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DOCTORAL THESIS

Summary

RESEARCH REGARDING THE IMPACT OVER THE ENVIRONMENT OF CLOSING VALEA JIULUI MINES

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CONTENT

Synthesis of the doctoral thesis

In recent years, Valea Jiului has gone through an extensive industrial restructuring, through the operational closure of most mines, which led to the loss of jobs, generated economic-social and environmental effects, which seriously affected the quality of life of the inhabitants communities in this area.

The doctoral thesis entitled ***Research regarding the impact over the environment of closing Valea Jiului mines,*** structured in nine chapters, addresses the consequences of the closure of the mines in Valea Jiului from the point of view of the effects generated by the cessation of mining activities on the stability and protection of the environment.

In the **Introduction,** the author establishes the demarcation line between the transition from mining at its peak in Valea Jiului to its decline, in order to highlight the negative impact of mining activities in this area on the environment. She believes that the closure is not yet relevant for Valea Jiului, because in 2022 two mines are still active (Livezeni and Vulcan) and two are in the process of closure.

In this doctoral work, the year 2010 was taken, against which all comparisons will be made (before and after closure) regarding the impact of mining on the environment in the Jiu Valley.

The purpose, objectives and research methods that were the basis of his approach to highlight the impact of mining in Valea Jiului on the environment are shown.

Chapter 1 ***General data on Valea Jiului*** presents the region's geography, hydrography and hydrogeology, climate, flora and fauna, as well as the geological-mining characteristics of the coal deposit. The Valea Jiului is an intramontane region, surrounded by the Retezat-Godeanu mountain group, part of the Southern Carpathians. The climate of Valea Jiului basin has a depressive character subject to thermal inversions and atmospheric calm. The difference in altitude to which is added the presence of calcareous rocks leads to the vertical differentiation of the vegetal carpet.

Chapter 2 ***The analysis of the mining activity in Valea Jiului*** makes a brief foray through the mining history of Valea Jiului, taking into account two major stages in its evolution, stages separated by a milestone: the restructuring of mining starting in 1997.

In the first stage, 1848-1997, mining in Valea Jiului has a continuous ascent (with some syncope) reaching its peak in the 80s, so that in 1989, 15 mining operations were operating in Valea Jiului, which exploited 11 million tons of coal with a volume of 1,500,000 m^3 of tailings, and the underground mining works (shafts, galleries, inclined planes, shafts, preparation works, investment works, aeration works and abatements), totaled thousands of kilometers. The staff employed in the 15 exploitations was approx. 55,000 people.

After 1989, when the situation created required the support of the mining sector by the state with a great budgetary effort, the unstoppable decline of mining in Valea Jiului began.

The thesis highlights some essential milestones in its regression, caused in particular by the so-called restructuring programs (especially those from the period 1997÷2000): massive layoffs, high expenses with compensatory payments, high production costs, drastic decrease in investments, which gradually led to the closure of mines, from 15 in 1989 to 4 in 2016 and to 2 in 2022.

Next, a brief presentation was made of the 17 exploitation perimeters into which Valea Jiului mining basin was divided and of the 5 preparation plants that operated here.

In the last part of the chapter, some benchmarks are presented regarding the advanced mining technologies applied in underground mines and the restructuring programs developed for Romanian mining and implicitly for the one in Valea Jiului. A SWOT analysis of mining in Valea Jiului is made and *the Mining Industry Strategy for the period 2017-2035* is presented with reference to Valea Jiului, noting that after 5 years from the launch of this *Strategy,* almost all the objectives/measures/actions have not started and from the analysis of the realities on the ground, there are no intentions to materialize them either.

It is considered that the implementation of the Strategy is an abandonment, but also a failure, both attributes having their share of blame.

Chapter 3 ***The closing of the mines in Valea Jiului*** analyzes the legal and institutional framework regarding the closing of mines, the criteria that were the basis of these closings (economic, integrative and of the points), the procedures for closing a mine, the methods and technologies of closing a mine.

Based on the criteria, an assessment of the mines is made and the decisions taken at different stages regarding the closure of the mines are presented.

When the state subsidies stopped, in 2011, 7 mines were in operation in Valea Jiului (Lonea, Petrila, Livezeni, Vulcan, Paroșeni, Lupeni and Uricani), and in 2015 only 4 remained (Lonea, Livezeni, Vulcan and Lupeni) and these with an uncertain status in 2017. They are given a short presentation.

At the end of the chapter, an analysis is made of how the closure of the mines in the Valea Jiului was carried out based on Activity Closure Plans (PIA) and Technical Projects (PT).

The author of the doctoral thesis, analyzing how these documents are drawn up, but also how they were carried out on the ground, came to the conclusion that a complete analysis, at this time, of the state of the mining perimeters in Valea Jiului which have closed or which are in the process of conservation-closing is difficult to achieve for several reasons presented in the paper. However, an analysis of the underground structure of the Jiu Valley mines can anticipate the occurrence of some post-closure phenomena caused by a series of factors with synergistic action.

Chapter 4 ***Research on air quality in Valea Jiului*** includes, at the beginning, general considerations regarding pollution sources (mining, the Paroșeni thermal power plant, road transport, agriculture and animal husbandry, construction, tourism, etc.), air quality indicators and indices, the methods for determining air quality and the equipment for measuring this quality.

