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Rehabilitation Strategies for the Anthropic Relief Caused by the Mining Exploitation. Case Study: Baraolt Mining Basin

– DOCTORAL DISSERTATION –

(*Abstract*)

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PART A – GENERAL INTRODUCTION

Chapter 1. Research Methodology

Introduction – Arguments Concerning the Choice of the Study

In contrast with similar closure processes of unprofitable mines from Western Europe, in Romania the changes produced in mining industry have led to major social problems, overlapping with those determined by the transition to the market economy.

The main objective of this study is the presentation and analysis of the closure procedure and ecological rebuilding of a mining area, after the start of such a project. The case study concerns the Baraolt Mining Basin and the present approach is multitasking. Thus the paper presents the rehabilitation strategies of anthropic relief caused by mining exploitations, considering also the possible impact induced on the environment components. This is not possible without the presentation of the international and national legislative background, the presentation of the environment management systems and the best practices existing in the mining sector.

Amidst the objectives of the present study is also the elaboration of a synthetic analysis, which regards knowing both internationally and nationally the study subject, concerning the rehabilitation of mining areas; this objective requires an analysis of the professional international literature. Thus, we have tried to emphasize the way in which the anthropic morphogenesis has been approached over the decades and the particularities of the area of study.

The next step was emphasising of morphometric, hydrological, edaphic, climate particularities etc. The third part of the study presents the morphogenetic dynamics layered in techno-structures, the anthropic relief forms and rehabilitation possibilities for the open-pit mining exploitations areas. Another objective of the present paper are the aspects of environmental management, the monitoring plan and the best ecological practices within the mining section. The last part of the present study covers the case study of the closed and rehabilitated mining exploitation area, in this case Bodoş Quarry.

The elaboration of this study would have not been possible without the support and help of some remarkable people. First and foremost, I would like to thank to Univ. Prof. Dr. Virgil Surdeanu for coordinating this doctoral dissertation, but also for his scientific support given along my doctoral years.

Furthermore, I am grateful to the following gentlemen: Ervin Robert Medves, Nicolae Turdean (Project Management Unit), Florin Amariei (Santedil Company Administrator), Szőcs Mihály (Coordinator of Closure Activities, Bodoş Quarry), Fehér Csanád (Bodoş Quarry), Tóth Levente and Dénes István (Racoş Quarry geologists), Unger Zoltán, Dr. Jordán Győző (Geology Institute of Budapest), Eng. Radu Butuza (Installations, Assembling and Building Company, Cluj), Balázsi Beáta (Environmental Protection Agency, Covasna) to my family and to all of my colleagues.

1.2. Methodology Used in the Present Study

The methodology used for the presentation of rehabilitation strategies for the anthropic relief caused by mining exploitations aligns with the tendencies mentioned in international and national specific literature. Because the relief is the result of numerous factors, an analytical and synthetic method was needed. In order to know and explain it properly, a detailed analysis of the processes, agents and forms, etc., was necessary, along with a series of classifications, generalisations and synthesis.

The geomorphologic analysis of functional reintegration solutions and landscaping development of Baraolt Mining Basin is a contemporary necessity, the appliance of which has both immediate and long term effects. The purpose was the presentation of rehabilitation strategies for the anthropic relief caused by mining exploitations, through case studies and their impact on the environment, thus evolving both a theoretical and practical approach on the subject. The interdisciplinary problem approach also required an analysis of both the methodological principles of the scientific knowledge and an analysis of the geographical principles, which have a methodological significance.

Chapter 2. Research History of the Anthropic Relief Caused by Mining Exploitation

2.1. Study of Anthropic Relief Forms in International Literature

Research Carried Out before the 1960s

The research has generally regarded only the environmental changes produced before the emergence of man, neglecting the morphogenetic role of the factor. The works of physical geography, geomorphology or geology could have presented at times, in short chapters positioned at the end of the study, a section dedicated to human activity.

Main Research Tendencies in the 1960s

Initially emerged several studies regarding general approaches on the man-environment relationship; a good example is the study called "Man and Natural Environment" (Wilkinson, 1963, according to Gregory, 1985).

One of the most important studies is the one in which Brown (1970, according to Gregory, 1985) has stated that the human activities have direct impacts through the creation of anthropic forms and indirect impacts through their influence on the geomorphologic processes.

Another concern of the 1960s research was the consequence of the importance of studying the processes which regard the magnitude of anthropic activity, thus leading to the debut of investigations meant to measure the impact of human activity. Equally important have been the researches about landscape evolution.

The 1960s marked the beginning of environmental research programs.

Main Research Tendencies in the 1970s

In the early 1970s, through the analysis of physical geography relationships, Chorley (1971, according to Gregory, 1985) proposed the kind of control systems that offered a concept, according to which the man acts as adjusting agent of the natural systems (Chorley and Kennedy, 1971, according to Gregory, 1985).

For the completion of the specific literature, Detwyler (1971) gathered published studies in order to write the study called "Man's Impact on Environment" and the Association of American Geographers Commission on College Geography published a collection of essays dedicated to the researches regarding environmental problems (Manners and Mikesell, 1974, according to Gregory, 1985). Around the same time "Man and Environmental Processes" (Gregory and Walling, 1979) was published and in 1981 A.S. Goudie published a study called "The Human Impact, Man's Role in Environmental Change" (Goudie, 1981, according to Gregory, 1985); Goudie's idea was to separate the physical geography into conventional fields; the role of one of the chapters being the densification and presentation of the human activity effect on the environment. The previous panoramic view was necessary in order to demonstrate what today seems almost incredible: the physical geography has been ignoring the importance of human activity for a very long time.

Today's Research Tendencies: Anthropogeomorphology or Neogeomorphology

The Anthropic Force is the combination of physical and social forces, which determines the changes of the landscape (Haff, 2001). Neogeomorphology is the field that studies the anthropic force and its effects on the landscape, the purpose of which is the temporary distribution of phenomena induced by the landscape changes, from an anthropic point of view, the direct impact on the society as well as the anticipation of possible trajectories that the global landscape can take.

2.2. Studies Regarding the Mining Anthropic Relief and the Environmental Effect of Mining Works

The concept according to which the man is an important morphogenetic agent is not a new one. The problem of managing the landscape changes and the environmental unbalance caused by the anthropic intervention emerged the same time the exploitation works started. Some researchers are handling both the study of relief forms emerged after the mining works and the aspects of re-cultivation and rehabilitation. The industrial impact on the relief arises in several studies of applied geography (Verstappen, 1987). The engineering geology studies ensure a technical database for the anthropogeomorphology referring to the impact of human activities over the contemporary dynamics and morphology. Thus, in the studies of Juhasz (2003) Bennett and Doyle (1997), Bell (1998, 1999), there are chapters which talk about the mining relief. Mario Panizza (1993) approaches the aspects of society impact on the natural morphodynamics.

The functional reintegration and esthetical rehabilitation of the abandoned mining exploitations surfaces is one of the most present subjects found in the studies of Bauer (1970); Elliott (1976); Down (1977, Down and Stocks, 1978); Bradshaw and Chadwick (1980); Tóth (1985), Ruthrof (1997) etc. These studies are few examples of the re-cultivation and rehabilitation of some of the closed exploitation sites from Great Britain, Australia, Canada and USA.

Rehabilitation means both reconstruction and insertion of new forms and ecosystems (Tóth, 1985, Blunden and Reddish, 1991, Kerényi, 1995, 1999, Ilyés 1999, Molenda, Rzetala 2002, Nicolau and collab. 2005 etc.). An important study subject is the existence of valuable biotypes in the mining exploitation areas: Davis (1979), Usher (1979), Wigglesworth (1990), Cairns (1994) etc.

Bezuidenhout and Enslin (1970, according Bell, 1998) have studied the causes and conditions that favour the subsidence processes.

Goodman developed a method for the evaluation of subsidence possibilities (Goodman et al. 1980, according to Bell, 1998). Methods concerning the forecast of relief strata subsidence situated above a mining gallery have also been published by Piggott and Enyon 1978, Bell 1986, Garrard and Taylor 1988, Cripps and collab. 1988 (according to Bell, 1998). Price has tried to locate the risk areas (Price 1971, according to Bell, 1998), whereas Stacey and Bakker have elaborated an "area delimitation system", based on the study of the role of strata thickness found above the mining galleries (Stacey & Bakker, 1992, according to Bell, 1998).

The first thematic maps intended for knowing better the local situation and problems were published by the British Geological Survey (McMillan & Browne, 1987, according to Bell, 1998). The ricks that emerged after the abandonment of the underground mining exploitation areas have been approached in the studies of Holla and Barclay (2000), Bell and collab. (2000), Karaman and collab. (2001), Bell and Donnelly (2006) etc.

The aspect of the criteria regarding the evaluation of the total amount of damages caused by the subsidence phenomena appears in the studies of Bhattacharya and Singh (Bhattacharya and Singh, 1985).

2.3. Main Research Tendencies of Anthropic Relief from Romania

The dynamic geomorphology has developed itself in parallel with the applied angle of geomorphology (Maria Rădoane and N. Rădoane, 2005); the emphasis is on a very active concern regarding the issue of improvements of the damaged terrains (Tufescu and Moţoc, 1969, Bălteanu, 1983, Surdeanu, 1998, Cioacă and Dinu, 1998, Rădoane and collab. 1999, Ioniţă, 2000).

Floca approaches the issue of rehabilitation off the technogenic soils from the tailings heaps (Floca, 1997, Floca and collab. 1997). Adrian Cioacă has published several studies and articles that approach the mining relief (Cioacă and Dinu, 1995a, 1995b, 1998, 2000, 2001, Dinu and Cioacă, 1997, 1998a, 1998b) and other geomorphologic studies about the environmental impact of anthropic activities (Cioacă and Dinu, 2000, 2002, 2005).

In 2003 emerged a study in which one can find a classification chart of the mining relief from the Igniş-Gutâi Mountains area and the magmatic massifs of Ţibleş and Toroioaga (Hodor and Bâca, 2003). In the study of Sigismund Duma (1998) there are aspects that concern the rehabilitation of mining areas, as well as an article about the history of mining exploitations research. Aspects regarding the environmental impact of mining exploitations and the relief caused by them can be found in the studies of Baican, 1998, Baican and Bogatu, 2000, Baican, Huidu and Ianc, 2000, Fodor, 1973, 1986, 1989, 1995-1996, 2008, Fodor and collab. 1977, 1978, 1984a, 1984b, 1992, 1997a, 1997b, 1998, 1999, 2000a, 2000b, 2003, 2004, Fodor and Baican, 2001 etc.).

Liviu Muntean approaches the anthropic impact on the environmental components and suggests an evaluation matrix of the anthropic impact (Muntean and collab. 1998, 2001, 2003, Muntean, 2004, 2005). Pretty, Oros and Drăghici study the extractive industry tailings (Pretty, Oros, Drăghici, 2003). Tomescu and his collaborators have carried out studies concerning the effect of human impact through the coil exploitations (Tomescu and collab., 1998, Tomescu, 2001, 2003, 2004).

The geomorphic studies published in Romania cover, in most cases, a chapter about the environmental influence of the human factor and the relief caused by human activity; however, until today we cannot say that studies fully dedicated to the anthropic relief have been published.

PART B – BARAOLT MINING BASIN: GEOGRAPHY OF PERSONALITY

Chapter 1. Regional Localisation and Geographic Research Regarding Baraolt Mining Basin

1.1. Geographic Location

The structural unit, known as Baraolt Basin, is the north-eastern extension of Bârsa Depression, which is part of the intramontane depressionary system from the Oriental Carpathians Mountains area (László, Dénes, 1995). Baraolt Basin actually represents a narrow depressionary unit, the edges of which are marked by perceptible subsidences towards the surrounding mountains. The western limit of the depression is marked by the Perşani Mountains, its southern limit is Bârsa Depression, Baraolt Mountains are the eastern limit and Harghita Mountains are the northern limit.

1.2. Geographic Research

Studies worth mentioning are: Mihăilescu, Stoenescu, Vintilescu, Toşa "Ţara Oltului" (1950), Iancu "Contribuţii la studiul unităţilor geomorfologice din Depresiunea internă a Curburii Carpaţilor" m (Contributions to the study of geomorphologic unit from the intern depression of Curvature Carpathians) (1957), Orghidan "Munţii Perşani" (Perşani Mountains). "Observaţii geomorfologice cu privire specială asupra Văii Oltului" (1965) (Geomorphologic observations regarding the Olt Valley), Posea, "Depresiunea Braşovului, caractere geomorfologice" (Geomorphologic features of Braşov Depression) (1981), Ielenicz, "Modelarea actuală în Carpaţii de Curbură" (Present shaping of Curvature Carpathians)

(1982), Bănică, "Studiul fizico-geografic al Bazinului Râului Bârsa – cu privire specială asupra peisajelor" (The physic and geographic study of Bârsa River Basin – focusing mainly on landscape) (2006, doctoral dissertation).

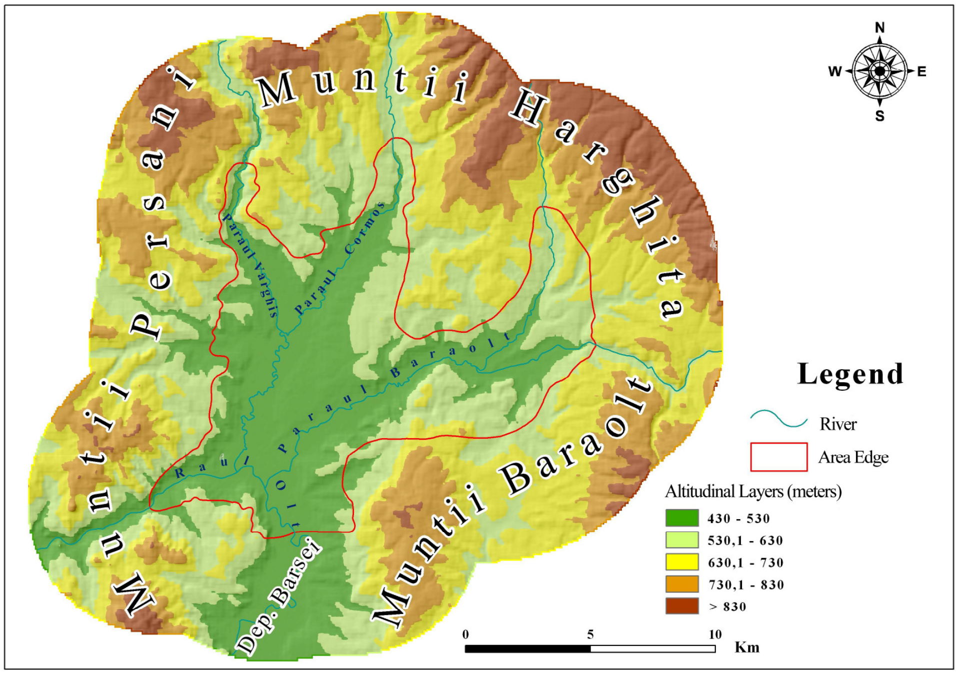

Fig. 1 Regional Framing Map of Baraolt Basin

In 1975 Mihai Elena published the climatic study entitled "Depresiunea Braşov. Studiu climatic" (Braşov Depression. Climatic Study). The surrounding soils have been studied by Păunescu in "Contribuţii la cunoaşterea depozitelor de cuvertură şi a solurilor de pădure din regiunea montană şi piemontană a Ţării Bârsei" (Contributions to the knowledge of curvature deposits and forest soils within the mountain and piedmont region of Ţara Bârsei) (1967) and by Bănică in "Solurile din bazinul hidrografic al Râului Bârsa" (Soils within the hydrographical basin of Bârsa River) (2006).

The most recent geomorphologic studies about the mountains surrounding the Baraolt Depression are "Munţii Baraolt. Studiu geomorphologic" (Baraolt Mountains. Geomorphologic Study) (Băcăinţan, 1999), "Munţii Harghita. Studiu geomorphologic" (Harghita Mountains. Geomorphologic Study) (Schreiber, 1994), "Munţii Perşani. Studiu geomorfologic" (Perşani Mountains. Geomorphologic Study) (Cioacă, 2002).

Chapter 2. Geologic Components

2.1. History of Geologic Research Concerning Baraolt Mining Basin

More recent studies that regard the structure and tectonics of Baraolt Basin are those of Pécskay and collab. (1992), Szakács and collab. (1993), László and collab. (1995, 1996, 1997), Balintoni and collab. (1995).

2.2. Regional Geology

The post-tectonic sedimentary Baraolt basin has a relatively complex geology, both in consequence of the geotectonic formation processes of the basin and the subsequent processes in which coal bearing formations have been driven, as well as the sedimentary processes that have caused coal strata accumulation. The formation of the sedimentary basin emerged at the beginning of the Pontian, on a Cretaceous paleorelief, defined by numerous depressionary areas.

2.2.1. Area Stratification

Over the tightly folded deposits of the Cretaceous flysch, which compose the central part of the Bodoc, Baraolt and Perşani Mountains, lie discordantly pliocene-pleistocene sandstone deposits, which exclusively form the intramontane depression filling of Ţara Bârsei, where, on the Baraolt-Căpeni eastern offshoot coal deposits can be found (Stănescu, Botnărencu, Zaharia, Stoicescu, Pelin, 1979).

These deposits are affected by a series of faults oriented WNW-ESE and NW-SE, which have determined the erosion to reach the deposits from the flysch facies, through the elevation of some compartments (László, Dénes, 1995).

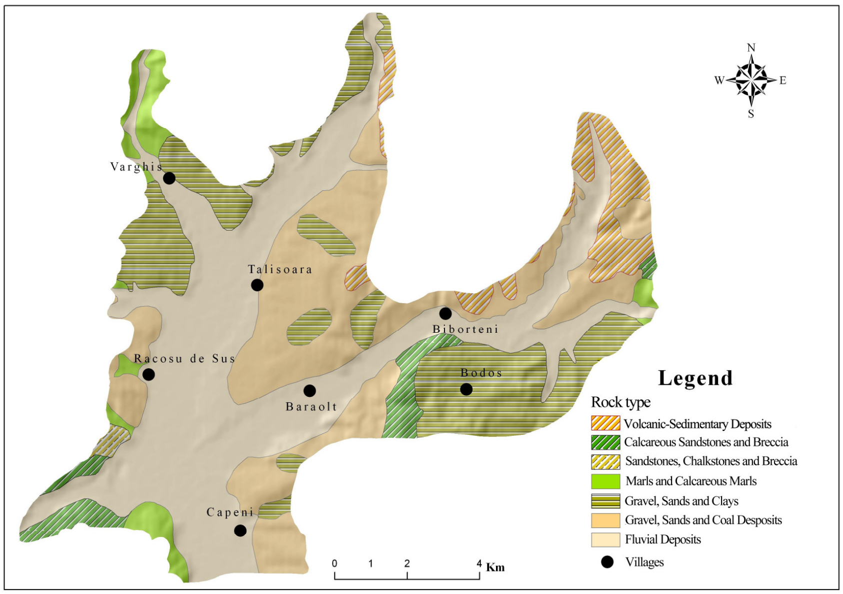

Fig. 2 Geologic Map of Baraolt Basin (following "Foaia Târgu Secuiesc", scale 1:200 000).

