for Mine Training and Energy Technologies in Logan, WV. All of the available centers provide training in a real or simulated underground mine and offer a range of classroom and first-aid teaching exercises. Most of them offer specialized firefighting and smoke-training exercises, but some must go offsite or utilize a mobile unit. Incident command or MERD training is provided by most facilities, except for the ones located in the Midwest United States (MS&T and RLC). Heavy-object removal and vertical rope rescue is offered at two training centers and water rescue is only offered at one. Teams at only two facilities can practice on indoor mine rescue contest fields, but two more are being proposed at two different facility locations. Finally, only one facility can provide lodging, the MSHA Academy. A review suggests that training capabilities and facilities are not universally available to all teams. Some regions require teams to travel long distances, especially in western Colorado/New Mexico, Ohio, Kentucky, Tennessee, Virginia and Oklahoma/Arkansas. However, NIOSH is currently investigating this issue further and will provide more detailed information in future reports. We have focused on two relevant mine rescue facilities.

Table 1. *List of the 13 mine rescue training facility capabilities and features*

Facility name	Available to public	UG Mine (real or simulated)	Classroom exercises	Specialized firefighting	Navigation in smoke
1. Buchanan	no	no	yes	proposed	yes
2. Lake Lynn	research only	real	no	yes	yes
3. Bruceton	research only	real	no	no	yes
4. WVU E&O	yes	sim.offsite MSL	yes	yes, offsite MSL	yes, mobile unit & MSL
5. MTTC	yes	sim.3rd Qtr 2009	yes	yes, 3rd Qtr 2009	yes
6. MSHA MSL	yes	sim.	yes	yes	yes
7. SWVCTC	yes	sim.	yes	yes	yes
8. RLC	yes	sim. 3rd Qtr 2009	yes	yes, 3rd Qtr 2009	yes 3rd Qtr 2009
9. KY Coal Academy	yes	sim.	yes	yes, 2010	yes
10. AMTC	yes	sim.	yes	no	yes
11. MS&T	no	real	yes	no	proposed
12. Edgar Mine	yes	real	yes	yes, offsite	yes
13. WETC	yes	sim. 2nd Qtr 2009	yes	yes, 2010	yes, 2nd Qtr 2009

The Mine Simulation Laboratory (MSL) of the National Mine Health and Safety Academy, Beaver, WV (www.msha.gov)

The MSL is one of seven complexes at the MSHA Academy that are available for public use. It contains a 4,500 m^2 building designed to simulate coal and metal/non-metal mines and has an outside burn area. It is available for public use and in 2008 it began operating on the weekends in order to keep up with the increasing demand for mine rescue training.

The burn area, on one end of the building, includes an incombustible burn tunnel and concrete pads. Mine rescue training includes problem solving and first aid classroom courses, numerous outdoor firefighting drills, exploration and members conduct hands-on mine rescue tasks, including the construction of temporary and permanent ventilation controls while under apparatus. Other noteworthy features of this complex are dormitory space for 320 people, classrooms and laboratories that can accommodate 600 students, a cafeteria, library, auditorium and wellness facilities.

The Mine Emergency Operations (MEO) Building and Mine Rescue Station is located next to the Mine Simulation Laboratory. The mine emergency command vehicles, office trailer, rescue capsule, ATV, emergency generators, and water pumps are housed in this building. Also, the mine rescue station for MSHA's Mine Emergency Unit (MEU) is located inside and contains a full complement of equipment for mine rescue/ recovery. The MSHA's MEU has mutual aid agreements with the Federal Emergency Management Agency (FEMA), Occupational Safety and Health Administration (OSHA) and the U.S. military. They also utilize a neighboring facility where they partner with The International Union of Operating Engineers

(IUOE) to provide HAZMAT and Disaster Site Worker Training. MSHA's mine rescue resources could be used to respond to local and nationwide disasters.

The Academy for Mine Training and Energy Technologies from Southern West Virginia Community and Technical College (SWVCTC), Logan, WV (http://southernwv.edu/mining)

The Academy at SWVCTC offers academic and certification programs to the public, along with specialized coal mine rescue training conducted on campus, at a local underground coal mine, at a firefighting area, in a trailer equipped with virtual-reality Computer based simulations and in a simulated coal mine. The downtown facility is designed to simulate underground coal mines, with low-, mid- and high-seam heights. It provides trainees the opportunity for hands-on training in a realistic environment. There is even a hoist elevator that is used for transportation and mine shaft evacuation training.

Mine rescue training exercises include navigation in smoke and water hazards, confined space rescue, advanced medical training, rapid transportation of injured miners and the use of new mine rescue technology, including exploration in poor visibility with thermal imaging cameras. Outdoor burn pads and a fire gallery are used for specialized firefighting training.

This facility also utilizes state-of-the-art 3D computer simulations, where trainees can be immersed in real-life situations, without exposure to hazardous conditions. SWVCTC places a heavy emphasis on incident command and mobilization of emergency assets and integrates this expertise into mine rescue training in the form of MERDs. This facility operates an on-call 24/7 fleet of five mine emergency response and support vehicles that is partly funded by the state of WV.

Given the name Task Force 1, they are specially designed to provide communications, rescue and fire service to mines in very remote locations. Rescue equipment includes light towers, rescue jaws and cutters, 816-t (900-st) airlift bags, technical rope equipment for vertical rescue, self-contained breathing apparatus (SCBA), portable power systems and medical equipment. The Mobile Communications Unit (Command 1), is equipped with 12 computer workstations with fax/copy/scanner capabilities, a GPS and three satellite communication systems, MSHA-approved radio systems, a portable weather station and helicopter landing-zone equipment. It can be used as an incident command center at any location that is accessible by a bus.

3. WORDWIDE MINE RESCUE TRAINING FACILITIES

Although funded, staffed and legislated in diverse ways, it is typical for international coal-producing countries to operate regional mine rescue training facilities. They are centrally located in the middle of coal fields or between groups of mines to keep travel time from each mine to a minimum. These facilities also have the capacity to train all of the local mine rescue teams. Highly specialized and all-inclusive training centers exist in South Africa, Australia, China, India, United Kingdom, Germany and Eastern Europe (Russia, Poland and the Ukraine). They provide physical, and sometimes rigorous, hands-on training in mines or simulated real-life environments. The full-time staff at these facilities are highly experienced mine emergency response specialists and provide expertise and leadership during mine emergencies. It is common in some countries to utilize specialized medical personnel as full-time staff and trained members of the mine rescue teams.

These centers offer the basic mine rescue training similar to those listed in Table 1. Some facilities offer other specialized training, including multiple-casualty extrication, life-support mine medics, rescue through boreholes, location of trapped miners and control-room and incident-command-center procedures. Australian training facilities utilize state-of-the-art virtual-reality theaters to simulate a wide range of mine hazards and mine rescue training exercises. Medical testing (heat tolerance and fitness for duty), first-responder training, standards evaluation and auditing, coordination of mine rescue teams, the housing of specialized mine-emergency equipment and technical expertise training are other uses of these facilities.

Finally, these centers are utilized for mine rescue contests. The contests are designed to have multiple real-life or simulated exercises that assess individual team member competencies.

In May 2001, in Ustron-Jaszowiec, Poland hosted a three-day international conference to review technical papers on mine rescue and to discuss the function and form of an international organization. Participants briefly discussed and discarded the possibility of creating an “international rescue team” capable of responding to mining and civil disasters in participating countries. Instead, they preferred the concept of an International Mines Rescue Body (IMRB) to promote the exchange of information between the mine rescue services of different countries. The purpose of the IMRB is to promote mine rescue operations at the international level and to improve mine rescue knowledge and practices through global cooperation. Mine rescue organizations from Canada, China, Germany, India and the Ukraine joined that in 2001, followed by New Zealand and Norway during the 2005 conference in Nashville, the United States, while Austria, Mongolia, Russia, Vietnam, and Zambia joined during the 2011 conference in Beijing, China.

4. MINE RESCUE TRAINING FACILITIES IN ROMANIA

In 1913 the first Norms for labor protection especially devised for the mining industry were developed and they addressed mainly those companies located in the Jiu Valley (the largest coalfield in Romania) and involved in coal mining. These norms included 8 chapters with 116 articles; one chapter referred to the first aid necessary for the injured people during mine accidents. All through the years, these Norms have been developed and adapted to the current demands; at present, "The Specific Norms for Labor Protection for the Mining Industry" includes the organization of rescue operations; they are presented in detail in the enclosed Technical Prescriptions that include 111 articles and 6 annexes on the location, equipment, documents and staff employed by rescue stations as well on the operation and training procedures for mine rescuers.

According to the above-mentioned norms, the mining units shall have their own rescue units (or this activity shall be supplied by a nearby unit); the personnel of these rescue units shall be made of volunteer rescuers whose number shall be at least 2% of the most numerous shift of workers for underground and they shall be made of workers with different training skills. Central mine rescue stations shall be founded in mine coalfields; they shall operate on a permanent basis with professional rescue teams. These rescue stations shall have at their disposition an adequate building, well-trained personnel with suitable certifications and equipment and the necessary training courses shall be carried out with high exigency and professionalism.

In compliance with the stated norms, the rescue stations shall be divided into three categories depending on the number of employed rescuers. Thus, we have:

- Mine rescue stations of third range with 10 - 15 rescuers;
- Mine rescue stations of second range with 15 - 25 rescuers;
- Mine rescue stations of first range with more than 25 rescuers.

Mainly, such a structure shall include different rooms adequate to carry out those activities specific for the range of the rescue stations. The designs for the erection of the construction or the projects necessary to re-arrange the structures that shelter the rescue stations shall be approved by INSEMEX Petrosani who shall also verify periodically whether the adequate provisions are observed. The rescue station shall include a training field, arranged at surface or in underground and where the rescue teams perform training exercises that simulate real working situations, real travelling or environment conditions (smoke, high temperature and humidity), similar to those that might occur during a mine accident. [Găman, 2009]

The personnel of mine rescue teams can include a large range of qualifications, starting from a simple miner up to the general manager of a mine company, with the observance of some regulations, such as: age between 22-45 or 22-50 for the personnel involved in the control or monitoring of the mine rescue operations; at least 3 years seniority in the activity performed during mine rescue operations; those involved shall be declared healthy from a physical and psychic point of view; no bad habits and/or hereditary problems.

For the medical and psychological selection, there exists a series of minimum demands that has to be observed by all those involved in this activity. The personnel that is member in the managing board (manager, technical manager, head of the mining unit, chief-engineer) or in the leading board can be part of the staff employed by the mine rescue station only as personnel involved in the control or monitoring of the rescue operations. INSEMEX Petrosani performs training courses for the certification or periodical certification (every 3 years) of the personnel. [Găman, 2009]

Every month, the rescue team members attend 20 hours of training courses that include theory and practice held in addition to the normal working hours; these courses are organized by every mining unit that has rescue teams. The classes of theory for the certification and re-certification of rescue team members as well the training classes held at the location of the mining units include notions on the rescue apparatus, mine gases, first aiding, transportation of injured people, mine damage starting with operations of preventions up to the operations necessary to remove all the negative effects of a mine damage, with a presentation of the risk factors and especially the suitable methods for avoiding the occurrence of unwanted accidents with tragic results.

First aiding and transportation of injured people form a separate chapter where theory mingles with the practical implementation of certain rescue practice. Rescue teams perform their training courses on training fields arranged at surface or in underground. Difficult training courses shall strengthen a rescue team, making them aware of their limits at great effort; thus, they can control better the effort and learn how to save their strength.

At present, in Romania, the mining activity develops within 5 companies and 2 national society that have under their subordination several mine branches and mining units with rescue stations. Accordingly, there exist 11 first range rescue stations, 7 second range rescue stations and 26 third range rescue stations, with 800 rescuers, 35 personnel involved in control operations and 55 mechanics for the maintenance of the rescue apparatus. [Găman, 2009]. A second range rescue station operates in the Jiu Valley coalfield, where professional rescuers work and it is the only one in Romania that supplies continuous service in this field of activity. All the other mine rescue stations employ volunteer personnel that performs this rescue operations additionally; basically they bear different other titles in the mining units where they work.

5. CONCLUSIONS

Training in a real-life environment with opportunities for hands-on experience has been established as beneficial to coal mine rescue teams. Most international mine rescue teams receive standardized skills training for a wide range of mine emergency responses. Right now there is a training disparity among teams for both skill competencies and opportunities to learn. Throughout this training facility and practices investigation, NIOSH researchers created a list of skills and knowledge for mine emergency response. This comprehensive list is provided below. Competencies in these skills are suggested for all teams to be better prepared for a mine emergency and to help standardize mine rescue skills across the United States.

Preliminary findings suggest that increasing the current number of training facilities and/or capacities may help coal mine rescue teams be better prepared for mine emergencies. Numerous countries utilize regional or centralized mine rescue training facilities to provide the above skills training. These facilities are structured to be systematic, efficient, self-contained and designed to provide realistic training. However, there are existing facilities that provide varying amounts and kinds of realistic and hands-on coal mine rescue training. This paper provides numerous examples of good and unique features that could enhance each facility in one area or another.

REFERENCES

[1]. Bealko S.B., Alexander D.W., Chasko L.L. and Grayson R.L., *Mine rescue training facility inventory – compendium of ideas to improve*, 2009.

[2]. Conti R.S., Chasko L.L., and Stowinsky L.D., *Mine rescue training simulations and technology*, Proceedings of the Fifth Annual Conference of the International Emergency Management Society, pp. 453-464, and 1998.

[3]. Găman A.G., *Techniques and methods regarding operative interventions and persons rescuing in toxic and explosive environments*, (in Romanian), Focus Publishing House, Petrosani, Romania, 2003.

[4]. Găman A.G., *Procedures and regulations of the formations for intervention and operation in toxic/explosive/flammable environments*, (in Romanian), INSEMEX Publishing House, Petrosani, Romania, 2009.

[5]. Mott M.L. and Snyder M.P., *Mine emergency responsiveness development program procedures*,Mining Engineering, Vol. 45, No 10, pp. 1258-1261, 1993.

[6]. ***, **Mine Safety Technology and Training Commission**, *Improving Mine Safety Technology and Training: Establishing U.S. Global Leadership*, December 2006, pp. 55-77.

[7]. www.msha.gov/programs/epdmsl.htm, Department of Labor, Mine Safety and Health Administration, Mine Simulation Laboratory, accessed October 2014.

[8]. http://www.cdc.gov/niosh/mining/works/coversheet85.html, accessed October 2014.

[9]. http://www.imrb2015.de/imrb2015.html, accessed October 2014.

[10]. http://www.usmra.com/rescueinromania.htm, accessed October 2014.

[11]. http://www.minerescue.org/conferences/2013_niagara_falls.htm, accessed October 2014.

Scientific Reviewers:
Prof. Ph.D. Eng. Eugen COZMA

MODERN PHYSICAL TRAINING METHODS FOR MINE RESCUERS

CRISTIAN COSTA[*]
DANIEL PUPAZAN[**]

Abstract: *We have studied physical mine rescue training programs and health-related and rescue-related fitness tasks during a mine rescue competition, made in China and Australia and on these basis we have design our own pre physical training method. We have stored the heart rate measured in bites per minute (bpm) during the 2012 year periodical training for 21 mine rescuers. We have designed a physical training procedure based on six training models: Body Building, Method of isometric efforts, Method ofInterval Training, Volumevariationmethod, Structuredmethodfor basic grip and release and Specificwork method. Then we measured again during the 2014 year periodical training, the heart rate for the same mine rescuer having the physical training procedure performed before. We have notice that the trained person has now lower bpm, during the tests that could represent better performances during the rescue actions.*

Keywords: *mine rescuer, physical training programs, heart beat rate*

1. INTRODUCTION

The mining industry has one of the highest occupational rates of serious injury and fatality. Mine staff involved with rescue operations is often required to respond to physically challenging situations. Mining accidents can have a variety of causes including leaks of poisonous gases, asphyxiant gases, dust explosions, collapsing mine stop's, flooding, or general mechanical errors from improperly used or malfunctioning mining equipment. Numerous accident scenarios can therefore develop that require specialist skills in handling hazardous materials, fires, search and rescue, vertical ascent, and vehicle accidents. The combination of the high incidence of accident with the multitude of possible accident scenarios requires that the mine staff who volunteer to be involved with rescue operations are commonly placed in both mentally and physically challenging situations.

2. LITERATURE REVIEW

In a study made in 2008 year by Ian B Stewart, Michael D McDonald, Andrew P Hunt and Tony W Parker, and published in the Journal of Occupational Medicine and Toxicology under the name "Physical capacity of rescue personnel in the mining industry", they studied 91

* *Ph.D. Eng. Student – Assistant Professor - University of Petrosani*
** *Ph.D. Eng. – III Scientific researcher – INCD INSEMEX Petrosani*

rescue personnel (34 ± 8.6 yrs, 1.79 ± 0.07 m, 90 ± 15.0 kg) participating in the Queensland Mines Rescue Challenge, Australia, they completed a series of health-related and rescue-related fitness tasks. Health-related tasks comprised measurements of aerobic capacity (VO_2max), abdominal endurance, abdominal strength, flexibility, lower back strength, leg strength, elbow flexion strength, shoulder strength; lower back endurance, and leg endurance. Rescue-related tasks comprised an incremental carry (IC), coal shovel (CS), and a hose drag (HD), completed in this order. As a result they concluded that Cardiovascular (VO_2max) and muscular endurance was average or below average compared with the general population. Isometric strength did not decline with age. The rescue-related tasks were all extremely demanding with heart rate responses averaging greater than 88% of age predicted maximal heart rates. Heart rate recovery responses were more discriminating than heart rates recorded during the tasks, indicating the hose drag as the most physically demanding of the tasks. They have done the Health-related Fitness tests. Health-related fitness was measured by assessing the following attributes: aerobic capacity (VO_2max), abdominal endurance, abdominal strength, flexibility, lower back strength, leg strength, elbow flexion strength, shoulder strength, lower back endurance, and leg endurance.VO_2 max was estimated from a 6 minute step test. The subject stepped up and down a step height of 12" to the beat of a metronome. The first 3 minutes were at a pace of 15 steps per minute and the final 3 minutes were at 27 steps per minute. The heart rate from the final minute of each stage was applied to a linear regression with VO_2 to extrapolate the data to the persons age predicted maximal heart rate, enabling an estimate of their VO_2max [American College of Sports Medicine , 2006]. Abdominal endurance was measured as the number of completed sit ups in 60 seconds [Palmer & Epler, 1998]. Lower back endurance was assessed by the Biering-Sorensen test [Stewart et all, 2003]. Maximal isometric strength was assessed with a customized strain gauge system linked to a computer program (LabVIEW, National Instruments, Austin, TX). The subjects performed a seated row, dead lift, standing shoulder press and bicep curl exercises. Force generated (kg) was obtained from a three second maximal effort. Abdominal strength was assessed as the number of different variations of sit up successfully completed. Seven different variations of sit up were used, each of an increasing difficulty. The subject attempted each one in order, until they could not complete a particular variation. The last successfully completed stage was recorded as their abdominal strength score [Palmer & Epler, 1998]. Flexibility was assessed via the sit-and-reach test [Barlow et all, 2004].

Based on their conclusions that: *Mines rescue requires strenuous effort at sporadic intervals, and it is unlikely that the physical demands of work and the process of on the job rescues will be of sufficient frequency to provide adequate training to maintain, let alone increase, physical fitness. It is therefore in their opinion recommended that (1) standards of required physical fitness be developed and (2) mines rescue personnel undergo regularly training (and assessment) in order to maintain these standards,* we have design our own pre physical training method.

In another study made by H. Xie and T. Yan, from North China Institute of Science and Technology, Hebei, China, and published in Progress in Mine Safety Science and Engineering II, 2014 Taylor and Francis, London, pp. 583-586, in the paper called *Mine rescue training programs and research.* They have proposed an exercise prescription library, with the following prescription library project items: the collective and humanity. Collective classes include power quality training, endurance quality training, flexibility quality training, anti-sea-sickness training, and responsive quality training and so on. Humanity classes are richer and more targeted.An example of the training project proposed by Xie and Yan, for power quality contains the followings:

1. Preparation section of 10 minutes, with jogging and two person gymnastics, pressure shoulder, side movement, enlarge chest, turn body movement, activity knee, wrist, shoulder, neck joints
2. Basic part section of 40 minutes, with pass grenade or solid ball exercise, pairs back to stand, left to right, right to left and up and down. Each method for a group of 10 times, two people two grenades face to face 15 times, two people two grenades back to back 15 times, tuck jump 20 times X 2, triple jump 20 times X 2, one foot jump 20 meters and rely 2 times
3. End of section of 10 minutes, containing breathing exercises, stretching, muscle relaxation exercises, double opioid antagonist activity.

3. RESEARCH METHODOLOGY

Methodology

We have proposed a pre physical training procedure to be made by mine rescuer before the standard training test conducted in the INSEMEX Petrosani laboratory. We have proposed our physical training exercise on the fact that training made changes in cardio respiratory result of the trained person. We know the fact that a trained person has a 40 -50 bpm, while a not trained person has a 70-76 bpm during the tests.We have used for our research 20 Polar Heart Rate Monitors sport watches and the Polar Pro Trainer Software for evaluating the results. Polar offers some of the most advanced heart-rate based training equipment in the world. It includes heart rate monitors for running, fitness & cross-training, as well as GPS-enabled cycling computers and sports watches for endurance training. We have used these sport watches for measuring the effort of the mine rescuers during the training programs. Polar sport zones offer a new level of effectiveness in heart rate-based training. Training is divided into five sport zones based on percentages of your maximum heart rate. With sport zones, we can easily select and monitor training intensities and follow Polar’s sport zones-based training programs.

The pre physical training procedure proposed

We have designed a procedure containing six training models: Body Building, Method of isometric efforts, Method ofInterval Training, Volumevariationmethod, Structuredmethodfor basic grip and release and Specificwork method.

Body Building. Bodybuilding represents the use of progressive resistance exercise to control and develop one's musculature. The method contains strength training through weights or elastic/hydraulic resistance. Weight training aims to build muscle by prompting two different types of hypertrophy: sarcoplasmic hypertrophy and myofibrillar hypertrophy.

Isometric efforts. Isometric sessions should be used just like regular strength training with peak frequency for the week at around three to four sessions. It can take the nervous system up to five times longer to recover than the muscular system, so the effects of isometric training can last a long time after the session. Isometric contraction occurs when the muscle tenses while not changing length. Examples of this are poses in body building or pushing against an immoveable object such as a wall.

Interval Training. Interval running enables the athlete to improve the workload by interspersing heavy bouts of fast running with recovery periods of slower jogging. The athlete runs hard over any distance up to 1k and then has a period of easy jogging. During the run, lactic acid is produced and a state of oxygen debt is reached. During the interval (recovery), the heart and lungs are still stimulated as they try to pay back the debt by supplying oxygen to help break down the lactates. The stresses put upon the body cause an adaptation including capillarisation, strengthening of the heart muscles, improved oxygen uptake and improved buffers to lactates. All this leads to improved performance.

Volumevariationmethod. The Variation Principle suggests that minor changes in training regimens yield more consistent gains in sport performance. Training programs for virtually every sport include variations in intensity, duration, volume, and other important aspects of practice.

Table1. *Physical training procedure*

Motility Qualities	Physical models of training	Data	Data	Data	Data
Strength	Method of segmental efforts Body Building	4;7;9;10; 3x	2;3;5; 3x	6;8; 3x	4;7;9; 3x
	Method of isometric efforts	1;2;4; 6″x3	3;5;6; 6″x3	2;5; 6″x3	1;3;5; 6″x3
Endurance	Method ofInterval Training	1;4; 1x	3; 2x	1;2; 1x	1;3; 1x
	Volumevariationmethod		4; 1x	5; 1x	5; 1x
Skill	Structuredmethodfor basic grip and release	1;3; 2x	2; 2x	3; 2x	5; 2x
	Specificwork method	1:2; 2x	1:3; 2x	1:4; 2x	2:4; 2x

Initial stage – the standard test results –the 2012 periodical training session

We have tested 15 surface rescue miners and 6 underground rescue miners during their periodicaltraining session made at INSEMEX Petrosani. Using Polar heart rate monitors watches we could notice a few syncope during the training. In the figure below we have presented the curve for the Heart Rate (HR) during a 90 minutes training program for two extreme cases of mine rescuers, during the 2012 training session.He have analyzed also the 90 discontinuous HR results for all the 90 minutes of the exercise for all the 21 mine rescuers.

We have observed the heart rate measured in bites per minute in 2012 year, for six underground mine rescuers, during the first 10 minutes of the training and the next ten minutes of training, as we can see in figure 1 and figure 2.

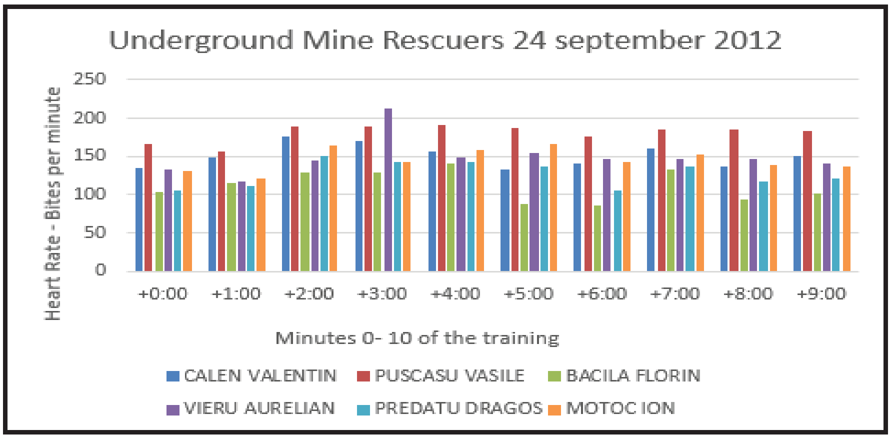


Fig. 1. Heart Rate for underground mine rescuers tested during their periodical training session in Risk-Rescue Operations Laboratory INSEMEXPetrosani, September 2012 (first ten minutes of the 90 minutes of the training program)

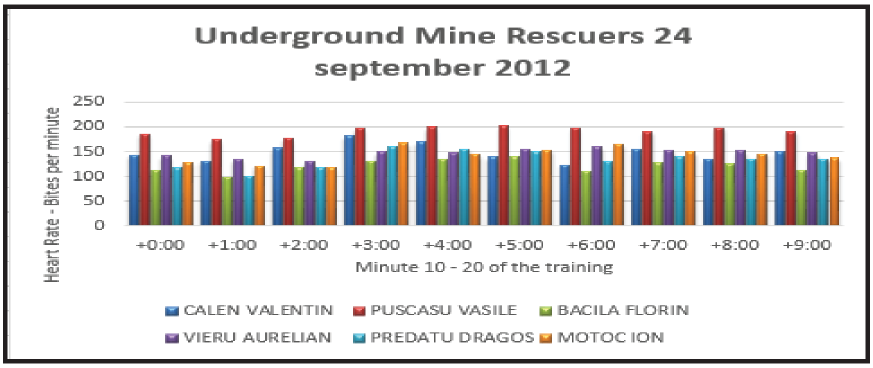


Fig. 2. Heart Rate for underground mine rescuers tested during their periodical training session in Risk-Rescue Operations Laboratory INSEMEXPetrosani, September 2012 (minutes 10-20 of the 90 minutes of the training program)

We have observed the heart rate measured in bites per minute in 2012 year, for eight surfaces mine rescuers, during the first 10 minutes of the training and the next ten minutes of training, as we can see in figure 3 and figure 4.

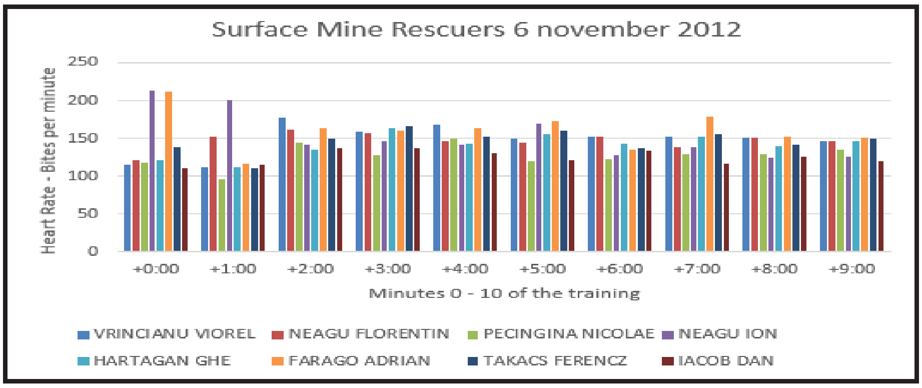


Fig. 3. Heart Rate for surface mine rescuers tested during their periodical training session in Risk-Rescue Operations Laboratory INSEMEXPetrosani, November 2012 (first ten minutes of the 90 minutes of the training program)

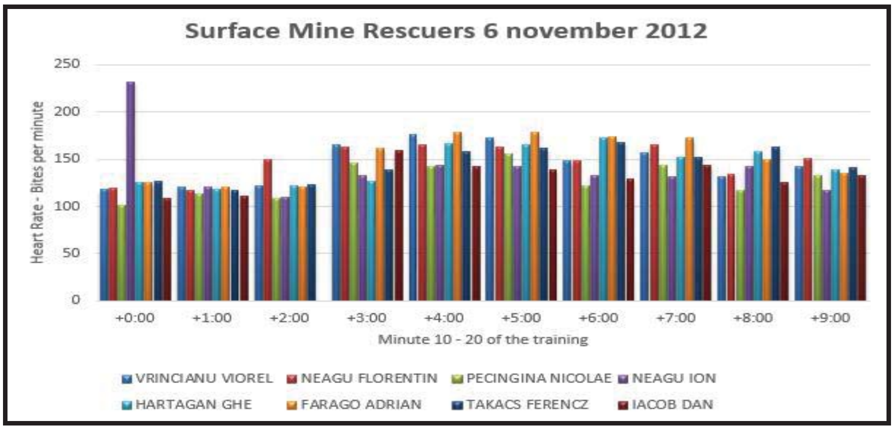


Fig. 4. Heart Rate for surface mine rescuers tested during their periodical training session in Risk-Rescue Operations Laboratory INSEMEX Petrosani, November 2012 (minutes 10-20 of the 90 minutes of the training program)

Final stage – the improved test results - after the implementation of the pre physical training procedure –the 2014 periodical training session

We have selected four surfaces mine rescuers, having an improvement of the heart beat rate between 11-13 percent for the two years. Below we present the improvement of the heart beat rate for one of them, for the first ten minutes of the exercise, relevant for a surface mine rescuer (11% decrease of the heart rate), the Polar heart rate monitors watches chart and the regression analysis for the 10 minutes of the measurement (R=0,952 –very good link).

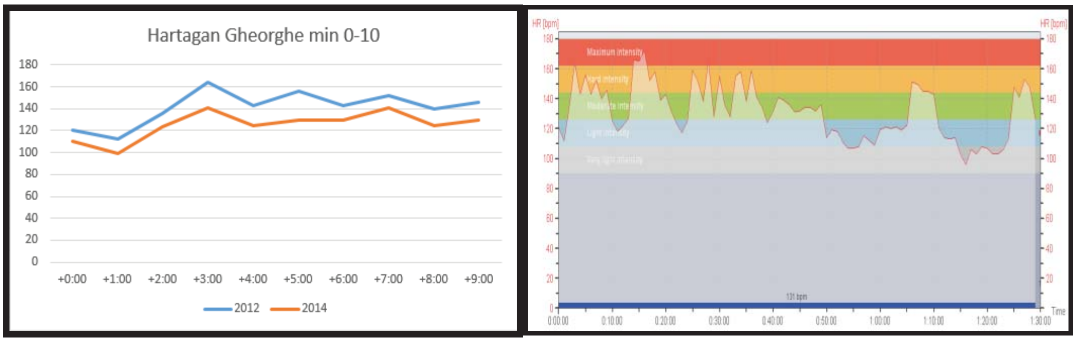


Fig. 5. Improvement of the heart beat rate, for the first ten minutes of the exercise and the Polar heart rate monitors watches chart

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,952[a]	,906	,895	4,171

a. Predictors: (Constant), hbr_5_hartagan

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1347,331	1	1347,331	77,450	,000[a]
	Residual	139,169	8	17,396		
	Total	1486,500	9			

a. Predictors: (Constant), hbr_5_hartagan

b. Dependent Variable: hbr_5_2014

Fig. 6. The regression analysis for the 10 minutes of the measurement

We have selected five underground mine rescuers, having an improvement of the heart beat rate between 5-20 percent for the two years. Below we present the improvement of the heart beat rate for one of them, for the 20-30 minutes of the exercise, relevant for an underground mine rescuer (20% decrease of the heart rate), the Polar heart rate monitors watches chart and the regression analysis for the 10 minutes of the measurement (R=0,969 – very good link).

