UNIVERSITY OF PETROSANI

DOCTORAL SCHOOL

DOCTORAL FIELD : MINES, OIL AND GASES

THESIS

RESEARCHES ON THE GEOMORPHOLOGICAL CHANGES GENERATED BY THE MINING ACTIVITIES IN THE BERBEŞTI MINING BASIN AND THEIR IMPACT ON THE ENVIRONMENT

SUMMARY

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1. KEYWORDS: geomorphological changes, the Berbeşti Mining Basin, impact, ecological conversion, rehabilitation, modeling, Panga quarry.

2. GENERALITIES

The doctoral thesis entitled ***"Researches on the geomorphological changes generated by the mining activities in the Berbeşti Mining Basin and their impact on the environment"*** proves to be real news, through its theme aiming at researches to identify and evaluate the main processes and geomorphological phenomena generated by the mining activities. In the doctoral research, I have also proposed ecological conversion solutions for rendering in the economic circuit the lands modified from a geomorphological point of view. The work is justified by the stringent requirements that are at national and European level in the field of energy resources, of the efficient exploitation of the mining of useful mineral substances, as well as of the rehabilitation and restoration of the lands modified by the mining activities.

The purpose of the doctoral thesis is to identify and evaluate the main processes and geomorphological phenomena generated by the mining activities in the Berbeşti Basin. Along with this, the specific aims of the work can be identified as follows: analysis of the interdependencies between geomorphology (natural / anthropic) and the components of the environment; research on the geomorphological changes generated by coal mining in the Berbeşti Mining Basin, the geographical presentation of the Berbeşti area, the dumps and quarries in the basin; identifying and evaluating the impact generated by the geomorphological changes in the Berbeşti Mining Basin on the environment, using modern methods and tools for impact assessment: matrices, impact networks and checklists; directions and solutions for eliminating / reducing the impact of geomorphological changes in the Berbești Mining Basin on the environment.

In order to respond to the ones presented above, we have chosen a logical and systematic approach. Thus, it was necessary to go through several stages, which ultimately led to the elaboration and choice of the optimal variant of ecological rehabilitation of the Panga quarry, a career chosen as a case study. It was necessary to use the analytical and synthetic method, because the relief is the result of a complex of factors. In order to be known and explained, thorough analysis was required on processes, agents, forms, etc. then it was necessary to make classifications, generalizations and syntheses. The analysis from the geomorphological perspective of the variants of functional reintegration and landscape design of the Panga career is a contemporary necessity, whose applicability has both immediate and long-term effects. The approach of the transdisciplinary problem required an analysis of both the methodological principles of the scientific knowledge and the geographic-mining principles with methodological significance.

The doctoral thesis is elaborated during 7 chapters, with a number of 172 pages, totaling 128 figures (maps / schemes / photos) and 28 tables with specific data and information, 15 concepts and ideas, all original, covered copy-right community.

In the last chapter of the paper are presented, systematized, the final conclusions, descriptions of the personal, original scientific contributions, as well as proposals, future directions of research in the field.

The bibliography contains 95 up-to-date references, from the country and abroad. To this is added a number of 13 personal bibliographic references, of the author.