2.2.2. Cowl Strata Specifications

During the seal off of Baraolt Basin with pliocene deposits there were several factors (lithologic, tectonic, bathymetric factors etc.) which favoured the installation of some peat moors, in which have formed up to 5-6 lignite strata, which alternate with pelitic and psamitic deposits. Lignite strata that form the carboniferous complex of Căpeni-Baraolt area, have mutual features with regards to the stratified conformity with the other pliocene deposit, but also dissimilarities when it comes to their thickness and spreading area; the latter are based on the bottom and sedimentation relief. The type of coal deposits is allochthonous.

2.2.3. Tectonics and Geological Evolution of the Region

The evolution of tectonic elements of rupture from the pliocene-pleistocene era has had a major importance in the course of geotectonic events, with implications in the formation and evolution of Baraolt Basin, the setting in place of the volcanic edifice from the southern area of Harghita and the completion of geomorphic profile of the southern intern sector of Eastern Carpathians (László, Dénes, 1995).

One of the most important elements for the tectonics of Baraolt Basin is the parallel ruptures system, which affects the whole surface of the sunken depressionary area, situated on the NE-SV direction (László, Dénes, 1995). The main Baraolt – Căpeni fault is NV-SE oriented and it divides the deposit in half. Besides the high degree of tectonisation, lignite strata have several thickness and quality variations going through several stages of thickening and narrowing, along with the thickness variations of the bond band. (Andriuc, 2003).

2.3. Elements of Hydrogeology

The presence of sands and volcanic agglomerates in the lithologic composition of pliocene and quaternary formations determine this to be a good groundwater collector and to quarter aquatic horizons. Overall, the placement area is a large hydrological basin with a high aquatic level and with an inflow coming from the permeable bottom areas, joined by of CO_2 and CH_4 emanations. The phreatic aquatic horizons from the area are evolving fast because the meadow and terrace deposits cover large surfaces. The main feeding source of these horizons is the direct infiltration of rainfall. During dry seasons the feeding source is the Cormoş rivulet. The denudation degree of the structure, which has a more pronounced erosion in the north-western side of the perimeter, where the Cretaceous is always present, as well as the monoclinal position of pliocene formations with downthrows of 10° to 12° towards south-east, offers favourable feeding and groundwater flow conditions (Andriuc, 2003).

Chapter 3. Pre-existent Relief

3.1. Morphologic, Structural and Tectonic Characteristics of Barolt Basin

Baraolt Depression is irrigated from north to south by Baraolt rivulet and Cormoş rivulet (along with its Vârghiş tributary), which originate in the western flank of Harghita Mountains. The last two rivulets, before entering the depressionary area, have carved deep valleys with pronounced slopes into the volcanic relief, inducing a rapid water flow. Rivulets enlarge their main bed and intensify the meandering of their water flows in the quaternary deposits specific to Baraolt Depression.

The largest width of Baraolt Depression (more or less 5 km) is in the confluence area of the rivulets with Olt River. The depression is finger-shaped and it is oriented on the direction of the three water flows.

On the Baraolt Valley the depressionary relief has a width which varies between 1 and 2 km. Cormoş Valley has a width that exceeds 3 km towards its confluence area with Vârghiş rivulet.

The altitude of the depressionary relief decreases from the north side to the confluence area from 500 to 460 m. At the edge of the depression there is a relief layer, approximately 20-40 m higher, build-up of terraces and quaternary piedmonts. Generally, it is fragmented by a semi-permanent water network. The hilly area covers about 80% of the perimeter surface, spreading especially on the basin frame. The terrace levels found here belong to Vârghiş, Cormoş and Baraolt rivulets.

3.2. Morphometric Features of Barolt Basin

Digital Elevation Model: In the case of the studied ground, it is notable the layout of the highest altitudes, aligned towards the periphery and the layout of the lowest altitudes aligned in the central side, where in fact the valley chutes and the depression lie.

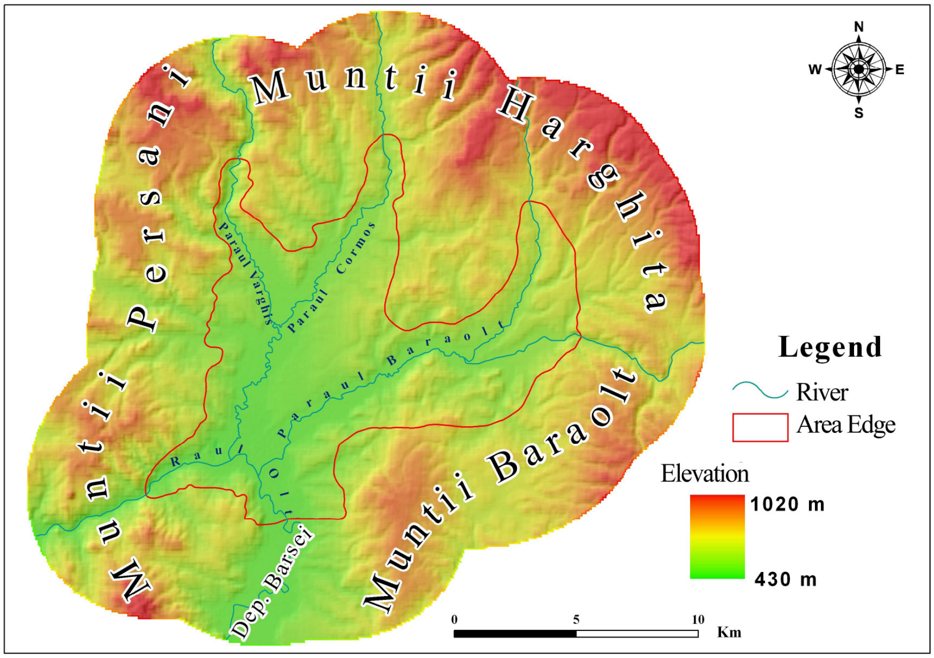

Fig. 3. Digital Elevation Model of Baraolt Basin

Hypsometric Layers: The main rivers of the area – Olt, Baraolt, Cormoş and their tributaries – have fragmented the Baraolt Depression, thus causing the multi-layering of the relief in several hypsometric layers. The analysis of the hypsometric layers weighing shows their irregular distribution. The layers with the highest weighing are those which have 430 – 500 m and 500 – 550 m, and the layers with the lowest weighing are those which have 600 – 650 m and over 650 m. The hypsometric analysis of Baraolt Depression shows the image of a very complex relief, which includes altimetric layers with specific altitudes for hilly units fragmented by valleys.

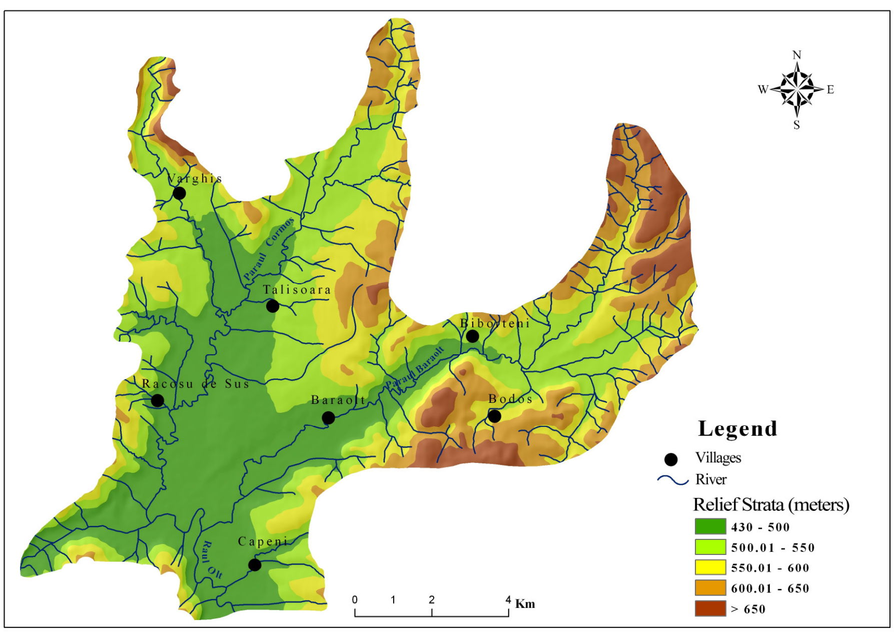

Fig.4. Hypsometric Levels Map from the Baraolt Basin Area

Declivity: The Baraolt Depression relief is characterised by the alternation of surfaces with various declivities. The slopes are the highest, which offers them a high morphodynamic potential, whereas the lowest values are specific to the meadow units of the main rivers and depressions.

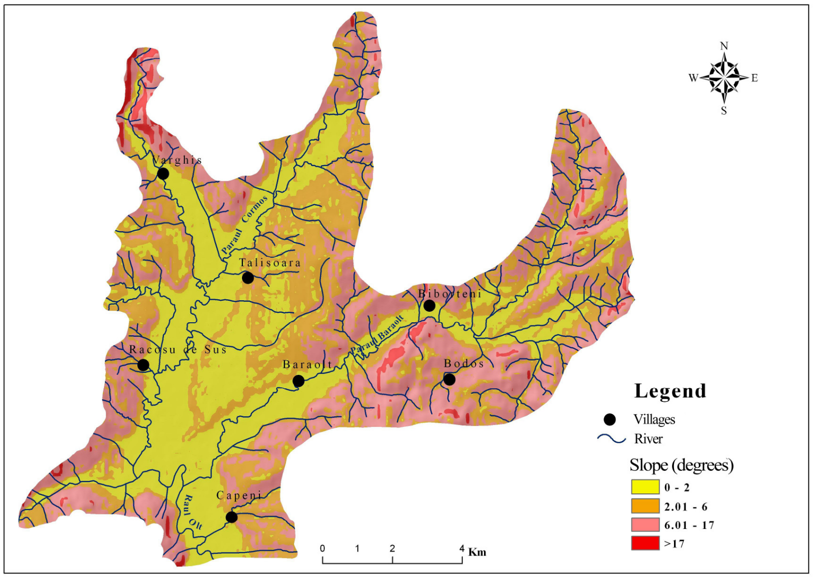

Fig.5. Baraolt Basin Slopes Map

The Depth of Relief Fragmentation: In the case of Baraolt Depression the depth values of relief fragmentation generally shows the intensity of linear (fluvial) erosion, which is spread under the influence of litostructural, neotectonic and hydroclimatic conditions.

The recorded values in this case generally place the Baraolt Depression relief amongst the hilly units fragmented, by valleys and depressionary chutes.

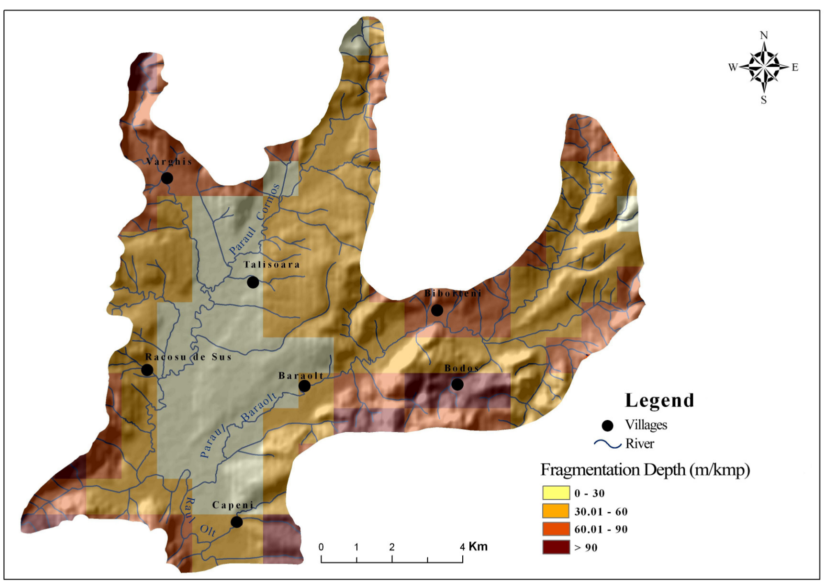

Fig.6. Baraolt Basin Fragmentation Depth Map

Fragmentation Density: The monitoring of the values of this perimeter, of Baraolt Depression, shows the tight link between the drainage density and physic and geographic conditions. Lithology had the biggest impact on the sizing, to which, later on, several other factors added up, like structure, tectonics, relief, forestation degree, etc. The density of relief fragmentation – conditioned, in this case, by lithology – as well as the density of fluvial processes is a major factor with direct implications in the dynamics and territorial distribution of geomorphic processes.

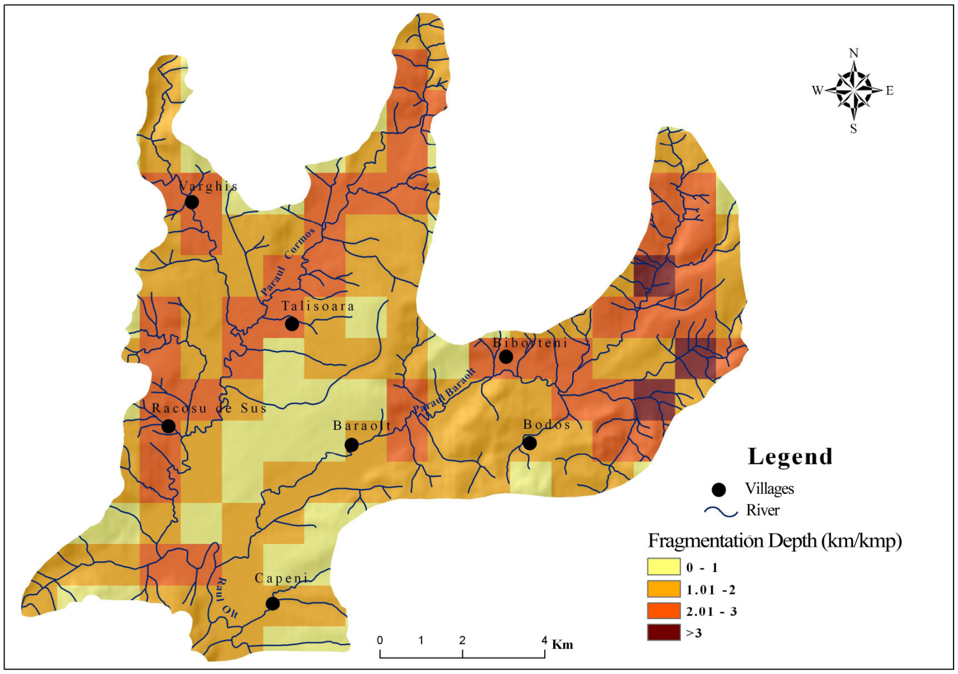

Fig.7. Fragmentation Density Map

Chapter 4. Climate

The climate specific to the studied area is a consequence of the interference between the western and eastern influences and its closure determined by the mountains, which imprints a topo-climate with thermic excess: intense and frequent thermic shifts, extremely low temperatures, early frosts, decreased air masses circulation (Pop, 2006).

On the flat platform of the depression, especially in the lowest area nearby Olt Valley, where frequent accumulations of cold air take place, the average annual temperatures never exceed 7,5° as opposed to 10°, which is the average temperature of the country (Mihai, 1975).

The lowest temperature recorded by the Baraolt weather station was -28,4°C and the highest was 33,7°C. The relative air humidity is fairly high, reaching values of over 75%. The placement of the studied area in the region where interferences between the eastern continental climate and the western oceanic influences happen, as well as the configuration of major relief, imprints a series of atmospheric features to the rainfall, thus the average multiannual values are 550-600 mm (Mihai, 1975). The dominating wind is the one coming from the western sector. The average annual values of wind speed vary between 2,2 – 2,7 m/s and on top of the peaks they frequently exceed 7 m/s. The annual number on windy days higher than 11 m/s is of 7,1 days a month. The minimum air temperature decreases below 0° during 90-95% of the cold season period, i.e. over 130 days of frost annually.

Chapter 5. Hydrography

The main hydrographical artery that crosses the Baraolt Depression is Olt River, which has a gently serpentine shaped flow with low beds that can frequently be flooded in case of abundant rains. When entering the depression, the average annual flow of the Olt River is 7,85 m^3/s and it increases up to 39 m^3/s towards its exit. The variety of the relief and the geologic conditions reflect also in the longitudinal profile of the rivers. The average density of the hydrographical network is of 0,3 –0,70 km/km^2 in the Baraolt Depression and of 0,60 – 0,90 km/km^2 up in the mountains. The average flow has low values of 2-3 $l/s/km^2$ (63-95 mm/year) almost all over the depression and the Baraolt and Bodoc Mountains have average values of 3-7 $l/s/km^2$ (95- 220 mm/year) or higher or 7-20 $l/s/km^2$ (220-630 mm/year).

The rivers are of Carpathian type (large and long-lasting waters), sub-type with large spring waters and summer floods, pluvio-nival feeding (Mihai, 1975).

Chapter 6. Biopedogeographical Aspects of Baraolt Basin

6.1. Soil

Within the studied area there is a large range of soils; this diversity results from the complex action determined by the lithologic conditions, relief forms, hydrogeological, hydrological and topo-climate factors. Thus, at an altitude of over 1500 m, under the spruce forest there are the **brown argiloiluvial mountain soils**. Another category of soils are the **brown** and **acid brown forest soils**, spread in the Baraolt Mountains, which also emerge, though rarely, in the Bodoc Mountains. The most spread are the **brown soils** and the **podzolic argiloiluvial soils**, found especially on the large and low crests, on slopes that are not very steep as well as on the depressionary relief. Another category of soils are the **cernoziom argiloiluvial soils**. On the lowest layer of the relief **hydromorphic soils** can be found, which are divided into the following sub-groups: **gleic soils**, **marshy and pseudogleic soils**, which have a low fertility degree and a humidity excess, especially during the rainy periods of the year.

6.1.1. Main Restraints Regarding the Soil Quality

Part of the arable surface has certain restraints when it comes to its usage. The main restriction are the areas of sanitary protection, located around the drinking water feeding pits within the village of studied area place. Another soil category, which has usage restrictions, are the terrains with slopes larger than those which are under the erosion process.