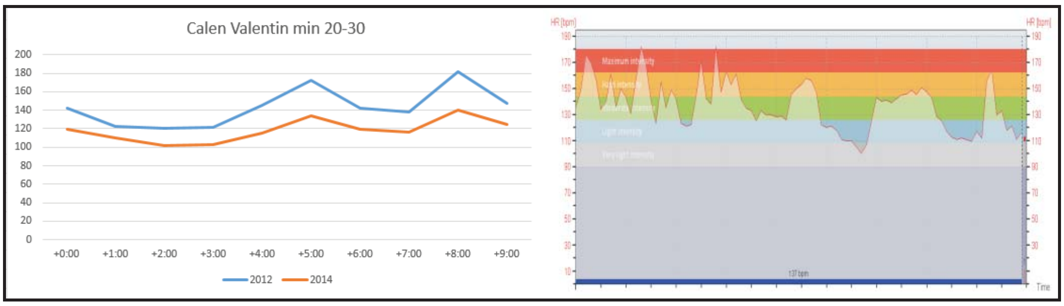


Fig. 7. Improvement of the heart beat rate, for the first ten minutes of the exercise and the Polar heart rate monitors watches chart

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,969[a]	,939	,932	3,236

a. Predictors: (Constant), hbr_1_calen

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1295,810	1	1295,810	123,720	,000[a]
	Residual	83,790	8	10,474		
	Total	1379,600	9			

a. Predictors: (Constant), hbr_1_calen

b. Dependent Variable: hbr_1_2014

Fig. 8. The regression analysis for the 20-30 minutes of the measurement

4. CONCLUSIONS

We have proposed a set of training exercises, in fact a pre training program to be made by the mine rescuers before the periodical training session. In 2014 year we have tested the same mine rescuers, tested in 2012 without a pre training program and we could observe a 7% decrease in the heart rate beating. This decrease could conduct to a better efficiency in the mine rescuers saving activity.

REFERENCES

[1]. **American College of Sports Medicine**, *ACSM's metabolic calculations handbook*. Lippincott, Williams & Wilkins; 2006.

[2]. **Barlow A, Clarke R, Johnson N, Seabourne B, Thomas D, Gal J,** *Effect of massage of the hamstring muscle group on performance of the sit and reach test*, Br Journal of Sports Medicine, no.38, pp. 349-351, 2004

[3]. **Palmer L.M. andEpler M.E.,** *Fundamentals of musculoskeletal assessment techniques. 2nd edition,* Philadelphia, Lippincott, 1998.

[4]. **Stewart I.B., McDonald M.D., Hunt A.P. and Parker T.W.**, *Physical capacity of rescue personnel in the mining industry*, Journal of Occupational Medicine and Toxicology, 2008, http://www.occup-med.com/content/3/1/22

[5]. **Stewart M, Latimer J, Jamieson M,***Back extensor muscle endurance test scores in coal miners in Australia*, Journal of Occupational Rehabilitation, no.13, pp. 79-89, 2003.

[6]. **XieH. and Yan T.**, Mine rescue training programs and research, Progress in Mine Safety Science and Engineering II, Taylor and Francis, London, 2014, pp. 583-586

Scientific Reviewers:
Prof. Ph.D. Eng. Eugen COZMA

INFLUENCE OF GAS GENERATED BY DETONATION OF EXPLOSIVES FOR CIVIL USES, ON THE WORK ENVIRONMENT

ATTILA KOVACS[*]
CRISTIAN RAUL CIOARA[**]
GABRIEL VASILESCU[***]
EMILIAN GHICIOI[****]
EDWARD GHEORGHIOSU[*****]
DANIELA-CARMEN RUS[******]
ILIE-CIPRIAN JITEA[*******]

Abstract: *External violent decomposition in extreme reaction of explosives for civil uses leads to the generation of explosion gases explosion after detonation. From solid explosive material form, to gaseous reached detonation during this process large molecules with complex structures suddenly turns into simple molecules releasing energy manifested significant mechanical work (increasing pressure) and heat (temperature rise). In most situation gases resulting from the explosion are nitrogen oxides, carbon oxides and water vapors with properties vary according to the explosive concerned. Both nitrogen oxides (NO, NO_2, NO_3) and the carbon ones (CO and CO_2) are toxic gases and the maintain of their concentration levels in permissible limits in the workplace is highly important. Determination of explosion toxic gases conducted by INCD - INSEMEX meet modern continuous measurement of CO_x and NO_x under the seal of the enclosure where the explosive detonates.*

Keywords: *explosives, nitrogen oxides, carbon oxides, admissible limits.*

---

* *Head of SECEMTI, Ph.D. Eng., INCD-INSEMEX Petroşani, attilakovacspetrosani@yahoo.com*
** *Eng., INCD-INSEMEX Petroşani, tiny_raul@yahoo.com*
*** *Head of Laboratory MEAP Ph.D. Eng., INCD-INSEMEX Petroşani, dragos.vasilescu@insemex.ro*
**** *Head of Department SEAP, Ph.D. Eng., INCD-INSEMEX Petroşani, emilian.ghicioi@insemex.ro*
***** *Head of Laboratory IT, Phd. Eng., student, INCD-INSEMEX Petroşani, edward.gheorghiosu@insemex.ro*
****** *Eng. Department SEAP, INCD-INSEMEX Petroşani, dana.rus@insemex.ro*
******* *Department SEAP, Ph.D. Eng., student, INCD-INSEMEX Petrosani, cipri_jitea@yahoo.com*

1. DESCRIPTION OF THE APPARATUS AND METHODS

Chamber Explosion

This space is designed to withstand the forces that occur during detonation of explosives breeze with a minimum volume of 15 m^3 room. Actual size of the space must be known accurately to within ±2%. The chamber is equipped with an effective mixing tool to ensure a homogeneous atmosphere in a few minutes after the explosion. The chamber must be equipped with means for measuring the ambient temperature and pressure inside the chamber and should have holes for gas collection [1, 2].

When using a circulating system in chamber the volume and flow rate must be such as to prevent a significant loss of gases.

Apparatus for analysis

It should be appropriate analytical equipment used to continuously measure the amount of CO, CO_2, NO and NO_2 for 20 min. For example, you can use infrared technology to measure CO and CO_2 and a chemi-luminescent analyzer for NO and NO_x and our TESTO type measuring system are fulfilling this requirement.

Gas extraction equipment

It must be used an air pump and a device for measuring the air flow to extract gas samples from the explosion chamber. The system not allows water vapors condensation in the sampling tube gas and the subsequent dissolution of NO_x.

Tube for detonation

A thick-walled steel tube (that is strong enough to withstand a large number of bursts), the inside diameter of 150 mm and inside length of 1400 mm.

Means of initiation

Must be in accordance with manufacturer's specifications in accordance with EN 13631-10 - *Explosives for civil uses. High explosives. Part 10: Verification of the means of initiation* [8].

2. SAMPLES FOR TESTING

For cartridge explosives must be used the minimum diameter of cartridges available on the market. Bulk explosives should be placed in glass tubes or, if necessary closing tighter, they must introduced in aluminum tubes. The inner diameter of the glass tube or aluminum should be the minimum diameter recommended by the manufacturer for the use of explosives. The minimum length of the column of explosives to be 700 mm or at least 7 times the diameter of the load. The minimum explosive mass-volume ratio room must be 30 g/m^3 but not exceed 50 g/m^3. Every test need to be recorded the amount of explosives.

Cartridges should be fixed for coaxial transmission so as to ensure detonation. The length of the load does not exceed the length of the steel tube.

3. TEST PROCEDURES

Load central insert steel orifice. The charge shall detonates. Allow gas to mix a maximum of 5 minutes. Initial sampling of gas from the explosion chamber. It measures the concentration of gas for 20 min. continuously.

If in the explosion chamber is sufficiently gas tight after the initial mixing of CO and CO_2 concentration remains constant. As the NO and NO_2 further give rise to side reactions, need to extrapolate the measured concentration to the initial concentration obtained. The initial concentration of each compound of nitrogen can be obtained by plotting concentration of conjugate according to the time elapsed from the explosion, and when extrapolating to zero the curve results [7].

Starting with initial concentrations as determined from chamber volume and quantity of explosives detonated, we had calculated the amount of each toxic gas in litter per kilogram of explosives (at standard temperature and pressure).

The test should be performed three times.

Figure 1. Bunker for the testing toxic gases

4. TEST REPORT

The test report shall conform to EN ISO/IEC 17025 [10] additionally the following information must be provided:

a) reference to the document, that is, EN 13631-16;

b) the volume and initial temperature explosion chamber, temperature and method of drying gas sampling tube gas;

c) the diameter and length of the cartridges used, as well as the material and quality of the coating cartridge;

d) opening and closing means used;

e) the quantity of each of toxic gas (CO, CO_2, NO and NO_x) calculated for each burst, the l/kg;

f) the average quantity of each toxic gas in l/kg.

5. RESULTS OF PILOT TEST

Specifications	Unit measurement	Testing no. 1	Testing no. 2	Testing no. 3
Explosion chamber volume	m^3	15		
The amount of explosive	kg	0,600		
The length of the column of explosives	m	0,700		
Means of initiation	-	Electric blasting caps. no. 8 + buster		
The initial temperature of the explosion chamber	°C	11	11	11
The amount of CO (measured)	ppm	838	1025	805
The amount of CO_2 (measured)	%	0,40	0,39	0,41

The amount of NO (measured)	ppm	366	300	365
The quantity of NO_x (measured)	ppm	464	350	533
The amount of CO (calculated)	l/kg	19,63	24,30	18,80
The amount of CO_2 (calculated)	l/kg	90	87,50	92,50
The calculated amount of NO	l/kg	8,45	6,80	8,43
The amount of NO_x (calculated)	l/kg	10,88	8,03	12,60
The average amount of CO	**l/kg**	**20,91**		
The average amount of CO_2	**l/kg**	**90**		
The average amount of NO	**l/kg**	**7,89**		
The average amount of NO_x	**l/kg**	**10,50**		

5. CONCLUSIONS

This new equipment is fulfilling the requirements of the harmonized European standard and allows making a proper measurement of the toxic fumes generated by the explosives, with hazardous impact for the health of personnel in underground works (shafts, tunnel etc.) [5].

The sealed bunker and the automat zed measuring system can generate exact information with recoding on a data-base for calculations and to let comparation to be made with the producer producers provisions specified in technical data sheets [6].

6. REFERENCE

[1]. DIRECTIVA 93/15/CEE a Consiliului din 5 aprilie 1993 privind armonizarea dispoziţiilor referitoare la introducerea pe piaţă şi controlul explozivilor de uz civil.

[2]. HOTĂTÂRE NR. 207 DIN 17 MARTIE 2005 privind stabilirea cerinţelor esenţiale de securitate ale explozivilor de uz civil şi a condiţiilor pentru introducerea lor pe piaţă.

[3]. Fodor, D. – *Ingineria Împuşcărilor, Materiale şi Tehnici de lucru (2),* Editura Namaste – Timişoara 2007, Editura Corvin – Deva 2007, Vol.1.

[4]. Fodor, D. – Ingineria Împuşcărilor, Materiale şi Tehnici de lucru (2), Editura Namaste – Timişoara 2007, Editura Corvin – Deva 2007, Vol.2.

[5]. D. Fodor, „*Explozivi industriali*”, Editura INFOMIN, Deva, 2000.

[6]. Tat, S., Zaporojan, M., Fissgus, K. - *Explozivi şi tehnica împuşcării în industrie*, Editura Tehnica, Bucureşti 1985.

[7]. EN 13631-16, Explosives for civil uses. High explosives. Part 16: Detection and measurement of toxic gases.

[8]. EN 13631-10, *Explosives for civil uses. High explosives. Part 10: Verification of the means of initiation.*

[9]. EN 13857-1:2003, *Explosives for civil uses. Part 1: Terminology.*

[10]. EN ISO/CEI 17025, General requirements for the competence and testing of calibration laboratories (ISO/IEC 17025:1999).

Scientific Reviewers:
Roland Iosif MORARU

DEVELOPMENT AND IMPLEMENTATION OF WATER AND SOIL SAMPLING, ASSAYING AND ASSESSMENT PROCEDURES MEANT TO DETERMINE THE HUMAN IMPACT ON THE ENVIRONMENT

KOVACS MARIUS*
GHEŢIE GHEORGHE**
TOTH LORAND*
CĂLĂMAR ANGELICA*

Abstract: *The human impact is significant and results from multiple and unprecedented development of human society. Almost all human activities have a negative impact on the environment by noxae emissions, loading surface waters with contaminating elements because of untreated wastewater discharge into the environment, changing hydrogeological regime and groundwater pollution. Within the Core Program "Development of national capacity to assess, prevent and limit the risks generated by industrial applications deployed in hazardous and/or toxic risk environments, in the fields of occupational health and safety and environment, mineral resources and materials protection " / HIGH RISK - PN 07:45, two operational procedures for sampling water and soil were developed, as well as two operational procedures for evaluation of the found results, in order to correctly asses the impact upon the environment. To meet the requirements of legislation on water and soil sampling to further determinations of physical and chemical parameters, within INCD INSEMEX - Petrosani were purchased a series of sampling, preservation and transportation equipments.*

Keywords: *procedures, sampling water, soil, environment*

1 INTRODUCTION

The environment is made up of a number of natural components, such as air, water, vegetation and fauna, topography, lithology and soil that through their attributes create the terrestrial ecosystem.

These components are in dynamic balance, achieved over time. Natural components are added to those created by human activity.

1.1. The importance of water as environmental factor

Considered a general phenomenon, pollution can be differentiated into several types:

---

* *Phd. Eng., INCD INSEMEX Petrosani, Romania*
** *Eng., INCD INSEMEX Petrosani, Romania*

- biological pollution - bacteriological, virological, parasitological, is the oldest type of pollution - linked directly to human presence,
- physical pollution, which refers specifically to radioactive pollution,
- chemical pollution is the water penetration by chemicals ranging from the organic easily degradable up to toxic highly persistent.

Additionally, there is thermal pollution and pollution caused by floating or sediment insoluble elements, considered as the latest type of pollution, specific to heavily developed areas.

In our country, almost all major companies or industrial plants, that are located in the vicinity of cities, separately purify their wastewater, which is then evacuated into neighboring water streams. [6]

1.2. The importance of soil as environmental factor

Soil is one of the environment components, being particularly important in the existence of terrestrial life.

It was formed on the surface of the lithosphere in the area of its contact with the atmosphere, hydrosphere and biosphere, representing an important natural resource for human society. Upon the soil is developed most of the growing season, the basis for human food source.

Soil is the product of mineral and organic substances transformation on the surface of the earth's crust, under the influence of environmental factors, in long time. Characterized by a certain organization and morphology of its own, it is the environment for higher plants development and the living basis for animals and people.

The soil consists of mineral components and organic organisms, which interact with the physical properties, chemical, biological and morphological characteristics different from those of the parent material from which they are formed.

They have evolved over time through specific pedogenetic processes under the action of climate and creatures in different conditions of relief.

The soil is also a reservoir of energy; it accumulates chemical energy in the form of humus, humus resulting from the processing of organic matter formed by plants by converting solar energy during photosynthesis.

This chemical energy can be released by mineralization process being used by the creatures.

2. METHODS OF WATER AND SOIL SAMPLING, UNDER CURRENT LEGISLATION

This paper aims to align sampling procedures to European practice, by making precise measurements of the concentrations of pollutants in soil and water by developing procedures to be consistent with international principles and practice, developing improved research laboratory facilities for providing data necessary for complete analysis.

Achieving the project’s goals will have a positive technological impact by increasing the accuracy of qualitative and quantitative measurements of the components of environmental water and soil. These results are the basis for a correct assessment of environmental impact.

Methods developed for soil and water sampling observe the recommendations and provisions mentioned by the General Order 184/1997 and the existing standards [4].

2.1. Sampling of water

The general conditions for efficient sampling require staff to know from where samples are harvested and to reasonably establish collecting points.

The water sampling will consider the following conditions:

- Water sample is representative (harvested water composition is identical to the composition of the water from which the harvesting took place or has the same composition at the time and place when it was harvested) [7];

- The volume of water sample is determined on a case by case basis [5];

- Container should be made of inert materials. Glass vials influence the content of Na and Si. To determine these elements, harvesting will be done in polyethylene bottles or other plastic.

During collection and until analysis, samples will be stored and transported properly.

Sampling program takes into account a number of important factors such as:

- Location of sampling sections;
- Frequency of the sampling;
- Sampling procedures.

Particular attention should be given to details referring to pollutant loads, maximum concentration, minimum, arithmetic mean, and outliers.

Of great importance is to make a list of parameters considered to be of interest, so that the designated sampling techniques, types of glass used and the

methods of preservation and handling would be pointed out.

2.2. Soil sampling

Soil analyzes must follow the requirements of Government Decision 1403 and 1408 from 2007 for investigation and restoration of contaminated land [1, 2].

In order to investigate land contamination, samples for soil analysis may be collected from the surface layer, from 5-30 cm and for evidencing in depth pollution, from 1, 5 m and even reaching the groundwater layer.

Sampling is the most important step for an analytical process. The collection may involve very complex processes, often requiring several stages of subdivision before giving the final analytical result. For the development of effective sampling procedures, one should take into consideration the following aspects:

- Sample taken must be representative for the entire volume of material;
- The amount of sample to be taken has to be determined;
- Subsequent sample handling and storage must be correct.

Soil sampling for analysis is a very important operation, results largely depending on its accuracy. Soil samples are taken from each horizon and sub- horizon in part; from thicker horizons are taken 2-3 samples and from thinner horizons a single central one. Samples are harvested at a depth of 1 m or more, depending on the type of soil pollutant, and the characteristics analyzed. Soil surface to be studied is determined by limiting a parcel between 25-50m^2 upon which are positioned sampling points.

Soil sampling is performed with different types of probes, depending on the depth at which we want to perform harvesting and on soil nature.

Soil sampling at depths of up to 0.5-0.7 m probe is done by hand; greater depths require mechanical equipment and machinery (drill).

Soil sampling will be performed, usually, in clean and dry plastic containers (approx. 0.5 kg). Number of soil samples collected varies depending on terrain, the character of uniformity or nonuniformity of the field.

Soil samples once collected, are packaged in paper bags paraffin, plastic bags, cans or cartons waxing. Afterwards, these are labeled, marking the sample number, collection location, depth, time of harvest, name of person who took the sample. It also draws an outline of the land falling figures indicating the sample number and location of harvest.

3 DEVELOPMENT AND EVALUATION PROCEDURES FOR SAMPLING AND GROUND WATER SAMPLES

Taking into account that the provisions of existing legislation on the collection, preservation, transport and storage of water and soil samples and purchase of advanced equipment must be observed, the need to

develop new operational procedures came into prominence.

We specify that within LAFC (Laboratory of Physico-Chemical) there exist the OP-04 "water sampling" procedure, which will change by detailing aspects of sampling surface water, groundwater, and water samples municipal waste and / or industrial / technology.

An operational procedure was also developed for procurement, preservation, transport and storage of soil samples. In this respect have developed two new operational procedures, namely:

- Water sampling - OP 01 reports for sampling of surface water, groundwater wells, and wastewater and industrial / technological
- Soil sampling - OP 02 soil sampling report.

For each operational procedure was defined the same chapters as for the testing procedures.

Based on current standards and national legislation, two new assessment operational procedures were completed, namely:

- Assessment of water samples - PO 03, the assessment report on the physical and chemical parameters of water and
- Evaluation of soil samples - PO 04 evaluation report on soil parameters.

In order to asses the results of water samples, Government Decision no. 188/2002 for approval of discharge conditions of wastewater into aquatic environments, supplemented and amended, was taken into account. For performing the evaluation of the soil samples results we have taken into consideration the provisions specified in the Order no. 756/1997 on approving regulations on environmental pollution assessment, issued by the Ministry of Waters, Forests and Environmental Protection, which establishes [3]:

a. Normal values of chemicals and some metals traces, aromatic hydrocarbons and polyaromatic hydrocarbons from oil, organic compounds organochlorine (PCBs), organochlorine pesticides and pollutants to be reported if the threshold is exceeded.

b. alert thresholds on the types of sensitive and less sensitive uses the same trace chemical elements mentioned in pt.

c. intervention thresholds kinds of sensitive and less sensitive uses the same trace chemical elements mentioned in pt. a.

Evaluation report on the physical and chemical parameters water include:

• Name and address of the applicant
• Order no.
• Type of water sample

• Name of the evaluation,
• Point / Place of harvest (GPS coordinates)
• Number of test report the basis for the evaluation,
• Date of sample collection,
• Date of test,
• The legal document on which assessment is carried out,
• Table summarizing the assessment results,
• The sensitivity of the method,
• Conclusions and recommendations.

Evaluation report for soil samples, comprising:
- The purpose of the analysis,
- Location,
- The exact location of sampling points,
- Number of test report according to which the evaluation is:
- The number of samples taken,
- Time and date of collection (day, month, year)
- Characteristics local
- Depth of harvest
- The amount of sample collected,
- Name of the person who carried out the collection,
- Observations.

4 SAMPLING EQUIPMENT AND GROUND WATER

In order to respect the requirements of the soil and water sampling procedures, in order to further determinations of physical and chemical parameters according to the legislation in force, a series of equipments were purchased.

4.1. Sampler for surface water – Burcle TeleScoop model

a)

b)


c)


d)

Fig. no. 1 – a) Sampling of surface water - b) adjustable bar, from 115-300 cm, c) Sampler angular glass; d) sampler type stainless steel pendular glass

The telescopic handle is used for sampling surface water from lakes, rivers or sewage systems for domestic wastewater (Fig. no 1).

The telescopic handle is a sampling device, interchangeable for a variety of applications. The tools (angular beaker, glass stainless steel) are attached to the telescopic rod for multiple uses.

4.2. Sampler water samples from wells - EASY-FLOW model, Burca

Features and characteristics of the container (Fig. no. 2 and 3) of the Immersion:

- Fitted with Easy-Flow (valve optimized flow rate);
- Heavy cylinder (favoring rapid descent);
- Capacity: 1000 ml;
- High capacity (with handle), 427 mm;
- Made of anti-sparkle, copper or stainless steel V2A (for areas with potential exhibitors);
- Can be used in hazardous areas: IIA, IIB and IIC.

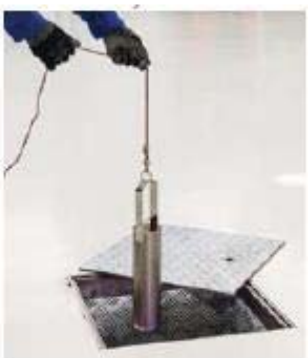


Fig. no.2 ,3- Systems of drilling water sampling

4.3. Thermostat thermoelectric Box - POL-EKO type preservation and transportation of water samples taken.

The box (Fig.no.4) is used for the transport of samples of water, wastewater, in compliance with the requirements of transport (stable at 4 ° C).

Fig.no.4- Thermostatic box

Features:

- The volume of the box, 25 l,
- The transfer of samples from the stable temperature of 4 ° C,
- Adjustable temperature from -18 to +10 ° C (stable temperature regardless of the ambient temperature),
- Internal or external batteries, power supply car or standard 230V, 50 HZ.

4.4 Sampler soil samples - Burke, Model MOLE

Equipment used for sampling to determine soil quality, humidity, etc, (is shown in fig. no 5).

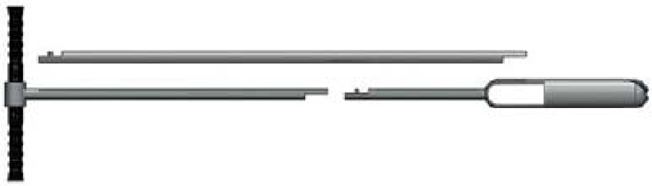


Fig. no. 5- Soil samples Burke, model MOLE

Shape sampler to minimize frictional forces which requires minimal physical effort from the user.

Mole sampler parts: handle stem 75 cm, 100 cm Extension rod seven bits available, each designed for a particular type of soil.

Extension bars allow increased sampling depth up to 5 m Mole device.

5. CONCLUSIONS AND SUGGESTIONS

Sampling of water and soil is an important step in the process of their physico-chemical analysis because samples must be representative, should not introduce errors caused by poor technique or improper conditions of preparation of the material, as errors caused by poor harvest can not be subsequently corrected.

Regulations that set physico-chemical parameter limits, for surface water, wastewater and soil are: - Ord. 161/2006 updated, which prescribes the classification of surface water quality to determine the ecological status of water bodies

- GD 188/2002 amended and supplemented by G.D 352/2005, which sets rules on their discharge into the aquatic environment of waste water

- Order 756/1997 update provides soil quality and soil pollution levels.

Following the purchase of advanced equipment used for collection, preservation, transport and storage of water and soil samples and in order to comply with legal provisions, came into prominence the development of new operational procedures.

Thus, four operational procedures were developed, namely:

- Sampling of water - OP 01,
- Soil sampling - OP 02,
- Evaluation of the results of water samples – OP 03,
- Evaluation results for the soil samples - OP 04.

Procedures OP 01 and OP 02 show how the sampling, preservation, transport and storage of water and soil samples take place, as well as their reporting.

Evaluation procedures OP 03 and OP 04 presents the results of analysis and their classification in legal provisions and their reporting.

For full compliance with the legal provisions in force and the requirements of the sampling procedures, purchase of the following equipment was required:

• *For procurement, preservation and transport of water samples,*

- Sampler surface water samples - Burkle Telescoop model,
- Sampler water samples from wells - EASY-FLOW model, Burke,
- Box / box-type thermoelectric thermostat POL-EKO preservation and transportation of water samples taken,
- Plastic containers for transporting water samples taken.

• *For soil sampling*

- Sampler soil samples with Accessories
- Burke, model and MOLE
- Bags conservation and transport of soil samples - ROTILABO model.

Based on these results we propose the comprisal of the procedures developed within the operational procedures of the Quality Manual developed by the Testing Laboratory of INCD INSEMEX - Petrosani Group.

REFERENCES

[1] - Decision no. 1403 of 19/11/2007 on the restoration of the soil, subsoil and terrestrial ecosystems have been affected

[2]- GD. 1408/2007 on how the investigation and assessment of soil and subsoil,

[3]- Ord. No 756/1997 updated, regulations on the assessment of environmental pollution

[4]- Ord. No. 184/1997 updated Procedure for Environmental Audits

[5]- Techniques wastewater Felix Stroe Technical Publishing 2011

[6]- The situation in Romania wastewater and sludge from sewage treatment plants, the Ministry of Environment Brochure public, Bucharest, 2012

[7]- Wastewater treatment unit processes, Technical University of Cluj-Napoca.

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

COMPUTATION OF POLLUTED AIR BIOLOGICAL FILTRATION SYSTEMS

ILDIKO TULBURE[*]

Abstract: *Beside desired effects industrial activities often have negative undesired effects on the environment and society. Currently there is the right moment to integrate new technological concepts for improving our life quality by reducing the environmental pollution. In this regard new approaches by using biological concepts have been considered. Biotechnologies for environmental protection did show good results, the most important element being represented by the biofilters. For biofilters modeling several aspects, also from the field of fluid mechanics, have to be considered. An example will be presented, where the applying possibilities of fluid mechanics into the biotechnological field will be emphasised.*

Key words: *biotechnologies, environmental protection, sustainable development, biofilters, fluid mechanics*

1. INTRODUCTION

In the time of raising the environmental consciousness of people in the world, some decades before, it became clear that human economic activities, especially industrial ones, do have beside the wanted effect of shaping a better life, also undesired environmental impacts. After the Conference for Environment in Stockholm in 1972 and the first report of the Club of Rome „The Limits to Growth" [7] was understood that besides wanted effects of technological progress, undesired and negative effects can appear. It was clear that the arisen regional and global environmental problems are very serious and need to be solved. Nowadays we confront us with several global problems, which can be grouped in three categories: world population growth, growth of energy and natural resources consumption and environmental pollution [5]m see Figure 1. Worldwide began discussions on scientific, political and social levels in order to find solutions for these problems, which could be applicable to the developed as well as to the developing countries.

The Brundtland Report of the World Council on Environment and Development represented a result of the worldwide political discussions to find solutions. The concept of sustainable development was for the first time defined in the Brundtland Report [11] and accepted as a possible solution for the global complex ecological, economical and social problems. This concept was very large discussed on the [2]Conference for Environment and

∗ *Assoc.-Prof. dr. ing. habil. at the University "1 December 1918", Alba Iulia, Romania, Tel: +40-(0)258-811512, Fax: +40-(0)258-812630 and Clausthal University of Technology, Graupenstr. 3, D-38678 Clausthal-Zellerfeld, Germany, ildiko.tulbure@tu-clausthal.de*

Development in Rio de Janeiro 1992 as well as stated in the closing document „Agenda 21“ (http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm).

Many actions after this time emphasize that the evolution of technical, social and ecological systems has to be analysed in synergetic relation [5], [6]. At this point several events can be mentioned like, for instance, the Western Cape Sustainable Development Conference 2005 in Cape Town, South Africa (http://www.capegateway.gov.za/eng/your_gov/406/events/101218) as well as the World Summit on the Information Society (WSIS), held in two phases, 2003 in Geneva, Switzerland, and 2005 in Tunis, Tunisia (http://www.itu.int/wsis).

Sustainable development has become a widely used term today. However, looking at texts dealing with the topic, the impression arises that there are as many definitions of sustainable development as there are users of the term [2], [10]. In order to make this concept more understandable rules, strategies and principles of sustainable development have been defined, see [5], [14]. One of the discussed strategies is the development of new technologies based on biotechnologies, that could be used in all fields of human activities, especially in the environmental protection.

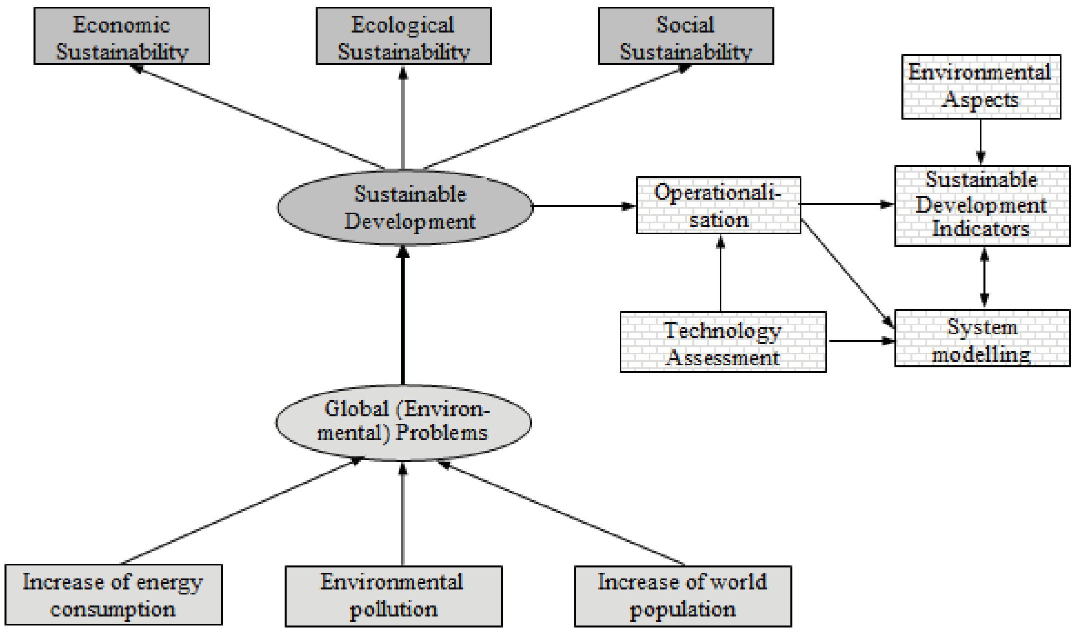


Fig. 1. Global (environmental) problems and the concept of sustainable development

2. METHODOLOGY TO APPLY SUSTAINABLE DEVELOPMENT

Applying into the practice the concept of sustainable development means the transformation or translation of its goals in political measures and controlling instruments. In the published literature regarding the application of the concept of sustainable development on different levels, two strategic possibilities can be found [2, 15]:

- establishing goals on global or national level, the measures to achieve these goals being prepared on global and national level and applied on national or regional level;
- establishing goals on regional level, the measures being prepared on regional or local level; but the possible effects of these measures being evaluated on national and global level too.