3. CONTENT OF THE WORK :

Chapter I is entitled ***"Anthropological geomorphology - research history".*** Mainly, this chapter presents aspects regarding the elements of geomorphology, the divisions of geomorphology, the relations of geomorphology with other sciences, the research methods used in geomorphology, the development of geomorphology in the world and in Romania, but also research on mining geomorphology. The geomorphology of the environment receives approaches of impact type, being the favorite subject of the researchers. Another well-defined direction is that of studying the risks and hazards affecting mining areas and living spaces. In this way, the contemporary geomorphology tends to acquire an accentuated socio-economic character, the landscape management and the rehabilitation of the degraded spaces being the most sought-after and generous topics from an application point of view. Anthropogeomorphology (neogeomorphology) aims to highlight the aggression that natural spaces endure. Within the studies integrated to this theme, environmental management strategies based on the idea of ecological rehabilitation of degraded spaces are proposed, especially in areas with mining operations. Recent studies address the problem of identifying areas with risks and the possibility of human harm. In order to achieve a modern and efficient management of the territory, it is necessary to make a correlation of the data characteristic of the case study chosen with the measures and experiences regarding the technique of rehabilitation of the areas degraded by mining. The geomorphological ideas promoted in the modern studies on the anthropic mining relief are highlighted by the interdisciplinary and transdisciplinary studies that appeared after 1990, which indicate an openness of the researchers to the problems generated by the irrational exploitation of natural resources. At the beginning of the 1990s there is a reorientation of geographers, geologists and engineers to study the human impact on contemporary morphodynamics. Thus, the analyzes regarding the anthropic intervention in the landscape are multiplied, being highlighted the aspects related to: environmental degradation, the risks and risks induced by anthropogenic impact, the anthropogenic morphogenesis, the rehabilitation of the degraded spaces and even studies of integrated management of the areas affected by the human intervention.

Chapter II is called ***"Geographic and geomorphological characterization of the Berbeşti Mining Basin"*** and presents the geographical, geological, hydrological, climatic, pedological, vegetation and fauna description of the studied area, as well as the local economic activities. The studied area is monoindustrial, the coal exploitation being documented since 1902 in the eastern extremity, at the Cuceşti mine in Oteşani.

There are also presented geomorphological aspects of the Berbeşti Mining Basin, such as morphology, morphometry of the area, analysis of the relief energy distribution, fragmentation

density, slope, slope orientation, highlighted geomorphological indicators and maps developed in the GIS system. From a geomorphological point of view, in the region are known sub-Carpathian units and the Getic Plateau, which develops up to the vicinity of the high plains of Piedmont located in front of the moesic platform. The sub-Carpathian hills have moderate heights, being fragmented by a strong transverse hydrographic network. The current relief in Berbeşti is on the one hand the result of the anthropic exploitation actions (land discoveries, excavations, slopes of exploitation, leveling of lands, storage of raw material or residues in the form of dumps, etc.), and on the other hand, the effect of the action atmospheric and hydrospheric factors (dynamics of air masses, precipitation, freeze-thaw, water leakage, substrate moisture), on the morphology determined by coal mining in the quarry. Following the action of the environmental factors on a substrate modified by the anthropic intervention, a series of geomorphological processes (rainfall, surface erosion, water leakage, collapses, landslides) and relief microforms (gullies, gorges, ravines, cones, sliding bodies (sliding bodies) which, even if they have a manifestation in accordance with the modeling in natural regime, are induced anthropically. Thus, the lack of strategies and measures to rehabilitate the degraded lands has practically led to the intensification of the geomorphological processes.

Field researches in combination with aerophotogram analysis were the tools used for geomorphological mapping. The mapping included all the aspects of the relief, respectively, morphography, morphometry, morphogenesis and morphochronology, in this way the past, present and future of the evolution of the relief of the Berbeşti Mining Basin will be understood. For the geomorphological maps in the thesis, the database contains spatial information on morphometry / morphography, hydrography, genesis and age of relief shapes and geomorphological processes. Some of these required field identification (extension and height of terraces, typology of current processes), while others were derived on the basis of numerical models of the land, topographic plans at 1: 5000 scale or specialized literature (age). relief forms). The analysis and graphical processing of the geomorphological details was performed in ArcView 9.2, and it was necessary, beforehand, to generate conventional symbols, according to the established legend. Thus, classes of symbols were created for each type of relief, then used in map making. Although the software used proved to be quite flexible in generating various types of lines or areas, to create point type symbolism (geomorphological processes) it was necessary to generate fonts in the Fontlab program, subsequently installed and used in ArcView. For the background we tried several variants, the purpose being to find the optimal way to represent the diversity of the relief, without however loading additional maps and to facilitate the interpretation of cartographic symbols. For the Berbeşti geomorphological map, for example, we have data on the distribution of slopes (in absolute and percentage values), the slopes of the slopes, their orientation, the surface occupied by certain lithologies. We have generated quantitative information on the areas occupied by certain geomorphological processes according to criteria, or forms of relief such as the extension of the terrace bridges, the piemontes, the glacis or the structural plateaus.