6.1.2. Soil Usage and Preservation

Soil rehabilitation is below the degradation and alteration rhythm. The causes of soil degradation are generally linked to the industrialisation process, uncontrolled animal grazing, agricultural activities (insufficient or excessive usage of fertilizers, inadequate agro-technical works, and irrational irrigation), deforestation and the forests overexploitation.

6.2. Vegetation and Fauna

Thanks to a specific topo-climate, within the area of study there are numerous old, specific and relict plant species (such as the sea pink (from Ţara Bârsei area, the lousewort, the bird's-eye primrose, the round-leaved sundew, etc.). The present vegetation is marked by aspects of natural vegetation, such as fragmentary ecosystems installed after the human intervention. The forest area is marked starting with the depressionary vegetation and ending with mountain vegetation, vegetation from the oak sub-region, durmast oak, beech, spruce sub-regions and the alpine area.

Fauna is very diverse, thanks to the numerous biotypes that can be found here.

Mountain and depression waters are filled with various species of fish (trout, grayling, barbell) and in the systems with excess of humidity, as well as in the forests, the waters burst with species of batrachians, reptiles, birds and mammals.

Chapter 7. Anthropic Pressures on Biodiversity

Direct Pressures: The main causes of habitat loses and their fragmentation are urbanisation, infrastructural development, uncontrolled exploitation of natural resources and partial restoration of some forest surfaces etc.

Indirect Pressures:

- Pollution. Acid rain affects the forest and eutrophication generates a negative pressure. The usage of pesticides has also a negative influence on the animal species in the area.

- Uncontrolled tourism and camping in forbidden areas, burning trees and shrubs and the lack of control over the vehicle access threatens the mountain ecosystems. There are species protected by law that are sold on the market.

- The existence of some conflicts between certain terrain users, the forest restoration, weak implementation and enforcement of the law regarding nature protection, the lack of financial and organisational resources of the involved institutions and the preservation of biodiversity.

- Weak public acknowledgment. In some areas there is a high anthropic pressure for the overexploitation of natural resources.

Anthropic pressures on the forest: the illegal cutting of trees from both the national and private sector.

Pressures on the environment: The promotion of an ecological agriculture is the way to guaranty for future generations the advantages of heritage and natural resources that we are enjoying today.

PART C - ANTHROPIC IMPACT IN THE OPEN-PIT COAL EXPLOITATION AREAS

Chapter 1. Anthropic Morphogenesis: the Man, Active Morphogenetic Agent

The open-pit mining activity brings profound changes to the environmental components. The human force, as morphogenetic agent, has become the most important factor in outlining the landscape. The last decades have been defined by an intense artificialisation and the relief shaping is a vital necessity of our modern society. The anthropic factor determines a new morphology defined by relief inversions as well as a reorganisation and rearrangement of disrupted material.

Chapter 2. Anthropic Relief Forms from the Open-Pit Mining Exploitation Areas

The magnitude of the human factor is perceived especially through the anthropic forms that it creates. The carbonaceous open-pit mining areas are defined by technogenic morphology, which is very diverse when it comes to dimension, shape and genesis.

2.1 Anthropic Relief Forms Aligned Above the Topographic Level

Tailings Heaps: have the most important scales. They have been classified by size in a study made by Brânduş and his collab. (1998); this control variable provides also data regarding the geomorphologic process (Anghel, Balazsi, 2005).

The building of heaps must follow at least three technical, economical and social conditions: to ensure the stability and to prevent any possible catastrophe, determined by the movement of heaped materials; to prevent environment pollution, especially water pollution, by taking substances from the heaps, and to ensure its reintegration into the economic and ecologic circuit of terrains.

From a geomorphologic point of view we must carefully evaluate the stability of the future placement and know they must be built on unproductive terrains, to ensure a disposal capacity and have a reduced surface and to eventually be reintegrated into the economic circuit. The evaluation of studies preceding the project is compulsory; the volume and the expansion of which shall be established on the basis of every case.

2.2. Anthropic Relief Forms Aligned Below the Initial Topographic Level

Quarries: are surface excavations of large proportions, which result from exploitation activities. Depending on the local morphology, there are valley floor quarries (meadow and inferior terraces), slope quarries and interfluve quarries.

Chapter 3. Morphogenetic Dynamics Layered in Techno-Structures

The anthropic shaping determines the natural balance breakage and the implementation of a speeding dynamics, resulting in a dynamic balance, which occurs in a shorter time than under normal conditions.

The anthropic shaping affects both the exploitation areas and the adjacent area. The nearby surfaces are sometimes severely unstable due to the extreme movement processes, such as: cave-ins, compaction and landslides. The human intervention can be quantified by the changes brought to the natural environment. Thus, the hydrographical network is unorganised from an anthropic point of view, the biotic field is profoundly damaged, the contemporary geomorphologic processes are speeding up and the pedologyc, aquatic and atmospheric components suffer from pollution. Changes also occur in the hydrogeologic dynamics as well as in concept existential and behaviour concepts (Duma, 1998).

For a better analysis of the geomorphologic contemporary processes within the mining area, we will approach their presentation on the background of techno-structures where they unfold. Considering the present size and procedural representation, we have chosen the case of heaps and quarries.

3.1. The Dynamics of Tailings Heaps

Because they are depositional techno-structures of large proportions, they have a very large spectrum of geomorphologic processes (such as meteorisation, pluvio-denudational erosion, underground erosion, landslides, muddy leaks, compactions, bulges, isostatic compensations, etc.). When the construction rules are not being followed, their morphodynamic potential is high. The exterior heaps located in the initial basins or on hills slopes are the ones with the highest instability.

3.2. Geomorphic Dynamics of Quarries

The quarries are excavations of large proportions. Both the active and the preserved quarries can be affected by a series of geomorphologic processes with a speedy dynamics, such a meteorisation, pluvial erosion, slope cave-ins, compaction, etc.

Chapter 4. Rehabilitation of Open-Pit Mining Exploitation Areas

Reintegration into the economic circuit: Involves the transformation of the techno-structures in the productive areas for agriculture, forestry, pisciculture, living spaces, commercial spaces, rest and treatment places, etc.

The integrated natural rehabilitation of areas affected by open-pit mining exploitation: it is divided in two stages (Anghel, Balazsi, 2005):

- **A. Technologic rearrangement** involves soil recovery and preservation, which is then pickled and laid in special heaps; the solid construction of heap techno-structures; the grading and stabilisation of the accumulative techno-structures (on a longitudinal and rarely transversal directions) is called capital graving; soil placement on stabilised heaps; the improvement of the terrain by amendments depending on the pedologyc expertise result (calcination, addition of ash and phenols).
- **B. Re-cultivation**: The re-cultivation projects must be part of a deposit exploitation study. The re-cultivation is a several types: agricultural, forestry, piscicultural, re-cultivation for technologic installations, sites and deposits, purge installations, crematories, etc.

Chapter 5. Implications of Coal Exploitations Activities in Morphology Alteration

The entire spectrum of the anthropic activities of coal exploitation (beginning with the geologic research and continuing with the stage of proper exploitation, until the moment of ecologic rehabilitation), determines substantial changes in the local geomorphic system frame. The morphologic changing of the initial landscape is the visual effect with the highest negative impact within the mining area frame.

The building of the mining accumulation forms, such as tailings heaps and mounds, brings important local changes, of morphologic, topo-climatic, hydrologic, edaphic nature and vegetation, etc.

Relief anthropic inversions are one of the main features specific to coal exploitation areas, thus quasi-horizontal spaces become real "anthropic hills" and the prominent areas are flattened, thus becoming depressionary or similar to sub-topographic excavations. Another local specification induced by the open-pit exploitation of the initial (slope or meadow) morphology is the reshaping of the natural profile of the slopes, shaping of the elements, compaction of the sloped natural surfaces, the growth of the slope segments number, total decrease of erosion of the slope and interfluve surfaces through the excavating activity etc.

5.1. Evaluation and Nature of Morphological Changes Caused by Mining Works

The evaluation of the morphologic changes caused by the mining works includes the analysis of three factors: the extension of area, the intensity or rate and the period of morphologic changes.

5.2. Geomorphologic Concepts and Processes Applied to the Areas Affected by the Mining Activities

The first step in evaluating the effect caused by anthropic changes from the mining areas involves the understanding of the processes that shape the relief.

The alteration of the parameters of the mentioned factors attracts a qualitative bounce and a balance alteration, thus a progressive dynamics of the relief forms.

PART D – ENVIRONMENTAL MANAGEMENT, MONITORING PLAN AND THE BEST MINING PRACTICES

Chapter 1. Introduction

Mining exploitations (both the closure and post-closure stages) are known to have a major impact on the environment and the human health. The environmental problems within the mining field require a systematic approach on the basis of the experience gathered by other advanced countries from Europe and North America, etc. Viable techniques of environment management have also been applied to the mining areas of Romania.

Internationally, starting with the 1990s, several guides, regulations and procedure codes regarding the fundamental principles of environment management in the mining sector have emerged. The Environmental Protection Law no. 137/1995 establishes the strategic principles and elements concerning the insurance of sustainable development.

Chapter 2. General Presentation of the Legislative Process

2.1 Legislative Background

The main legislative elements concerning the environmental sustainability are the Sustainable Environment Law, Water Law and Mining Law.

Mining Law no. 85/2003 regulates all the mining activities from Romania. The Minister of Economy, Commerce and Business Environment (MECBE) has the responsibility of strategic planning and development of policies concerning the mining sector, but the competent authority for the application of Mining Law provisions is the National Environmental Protection Agency. The focus of Mining Law is on the administration of exploration and the exploitation activities.

2.2 Evaluation of the Risk and the Principles of the Environmental Risks Management

The application of risk evaluation has become a common technique of the word wide mining sector. This chapter focuses on the basic principles of the risk evaluation analysis. Risk evaluation is a tool used to quantify the impact caused by regular contamination, for the purpose of authorisation and privatisation.

Chapter 3. Sustainable Development of Mining Exploitation Areas

The sustainable development concept is the assembly of forms and socio-economic development methods, firstly based on the insurance of a balance between socio-economic systems and elements of natural capital.

The rehabilitation of topography, soil, waters, vegetation etc., according to the standards that allow a healthy usage from a social point of view, is an essential component of the mining planning and functioning, according to the sustainable development requirements (Harworth Mining Consultancy Limited, URS Corporation, Agraro Consult, 2002).

Chapter 4. Environmental Management Systems (EMS)

4.1 Introduction

The application of management systematic procedures may be a powerful way of controlling of the environmental impact within the mining sector. One of these key tools used by environment field practitioners is the environmental management system (EMS). EMS is a structural approach for the management of an environmental program.

The integration of environmental circumstances in the strategic planning is vital, because any negligence can lead to a broad environmental impact but also to an adverse reaction from the local community, the remediation of which can be very costly (BRGM, Atkins, 2006).

4.2. Environmental Management System in the Romanian Mining Sector

The implementation of a EMS requires preparation and effort for the motivation and implication of the company administration and employees. An EMS should be built on the "plan, apply, check, act" model, proposed by Shewart and Deming (analysis, continuous and cyclic measuring and improvement of the environment performance). The essential element is the "endless" improvement of environmental performance along the time.

In Romania, the Project Management Unit has proposed some directions and regulations regarding the extractive activities and closure and ecological rebuilding activities of mines, which concerned the legal improvement actions of the legislative and procedural background; these proposals have been issued as manuals and guides.

4.3. Building and Implementation of the Environmental Management Systems

Medves, Turdean and Baican researches (2008) bring forward the main steps in building and implementation of an EMS:

a) Preparation of the EMS building
b) Making a initial environmental analysis
c) Building and implementation of the system
d) Protection and improvement of the system

All of these steps define in fact the environmental management as an assembly of provisions and technical, organisatoric and administrative actions that allow the knowledge, control and minimisation of the effects of certain organisations on the environment.

Chapter 5. Identifying the Performance Indicators

The performance indicators have the following purposes: supporting the implementation of procedure codes, focusing on conformity as being first priority, offering a background for an efficient environmental risks management, offering an environmental data gathering system etc.

For every procedure code, there is a list of possible problems that the code can cover, but the applied parameters to every site depend on the environmental risks evaluation (Harworth Mining Consultancy Limited, URS Corporation, Agraro Consult, 2002).

Chapter 6. Monitoring the Environmental Factors

The monitoring of the environment factors within the mining perimeters concern a follow-up on the evolution of air quality and meteorological conditions; a follow-up on the discharged water quality from the mining perimeter and the emissaries where it discharges; a follow-up on the mining acid leaks; a follow-up on the soil and vegetation quality; a follow-up of the noise and vibrations during the closure and greenings works; a follow-up on the stability and terrain surfaces conditions within the tailings deposits perimeter (tailings management facilities, mining tailings heaps).

6.1. Monitoring Aspects and Required Data

The proper monitoring involves taking and analysing of samples and rendering their results. The monitoring aspects are coded and take the shape of terminals, pins, boards, etc., with well established topographic coordinates.

The database built by the user during the functioning of the mining site (periodic analysis and analysis determined by the preparation of environmental follow-ups as well as that of the closure and greening technical projects, etc.), will be absorbed (during the editing of monitoring results, as well as the precedent aspects of the assays shall be maintained) into the program of rehabilitation monitoring and in the post-rehabilitation stage. The data must be documented and well defined from a qualitative point of view. The assays and the sample analysis as well as the results of the actual measurements are equally important.

6.2. Environmental Monitoring Plan

The environmental monitoring plan describes the environmental data gathering system. Within this plan, a series of systematic (preliminary and confirmation) measurements are carried out on well established timeframes, with carefully selected parameters. For the issue of the Environmental Monitoring Plan of the mining activity, several elements must be considered: air, water, soil quality and the vegetation features, sediments, tailings heaps, tailings management facilities, noise and vibrations, monitoring of meteorological factors of the area.

The Environmental Monitoring Plan should cover all the environment components: *Source → Means of Conveyance → Receiver*. The areas where the impact of direct pollution or the impact of closure works are expected to arise, must also be included (Order no. 1525/22.01.2007).

6.3. Structure of the Environmental Monitoring Program

6.3.1. Monitoring of Air and the Quality of Meteorological Conditions

During the closure and greening works the main air pollution sources are particulates (PM_{10} aerosols) and gases (CO, SO_2) from the mining cites and from the equipment used for closure and greening works. The air quality will be monitored by periodic particulates assays (aerosols), and gases within the industrial sites perimeter, analysis of tailings management facilities and of tailings heaps, followed by the analysis of samples in special labs.

Within the coal exploitation areas there are two types of atmospheric emissions:

- CO, NO_2, SO_2 and H_2S, from the air shafts of the underground works;
- NO_2, SO_2, H_2S and HCN emissions from the dried section of the tailings management facility surface.

6.3.2 Monitoring the Water Quality

The monitoring of water quality must cover both the surface water and the groundwater, at the lever of the local reception basin. The sources of contaminated water are point sources, with a precise location, such as old mining galleries, springs at the base of tailings heaps, or leaks at the base of tailings management facilities.

Toxic metals and metalloids are driven by both the surface waters and the groundwater as solid particulates and soluble matters. From this perspective, the program of water monitoring should focus on the following aspects:

- monitoring the sources (mining area leakages in surface waters);
- monitoring the transfers (in the surface and groundwater, sediments load);
- monitoring the receptors (springs and fountains in the inhabited areas).

6.3.3. Acid Drainage Evaluation

The monitoring of the acid mine drainage (AMD) must be performed in the shape of a source monitoring, along with the evaluation of the total potential and of the release rate. The evaluation is made only once during the closure and greening stage. The quantification of the potential of generating the acid drainage shall be performed by:

- tailings assays from the tailings management facilities; from the mine tailings heaps;
- the analysis of physic-chemical composition of tailings assays;
- elutriation tests of the tailings assays, finely milled (maximum 4mm);
- static tests for predicting the acid waters.

6.3.4. Monitoring the Soil and Vegetation

The monitoring of soil and vegetation is performed based on the location and terrain usage, thus accomplishing three types of monitoring programs:

- the first type of monitoring program applies to the superior areas of the tailings heaps, to the surface and down river side of the tailings management facility and the areas that are no longer taken by mining equipment (industrial and social yards).
- the second type of monitoring program applies to the areas aligned at the base of the tailings heaps, to the areas nearby the tailings management facility and the areas crossed by the watercourses that they drain.
- the third type of monitoring program applies to the down river side surfaces, which are made of cultivated areas and grazing lands and these can be affected by repeated infiltrations of contaminated waters or the deposition of wind carried particles.

In order to estimate the soil pollution level caused by mining exploitation, carried out on the monitored perimeter, a monitoring system for soil quality is required. This system includes: soil assays and determining the physical-chemical indicators. The issued results from soil analysis shall be compared with the initial values for of soil chemical elements, regarding the evaluation of environment pollution.

6.3.5. Monitoring the Terrain Stability and Tailings Heaps

Instability phenomena that can emerge within the tailings heaps, the tailings management facilities (compaction, suffusion, cracks, etc), the guard shafts or galleries which discharge the waters within the tailings management facilities/heaps and the mining galleries etc. affect the safety of the area.

Within the area affected by mining subsidence it is recommended to visually monitor the area affected by cracks, subsidences, embankment cave-ins of the landslide cones) and performing topographic measurements for the reference points (topometric terminals), placed on the landslides cones in a concentric order.

6.3.6. Monitoring the Noise and Vibrations

Excessive levels of noise and vibrations appear only during the closure works, as result of the land blasting or relocation operations and the circulation of heavy-duty vehicles. The noise and vibration levels must be annually monitored there where the roads cross through districts with intense traffic.

6.4. Stages of the Environmental Monitoring Program

Pre-closure stage

a. Initial operation which will be carried out one time only: initial analysis of discharged water and its quality; the initial evaluation of the acid-base follow-up; initial analysis of sediments quality.

b. The biannual and annual monitoring program: dust monitoring; the monitoring of soil and vegetation; monitoring of the sediments quality and quantity in the selected areas; monitoring of the terrain stability and tailings heaps; topographic measurements of the tailings management facility;

c. Quarterly monitoring program: the monitoring of discharged water and watercourses quality, as well as the discharge points; the level and quality of the selected groundwater pits; survey system of the building behaviour of the tailings management facility.

d. Monthly monitoring program: the monitoring of discharged water and watercourses quality, as well as the discharge points; the monitoring of discharged water and the tailings management facility leakage, sediments level and the piezometric drilling level in the tailings management facility; monthly monitoring visits at the tailings management facility;

e. Daily monitoring program: measurements regarding the discharge of permanent installations, infiltration leakage through the tailings management facility, rainfall monitoring (automatic recording), the level of the phreatic in the processing residues, if an automatic recording is taking place.