As an application example of the first strategy studies in form of scenarios could be mentioned, for instance with the goal to find future sustainable energy supply systems with minimal effects on the environment. Such a project has been realized at IIASA (International Institute for Applied Systems Analysis) in Laxenburg/Vienna „Global Energy Perspectives" [9] and another one was carried out in Germany, IKARUS, with the goal to deliver a concrete instrument to reduce the pollutants emissions in the air [17]. On this point international and national scenario studies could be mentioned, which try to find sustainable ways for the future national development in global context, for instance the actionplan „Sustainable Netherlands" by Friends of Earth Netherlands in 1992, the study „Zukunftsfähiges Deutschland" (Sustainable Germany) initiated from BUND (Friends of Earth - Association for Environment and Nature Protection) and Misereor and leaded by the Wuppertal Institute for Climate, Environment and Energy [2] or the study „Towards a Sustainable Europe" carried out 1995 by the Wuppertal Institute. The mentioned studies base on mathematical models to describe industrial and economic processes and their impacts. With the help of databases, which describe economic, social and political frames, simulations have been carried out and different development scenarios have been gained. The goal is to find the right ways to get the proposed aims and to help with concrete measures the decision making process on political level.

The second strategy is illustrated by many actions in form of Local Agendas 21 carried out especially in Western European countries after the Rio-Conference in 1992. Also studies concerning regional future energy supply systems in the context of economic, environmental and social impacts can be mentioned here, like the study about withdrawal from the nuclear energy program and existing options for Baden-Württemberg carried out by the Academy for Technology Assessment in Baden-Württemberg [13].

Sustainable development can be operationalised with technology assessment (figure 1). This actually means to analyse the stability of complex dynamic environmental, economic and social systems in order to try to discover possible developments which lead to instabilities [14]. In this context there are many fields where research is needed, as for instance mathematical modeling of environmental impacts of economic activities on regional level as well as defining sustainable development indicators [8].

In order to apply sustainable development a general methodology, materialized in the following steps, can be used [15]:

- defining the sustainability problem;
- establishing the space and time scales;
- systemic approach of the region by modelling the interactions;
- establishing concrete aims for the studied case;
- developing concepts and measures by establishing priorities;
- developing evaluation and control instruments, indicators;
- verifying the possible results, which could be obtained after introducing the proposed measures, comparing different scenarios;
- applying into the practice the developed concept.

The operationalisation is only possible, when for an individual problem-case concrete aims are established and from these aims concepts to achieve them are developed. Sustainability is to be newly defined for each different case [10]. The space and time scales are to be established for each case.

Very often for applying sustainable development, issues connected to environmental protection are very important [6, 15], especially nowadays, when the complexity of pollution processes is very high and not only technologies, but biotechnologies for environmental protection have to be used [12, 16].

3. BIOLOGICAL FILTRATION SYSTEMS OF POLLUTED AIR – BIOFILTERS

Biotechnologies are used for protecting different environment components: air, water, soil. In the followings especially biofiltration systems for polluted air will be discussed. Biological filtering systems of the polluted/ contaminated air from industrial activities represent one of the actual possible alternatives for air purification after its pollution, without affecting the natural environment [1].

The biotechnologies used for air cleaning have as a main component element the so-called biofilters. These bio-filters are based on different species of microorganisms, normally bacteria, used for cleaning the gas emissions.

It is to be mentioned from the beginning that these technologies used for air cleaning, but based on microorganisms, do not generally have a negative impact on the environment and there are as efficient as possible from a technical and economic point of view [3].

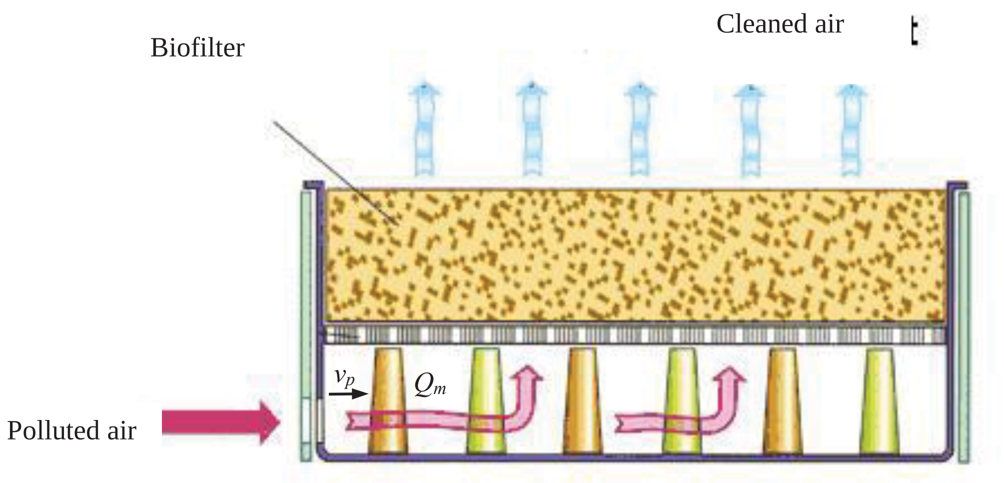
Biofilters, see Fig. 2, are used for polluted air cleaning and do have a technology based on micro-organisms, in most of the cases on bacteria, that are cleaning the specific pollutants, causing the air pollution. These bacteria do live in suspension in liquids or there are deposited on a solid support, composed of wood cap pieces or woody brown coal pieces [12].

The biofilters are in fact spongy filters, through which the polluted air is passing, as it is to be remarked from Fig. 2. The micro-organisms, deposited on the solid support of the bio-filters and fixed on the spongy undersurface, do represent the main component of the bio-filter, and do feed on specific pollutant elements from the polluted gas [12].

The biofiltering process is similar to other cleaning treatment processes, but in this case the bacteria do have the role of cleaning the polluted air, as it would be oxidated to get at the end CO_2 and water. The undersurface does assure the structural support and the essential nutriments for the microorganisms growing as well as reproducing, and the fact that this undersurface is spongy does represent the optimum surface conditions for the feet process for these microorganisms, taking into account that the gas pressure losses during its passing through the biofilter is also minimum. Considering the biofiltering process in this way, there are actually several issues connected to fluid mechanics, that have to be taken into account, as the optimum cleaning conditions of bacteria by feeding on specific pollutants is assured by achieving a certain flow velocity of the polluted air, v_p, and a certain mass flow rate, Q_m, through the biofilter, as it is to be recognised from fig. 2 [16].

When the polluted air does pass the bio-filter, the pollutants contained in the air do diffuse into the spongy structure, the bio-film, and remain there or are degraded. The pollutants are usually degraded by an aerobic process of biodegradation in the bio-filter. The get degradation efficiency by this procedure is usually over 90% , especially in the cases when water soluble organic substances are used, as for instance alcohol or aldehydes [12].

From this presentation it is more than clear that the cleaning capacity of a biofilter, this means the air flow rate, which can be cleaned in the respective biofilter, is depending on the microorganisms capacity of cleaning the polluted air, in most of the cases contaminated with heavy metals.



Q_m - Mass flow rate [kg/s]
v_p - Flow velocity of the polluted air through the biofilter [m/s]

Fig. 2. Biofiltering system and the structure of a biofilter

4. BIOFILTERS MODELLING BY ESTABLISHING THE DIMENSIONS FOR A SPECIFIC CASE

From a technical point of view, depending on the type of microorganisms used in the biofilter, which imposes the needed flow rate, by taking into account the maximum velocity, that can be adopted for the polluted air flow, it is possible to calculate the biofilters dimensions, which will be posed in the flow evacuation pipe [5].

If there are limitations regarding the maximum dimensions of the flow pipe, because of the total space being at disposal, which can be used for posting there the biofiltering system, it is a complex process to establish the optimum dimension of the biofilter, so that the cleaning process should be an optimum one, when the polluted air emission is known, and the biofilter will work in the most efficient way [12].

It is to be mentioned that the emission of the polluted air, E, can be understood as being the mass flow rate, Q_m, of the polluted air, passing the evacuation smoke pipe. The evacuation process through the smoke pipe, where the biofilter is also posed, can be represented as being a pipe flow, as presented in fig. 3. In this way the evacuation issue of the polluted air has been transferred to a problem from the field of fluid mechanics, where the concept of flow rates is very often used. In order to know the proper dimensions of the biofilter, that should be used, by a specific type of microorganisms, used in the biofilter, the theories and equations from fluid mechanics can be applied [12, 16].

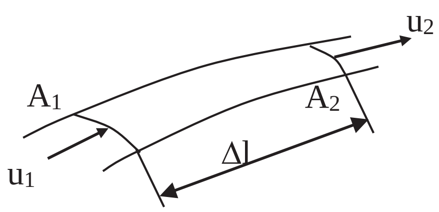


Fig. 3. Continuity equation for a pipe flow

By taking into consideration a pipe flow, as presented in fig.3, the continuity equation known from fluid mechanics for a pipe flow can be applied for modeling the biofilter, by given cleaning performances of the used bacteria in the biofilter [16]. The mentioned continuity equation has the following form:

$$Q_m = \frac{\Delta m}{\Delta t} = \frac{\Delta(V \cdot \rho)}{\Delta t} = \frac{\rho \cdot \Delta V}{\Delta t} = \frac{\rho \cdot A \cdot \Delta l}{\Delta t} = \rho \cdot A \cdot u \quad \text{[kg/s]} \qquad (1)$$

where:

Q_m - mass flow rate, in the presented case being the pollutant air emission
Δm - gas mass passing the pipe
Δt - time interval
ΔV - gas volume passing the pipe
ρ - gas density
u - flow velocity of the polluted air
A - surface through which the polluted air passes

By using relation (1) the necessary surface of a biofilter can be calculated by using the got relation:

$$A = \frac{Q_m}{\rho \cdot u} \qquad [\text{m}^2] \qquad (2)$$

In case that the gas density remains approximately constant, the volume flow rate Q_v can be used. By knowing the connection between the two flow rates types, it follows:

$$Q_m = \rho \cdot Q_v \qquad \text{[kg/s]} \qquad (3)$$

Taking into account this calculation way, the bio-filter surface can be obtained as given bellow:

$$A = \frac{Q_v}{u} \qquad [m^2] \qquad (4)$$

Table (1) does present possible dimensions *l* of the biofilter, having a square surface, *A*, resulted from specific calculations, when the polluted air emission, this means actually the mass flow rate, Q_m, is known. The mass flow rate does represent in this case the polluted air emission.

Table 1. Possible dimension of the square surface biofilter depending on the pollutant emission

Nr. crt.	Polluted air emission [m^3/h]	Optimum velocity, v_p [cm/min]	Dimension of the square surface biofilter, *l* [cm]
1	0,1	2	28,6
2	1	2	91,6
3	10	2	289,72

From the obtained results it follows that for often met polluted air emissions of about 1 m^3/h, for a necessary velocity that should be not more than 2 cm/min, in order to get the best cleaning efficiency of the polluted air [12], the necessary biofilter dimension for succeeding decontaminating the polluted air is about 91,6 cm. This calculation is made by considering *A* as being a square surface of the biofilter.

5. CONCLUSIONS

Biological filtering systems of the polluted air from industrial activities represent one of the actual used methods in order to clean polluted air. Biofiltering procedures do have applications in several industrial fields, where other cleaning methods do not bring the same good results as the usage of biofilters.

First of all biofiltering procedures do have a direct application in each field where unpleasant smells are to be recognised, unpleasant smells because of certain organic or inorganic substances available in the pollutant emissions. Presently there are several industrial fields, where biofiltering systems are successfully used, some of them being mentioned in the followings:

- food industry and meat processing field
- animal food processing industry
- waste and wastewater treatment
- paper manufacture and printing industry
- petrochemical industry, adhesive substances producing industry, oil recovery industry
- plastics industry and dye industry, tobacco producing industry.

In the present paper an example regarding modelling a biofilter is presented, by calculating the necessary biofilter surface, as well as the biofilter dimension, when the pollutants emission is known, actually the flow rate of the polluted air, as well as the maximum flow velocity through the biofilter, so that this can bring the best cleaning efficiency. For the biofilter modelling process, fluid mechanics notions and equations can be successfully used. This is demonstrating that actually solving environmental pollution issues needs an interdisciplinary approach, using basic notions and theories from different scientific fields.

6. REFERENCES

[1] Bank, M., *Basiswissen Umwelttechnik*, 4. Auflage, Vogel Buchverlag, Würzburg, 2000.

[2] BUND/MISEREOR(Ed.), *Zukunftsfähiges Deutschland, Birkhäuser*, Basel, 1996.

[3] Dieren, van W. (Ed.), *Taking Nature into Account, Springer*, New York, 1995.

[4] Eurostat, *Towards environmental pressure indicators for the EU,* European Commission, 1999.

[5] Jischa, M. F., *Herausforderung Zukunft*, second edition, Elsevier, Spektrum Akademischer Verlag, Heidelberg, 2005.

[6] Ludwig, B., *Methoden zur Modellbildung in Technikbewertung*. Doctoral thesis, TU Clausthal; Papierflieger, CUTEC nr. 18, Clausthal-Zellerfeld, 1995.

[7] Meadows, D. and D.: *The Limits to Growth*; Universe Book, New York, 1972.

[8] Mitchell, G.: *Problems and Fundamentals of Sustainable Development Indicators. In: Sustainable Development*, London, Vol. 4, Number 1, March 1996, pp. 1-11.

[9] Nakicenovic, N., Grübler,A., McDonald,A. (eds.): *Global Energy Perspectives*; Cambridge Univ. Press, 1998.

[10] National Research Council: *Our common Journey – a Transition toward Sustainability;* National Academy Press, Washington, D.C., 2000.

[11] Our Common Future, *The Brundtland Report to the World Commission on Environment and Development*; Oxford Univ. Press, Oxford, 1987.

[12] Petre, M., Teodorescu, A., *Biotehnologia protectiei mediului*. Editura CD Press, Bucuresti, 2009.

[13] Renn, O., Leon, C., Clar, G.: *Nachhaltige Entwicklung in Baden-Württemberg*; Akademie für Technikfolgenabschätzung in Baden-Württemberg, Stuttgart, 2000.

[14] Tulbure, I., *Zustandsbeschreibung und Dynamik umweltrelevanter Systeme*. Doctoral thesis, TU Clausthal; Papierflieger, CUTEC nr. 25, Clausthal-Zellerfeld, 1997.

[15] Tulbure, I., *Integrative Modellierung zur Beschreibung von Transformationsprozessen. Habilitationsschrift*, TU Clausthal. VDI-Fortschrittsberichte, Reihe 16, Nr. 154, VDI-Verlag, Düsseldorf, 2003.

[16] Tulbure, I., *Biotehnologii de protectia mediului (Biotechnologies for environmental protection)*. Curs. Universitatea”1 Decembrie 1918” Alba Iulia. 2012.

[17] VDI-Berichte 1043, *Instrumente zur Minderung energiebedingter Klimagasemissionen IKARUS*; VDI-Verlag, Düsseldorf, 1993.

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

ASPECTS REGARDING INDUSTRIAL POLLUTION AND MEASURING POLLUTANT EMISSIONS

ANGELICA CĂLĂMAR[*]
GEORGE ARTUR GĂMAN[**]
MARIUS KOVACS [***]

Abstract: *Trough environment protection's point of view, industry represents the most important field of anthropic activity. As a result of industrial operations, substantial quantities of carbon oxide, carbon dioxide, sulphur oxides and mostly SO2, nitric oxides (NO/NO2), cove hydrocarbons, volatile salts (chlorides, fluorides, sulphates), water vapours and so on are released in the atmosphere. Given the importance of emission and immision levels for environment's and general population's health, it is mandatory that measurements of their levels are made by laboratories experienced and authorized in this field of activity. Considering the above, the study outlines the imperatives of the effective legislation on gas measurements, dusts and hydrocarbons and the elements that must be considered when performing determinations for quantifying environment quality in industrial areas, using efficient equipments*.

Key words: *emissions, monitoring, pollution, environment, fixed sources*.

1. LEGAL BASIS AND NATIONAL MEASUREMENT PROVISIONS, COMPARISON WITH EU

At EU level, a series of regulations on air quality have been developed, namely:

Air Quality Framework Directive 2008/50/EC of the European Parliament and the Council of 21 May 2008, on ambient air quality and cleaner air for Europe, followed by the so-called "daughter directives", which set numerical limit values and target values for each of the identified pollutants. The "daughter" directive objectives are to consolidate monitoring strategies, methods of measurement, calibration and estimation methods to reach air quality measurements comparable with those in EU and provide definitive information to the public.

The directive was transposed and implemented through Law 104/2011 on ambient air quality.

---

* Senior Researcher III Ph.D. Eng. - Head of Laboratory, *National Institute* for *Research* and *Development* in *Mine Safety* and *Protection* to *Explosion – INSEMEX Petrosani,* e-mail: angela.calamar@insemex.ro; mobil: 072720077

** General Manager Ph.D. Eng., *National Institute* for *Research* and *Development* in *Mine Safety* and *Protection* to *Explosion – INSEMEX Petrosani*

*** Senior Researcher III Ph.D. Eng., *National Institute* for *Research* and *Development* in *Mine Safety* and *Protection* to *Explosion – INSEMEX Petrosani,* e-mail: marius.kovacs@insemex.ro

At EU level, the legal framework for industrial emissions is ensured by Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control). This European regulation is the result of reuniting seven different directives into only one, through the reformation procedure.

The main issues induced by Directive 2010/75/EU consist in extending the scope of the Directive by including new activities in its first appendix, obligation to apply the conclusions on best available techniques, imposing more stringent emission limit values for some pollutants and specific rules for inspection and control activities within its scope.

Directive 2010/75/UE on industrial emissions was transposed into national legislation through Law 278/24.10.2013 which recalls Law 84/2006, HG 128/2002, HG 699/, HG 440/2010 and the Order of the Ministry of Environment and Waters Management secretary, State Ministry and Ministry of Economy and Trade no. 751/870/2004.

2. EMISSIONS MONITORING

Monitoring of emissions is a necessary tool to control and implement specific requirements of effective regulations. It is also absolutely necessary mean of information on the contribution brought by different pollution sources and allows prioritization regarding downsizing pollution.

Determination of noxious content of emitted substances and measurement methods differ depending on the physical condition they are in, respectively gaseous (gas), liquid (vapours of different substances) or solid (sediment or suspended particles) [1].

• Major gaseous pollutants are: sulphur oxides; nitric oxides; carbon monoxide and dioxide; ammonia; fluorides; chlorides etc.

• Liquid pollutants are present in the form of fine particles or vapours of hydrochloric acid, nitric acid, sulphuric acid and so on;

• Suspended particles are solid pollutants of smaller dimensions, but whose specific weight allows them to float in the air;

• Sediment particles are micrometer-sized solid particles that are involved in ascending movements by the ascending currents of pollution source (air shaft) or those of the atmosphere, but who in calm atmospheric conditions are deposited on the ground.

Periodic measurements of emissions from stationary sources are widely used, especially where there are no available automated measurement systems, for permanent installation, or when the automatic measuring systems are considered inadequate because of technical or cost reasons.

These uses of measuring emissions from stationary sources, conducted for regulatory purposes include [1]:

- measurements to determine compliance with emission limit values;
- field-testing of automated measuring systems for conformity assessment;
- acceptance studies for new plans to reduce pollution;
- determination of emission factors for use in emission certificates trading and reporting records.

In order to prevent and improve air quality in order to avoid adverse effects on human health and the environment as a whole, an important role is played by the compliance of activities and facilities to European provisions on atmosphere protection. To that effect, ANPM's Atmosphere Protection Service monitors the implementation of European Union legislation on atmosphere protection, thereby ensuring alignment with international legislations and European Union regulations in the field of environmental protection.

3. DIRECT (DISCONTINUOUS) MEASURING METHOD

Monitoring of air pollutants emissions is performed mainly in order to verify compliance with the concentration limit values set by effective legislations or environmental authorizations.

Discontinuous emission measurements are necessary for punctually establishing, in a certain limited time, the emission behaviour of an installation [4].

Emission monitoring can be performed by the operator (self-monitoring) or by specialized accredited laboratories. Measurements must be carried out based on procedures complying with regulations and standards related to general requirements for measurement.

In order for the results to be able to be used for calculating emissions or assessing emission factors associated with a facility, they must meet the following requirements [4]:

The use of appropriate methods and use measuring equipment;

Provision of measurements representative ness;

Provision of time coverage and data capture indicated by effective regulations and standards;

Implementation and compliance with procedures for ensuring and controlling measurements quality control.

Typically, during test measurements, compound concentration in the exhaust gases is measured. Simultaneously, there are other measurements that have to be taken such as exhaust gases volume flow, which serves to convert concentration to emission rate (weight rate).

Pollutant weight rate is calculated by multiplying the measured concentration of the pollutant by effluent volume flow.

There are three types of techniques for discontinuous emissions measurement (test) [4]:

■ in-situ analysis, used for periodic campaigns - The equipment used is portable, being transported to the source location. Samples are taken from the effluent using a probe and analyzed in-situ.

■ laboratory analysis of samples taken using online fixed samplers - These samplers continuously extract samples and collect them in a special container. From the container is extracted quantity which is analyzed, obtaining the average concentration in the total collected volume.

■ laboratory analysis of instantaneous samples taken in sampling points - The amount taken must be sufficient to provide a detectable amount of the pollutant. Results represent instantaneous values, valid for the time when the sample was taken.

Continuous or discontinuous measurements of pollutants concentrations and process parameters are performed using relevant standards of the European Committee for Standardization (CEN) and ISO standards, national/international regulations meant to ensure the provision of data of an equivalent scientific quality.

Emissions monitoring/performing determinations involve the following steps: flow measurement, sampling, storage, samples transport and preservation, sample treatment, sample analysis, processing data, reporting data.

Total emissions from a facility or unit are given not only by normal emissions from shafts and pipes; diffused and fugitive emissions should also be considered. It is acknowledged that these emissions can cause potential health and environmental damage and that sometimes these flaws may have economic significance for a facility.

There are many reasons for performing discontinuous emission measurements. In addition to measurements required by relevant authorities, there also are measurements requested by station operators, such as measurements for self-monitoring or for optimizing the facility.

4. PERFORMING MEASUREMENTS

- ✓ **Selecting the distance and surface of measurement**

In order to perform a measurement of the emission values and obtain quality results, it is very important to carefully choose the measuring distance and surface. The place for performing trial measurement should be selected so that it reflects a representative measurement, in order to assess the emission behaviour of the installation [6].

In choosing the measurement surface it is preferable to select the areas behind the suction fan, because there it is more likely to find a homogeneous mixture of residual gases that in front of the fan. Taking samples for the measurement of substances in particulate form, from horizontal residual gases ducts, should be carried out along a vertical measurement axis, as there is the possibility of sedimentation phenomena.

The measurements of the measuring range should be sufficient for the assignment (fig. 1.) as follows:

- for accessing the measuring points it's necessary to prepare a fixed or mobile platform, ensuring a sufficient working space, required electricity connections, attending to given specific measures of occupational safety;

- measurements of the network have to be made, and then there must remain enough crossing space, in order to push the probes.

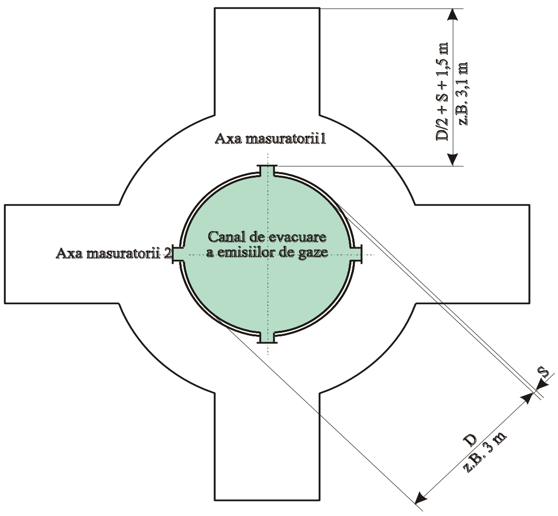


Figure 1. Model of measurement field from a perpendicular residual gas shaft, with 2 measuring axes and 4 measuring openings for performing crossing measurements

Working height [4] from field measurement to measurement axes should be about 1.2 to 1.5 m. Introduction of probes in measuring openings must take place in conditions of maximum security and should not be prevented by grids or protective guard rails.

Access holes in the shaft and measuring places have to be dimensioned in such a manner that they allow good sampling.

- ✓ ***Network measurements***

In order to perform a network measurement, the measurement cross section is divided into several equal areas. Figure 2 highlights the cross section of a rectangular duct, a round duct and dividing into equal areas. Rectangular cross-sections are divided in similar surfaces and round sections are divided into circular rings. The measuring points are found in the most important points of the divided surfaces [5].

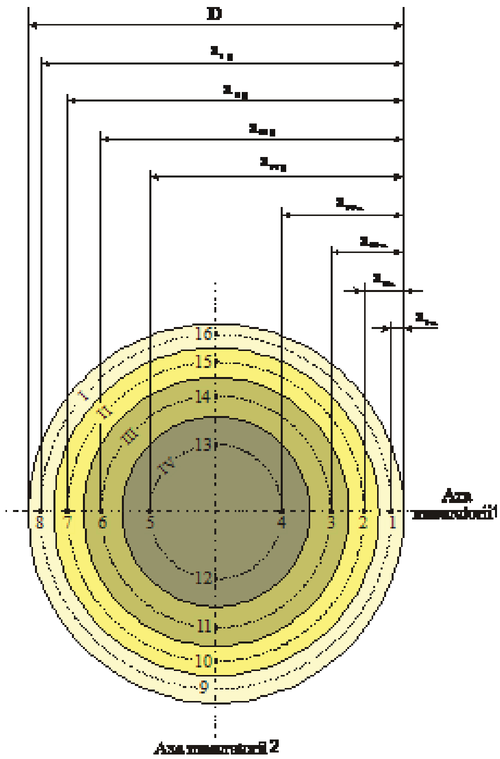


Figure 2 Positioning of measuring points in cross, rectangular and circular sections of a culvert

In the case of circular cross-section, distances between measuring points and duct walls are calculated using equation (1), in close liaison with the number "i" of subdivided surfaces and ordinal number "n".

$$a_n = \frac{D}{2}\left(1 \pm \sqrt{\frac{2i-2n+1}{2i}}\right) = DK_n \qquad (1)$$

i = number of subdivisions
n = ordinal number
D = chimney diameter

4.1. Isokinetic extractive sampling

Extractive sampling to collect particles, substances associated to particles or aerosols must be isokinetic sampling.

As isokinetic sampling corresponding to a previously established flow profile is concerned, at each measuring point the suction flow speed must be adjusted to the flow rate measured previously. Suction duration must be the same for each measuring point. A calculation of the density of different mass concentrations at different measuring points is automatically performed through the absolute sucked volume of the item being measured [7].

Automatic manual dusts sampling systems continuously measure flow rate or probe's pressure ratios and automatically adjusts the rate of suction.

4.2. Extractive sampling for gas measurements

Extractive sampling for gas measurement can be performed either in the form of network measurements (integrating the cross section), either punctual. Sampling from a measuring point in of the measurement range (punctual sampling) implies that the chosen measuring point has to be representative of the entire measurement cross section, regarding the mass density of the object's flow. This representativeness must be provable.

In order to more clearly describe a gas flow, one must follow the following parameters of residual gases: density, moisture content, temperature, flow rate and static pressure.

4.3. Evaluation / Making the report

In order to make an assessment, the measurement values are generally referred to a dry-gas volume at standard temperature and pressure. The measurement results refer to a time period of evaluation. Usually this time for evaluation corresponds the half an hour sampling period [6].

The measurement results are forwarded in the form of a test report. Besides the measurement results, the report also contain (according to EN 15259:2009) other adjacent information, important for the emissions measurement assessment and measurement results interpretation (sampling site description, measurement methods, equipment used, stage of installation functioning during measurement, and so on).

5. Monitoring equipment

Environmental Laboratory of INCD INSEMEX performs dust and exhaust gas emissions determinations (under RENAR accreditation) and measurements of volatile organic compounds emissions.

The sampling equipment used to determine emissions of dust, gas and VOC is of the latest generation, with heated sampling lines to avoid condensation.

All procedures regarding gas, dusts and volatile organic compounds emissions observe the effective standards, namely ISO / IEC 17025: 2005, SR CEN / TS 15675:2009, ISO 10396:2008, ISO 9096/2005, EN 12619: 2013 EN 15446: 2009.

5.1. Exhaust gases portable analyzer

The equipment is designed for determinations of nitrogen dioxide, nitric oxide, sulphur dioxide, carbon dioxide, carbon monoxide and oxygen concentrations in the emissions of stationary sources.

Samples are taken with the help of an internal pump unit and gas is cooled on the suction route, water vapors being condensed with the direct result that NO_2 and SO_2 have the lowest humidity absorption. Condense is pumped to the desiccators installed in the equipment's body [7].

Figure 3 TESTO 350 XL multigas analyzer

In case of continuous technological flow, the duration of a measurement is 30 minutes. If the technological flow is discontinuous then the time of sampling / measurement is considered to be the period with relevant records of gaseous effluent concentration.

5.2. BASIC ISOSTACK system for determinations of dusts from emissions mass concentrations

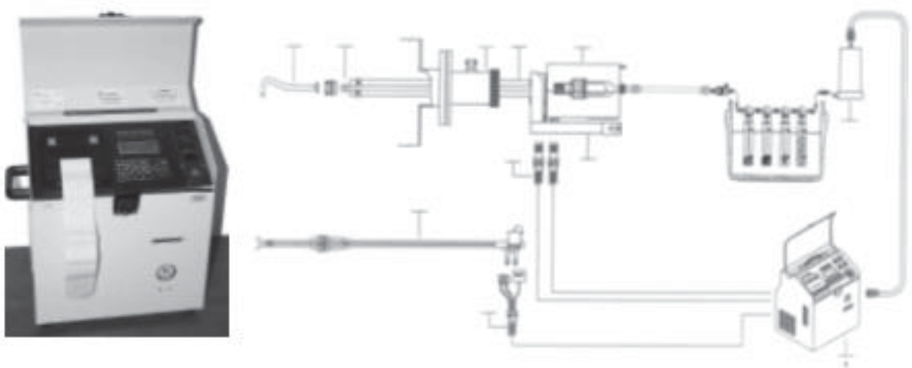


Figure 4 BASIC ISOSTACK systems for dust and gas isokinetic sampling

This equipment is designed for measurements of dust and gases from stationary sources (chimneys).

The ISOSTACK BASIC (figure 4) includes:

- ISOSTACK BASIC hot probe sampler;

- Quick gas entry connector;
- Raufilam suction tube, suction nozzle;
- Gas entry filter cartridge;
- silica gel Box to absorb moisture;
- Power cable, sampling filters.

The device can be configured in two sampling lines:

- Isokinetic particulate sampling line;
- Isokinetic gas line.

The method consists in sucking through the filter a known volume of air with the help of a isokinetic probe and weighing the dust mass deposited on it.

Extractive sampling for determination of pollutants concentrations can be carried out either as a network measurement (integrating the cross section) either punctual.

Sampling time for one sample is at least 30 minutes.

5.3. Analyzer for volatile organic compounds (VOC) determination

Determination of the total gaseous organic carbon mass concentration is performed by SmartFID analyzer (Figure 5), using flame ionization detector, according to SR EN 12619:2013, which is intended for use as a reference standard method for measuring the mass concentration of gaseous or vapor organic substances (expressed as TVOC) in emissions from stationary sources.

Measuring technique used by the flame ionization detector (FID) is the ionization of organically bound carbon atoms in a hydrogen flame.

Figure 5 SmartFID hydrocarbons analyzer

Flame ionization detectors (FID) are acknowledged as safe and robust analyzer to measure volatile organic compounds (VOCs) whose principle of operation (Figure 6) consists in chemical ionization of organic substances in a hydrogen flame.

6. CONCLUSIONS

- Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control) was transposed into national legislation by Law 278/24.10.2013;

➢ Compliance of activities and facilities to European provisions on atmosphere protection play an important role in prevention and improvement of air quality in order to avoid adverse effects on human health and the environment as a whole;

➢ Periodic measurements of emissions from stationary sources are widely used, especially where there are no available automated measurement systems, for permanent installation, or when the automatic measuring systems are considered inadequate because of technical or cost reasons;

➢ Monitoring of air pollutants emissions is performed mainly in order to verify compliance with the concentration limit values set by effective legislations or environmental authorizations.