Chapter III ***"Geomorphological changes generated by the mining activities in the Berbeşti Mining Basin, Panga Quarry case study"*** presents the modification of the relief of the region, by the appearance of the new negative relief forms (lignite quarries), but also the positive relief forms (tailings dumps), the modification of the hydrogeological conditions through the drying works, river deviations, edaphic changes and the appearance of the anthropic mining protosol. Also in this chapter we have detailed the phenomena of land degradation facilitated by the geomorphological changes. According to the geomorphological map of the study area, the landslides are present both in the mining area and in the surrounding areas, each having different causes and correlating with other geomorphological phenomena: ravages, collapses, settlements, surprises, melting cones, phenomena rain. In the area of mining, the landslides are also influenced by the artificial changes brought to the relief and hold 49% percentage as a frequency, surprises 29%, erosions 12%, followed by settlements with 10%. The triggering factors are favored by the geology of the area, by morphology and morphometry, to which are added the external factors: climate, water, man and its activities. The land degradation phenomena facilitated by the geomorphological changes in the Berbeşti Mining Basin contribute to the highlighting of the anthropic mining landscape, the relief modifying its morphological configuration. The modification of the natural lithological structure of the land was made on depths that can reach 150 - 200 m. Following the exploitation of lignite from the Berbeşti Mining Basin, against the background of a lithology of clays, marls, sands, it was reached from an initial hilly relief, considered primary, to an anthropic one, considered derivative.

Chapter IV is entitled ***"Identification and evaluation of the impact of geomorphological changes in the Berbeşti Mining Basin on environmental factors"*** and issues related to the impact of mining and geomorphological changes on the environment are addressed. We aimed to identify the impact on morphology, landscape, soil, air, vegetation, fauna, human communities, through checklists and impact networks. The network was structured taking into account the main geomorphological changes in the Berbeşti Mining Basin: on the ground: the appearance of the dumps, the degradation of the land, the degradation of the morphology, the geology, the risk of rock detachment and landslides, the destruction of cultural assets; on the air: noise, vibration from shooting, dust caused by traffic, shooting and wind, smoke from self-igniting dumps, noxious gases, potential changes in the local microclimate; on surface water: degradation of nutrient level (risk of eutrophication), pollution by wastewater discharge, pollution due to intensification of erosion; on groundwater: reduction of hydrostatic level, deterioration of groundwater quality; on the soil: the clearing of the perimeters of exploitation, the loss of agricultural crops, the drying of the soil, the risk of soil loss by local restoration of the hydrostatic level, erosion; on the flora: total destruction in the working areas, destruction or partial alteration in the adjacent areas due to the lowering of the hydrostatic level; on wildlife: the disappearance of wildlife; on the human community: conflicts over land use, displacement, destruction of recreational areas.

At this stage of the study, we also evaluated the impact on the environment, generated by the geomorphological changes, with emphasis on the Panga career, where I highlighted the