Performing the closure and ecological reconstruction works

a. The monthly monitoring program involves: monitoring of discharged water and watercourses quality as well as the discharge sites, where works may produce a temporary impact; monitoring the sediments from the watercourses and the discharge points, where works may produce a temporary impact; monitoring the terrain and tailings heaps stability, where works may produce a temporary impact.

b. The daily monitoring program involves: the noise and vibrations caused by the rehabilitation operations, the phreatic level in the processing residuals in the case of automatic recording.

Guaranty and post-closure stage

The final chart for the post-closure monitoring must be performed based on the results of the monitoring from pre-closure and ecological rehabilitation stages. As a general rule, this will be a more simple version and less frequent than the monitoring chart from the pre-closure stage.

Chapter 7. The Best Mining Practices

The phrase "*best* practices" was initially used to describe the mechanical means of reducing and removal of all problems concerning the quality of water. Later, it was applied in the mining sector (Norman, Wampler, Throop, Schnitzer, Roloff, 1997). This phrase (in most practices) describes a management approach, which implies the engagement of obtaining better results than those previously expected in compliance with the legal decisions. In order to obtain the best practices, un operator should develop a management system, which would insure the improvement opportunity identification and to make sure that the changes are implemented, monitored and evaluated. Thus, the best environmental management practices in the mining sector require an integrated continuous process, along all the project stages, from the initial exploitation to construction and operating to closure. In order to be fully efficient, this approach must be based on a viable set of general and specific principles for the mining sector.

Check lists (issued based on the brochures series "Sustainable Minerals", published by Environment Australia) present shortly the solutions for a proper mining perimeter management, under the principles of the best environment practices.

7.1. Water Economy

The discharge of unpurified mine waters has often led to substantial surface and groundwater pollution. One of the main causes of groundwater pollution from several mining sites are the contaminated water leakages from tailings heaps; the contamination starts while the mine is still operational and continues long after the abandonment of the mine. Equally important is the hydrological impact, associated with disturbances of the groundwater system, the flow regime, the alteration of the groundwater, the alteration of flow debit/speed.

The essential requirement for the best practices concerning water economy in the mining areas is represented by the acknowledgement of the necessity of developing and implementing of an economy plan for the waters within the mining area (EPWMA)

7.2. Controlling the Erosion and Deposition

The problems that need to be fixed in the mining areas are: decrease of rain water dynamics and attenuation of soil particles mobility. The issuing and implementation of an appropriate control plan, regarding erosion and deposition for a responsible economy of mine waters within the settlement is compulsory. The plan must include standard control techniques of sediment loss risk from the areas affected by the mining activities. The plan must also foresee rehabilitation and re-cultivation options.

7.3. Preventing Acid Leakages

Burning of sulphuric mining tailings and thus generating mining acid leakages (AMD-Acid Mine Drainage) is one of the main strategic problems that concern the mining industry. One of the most severe aspects is the environmental persistence of acid leakages. AMD prevention can be achieved by a careful planning before the initiation of exploitation, and by progressive implementation of financial improvement measures for the terrains affected by mining exploitation and tailings heaps (BRGM, ATKINS, 2006).

7.4. Tailings Management

The main problems that must be solved within the management of tailings are (BRGM, ATKINS, 2006):

- removing the tailings and/or the cover strata is the main activity thus, their handling is essential for the economic viability of the company; this is a very serious environmental issue.
- geotechnical instability and the massive movements of these techno-structures, erosion and dissolution, biologic elements inflow or the action of the human factor may lead to the conveyance of pollutants in the environment.
- one must examine the location, the quantity, the features of these tailings as well as the depositing arrangement types and make sure they can be properly managed and their impact on the environment and population is as low as possible.

A universal practice for the mining industry, generally accepted by mining companies, authorities and financial institutions, is the evaluation of the following elements for the long-term maintenance and management of mining installation, after closure (BRGM, ATKINS, 2006):

- physical stability: arrangements for tailings depositing should not put in danger the health and safety of the population, should not be exposed to erosion and they should also not suffer movements from initial location, in case of extreme atmospheric events or under the action of dislocation forces.
- chemical stability: the consequences of chemical instabilities and leaching of some chemical substances in the environment should not endanger the health and safety of people.
- terrain usage: must be compatible with the usage of the other surrounding terrains.

Tailings managements plan is supposed to insure the responsible management of all tailings and reduce the environmental risks. (BRGM, ATKINS, 2006).

I. The construction plan and location choice for tailings heaps

The most important projection parameters for the construction of tailings heaps are:

- strong strata stability;
- reduced permeability of bottom strata;
- short transport distance from the mine;
- possible ways of using the material in the future.

Special attention should be given to the leakages around the heap, in order to prevent the infiltration of groundwater in the heap and water accumulation at the base of the heap.

The selection of the tailings heap location must regard (BRGM, ATKINS, 2006): the limits of the leased terrain surface and of every natural features of relief forms; the non-disruption of important drainage ditches; the integration of heaps into the hilly landscape of the area (when possible); choosing the location so that it does not overlap to possible exploitation reopening of the quarry, or any other future development, but also the placement of the heap at an acceptable distance from the quarry;

II. Tailings depiction: Materials which have a high potential of generating acid leakages (ARD – Acid Rock Drainage), an elevated salinity, high potential of generating pollution through leach and high potential of dispersion should be sealed properly inside the heap (BRGM, ATKINS, 2006).

III. Heap projection: The profile of the heap (height and slope angles) should be designed in order to insure a safe final structure, stable and protected against strong erosion phenomena.

IV. Drainage: the projection and building of leakage control measurement (rain water collection) is essential.

V. Re-vegetation: The uncovered soil can be redistributed on the tailings heap surface (5-20 cm of thickness depending on the nature of the basic sterile rocks). The surfaces should then be deeply ploughed (min. 1 m) on the heap outline at an appropriate distance; the furrows on the exterior slopes should be horizontal all over its length (BRGM, ATKINS, 2006).

VI. Recycling of sterile rocks: Sterile rocks which come from volcanic or metamorphic rocks, such as properly consolidated chalkstones, sandstones and dolomites, are generally appropriate to be used for embankments or a filling material for different constructions, provided that the rocks do not have noxious components and they are not mixed with materials from the cover stratum. Coarse coal tailings can be used for embankments. Burned coal tailings are also a very useful material for embankments and as filling materials. The sterile can also be used as road construction material for highroads or as filling rock for embankments and as riprap for the protection of riverbed and pipes. The performance of these materials has been accepted for each of these applications (BRGM, ATKINS, 2006).

VII. Processing requirements: Crushing and grading depending on the size are the only processing operations required for the usage of large sterile rocks for embankments.

VIII. Projection properties: Sterile properties which are of high interest when it comes to its usage for embankments or as filling material include: granularity, specific gravity and resistance to detrusion.

XI. Compaction: Compaction operations and methods must be continuously visually examined in order to insure the specified compaction degree or to insure that no dislocation happens under the action of compaction equipment.

7.5. Management of Dust and Gas Emission

The main air pollutants that result from mining activities include particulates of different sizes and types, gases such as sulphur and nitrogen dioxide, carbon oxides resulted in the burning processes (ex. from Diesel engines), and less noxious gases such as methane (ex. from underground coal deposits). Emissions of sulphur dioxide and hydrogen sulphide may also be a serious problem if they occur near the area where unexpected coal strata combustion happens.

The monitoring of gases must be done before the beginning of a mining activity, during and after it has ended. The gathered data during the closure program is the base for the elaboration of a post-closure monitoring plan and response plan.

7.6. Management of the Subsidence Process

For the understanding and proper management of every potential impact caused by subsidence, it is compulsory to focus both on the vertical and horizontal components of this movement.

For some mines, the sterile rock and/or the tailings resulting after the processing are used for mine filling in order to reduce the subsidence danger. The sinkholes or the depressions emerged in the landscape disrupt the normal water courses; the pools or the water courses can be drained or redirected. The farm land can be affected up to point where the agricultural equipment can no longer perform the specific activities. The irrigation systems and the drainage pipes boards can be affected. In developed areas, the subsidence can affect the buildings foundations and walls, the roads and the pipes. The groundwater flow may be affected or disrupted once the impermeable stratum is cracked, which can lead to the flooding of mining cavities. The impact on groundwater also includes changes in water quality and water flow direction, including the feeding of surface waters. Subsidence management must be based on the risk evaluation, must be flexible, appropriate and capable to face unexpected changes or uncertainties (BRGM, ATKINS, 2006).

7.7. Involvement of Community in Decision Making

The development of the community must be one of the main components of mining activities and ore processing, from the beginning of the exploitation and after it is completed. This process should also be aligned with other organisatorical processes and strategies, including ricks and impact evaluation, communication and accession, workforce hiring and the development of local companies and to focus on reducing the negative impact and increase of opportunities associated with the mentioned development (BRGM, ATKINS, 2006).

It is very important to keep the community involved when it comes to rehabilitation aspects during all of the stages of mining exploitation process.

7.8. Closing and Rehabilitation Management

The closure plan defines the outlook on the final result of the process and establishes the real objectives for the implementation of the mentioned outlook.

The vegetation rehabilitation and rebuilding are just some of the closure planning aspects. The closure plan should also include aspects like mine staff guidance concerning rearrangement options during the period preceding the ending of activities.

Closure planning must include all the aspects that concern sustainability. It may also include: a report regarding the closure objectives; a study regarding the closure objectives; an advisory process with the implication of local communities; a program of studies and testing works.

The planning process should cover the following aspects: integration, cost estimation and financial provisions; risk based approach; closure planning; closure viability; periodical and critical review.

The key objectives that must be taken into consideration when issuing the Closure Plan (BRGM, ATKINS, 2006) are environmental protection and the guaranty of public safety and health through the usage of safe and responsible closure practices; reducing and eliminating all possible environmental effects once the mining activities are done; establishing the conditions which are consistent with the pre-determined objectives of terrain usage; reducing the monitoring and long-term maintenance by insuring the physical and chemical stability of the areas affected by mining activities.

Closure and biodiversity: During a mining project, the mining activity can affect the biodiversity both directly and indirectly. The direct or primary impact may result from every activity that involves deforestation (construction of access roads, exploitation drillings, cover stratum stripping or the construction of tailings management facilities dams) or direct discharge in a body of water (tailings discharge in rivers, tailings management facilities discharge) or in the air (dust emissions and foundry gas). Usually, the direct impact is easily detected. The indirect or secondary impact may result from environmental or social changes caused by mining activities. This type of impact is often much harder to detect. The cumulated impact emerges when mining activities unfold in the areas which are influenced by other activities too (BRGM, ATKINS, 2006). Thus, the re-plantation of vegetation is required, using important species from a functional point of view (for erosion control), species with an esthetical value and any other species which are important for the preservation of biodiversity; its usage is very practical, but at the same time it insures protection against the insertion of exotic (non-native) species that could proliferate in the absence of adequate control; re-establishing the key species, such as rare or threatened plant species, or the development of adequate habitats for the re-colonisation of rare or threatened fauna species; stable and sustainable rehabilitation, made by usage of native species, in the areas where this is possible.

PART E – REHABILITATION STRATEGIES OF MINING AREAS FROM BARAOLT BASIN. CASE STUDY – BODOŞ QUARRY

Chapter 1. Mining Exploitations in Baraolt Basin (Fig. 17., Fig. 18., Fig. 19.)

Chapter 2. General Data Regarding Bodoş Mining Exploitation

2.1. Location and History

The mining exploitation perimeter Bodoş, included in the Căpeni-Baraolt carbonaceous basin perimeter, is located in the south-eastern side of the basin, nearby Bodoş village, which is part of Baraolt city and Covansa County. Bodoş quarry was established in 1987. The inefficiency caused mainly by the poor coal quality led to its shutdown in April, 2004. The cumulated total volume of the stripping from the beginning of quarry works reached over 16 million sqm, and the extracted production reaches approximately 2.000.000 tones of lignite.

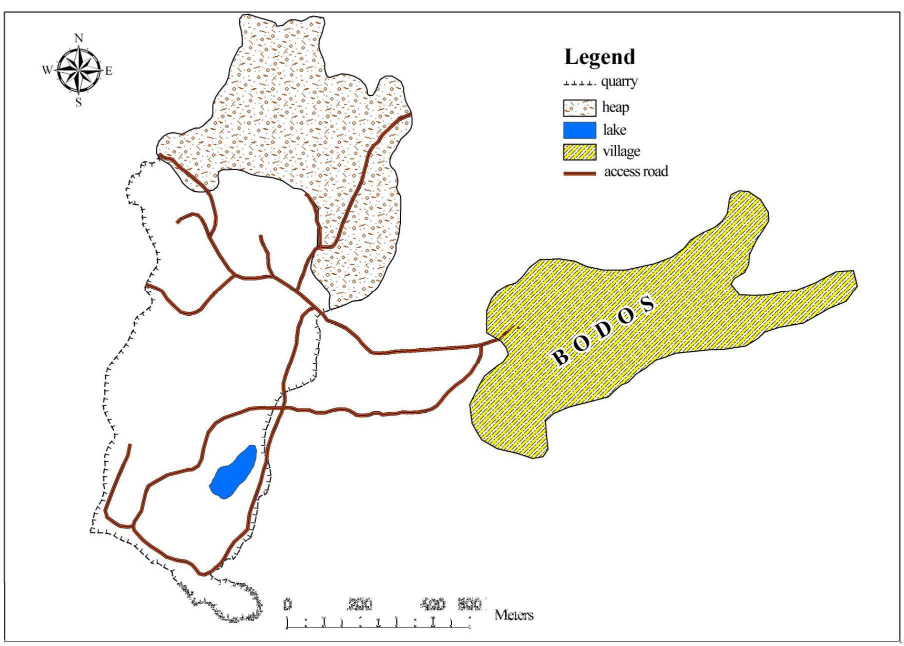

Fig.8. Geographic Location Map of Bodoş Mining Exploitation

2.2. Description of Exploitation Methods

In the Bodoş quarry, the exploitation method used involved several stages; the first stage was the stripping of coal stratum (excavating the sterile rocks covers and fat soil) and their transportation to the interior tailings heap. The following step involved the extraction of coal in stages. Inside the quarry, in the coal stratum floor (under the quarry bottom) excavators were used to dig basins (cesspools), which have followed the working face and have entrapped infiltration and rain water. For the slopes stability, both for the stripping stage and the tailings heap establishment stage berms and embankments were built, at different level heights. The exploitation technology applied to Bodoş quarry was single layered. The maximum exploitation depth, unto the natural terrain lever, was of 100 m, with a variable stripping proportion, depending on the surface configuration. The tailings resulted after the exploitation process was transported and deposited in the areas exploited for filling the cavities caused by extraction.

Chapter 3. Features of Bodoş Mining Exploitation

3.1. Mining Area Morphology

From a morphological point of view the region has a hilly aspect, found in sub-Carpathian areas. The initial exploitation surface of Bodoş quarry had a hilly shape, with medium mountain slopes of $10^0 - 15^0$. The areas influenced by quarry mining works are displayed by the tailings heap surface (sensitive to landslides in the eastern areas of the mountain slope and the westerns area of the quarry and tailings heap as well as bed cave-ins from the final frame of the quarry). Through the open-pit exploitation of the Lignite-bearing strata no. III a gap emerged. The potential influence of this gap is the accumulation of floor waters (without the possibility of discharging them freely), the cave-ins of embankments at the edge of the produced gap, eastern mountain slope cave-in and landslides towards the village, as well as landslides in the tailings heap surface, but also inside the quarry excavation. Within the mining sector the instability risk caused by folding, mining works flooding or subsidence caused by the presence of underground gaps has never existed.

3.2 Hydrological and Hydrogeological Aspects

Sands and volcanic agglomerates, which compose the pliocene and quaternary formations from the studied perimeter, determine these formations to be good groundwater collector and to form aquatic horizons, both above and at the level of local erosion. The superior aquatic complex of Lignite-bearing strata no. III's top was emphasised through drillings. The water sources from the area are the phreatic waters from the Quaternary, stored in the alluvial deposits of Bodoş and Baraolt rivulets; rain waters infiltrated in the edgy areas, where sands crop out; groundwater from pliocene formations, which are stored in sand strata from the sandy aquatic complex, waters with a captive pattern, under pressure, generating aquatic horizons with a ascensional level, feeding from rainfall or from the hydrographical network through the denudation areas of the sands, or though infiltration at the stratum edges; groundwater from Cretaceous formations, stored in areas with fissures and with a free level in the denudation areas and under pressure, where they are covered by impermeable pliocene formations.

The quality of these waters is determined mainly by the chimism of rocks, where they are stored. The main pollutant of discharged quarry waters is represented by a suspension of sandy-shaly nature (Cordonaşu, 2006).

The process of drainage and collection of waters resulted from infiltrations and rainwater during the mining exploitation period has been performed through water collection in the cesspools dug at the lowest level of the quarry floor; water drainage from cesspools to Bodoş rivulet it is done by means of electric pumps, hence the discharge is made in Baraolt rivulet.

Water debits resulted from the quarry were of 450 m^3/day and 164.250 m^3/year. These debits have been recorded during the productive activity period; during the period between the end of all activities (April, 2004) and the start of rehabilitation process, waters have not been discharged, thus accumulating in the shape of quarry floor lakes. For the closure of the quarry and during the reconstruction of the quarry surfaces, the accumulated waters should have been entirely discharged. The pollution sources are represented by fine clay and sand particles within the majority of rain waters that were washing the quarry slopes. The waters from Bodoş quarry are neutral waters, since there are no sources for the creation of possible acid waters drain in the emissary.

The hydrographic formations from the area have had favourable conditions of self-cleaning, regarding: drainage of particulates in the collecting and storage basins (cesspools); slope, nature of alluvial zone and existing routing breakage, a natural oxygenation of the water and a permanent decrease of water charging in pollutant and organic substances (Cordonaşu, 2006).

The analysis of mine waters have not shown any trace of heavy metals, cyanides, extractible substances, phenols and other toxic substances.

3.3. Ventilation of the Mining Exploitation

The relatively low depth of the quarry allowed the natural ventilation. The edges of the Lignite-bearing strata no. III, have been covered by the filling of exploitation gap, with compacted ground. Under these conditions, the possibility of unexpected combustion emergence, produced by coal self-ignition, has been eliminated.

3.4. Mining Works, Equipment and Mining Constructions

The free profiles of the two coast galleries, dug for the research of the Lignite-bearing strata no. III, have been closed through the direct cave-in of the covering and through the breakage of biddings. The two galleries are located at the bottom of the eastern slope of the quarry and they have been closed by the usage of isolation dams. The connexions from the quarry surface, which have stopped being used once the quarry was also closed, did not involve any risk; their closure caused liberation of the load surfaces. The access road to quarry surface and to the tailings heap has not been closed, but rebuilt, rehabilitated; the purpose of this road is to reintegrate the reshaped and greened surfaces into the agricultural and forester circuit.