➢ Environmental Laboratory of INCD INSEMEX performs dust and exhaust gas emissions determinations (under RENAR accreditation) and measurements of volatile organic compounds emissions.

REFERENCES

[1]. Radu Mihăescu – *Integrated environment monitoring*, Cluj Napoca, 2014.

[2]. *Guide for monitoring and auto-monitoring of sulphur dioxide, nitric oxides and particulate emissions, generated by large combustion plants*.

[3]. BREF, 2005 - *Prevention and integrated control of pollution - Reference document on best available techniques for large combustion plants*, http://eippcb.jrc.es, e-mail: JRC-IPTS-EIPPCB@ cec.eu.int.

[4]. Victor Voicu, 2002 – Combating noxae in industry – Editura Tehnică, Bucuresti.

[5]. SR EN 15259:2009 – *Air quality. Measurement of stationary source emissions. Requirements related to sections and measurement emplacement, measurement plan and report*.

[6]. SR CEN/TS 15675:2009 – *Air quality. Measurement in stationary sources. Applying EN ISO 17025: 2005 for periodic measurements*.

[7]. INCD INSEMEX Petroşani Test procedures.

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

THE INFLUENCE OF DIFFERENT ASH CONTENTS ON STERILE SLURRY FILTERABILITY

EUGEN TRAISTĂ*
CAMELIA BĂDULESCU*
DIANA MARCHIŞ**
NICOLAE CRISTEA*

Abstract: *This paper presents the research regarding the influence of ash on the filterability of sterile slurry from coal processing. For this there were made some fileterability tests using 1%, 3%, respectively 5% of ash content. After calculating the compression coefficient the best filtering installation was concluded to be press filters.*

Key words: *raw slurry, sterile slurry, filterability, ash*

1. GENERAL CONSIDERATIONS

Mining industry uses and returns to the environment relatively large quantities of water, resulted both in the process of preparation and during extraction. However, the most important polluting agents are coal processing plants with argillaceous suspensions as main contaminator. Released effluent flow rates are around 150 l/s, and solid flow rates are between 6000÷8000 g/s. Purification of these effluents implies solving two important aspects:

- Clearing waters through destabilization of argillaceous colloidal suspensions
- Draining and depositing sterile slurry resulted from clearing effluents.

In this paper only the second aspect of purification is dealt with, that is draining sterile slurry.

In the studied case, the processing plant uses press filters for draining sterile slurry. The main problem arising at the use of those filters is filter cloth loading. The rapid clogging up of the filter clot is due to the presence of ultrafine argillaceous particles (<10μm) in sterile slurry.

2. STERILE SLURRY CHARACTERISTICS

The granulometric composition of the mineral suspensions from treatment plants has a decisive influence on the coagulation and flocculation processes. In this paper the tests were conducted on representative samples from Coroesti processing plant.

---

* *Associate Professor, Dr.,Eng., University of Petrosani, Romania*
** *Lecturer, Dr., University of Petrosani, Romania*

As it is shown in figure 1 the -40μm class's share is 36%, and the -10 μm class's share is 43%. The large share of ultrafine material determines a high specific surface leading to high clearing reagent consumption.

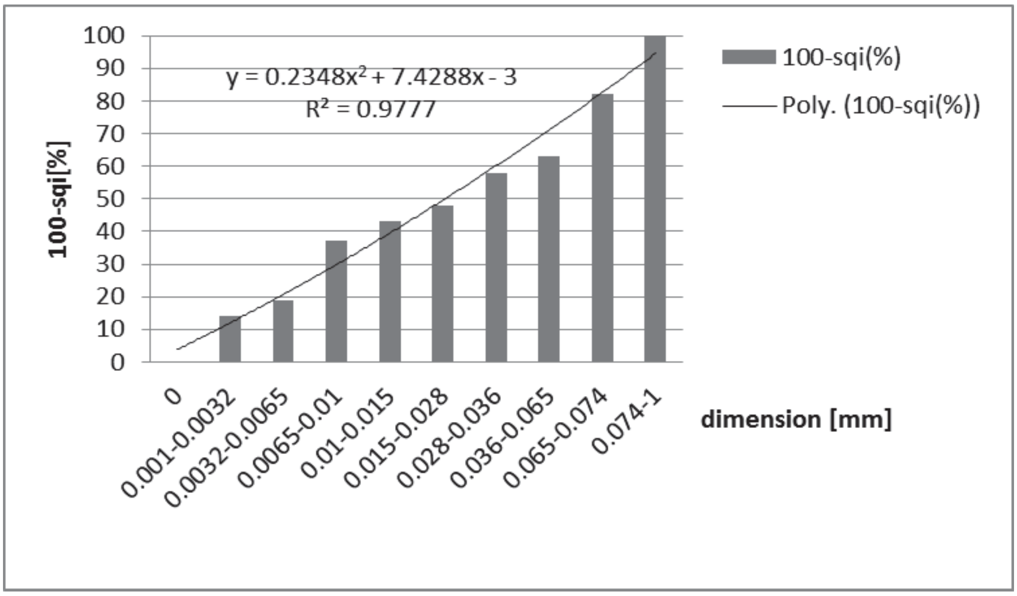


Fig. 1 Granulometric analysis of the raw slurry

Table 1 **Comparative results of the characteristics of press filters input and of filtered cakes on two types of slurry: sterile and raw**

Product	**Characteristics of press filters input**		**Characteristics of filtered cakes**		
	Concentration, g/l	Density, kg/dm^3	Humidity, %	Ash, %	Caloric Power, kcal/kg
Sterile slurry	471.2	1.12	20.4	63.26	1745
Raw slurry	704.5	1.292	28.1	46.95	2446

Analyzing the average values for the main qualitative characteristics of filtration products the following may be concluded:

- The concentration of the thick material is higher in the raw slurry leading to higher densities
- The humidity of the raw slurry cakes is higher than that of the sterile ones. This is explained by the fact that due to lower share of argillaceous slurry from the filters input and to the presence of grobe fractions inside cakes, between the coal particles remains a larger amount of water, which raises humidity in the resulting cakes.
- The ash content in the raw slurry cakes is lower leading to the improvement of the caloric power with 700 kcal/kg.

Filtration tests did not require great changes in the technological process. Although the raw slurry cakes humidity is higher, the filtration time is about three times lower than in sterile slurry cakes, because of the granulometry of filter input.

Filtration is an operation which results in dynamic conditions (unsteady) and which depends on a number of factors. Therefore, it seeks to avoid filtering operations, where possible. All of the large number of factors, can develop a pretty simple theory to be useful in practical terms. Existing Simple theories take into account only some of the factors involved in the filtration operation. However they explain the overall conduct of the operation and whether management complete experimental determinations may serve to design filters and filtration rational management.

3. DETERMINATING FILTERABILITY CHARACTERISTICS OF STERILE SLURRY

Wastewater sludges are complex colloidal systems with heterogeneous composition.

Knowing the filterability thereof is found to be necessary to choose a drying process and subsequent processing. Filterability was determined quantitatively based on the filter parameter called specific resistance "r" and the coefficient of compressibility "s". In practice, to determine the parameters of filtering is necessary to conduct tests filterability. These is carried out in the laboratory by standard methodology, filtration under vacuum, at a constant depression for several values Ap known volumes of suspensions. Using a Buchner funnel and the filter paper with medium porosity.

To determine the characteristics of filterability by calculation is necessary to determine the following parameters: - Filtration pressure constant during each experiment; - Volume of slurry subjected to filtration; - Volume of filtrate resulting from filtration; - Filtration time; - Humidity of the suspension before and after filtration; - cake mass of dehydrated suspension; - Dehydrated cake thickness;

The values of r and s are features that provide general information on the nature of the sludge, as follows:

r = 1010 -1013 cm/g characterize raw and urban sludge fermented;

r = 1012 characterize organic sludge industrial assets; s = 0 rigid sludge; s> 0 compressible sludge; s> 1 Gross municipal sludge and sludge fermented and some industrial; s <1 industrial sludges.

Compressibility index s was determined as line gradient of lg r=f(lg p).

Sterile slurry filtration or drainage coming from the tailings slurry settling tanks is in fact the most difficult technological problem of wastewater treatment process from coal preparation plants.

An advanced clearing has as result getting a thickened sludge hard filterable. A good coagulation, followed by an effective flocculation, removes these deficiencies. Also filterability can be improved considerably if you add ash to thickened slurry. Ashes role is to retain fine particles of clay in pores and also to prevent compromising the filtrate, by absorbing the ash particles to the surface flocks

4. THE IMPROVEMENT OF FILTERABILITY

To improve the capacity to be filtered of those slurries the effect of adding coal ash has been studied. Coal ash favorably influences filterability, through the following mechanisms:

- Adsorption of ultrafine argillaceous particles at the spongy surface of slag particles

- Adsorption of slag particles at the surface of useless slurry flakes when forming a filtering film.

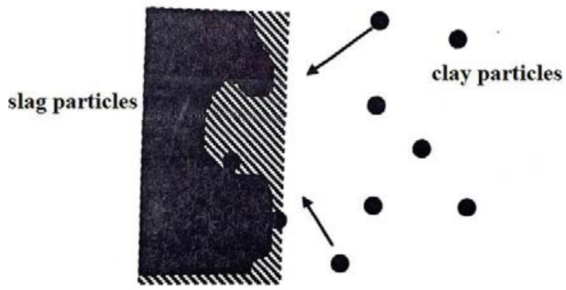


Fig. 2 Adsorbtion of ultrafine argillaceous particles at slag particles surface

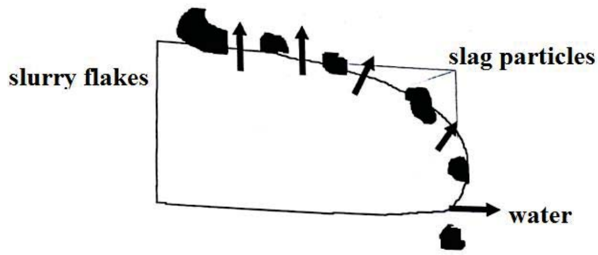


Fig. 3 Adsorption of ash particles at sterile slurry flakes surface

Filterability is quantitatively determined based on the parameter named specific resistance “r” and on the compressibility index “s”.

In practice, to calculate filtering parameters it is necessary to effect filterability tests. These were made in laboratory through a standardized methodology, vaccum filtering, at constant depression Δp values for known suspension volumes. A Buchner suction funnel is used, and as support medium porosity filter paper.

Figure 4 gives filterability tests for sterile slurry and figure 5 and 6, filterability testes for sterile in which 5% ash was added, particle size being <0.25 mm and >0.25 mm, respectively.

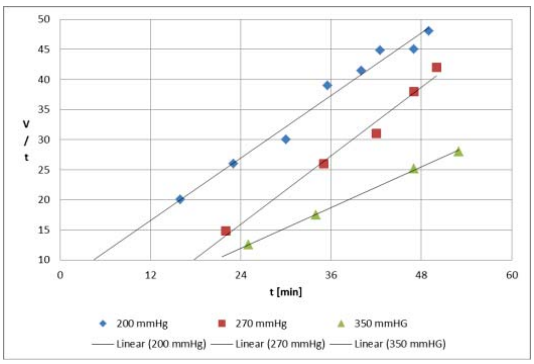


Fig. 4 Filterability tests for sterlie slurry

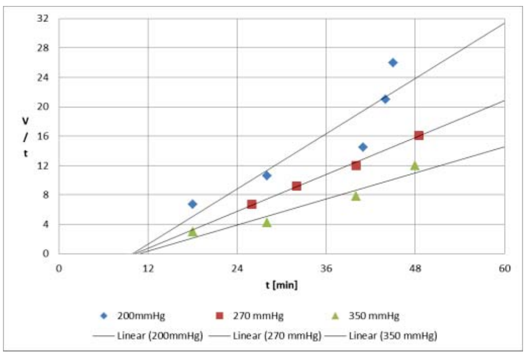


Fig. 5 Filterability tests for sterile slurry

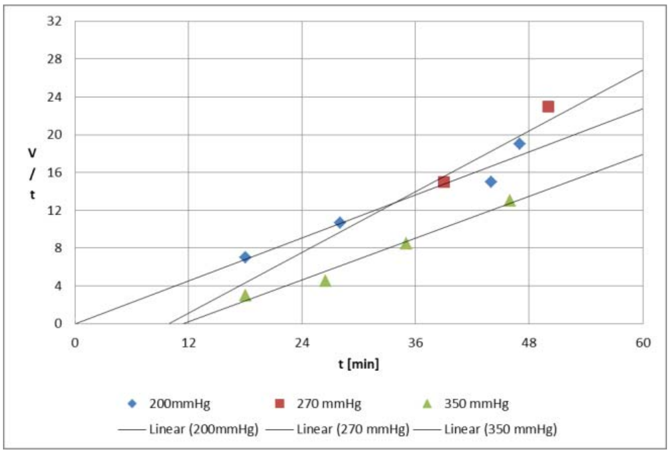


Fig. 6 Filterability tests for sterile slurry with 5 %, d>0.25 ash additive

Specific resistance to filtering (r) was determined by:

$$r = \frac{2 \cdot a \cdot P \cdot A}{\eta \cdot c} \quad [cm/g] \tag{1}$$

Where:

P – working pressure (dyn/cm^2)
A – filtering surface (cm^2)
η – filtrate viscousness (g/cm·s)
c – solid concentration in cakes (g/cm^3)
a- line slope which is determined either plotting or mathematical processing of experimental data representing the relationship of filtered volume - filtration time. The methodology of calculating "a" has as its starting point the equation of filtration, equation of the form:

$$t = a \cdot V^2 + b \cdot V \tag{2}$$

t - duration in seconds, necessary for harvesting the volume V (cm^3) of filtrate and a and b are parameters which depend on the nature of the phases and the container used for the filtration. The determination of the coefficients a and b are made using regression method (least squares estimation). For most cases, the coefficient b is not significant and can be considered zero. In this way simplifies the equation:

$$t = a \cdot V^2 \tag{3}$$

Using regression coefficient values to calculate the resistance values r deducted individual resistors filtration characteristics of each part. For compressible precipitates r is dependent on the operating pressure by the relationship:

$$r = r_1(\Delta n \cdot p)^s \tag{4}$$

where:

p - differential pressure (atm);
r_1 = precipitate specific resistance Δp= 1;
s = exponent which provides information about the compressibility of the precipitate: exponent called brackish water is dimensionless.
Determination of compressibility is made from the previous equation that logarithm:

$$\log r = \log r_1 + s \log(\Delta p) \tag{5}$$

ie an equation of the form y = A + sB
"s" exponent is therefore the line slope: $\lg r = f[\lg(\Delta p)]$

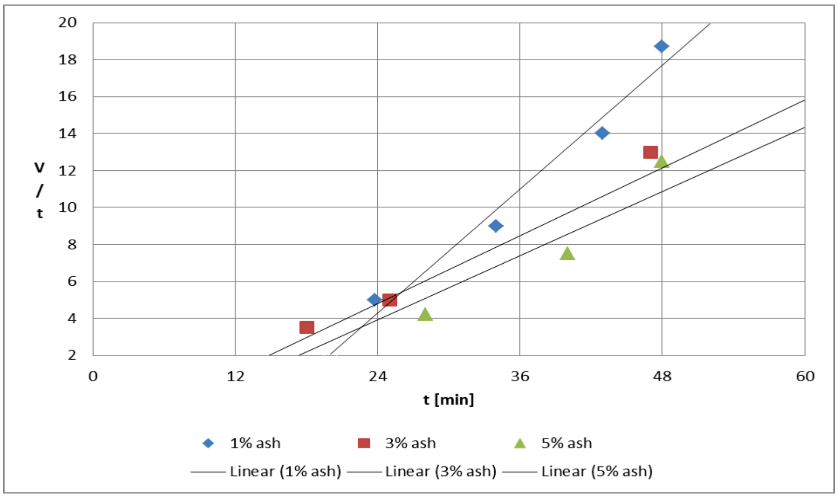


Fig. 7 Dependence of filterability on added slag concentration

The presented data show that filterability is much improved when slag is used with particles <0.25 mm. Figure 7 gives the dependence of filterability on slag concentration in sterile slurry.

It can be noticed that the best filterability of sterile slurries is achieved at 5% slag concentration.

5. CONCLUSIONS

Filtration tests did not require great changes in the technological process. Although the raw slurry cakes humidity is higher, the filtration time is about three times lower than in sterile slurry cakes, because of the granulometry of filter input.

Filterability is quantitatively determined based on the parameter named specific resistance “r” and on the compressibility index “s”.

The presented data show that filterability is much improved when slag is used with particles <0.25 mm. Figure 7 gives the dependence of filterability on slag concentration in sterile slurry.

It can be noticed that the best filterability of sterile slurries is achieved at 5% slag concentration.

6. REFERENCES

[1]. **Traista E., Ionescu C., Badulescu C.,** *Study on the Improvement of Filterability of Useless Slurry Resulted in Jiu Valley Coal Preparation Plants*, 5th International Symposium on the Reclamation, Treatment and Utilization of Coal Mining Wastes, Ostrava, 1996

[2]. **Krausz S., Ciocan V**., *Posibilitati de valorificare a slamului steril ingrosat sau filtrat,* Research Contrat SC ICPM SA, Petrosani, 1998

[3]. **Ciocan V., Badulescu C**., *Studiul posibilitatilor de valorificare integrala a slamului brut prin filtrare in filtre presa*, International Symposium Universitaria ROPET 2000

[4]. **Badulescu C., Traista E, Matei A.,** *Argillaceous suspension destabilization tests of wastewater with slurries*, Annals of University Petrosani, 2008.

[5]. **Sarbu R**, *Procedee si echipamente de epurare a apelor reziduale*, Focus Publishing House, Petrosani, 2008

Scientific Reviewers:
Prof. Ph.D. Eng. Romulus-Iosif SARBU

THE ECOLOGICAL REHABILITATION POSSIBILITY OF PESTEANA MINING AREA

GABRIEL NANU*
ROMULUS-IOSIF SARBU**

Abstract: *Ecological rehabilitation of mining sites with must consider not only the standard works, but consider the possibilities of socio-economic regeneration of the mining regions. At present accent is increasingly on the development of natural environments, agriculture and landfills. This paper aims to provide some solutions to environmental rehabilitation of mining Peşteana.*

Keyword: *environmental restoration, natural environment, agriculture, waste landfills, mining areas*

1. INTRODUCTION

The lifecycle of an opencast mining, the last step consists of decommissioning and environmental rehabilitation of its.

Pollution and risks to human communities and natural ecosystems of the sites do not disappear with the cessation of mining activity exploiting minerals, but also continues after their termination. Sit mining sites still remain pollution sources and the ecological risk.

The design of environmental rehabilitation of the mining sites with must consider not just the standard works, but also consider the possibilities of socio-economic regeneration of the mining regions (mainly mono-industrial regions).

Using a conceptual rehabilitation plan as a basis and the interpretation of survey results, which are compiled detailed rehabilitation plan for mining, and implementation on the site, of 630,5 ha. It is also necessary to achieve a cost model will be developed a system for monitoring and evaluation of environmental quality.

Today the focus is increasingly on the development of natural environments due to increasing human needs for recreation, agriculture and landfills.

Ecological restoration is the process intended to restore and stabilize an ecosystem which is in a state of deterioration, to restore the structure, function, and dynamics of diversity.

Ecological restoration strategies of degraded ecosystems can be four categories:

- **natural regeneration** - can be defined as a way of restoring natural means also without human intervention usually of a certain ecosystem;

- **ecological recovery** - is a process of ecosystem restoration, conducted by humans based on knowledge provided by natural regeneration processes;

---

* *Ph.D. student, at the University of Petroșani*
** *Prof. Ph.D. at the University of Petroșani*

- environmental rehabilitation - is the restoration is partially achieved certain ecosystem functions or some of its components;

- ecological restoration by substitution - is to restore the ecological retrogression after a new type of ecosystem, both native species and alohtone species. (Dinu, M., Cioaca A, 1998)

2. ECOLOGICAL RESTORATION POSSIBLE MINING PERIMETER PESTEANA

The restoration work ecological, mining area Peşteana, wish to remove sources of pollution, minimizing the effects of pollution on the environment and reintegration in the natural landscape of the area.

Ecological restoration the possibilities are multiple Peşteana perimeters, considering morphology of the area and local community needs, they are:

- the use of space exploited South Peşteana of the quarry as the household waste deposit;
- arranging a recreational area in North Peşteana quarry;
- afforestation, dump interior of the North Peşteana quarry,

2.1. The use of space exploited South Peşteana of the quarry as the household waste deposit

In order to use the remaining space by exploiting substance minerals as the landfill waste, measures are needed waterproofing to prevent any possibility of penetration of possible chemical compounds into the groundwater of the adjacent area, which may have serious environmental consequences on a stretch very great (Marunteanu, C., Stanciucu, M., 2001). The choice of optimal waterproofing system is made taking into account a number of factors, among which: nature of the waste to be stored; hydrogeology conditions; geomorphology of the area; stresses that may occur during operation; the nature and characteristics of the material used;

The waterproofing system has to ensure: tightness of the entire deposit; chemical and thermal stability compared to the deposited waste and foundation rocks; mechanical resistance to the efforts that occur during construction and during use; resistance to meteorological phenomena (including frost, high temperatures also ultraviolet radiation); dimensional stability to temperature changes; endurance to aging; sufficient elasticity of also breaking strength;

Realization of waste deposits, resulting from domestic activities should take into account a number of technical, economic and social criteria, which also include:

- *opportunity and necessity of planning waste landfill;*
    - in sizing deposit storage capacity calculation (area and volume of stored) must take into account the average amount of waste, given that the period of operation of the deposit must be 15-20 years;
    - placement, training and dimensioning of waste landfill in order to ensure optimal storage capacity, the investment and operation costs minimal;
- *the design of domestic waste landfill:*
    - considerations regarding of domestic waste landfill stability under adverse effect of infiltrations (figure 1.);
    - of the foundation verifying overpressure of domestic waste landfill;
- *environmental protection measures to also possibilities for using domestic waste;*
    - preventing environmental pollution with substances entrained in deposits;
    - prevention in disaster areas adjacent to the destruction caused by their structure and movement of these residues;
    - air quality protection area of domestic waste landfill;

- supervision of waste deposits behavior through specific means, both during the operation and after exhausting the deposition space providing reintegration into the economic and the ecological lands occupied;
- composting domestic waste possibilities and their use in agriculture.

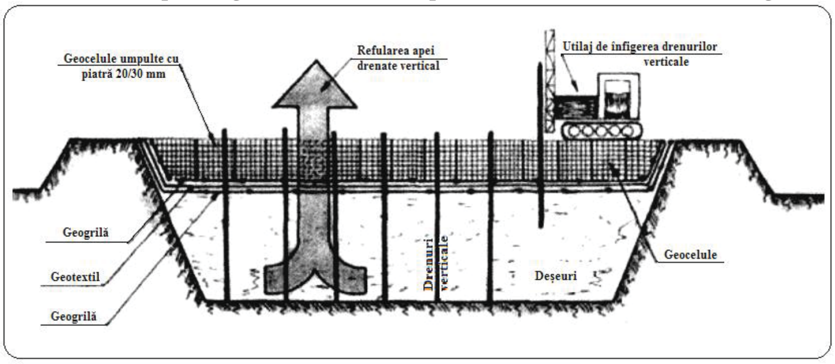


Figure 1. The waterproofing of a household waste deposit, (Marunteanu, C., Stanciucu, M., 2001)

The land used for the storage of household waste must meet a number of geological, geotechnical and hydrogeological including:

- geological structure stable and healthy, with no faults or karst formations under landfill site;
- argillaceous texture or predominantly argillaceous;
- groundwater levels to the quota removals are at a depth greater than 5 m;
- to be possible on the basis of a stable version, which present no danger of sliding;
- to avoid coastal areas with springs or streams near some permanent or nonpermanent;
- geotechnical characteristics of the land to store safely the effective economic heights (h_d < 40 m)

The site selection will avoid areas of underground cables (electrical, telephone), underground pipelines (water supply, sewage, oil, industrial liquids) and the above-ground utility areas (ex. high voltage power cables).

Municipal waste generated and collected waste generated comprise both (mixed selectively to ensure that collection and transport by specialized operators or service organized within local government) and waste generated and the not collected.

Table 1 lists the quantities of municipal waste generated at Gorj County, according to the Regional Waste Management Plan for Region IV South West Oltenia and the PJGD conducted in 2013 and other data available at APM Gorj. Regarding the amount of municipal waste collected selectively, the amounts declared by sanitation operators were added and quantities of waste collected from households by economic agents authorized to collect recyclable waste.

The rural areas of the region are areas where waste collection services are not provided to the same degree as in urban areas.

No or insufficient statistics report, calculating waste collected for rural as well as urban areas, are based on two indices generation used in the National Waste Management Plan and the Regional Waste Management Plan. These are:

- 0,9 kg / habitant / day in urban areas; (3285 tones / person / year),
- 0,4 kg / habitant / day in rural areas; (0,146 tones / person / year).

Table 1. *The evolution of municipal solid waste in the last 5 years in Gorj*

Wastes		Quantities (tones)				
		2010	2011	2012	2013	2014
1.	Municipal and similar waste from commerce, industry, institutions, of which:	133.765	131.939	140.813	136,651	136,956
1.1.	Mixed household waste collected from population	54.690	48.100	37340	42.597	33.33
1.2.	Assimilated domestic wastes collected from commerce, industry and institutions	46.300	51.900	47600	42.923	27.755
1.3.	Municipal and similar waste collected separately (excluding construction and demolition waste), of which	7.737	9.060	10610	12.850	16.932
	Paper and paperboard	389	418	868	1.039	1.055
	Plastic		5	21	494	684
	Metals	7.348	8.637	9.721	11.317	15.193
1.4.	Large waste			50		
1.5.	Waste from gardens and parks	680	210	1.144	674	856
1.6.	Wastes from markets	743	331	1.854	1.338	1.926
1.7.	Street waste	915	938	2.519	1.847	4.794
1.8.	**Wastes generated and collected**	**22.700**	**21.400**	**39.696**	**51.801**	**58.938**

Source: Environmental Protection Agency Gorj and the sanitation operators

The storage capacity in South Peşteana of the quarry goal remaining is 100.000 tones / year, an estimated lifetime of 24 years. Site area will be divided into storage cells, each cell will have an area of 1,3 ha, and the storage capacity will be 200.000 m^3/cell, and the estimated duration of 4 years running.

The warehouse will serve approximately 40,000 inhabitants ecologically from southern county of Gorj, it will be dimensioned to have the necessary capacity to take household waste in the county.

The total area is 13.7 ha project repository and the total capacity of the entire deposit will be about 2.400.000 m^3 (cells will be built in stages from 1 to 10). (Figure 2)

2.2. Recultivation works in South Pesteana quarry

Restoring land degraded by lignite quarries, constitutes a claim for restitution of the useful capacity, or soil production through technical and biological treatments. Fertilization and restoring land degraded is a primary concern of specialists and requires harmonious cooperation between a large number of scientific and technical disciplines, (Huidu şi Jescu, 1987). The biological recultivation means proper cultivation lands cultures.

Environmental rehabilitation of vacant land from its technological, after coal mining activity involves a complex technology that can be achieved through the collaboration of several specialties and the several steps of which are two essential:

- Phase I - Landscaping;
- Stage II - The recultivation.

Considering the appearance of the dump, the general form that are to be conducted by the stakeholders in the redevelopment of the area must allow the classification to be landscaped into production within the natural area.

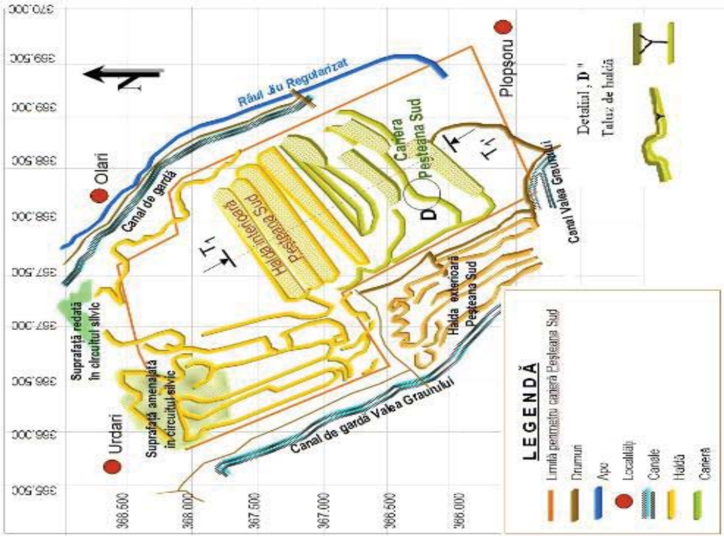


Figure 2. Ecological rehabilitation plan South Peşteana Quarry

The perimeter will be arranged in the form of a plateau with a slope of 0 to 5%, and deposits in the form of strings, will be equalized.

Sloping surfaces resulting from the arrangement will have a slope of 15% (the plateau) and slopes bordering them will have a slope of 29%. The areas resulting from decorations with slopes over 15% will be forested, and the final use of the perimeter will be consistent with the demands of the local community.

As regards water management, to avoid or reduce erosion processes, especially on slopes. Areas with a slope up to 5% should be modeled with a slight slope to drain without unevenness, depressions in small spaces and the areas where stagnant water.

Following Anthropic functional framework arrangement improvements are needed the physicochemical characteristics of the material stockpile, ensuring edaphic conditions for creating a fertile layer and further development of biodiversity.

It will achieve ameliorative fertilization with mineral and organic fertilizers in varying doses depending on the state of supply organic matter, nutrients (phosphorus and potassium) of the material from the dump. Fertilization fertilizer for this step is considered basic, run-of the phase II of the play into production respectively (biological re-cultivation stage), which is the subject of a study phase agrochemical that are to be executed later.

Doses of mineral fertilizers are recommended by soil studies:

- 450 kg/ha s.a. phosphorus,
- 450 kg/ha s.a. potassium.

In order to set the conditions for stability of the dump, it is necessary that the restoration works to achieve:

- existing drainage ponds (then reverse, run terraced embankment works);
- eliminating depression areas by obtaining the appropriate slopes;
- reducing the slope of the step slope stability conditions;
- water drainage of a permanent nature open channel;
- the works erosion, on slopes as a complementary modeling (afforestation stage II).

Of the total area of 162,5 ha, modeling works are designed on 54,5 ha the area of perimeter South Peşteana.

On the area of the proposed dump forestry use, does not apply to earthworks.

The main design base for this category of work, was the situation with topographical plan Sc. 1: 1000.

Department location profiles modeling followed the line of the greatest slope embankments, to play in the right size general slope angle of descriptive terms. Usually, this direction coincides with the direction of circulation through earthmoving earthworks.

On modeling cross sections have been established pickets at each change of slope, taking into account the density of the points drawn from surveying.

In the absence of quotas relating picket topographic so established, it proceeded to obtain quotas by linear interpolation using the nearest allowances from one side and the other cross-sectional modeling.

Through the work of reprofiling was to obtain cumulatively the following questions of general interest:

- transport distances earthmoving vehicle to be minimal;
- conveying the upstream embankment to be carried by the downstream, and possibly where it is not possible maximum vehicular slope of the downstream side in the upstream direction to be less than 3%;
- obtaining relief with as small differences in slope between two adjoining profiles or obtain a uniform relief, mapping groups of slopes;
- to avoid depressions by planning, leading to local accumulations of rainwater;
- connection of the area of interest, with final rates of landfill wooded of the area on the north side and northwest;
- providing further opportunities for landscaping dump, without being affected area restored into the economic. Also, if further development works would require re-profiled of the area damage within the boundaries set.
- increasing the supply of individual slope stability by reducing the slope respectively downloading Prism active upstream slope area, and loading Prism passive (resistance) in the downstream area. As observation reserve slope stability will be enhanced by subsequent afforestation works, which provide the area bio-drainage.

For the reasons described herein, they are located on the plane of the case in a number of cross-sections of the molding 83 placed at equal distance of 30 m to several groups with different orientation.

Considering how further use of the landscaped of the area will be Silva slopes and areas for composting platform plateau slopes mapping was done on two groups presented in Table 3.