evaluation of the impact on the soil, flora, local fauna by the method of impact matrices. In the impact matrix inserted in the doctoral thesis, we noted on the columns the geomorphological changes and the most active geomorphological phenomena in the Berbești Basin: dumps, quarries, erosion, landslides, settlements, radishes, sulfur, creep, and along the lines, the environmental components affected by processes: morphology, landscape, soil, subsoil, surface and deep water, vegetation, fauna, ecosystems and local communities. In detail, we notice the negative impact of the dumps (3.7), the quarries (4), the landslides (3.3) on all the environmental components, the dumps change the local morphology on large areas of land by the appearance of the positive topographic forms, by diverting the land from the initial uses, by visual impact selenary, through the high costs of rehabilitation of the land, by increasing the stress level of the local community. The quarries (4) have a major impact on the landscape by the appearance of negative relief forms, on the morphology due to risk of accidents / rock falls, visually print the gap seals of the landscape, on the waters determines the accumulation of career lakes, of marshes, the increase of the evaporated water quantity, the emergence of marsh vegetation, the disappearance of wildlife, the emergence of new ecosystems, the risk of drowning for the community, the change of the microclimate. The landslides (3.3) have a major negative impact on the local landscape and geomorphology by modifying the topography, altering the soil, local geology, by material and human great damages, by affecting the ecosystems, by destroying the water-air-nutrient balance of the soil, it prevents photosynthesis, the reduction of CO2 from plants, increasing CO2 in the air, greenhouse effect. The soil is affected by tailings discoveries and deposits. The vegetation and the local fauna disappeared almost entirely as a result of the emergence of the quarry (forests were cleared, wild animals migrated to other places, the lack of soil led to the impossibility of installing some plant species). Geomorphology and landscape architecture have been deeply modified; whole hills were excavated, watercourses disappeared; Instead of valleys, true hills appeared by depositing waste dumps. The human population also suffered from the existence of the quarry: houses were demolished, residents were displaced, villages were destroyed. The rest of the geomorphological changes and the geomorphological phenomena have a local impact, especially within the quarries, being associated with the relief unit, the geology, the slopes of the area, the type of design, excavation, haldering, the local weather phenomena, the appearance of the local topoclimates, the local ecosystems, of ecological reconstruction.

Chapter V is entitled ***"Ecological reconversion solutions in the Berbeşti Mining Basin - Panga Career case study".*** Within this chapter, the types of recovery practiced for the rendering in the economic circuit of the geomorphologically modified lands such as naturalistic, recreational and recreational, productive, residential, cultural, for controlled waste deposits are analyzed. Mining redevelopment of degraded mining land is a component of mining activity and is defined as methodical modeling of areas occupied by mining activities, taking into account public interests and requirements for sustainable development of a region. The rendering in the economic circuit of the lands degraded by the geomorphological changes, but also by the mining activity, is based on a complex of works that refers, first of all, to the mining redesignation of the

affected areas. Through the redevelopment work, some of the area's previous economic potentials or innovative ones must be created again. Land reclamation must become an integral part of mining operations and not an "after mining" treatment with incalculable additional costs. There are three types of interventions for environmental recovery of the affected territory: the first type requires the reconstruction of the landscape as it was before the degradation; the second type seeks a destination for reuse by inventing new forms of use or trying to meet the precise demands made by the community; the last type refers to the provisional systematization of the affected areas, pending the final decisions taken by the law bodies. The recovery of the waste dumps aims to mitigate the changes of the micro-relief, so that the accumulations of residues in the area will be leveled, retrained, terraced, arranged for agricultural, forestry, tourism reuse, at the end of the arrangement the initial negative visual impact given by these residues will be positive, through recovery environmental, by the local aesthetics of insertion in the typical hilly morphology of the area, at the same time this recovery, will diminish the stress of the community triggered during the period of accumulation of the residues, and the risk of illness of the population due to the appearance of the residues in the area will be eliminated. The remaining gaps of the former Berbeşti quarries can be filled with water, thus taking on different functions, from industrial to recreational ones, or they can be used for the storage of industrial residues or household waste. As a recreational function, in the Panga quarry, the remaining void can function as an adventure park or as a biologically active region.