The majority of equipments, installations and fix construction within the surface of mine yards, as well as the equipments, specific quarry gear and other facilities required for the maintenance, have become part of the Racoş-Sud quarry patrimony.

The affected constructions and the utilities that have disappeared after the closure of the quarry have not contained contaminated materials or any other risk factor.

The electrical energy was disrupted in the first closure stage, followed by tailings heap shaping hence resulted the mine filling necessary for the shaping of the gap create by means of quarry exploitation.

The electric energy interruption imposed the LEA 20 kV decommission, the north-southern alignment of which is situated in a tailings heap trench. The Bodoş quarry has not been fed with potable water.

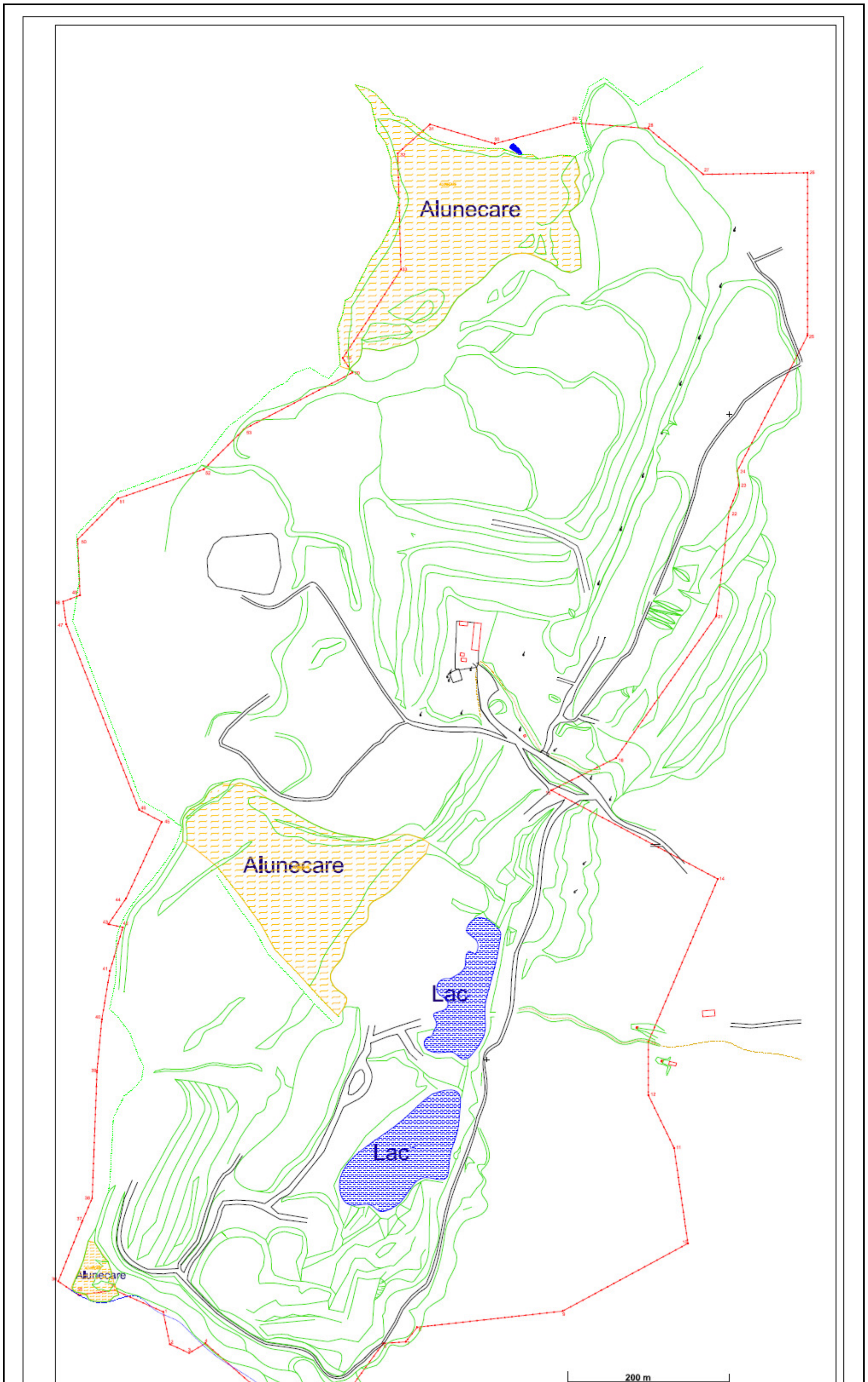

Fig. 14. Cariera Bodos dupa incetarea activitatii de exploatare

3.5. Tailings Heaps, Dangerous Tailings and Other Types of Tailings

The solid residual substances resulted during the activities have consisted mainly of sterile, refuses, different solid residuals resulted from the basic technological processes and the auxiliary activities performed for the purpose of coal exploitation (repairs, maintenance, etc.)

Tailings resulted from the stripping process of the Lignite-bearing strata no. III and heaped in the exterior techno-structure is composed of sands, clay and marl rock. The volume of extracted tailings from the quarry area during the productive activities rises up to 16.068.238 m^3. From a chemical point of view, the heaped tailings material has not affected the environment, excepting when it came to the coating of a surface of 90,0529 ha, initially cultivated and from which the fat soil has not been pickled and deposited.

Refuse and other solid residuals resulted from auxiliary activities or technical yard operating activities have been partially storage in the tailings heap and partly transported to the municipal landfill and the ecological waste deposit in the area associated with the tailings heap and which was closed after reaching the storage capacity.

Metallic waste resulted after the productive and auxiliary activity has been collected and exploited, thus on the quarry areas such waste has not bed deposited. Both after the previous productive and auxiliary activities performed within the Bodoş quarry perimeter as well as during the closure and greening period there have been no signs of toxic or dangerous waste.

The influence on environmental factors and the estimation of environmental risks: In terms of waste produced during the Bodoş quarry activity, the negative environmental impact is fairly insignificant. Obvious recorded effects are the degradation of surfaces, which concern the greening process.

- The impact on the "water" environmental factor asserted in groundwater changes, changes of surface and collecting runoff, the increase of the quantity of transported solid material and deposited on the bed of Baraolt rivulet.
- The atmospheric air has been vitiated during the functioning of the quarry through dust emission and emission of noxae from machinery performing on internal combustion engines.
- The pollution sources and their impact on ground and underground; the exploitation of the Lignite-bearing strata no. III through quarry has produced an exploitation gap and an important geomorphologic change through the formation of exterior heap; the fat soil from the initial deposition surface has been covered. Also, before the execution of an opening trench and the first stripping levels, the fat soil has not been pickled and deposited separately. Under these conditions, the rearrangement on the sculptured surfaces, the fat soil is composed of the first ground layer, which was excavated from the heap surfaces, lower grade ground than the initial one, before the start of quarry activity.
- The impact on human establishments and on other objectives of human interest: through its economic and social functions the quarry created a positive impact on the sites located nearby the mining perimeter. The coal transportation on the exploitation road and the earth road has affected the infrastructure of the earth road, but has underlined the deterioration of the platform crossing Baraolt rivulet, the deterioration of the guarding trenches of the earth road, the air infestation with particulates and the deterioration of over 80 ha of terrain, which have made the object of the reshaping and greening process. The emergence and development of Bodoş quarry has changed more or less the economical function of nearby locations trough the emergence of mono-industrial component in the economic plan (Cordonaşu, 2006).

Chapter 4. Technical Program Regarding the Closure of Bodoş Exploitation Area

4.1. The closure and greening process of Bodoş mining perimeter

The closure and greening technical process of Bodoş Quarry was made after the model presented in „Mine Closure Manual".

The closure of quarry preparation and opening works involved the shaping of all surfaces affected by the productive activity (filling the gap created in the surface of the quarry so that the new created surfaces are stable – slopes of maximum 15^0, insuring the possibility of mechanical agricultural works).

The discharge of accumulated waters on the quarry floor has been made with heavy duty motor-pumps for the short-time drainage of the quarry floor and the filling of the exploitation gap with ground, to a + 570 m level.

The reintegration of quarry areas and its exterior heap into the agricultural and forester circuit has been the most important objective of all, judging by the volume of the works and their complexity.

The reshaping imposed the insurance of safety by:

- the embankment angle of reshaped surfaces (between 12 and maximum 15 degrees in the eastern slope of the quarry;
- level height of maximum 5 m in the shaping areas of the surfaces;
- berms width of minimum 20 m;
- general embankment angle of 7 degrees;
- the prevention of landslides in the areas where these phenomena have taken place through the changing of upstream embankments, the easy shaping on the surface of slided areas, the unsilting and reshaping of the rain water collecting pipes from the slided terrain surface, the fertilisation and afforestation of slided terrains with an equal amount of beech and oak trees, the afforestation of the surfaces which have been built in the mine filling, surfaces located on the eastern slope of the quarry.

After creating horizontal or sloped surfaces, the following works were necessary: the levelling of new surfaces; the compaction of new surfaces; placement and compaction of fat soil; the fertilisation of new surfaces; forestation or grassing of the reconstructed surfaces. The construction of the new surface was made by reusing the "spreading-compaction" cycle; the final phase being the placement of fat soil and its compaction, followed by fertilisation-grassing and afforestation stages..

The stripping of the formed fat soil was made nearby, being used as soon as the shaped surfaces emerged.

For the drainage of rainwater and the water from limitrophe springs of the rehabilitated and greened surfaces nearby, the quarry and the heap has been reshaped through stripping and digging of the guard pipe from the northern, western and southern side areas previously mentioned; the ground has been placed, compacted and grassed on the left and right berms of this guard pipe.

Adjoining and spread to the quarry areas and the heap (which have also required reconstruction) are the surfaces less affected by the mining activities, which have not required rehabilitation and greening processes. The works imposed for regaining the initial agricultural capacity of these surfaces have been: the scarification of roots and herbage; levelling; fertilisation; grassing by means of specific seeds of perennial herbage.

The rehabilitation of quarry surfaces imposed the elevation of the quarry floor at a maximum level of + 570 m; this level can also be found at the entrance of the existent pipe at the bottom of the hill slope of the quarry. Through the elevation of the quarry floor level at a height of + 570 m and the hilly slope breakdown between the quarry and the water drainage pipe in the Bodoş rivulet the safe and stable possibility for the drainage of rainwater from the shaped and greened quarry surfaces has been created.

The construction of an outlet trench for rainwater from the shaped and greened quarry surfaces was vitally necessary for future seedlings from these surfaces.

The purpose of the construction of rainwater collecting and drainage pipes was the collection of excessive rainwater from berm upstream + 595 m with the purpose of decreasing the quantity of rainwater from the eastern slope of the heap.

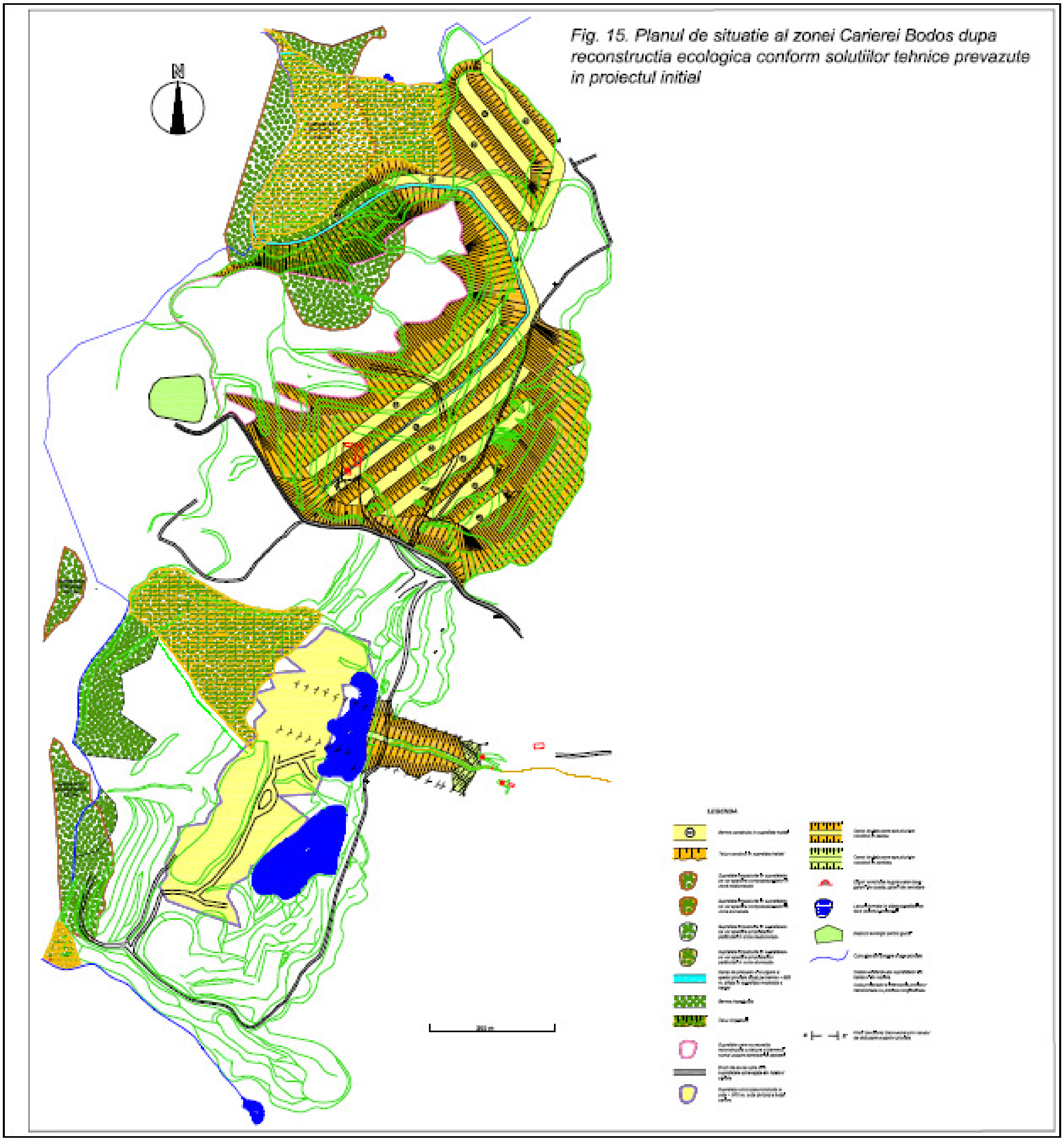

Fig. 15. Planul de situatie al zonei Carierei Bodos dupa reconstructia ecologica conform solutiilor tehnice prevazute in proiectul initial

The necessity of stripping and reshaping of Bodoş rivulet bed was imposed by: the drainage from the edge of the rebuilt road leat, the drainage of the waters coming from Bodoş rivulet and from the drainage of rain waters, which flow out from the rehabilitated and greened quarry surfaces. Due to existence of rock particulates in the suppressed water, along the time several sediments coating have been taking place, which have led to the shrinking of riverbed profile and the collecting capacity of waters with water discharge in the lower surfaces of the left bed of the river. Under these conditions several unsilting and reshaping works were necessary, which were supposed to lower the base level of the riverbed. Once these works were performed, the swamp formed nearby the earth road was excluded and the water flows were fully insured.

The road section between the western edge of Bodoş village and the shaped and greened surfaces of the heap and quarry, have been rehabilitated. After rehabilitation, the road insures background and safety for the transportation, specific to agriculture and agricultural machinery, used to work the land.

The fertilisation of built areas has been performed son after the finishing of the rehabilitation works. Coating the area with fat soil and the seeding or plating of saplings for afforestation has been made every time the land, which was supposed to be protected, did not contain substances, which could block germination and vegetation development.

4.2. Technical Program Estimated in the Revised Technical and Economical Documentation

During the working period the conclusion of the opportunity of changing some of the mentioned solutions, pursuing to the permanent monitoring of works performance and the consultations with the representatives of the local administration and the local community, regarding technical solutions by which the areas affected by extractive activities must be rebuilt. These changes included updated technical solutions, adapted to the terrain conditions, thus obtaining some sparings which have finally allowed the completion of some of the works claimed by the local community.

The claims were formed for avoiding the outlet of rain waters towards Bodoş vilage. That is why, through redesign, was proposed the creation of a lake that could store over 55.000 m^3 of water; an impressive debit in case of abundant rainfall and this lake is used today for fishing and recreation.

By comparison with the first version, a few measures are notable, especially the ones taken with the purpose of stability and safety increase of the rehabilitated area. The revised technical program followed first of all the discharge of waters from the quarry floor, the decommission of the two sites, concerning the order or works.

The rehabilitation and greening of mining surfaces followed the initial version. For the rehabilitation and greening of quarry and heap areas, several changes were imposed.

Unlike the initial proposed version, the shaping of quarry surfaces from the northern, southern, eastern and western areas was made entirely, including also the outlet trench of rain water from the protection and storage lake, which are discharged in the riverbed, located in the southern side of the quarry and hence the Baraolt rivulet (in the area of Baraolt closed mine no, II).

At the height of + 571 m, 1 m above the lake, in the eastern and western side of the lake protection and recreation berms have been built. Total work volume (the movement of sterile rocks for the completion of cut-and-fill works) is shown in **table 1**.

Table 1. Follow-up on Terrain Movement

No.	Provenance	U.M.	Excavating	Filling	The refilling input for the quarry
1.	Decommission of quarry yard (foundations, platforms)	m^3	600	-	+ 600
2.	Quarry	m^3	710.900	1.615.200	- 904.300
3.	Heap	m^3	1.029.200	162.600	+ 866.600
4.	Quarry drainage, alignment T24-T24 for the collection of infiltration waters (rolling stone)	m^3	-	2.000	+ 2.000
5.	The construction of collection pipes and water drainage	m^3	6.500	-	+ 6.500
6.	Unsilting the pipe from the eastern slope of the quarry and of reshaping coast galleries	m^3	165	-	+ 165
	TOTAL	**m^3**	**1.747.365**	**1.779.800**	**- 28.435**

The shaped quarry surfaces have been banked at a lever of under 15 degrees angle, excepting the lake surfaces and the ones that have outlet trenches.

For the contact of the bank surfaces from the eastern and western side of the quarry with the central bank surface on the north-southern side, rainwater collection pipes have been built for collecting rainwater from the quarry surface and part of the waters resulted on the heap surface; the water is directed and discharged in the lake.

The surfaces affected by the exterior quarry heap have been shaped in less levels at a general gradient of 13 degrees; the berms of the levels are located at heights of + 590 m, + 589,50 m and + 594,40 m (heights given by the ground input as filing for the quarry), necessary for the insurance of stability and the necessary filling for the quarry surfaces.