Table 2. *Further use of the landscaped of the area*

Type of surface	Slope (%)	Surface (ha)	Directions for utilization earlier
the modeled surface	0 ÷ 12 %	23,44	Platform compost
modeled slopes	15 ÷ 29 %	14,40	Grass surface
unshaped surface	0 ÷ 12 %	2,96	Access roads, drainage channels
unshaped slopes	> 29 %	108,0	forested area
the modeled surface deposit (L=514 m x l = 200 m)	0 ÷ 12 %	13,70	Household waste deposit
Total surface:		**162,5**	

The slopes are obtained after fitting oriented marginal areas or rainwater on the surface landscaped of the area will be directed to the outside of designated areas.

Work technique for setting the dump was designed by bulldozer trenching or pushing, due to the high degree of inclination of the land.

The volume of earthwork related modeling work is 284280 m^3.

Cubing of earthworks specific area of 162,5 ha reported to be 3143 m^3 / ha.

Modeling profiles will be drawn according to coordinates marking field related tables on the plan situation, earthworks movement.

Land leveling, a category of works is absolutely necessary in order to remedy deficiencies arising from reprofiling cover local irregularities and the achieve connection between profiles. As thee area has many lowland areas, subsidence is differentiated, leveling entire surface was laid readjusted. Work leveling will be executing tracked bulldozer.

CONCLUSION

From the field studies on soil sampling of the stockpile interior, I found that some areas have been afforested with acacia integrating these degraded lands anthropogenic landscape zone. As early as the 2010, sown crops have been satisfactorily without previous fertilization or irrigation of these lands.

To eliminate the impact Peşteana Nord quarry, on the environmental components, we proposed setting a recreation area. In arranging this area, I found it necessary to design the layout of all the elements taken into account. The steps quarries have decided to be afforested with acacia view that stabilization will be achieved more quickly.

REFERENCE

[1]. Bauer, A.M. (1970), *A guide to site development rehabilitation of pits and quarries*, IMR 33, Ontario Department of Mines, Toronto, Canada

[2]. Bhattachaya, S.-Singh, M.M. (1985), *Development of subsidence damage criteria*. Office of Surface Mining, United States Department of the Interior, Washington DC. In: Bell et al (2000). Mining subsidence and its effect on the environment: some differing examples. Environmental Geology 40, 135-142 pp

[3]. Bradshaw, A.D., Chadwick, M.J., (1980), *The Restoration of Land*, Blackwell, Oxford.

[4]. Cairns, J. Ed., (1994), *Rehabilitating damaged ecosystems*, Lewis Publishers.

[5]. Elliott, R. J., (1976), *The Kerr Quarry Project, In: Landscape and land use planning as related to mining operation*, Australian Institute of Mining and Metallurgy, Victoria.

[6]. Ruthrof, K.X., (1997), *Improving the success of limestone quarry revegetation*, Cave and Karst Science Vol. 24.

Scientific Reviewers:
Prof. Ph.D. Eng. Romulus-Iosif SARBU

STUDY OF SO_2 EMISSIONS RESULTED FROM COMBUSTION OF JIU VALLEY COAL

LIANA SIMONA SBIRNA*
CLEMENTINA SABINA MOLDOVAN**

Abstract: *This paper reports the results obtained for the emissions of SO_2 from a large coal under staged combustion without any additive. The experiments were carried out at fluidizing velocities of 1 and 2 m/s, bed temperatures of 1000-1100 K, 20% and 40% excess air, at a primary air staging of 70:30 and a secondary air staging of 60:40, by using bed particle sizes of 0.2 and 0.7 mm. The effect of each of these work parameters on SO_2 emissions was investigated, in order to draw the conclusions of the study.*

Keywords: *Jiu Valley coal, sulfur dioxide emissions, FBC technology*

1. INTRODUCTION

Coal, which is primarily used for the generation of electricity, is one of the largest domestic contributors to sulfur dioxide emissions. The public has become more concerned about global warming which has led to new legislation.

The coal industry has responded by running advertising touting clean coal in an effort to counter negative perceptions.

Fluidized bed combustion (FBC) is a combustion technology that is based on suspended solid fuels in upward-blowing jets of air during the combustion process. The result is a turbulent mixing of gas and solids [5].

The mixing action of the fluidized bed brings the flue gases into contact with a sulfur-absorbing chemical, such as limestone or dolomite.

More than 95% of the sulfur pollutants in the fuel can be captured inside the boiler by the sorbent. The sorbent also captures some heavy metals, though not as effectively as do the much cooler wet scrubbers on conventional units.

The literature reports that FBC technology involves either two beds in series with two distributors or a simple air staging technique.

In the staged operation mode, the combustion air is separated into a primary air stream.

This constitutes the fluidizing air supply to the bed and a secondary air stream that is injected higher up in the bed or freeboard [3].

Combustion is then completed following the introduction of secondary air. However, overall excess air conditions are maintained in a similar way as in conventional operation.

---

* *Ph.D., University of Craiova*
** *Ph.D., University of Petrosani*

Air-staging is a proven technique to reduce NOx emissions, but is known to increase in SO_2 emissions.

This increment is due to the presence of secondary air in the freeboard that allows further combustion (it seems that at high staging this increment is caused by the carryover of unburned fuel sulfur into the freeboard).

The objective of this study is to determine the effects of different work parameters on SO_2 emissions.

One can compare the efficiency of SO_2 reduction with the one obtained if a sorbent is added to the bed (as previously mentioned, a sorbent denotes here a sulfur-absorbing chemical, such as limestone or dolomite).

Bed temperature exhibits a significant effect on SO_2 emissions which indicates that the rate of formation of SO_2 in the freeboard is affected by staging and changes in the temperature profile of the freeboard [1].

In this study, the simple air staging technique was adopted where most part of the total air is injected through the distributor and the remainder is injected in the freeboard of the fluidized combustor.

2. EXPERIMENTAL

A stainless steel combustor, 0.3x0.3 m in cross section and 2 m high was used.

Fluidizing air was supplied through a multi-hole distributor. An adjustable secondary air injector was used along the vertical axis of the combustor to introduce secondary air in the freeboard.

Investigations were carried out at 20% and 40% of total air injected in the freeboard above the bed, at a primary air staging of 70:30 and a secondary air staging (primary/secondary air) of 60:40, whereas the fluidizing velocities were of 1 and 2 m/s, bed temperatures of 1000 and 1100 K. The bed particle sizes were of 0.2 and 0.4 mm [2].

The fluidized bed was preheated by a propane burner, fixed above the bed, and the fluidizing air flow rate was set at the lowest level to minimize the heating time.

The secondary air was injected through a secondary air injector consisting of a stainless steel pipe with a 15 mm inside diameter, containing twelve holes of 3 mm diameter. This injector was located on the vertical axis of the combustor and its position above the bed or in the freeboard was adjustable. The bed temperature was maintained by using an adjustable cooling coil [4].

Coal sampled from Jiu Valley was used in the experiments.

3. RESULTS AND DISCUSSION

Coal feeding started when the bed temperature reached 1000 K.

The proximate and ultimate analysis of coal is given in Tables 1 and 2.

Table 1. Proximate analysis of coal used

Proximate analysis (dry basis)		Weight (%)
Ash	6.23	6.22
Volatile matter	33	33.00
Fixed carbon	60	60.78

Table 2. Proximate analysis of coal used

Ultimate analysis (dry basis)		Weight %
Carbon	70	77.51
Hydrogen	5	4.8
Oxygen	8	8.5
Nitrogen	1	1 .43
Sulfur	11	15
Moisture	5	5.0

Values of SO_2 emissions were continuously recorded.

More specifically, the SO_2 in the flue and the axial concentration profiles of SO_2 through the combustor were measured for a fluidizing velocity of 1 and 2 m/s; the bed material was sand, of about 0.2 and 0.7 mm size respectively, staging 70:30 and 60:40, excess air 20 and 40%, at bed temperatures between 1000 and 1100 K (the Ca:S molar ratio was found to be approximately 3:1).

The results (*i.e.*, the values of SO_2 emissions – measured in ppm) are summarized in Tables 3 and 4 for the two particle types that were used. As is obviously that the particle size does not practically affect the results, one may reduce the study to the one involving the particles of 0.7 mm.

Table 3. The values of SO_2 emissions (ppm) for the case of 0.2 diameter sand particles in fluidized bed

	70:30	60:40	70:30	60:40	
1 m/s	627	670	653	700	40%
1 m/s	689	719	703	823	20%
2 m/s	731	781	833	904	40%
2 m/s	818	885	1020	1204	20%
	1000 K	1000 K	1100 K	1100 K	

Table 4. The values of SO_2 emissions (ppm) for the case of 0.7 diameter sand particles in fluidized bed

	70:30	60:40	70:30	60:40	
1 m/s	628	670	653	700	40%
1 m/s	690	720	703	823	20%
2 m/s	732	780	834	905	40%
2 m/s	818	885	1020	1205	20%
	1000 K	1000 K	1100 K	1100 K	

4. EFFECT OF DIFFERENT WORK PARAMETERS ON SO_2 EMISSIONS

It shows that the SO_2 emissions decreased when the amount of the secondary air was increased and the fluidizing velocity decreased. One may notice that the SO_2 emissions are sensitive to bed temperature, increasing as it increases.

The SO_2 emissions at different secondary air ratios appear to be affected by combustion efficiency.

They exhibit higher values at higher secondary air (which equals to lower air staging) are due to increased combustion of sulfur in the bed and freeboard.

Figures 1-4 illustrate the two charts representing SO_2 emissions as functions of bed temperature at a particular air staging (either 70:30 or 60:40) for a fixed fluidizing velocity (either 1 or 2 m/s) and also for a fixed excess air (either 20% or 40%).

The results demonstrate that the extent of SO_2 emission during staged combustion is influenced by the amount of secondary air and by the bed temperature. More specifically, it increases as bed temperature increases and the primary/secondary air increases (*i.e.*, at higher secondary air).

One can observe that the trends obtained are alike for these charts.

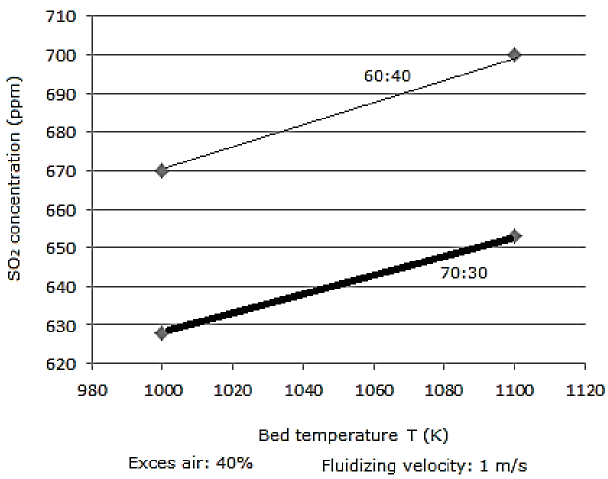


Figure 1. SO_2 emissions as functions of bed temperature at two particular air staging levels (the fluidizing velocity is fixed at 1 m/s, whereas the excess air is fixed at 40%)

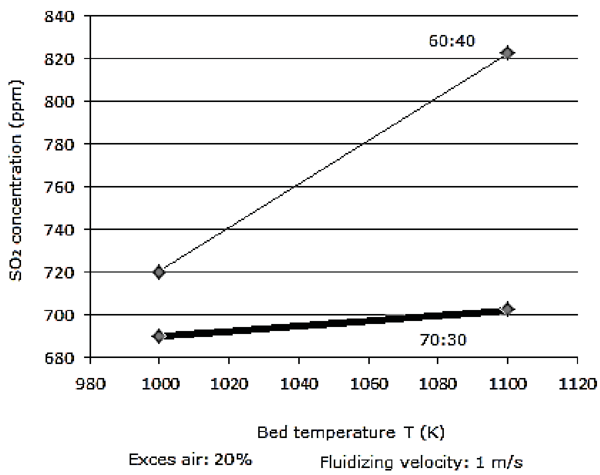


Figure 2. SO_2 emissions as functions of bed temperature at two particular air staging levels (the fluidizing velocity is fixed at 1 m/s, and the excess air is fixed at 20%).

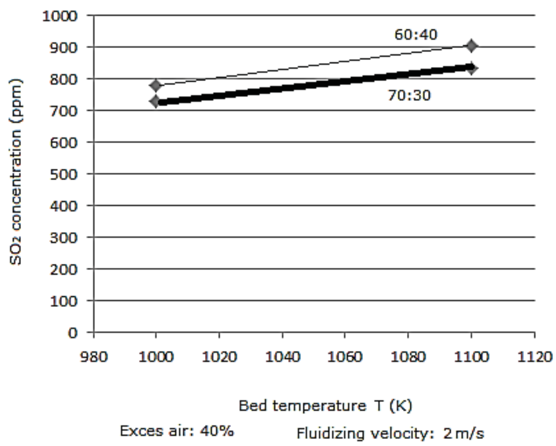


Figure 3. SO_2 emissions as functions of bed temperature at two particular air staging levels (the fluidizing velocity is fixed at 2 m/s, whereas the excess air is fixed at 40%)

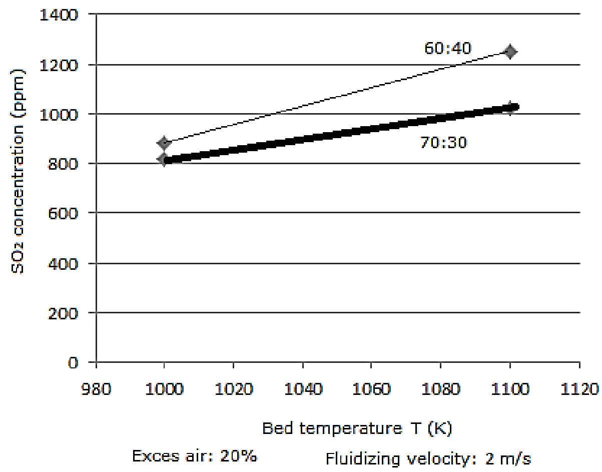


Figure 4. SO_2 emissions as functions of bed temperature at two particular air staging levels (the fluidizing velocity is fixed at 2 m/s, whereas the excess air is fixed at 20%)

The primary air to coal ratio (air/fuel ratio) is defined as the ratio of primary air supplied to the stoichiometric air required, calculated from the coal composition (at 40% staging, an excess air level of 40% resulted in a primary air to coal ratio of 0.8, and 20% excess air resulted in a primary air to coal ratio of 7:10, *etc*.).

At a low primary air to coal ratio, an increase in carryover of unburned fuel sulfur species into the freeboard where it subsequently oxidizes also increase SO_2 emissions.

This indicates that oxidation of some of the sulfur bearing compounds to SO_2 cannot be ignored in the second stage (above the bed).

The air : fuel ratio has significant influence on the rate of sulfur release from the coal and on the ratio of H_2S formed during fuel-rich combustion.

5. CONCLUSION

The results indicate that SO_2 emissions increase with a rise in bed temperature. The extent of SO_2 emission during staged combustion is strongly influenced by the amount of secondary air and bed temperature.

For a given bed temperature and excess air level, increasing the level of air staging or lowering the primary air to coal ratio causes an increase in SO_2 emissions.

An increase in SO_2 emissions as excess air is reduced was observed at both fluidizing velocities and at all secondary air ratios.

6. REFERENCES

[1]. Modrak, T. M., Tang, J. T., Auliso, C. J., *Fuel*, 2007
[2]. Tatebayashi, J., Okada, Y., Yano, K., Ikeda, S., *Fuel*, 2007
[3]. Tomita, M., Hiramo, T. Adachi, T., Yamaguchi, H., Horio, M., *International Conference on Fluidized Bed Combustion*, Atlanta, Georgia, USA, ASME, 2000
[4]. Valk, M., Bramer, E. A., Toissant, H. H. J., *Conference on Fluidized Bed Combustion*, Montreal, Canada, ASME, 2002
[5]. www.netl.doe.gov

Scientific Reviewers:
Assoc. Ph.D. Eng. Roland Iosif MORARU

POSSIBILITIES FOR REDUCING THE SULFUR OXIDES EMISSIONS

CAMELIA BĂDULESCU*
ARONEL MATEI**

Abstract: *In this paper there are emphasized the main sulfur oxides pollution sources. An important attention is being given to the sources that originate from coal combustion. There are introduced short considerations upon the physiological action of the sulfur oxides. The processes of removing the sulfur from fuel are expensive. In order to reduce the pollution with SOx, it is being given an important attention to the desulfuration systems of the gases.*

Key words: *pollution, SOx emissions*

1. GENERAL CONSIDERATIONS

The sulphur oxide pollution refers specially to SO_2 and SO_3. Both oxides are formed by the combustion of any material which contains sulphur. The relative quantity for each of them doesn't depend very much of the oxygen quantity available, like in carbon oxides case. When it is air in excess sulphur dioxide is forming in a high quantity. SO_3 quantity formed in combustion process depends of reactions quantities, special temperature and it is between 1% and 10 % from total SO_x.

The small quantity of SO_3 produced through reaction:

$$2SO_2 + O_2 \qquad 2SO_3$$

is the result of two factors: reaction speed and SO_3 concentration to equilibrium.

SO_2 is a colourless gas in usual conditions. One litter of SO_2 has 2.926 grams. Its critical temperature is 157.2, critical pressure is 77.7 atm. and critical density 0.52. It can be liquefied by compression at 4-6 atm.

The liquid has its boiling point -10.02 °C and solidification point -77.7 °C.

SO_2 molecule is diamagnetic. Dielectric constant at 32 °C is 13.3. Electric conductivity for liquid SO_2 at 0o C is $5*10^{-7}\Omega.\ cm^{-1}$. Vapours density shows that the SO_2 molecules aren't associates.

Gas SO_3 is low associated. The association is growing by lowering the temperature. Liquid SO_3, in the presence of water vapours polymerizes and solidifies if it isn't added a solution for impeding the chain formation (B_2O_3, BCl_3).

Polymerization grade of stabilized liquid anhydride sulphur it doesn't pas 2-3%. Liquid anhydride sulphur is a mediocre cryoscopy dissolvent, because cryoscopy constant is 1.34.

* *Associate Professor, Eng., PhD, University of Petrosani, Romania*
** *Associate Professor, Chim, PhD, University of Petrosani, Romania*

Boiling point is 44.8°C. Liquid dielectric constant at 21°C is 35.7. It has a low boiling point, a high vapour pressure and forms vapours even at usual temperature.

2. POLLUTION SOURCES OF SO_X

Sulphur dioxide is considered the most injurious substance from air. Continue technical productive development determinate a rapid increase of SO_2 emissions.

SO_x pollution, which comes from human activities, has bigger distribution problems than quantity problems. Natural pollution with SO_x is almost uniform spread. The human pollution is concentrated in relatively small urban areas. The main source of SO_x pollution is the burning process of fossil fuels. Metallurgic industries, oil distillery, sulphuric acid plants and coal coking process are the most important industrial sources.

Sulphur forms in coal

In coal, sulfur is present in two forms: mineral (pyrite, marcasyte, sulphate) and organic (mercaptan, sulphur, disulphuric). Total content of sulfur is varying in large limits even for the same ore.

Romanian coal has a sulphur content of 1-3%.

3. DECREASING AND CONTROLLING THE SO_X EMISSIONS

Decreasing and controlling the SO_x emissions from combustion and industrial process can be realized by:

1. Using a fuel with low sulphur content
2. Replacing the sulphur fuel processes with other energy sources
3. Removing the sulphur from fuel before burning process
4. Removing SO_x from gases.

Regarding SO_x emissions control, the biggest attention in the fight against SO_x pollution, is given to desulphurization system for effluent gasses. There is no satisfactory method for each case.

Analyzed in big category, SO_2 removal methods from gasses are classified as follows:

a) Regenerative alkaline method - where an alkaline agent combines chemically with SO_2. In a separate step it is restored the agent (regeneration faze) and sulphur is recuperated as liquid SO_2 or H_2SO_4. Alkaline agents are: magnesium oxide, $NaSO_3$, alkaline carbonates and manganese dioxide.

b) Unregenerate alkaline method - where alkaline agent doesn't regenerate because of the low costs. Alkaline agents are limestone, lime, dolomite and solid wastes from manufacturing acetylene.

c) Directly injection in furnace of some agent and sulphur product is separated from gas by washing. A SO_2 part is collected in furnaces and the other part is collected in scrubber through washing.

d) SO_2 catalytic conversion in SO_3 and H_2SO_4 recuperation can be made only on high temperatures for entrance gasses.

e) Regenerative solid absorption use activates coal for SO_2 absorption. Through absorption H_2SO_4 is produce. Organic regenerative absorption can be made in the same way.

The restriction for SO_2 emissions in the world, entail reconsideration for all the industrial gasses treating systems.

The emission of some installation depends of its exploiting way, but at ground it depends of external conditions, atmospheric condition and the approach of some pollution sources. The influence of these sources is exercised to an 80 km distance, but if we have troubled land the influences cannot be foreseen and they must be evaluated through local research or in aerodynamic tunnel.

At isolated plants, with ideal emplacement, C_m concentration is:

$$C_m = \frac{2.15 \cdot Q_1 \cdot 10^5}{u \cdot H_e^2}\left(\frac{P}{Q}\right)$$

Where:

$Q_1 = SO_2$ flow;
P/Q = dispersion coefficient from horizontal to vertical = max 0.625
u = wind speed
H_e= effective height of the chimney

The research showed that the maximum concentration normally appear for a wind leaded to soil to a distance higher with 5-20 time comparative with chimney's height from emission point.

Sulphur concentration in feed gasses influence chimney's height H_s, which is one of the most important parameters, because it can affect the effective height of chimney H_c, the thermal effect for gas floating H_t and the speed H_v.

$$H_e = H_s + 0.75(H_v + H_t)$$

H_t and H_v are determinate by chimney's type, equipment total capacity, conversion efficiency and atmospheric condition. The speed is limited at 66 m/s because in these conditions the erosion is minimal for chimneys with 900 - 1200 mm in diameter.

An efficient proceeding is using the manganese oxide as absorbent for sulphur dioxide. The absorbent can be regenerated at low costs with a high productivity, after it is cooled in an exchanger heat, with air current from exchanger heat. Manganese oxide, at suitable temperature, is put into the circuit through suspension preparation device. Manganese oxide it is mixed with sufficient water to maintain it in suspension. Gases are passed through this suspension, sulphur dioxide is absorbed and gases can be evacuated in atmosphere. Manganese sulphate, produced in absorption step, reacts with hydrochloric acid gas to a temperature lower than 50°C. At 500 - 900°C it produces a $MnCl_2$ oxidation and decomposition forming MnO_2 and Cl_2. Suspension manganese oxide goes in SO_2 absorption process.

Relatively recent, at pilot scale, it was concluded and extended a proceeding based on reaction between sulphite and citrate ions. The gas with SO_2 cooled under 50 °C, cleaned by particles and sulphuric acid, is passed through an absorption tower and put in contact with a citrate ion solution. The reactions are:

$$SO_2 + H_2O \rightarrow HSO_3^- + H^+$$

$$HSO_3^- + [H_3Cit]^- \rightarrow [HSO_3 \cdot H_3Cit]^{-2}$$

The final solution $([HSO_3 \cdot H_3Cit]^{-2})$ is passed through a close enclosure. Lubricating with H_2S sulphur precipitated by reaction:

$$[HSO_3 \cdot H_3Cit]^{-2} + H^+ + H_2S \rightarrow 3S + (H_3Cit)^- + 3H_2O$$

And it is removed.

For forming acid mist sulphur trioxide has the main part. It combines with air humidity and other components from effluents gases, forming a fine aerosol divided by sulphuric acid. Condensing drops can be accelerated by the presence of material drops which forms condensing nucleus.

Of acid mist removing systems we can re mind: electric precipitation, separation on padding separators, removing with mist eliminators with wire-gauze, ceramic filter, etc.

4. POSSIBILITIES FOR REDUCING THE SO_2 EMISSIONS

Flue gas desulphurization is currently the most common depollution technique.

The prospect of mandatory endowment of power plants and all stationary sources emitting gaseous sulphur with desulphurization installations in order to comply emission standards, has spurred research into flue gas depollution.

When choosing one or other of desulphurization technologies there must be taken into account the following:

- Desulphurization efficiency obtainable in order to attain emission standards;
- The economic factor - investment, operating and maintenance costs, reagents costs etc.
- Handling, storage and - possibly - marketing of secondary products resulted from desulphurization processes.

Very severe emission standards require the use of chemical gas desulphurization installations in all cases of coal burning in classical outbreaks or of burning fuel oil with high sulphur content.

In the last 30 years were developed several desulphurization processes, namely:

- Non-regenerative processes - in which SO_2 is reacted with an absorbing agent, by reaction resulting in a product;
- Regenerative processes - the components of SO_2 - by regeneration may give rise to liquid SO_2, sulphuric acid or elemental sulphur.

Non-regenerative processes are the most modern and currently used. They can be divided - depending on the absorbent substance - in:

- dry non-regenerative processes;
- semi-dry non-regenerative processes;
- wet non-regenerative processes.

If dry methods there are used as absorbents both limestone and slaked lime introduced into the combustion chamber or in the flue gas channels. The absorbent substance used in semi-dry method is slaked lime. Over the past years there have been developed other desulphurization processes, such as, for example, the activated carbon absorption process and the electrons emission one. In the wet desulphurization the absorbent substance may be a suspension of lime or lime stone, a solution of sodium hydroxide or carbonate, an aqueous ammonia solution, a suspension of magnesium hydroxide and diluted sulphuric acid.

Analyzing methods of SO_2 removal from flue gases used worldwide and taking into account the environmental legislation it is intended to equip the thermal power plants with wet desulphurization installations type limestone - gypsum. In this process, SO_2 reacts with the absorbing agent (limestone) from the reaction resulting a new product (gypsum).

The main advantages of this method are:

- very high desulphurization efficiency

- treatment of high flow rates of flue gases
- slight obtaining and in sufficient quantities of absorbent substance
- increase stability coefficient of the deposit;
- the ash is fixed and not wind-blown;
- infiltration water is in very low quantity and clean.

The flue gases from burning fossil fuels in the boiler will be treated in an absorber washing counter current with the limestone solution having the mass concentration of 30%. The main types of absorbers used for large combustion plants are spray absorber tower; absorber with liquid column; bubbling absorber. Spray absorber tower is the most common type of absorber used in the limestone gypsum wet process.

The flue gases deducted by means of electrostatic precipitators at a temperature range of 140 - 150^{0}C are introduced into the top of the absorber reaction tank. On entry, the gases are pre-washed with process water or lime solution. Then enter into the absorber and are backwashed, as noted above, using the limestone solution, which is then collected at the bottom of the absorber and recycled. Recycling will be done with the absorber recirculation pumps, one for each level plus a spare one. Desulphurization may be described in the following equations. In solution, the sulphur dioxide reacts with the calcium carbonate from the washing solution to form calcium sulphite:

$$CaCO_3 + SO_2 + H2O \text{ ---> } CaSO_3 * ½H_2O + ½H_2O + CO_2 \qquad (1)$$

Part of this sulphite is converted into gypsum; calcium sulphate dehydrates is using the oxygen from the flue gases passing through the intermediate stage of acid sulphite:

$$CaSO_3 * ½H_2O + SO_2 + H_2O \text{ ---> } Ca(HSO_3)_2 + ½H_2O \qquad (2)$$

$$Ca(HSO_3)_2 + ½O_2 + 2\ H_2O \text{ ---> } CaSO_4 * 2\ H_2O + SO_2 + H_2O \ (3)$$

In the settling tank of the absorber, much of the remaining sulphites are further oxidized by introducing atmospheric oxygen according to equation (2) and (3) resulting sulphates. The introduction of air is carried out by means of an air blower. Oxidation is considerably faster by forming hydrogen sulphite so direct oxidation has little importance:

$$CaSO_3 * ½H_2O + ½O_2 + 2\ H_2O \text{ --> } CaSO_4 * 2\ H_2O + ½H_2O \quad (4)$$

Of course, there are also other types of oxidation, for example, sulphur trioxide reactions, hydrochloric acid and hydrofluoric acid with calcium carbonate, which results in the formation of compounds of gypsum and calcium chloride and / or calcium fluoride:

$$CaCO_3 + SO_3 + 2\ H_2O \text{ ---> } CaSO_4 * 2\ H_2O + CO_2 \qquad (5)$$

$$CaCO_3 + 2\ HCI \text{ ---> } CaCl_2 + H_2O + CO_2 \qquad (6)$$

$$CaCO_3 + 2\ HF \text{ ---> } CaF_2 + H_2O + CO_2 \qquad (7)$$

The air necessary for the oxidation reaction is injected into the tank by the blower. In the reaction tank gypsum crystals are formed. After the chemical reactions and catalyzed by the injected oxygen introduced - arises gypsum in form of crystals. Gypsum slurry extracted from the absorber tank has a density ranging around 15% and therefore must be dehydrated to meet the requirements for its commercialization as raw material of high quality in the gypsum industry.

The characteristics of the resulting gypsum are:
- Purity ($CaSO_4$ $2H_2$)> 95%
- Moisture content <10%

- Chlorine ions <0.01%
- Particle size> 35 µm
- pH value between 6-8.

Gypsum resulting from the process of desulphurization has a very good quality, similar to natural gypsum. Therefore it can have many uses such as: raw material in the cement industry (3-5% of cement composition); raw material in the building materials industry - as drywall, plaster, plastic, or semi; raw material in the construction of roads, highways, motorways; filler in disaffected mines; neutralizing alkaline soils in agriculture.

5. CONCLUSIONS

SO_2 presence in air is the main cause for plants destructive process

Removing sulphur from fuel before burning necessitate many remaking depending by type fuel and by the sulphur shape

Desulphurization processes are complex and necessitate high costs

It is accentuated the efforts against SO_x pollution on effluent gases desulphurization system

Unfortunately there isn't a sufficient satisfactory unique method

Factors like high luminosity, humidity and temperature encourage the lesion apparition even for small SOx quantities

The synergism with other atmospheric pollutants especially solid particles, point out the SO_2 toxic effects

In urban aria we can meet also SO_3 in important concentrations

Inhaled by human and animals SO_3 can produce irritant effects stronger than SO_2

SO_2 eliminate methods from gases are particularized in practice to case to case, even in specialized literature are analyzed on large categories.

Flue gas desulphurization is currently the most common depollution technique.

Non-regenerative processes are the most modern and currently used.

Analyzing methods of SO_2 removal from flue gases used worldwide and taking into account the environmental legislation it is intended to equip the thermal power plants with wet desulphurization installations type limestone - gypsum.

REFERENCES

[1]. Negoiu D., *Inorganic chemistry treaty***,** Technical Publishing House, Bucharest, 1972

[2]. Negoiu D., Krisa A., *Inorganic pollution in air*, Romanian Academy Publishing House, Bucharest, 1977

[3].Niac Gv., Damian L., *Coal ennobling through desulphurization*, Mine, oil and gas magazine, nr. 1, 1984

[4]. Matei A*, Environment chemistry***,** Universitas Publishing House, Petrosani, 2000

[5].Matei A. , Badulesu C., Onofre D., *Theoretical and Practical Aspects of the Pollution and the Control of the Sulphur Oxides Emissions,* 10-th Conference on Environmental and Mineral Processing, Ostrava, 2006.

Scientific Reviewers:
Prof. Ph.D. Eng. Romulus-Iosif SARBU

RESEARCH ON THE STRUCTURE AND COMPOSITION OF THE SLUDGE OBTAINED FROM THE WWTP DANUTONI

DANIELA IONELA CIOLEA[*]
TIBERIU RUSU[**]

Abstract: *The sludge's formed at the similar municipal and industrial treatment plants are considered secondary products „unwanted", which focuses the removed pollutants from wastewaters and may represent a danger to the environment. The technological scheme of a treatment plant contains two production lines: 1. Technological wastewater line, which aims the compliance of the effluent quality requirements, before their discharge into the natural receptors (NTPA 001/2005); 2. Technological sludge line, which aims to: reducing the quantity of the sludge; sludge as less dangerous to the environmental factors; obtaining substances that can be financially exploited (agriculture, energy, construction materials, e.t.). The sludge's derived from the wastewater treatment, are complex colloidal systems, gelatinous aspect, with heterogeneous composition, which contains: colloidal particles (d<1 µm); dispersed particles (d<1-100 µm); suspended material; organic polymer from biological origins; water. This paper aims to the structure and composition of the obtained sludge from the WWTP, Danutoni from Jiu Valley-Romania.*

Keywords: *sludge, waste water, protection of the environment, ecology, human health.*

1. INTRODUCTION

With industrialization, urban and rural development, as well as in the light of the development of modes of consumption, waste-water, and known under the name of the waters "waste", has evolved substantially since quantitative and qualitative. Domestic waste waters have grown from day to day in more complex products (detergents, polishes and cleaning products, etc.), and networks reorganization receive sewage industrial, commercial or craft with features that are very different. The rain waters that wash areas, growing larger, which is covered with asphalt and paved, are loaded into mineral products and organic matter and increase the more than flow pollutant by the treaty. When waste waters are not dealt with, watercourses are exceeded in their capacity of natural purification and remain polluted.