In **Chapter VI** called ***"Choosing the way of rehabilitation and restoration of the geomorphologically modified land from Panga Career"*** we designed several indicators to highlight the geomorphological changes in the area, checklists, an online survey on choosing the type of reuse of the land in Berbeşti, a questionnaire consisting of questions regarding the rehabilitation activities of the Panga quarry, the Wram matrix for the quantitative assessment of the environmental impact generated by the rehabilitation project. According to the final evaluation matrix, variant 3 of land reuse in the Panga quarry (leisure complex, fishing lake, adventure park) had the highest value of 2.84, which shows that this is the most viable reported to all aggregate indicators for this final result. Comparatively, the variant 1, which aims at the agricultural recultivation of the inner waste, obtained a score of 1.31, and the variant 2, respectively the forest recultivation of the inner waste, a value of 1.71. The importance of choosing the best reuse variant also involved an initial consultation of the population in the area and of the decision-makers on how to reuse the land in the Panga quarry. If the main modes of recovery so far have been agriculture and forestry, which has been determined by large areas of land exploitation by quarry exploitation methods and surface overloading of landfills and land, the present objective is to provide post-mining areas, often with extensive industries infrastructure and housing, new values of use, appropriate to the social conditions it needs. The implementation of such a scenario for the rehabilitation of the Panga quarry, could illustrate the true ecological value of the Berbeşti-Panga mining area, the rehabilitated area becoming an important point for biodiversity, for Valcea tourism, and the Panga mining perimeter could thus

be developed and put in place records in the most useful way, which will give the whole region a new value, with effects beyond its borders.

Chapter VII refers to ***"Modeling and designing the ecological rehabilitation works of the Panga Career".*** Modeling and designing works for ecological rehabilitation of the Panga quarry combines civil engineering and landscape architecture with geotechnical engineering, geology and hydrogeology, pedology, geomorphology, ecology, planning, forestry, horticulture, bioengineering, industrial archeology, and the volume of modeling and landscaping the degraded land is dependent on the way in which the geometric elements of these mining constructions and especially on the final destination of the land were respected in the exploitation phase. In this context, the stability and stabilization of natural slopes and slopes is presented, by W. Fellenius's method. The importance of ensuring the stability of the definitive slopes of the quarry, as well as the slopes of the slag, is prioritized even before the beginning of the works of land management, because, by analyzing the state of stability of the slopes existing after the cessation of the operation, the types of works necessary to ensure the stability of the lands are established, but and their ecological restoration and playback in economic, tourist, cultural or sports circuit. We have detailed the design of the land remodeling works. These were designed using three-dimensional digital models, made using the Civil 3D software product. Thus, 3D models of the surface of the land were created, in three moments: the initial surface of the land, before starting the mining works; the surface of the land at the time of completion of the mining works; the surface of the land after the rehabilitation-greening works. The three surfaces were created through the Autodesk Civil 3D product procedures, on the AutoCAD platform, using the following data types: text information, taken from XYZ type files, containing detail points at ground level, defined by X, Y coordinates and dimension Z; vector type information, taken from topographic plans in digital format: defined points X, Y, Z; 3D polygons, defined by points X, Y, Z; level curves, defined by points X, Y and the common elevation Z; raster-type information, taken from georeferenced images, which are then transformed, digitized, into the aforementioned vector-type information. The surfaces, once constructed, allow for a variety of operations, such as meeting, intersection, volumetric calculations, vertical sections.

On this support, both the actual design work of the area rehabilitation project can be carried out, while providing the basis for creating the presentation format of the results. To create the 3D model of the initial surface of the land prior to the start of the mining works, the old topographic plans with level curves, obtained from the mining operator, made before 1980 were used. These plans were scanned and georeferenced. After insertion into the AutoCAD Map environment, the plans were vectorized, extracting points and level curves which were then the basis for creating the 3D model of the initial surface, in TIN format.

Also in this chapter I checked the stability after the surface remodeling, following the description of the structures necessary for the rehabilitation of the career: zone A - leisure complex, zone B - indoor dump with leisure lake, area C with Adventure Park. Through the project of development and tourism development of the Panga quarry, we aimed to diversify the tourist offer of Vâlcea county; creation of a leisure complex within the perimeter of a quarry in

which lignite was exploited; development and promotion of recreational tourism and ecotourism. The project can also be a business plan model, applicable for start-ups, non-reimbursable grants, if the business operation is detailed, the marketing plan, the promotion strategies, the financial plan, the premises of the development in the real market.