The difference between this version and the initial one is that fact that afforestation was extensioned in the western surfaces. The water collecting and drainage pipe, located in the berms from the eastern side of the heap (+ 589,40 m and + 590 m) has been fastened to the pipe from the eastern side of the quarry through the sub-crossing of the earth road, thus the waters are discharged in the lake.

The surfaces follow-up issued at the completion of rehabilitation and greening works and their destination is presented in table 2.

Table 2. Surfaces destination at the end of rehabilitation and greening works

No.	Surface	U.M.	Grass land	Forest	Lake	Total
1.	From inside the yards	m^2	11.318	-	-	11.318
2.	From inside the quarry	m^2	328.769,8	60.930,2	16.800	406.500
3.	From the eastern slope, under extension for shaping	m^2	28.683	-	-	28.683
4.	From the western slope, under extension for shaping	m^2	-	11.640	-	11.640
5.	Outside the quarry surfaces (western area)	m^2	-	4.000	-	4.000
6.	Taken by the heap	m^2	332.943,4	86.356,6	-	419.300
7.	Limitrophe to the surfaces of the quarry and the heap	m^2	229.355	-	-	229.355
	TOTAL	**m^2**	**931.069,2**	**162.926,8**	**16.800**	**1.110.796**

4.3. Comparison between the Two Ecological Rebuilding Versions of Bodoş Quarry Area

By the comparison of the two followed versions, i.e. version I – the solutions mentioned in the initial project – and version II – solutions mentioned in the revised project, following the application of these solutions to the field conditions from the period of undergoing closure and ecological reconstruction but also following the solicitudes of local community, one can observe—including the works claimed by the local community in version II (mainly the development and asphalting of the road and the construction/reshaping of the new lake)—

the total volume of works comes under the contracted signed with the designed constructors by the execution of closure and ecological reconstructions works (Medves, Turdean, 2008).

Table 3 shows the movement of materials (sterile rocks from the working areas, which come from different locations and sources.

Table 3. Material movements

No.	PROVENANCE	VERSION II		VERSION I		DIF. II - I	
		Excavating	**Filling**	**Excavating**	**Filling**	**Excavating**	**Filling**
1.	Demolition of foundations, platforms within the quarry yards	600	-	600	-	-	-
2.	Quarry	710.900	1.615.200	379.200	1.525.100	+ 331.700	+ 90.100
3.	Heap	1.029.200	162.500	1.392.300	119.700	- 363.100	+ 42.900
4.	Drainage from rolling stone	-	2.000	-	-	-	+ 2.000
5.	Water collection and drainage pipes	6.500	-	7.670	-	- 1.170	-
6.	Water outlet trenches	-	-	80.500	-	- 80.500	-
7.	Unsilting the pipe from the western slope of the quarry	165	-	165	-	-	-
	TOTAL	**1.747.365**	**1.779.800**	**1.860.435**	**1.644.800**	**- 113.070**	**+ 135.000**

It is notable the rearrangement of material qualities of the excavation, differences found in the volumes and transport distances, which eventually take the shape of sparings for the costs involved by works in version II.

Table 5 presents the comparative analysis of greened land surfaces depending on their destinations, for the community. An improvement of the resulted surfaces, given to the community usage, by the embracement of technical solutions presented by version II has been seen.

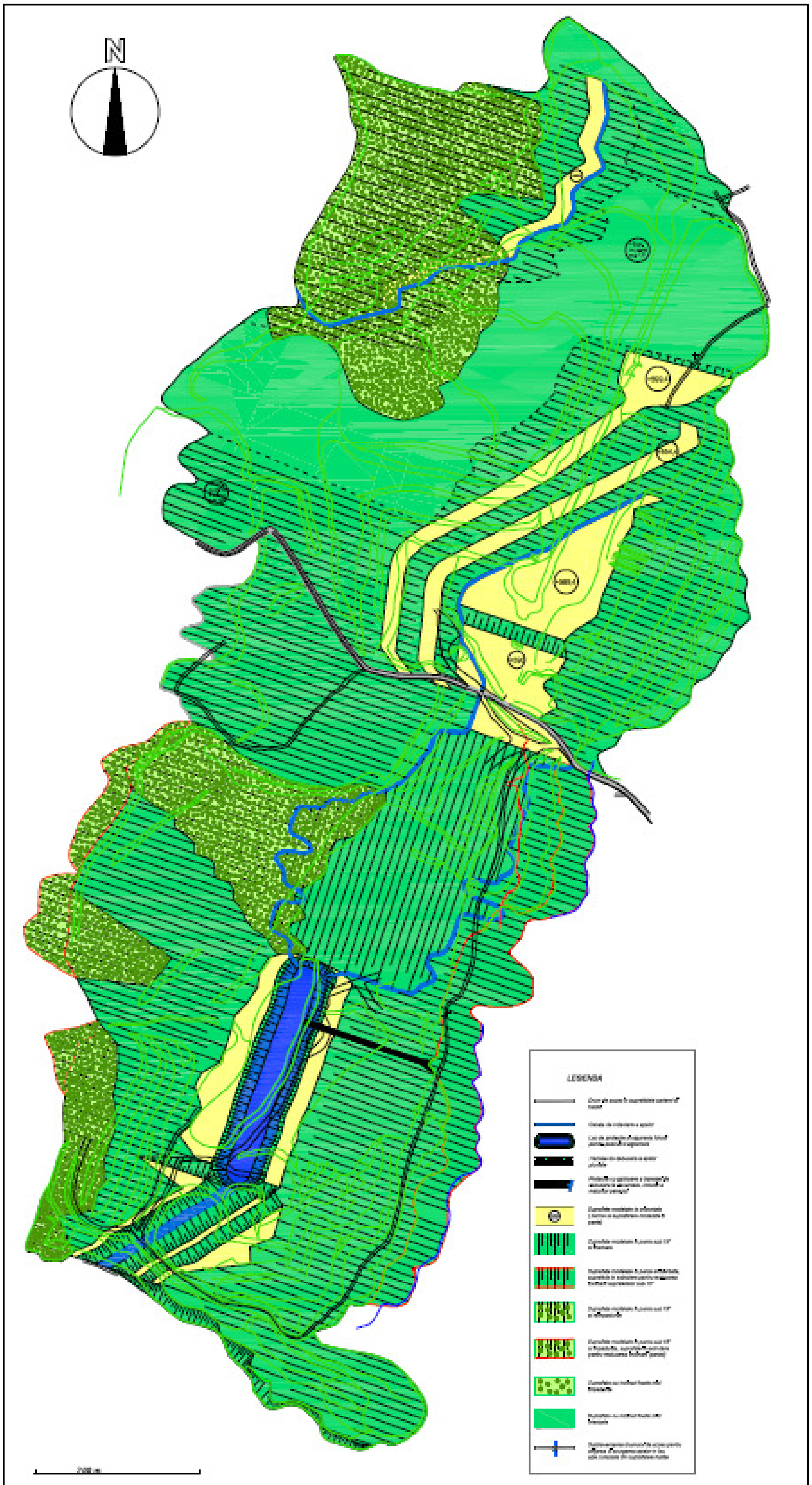

Fig.16. Planul de situatie al zonei Carierei Bodos dupa reconstructia ecologica conform solutiilor tehnice prevazute in varianta reproiectata

Table 4. The destination of rehabilitation and greening works after their completion

(m^2)

No.	Surface	VERSION II				VERSION I				DIF. II - I			
		Grass land	Forest	Lake	Total	Grass land	Forest	Lake	Total	Grass land	Forest	Lake	Total
1.	From inside the yards	11.318	-	-	11.318	11.318	-	-	11.318	-	-	-	-
2.	From inside the quarry	328.769,8	60.930,2	16.800	406.500	336.018,2	70.481,8	-	406.500	- 7.248,4	- 9551,6	+ 16.800	-
3.	From the eastern slope, under extension for shaping	28.683	-	-	28.683	-	-	-	-	+ 28.683	-	-	+ 28.683
4.	From the western slope, under extension for shaping	-	11,640	-	11.640	-	-	-	-	-	+ 11.640	-	+ 11.640
5.	Outside the quarry surfaces	-	4.000	-	4.000	-	4.000	-	4.000	-	-	-	-
6.	Taken by the heap	332.943,4	86356,6	-	419.300	33.294,34	86.356,6	-	419.300	-	-	-	-
7.	Limitrophe to the surfaces of the quarry and the heap	229.355	-	-	229.355	229*.355	-	-	229.355	-	-	-	-
	TOTAL	**931.069,2**	**162.926,8**	**16.800**	**1.110.796**	**909.634,6**	**16.838,4**	**-**	**1.070.473**	**+ 21.434,6**	**+ 2.088,4**	**+ 16.800**	**+ 40.323**

Table 5. Comparison of the objectives that represent the closure and greening of the Bodoş quarry value

(lei)

OBJECTIVES	VERSION II (proposed version)	VERSION I (initial version)	DIFFERENCE II - I
Rehabilitation and greening of the surfaces	7.624.326,66	7.917.140,50	- 292.813,84
Building water outlet trenches	92.421,33	192.227,20	- 99.805,87
Building of water colleting pipes	24.050,00	30.495,00	- 6.445,00
Rehabilitation of the access road from the shaped surfaces	43.223,30	33.642,50	+ 9.580,80
The reshaping of the pipe from the quarry eastern slope	1.193,20	1.633,20	- 440,00
The reshaping of the guard pipe, northern, western, southern limit	17.542,00	17.542,00	-
Rehabilitation of the earth road	4.181.655,64	2.137.014,01	+ 2.044.641,63
Rehabilitation of the Bodoş rivulet bed	8.860,00	8.860,00	-
Baraolt river bridge rebuilding	977.197,10	977.197,10	-
Protection of the Baraolt riverbed	690.914,14	690.914,14	-
Closure of the coast galleries	15.302,00	15.302,00	-
Cleaning of the working site	36.200,00	36.200,00	-
TOTAL of OBJECTIVES	13.712.885,37	12.058.167,61	+ 1.654.717,72
Initial amount; payment of the litigation committee	60.000,00	60.000,00	-
Contingents (20 % from the total of works lists)	2.926.730,27	2.518.386,72	+ 408.343,55
List no. 1 Preliminaries	950.766,00	950.766,00	-
GENERAL TOTAL	**17.650.381,64**	**15.587.320,33**	**+ 2.063.061,27**

The total value of the works, associated with version II are part of the total value of the contract, the extra costs required for the works have been covered by the sparings made due to the new work version (the amount spent on other types of works) and the value of the contingents mentioned in the works estimate (value of contingents from version I = 2.518.386,72 lei > the necessary additional value from version II = 2.063.061,27 lei).

Chapter 5. Monitoring Works Carried Out During the Closure and Post-Closure

The quality check and monitoring of the works were made at the same time with their execution, without affecting the workflow. The quality check and monitoring of the works consisted of: visual control, dimensional control through topographic-geodesic methods; quality check of the ground works, made in the lease lab of the branches, of the constructor and in the central labs, as well as the control of building behaviour during the works execution period.

The monitoring is made over a period of minimum 3 years from the issuing of the acceptance upon completion of works and development activities. The monitoring is punctually made, by means of measurements and observation regarding:

- follow-up on the rebuilt surfaces dynamics regarding the removal of any possible effect that could create instability; the monitoring is made through:
    - marking the built surface in order to reach the initial level of stability and vegetation reinstallation, with the final purpose of reclaiming the areas with modified level and with wooden terminal indicators (wooden pins);
    - the performance of topographic measurements, on a period of 3 years, during an entire year and only during the period the land is not frozen;
- observations and measurements regarding the finalised constructions, exclusively, for collecting and drainage of rainwater.
- observations and measurements regarding the new finalised constructions such as the bridge, protection for the Baraolt riverbed, the earth road and its accessories and the access road to the surfaces which have been rehabilitated and greened;

- observations regarding the evolution of the surfaces where afforestation and grassing has been used, concerning the safety of seedlings and perennial herbage;
- observations and measurements regarding the gas emissions from the ending sides placed above the isolation constructions of the research galleries (coast galleries);
- observations and measurements regarding the drainage of waters from within the two coast galleries through drainage pipes, which are integrated in the isolation constructions (dams).

During the monitoring active days of the company the following activities are being carried out: evaluation of the compaction evolution of and movement of the developed surfaces and the finalised constructions; water measurements of the two collecting places; analysis of gases, water and soil (if necessary) in special labs.

Chapter 6. Environmental Events That Took Place during the Closure Works

The due date of works, according to the signed contract was March 15th, 2010, but the majority of the works have been completed ahead of time. Thus, on 22.09.2009 the objective was established and soon after the performance of a technical audit with specialists from MonTech company, from Germany. The works have been absorbed at their completion on 11.11.2009. After the two warranty years the works associated with Bodoş mining areas have been re-evaluated on 29.11.2011 by an acceptance committee, designed by the Minister of Economy, Commerce and Business Environment, consisting of representatives of MECMA-DGRM, Covasna Prefecture, Baraolt City Hall, the Environmental Protection Agency of Covasna and other guests, has performed the final works acceptance. Today, the works are in the post-closure stage.

According to the Environmental Law, at the completion of the activity in the Bodoş Quarry area, the environmental impact was acknowledged, as well as the complete change of morphology of the terrain through the created gap by excavation processes and the tailings deposits on the surface initially destined for the creation of the heap, but also changes determined by the construction of mining yards.

The excessive water accumulation on the quarry and tailings heap surfaces have generated landslides within the quarry and on the western slope of the heap, which is still active.

The structure of the earth road was affected, thus its rehabilitation through asphalt works was necessary (work solicited by the local community).

The bridge crossing Baraolt rivulet, which connects the earth road with the inter-district road Baraolt- Sfântu Gheorghe has been affected, the flow of Baraolt rivulet has been deviated in the area of the bridge, where the right riverbed is severely affected, thus endangering the nearby high voltage power line. The erosion was visible on a distance of 500 m. Several sectors of Bodoş rivulet have been clogged up. The entrance footbridges of the households in Bodoş village have also been damaged, including the guard ditches of the earth road. Changes have also emerged in section of the southern, western and northern collecting pipe of the quarry and tailings heap surfaces (Fig. 20.).

The possibility of landslides also emerged in the eastern slope of the slope, located in Bodoş village. The disruption of the vegetation and changes emerged in the terrain slopes have contributed to the major changes of hydrologic regime of the area. In the nearby area the vegetation and fauna have been little affected by depositions of sedimentary dust and anthropic stress. The vegetation has suffered only quantity changes. During the exploitation rare or protected species have not been destroyed, nor were the natural monuments.

For the rehabilitation of the areas where landslides had emerged, during and after the ending of the quarry activity, afforestation was necessary for the reestablishment of the natural background, balance and stability.

All of the affected surfaces, which were taken by the quarry, heap and mining yards, have been reshaped, fertilised and reintegrated into the agricultural and forester circuit.

The new built surface, both in the quarry area and the heap area, has a more "poor" soil, which has been fertilized with the purpose of reaching a natural background as close as possible to the initial one.

The proposed measures also included the drainage of excessively accumulated rainwater, reducing the slopes of the entire area so that the land of the whole surface may be used for agricultural purposes, performed by mechanical means. These measures have also been approached by those people who owned lands in the areas affected by quarry coal exploitation; the entire affected and rehabilitated area was given the same destination it previously had, before Bodoş quarry began its activity.

CONCLUSIONS

The main objective of the present paper, entitled "***The Environmental Impact of the Mining Exploitation. Rehabilitation Strategies for the Anthropic Relief Caused by the Mining Exploitation. Case Study: Baraolt Mining Basin***", is to present and analyse the closure procedure and green reconstruction of a mining objective, in this case Bodoş Quarry.

Thus, the paper presented the rehabilitation strategies of the anthropic relief generated by mining exploitation, considering as well the possible impact on the environmental components. This is not possible without the presentation of an international and national legislative background, the environmental systems and the best practices that exist in the mining sector.

Among the objectives of this paper is the performance of a syntactical analysis, referring to the knowledge of the rehabilitation of mining areas topic, both nationally and internationally; this objective involves the analysis of specific international literature. Thus, the emphasis of the paper is on the way in which the anthropic morphogenesis was approached along the years, the environmental impact of mining exploitations and the rehabilitation strategies for the mining areas.

The following step was the emphasis of the particularities of the case study area. The focus was on the geological, morphological, morphometric, climatic, hydrological, edaphic aspects, etc. The third part of this study presents the morphogenetic dynamics layered on techno-structures, anthropic relief forms and the possibilities of rehabilitation of the open-pit mining areas. Another objective of this paper are the aspects regarding environmental management, the monitoring plan and the best greening practices of the mining sector. The last section of the present paper focuses on the case study of closed and rehabilitated mining exploitation areas, in this case Bodoş Quarry.

In conclusion, we can assert that the closure and green reconstruction activities of a mining area are part of a series of very complex procedures and processes, the most important of which are the ones concerning the permanent analysis of the field conditions and the appliance of solutions from the technical projects to them; but also the appliance of the solutions that are yet to be applied to the demands and requirements of the local communities, affected by the mining activities. By the appliance of FIDIC procedures and the technical closure and green reconstruction solutions, according to the BAT (Best Available Technology) and issued by European organisations, very good results have been reached within the closure and green reconstruction works of Bodoş quarry.