[*] *Lecturer PhD. Eng. at the University of Petrosani, cdipentrucdi@yahoo.com*
[**] *Prof. PhD. Eng. at the Technical University of Cluj Napoca*

Treatment or cleaning waste water aim reduce pollutant load on which a nodal point in such a way as to play aquatic environment a quality water, which do not affect natural balances and uses its future (fisheries, leisure, food, agricultural use or industrial, etc.). Can't talk about sewage sludge without talking about sewage, because sludge shall be just as a result of cleaning used water. He also heard of waste waters cannot forget that waste waters are a result of human activities (domestic, industrial, etc.), and the water is a resource indispensable of life, which is located in deficit in many regions of the world, a resource that lies at the very basis of conflicts inter-state, or of any other nature. Water is a component of the environment in danger as air, as well as soil or as biodiversity. [2] This risk is determined by the various sources of pollution and the effects they may cause.

2. SLUDGE CLASSIFICATION

Wastewater sludge from municipal waste water scrubbers may be classified:

1. After processes of the waste water treatment plant in:
   - ✓ Primary sludge from sewage plants mechanical gear;
   - ✓ Secondary sludge from sewage gear organic production methods;
   - ✓ Sludge combination-sludge mixture of primary and secondary after decanting;
   - ✓ Sludge precipitation (chemical) **-** from the cleaning physic-chemical by the addition of neutralizing agents, precipitation.
2. After their stage of processing under sludge management, into the following groups:
   - ✓ Raw sludge (unprepared);
   - ✓ Sludge stabilized (aerobically or anaerobically);
   - ✓ DRIED sludge (natural or artificial);
   - ✓ Sludge cleansed (pasteurization, chemical treatment or composting);
   - ✓ Sludge fixed **-** by solidification in order to immobilizes toxic compounds;
   - ✓ Ash-sludge from the incineration.
3. After sludge composition, in two categories:
   - ✓ Organic sludge’s containing more than 50% volatile substances (expressed as dry matter), which come from the cleaning mechanical/biological;
   - ✓ Sludge’s minerals, which contain more than 50% inorganic substances (expressed as dry matter), which come from the cleaning mechanical/chemical.
4. After progenitor waste water, sludge shall be classified in:
   - ✓ Sludge’s from municipal waste water cleaning process;
   - ✓ Sludge’s from scrubbers’ industrial waters.

The colour and odour provides first information on the state of activated sludge. Sludge’s containing fresh catering waste and fits easily in fermentation and produce gases with unpleasant odours (hydrogen sulphide). [3]

1. Sludges from fresh primary separator have:
- ✓ Gray color pale or yellowish;
- ✓ Almost smell low-low.

2. Sludges active after the aeration basins have:
- ✓ The color of the yellow-brown, brown-gray to brown closed depending on predominant bacterial species;
- ✓ Faint smell the humus.

3. Sludges from precipitation:
- ✓ Look muddy conditions;

- ✓ The color and odour varies according to the type of precipitant used.

4. Sludge anaerobically fermented have:

- ✓ Brown to black;
- ✓ Smell of tar and granular appearance.

3. CALORIFIC POWER

Calorific power of sludge varies depending on the content of organic matter. Calorific power is determined experimentally, or through the use of closer relations of calculation laid down on the basis of the content in sludge volatile material (volatile substances, Sv). [12]. In table 1 may be observed calorific powers of sludge from a purification station sorcery work:

Table 1. Calorific power of activated sludge

Organic matter (% of dry matter)	**Calorific power (kcal/kg Sv)**	
	Primary sludge	**Excess activated sludge**
100	6650	5650
90	5850	5050
80	5100	4450
70	4300	3850
60	3600	3300
50	2800	2650
40	2150	2050
30	1400	1500

4. CHEMICAL CHARACTERISTICS OF SLUDGE

1. Total solids.

Sludge shall contain, on average, over 90% water, with the rest being solid substances which, from the chemical, can be minerals and organic substances (volatile).

Determination of organic compounds (volatile) of fixed residue obtained after drying a sample of sludge at 105 C, shall be by its calcinations at a temperature of 550 C. A primary sludge contains 95 - 97% water and 3 - 5% solid, of which about 70% is the volatile acid (V). If this sludge is then fermented, organic part shall be reduced by 40 to 50 percent of the votes, and the mineral (M) increase by 60 - 65 %. And volatile mineral indicator in the dry matter is criterion for the classification of sludge, such as [1]:

- sludge organic shows M/V < 1;
- and the inorganic shows M/V > 1.

This criterion shall constitute a basis for the selection of processing procedures, whereas a sludge is organic rotten and considering first stable, especially on the way biological (fermentation aerobic or anaerobic), while a sludge is processed by inorganic processes physico-chemical (solidification, extraction of components useful etc). [12]. Chemical characteristics of activated sludge:

1. Organic substances - fractions of volatile solids - V and inorganic (mineral) - M, see Table 2 and Table 3.

Table 2. Type of sludge and volatile fraction and mineral

Type sludge	**V (%)**	**M (%)**
freshly	cca 70	cca 30
in fermentation	40-50	50-60

Table 3. Method of treating sludge on the basis of the ratio M/V

M/V	**Method of treating**
<1	with the stabilisation biological (with fermentation aerobic or anaerobic),
>1	Processed directly by means of processes which physico-chemical (solidification, extraction of components useful, etc.)

2. Mineral sludge constituents of latter (report in terms of dry weight) after Babbit and Bauman, in table 4. [11]

Table 4. Mineral sludge constituents of town

Item	**Primary Sludge**	**Fermented Sludge**	**Activated sludge**
	(ppm)	**(ppm)**	**(ppm)**
N_t	45000	22500	62000
P_2O_5	22500	11000	25000
K_2O	5000	5000	7500
Al_2O_3	21000	43000	32000
Cl^-	5000	5000	5000
CaO	27000	57000	17000
MgO	6000	10000	14000
Na_2O	8000	15000	10000

2. The fermentation

This property of sludge shall be determined by the analysis fermentation in a fresh sludge mixing well fermented sludge, respectively, two sides and a fresh sludge fermented side. This mixture of sludge is being tracked for about 30 days. Throughout the experiment, determine the quantity and composition of gas product, the quantity of volatile acids and pH. [11]

Organic substances in fresh sludge shall be assessed as ranging between 60 to 80% of the total quantity of dry matter, which lead to the appearance of difficulties as regards drying sludge. [3]

Production of gas refers to kg organic matter, with a peak in the subjects with composition organic high fat content of organic nature. In the case of sludge freshly from urban waste waters, the amount of gas that can be produced is between 0.85 - 1.0 Nm^3/kg organic solids that may have been damaged. If it is considered organic matter in sewage sludge freshly, then production can be estimated at 0.4 -0.7 Nm^3 LPG/kg organic matter introduced into the basin to fermentation.

Quantities of volatile organic acids must be approximately 500 mg/dm^3. If the value is exceeded 2,000 mg/dm^3, there is a risk that mechanic fermentation to stop, so that acid fermentation will be dominant and therefore will appear bad smelling gases and a sludge which is dangerous to quality of the environment.

3. Heavy metals and nutrients

The content of nutrients (N, P, K) is of particular importance when considering recouping sludge that agricultural fertilizer or as an agent of soil-conditioning. In addition, the use of sludge in agriculture is conditional on the presence and quantity of heavy metals (copper, cyanide, arsenic, lead, etc.), which have a high degree of toxicity and accumulates in the soil. When sludge urban contains small quantities of heavy metals, usually below allowable limits, sewage sludge from the cleaning of waste-water with industrial, depending on the industry, may result in increased concentration of heavy metals in sludge and as a result it is appropriate periodic chemical analysis of sludge.

5. RESULTS AND DISCUSSION

Sludge treatment sludge stabilization includes all aerobically, using biological treatment with extended aeration, wall thickening sludge in gravitation interaction and dehydrating sludge using tape mills with respirators including wrapping sludge using polyelectrolyte. The procedure for dealing with sludge Danuţoni mainly consists of: existing sludge; the new pumping station for sewage sludge thickened; new plant for the preparation and assay polymer; new plant for dehydrating sludge by mills filter bandwidth; a new pumping station water for washing; a new plant with cakes auger for the transport of sludge as well as the storage container; new space for the storage of sludge.

Sludge quality is an important factor in determining feasible options for the management of sludge, especially those relating to the use in agriculture, field for which quality sludge must correspond to strict limits of concentrations in heavy metals (table 5, Fig.1).

Table 5. Quality sludge from Danutoni

No	Sample	U.M.	Values det.	MAC	Method
1	pH	*unit. pH*	7,47	-	SR EN 12176/2000
2	Humidity	*%*	58,39	-	SR EN 12880/2002
3	Dry ashing	*%*	56,00	-	SR EN 12879/2002
4	N_t	*%*	2,25	-	ASTM D 5373/2008
5	TOC	*%*	21,67	-	SR ISO 10694/1998
6	P_2O_5	*mg/kg s.u.*	4068	-	SR EN 14672/2006
7	K_2O	*mg/kg s.u.*	2838	-	STAS 12678/1988
8	CaO	*mg CaO /kg s.u.*	27610	-	STAS 12834/1990
9	Cd	*mg/kg s.u.*	3,10	**10**	STAS 12876/1990
10	Cu	*mg/kg s.u.*	132	**500**	SR ISO 11047-99
11	Ni	*mg/kg s.u.*	81,1	**100**	STAS 13094/1992
12	Pb	*mg/kg s.u.*	64,7	**300**	SR 13225/1995
13	Zn	*mg/kg s.u.*	542	**2000**	SR 13181/1994
14	Hg	*mg/kg s.u.*	<0,05	**5**	SR ISO 11466-1999 SR EN 1483-03
15	Cr_t	*mg/kg s.u.*	58,8	**500**	STAS 13117/1992
16	Co	*mg/kg s.u.*	6,0	**50**	SR ISO 11047-99
17	As	*mg/kg s.u.*	4,48	**10**	SR EN ISO 11885/2009
18	AOX	*mg/kg s.u.*	187	**-**	SR EN 13370/2004 SREN ISO 9562/2008
19	PAH	*mg/kg s.u.*	0,77	**5**	SR ISO 13877-99
20	PCB 28,52,101,118,138,153,180	*mg/kg s.u.*	0,008	**0,8**	SR EN ISO 6468-00 SR EN 15308/2008

Fig. 1. Determination of the pH of sewage sludge dehydrated – Danuţoni, Jan. 2015

6. CONCLUSION

➢ Sludge obtained may contain particles of clay waters driven street into drains, organic substances derived from sewage sludge and human manures, salts soluble or insoluble, various species of cation and anion trapped colloidal fraction of organic or mineral.

➢ Sludge treatment sludge stabilization includes all aerobically, using biological treatment with extended aeration, wall thickening sludge in gravitational interaction and dehydrating sludge using tape mills with respirators including wrapping sludge using polyelectrolyte.

➢ High relative humidity sludge analyzed has values ranging between 61% and 85 %.

➢ The organic carbon content is acceptable, with values ranging between 13.1% and 28.5 %.

➢ Contents of macroelements (N, P, K, and Ca) shall be entered in reasonable intervals for municipal sludge.

➢ The contents of AOX, PCB have had values below maximum allowable limit established by Minister Order No. 344/2004.

➢ The contents of heavy metals - cadmium, copper, lead, zinc, nickel and chromium laid down by this Minister Order No. 344/2004 have not been exceeded in sludge samples from the year 2012, but have been exceeded on two samples of old sludge beds.

REFERENCES

[1] **Ciolea D.I., Dunca E.** - *Research on muds resulted from water purging in Romania.* 14th SGEM GeoConference on Ecology and Environmental Protection, www.sgem.org, SGEM 2014 Conference Proceedings. DOI:10.5593/SGEM2013/BD4/S17.015. ISI http://www.sgem.org/sgem_lightbox/programme/_Publish_Programme_PUBLISH.pdf

[2] **Ciolea D.I., Rusu T., Gabor T.** - *Measures for decreaseding negative impact of sludge capitalization,* ECOTERRA, Journal of Environmental Research and Protection, Vol 11, no 1, 2014, http://www.ecoterra-online.ro/files/1402003034.pdf

[3] **Ciolea D.I.** – *Research on the obtaining and disposal sludge in the Jiu Valley*, Mining Engineering, vol. 14 (XXXXI), CNCSIS - revistă categoria B+, ISSN 1454-9174, pag. 255-260, 2013

[4] **Ciolea D.I.** – *Studies on the wastewater sludge from the western part of Romania*, Mining Engineering, vol. 14 (XXXXI), CNCSIS - revistă categoria B+, ISSN 1454-9174, pag. 269-276, 2013

[5] **Dunca E., Ciolea D. I.** - *Recherche sur le compostage des déchets verts et de son utilisation dans le rétablissement de dégradés par les activités industrielles*. Annals of the University of Petroşani - Mining Engineering, vol. 11 (XXXVII), pag. 238-244, Editura Universitas, ISSN 1454-9174, 2011

[6] **Czechowski, F., Marcinkowski T.** - *Sewage sludge stabilisation with calcium hydroxide: Effect on physicochemical properties and molecular composition*. Water Research, 2006. 40: p. 1895-1905

[7] **Eganhouse, R.P., Olaguer, D.P., Gould, B.R. & Phinney, C.S.** - *Use of molecular markers for the detection of municipal sewage sludge at sea*. Marine Environmental Research, 25, 1-22, 1998

[8] **Elsäßer, T.,** - *Perspective methods of sewage sludge utilisation for energy production*, in *Faculty of Mechanical Engineering, Institute of Process and Environmental Engineering*. 2011, University of Technology BRNO. p. 28

[9] Fytili, D. and A. Zabaniotou, *Utilization of sewage sludge in EU application of old and new methods—A review.* Renewable and Sustainable Energy Reviews, 2008. 12(1): p. 116-140

[10] **Jardé Emilie** - *Composition organique de boues résiduaires de stations d'épuration lorraines: caractérisation moléculaire et effets de la biodegradation,* Thèse présentée pour l'obtention du titre de Docteur de l'Université Henri Poincaré, Nancy I, en Sciences de l'Univers, 2002

[11] **Kalloum S., Khelafi M., Djaafri M., Tahri A. et Touzi A.** - *Etude de l'influence du pH sur la production du biogaz à partir des déchets ménagers.* Revue des Energies Renouvelables Vol. 10, Nr. 4 (2007) 539 – 543 539

[12] **Traşcă F., Mihăilescu D.,** et - *Research on the possibility to use sewage sludge as organic fertilizer of heavy acid soils*, AN. I.N.C.D.A. Fundulea, Vol. LXXIX, nr. 2, 2011, Electronic (Online) ISSN 2067–7758, www.incda-fundulea.ro

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

ANALYSIS ON THE MUD LIFE CYCLE RESULTED FROM WATER PURGING IN ROMANIA

DANIELA IONELA CIOLEA*
TIBERIU RUSU**
EMILIA DUNCA***

Abstract: *About 80% of Romanian cities have a combined sewerage system (domestic wastewater and rainwater). Industrial discharging have also an important share in the final outcome of WWAT, consequently, the discharge of industrial wastewater might significantly influence the mud quality. The main options for mud management include: agricultural administration, incineration or co-incineration, waste deposit discharging, forest or degraded land administration. The main principle chosen for national and regional mud management strategy development is to ensure that the mud is beneficial as organic fertilizer or as renewable energy source. The storage in ecologic waste deposits is considered the least solution if there are no other environmental and economic viable possibilities. However, the temporary storage is accepted as necessary for a transition period until the water and wastewater operators prepare the beneficial mud use system.*

Keywords: *agriculture, deposits, energy recovery, mud, research, water purging.*

1. INTRODUCTION

Two approaches were used in order to evaluate the Romanian mud quality:

✓ developing questionnaires for obtaining data from regional operators regarding the mud quality during 2006-2010;

✓ taking and analyzing mud samples from half of the operating WWTP stations.

It was noticed that not all the WWTP stations do yearly mud analysis while some of them haven't done any kind of analysis. Responses from 150 WWTP stations were collected, but only one third of them could give details of the physical quality of the mud. The chemical analysis of the mud was low in 2006 (2-15% depending on the parameter); it was improved up to 2010 but it is still fairly low (17% of the WWTP stations do nutrient and heavy metals analysis). 73 of the 114 operating WWTP stations were visited. [5]

* *Eng. Ph.D. Lecturer at the University of Petrosani, e-mail: cioleadaniela@gmail.com*
** *Eng. Ph.D. Professor at the Technical University of Cluj-Napoca*
*** *Eng. Ph.D. Assoc. Prof. at the University of Petrosani*

2. MATERIALS AND METHODS

Quantities of sludge removed from the slave cylinder and methods of disposal are summarised in table 1 and Table 2. [4]

Table 1. National production of sewage sludge

Type sludge	**Quantity (t DS)**
Primary sludge	37.643
Secondary sludge	18.033
Mixed sludge	83.173
Total	138.847

Table 2. Receptors of sludge in Romania

Receiver	**Quantity (t DS)**
Storage in SEAU	125.737
Disposal at landfills	12.630
Use in agriculture	282
Incineration	0
Other options for use/disposal	0

Current methods for the disposal of sewage sludge are shown in table 3. Predominant method of disposal a means on-site or off-site. [1] [2]

Table 3. Current methods for the disposal of sewage sludge

Sludge receiver	**No. of WWTP**
Disposal (waste depot, storage on site)	87
Unknown slave	72
Drying beds	36
Storage lagoons	4
Storage	4
Composting	4
Sludge waste area	2
Agriculture	2

About 80% of Romania's towns have a combined system of the sewage (waste water housekeeper, drencher). Industrial Landings will also have a considerable part to play in final flows which arrive at **WWTP**; therefore it is possible that industrial waste water discharges to considerably influence sludge quality.

3. RESULTS AND DISCUSSION

Table 4 presents the physical quality and nutrient composition results while table 5 presents the heavy metal and organic pollutant results.

Table 4. Summarise the results of analyzes of sewage sludge/parameters generals and nutrients [5]

Parameter	Unit	No. results	Concentration			
			Average	Middle	Minimum	Maximum
pH	-	96	7,68	7,70	6,05	9,21
The dry substance	%	96	22,0	20,6	1,70	77,7
Organic substance	% D.S.	96	49,8	50,3	2,3	79,1
Total nitrogen	% D.S.	95	3,57	3,41	0,47	8,40
Ammonia	mg/kgD.S.	95	1747	1462	0,57	9187
Total phosphorus	mg/kgD.S.	95	10804	9187	1174	27984
Potassium	mg/kgD.S.	96	2310	1772	251	6217
Calcium	mg/kgD.S.	47	26847	23870	3743	73920
Magnesium	mg/kgD.S.	47	5847	5474	1776	15270
Sulfur	% D.S.	47	0,33	0,28	0,03	0,78

The average nutrient concentration is typical, with the values 3.5% N, 1% P and 0.2% K.

Table 5. Summarise the results of analysis of sewage sludge-heavy metals and organic pollutants

Parameter	Unit	No. results	Concentration				Limit value MO 344/2004	% WWTP Meeting MO 344/2004
			Average	Mid	Min	Max		
Zinc	mg/kgD.S.	96	1163	860	85,7	7147	2000	91
Copper	mg/kgD.S.	96	207	177	7,71	716	500	96
Nickel	mg/kgD.S.	96	45,5	31,2	4,15	654	100	96
Cadmium	mg/kgD.S.	68	5,19	2,09	0,25	124	10	94
Lead	mg/kgD.S.	96	99,8	67,1	5,03	972	300	96
Total chromium	mg/kgD.S.	96	128	71,6	11,7	1409	500	94
Mercury	mg/kgD.S.	85	1,24	0,89	0,19	6,08	5	98
Boron	mg/kgD.S.	44	85,1	70,5	1,25	296	-	
Cobalt	mg/kgD.S.	47	9,47	7,52	0,78	37,5	50	100
Iron	mg/kgD.S.	47	21723	17987	1311	5914,9	-	
Manganese	mg/kgD.S.	47	1097	449	32,8	12685	-	
Molybdenum	mg/kgD.S.	31	3,76	3,27	1,39	22,0	-	
Arsenic	mg/kgD.S.	47	13,9	9,87	0,63	65,2	10	51
Selenium	mg/kgD.S.	47	<0,13	<0,13	<0,13	<0,13	-	
AOX	mg/kgD.S.	95	222	214	87	327	500	100
LAS	mg/kgD.S.	47	3524	3140	555	8937	(2600)	(40)
DEHP	mg/kgD.S.	88	5,45	3,9	0,29	24,5	(100)	(100)
NPE	mg/kgD.S.	47	1178	1096	132	4459	(50)	(0)

PAH	mg/kgD.S.	95	12,3	10,56	0,81	34,9	5	20
PCB	mg/kgD.S.	93	0,31	0,18	0,01	1,54	0,8	91
PCDD, PCDF	μg/kg D.S.	93	<1	<1	<1	<1	(0,1)	

The organic matter content of 50% indicates that the mud is generally stable while the maximum value of 80% is valid for raw mud (unstable). The average content of dry substance is 22%, typical for dehydrated mud, but there is a large range between the liquid and very dry mud. [4]

The mud was analyzed from the point of view of the organic pollutants given by MO 344/2004 but also from the ones considered for the EC Directive review [8]. While all the WWTP stations follow the limit values for AOX and DEHP and 91% for the PCB value, the LAS and PAH levels are low (40% respectively 20%); no WWTP station follows the NPE suggested limit. [5]

The mud samples were also object of microbiological examination. The results indicate typically the presence of Salmonella (62% of the samples) while the number of excremental coliform bacteria is between 103 and 108 MPN/g d.s., geometric mean of 106 MPN/g d.s.

4. QUALITY SLUDGE GENERATED BY THE TREATMENT WORKS OF DRINKING WATER

Data applied by operators are summarised in table 6.

Table 6. Quality sludge generated by the treatment works of drinking water

Parameter	Unit	Concentration				No. results	% WWTP Meeting MO 344/2004
		Average	Middle	Minimum	Maximum		
pH	-	7,01	7,21	6,02	7,63	12	
Dry substance	%	0,058	0,020	0,0003	0,22	5	
Organic substance	% D.S.	5,48	5,48	5,48	5,48	1	
Total nitrogen	mg/kgD.S.	78,5	16,4	6,82	288	6	
Total phosphorus	mg/kgD.S.	440	12,0	1,5	2,17	5	
Potassium	mg/kgD.S.	1171	1013	0,30	2,17	7	
Cadmium	mg/kgD.S.	11,5	6,40	1,86	38,9	6	67
Copper	mg/kgD.S.	95,1	113	14,7	169	7	100
Nickel	mg/kgD.S.	74,0	25,9	18,1	183	7	71
Lead	mg/kgD.S.	105	32,9	0,30	508	7	86
Zinc	mg/kgD.S.	746	363	1,60	2,35	8	88
Mercury	mg/kgD.S.	14,1	1,90	0,055	78,1	7	71
Chromium	mg/kgD.S.	87,3	10,8	3,77	324	4	100
Cobalt	mg/kgD.S.	27,0	5,43	2,93	110	7	86
Arsenic	mg/kgD.S.	85,9	12,3	1,47	444	6	33
AOX	mg/kgD.S.	1,25	1,25	0,010	2,48	2	100
PAH	mg/kgD.S.	18,3	1,35	0,010	104	6	83
PCB	mg/kgD.S.	0,23	0,015	0,002	1,30	6	83
PCDF/F	Ng TE/kg D.S.	6,50	6,50	6,50	6,50	1	0

Share of arable land with a soil pH greater than 6.5 for Romania is presented in Table 7, which is especially marked in the West. [5]

Table 7. Share of arable land with a soil pH greater than 6.5

Region	Total area (ha)	Arable land (ha)	Arable land with pH> 6.5		Arable land with pH> 6.0	
			(ha)	(%)	(ha)	(%)
North-East	3.685.282	1.219.868	811.535	66,5	1.046.681	85,8
South-East	3.576.047	1.967.166	1.856.851	94,4	1.910.422	97,1
South	3.446.639	2.034.674	1.374.892	67,6	1.769.352	87,0
South-West	2.921.483	1.191.866	551.415	46,3	881.115	73,9
West	**3.203.416**	**1.010.940**	**328.281**	**32,5**	**602.120**	**59,6**
North-West	3.416.182	829.800	222.714	26,8	360.327	43,4
Center	3.408.703	580.550	307.038	52,9	357.454	61,6
Bucharest-Ilfov	180.528	103.855	5.456	5,3	89.085	85,8
Total	**23.838.281**	**8.938.719**	**5.458.181**	**61,1**	**7.016.555**	**78,5**

The land applications of sludge suitable potential regions are shown numerically in Table 8. [6].

Table 8. The land application of sludge on areas potentially suitable [6]

Region	Arable land - total (ha)	Land slope <5% and pH> 6.5		Land slope <10% and pH> 6.5		Tern slope <10% and pH> 6.0	
		ha	% of total arable land	ha	% of total arable land	ha	% of total arable land
North-East	1.219.868	54.053	4,4	228.909	18,8	291.204	23,9
South-East	1.967.166	399.681	20,3	694.368	35,3	712.728	36,2
South	2.034.674	557.529	27,4	696.077	34,2	846.589	41,6
South-West	1.191.866	122.566	10,3	146.191	12,3	225.445	18,9
West	**1.010.940**	**99.213**	**9,8**	**110.009**	**10,9**	**194.142**	**19,2**
North-West	829.800	6.543	0,8	25.702	3,1	50.418	6,1
Center	580.550	17.166	3	57.818	10	68.489	11,8
Bucharest-Ilfov	103.855	1.883	1,8	2.270	2,2	86.997	83,8
Romania	**8.938.719**	**2.517.267**	**28,2**	**3.922.690**	**43,9**	**4.952.027**	**55,4**

5. CONCLUSIONS

In Romania, the mud is currently stored in WWAT (91%), discharged to waste deposits (9%) or used in agriculture (0.2%). The incineration is not used since Romania doesn't have operating incinerators for solid waste and mud. The mud production is a continuous process which implies finding flexible and safe discharging solutions.

The mud use in agriculture or its recycling for energy recovery are forbidden for waste deposits, so the alternative options, such as the use on forest or degraded land administration, become important.

The organic matter content of 50% indicates that the mud is generally stable while the maximum value of 80% is valid for raw mud (unstable). The average content of dry substance is 22%, typical for dehydrated mud, but there is a large range between the liquid and very dry mud.

While all the WWTP stations follow the limit values for AOX and DEHP and 91% for the PCB value, the LAS and PAH levels are low (40% respectively 20%); no WWTP station follows the NPE suggested limit.

The mud samples were also object of microbiological examination. The results indicate typically the presence of Salmonella (62% of the samples) while the number of excremental coliform bacteria is between 103 and 108 MPN/g d.s., geometric mean of 106 MPN/g d.s.

REFERENCES

[1] Ciolea D.I. Dunca E., - *Research on mud's resulted from water purging in Romania, SGEM, Albena, Bulgaria, 2014*

[2] *** Options *for the management of sludge and best practice*, 2011

[3] *** Report *to the environment-sludge strategy*, 2011

[4] *** *Master Plan Arad*, 2010

[5] *** *National Strategy for the management of sewage sludge*, 2012

[**6**] *** *Directive 86/278 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture.*

Scientific Reviewers:
Prof. Ph.D. Eng. Mircea GEORGESCU

MAGNESIUM MINERAL RESOURCES USED IN DOMESTIC WASTEWATERS TREATMENT

CAMELIA BĂDULESCU*
VIORICA CIOCAN**
DIANA MARCHIŞ***

Abstract: *The most widely used technologies for nutrient removal include biological nitrification/denitrification for nitrogen removal and metal salt precipitation for phosphorus removal. An alternative to these conventional technologies which can provide for recovery of the nutrient as a commercial fertilizer could be the production of struvite. Starting from the most well-known example of salt as "struvite" or $MgNH_4PO_4$, which is commonly formed in anaerobic digesters when significant levels of Mg occur in the raw sewage, the paper present a new type of reactor called "denitrification" with fluidized bed.*

Key words: *nutrient, struvite, domestic wastewaters*

1. INTRODUCTION

Nutrient removal from wastewater discharges is an increasing challenge for water authorities in order to avoid eutrophication problems in receiving waters. Nitrogen and phosphorus are normally present in domestic sewage at concentrations of around 40 and 10 mg/l respectively. With wastewater treatment operating high costs, the recovery of the nutrients as a fertilizer is obviously not a direct economic process. However, it could be a good way to offset some of the unavoidable costs associated with treating the wastewater before discharge and final disposal of the sludge, using new installations. This research is concerned with the removal of ammonium nitrogen and phosphorus in domestic wastewaters using magnesium limestone with 20-25% MgO. The calcinations operation emphasizes MgO from brucitic or dolomitic limestone.

2. THEORETICAL ASPECTS

The range of salts called metal ammonium phosphates have the propitious properties of being not only insoluble enough to achieve significant phosphorus removal but also of being able to make the phosphorus and ammonium available to plants by a biologically based slow release mechanism. The most well known example of this type of salt is "struvite" or $MgNH_4PO_4$, which is commonly formed in anaerobic digesters when significant levels of Mg

* *Associate Professor, Dr.Eng, University of Petrosani, Romania*
** *1st Degree Researcher, Dr.Eng., INCDMRR Bucuresti, Romania*
*** *Lecturer Dr., University of Petrosani, Romania*

occur in the raw sewage. The excellent fertilizing properties of struvite have been well studied and reported in a number of publications (Lunt et. al., 1964) Salutsky et. al. (1972) have clearly demonstrated the efficient precipitation of phosphorus from anaerobic digester effluents as MgNH4PO4, with P levels being reduced from around 100 mg/l to 2-3 mg/l. Simultaneous ammonium removal was also achieved and elemental analysis found the precipitate to be largely.

The most feasible procedure adequate for low flow rate waste waters containing nutrients has proved to be the precipitation as double phosphate of ammonium and magnesium, compound well known as "struvite". That compound owns such a low solubility that it is used in analytical practice to determine magnesium content. The precipitation reaction is as follows:

$$Mg^{2+} + NH_4^+ + PO_4^{3-} = MgNH_4PO_4 \qquad (1)$$

A lot of other elements such as Hg, Ag, Pb, Al, Fe, Mn, Zn are partially removed from the waste waters by co-precipitation or adsorption under the same conditions when struvite is precipitated. In the same time arsenic is precipitated as AsO43- as well. The solubility product also points out a very low solubility of the residual ions of residual phosphates and ammonium that remain in solution:

$$Ps = [Mg^{2+}] \cdot [NH_4^+] \cdot [PO_4^{3-}] = 2.5 \cdot 10^{-13} \qquad (2)$$

The residual concentration of ammonium and phosphate ions is about 1-10-5 mol/l, but under industrial conditions the obtained residual concentrations weren't less than 0.1mg/l.

The ratio between ammonium and phosphate ions should be 18:95 in respect with the precipitation reaction stoichiometry as well. The necessary magnesium to occur the precipitation shouldn't be added as precipitation reagent. The researches carried out at the University of Petroşani aim to use the dolomite (CaMgCO3) in order to generate the required magnesium. Magnesium dissolution takes place in a less amount due to the solubility:

$$Ps = [Mg^{2+}] \cdot [CO_3^{2+}] = 2.6 \cdot 10^{-5} \qquad (3)$$

The solubility product allows magnesium solubility of 0.005 mol/L. The magnesium dissolution takes place in a higher proportion due to its reaction with the carbon dioxide:

$$Mg(CO_3) + CO_2 + H_2O = Mg(HCO_3)_2 \qquad (4)$$

The struvite that is obtained due to those reactions in case when is not contaminated by heavy metals may be successfully used as chemical fertilizer with phosphorus and ammonium. The chemical composition of struvite is as follows: NH_3^- 23.29%; PO_4^{3-} -69.34%; Mg^{2+}-7.37%.

The nutirents removal as struvite from water has proved to be highly advantageous because from technological viewpoint it is enough to pass on the contaminated water on a dolomite bed.

3. EXPERIMENTAL RESEARCH

3.1 The denitrifying reactor design

In order to achieve an advanced purge of sewage wastewaters an apparatus named denitrifying reactor, which works on continuous regime, has been conceived and its schematic representation is showed on figure 1.