4. CONCLUSIONS, OWN CONTRIBUTIONS

The structure of the doctoral thesis ends with its own conclusions and contributions. I have also concluded conclusively in a contributory context, the results reached by the research carried out for the scientific elucidation of the PhD thesis topic. , the influence of the mining activity on the environmental factors will be reduced considerably, and as a result of the afforestation that is achieved, by restoring the fauna and flora, the forest microclimate is restored, the whole environment is restored, aligning with the sustainable development. The ecological restoration of the lands affected by the geomorphological changes specific to the mining activities, respects a requirement of the current legislation on the one hand, and on the other hand a requirement of the local community, solving in this way the problems related to: eliminating the risk of slipping the relief forms positive, appeared in a territory by depositing the sterile material in external dumps; eliminating the negative visual impact of the areas with selenium appearance; the need to reintegrate the degraded surfaces into the productive and / or ecological circuit of the regions in which they are located, which leads to the regeneration of their economic potential; improving the quality of the environment; reducing the slopes and, with this, reducing the intensity of erosion phenomena and accelerating the processual installation of vegetation; the possibility of creating new storage spaces of different types of waste in the remaining gaps of the quarries.

The originality of the researches carried out, in accordance with the scientific objectives of the doctoral thesis, is materialized by a series of novelty elements, which increase the scientific value of the studies performed. Thus, the original contributions of the doctoral thesis can be summarized as follows:

1. I have made geomorphological maps in GIS technique (hypsometric map, relief energy map, fragmentation density map, slope map, geomorphological map, physical map with hydrographic networks and geographical positioning of the Berbeşti Mining Basin, 3D map before and after mining);
2. I have inserted graphs, tables, photos from the field that highlight the geomorphological changes both natural and those generated by mining activities;
3. Through field trips, in addition to observations, measurements, photographic processing, we discussed with representatives of the local community about the recent and large landslides in Alunu, about the reactivation of some landslides in Berbeşti, about the social situation of the area (closing of quarries, migration) the young population abroad, the awkward attraction of European funds for beekeeping, about the ecological restoration of the area and accessing European funds for tourism projects;
4. I have characterized the environmental factors in order to identify and evaluate the impact of the geomorphological changes in the Berbeşti Mining Basin on the environment, in order to highlight the relationships between components;

5. I presented the methods of identifying the impact through the checklists and the impact networks regarding the geomorphological changes in the Berbești Mining Basin on the landscape, soil, water, climate, ecosystems, community;
6. I have created impact matrices for evaluating the impact of geomorphological changes;
7. I have presented the importance of the recovery and rehabilitation of the degraded lands, the national and international policies and strategies regarding the recovery and restoration of the lands, as well as the legislative framework in Romania aligned with the EU legislation;
8. In choosing the variant of reuse of the lands affected by geomorphological changes we used tools suitable for this purpose (questionnaire, online survey, WRAM matrix);
9. I selected and analyzed the types of recovery and restoration in the economic and natural circuit of the lands affected by the geomorphological changes generated by the mining activities (environmental recovery, naturalistic, recreational, productive, residential, cultural recovery, for controlled waste deposits);
10. I made GIS thematic maps with Panga area (map of land use, map of the types of tourism practiced in Panga career after arrangement);
11. I performed an Arhicad simulation on reducing / eliminating the impact in the area Berbești also in the Panga quarry and the ecological arrangement of the area, by designing and designing a complex plan for the tourist development of the Panga quarry after closure and greening ;
12. I presented the stages of career development for ecological rehabilitation and analyzed the conditions of stability of the career slope;
13. I made a 3D modeling of the surface of the Panga quarry, using the Civil 3D software, as well as designing the land remodeling works using the Civil 3D Grading (leveling) method;
14. I approached the subject of transdisciplinary rehabilitation and reuse of degraded lands;
15. I consulted, selected, interpreted specialized bibliography in the country and abroad.
The doctoral thesis is a topical scientific challenge, emphasized being the variants of ecological rehabilitation of the lands degraded by the mining activities for the studied subject but, also, for future developments of the innovative research in the field.