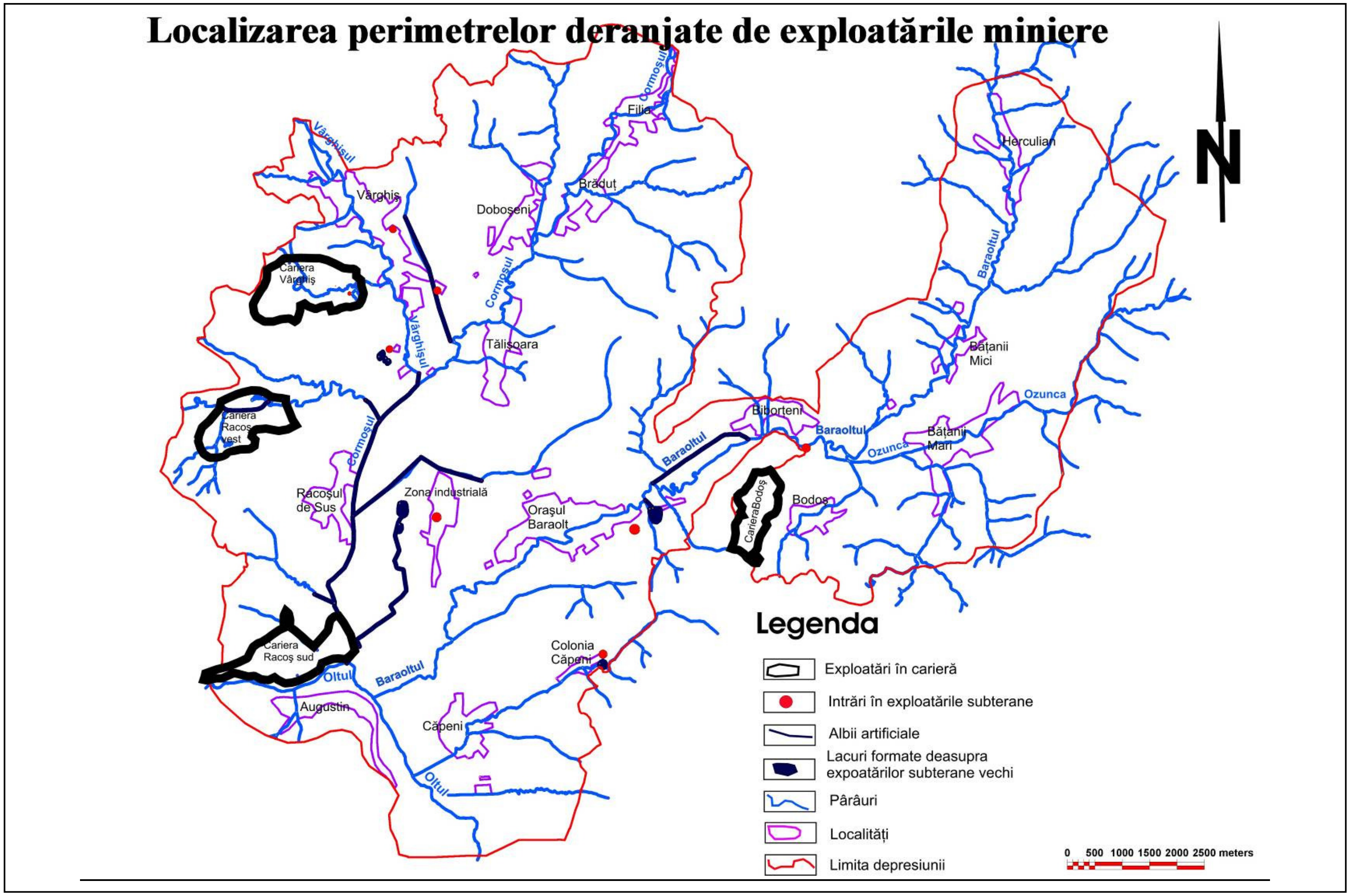

Fig. 17. Mining exploitations in Baraolt Basin

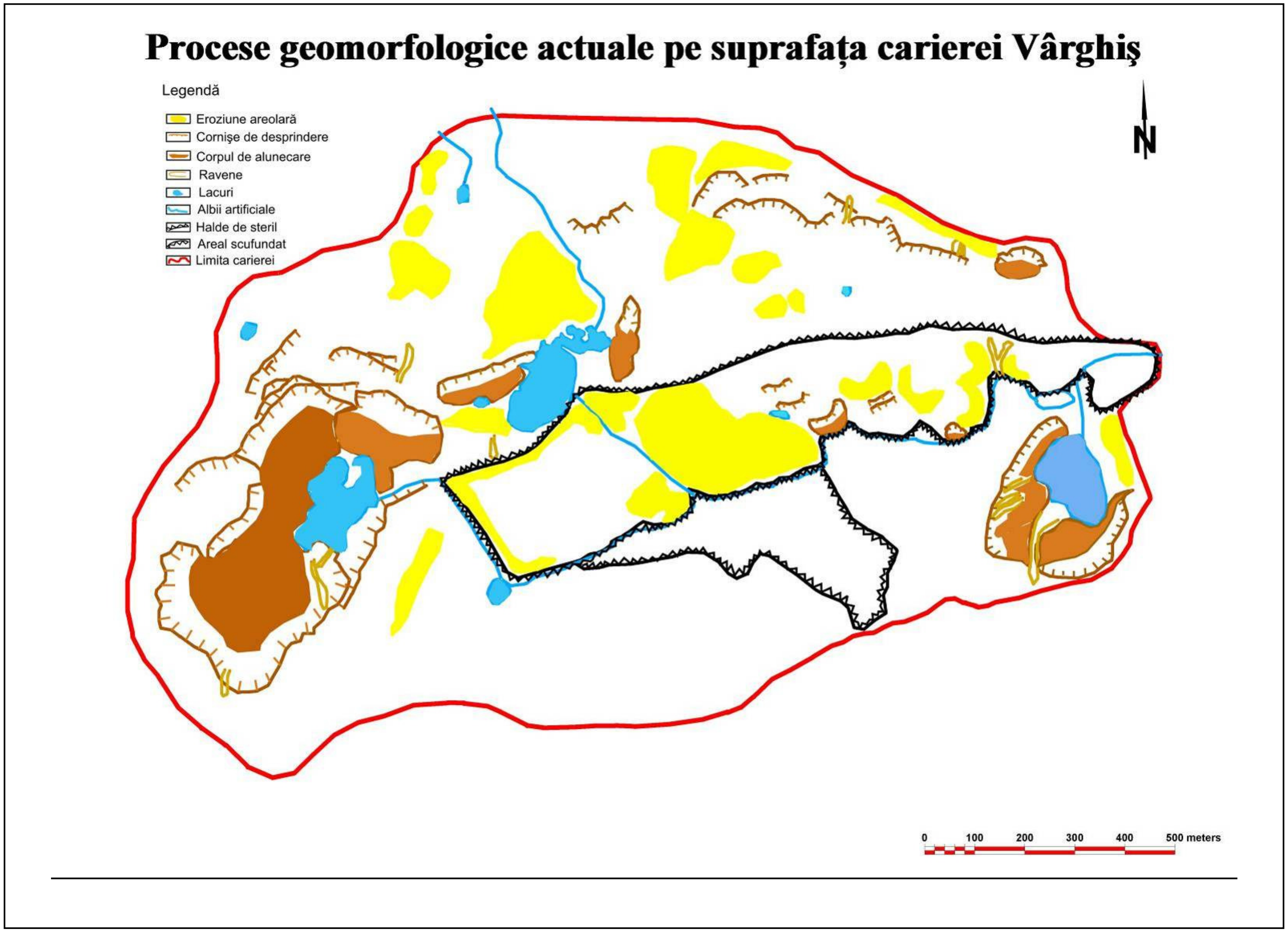

Fig. 18. Geomorphological Processes in Varghis Mining Exploitation

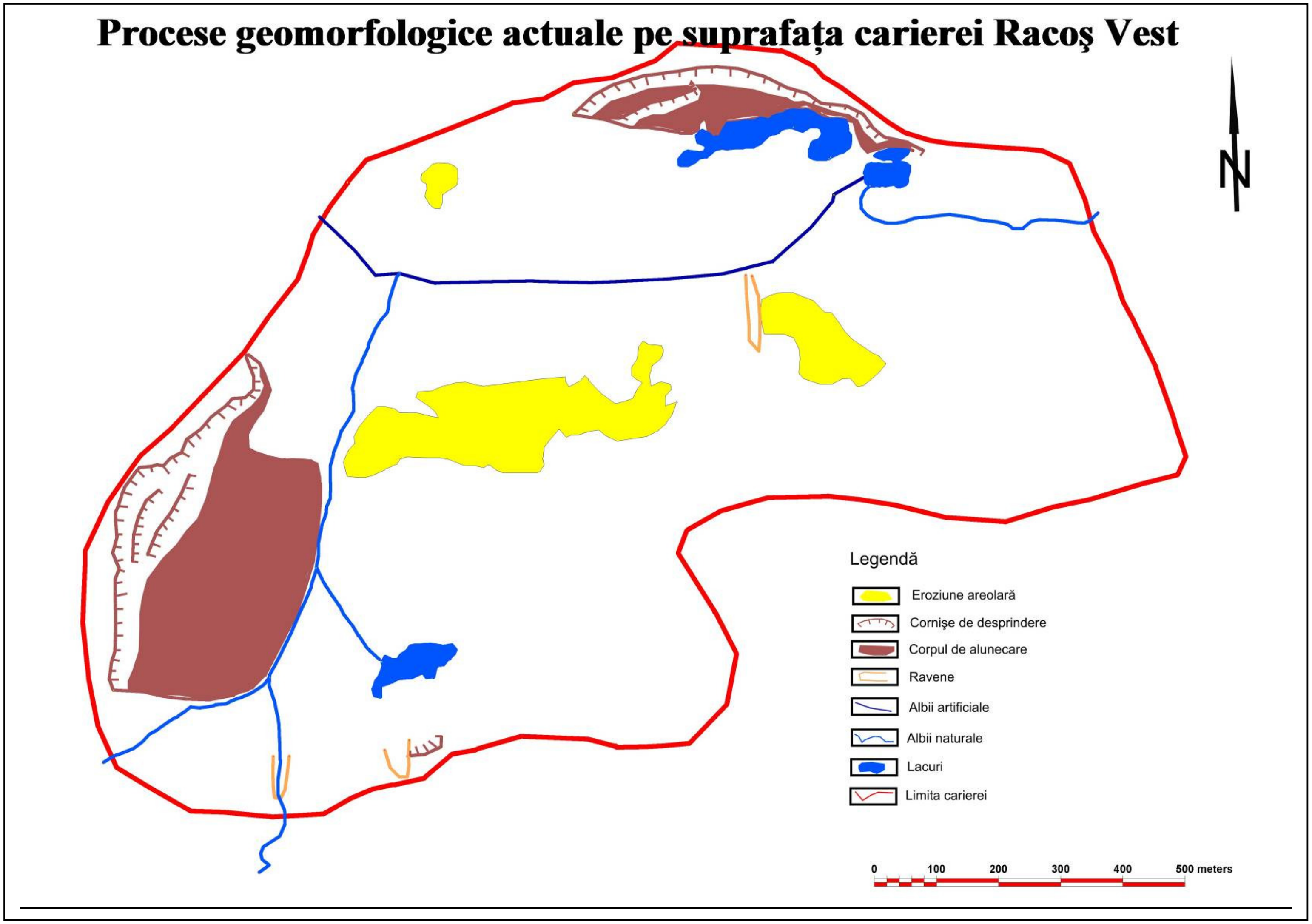

Fig. 19. Geomorphological Processes in Racos Vest Mining Exploitation

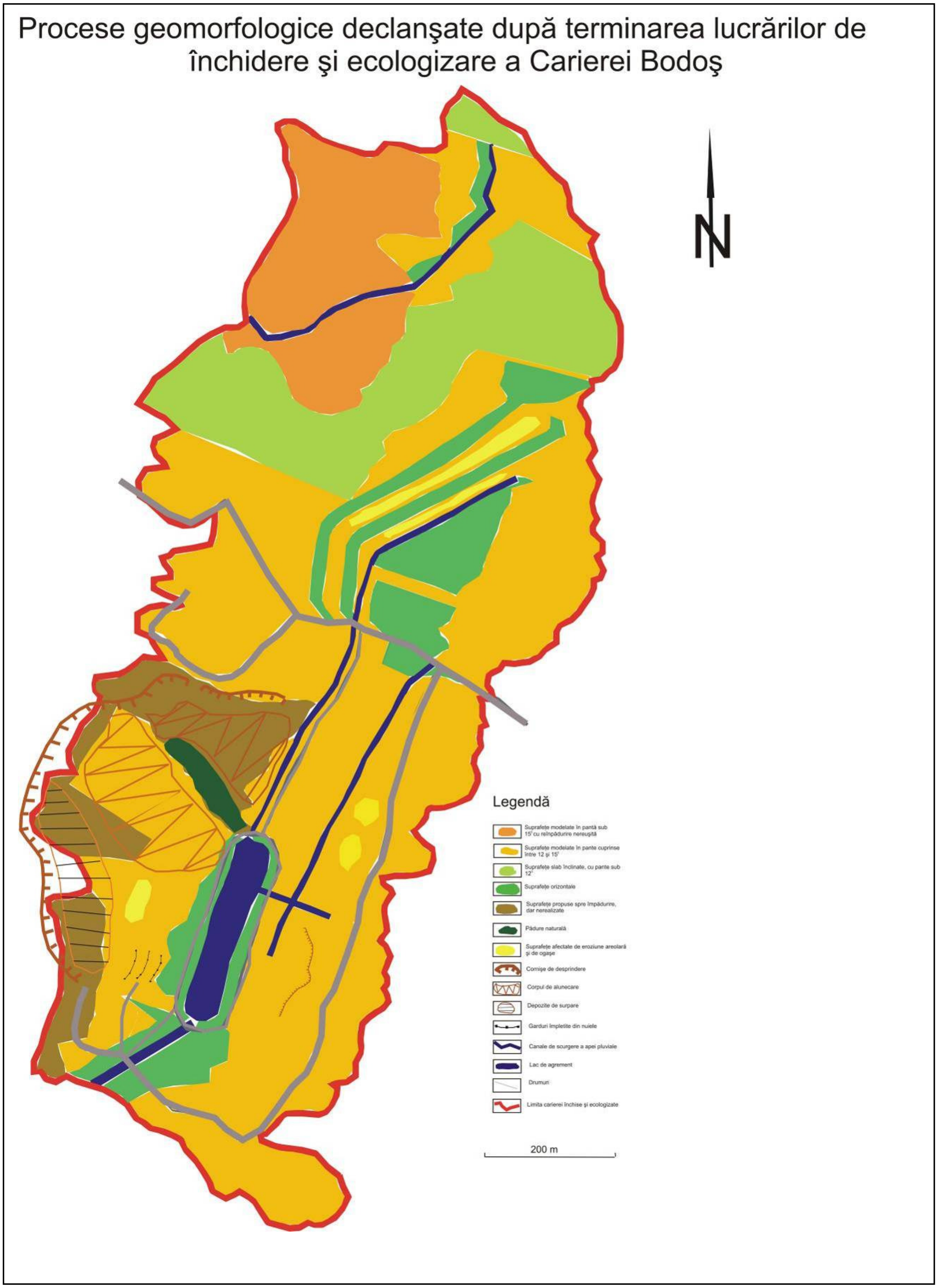

Fig. 20. Geomorphological Processes in Bodos Mining Exploitation after rehabilitation

BIBLIOGRAPHY

1. **Anghel, T. - Balazsi, K.** (2005): ***Modelling Processes On Spoil Heaps***, Revista de Geomorfologie, vol.7, Editura Universităţii din Bucuresti, Bucuresti
2. **Andriuc, I.** (2003): ***Bilanţ de mediu nivel I – Reactualizare – Cariera Bodoş***
3. **Baican, G.** (1998): ***Contribuţii la dezvoltarea tehnologiilor de exploatare a stratelor de lignit situate în condiţii hidrogeologice grele (Teză de doctorat),*** Universitatea Petroşani.
4. **Baican, G. - Bogatu, L.** (2000): ***Current state of affairs and future developments in the coal and lignite industry in Romania*** – Seminar – Bruxelles – Belgium – 2000, 18– 19, october.
5. **Baican, G. - Huidu, E. - Ianc, I.** (2000): ***Redarea în circuitul economic a suprafeţelor de teren afectate de exploatarea lignitului***. Trends in restructuring of coal industry in central and eastern European countries, 29 – 30 Mai, 2000, Sinaia, România
6. **Baican, G. – Medves, E. – Turdean, N**. (2008): ***Punerea în siguranţă şi amenajarea ecologică durabilă a depozitelor de deşeuri miniere (halde de steril şi iazuri de decantare)***, la „A III-a Conferinta pentru Sănătate şi Mediu din Europa Centrală şi de Est; Protecţia mediului – o platformă pentru sănătate" România, Cluj Napoca, 19 – 22 octombrie 2008
7. **Balintoni, I.; Seghedi, I.; Szakacs, A.** (1995): ***Geotectonic Framework of the Neogene Volcanism in Romania***. X-th R.C.M.N.S. Congress Bucharest, Sept. 1995, D. S. Sed. Inst. Geol. Geof., vol. 76., Supplement Nr. 7, p. 7-10, Bucharest
8. **Bălteanu, D.** (1983), ***Experimentul de teren în geomorfologie***, Editura Academiei, Bucuresti.
9. **Bănică, S.** (2006): ***Studiu fizico-geografic al bazinului râului Bârsa – cu privire specială asupra peisajelor,*** Teză de doctorat, Univ. Din Bucureşti
10. **Bănică, S.** (2006): ***Solurile din bazinul hidrografic al Râului Bârsa,*** Rev. A. U. Spiru Haret nr 8, Bucureşti
11. **Bauer, A.M.** (1970): ***A guide to site development rehabilitation of pits and quarries,*** IMR 33, Ontario Department of Mines, Toronto, Canada, 123p.
12. **Bell, F.G.** (1998): ***The Impact of Mining on the Environment***, In: Principles and Practice p. 415-458.
13. **Bell, F.G.** (1999): ***Geological Hazards, Their Assessment, Avoidance and Mitigation***, Routledge, London,
14. **Bell, F. G., Stacey, T.R. Genske, D.D**. (2000): ***Mining subsidence and its effect on the environment: some differing examples***. Environmental Geology 40, 135-142 pp
15. **Bell, F. G. - Donnelly, L. J.** (2006): ***Mining and its Impact on the Environment*.** Spon Press, London
16. **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
17. **Blunden, J. - Reddish, A.** (eds.) (1991): ***Energy, resources and environment***, Hodder and Stoughton, London, 339p.
18. **Bradshaw, A.D. - Chadwick, M.J.** (1980): ***The Restoration of Land***, Blackwell, Oxford, 310p.
19. **Brânduş, C., Chiriţă, V., Popescu, I.** (1998): ***Relieful antropic minier din zona montană a judeţului Suceava,*** Analele Universitaţii "Ştefan Cel Mare", Suceava, (67-73 pag.)
20. **BRGM, Atkins** (2006): ***Manual de proceduri de mediu şi de Implementare a unui Sistem de Management de Mediu în sectorul minier***
21. **Cairns, J. ed**. (1994): ***Rehabilitating damaged ecosystems***, Lewis Publishers, 415p.
22. **Cioacă, A. – Dinu, M.** (1995): ***Geomorphological hazards. Lignite mining and the newly-built relief în the North af Oltenia***, Geografia Fisica e Dynamica Quaternaria, Nr.18, (1996) Sherlock, 3-6 pp.
23. **Cioacă, A. – Dinu, M.** (1995): ***Hazardele geomorfologice în regiunile de exploatare a lignitului din nordul Olteniei. Studiu de caz câmpul minier Olteţ***, Analele Universităţii din Oradea, Seria Geografie, Nr. V, 57-67 pp.
24. **Cioacă, A. – Dinu, M**. (1998): ***Restructuring Lignite mining în Romania and its environmental effects with special reference to landforms***, Revue Roumanine de Geographie, Tome 42, (pp.135-147), Ed. Academiei, Bucuresti;
25. **Cioacă, A. – Dinu, M.** (2000): ***The impact of exploiting natural subsoil, resources on the subcarpathian relief (Romania)***, Geografia Fisica e Dinamica Quarternaria, Vol.23, 131-137 pp., Torino
26. **Cioacă, A.** (2002): ***Munţii Perşani. Studiu geomorfologic,*** Bucureşti, Ed. Fundaţiei România de Mâine
27. **Cioacă, A. – Mihaela, D.** (2001): ***Pliocene-Quaternary Evolution in the contact area between Brasov Depression and the surrounding mountains, (Romania),*** Geografia Fisica e Dinamica Quaternaria. Comitato Glaciologico Italiano, Torino, 24, p. 3-14, 2 fig, Abstr., Italia.