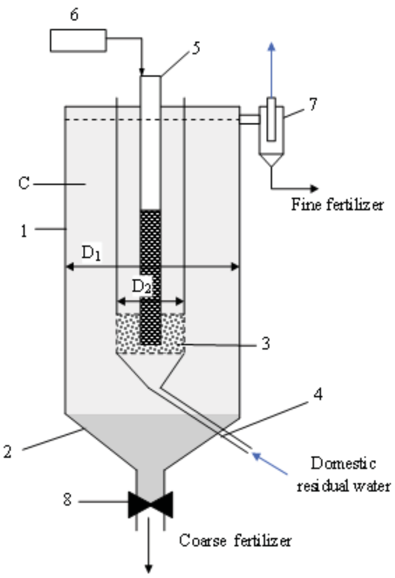


Fig. 1. *Denitrifying reactor*

The conceived and tested apparatus from the sewage wastewater treatment station of Petroşani city has a relatively simple design and operation. The denitrifying reactor is made of two concentric jackets, 1 and 5 respectively. The inner tube 5 is used for the feeding with dolomitic limestone with brucite previously calcined at a temperature of maximum 850ºC with a view to setting free the activated magnesium oxide. Through the feeder 6 within the metallic crook 3 the dolomitic limestone with brucite having a grinding size 0-3 mm is introduced in order to generate the fluidized bed through which the sewage wastewater containing phosphate and ammonium is circulated in counter current. Those ions will react with the magnesium from the dolomitic limestone so the struvite occurs. It will be evacuated on the inferior part of the reactor.

The fine particles of dolomitic calcium with brucite and formed struvite will be evacuated on the inferior part of the reactor after a previously thickening in the hydrocyclone 7 attached to the denitrifying reactor.

The main technological parameters established by the specific sizing calculus for that apparatus are: the maximum size of particles of considered activated brucitic ore is: d_{max} = 30 mm, to which corresponds a velocity of the fluid in the fluidized stratum of de ω_{cr} = 0,03 m/s with which the particles with a size less than d_{antr} = 0,19 mm ≅ 0,2 mm are carried. The considered activated brucitic ore has had the following granulometric composition compared to the carrying diameter: 29.4% material with the diameter less than 0.2 mm and 70.6%, material with the diameter 0.2 – 3 mm. Table 1 shows the maximum concentration of formed struvite in the final product.

Table 1. **Struvite concentration depending of the dolomitic limestone size**

Granulometric class (mm)	Struvite, %	Exhaustion grade related to the initial material, %
-0,2	19.0	9.0
+0,2	4.0	1.7
average	8.4	3.84

From the granulometric analysis results that for a diameter d_{antr} of about 0.2 mm, approximately 26% of material is carried, which corresponds to a suspension concentration of 541 mg/dm^3 in water that has to be eliminated by hydrocyclonation. The average porosity of the material in the fluidized stratum is 0.575.

For the fluidized bed calculation it was very important to establish two critical parameters such as: the critical velocity at which is formed the fluidized bed and the speed drive of the fluidized bed. Table 2 shows the denitrifying reactor parameters.

Table 2. **Denitrifying reactor parameters**

Parameter	**UM**	**Residual water flow, (m^3/day)**		
		500	**1500**	**2500**
Dolomitic limestone	Kg/day	1041.7	3125.0	5208.3
Bad surface	m^2	0.19	0.58	0.96
Ascending velocity	m/s	0.03	0.03	0.03
Reactor parameters				
D1/D2=3				
Radius	m	0.74	1.29	1.66
Surface	m^2	1.74	5.21	8.68
Ascending velocity	m/s	0.0033	0.0033	0.0033
d_{min}	mm	0.41	0.41	0.41
D1/D2=4				
Radius	m	0.99	1.72	2.22
Surface	m^2	3.09	9.26	15.43
Ascending velocity	m/s	0.0019	0.0019	0.0019
d_{min}	mm	0.27	0.27	0.27
D1/D2=5				
Radius	m	1.24	2.15	2.77
Surface	m^2	4.82	14.47	24.11
Ascending velocity	m/s	0.0012	0.0012	0.0012
d_{min}	mm	0.21	0.21	0.21
D1/D2=7				
Radius	m	1.74	3.01	3.88
Surface	m^2	9.45	28.36	47.26
Ascending velocity	m/s	0.0006	0.0006	0.0006
d_{min}	mm	0.16	0.16	0.16

3.2 Laboratory trials

In order to validate the possibility to use the proposed and design denitrifying reactor, such an apparatus has been assembled based on its constructive simplicity and has been tested in the laboratory. A key role plays the hydrodynamic parameters of the apparatus as well as the quality of the dolomitic limestone with brucite, the last one constituting the raw material for a certain type of fertilizer with very good agronomic properties.

The feeding of denitrifying reactor consists of residual waters which contain: NH_4^+ = 150-200 mg/l and PO_4^{3-} = 80-100 mg/l. The ratio between the magnesium limestone and residual waters is between 2:1 – 2.2:1. The contact time is around 1 hour for a good quality of the final product.

In the next section are presented the experimental tests carried out on two water samples polluted with nutrients, which were collected from the sewage wastewater treatment station from Petroşani city. The residual phosphate concentration of those water samples has been determined at the treatment with different magnesium concentration and as a function of ammonium present in water. Both figures points out the decreasing of phosphate concentration at concentrations less than 0.05 mg/L corresponded to the first class of quality.

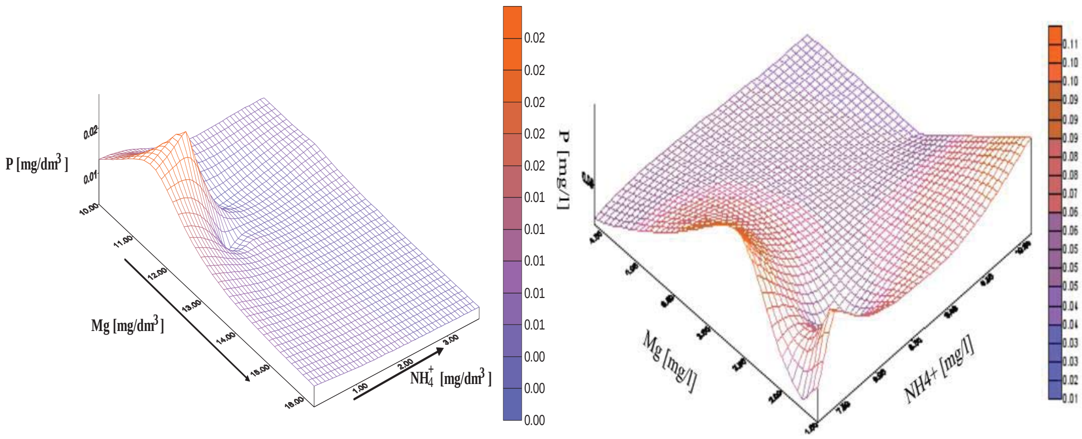


Fig. 2 – *The PO_4^{3-} and NH_4^+ variation in denitrifying process*

The dolomitic limestone grinded up to 3 mm and previously calcined contains 23% MgO, 1.5% micro-elements consisting of cobalt, copper, nickel, zinc, boron, metallic oxides of manganese , aluminium, titan, sodium, potassium, phosphorus, iron, silicon and the difference of CaO, as one can observe in the chemical analysis presented on table 3. That raw material contacted with the sewage wastewater containing ammonium and phosphate ions forms struvite weighting 25% associated with 1.5% micro-elements and the difference up to 100%, calcium and other metals oxides. The product colour is white, white-yellowish or with-brownish with specific smell of ammonium content, is water soluble and has a specific density of 1.7 kg/dm^3.

Table 3. **The dolomitic limestone composition**

Component	**UM**	**Values**
SiO_2	%	0.42
TiO_2	%	0.01
Al_2O_3	%	0.03
MnO	%	0.02
Fe_2O_3	%	0.13
MgO	**%**	**23.18**
CaO	**%**	**33.12**
Na_2O	%	0.09
K_2O	%	0.06
P_2O_5	%	0.18
L.C.	%	42.28

Previously studies have confirmed the excellent agronomic properties of $MgNH_4PO_4$. While only slightly soluble in water and soil solutions, struvite was found to be a highly effective source of phosphorus, nitrogen and magnesium for plants through both foliar and soil application. The release of nutrients appeared to be enhanced by a biological nitrification mechanism, with the nutrients being released at a controlled rate over an extended period of time. When properly granulated, it can be applied to soil at rates greatly exceeding those of conventional fertilisers without danger of burning plant roots. Despite such attractive agronomic properties struvite is not widely used in the fertiliser industry, the main reason appearing to be its high cost of production from the raw chemicals, because it had to use both $MgCl_2$ and NaOH in addition to ammonium and a phosphate source.

In a wastewater treatment plant which is required to remove both nitrogen and phosphorus, the cost of supplying N and P is just the incremental cost associated with changing the treatment plant design as discussed in previous sections. The supernatant from the anaerobic digester of domestic sewage cleaning plants is an excellent source of both N and P for struvite production, but this still leaves the cost of both $MgCl_2$ and NaOH supply. However, a good understanding of the process chemistry, combined with clever design, has the potential to produce a cost effective process for struvite production.

4. CONCLUSIONS

In Romania, most of the sewage wastewater treatment station doesn’t have a tertiary treatment stage to eliminate the phosphate and ammonium ions from the water discharged into the emissary.

Designing and utilization of a reactor called denitrifying reactor, which operates in continuous regime, may be easily integrated within the technological flow sheet of the treatment station. The operating principle is very simple, the wastewater resulted from the secondary treatment stage is passed through a fluidized bed composed of dolomitic limestone previously calcined to set free the magnesium oxide, which reacts, resulting a fertilizing product, which contains 25% of double phosphate of magnesium and ammonium, named struvite ($MgNH_4PO_4$) associated with 1.5% micro-elements and the difference of up to 100%, oxides of calcium and other metals.

The feeding of denitrifying reactor consists of residual waters which contain: NH_4^+ = 150-200 mg/l and PO_4^{3-} = 80-100 mg/l. The ratio between the magnesium limestone and residual waters is between 2:1 - 2,2:1. The contact time is around 1 hour for a good quality of the final product. The final concentration of PO_4^{3-} was between 0,05mg/l – 1 mg/l, with 78% efficiency recovery.

5. REFERENCES

[1]. Jaffer,Y. et all: *Potential phosphorus recovery by struvite formation***,** Cranfield University, Bedfordshire, pp.1-202, UK, 1995

[2]. Lee, JJ et all: *A study of NH3-N and P refixation by struvite formation in hybrid anaerobic reactor*, Chonnam National University, Gwangju pp 500-757, Korea 2001.

[3]. Sarbu, R: *Gravitational methods of mineral processing*, vol. II, Petrosani, 2002.

[4]. Ciocan, V et all: *Residual waters treatment*, Universitas Ed., pp 1-185, Petrosani, 2005.

Scientific Reviewers:
Prof. Ph.D. Eng. Romulus-Iosif SARBU

FACETS OF THE ENVIRONMENT POVERTY IN ROMANIA

**SABINA IRIMIE*
MARIA LAZĂR*
RARES MUNTEANU****

Abstract: *The main issue of this article is one of the most spread present economic phenomena – the poverty. It is a global problem due to its amplitude, sources and effects, and requires a multidisciplinary approach, from vision to actions and concrete solutions. "The new poverty" brings back into attention the influence of the environment as a decisive factor of the poverty at local, area or regional level and having a high weight in causing the poverty in the world. We present in this article two case studies in Romania regarding the influence of the environmental factors on the deterioration of the regional development and this is an alarm for this process in one of the most poor European country.*

Key words: *poverty, environmental poverty, ecological, economic and social disasters*

1. Poverty - Concept delimitations and statistical data

There is an indissoluble, mutual connection between human and nature: human as an element of the nature and nature as a life support for human life. The quality of the air we breathe, the water and the food given by the land are all natural vital elements for the human life. This was the determining factor for the evolution of the society. But this trend to development generates one of the "modern world's trilemmas (figure 1).

The eradication of the extreme poverty is an essential Millennium Development Goals. In December 2000, the Council of Europe decided that all the member states should realise until 2001 strategies against poverty and for social inclusion. The principles and the experience of the plans of the 15 member states of the EU represented an important source of inspiration for the elaboration of the National Plan against Poverty and Social Exclusion. This plan respects the EC model established in 2000 for the national plans of the EU countries, but taking into account the specific features of Romania. This National Plan for Action was the first experiment realised by Romania in the view of the European integration.

In the EU, a person considered as poor has an income less than 60% of the national average income.

* *Prof. PhD. Eng. at the University of Petrosani, Romania*
** *Lecturer PhD. Eng. at the University of Petrosani, Romania*

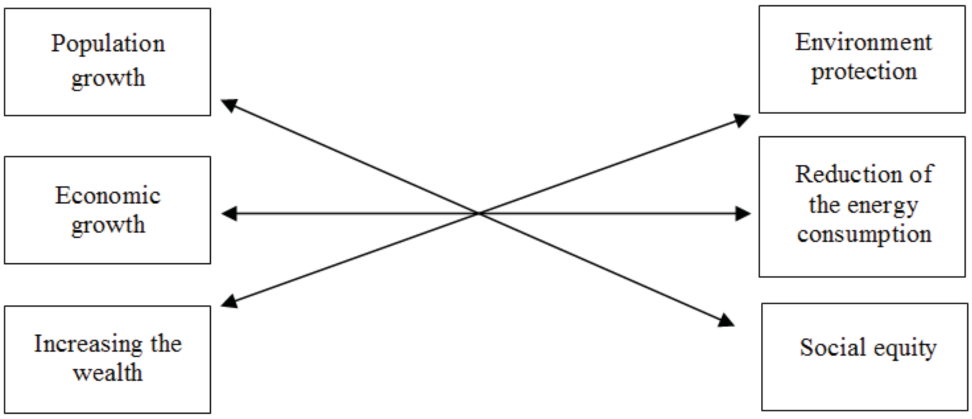


Fig. 1. Modern world trilemmas

The Europe 2020 strategy promotes social inclusion, in particular through the reduction of poverty, by aiming to lift at least 20 million people out of the risk of poverty and social exclusion. This indicator corresponds to the sum of persons who are: at risk of poverty or severely materially deprived or living in households with very low work intensity. Persons are only counted once even if they are present in several sub-indicators. (Table 1)

The first place in the poverty ranking has been hold by Bulgaria for many years and our country is the second, but very close, as 40.4% of the Romanians live at the poverty limit.

According to the National Institute for Statistics (NIS), a quarter of Romania's population lives with the minimum salary (from January 1st 2015 it is of 975 RON/month, aprox. 236 EUR/month) and 8,500,000 Romanians have an income under 60% of the average national salary, having about 100EUR/month (Mihailovici, 2012).

The specialist literature in Romania emphasized the dynamics, dimension, depth, profile of the poverty and also structural, individual and regional factors of the poverty (for example, CASPIS, 2004, World Bank, 2003, Chircă şi Teşliuc, 1999, PNUD, 1998, 1999, Sandu, 1998, 1999, 2000, 2003, Stănculescu şi Berevoescu, coord., 2004, Teşliuc, Pop, Teşliuc, 2001, Zamfir, 1995, 2001).

The extreme poverty in Romania is found in the urban areas, among the young and the children and is closely related to the phenomenon of the homeless persons, changes of the labour market (unemployment) and forms of social disorganisation. In the rural areas this type of poverty is only marginal, the key problem in the rural environment is the traditional poverty, associated to the low level of modernization and an economic life dominated by agriculture.

The "new poverty", generated also by the environmental factors emphasises and encompasses new social groups affected by the risk of the poverty. „There are several basic causes of extreme poverty. These include:

(1) Adverse geographical condition:

- Physical isolation of the region (landlocked, small island, mountainous) and sparseness of the population
- Poor climate (hyper arid, flood prone)
- Poor agriculture (poor soils, land degradation, adverse climate) or poor fisheries
- Lack of energy resources (no fossil fuels, no hydro power)
- Disease ecology (hyper-endemic vector-borne diseases such as malaria)

• Major vulnerability to hazards such as floods, droughts, typhoons, earthquakes and other hazards.

Tabel 1 People at risk of poverty or social exclusion [% and 1 000 persons]

geo\time	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
EU (27 countries)	:	25.7(e)	25.3(e)	24.4	23.8	23.3	23.6	24.2	24.7
Belgium	21.6	22.6	21.5	21.6	20.8	20.2	20.8	21	21.6
Bulgaria	:	:	61.3	60.7	44.8(b)	46.2	49.2	49.1	49.3
Czech Republic	:	19.6	18	15.8	15.3	14	14.4	15.3	15.4
Denmark	16.5	17.2	16.7	16.8	16.3	17.6	18.3	18.9	19
Germany	:	18.4	20.2	20.6	20.1	20	19.7	19.9	19.6
Estonia	26.3	25.9	22	22	21.8	23.4	21.7	23.1	23.4
Ireland	24.8	25	23.3	23.1	23.7	25.7	27.3	29.4	30
Greece	30.9	29.4	29.3	28.3	28.1	27.6	27.7	31	34.6
Spain	25	24.3	24	23.3	24.5	24.7(b)	26.1	26.7	27.2
France	19.8	18.9	18.8	19	18.5(b)	18.5	19.2	19.3	19.1
Croatia	:	:	:	:	:	:	31.1	32.6	32.6
Italy	26.4	25	25.9	26	25.3	24.7	24.5	28.2	29.9
Cyprus	:	25.3	25.4	25.2	23.3(b)	23.5	24.6	24.6	27.1
Latvia	:	46.3	42.2	35.1	34.2(b)	37.9	38.2	40.1	36.2
Lithuania	:	41	35.9	28.7	28.3	29.6	34	33.1	32.5
Luxembourg	16.1	17.3	16.5	15.9	15.5	17.8	17.1	16.8	18.4
Hungary	:	32.1	31.4	29.4	28.2	29.6	29.9	31	32.4
Malta	:	20.5	19.5	19.7	20.1	20.3	21.2	22.1	23.1
Netherlands	:	16.7	16	15.7	14.9	15.1	15.1	15.7	15
Austria	17.9	17.4	17.8	16.7	20.6(b)	19.1	18.9	19.2	18.5
Poland	:	45.3	39.5	34.4	30.5(b)	27.8	27.8	27.2	26.7
Portugal	27.5	26.1	25	25	26	24.9	25.3	24.4	25.3
Romania	:	:	:	45.9	44.2	43.1	41.4	40.3	41.7
Slovenia	:	18.5	17.1	17.1	18.5	17.1	18.3	19.3	19.6
Slovakia	:	32	26.7	21.3	20.6	19.6	20.6	20.6	20.5
Finland	17.2	17.2	17.1	17.4	17.4	16.9	16.9	17.9	17.2
Sweden	16.9	14.4	16.3	13.9	14.9	15.9	15	16.1	15.6
United Kingdom	:	24.8	23.7	22.6	23.2	22	23.2	22.7	24.1(b)
Iceland	13.7	13.3	12.5	13	11.8	11.6	13.7	13.7	12.7
Norway	15.8	16.2	16.9	16.5	15	15.2	14.9	14.5	13.7
Switzerland	:	:	:	17.9	18.1	17.9	17.2	17.2	17.5

Source of Data: Eurostat, **Last update:** 18.05.2015, **Date of extraction:** 19 May 2015 21:14:48 CEST.

(2) Prolonged violent conflict and international sanctions; (3) Despotic government and poor governance; (4) Gender and ethnic or social discrimination; (5) Extreme total fertility rates (6 or higher); (6) Lack of access to land." (*Secretariat of the Sustainable Development Solutions Network,* **2012,** pp.1-2)

In the following, we present two relevant Romanian case studies related to this issue.

2. ECOLOGICAL, ECONOMIC AND SOCIAL DISASTERS IN OCNELE MARI AND OCNA MUREŞ

2.1 Ocnele Mari

Although closed since 1992, the salt mine in Ocnele Mari from Field 2 Teica has caused damages worth tens of billions of lei in 2001, when part of a cave collapsed and the brine has flooded over 60 houses. The disaster in Ocnele Mari began in September 2001 and repeated itself in 2002 and in 2004.

On September 12th, 2001, the top of Teica Hill cracked and two wells sank. The crater which was formed initially had a diameter of approximately 300 meters and the height of the superior bank that had collapsed was of 40 meters. 30 houses were flooded but no human lives were lost. The damages were estimated then at 150 billion lei.

After a year, in September 2002 the collapsing phenomena repeated, but in a different area of the locality. The 356 well's tower collapsed and four houses were damaged. At that time, 200 people were evacuated from the area.

In 2004, was once again invaded by brine, after another well had collapsed. The brine overflowed the protection dam built in Teica village and 50 houses were affected.

The measurements of the water from Pârâul Sărat (Salted Creek) indicate salinity of 3.829 mg /litre and on nearly 2.500 square meters of the cave's ceiling show signs that there will be an opening in the salt layer.

Up to now, the most significant problems in Ocnele Mari were created by the cave situated in the Well Field 1. However, specialists claim that the ceiling of the cave that was formed in Well Field 2 is also very thin and it could cause various problems at any given moment.

The locals whose houses are in the vicinity of the accumulation lake on Pârâul Sărat and who must be moved declared that they are terribly unhappy about the way the local and county authorities handled their situation, as part of those who had or, indeed, still have houses (some of them brand new) in the risk area have not been compensated for the loss of their houses.

On the overall, over 120 households were moved from the salt exploitation fields. Nevertheless, not just these few hundreds of families are affected by the salt exploitation in Ocnele Mari, but the development of the entire town is affected. People are afraid that, due to the huge economic stakes represented by the giant salt deposit on top of which the town is situated, even the locality could be destroyed to support the exploitation of salt. At the moment, the life of the inhabitants is extremely difficult as almost every economic activity is paralysed as a result of the numerous problems created by the mines' cave-ins.

2.2 Ocna Mureş

The town of Ocna Mureş was largely built around the former galleries of the salt mines that functioned in the area, the town being a centre of salt extraction since the Roman period.

The locals claim that, till mid 19th century, the river Mureş used to run in the immediate vicinity if the salt massif in the area. Ocna Mureş was built near the river's course. In that time it was decided to move the riverbed with several hundreds of meters as the salt mines were frequently flooded. In 1912, most of the old salt mines were flooded causing the collapse of their ceilings and the surface was ruptured by funnels and craters of large dimensions that affected the inhabited areas as well. In 1952 it was decided to fill all the caves and craters that were formed above the former Roman mines with high concentration brine. In the '70s, the chlorine products manufacturing plant in town started to develop so that the salt mine in the locality could not cover for the salt requirements of the plant any longer. At that time, the representatives of the company decided to pump the volume difference from the lakes on the salt massif filled with concentrated brine, which led to the corrosion of the safety wall between the 1 Mai Mine and the nearby lake. In 1978, the wall between the mine and the lake gave way, and the mine's chambers were flooded entirely. Fortunately, there were no victims recorded as the miners managed to save themselves, but then the flooding of the galleries of the old salt mines started. The phenomenon has been going on ever since.

Fig. 2

The last collapse took place in December 2010, when a warehouse, a supermarket and a house were swallowed by the underground lake. Also, a car service, a parsonage and the headquarters of the fiscal authorities were severely damaged presenting cracks in the walls. A street from the town's centre was rendered unusable because of the cracks in the road. All these are the result of the appearance of a 16 meters deep crater and a surface of approximately 2000 m^2, which appeared in the middle of the town. The main cause is represented by the existence of numerous underground works by which rock salt is exploited and which were flooded.

The phenomenon affected the resident population, inducing a state of panic, first of all, beyond the direct material losses suffered by some people. According to the mayor's statements, the damages are estimated at 17,6 million RON (4,14 million Euro), but nobody knows where this money will come from. Because of bad management, the salt plant in Ocna Mureş only has a few dozens of employees now, bearing in mind that once it was the main economic entity in the locality. Also, the former salt baths became a ruin. Most of the inhabitants here are unemployed or retired, but without further investments new jobs cannot be created. The inhabitants feel that after this last disaster, things will go from bad to worse, as nobody has enough confidence to invest in a town that may disappear. Almost every year certain gardens are flooded and the water in the wells in undrinkable due to the high concentration of the salt. The sewers system hasn't been repaired in a long time and the centre of the town is represented by a muddy lake now.

Currently, some geologists claim that a part of Ocna Mureş is situated right above the galleries of the former salt mines and, as they are flooded, landslides or cave-ins may occur at any moment.

3. „OLTENIA'S SAHARA" THREATENS THE POPULATION IN SOUTHERN ROMANIA

According to studies regarding the impact of global warming on Europe, Romania together with Spain, Italy and Greece, is situated in the area with a high risk of desertification. One third of Romania (approximately 7 million hectares) and 40% of its agricultural surface is situated in areas with desertification risk. The most exposed regions are those in the south of the Romanian Plain, Dobrogea, and Southern Moldavia.

In order to illustrate the impact of drought and the phenomena induced by it on the quality of the population's life, we propose a case study on Dolj County, which is considered to be the drought pole in Romania from the climatic point of view. In this part of the south-west of the country, drought tends to become an ordinary fact. Its occurrence on longer and longer periods of time and on ever growing surfaces is also favoured by the presence of certain sandy areas (between 8 and 9% of the county's surface), but it is also favoured by the massive deforestation. As a result, there is a significant increase in the growth of aridity (deepening of the underground water levels) and even of desertification (the absence of the vegetal cover).

In the area Calafat - Poiana Mare - Sadova - Bechet - Dăbuleni in the southern part of the county, over 100000 hectares of land became arid and the sandy soil tends to desertification. Due to the phenomenon, the area was called „Oltenia' Sahara".

Fig. 3.

During the past three years, a very high percentage of agricultural land was affected (between 50% and 100%). Accordingly, the losses of crops were considerable (between 73,8%, in 2001 and 92,8%, in 2002).

Fig. 4.

In the past few years, the plants were simply burnt by the sun, and the potatoes baked underground. The corn fields, where the plants are underdeveloped and dry, complete the desolating landscape in this area. The drought here affects the entire social and economic life. The strongest social impact is felt in the rural areas, where 47% of the population lives. Agriculture represents the most vulnerable economic activity. The vegetable production is mainly affected and its problems are transferred to zootechnics. The most important losses are connected to the grain cultures' reduction. The decrease in the agricultural production affects food security, which in its turn increases the risks regarding the deterioration of the population's health. In the areas directly affected there is a higher occurrence of nutritional diseases and of other disorders associated with malnutrition.

The influence of drought is severely reflected on the current status of agriculture, on the water supply of various localities, as well as on the population's health and food security. As a result, we can estimate a shift in the areas with vegetation and, along with it, a migration of the affected population towards the northern part of the country.

REFERENCE:

[1]. Halla O., Duitbc A. & Caballerod L. N.C., *World Poverty, Environmental Vulnerability and Population at Risk for Natural Hazards*, Journal of Maps, Volume 4, Issue 1, 2008, pp.151-160, DOI: 10.4113/jom.2008.95, available at: *http://www.tandfonline.com/doi/abs/10.4113/jom.2008.95?journalCode=tjom20*

[2]. Christof Ruhl, Daniel Daianu (coord.), Pop L., *Poverty, Inequality and Social Protection*, Conferinţa "România 2000", organizata de World Bank si The Romanian Center for Economic Policies, in volumul Economic transition in România, 2000

[3]. Dana Mihailovici, *Circa 8,5 milioane de romani se zbat in saracie. Vezi cu cati bani pe luna trebuie sa traiasca aproape jumatate din populatia Romaniei*, 2012, available at *http://www.econtext.ro/eveniment--2/social/circa-85-milioane-de-romani-se-zbat-in-saracie-vezi-cu-cati-bani-pe-luna-trebuie-sa-traiasca-aproape-jumatate-din-populatia-romaniei.html,* accesed in 21.09. 2012.

[4]. Pop L. (co-autor), *Metode si tehnici de evaluare a sărăciei*, Programul UNDP de eradicare a sărăciei, Bucureşti, 1998

[5]. Pop L. (co-auto), *Sărăcia şi Protecţia Sociala in România*, Editura Polirom, Bucureşti, 2001

[6]. Pop, Lucian si Tesliuc, Cornelia Mihaela, *Saracie, inegalitate si protecție sociala*, RCEP, Working Paper, nr.7, Octombrie, 1999

[7]. *European Commission, Sustainable development in the European Union* - 2013 monitoring report of the EU sustainable development strategy, Eurostat, 2013, (DOI): 10.2785/11549, available at *http://ec.europa.eu/eurostat/documents/3217494/5759629/237EN-EN.PDF*

[8]. *Secretariat of the Sustainable Development Solutions Network,* **Global Profile of Extreme Poverty,** Background paper for the High-Level Panel of Eminent Persons on the Post-2015 Development Agenda, 15 October 2012

[9]. *Statistical Office of the European Communities* (EUROSTAT), available at http://ec.europa.eu/eurostat, accessed in 19 May 2015.

SCIENTIFIC REVIEWERS:
Prof. PhD. Eng. ROMULUS-IOSIF SARBU

FIXING THE QUARRY SLOPES PESTEANA BY USING THE DEEP-ROOTING SPECIES

GABRIEL NANU*
ROMULUS-IOSIF SÂRBU**

Abstract: *Consolidation of land plant technology is a new ecological of consolidation of technique slopes vegetalization, erosion and desertification degraded or arid areas. It uses a mixture of perennials - many of them indigenous - which consolidates the depth field and creates a dense vegetal cover, which significantly reduces the infiltration of rainwater, the main cause of landslides. The herbaceous species that can rapidly form a mulch and protect hillsides from erosion, acting like pioneers plants able to grow even in the poorest soils organic matter and nutrients. These plants therefore favor sequential increase plant shrubs and trees on a consolidated and fertile soil. Renaturalisation can be facilitated and accelerated by adding seed native species at the same time the hydro-seeds, or in succession, with work involving before or after sowing*.

1. INTRODUCTION

Environmental restoration of an ecosystem degraded by human intervention must ensure support for the regeneration of the original ecosystem with all its components abiotic and biological communities. Is also very important the creation of conditions of life for the first links of food chains that are superior links and support ecosystem trophic pyramids base. Plant communities are the main producer of biomass and fundamental support of other biological communities in the ecosystem. But the community should not be neglected by bacteria and fungi which play a major role in the nutrient cycle and the fertile upper soil layer formation.

The introduction of these organisms in an ecosystem to be restored can be achieved through grassy soil fragments of similar ecosystems to the person who undergoes rehabilitation operations.

Restoration of biological communities other animals, can be carried out slowly by natural re-colonization of the ecosystem restored at the expense of the ecosystems surrounding or animal populations can be accelerated by the introduction of population cores made of similar ecosystems.

The success of reconstruction or ecological rehabilitation program can be evaluated based on five criteria:

a. The resulting ecosystem sustainability, expressed in the ability of communities standing and perpetuation components over time without human intervention;

b. resistance to invasive species - natural ecological communities are more stable against invasive species than degraded and that some key species or groups of species have

---

* *student Ph.D. Eng., at the University of Petrosani, gaby_nanu69@yahoo.com*
** *Prof. PhD. Eng., at the University of Petrosani*

disappeared key; Ecosystem sensitivity to invasive species entering is proof of the fragility of the biological communities;

c. productivity is the criterion for the assessment of plant and animal communities in the ecosystem to use the resources available through the functions of photosynthesis, chemosynthesis, respiration, metabolism, etc .; a restored ecosystem must realize the same productivity as the ecosystem initially, before its degradation.

d. nutrient retention is a feature of any ecosystem found in a continuous flow of matter and energy; proper functioning and sustainability of an ecosystem rebuilt nutrient losses are correlated with ecosystem similar to the original. In case of greater losses in the long term, the ecosystem will be particularly fragile invasion of species that can harness the nutrients lost, affecting productivity and sustainability of ecosystems created through ecological restoration;

e. interspecific relations are the key to restoring the functional integrity of the ecosystem rehabilitated. Typically, restoring plant communities involves installing animal communities, more mobile, but there ecosystem is conditioned by the presence of key species (pollinators, nitrogen fixing bacteria or other nutrients, etc.) with essential position in food chains.

Environmental rehabilitation of areas affected by mining activity involves a rigorous, step by step, and appropriate for each situation.

This category includes polluted areas for which there is a project to reuse the sites that have an impact on the environment and industrial sites where hazardous pollution potential and should be observed. [Wang, Y., Dawson, R., Han, D., Peng, J., Liu, Z., Ding, Y., 2001].

Are steps leading environmental rehabilitation:

- identifying potential sources of pollution;
- pollutants released from these sources identify the environmental factors;
- identifying the effects on the environment;
- identifying ways to minimize impacts on the environment.

2. RESEARCH METHOD

The experiments were placed on dumps (medium-textured materials), which have completed the planning process in order to re-cultivation, including fertilization ameliorative. Experiments aimed located in the area the main crops (wheat, maize, sunflower, peas and beans). For deep-rooting crops (trees and vines), they were executed researches concerning the relations soil - plant (the root system). Before placing experiences, agrochemical study was performed to determine the supply of the soil. Due to improvement of fertilization achieved apparent increases in phosphorus and potassium, amid good environmental chemistry synthetic edaphically by a reaction expressed by between 6,4 and 8,1. The crops tested the highest increases protections (compared to controls) were obtained from the organic-mineral fertilizer of followed by mineral fertilizers. (Bischetti G.B., Chiaradia E. A., Epis T., 2009)

Regarding deep-rooting species is found that is distributed throughout the root system control section 100 cm. Frequency and length of the root for the most part is made in a depth of 20-60 cm as in natural soils suitable. Root distribution index (RDI) at researched copies is between 2,16 and 4,57, with averages of 3,25 the species plum, apple species and 3,94 to 3,65 vine-vine.

This technology consolidation crop land, using a mixture of species of plants with deep roots, to address problems related to erosion and often completely eliminated (with considerable benefits for beneficiaries and companies performing work) materials, works and additional costs, because:

- added vegetable land (because they grow even in completely sterile environments, tailings, slag, ash ...);
- surface slopes (which should preferably be cleared, rough and irregular);
- traditional hydro-seeding, enriched with fiber, etc. (which solves the problem of erosion)

It significantly reduces the duration of the work and the risks of their achievement and eliminates periodic maintenance costs.

It is a completely natural technology that enables complete and very fast renaturalising sterile areas and avoids impacts with negative effects on the environment that characterizes geogrids, geotextiles etc.

The mixture is composed mostly of plant grasses very effective at absorbing CO_2 from the atmosphere (they absorb more than 30% CO_2 from the atmosphere to plants usual), thus contributing to the requirements set by the Kyoto Protocol and especially if roadworks, to achieve environmentally compatible infrastructure.

Technology crop land consolidation involves mostly plant grasses showing a modified photosynthesis compared to common bean plants (more than 90% of plant species on the planet are legumes).

In the process of photosynthesis of vegetable plant, the CO_2 is incorporated into compound 3 carbon atoms. In these plants there is breathing or breathing camera, which can reduce photosynthesis by up to 50%. Photosynthesis is deactivated at very high temperature and brightness.

3. RESULTS AND DISCUSSIONS

3.1. Testing of the herbaceous plant growth

To test the ability of the herbaceous species grow on degraded soil, germination tests were conducted on similar materials to those of the dump in South Peşteana Quarry.

To test germination of the herbaceous species with different deep rooting system were used seven soil samples, similar in terms of features, the heap tailings material taken from different areas. Germination tests of the 9 different species of herbaceous plants with deep rooting system: each sample pot diameter 16 cm was filled with waste from the dump.

They were monitored in total the 63 pots (figure 1). The pots were taken every two days. One month after sowing, was shown the following results:

- from 9 the herbaceous species tested, only four were able to germinate in all soil samples, while developing a unit root on the entire volume of soil from the pot.
- the same experiment has been identified, that of herbaceous species tested have proven adaptability to critical conditions, which can be used to rehabilitate the quarry steps.

After the initial germination tests followed the second test phase, the development of the roots towards the various the herbaceous species analyzed.

3.2. The samples rooting

Of the pots species that have managed to germinate in the tailings dump, I chose four, one for each species. Each pot was transplanted in a transparent plexiglass tube with a length of 2 m and a diameter of 20 cm, which contained the same type of landfill material as the original found in pot trial. The tubes were provided with a drip irrigation system. Due to the transparency material from which these tubes were made while it was possible to monitor growth of 4 species the herbaceous roots.

Figure 1 Results after one month of sowing.
a) Sample pots. b) Developed root device inside the pot

Approximately a year after sowing it was revealed that root growth was intense in all species tested, and in 50% of cases exceeded one meter root depth, reaching one species to exceed 1.80 m depth.

Test-depth development of the roots showed that not only herbaceous species were able to germinate in landfill material and the fact that they fail to grow and develop in-depth root system. (figure 2)

Fig. 2 Plexiglass tube for evidence of ingrowth roots

Through this experiment we were able to identify which of herbaceous species tested were able to grow in tailings heap. Thus, it was possible useful the herbaceous species selection for the rehabilitation of quarry steps Peşteana South Indoor tailings dump.

The use of perennial herbaceous plants with deep rooting system allows blocking renaturalising erosion and areas where climatic conditions until a few years ago were considered unfit for vegetation. This technique can give a quick naturalization even if pits, where usually rooting vegetation is particularly difficult.

Tabel 1 *Species of grasses and legumes that responded experiment*

No. crt.	The herbaceous plant species	The depth of the roots growing in pots (cm)	Experimentally root dip tube (m)
1	*Lucerne (Medicago sativa)*	25	1,85
2	*Small trefoil (Lotus corniculatus)*	20	1,65
3	*Red clover (Trifolium pratense)*	18	0,75
4	*Sainfoin (Astragalus onobrychis)*	17,5	0,60

4. CONCLUSIONS

- the use of deep-rooted herbaceous species and other biological engineering works (building structures and drainage stone banks) for quick rehabilitation of embankments South Pesteana Quarry;

- extraordinary ability of plants to survive drought conditions are explained by deep roots network that can detect moisture present in the deeper layers of soil, either through plant science that make up this blend of plant species with deep roots.

- the natural systems, plants are able to regulate their own growth conditions: when the soil shows a high degree of moisture, the plants extract excess water from deeper layers, causing evaporation and increasing the geotechnical properties of the terrain. In summer, the degree of evaporation is reduced as a result of plant capacity to reduce stomata.

- fast growing herbaceous species rapidly consolidating land, fertilized it and improving soil organic structure

As a result of using this technology, resulting on the one hand combined effects of stabilizing the slope and a rapid and drastic erosion surface, and on the other hand, a decrease obvious infiltration of storm water into the ground (infiltration primary cause of cave-ins and landslips).

REFERENCE:

[1.] **Andrei M. & al.,** *Practical applications plant biology*. Didactical and Pedagogical Publishing House Bucharest, 1981.

[2.] **Andrei M., Paraschivoiu Roxana Maria,** *Botanical Microtechnology*, Niculescu, Publishing House Bucharest. 2003.

[3.] **Bischetti G.B., Bonfanti F., Greppi M.,** *Measurement of the tensile strength of roots: equipment for experiments and analysis methodology*. Documents Agronomies Montana, 21/1, 349-360, 2001.

[4.] **Bischetti G.B., Chiaradia E. A., Epis T.,** *Traction tests done on the roots of various plant species PRATI ARMATI®*. Final report. Department of Agricultural Engineering, University of Milan, 2009.

[5.] **Bonfanti F., Bischetti G.,** *Tensile strength of roots and example of interaction soil - roots*. Agricultural Hydraulics Institute, Milan - Internal report. Reinforce Prati SRL, photographic archive and database, 2001.

[6.] **Rassam D.W., Cook F.,** *Predicting the shear strength envelope of unsaturated soils*. Geotechnical Testing Journal, Technical Note, 25: 215-220, 2002.

[7.] Rettori A., Cecconi M., Pane V., Zarotti C. *Superficial Slope Stabilization technology Armati® Prati: implementing a computational model to assess the safety coefficient*. Accademia Nazionale dei Lincei – X, World Water Day Conference: Landslides and hydrogeological instability March 2010.

[8.] Richards, L.A., *Capillary conduction of liquids through porous medium*. Physics, Vol. 1., 1931.

[9.] Waldron LJ, *The shear stress resistance of root-permeated homogeneous and stratified soil*. Soil, 1977.

[10.] W.H. Wishmeier, D.D. Smith, *Predicting rainfall erosion losses from cropland east of the RockyMountain*. Agr. Handbook, n. 282, U.S. Dept. of Agr, 1965.

SCIENTIFIC REVIEWERS:
Prof. PhD. Eng. ROMULUS-IOSIF SARBU

METHODS AND TECHNICAL EXPERTISE, LEGAL AND ECONOMIC MINING RESTRUCTURING PROCESSES IN THE JIU VALLEY

MARIANA NEGRU[*]
MARIN SILVIU NAN[**]

Abstract: *In the Jiu Valley mining coal in critical situations occur frequently. They are considered critical situations occurrence of damage, the occurrence of accidents, disasters or development of production technology destructuration. Damages are dysfunctions that arise mainly from different machines and they influence and affect the effective exercise of production and labor productivity. This paper aims at applying methods of technical expertise, business and law to solve problems induced by mining restructuring in the Jiu Valley.*

1. INTRODUCTION

In the Jiu Valley coal mining sector encountered some dysfunctions are so technical, economical and legal dysfunctions are mainly due to the economic situation, but to a certain extent and the management of the available funds.

The analysis made on CEH-Mining Division found some dysfunctions which may be deemed to adversely affect the activity of these coal units. Thus, depending on their nature, they are:

- low technological level - still in use, with few exceptions, 1980s technology.;
- mining equipment used has a high degree of wear, because it was reused multiple times, and this leads to frequent interruptions of technological process. Both allegations mechanized slaughter and combines, combine forwarding, transportation equipment are used even if they are worn out because most often there is the possibility of replacing their lack of funds;
- lack of equipment for automation;
- obsolete equipment dispatching;
- absence of advanced equipment for the execution of openness and readiness, they are running through the classical drill and blast, there rarely combine forward that give much higher yields;
- because of the lack of modern equipment and the fact that many of the existing ones are old and worn, the risk of injury to workers;
- there is often lagging behind in terms of execution of investment, and this affects how the commissioning of new production capacities, leading to significant economic losses;

* *student PhD. Jr. Ec., ar the University of Petrosani*
** *Prof. Ph.D. Eng., at the University of Petrosani*

- there are frequent situations where not comply with the rules of labor protection, leading to an accident (mining Jiu Valley occupies a leading position in terms of the number of accidents), or the temporary or permanent closure of some production;

- due to redundancies made was reached where the number of employees is not sufficient or well distributed, there are still a large number of staff, and staff working on the surface, compared to that which is directly productive;

- due to lack of personnel, maintenance work is increasingly difficult mining;

- there is a good correlation between the preparatory work and the front, so that when capacity has been exhausted can be made according to another in a very short time if it is not possible simultaneously.;

- scraper conveyors and belt transport used ensures lower flow rates compared to others used in European or world level;

- mining methods are used that require minimal investment costs (method of operation undermining coal and surrounding rock), but have reduced yield than if the operation would be done mechanically;

- frequently planned production is not achieved nor take concrete measures to achieve it, are only presented the causes that led to its failure, or make some debate without a practical purpose.

2. METHODS SYSTEMATIZATION, TECHNIQUES AND PROCEDURES OF THE TECHNICAL EXPERTIZING

The most representative analysis and design methodologies economic systems are: analysis methodologies - diagnosis; informational methodologies - decision; conceptual methodologies.

Analysis method - diagnosis derived from the methods of establishing a medical diagnosis and seeks elucidation of the structure and functioning of an economic system, characterization accurate in his state information - decision, highlighting the positive aspects (strengths) and the malfunction (weaknesses) in the formulation of comprehensive strategies and ways of intervention to improve its performance, taking into account the influence of the disturbing factors in the environment in which it operates.

The analysis is characterized by the fact that diagnosis is achieved in a relatively short period of detail and seek solutions but solutions are global solutions in the form of recommendations - setting and a program of action that will include detailed analyzes future.

This analysis represents a starting point, and while the basic stage in the foundation of economic and social policy decisions. The success of a strategy can be ensured by following several conditions:

- adapting the strategy to the competitive environment it belongs to the organization by exploiting the opportunities and minimize foreseeable major hazards;

- strategy formulation so as to facilitate reaping the perceived opportunities and skills they possess outstanding organization;

- compliance with the chosen strategy.

Analysis of strengths, weaknesses, opportunities and a "threat" is known, due-diligence.

The strengths are the resources, skills and other benefits that the organization possesses and its competitors do not have, in the work of covering the needs of actual or potential purchases.

Weaknesses are limitations and weaknesses in terms of resources, skills and competences and seriously harm the organization's performance.

Opportunities are favorable situations existing in the environment in which the company operates.

The threats are posed by unfavorable events in the environment of the company and the main obstacles in achieving a desired favorable situations.

Once the scope is that of the diagnostic analysis can be generated when the unit is considering the socio-economic system or in whole, part or specialist, if only analyzed problems or subsystems of the organization.

Through systematic comparison of the strengths and weaknesses, opportunities and threats identified in the diagnostic analysis can determine the situation in which the company and can choose how strategic action.

After comparing four situations may arise and ways following four strategic action, as shown in Figure 1.

Quadrant 1 - is the most favorable circumstances arise when the organization and has more opportunities and strengths that give reason to question the opportunities. In this situation it is recommended aggressive growth strategy.

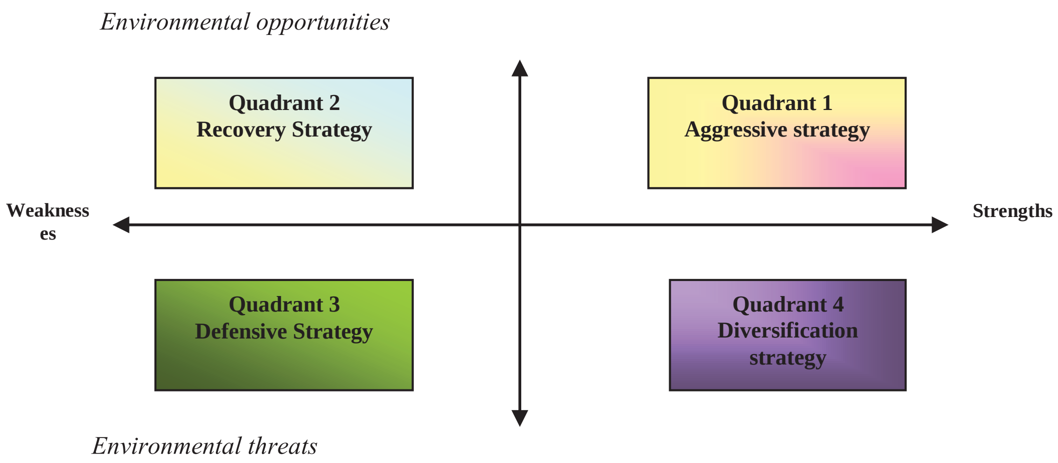


Figure 1 The situations in which a company can find

Quadrant 2 - shows a firm and substantial opportunities arise that can not capitalize because of internal weakness. In this case it will address a recovery strategy to eliminate weaknesses.

Quadrant 3 - is the least favorable situation, the company is relatively weak and have to face major threats from the environment. In this case it is worth examining, through analysis and diagnosis opportunities for scaling down or diverts business or sales in a particular market. In this case we recommend a defensive strategy.

Quadrant 4 - is the situation where a company with much strength encountered an unfavorable environment. In this situation, the strategy will use their strengths to create opportunities in other fields or in other markets and recommended a diversification strategy.

The main areas of diagnostic analysis are: financial; trade; production; human resources; research - development; managerial.

The production data are collected and information on:

- degree of accomplishing the plan of physical production and production capacity utilization;
- the level of inventories of unfinished products;
- rationality technological process and process flow;
- effectiveness of internal transport and forms of production organization in sections and workshops;
- the degree of organization of maintenance, repair, energy management and insurance tools and controllers;
- correlation of production capacities with demand and organizational capacities of the different links;
- main possibilities of increasing the use of production capacities;
- efficiency of quality control products;
- application of quality management in the company;
- the existence of programs to improve quality and achieve quality indicators.

Analysis - diagnosis seeks to achieve several activities:

- detection of favorable aspects that deserve to be extended or generalized;
- prevent structural imbalances producing phenomena or functional disorders;
- finding ways to remedy any imbalances, weaknesses and difficulties highlighted by analysis, taking into account the objectives of competition and restructuring and privatization;
- preparing the next steps to improve the organization and management of social-economic unit;
- determining the level (degree) of social and economic organization of the unit in question (health);
- accurate directions for the organization and management development (state of vitality).

Phase I - preparing diagnosis is a preparatory phase in which a series of preliminary contacts between analysts; unit management and future partners in order to establish the need and opportunity analysis - diagnosis and the creation and ensure a climate of trust and mutual understanding between participants.

At this stage, taking into account several activities:

- defining problems and objectives pursued by analysis - diagnosis;
- the analysis team training, in addition to analysts - external consultants and specialists are included in each analysis system;
- establishing methods of approach, the necessary auxiliary materials (diaries, questionnaires, etc.);
- conducting preliminary investigations to establish the necessary data;
- establishing concrete action plan.

This first stage ends with elaborating a graph of action and agreement with the beneficiary on the mode, time, people involved etc..

Phase II - Analysis - assessment contains a number of investigations completed by an analytical study - Diagnostic Report that includes an action plan and proposed solutions. Analysis of documents and information available, to allow detailed and accurate knowledge, of system operation and its status. Based on detailed analysis of credible scenarios can be developed evaluation.

The achievement this stage requires several steps:

- data collection, verification, systematization and grouping data using different statistical techniques, including graphics;

- interpretation of data, critical analysis of the results, categorizing and grouping data using different statistical techniques, including graphics;
- interpretation of data, critical analysis of the results, systematization and discussion of critical points with the customer in order to make them consistent with the results of data analysis;
- recovery analysis by developing recommendations must be well justified and to be accepted by beneficiaries;
- drafting final study or final evaluation report, containing an action plan and proposed solutions, endorsed by the beneficiary.

Phase II - post diagnosis - envisages implementation and evaluation of the proposed solutions, the principal purpose of verifying the actual effectiveness of implemented solutions.

When assessing a company, the main stages of the diagnostic analysis aim at preparing the report - diagnosis, analysis and assessment of the state enterprise and its operation by an analyst on documents and existing information and drafting the evaluation report.

3. SYSTEMATIZATION METHODS, ECONOMIC SURVEY TECHNIQUES AND PROCEDURES

Methods of expertise represents all procedures used by a company to attain its.

The process consists of systematically perform work, the way to act in order to achieve objectives. All of the processes used in the practice of science or scientific discipline its technical form.

The economic and financial expertise in their place a number of methods and shared with other sciences, designed to help achieve its object.

One can remark:

a) methods of qualitative analysis that the essence of the phenomenon, tracing causal links;

b) methods of qualitative analysis quantifying the object influences or factors that explain the phenomenon items.

In the category of qualitative analysis methods may include: comparison; division and decomposition results; group; generalization or evaluation results.

Quantitative analysis methods include:

1. Chain substitutions method that applies deterministic relationship that takes the form of mathematics or report product.

The direct connection of conditioning factors expression becomes a function:

$$\gamma = f(x) \tag{1.1}$$

For example, in a relationship of three factors, the result is expressed as a function of:

$$\gamma = f(x_1, x_2, x_3) \tag{1.2}$$

Using values and actual comparison basis, the relationship is marked:

$$R_o = a_o\, b_o\, c_o \tag{1.3}$$

$$R_1 = a_1\, b_1\, c_1 \tag{1.4}$$

$$DR = R_1 - R_o \tag{1.5}$$

The method involves observing substitutions chain of three principles:

a.) factors settlement is made according to their economic conditionality, which means that substitute quantity first and then the quality factor;

b.) successive substitutions are made;

c.) a substituted factor is maintained as a state in subsequent operations.

Doing separation of each of the three factors influence the change (DR), relationships are:

- the influence factor A: $A = (a_1 b_o c_o) – (a_o b_o c_o) = (a_1 – a_o) b_o c_o$ (1.6)
- the influence factor B: $B = (a_1 b_1 c_o) – (a_1 b_o c_o) = a_1(b_1– b_o) c_o$ (1.7)
- the influence factor C: $C = (a_1 b_1 c_1) – (a_1 b_1 c_o) = a_1 b_1 (c_1 – c_o)$ (1.8)

The literature is found and isolated action method of determining factors. With this method observed one principle of the three mentioned - substitutions are successively:

$$DR = R_1 - R_o \tag{1.9}$$

- the influence factor A: $A = a_1 b_o c_o – a_o b_o c_o$ (1.10)
- the influence factor B: $B = a_o b_1 c_o – a_o b_o c_o$ (1.11)
- the influence factor C: $C = a_o b_o c_1 – a_o b_o c_o$ (1.12)

$$DR = A + B + C + r \tag{1.13}$$

where "r" is the remainder decomposed on which were issued on several assumptions distribution factors.

2. The balance method

Links balance sheet reflects the interdependence phenomenon quantitatively analyzed. Their analysis allows revealing the causes of modifying a result, comparing the balance elements - the actual values with the baseline.

3. Matrix calculation method – apply in cases of product functional relationship or ratio between the reported situation and influence factors.

4. Operational research is a set of methods that are used in deciding where involved many factors must be considered. Among the main elements that characterize the operations research are mentioned:

a.) investigation of organized systems;

b.) the application of scientific methods to highlight the ties of interdependence, express them in a mathematical form and assign weights of all the elements and factors;

c.) rationalization decisions based on information and analysis of scientific methods and post-operation analysis, forecasting.

Reviews and accounting expertise to meet certain general principles (applicable in any work of some importance), must be conducted in accordance with legal rules and specific accounting methodology, should be a critical analysis of documents, records and accounting summaries.

The methods and techniques are characterized by extra-they have only as a starting point the accounting data officially recorded and using processing techniques that are not (in all cases) approved accounting methodology. In most cases, these methods and techniques to take more initiative and skill of the expert being able to rely on logical reasoning on inferences, assumptions on causation, analogies and similarities, which obviously affect the probative force of the results.

4. METHODS SYSTEMATIZATION, TECHNIQUES AND PROCEDURES JURIDICAL EXPERTISE

The legal expertise is intended to determine how to meet the requirements of current legislation in order to pursue extractive activity in good condition both economically and especially legal.

Over time today, due to the importance of the economic and technical specifics related to the extractive sector, natural resources and minerals became covered by State legislation appropriate legal regulations.

Mining laws are an expression of policy by which the state directs the activities of sectored natural resource being promoted ways in which governments influence sustainability.

Domain specific legislation affect investment flows. However, legal regulations highlight the main lines fundamental to long-term operating activities.

The mining laws to combat insurers sources (reduction or elimination) of investment risks or improve the stability of economic production-operating activities.

The new changes in the legislation contemporary mining concern: the obligation to observe strict environmental standards; a stronger contribution and capitalization processes to overall sustainability of the company.

The utmost importance is proving concern each entity states, including Romania, to ensure the legal framework for conducting exploration and exploitation of natural resources, requiring compliance with the area resulting from the intersection of elements of the set influences and conditioning of natural resources, investment and environment.

In general, a work plan in order to achieve an expert will have three parts:

- an introduction to the preparation work for information and for determining points investigated;
- a side that required to conduct the work actual;
- the final part comprising a summary of research and expert's report.

Legal expertise should investigate the legal reality very dynamic and complex, being concerned with constantly improving laws. In a world characterized by great mobility of its component structures, legal expertise should operate alongside traditional research methods, new ways of explaining and interpreting legal reality. The role of scientific research methods to analyze the legal expertise lies methodology can be defined as a science that reveals important aspects of the legal phenomenon.

1. The logical method of legal research

The logical method is the most common method; it is virtually present in every act of elementary and scientific thinking. In the scientific research legal logical method designates the sum of processes, techniques and operations methodological and genealogic specific, which put us in situations, as a researcher or analyst to decipher the structure and dynamics of relations (relations) set among the components of the existing legal system in society on approach our scientifically. The logical method is proper systematic sciences.

2. The comparative method of research juridical

The comparison is defined as the operation by the researcher and analyst legal phenomenon seeks to find, fix, or divergent elements identical to two phenomena investigated.

Among the methods used to achieve legal expertise I could list could include:

- Progressive methods starting from the act or acts which led to the drawing up of certain laws;
- Regression methods based on the effect of these laws to their origin.

Expertise of the processes used includes:

- examination of documents (laws) governing the conduct of the coal extraction;
- comparison method, which consists in comparing these with similar laws in Europe or in the world.

Exercise mission involving both legal expertise on solving the scientific and legal background of the issue, closely related objectives.

In legal expertise to draft the report, the expert should study the appropriate documentary material. Study material appropriate documentation and condition necessary prerequisite compiling a report based solid legal expertise, based on documents and not on assumptions.

5. CONCLUSIONS

The restructuring of mining activity consisted mainly in closing and mass layoffs personnel compensation, without providing viable alternatives for creating new jobs for redundant staff absorption.

Restructuring manifested by closing activities of mining and mass layoffs personnel compensation, without providing viable alternatives for creating new jobs to absorb redundant staff.

We conducted a synthesis and a reassessment of the models, methods, techniques and tools diligence, in order to select the most suitable elements and adapting them to the needs of the coal mining enterprises to increase efficiency assessments by restructuring the mining activity

REFERENCE:

[1.] Ciutacu, C., Perţ, Steliana, - *Analysis of the Regional Social and Economic Background. Case studies for RICOP, with the financial support of the European Training Foundation*, Turin, 1999.

[2.] Gâf-Deac, I., - *Legal and economic bases of system resources in the new economy*, INFOMIN Publishing House Deva, 2007.

[3.] Petcu Monica, **-** *Economic and financial analysis of the company. Problems, approaches, methods, applications*. Second Edition. Economic Publishing House. Bucharest, 2009.

[4.] Stegar I., - *The Jiu Valley - and social politics problems*, Focus Publishing House, Petroşani, 2007

SCIENTIFIC REVIEWERS:
Prof. PhD. Eng. ROMULUS-IOSIF SARBU

INDEX OF AUTHORS

INSTRUCTIONS FOR AUTHORS[1]

THE TITLE OF THE PAPER WILL BE WRITTEN WITH CAPITAL LETTERS, CENTERED, AT 7.0 cm FROM THE UPPER EDGE OF A4 FORMAT, ALONG THE ENTIRE WIDTH, TIMES NEW ROMAN, 14 POINTS, BOLD.

· (14 points)

· (14 points)

The first name and the family name will be written with CAPITAL LETTERS, BOLD, CENTERED, 130 mm width, Times New Roman, 12 points, each name being followed by number, *and in the footnote the didactic and scientific degree, the position and place of work of the authors (possibly fax, E-mail) are indicated, with italics, 130 mm width, Times New Roman, 11 points.*

· (12 points)

· (12 points)

<Tab> **Abstract: (Times New Roman, 10 points, bold)** The Abstract will only be in English and will have between 50 and 100 words, arranged all over the entire width, single, left – right alignment, all over the width of the printed space, Times New Roman, 10 points.

· (10 points)

· (10 points)

<Tab> **Key words: (Times New Roman, 10 points, bold)** 5 – 10 words, in English, along the entire width, Times New Roman, 10 points.

· (10 points)

· (10 points)

· (10 points)

<Tab> **1. THE TITLE OF THE CHAPTER IS WRITTEN WITH CAPITAL LETTERS, BOLD, TIMES NEW ROMAN, 11 POINTS AND WILL BE NUMBERED WITH ARABIC NUMBERS.**

· (11 points)

<Tab> The paper text paragraphs will be left – right aligned. The lines of the entire text will be single spaced with Times New Roman fonts, size 11 points.

The paper will be edited in a language of international circulation (English, French, German) on A4 format (210 x 297), page setup: top 5,6 cm, bottom 4,6 cm, left 3,7 cm, right 3,7 cm, in WORD or WORDPERFET or WINDOWS and the number of pages must be even between 4 and 16. The size of the symbol is given next and is written in the instructions used to assist in editing the text. It indicates a blank line and does not show in the text of the paper, being obtained by pressing <ENTER>. The size of a <Tab> is 1,27 cm. No blank line is left between the paragraphs. Between the last line before the title and the title of the chapter and between the title and the first next line a blank line is left for each.

---

[1] *Professor Eng., Ph.D. at the University of Petroşani, adresa email*

<Tab> **1.1 Subchapter. Subchapters can be used in the text, numbered with the number of the chapter and a number showing the number of the subtitle within the chapter. The subchapters and the numbers are Times New Roman, 11 points, bold.**

· (11 points)

The text is written in new paragraph and not continuing the subtitle, an 11 point blank line being left between the subtitle and the following text.

· (11 points)

2. PRESENTATION OF THE FIGURES

· (11 points)

Figures should be enclosed in the text in the order of their presentation, as far as possible on the page where reference is made to them. They shall be numbered with Arabic numbers. Black – and – white, high contrast figures are recommended. Photos can be used as well, but they should be of good quality, clarity and sufficient contrast. The figures will have a legend (name of the figure), which, along with the number, will be written underneath with Times New Roman, 10 points, centered as to the figure. The figures will be surrounded by text.

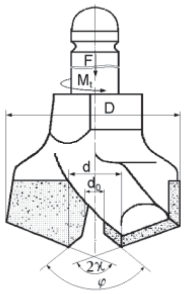


Fig. 1. Detachable bit

· (11 points)

3. PRESENTATION OF THE TABLES

· (11 points)

The tables will be enclosed in the text, a 10 points blank line being left above and under the table, and will be numbered with Arabic numbers. Both the number and the explanations to the table are written with Times New Roman, 10 points, italic, for the number and bold for the explanation to the table, centered in the space of the table and above it. The table entries will be Times New Roman, 10 points, bold, and the data in the table will be Times New Roman, 10 points. The thin lines of the table will be ½ points (0,02 cm), and the thick ones will be ¾ … 1 points (0,03 … 0,04 cm).

· (11 points)

4. PRESENTATION OF THE MATHEMATICAL EQUATIONS

· **(**11 points)

The mathematical equations will be with times New Roman, 11 points, center of the page and numbered on the right with Arabic numbers between round brackets.

· (8 points)<Blank line 8 point high>

$$X^2 + Y^2 = Z^2 \qquad (1)$$

· (8 points) < Blank line 8 point high>

An 8 point high blank line is left between the last line before the relation and the relation and between the latter and the next first line.

The last page will be at least 2/3 full.

The pages of the paper will only be numbered by a pencil outside the printing space.

· (11 points)

REFERENCES (will be written according to the model, Times New Roman 10 points).

· (10 points)

[1]. Marian I., *Mecanizarea în minerit,* Editura Tehnică, Bucureşti, 1969.

SCIENTIFIC REVIEWERS

*Commission reviewers for article in the journal **„Annals of the University of Petroșani Mining Engineering”***

FIELDS OF COMPETENCE

- ✓ **MINING ENGINEERING:**
  Prof. Ph.D. Eng. Dumitru FODOR – University of Petroșani
  Prof. Ph.D. Eng. Eugen COZMA - University of Petroșani

- ✓ **MINING SURVEYING:**
  Prof. Ph.D. Eng. Nicolae DIMA - University of Petroșani
  Assocc.Prof. Ph.D. Eng. Ioel VEREȘ - University of Petroșani

- ✓ **MANAGEMENT IN MINING**
  Prof. Ph.D. Eng. Florian BUȘE - University of Petroșani
  Prof. Ph.D. Eng. Petru HODOR - University of Petroșani

- ✓ **ENGINEERING AN ENVIRONMENTAL PROTECTION:**
  Prof. Ph.D. Eng. Mircea GEORGESCU - University of Petroșani
  Prof. Ph.D. Eng. Romulus SÂRBU - University of Petroșani
  Prof. Ph.D. Eng. Maria LAZĂR - University of Petroșani

- ✓ **MINE CONSTRUCTION:**
  Prof. Ph.D. Eng. Constantin SEMEN - University of Petroșani
  Prof. Ph.D. Eng. Ilie ONICA - University of Petroșani

- ✓ **VENTILATION AN MINE SAFETY:**
  Prof. Ph.D. Eng. Nicolae BĂNCILĂ - University of Petroșani
  Assocc.Prof. Ph.D. Eng. Roland MORARU - University of Petroșani

- ✓ **PROCESSING OF MINERAL RESOURCES:**
  Prof. Ph.D. Eng. Sanda KRAUSZ - University of Petroșani
  Prof. Ph.D. Eng. Mihaela PODARIU – North University of Baia Mare

- ✓ **MINING GEOLOGY**
  Assocc.Prof.Ph.D. Laura COMĂNESCU – Universitatea din București
  Prof. Ph.D.Eng. Grigore BUIA - University of Petroșani

- ✓ **ROCK ENGINEERING**
  Prof. Ph.D.Eng. Victor ARAD - University of Petroșani
  Prof. Ph.D.Eng. Ioan BUD - University of Petroșani