28. **Cioacă, A, Dinu, M.** (2002): ***Pliocene-Quaternary Evolution in the contact area between Brasov Depression and the surrounding mountains,(Romania),*** Geografia Fisica e Dinamica Quaternaria. Comitato Glaciologico Italiano, Torino, 24, pp. 3-14, 2 fig, Abstr., Rezumat, Italia.
29. **Cioacă, A, Dinu, M.** (2005): ***Particularităţile resurselor reliefului din Depresiunea Braşovului şi valorificarea lor în contextul dezvoltării durabile***, Studia Universitatis Babeş-Bolyai, geographia, 1-2, Cluj-Napoca, p 83 – 67, abstr., 2 fig.;
30. **Cordonaşu, I. (2006):** ***Proiect tehnic de închidere şi ecologizare cariera Bodoş- E.M. Căpeni, jud Covasna***
31. **Davis, B.N.K.** (1979): ***Chalk and limestone quarries as wildlife habitats***, Minerals and the Environment 1., pp. 48-56.
32. **Dinu, M., CIOACĂ, A.,** (1997): ***Modificarea arealelor de risc geomorfologic şi hidrologic ca efect al lucrărilor de corectare a albiei Oltului în Depresiunea Braşovului***, AUO-Geogr., VI, p. 47-52, 3 fig., abstr
33. **Dinu, M. - Cioacă A.** (1998): ***Impactul activităţilor de exploatare a lignitului asupra mediului în regiunile colinare din bazinele Crasnei şi Barcăului***, A.U.S.M.S., Vol. VI, 237-243 pp.
34. **Dinu, M. - Cioacă A.** (1998): ***Environmental effects of restructuring Lignite mining with special reference to landforms în Romania***, Revue Roumaine de Geographie, Nr.42, 21-33 pp.
35. **Down, C.G.** (1977): ***Amenity Banks and Quarry Landscaping***, Quarry Management and Products 4., pp. 231-239.
36. **Down, C.G. - Stocks, J.** (1978): ***Environmental Impact of Mining***, Applied Science, London, pp. 213-292.
37. **Duma, S.** (1998): ***Studiul geoecologic al exploatărilor miniere din zona sudică a Munţiilor Apuseni, Munţii Poiana Ruscă şi Munţii Sebeşului,*** Editura Dacia, Cluj–Napoca, 380 p.
38. **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, pp. 177-228.
39. **Floca, L.** (1997): ***Observaţii asupra stării environmentale din perimetrul protejat al Văii Căpuş***; Rev.Minelor
40. **Floca, L. – Bedelean, I. – Mihăiescu, R. - Stroia, A. F.** (1997): ***Recuperarea solurilor tehnogene rezultate din activitatea de extracţie a cărbunelui la zi***, Revista Minelor, Vol. 76, Nr.7, Ed. Infomin, Deva, pp. 4-5
41. **Fodor, D.** (1973): ***Stabilitatea taluzurilor în cariere, la halde şi iazuri***. ODPT Bucureşti.
42. **Fodor, D. – Georgescu, M. – Rotunjanu, I.** (1977): ***Consideraţii privind stabilitatea treptelor individuale de haldă din carierele bazinului Rovinari***. Revista Mine, Petrol, Gaze nr. 9/1977
43. **Fodor, D. – Iliaş, N. – Ţâştea, D.** (1978): ***Mecanizarea în exploatările la zi***. Editura Tehnică Bucureşti
44. **Fodor, D.** (1980): ***Exploatări miniere la zi***. Editura Didactică şi Pedagogică – Bucureşti
45. **Fodor D. – Rotunjanu, I.** (1984): ***Manualul Inginerului de mine. Vol I – secţiunea Hidrogeologie minieră***. Editura Tehnică Bucureşti.
46. **Fodor, D. – Păsărin, C. – Ştefanache, M.** (1984): ***Consideraţii asupra îmbunătăţirii tehnologiilor de exploatare a zăcămintelor de lignit din România în scopul creşterii gradului de recuperare a rezervelor.*** Al 12-lea Congres Minier Mondial. New Delhi India
47. **Fodor, D.** (1986): ***Prevenirea şi combaterea deformaţiilor elementelor constructive ale carierelor şi haldelor de steril***, Revista Mine, Petrol, Gaze 1/1986.
48. **Fodor, D.** (1989): ***Influenţa industriei miniere asupra mediului înconjurător şi redarea în circuitul economic al terenurilor degradate***. Revista Minelor nr. 7-8/1989.
49. **Fodor, D. – Georgescu, M**. (1991): ***Consideraţii privind clasificarea şi alegerea metodelor de exploatare în cariere,*** Revista Minelor nr. 2/1991.
50. **Fodor D. – Georgescu, M**. (1992): ***Preocupations et realisation concernant la reductions des effets negatifs de l industrie miniere de Roumanie sur le milieu environnant.*** Al 15-lea congres minier mondial, Madrid 1992.
51. **Fodor, D.** (1995,1996): ***Exploatarea zăcamintelor de minerale si roci utile prin lucrari la zi,*** vol I şi II, Editura Tehnică, Bucureşti, (695 pag., 597pag:)
52. **Fodor, D. - Lupulescu, I.. - Cosma, N. - Baican, G. - Stanca, N.** (1997): ***Investigations concerning the viability, the reduction and closure of mines in Romania***. 17th World Mining Congress – Acapulco, Mexico
53. **Fodor, D. – Georgescu, M. – Rotunjanu, I.** (1997): ***Consideraţii privind stabilitatea ansamblului de trepte de haldă din carierele bazinului Rovinari***, Revista Mine, Petrol, Gaze nr. 10/1997.
54. **Fodor, D. - Baican, G. - Manţoc, I.** (1998): ***Restructuring of the Lignite Mining Activity in Romania,*** X Congreso Internacional de Mineria y Metalurgic din Valencia, vol. II, pag. 337 – 348

55. **Fodor, D. - Baican, G. - Păsărin, C. - Bonci, Gh.** (1999)**:** ***Coal Mining in Romania at the Beginning of the 21st Century*****,** Revista Minelor, nr. 10-11/1999, vol. 130, pag. 6-12.
56. **Fodor, D. - Lazăr, M. - Baican, G. (**2000): ***Aspects regarding lignite mining in quarry impact on soil in Romania***. 3rd International Conference of Balkan Environmental Association – Bucharest – Romania 2000, pag. 76 – 77.
57. **Fodor, D. - Lazăr, M. - Baican, G.** (2000): ***Some aspects regarding the Romanian open pit lignite mining impact on soil*** – Symposium Athens, Greece, 6 – 9 november 2000, pag. 899 – 904.
58. **Fodor, D. – Baican, G.** (2001): ***Impactul industriei miniere asupra mediului*****,** Editura Infomin Deva, 392 pag.
59. **Fodor, D. şi colab** (2003): ***Consideraţii privind stabilitatea haldelor din Oltenia***, Buletin AGIR nr. 1/2003.
60. **Fodor, D. – Rotunjanu, I. – Lazăr, M.** (2004): ***Probleme de stabilitate a haldelor de steril şi a iazurilor de decantare,*** Revista Minelor nr. 5/2004.
61. **Fodor, D.** (2008): ***Exploatare în carieră a zăcămintelor de substanţă minerală utilă şi roci utile vol. I şi II***. Editura Corvin Deva
62. **Gregory, K.J.** (1985): ***The Nature of Physical Geography***, Edward Arnold (Publishers) Ltd., 262 p.
63. **Haff P.K. (2001):** ***Neogeomorfology, Prediction, and the Anthropic Landscape***, Duke University
64. **Harworth Mining Consultancy Limited - URS Corporation - Agraro Consult** (2002): ***Ghidul procedurilor de Management de mediu în sectorul minier***
65. **Hodor, N. – Bâca, I.** (2003): ***Consideraţii privind relieful minier din cadrul Munţiilor Igniş-Gutâi şi a masivelor magmatice Ţibleş şi Toroioaga*****,** Studii şi Cercetări, Geologie-Geografie, 8, Bistriţa, p. 107-112.
66. **Holla, L. –Barclay, E.** (2000): ***Mine Subsidence in the Southern Coalfield, NSW, Australia***. Mineral Resources of NSW, Sydney.
67. **Iancu, M**. (1957): Contribuţii la studiul unităţilor geomorfologice din Depresiunea internă a Curburii Carpaţilor (Bârsa, Sf. Gheorghe, Tg. Secuesc, Baraolt), partea I, în Probleme de Geografie, vol. IV, 1956, Ed. Academiei R.P.R., Bucureşti, 1957, p. 127-165
68. **Ilyés, Z**. (1999): ***A bányászati (montanogén) táj védelmének lehetőségei Magyarországon,*** In: A környezetvédelem helyzete és feladatai a bányászatban és a kohászatban, Balatonfüred, pp. 336-341.
69. **Ioniţă, I.** (2000): ***Geomorfologie aplicată. Procese de degradare a regiunilor deluroase,*** Editura Universităţii ''Alexandru Ioan Cuza'', Iaşi
70. **Ielenicz, M**., (1982): ***Modelarea actuală în Carpaţii de Curbură (sectorul Prahova-Oituz),*** Terra, 2, p. 16-22
71. **Juhasz, J.** (2003): ***Mernokgeologia***, vol III., Miskolci Egyetemi Kiado
72. **Karaman, A. – Carpenter, P.J. – Booth, C.J.** (2001): ***Type-curve analysis of waterlevel changes induced by a longwall mine***. Environmental Geology 40, 897-901 pp
73. **Kerényi, A.** (1995): ***Általános környezetvédelem***, Mozaik Oktatási Stúdió, Szeged, 383p.
74. **Kerényi, A**. (1999): ***Regionális környezetvédelem I., Európa környezeti állapota***, Debrecen, 156p.
75. **László, A., Dénes, I.** (1995): ***Elemente structural-tectonice pentru un model evolutiv în zona bazinului Baraolt.*** ACTA – 1995, p. 1–16, Muzeul Naţional Secuiesc, Sf. Gheorghe.
76. **László, A. – Kozák, M. – Püspöki, Z.** (1996): ***Szerkezeti vulkanológiai és magmás kõzettani vizsgálatok a Baróti–medence keleti részén. (Cercetãri structurale, vulcanologice si petrografice asupra magmatitelor pliocene din zona esticã a Bazinului Baraolt.)*** ACTA – 1995, p. 17–32, Muzeul Naþional Secuiesc, Sf. Gheorghe.
77. **László, A. – Kozák, M. – Pető, A. K.** (1997): ***Korrelatív eseménytörténeti rekonstrukció a Baróti-medence és a DNy-Hargita pontusi–pleisztocén vulkáni-vulkanoszediment képzõdményei alapján. (Reconstituire corelativã a evenimentelor geologice din Bazinul Baraolt şi din sud–vestul Harghitei, pe baza formaţiunilor vulcanice şi vulcanogen–sedimentare ponţian–pleistocene.)*** p. 9–20, Muzeul Naţional Secuiesc, Sf. Gheorghe.
78. **Medves, E., Turdean, N.** (2008): ***Închiderea şi reconstrucţia ecologică a obiectivelor miniere, procese dinamice în continuă adaptare la condiţiile concrete din teren şi la solicitările comunităţilor locale, într-un context economic viabil (Studiu de caz asupra Carierei Bodoş din jud. Covasna,*** Revista Minelor nr 3, Petroşani
79. **Medves, E., Turdean, N. Şi Baican, G.** (2008): ***Elaboration concept of an environmental management plan for the performance of the mining activities***, la „A III-a Conferinţa pentru Sănătate şi Mediu din Europa Centrală şi de Est; Protecţia mediului – o platformă pentru sănătate" România, Cluj Napoca, 19 – 22 octombrie 2008;
80. **Mihai, E.** (1975): ***Depresiunea Braşov: Studiu climatic,*** Editura Academiei Române, 211p.
81. **Mihăilescu, V., Stoenescu, M., Vintilescu, I., Toşa, A.** (1950): ***Ţara Oltului,*** Lucr.Inst. de Cerc. geogr. al R.P.R., Bucureşti, p. 13-36.

82. **Molenda, T., Rzetala, M. (2002):** ***Morphogenetic processes within post-minig dumping sites***, Aplikovana antropogenni geomorphologie, Sosnowiec, 6 p.
83. **Muntean, L. – Rus, R. - Surdeanu, V.** (1998): ***Relieful antropic din regiunea minieră Abrud-Roşia Montană,*** Studia U.B.B., Geographia, Nr.2, Cluj-Napoca
84. **Muntean, L. – Baciu, N. – Surdeanu, V. – Rus, R.** (2001): ***Impactul antropic asupra componentelor environmentale din regiunea minieră Abrud-Baia de Arieş***, pp.245-250
85. **Muntean, L. – Ferencik, I.** (2003): ***Evaluarea impactului environmental în culoarul Târnavei Mari, sectorul Vânătari-Micăsasa,*** Environment and Progress, Cluj-Napoca, pp.337-342
86. **Muntean, L.** (2004): ***Impactul antropic asupra componentei enviromentale în culoarul Târnavei Mari,*** Teză de doctorat, Cluj-Napoca
87. **Muntean, L.** (2005): ***Evaluarea impactului antropic asupra mediului***, Casa Cărţii de Ştiinţă, Cluj-Napoca, 129 p.
88. **Nicolau, J.M., Moreno, M., and Espigares, T. (2005)**: ***Ecohydrology of rilled slopes derived from opencast mining reclamation in a semiarid area***, Geophysical Research Abstracts,Vol.7
89. **Norman, D.K., Peter, J., Wampler, P.J., Throop, A.H., Schinitzer, E.F., Roloff, J.M. (1997)**: ***Best Management Practices for Reclaiming Surface Mines in Washington and Oregon*** Washington, Division of Geology and Earth Resources, Open File Report 96-2, Revised Edition, 130 p.
90. **Orghidan, N.** (1965): ***Munţii Perşani***, în „Natura”, Seria Geografie-Geologie, Bucureşti, XVII, 4, pp. 74-78.
91. **Panizza, M.** (1993): ***Geomorfologia applicata***, (242 pag)
92. **Pécskay, Z. – Szakács, S.- Seghedi, I. – Karátson, D.** (1992): ***Új adatok a Kakukkhegy és szomszédsága (Dél-Hargita, Románia) geokronológiai értelmezéséhez. (Contributions to the geochronology of Mt. Cucu volcano and the South Harghita »East Carpathians, Romania«.)*** Földtani Közlöny, 122/2–4, Budapest, p. 265–286
93. **Pop, Gr.** (2006): ***Depresiunea Transilvaniei,*** Cluj-Napoca : Presa Universitară Clujeană, 274 p. ; 23 cm.
94. **Posea, Gr.** (1981): ***Depresiunea Braşovului (Caracterizare geomorfologică),*** Analele Univ Bucureşti, seria Geografie, XXX, pp. 3-18
95. **Pretty, J. – Oroş, V. – Drăghici, C.** (2003): ***Waste management***, Editura Academiei Române, 293 p.
96. **Rădoane, M., Rădoane, N., Ichim, I., Surdeanu, V.** (1999): ***Ravenele: Forme, procese, evoluţie,*** Press Universitaria, Cluj – Napoca, 260 p.
97. **Rădoane, M., Rădoane, N**. (2005): ***Dinamica actuală a reliefului României. Premize de abordare***
98. **Ruthrof, K.X.** (1997): ***Improving the success of limestone quarry revegetation,*** Cave and Karst Science Vol. 24., pp. 117-125.
99. **Stănescu, Botnărencu, Zaharia, Stoicescu, Pelin** (1979): ***Documentaţie-*** studiu nepublicat
100. **Szakács, Al. - Seghedi, I. - Pécskay, Z.** (1993): ***Pecularities of South Harghita Mts. as Terminal Segment of the Carpathian Neogene to Quaternary Volcanic Chain***. Rev. Roum. Geologie, Tom. 37, Bucureşti, 21–36 pp
101. **Surdeanu, V.,** (1998): ***Geografia terenurilor degradate***, Editura Presa Universitară Clujeană, Cluj-Napoca, (274 pag.)
102. **Tomescu, V. - Savin, C. – Pleiniceanu, V.** (1998): ***Impactul exploatărilor miniere asupra factorilor de mediu din bazinul Motrului,*** Analele Universităţii din Craiova-Seria Geografie,Vol. I, Ed. Universitaria, pp.143-149
103. **Tomescu, V.** (2001): ***Procesele geomorfologice actuale din bazinul Motru în urma exploatării lignitului,*** Analele Universităţii Din Craiova-Seria Geografie,Vol. IV, Ed. Universitaria, pp.35-45
104. **Tomescu, V.** (2003): ***Modificarea calităţii aerului în arealul carierei de exploatare a lignitului Roşiuţa din bazinul carbonifer Motru***, Analele Universităţii din Craiova-Seria Geografie,Vol. VI, Ed. Universitaria, pp.24-31
105. **Tomescu, V.** (2004): ***Podişul Piemontan al Motrului. Studiu de geografie regională***, Editura Universitară Craiova, Craiova, pp. 232
106. **Tóth, S.** (ed) (1985): ***Rekultivációs értelmező szótár***, GATEKI, Kompolt, 185p.
107. **Tufescu, V. - Moţoc M**.(1969): ***La geomorphologie au service de l’amelioration des terrains degrades en Roumanie***, Travaux du Symposium International de Geomorphologie Appliquee, Bucharest, 49 – 54.
108. **Usher, M.B**. (1979): ***Natural communities of plants and animals in disused quarries,*** Journal of Environmental Management 8., pp. 223-237.
109. **Verstappen, H**. (1987): ***Applied Geomorphology***
110. **Wigglesworth, P.** (1990): ***Limestone quarrying and nature conservation***, MSc thesis, CNNA, Manchester Polytechnic, 95p.
111. *** (2001): ***Manualul de închidere a minelor***