Next, a detailed analysis of the air quality in Valea Jiului before and after the closure of the mines is made.

Based on the *Air Quality Index (AQI)* in the period 1976-2010 (before the closing of the mines) Valea Jiului was in the orange zone (AQI= 128), which meant an unsatisfactory air quality, a relatively high level of pollution with effects moderate impacts on the health of people, ecosystems and materials.

After 2010, for example in 2020, the air quality in Valea Jiului was good (AQI = 22) with a very low pollution level and no effects on human health, ecosystems and materials. In these analyses, the author participated directly, from the collection of samples, the performance of the analyzes and the interpretation of the results.

From the analysis of the air quality in Valea Jiului from the two stages of mining in this area, it is found that it has improved as a result of the restructuring (closures) in the mining sector and in the adjacent sectors, their direct effect, consisting in the reduction of exploitation activities and coal preparation, construction of mining machines and equipment, considered to have a major, negative impact on the environment.

Chapter 5 ***Water quality research in Valea Jiului***, at the beginning, highlights the sources of pollution (mining, agriculture and animal husbandry, construction, tourism etc.), presents the methods for determining water quality, the equipment for water quality analysis/monitoring and specifies the water sources to be analyzed (river water, waste water and meteoric water).

Next, a detailed analysis of the air quality in the Jiu Valley before and after the closure of the mines is made.

For the period before the closure, based on studies carried out by various researchers and institutions, the author presents (and graphs) the average annual values of suspensions, organic substances (CBO_5), nitrites (NO_2) and ammonium (NH_4^+) established after of the measurements carried out in the period 2001-2003 along the Jiu river, on the two branches, up to their confluence, as well as on its course between the confluence point and the municipality of Târgu -Jiu.

The general conclusion that the author draws, regarding *the water quality in Valea Jiului before the closure of the mines*, is that the main polluters of the surface water were the mining and processing units that discharged waste water into the Jiu River.

In order to establish the quality of the waters of Valea Jiului in the period after the closure, the author had the opportunity to consult several works, but also to be directly involved in highlighting the degree of surface water pollution in this area, reaching the conclusion (argued in the thesis) that with the restructuring of the mining sector an improvement in the water quality of the Jiu is observed, mainly through the considerable decrease of mineral suspensions, and it is proposed to continue monitoring the water quality in Valea Jiului.

Chapter 6 ***Research on the quality of the soil and land related to the mining perimeters in Valea Jiului*** deals, paying special attention, to the sources that lead to the degradation of the soil and land in this region, as these are the components of the environment that are most affected by mining activities.

In this chapter, there was no analysis of the quality of the soil and the lands related to the mining perimeters in Valea Jiului in the two stages of existence of mining in this area (before and after closure), because it was considered that their pollution sources (soil/ land) have existed and

continue to exist throughout the *lifetime* (and beyond) of mining in Valea Jiului, the effects produced manifesting themselves more prominently now that mining activities have ceased.

Three sources of pollution are analyzed: tailings deposits, mining premises and constructions, and mining and chemically polluting soil preparation activities.

In relation to *tailings deposits* (mining, preparation dumps, slag deposits and abandoned quarries), which have undesirable repercussions on the land surface, the author presents them in detail and notes that, in Valea Jiului, they occupy a small area (0.39 %) of the area corresponding to the economic field of Jiu Valley.

The land surfaces in Valea Jiului that are/were occupied by *mining precincts and related constructions*, directly or indirectly related to mining in this area, show that around 1900ha (1.84% of the area of Valea Jiului) were affected by these activities, surface which, at a first estimate, would not be relevant, but the objectives, mostly inactive, on these lands leave a landscape and visual aspect much more significant than their extent.

In addition to the physical degradation processes, in Valea Jiului there are also processes of *chemical degradation* of the land, through *pollution with heavy metals* (in the areas occupied by tailings deposits and in the mining premises), with *sedimentable powders* transported from the dumps or *other pollutants* (e.g. SO_2). The thesis presents the results of the laboratory analyses, carried out in the chemistry laboratories of the University of Petroșani and the environmental laboratory of CNH Petroșani, of the soil samples collected both from the mining premises and neighboring areas, as well as from the tailings dumps on duration of several years (2010-2020).

From these analyses, it can be observed that there are no exceedances of the concentrations of chemical elements (except barium, chromium and vanadium) compared to those established within the norms for less sensitive uses.

The presence of certain elements, both in the composition of the soil and in that of the waste heaps in concentrations close in value, leads to the conclusion that there is no contamination of the soil caused by the chemical composition of the waste materials stored in the heaps.

Chapter 7 ***The influence of underground exploitation on the stability of the lands on the surface of the mines in Valea Jiului*** makes an analysis of the subsidence phenomena that appeared in the mining perimeters of Valea Jiului, emphasizing the effects produced by underground exploitation on the objectives on the surface, without detail the methods of tracking subsidence phenomena applied and known in the specialized literature.

Taking into account the complex and long-lasting nature of the processes regarding the deformation of the land surface under the influence of underground mining in the case of mines in Valea Jiului Mining Basin, the paper briefly presents the research carried out, over many years, in eight perimeters using the highlighted results in numerous studies and doctoral theses developed to study the phenomenon of subsidence.

Thus, at *the Lonea mine*, the displacements and deformations of the land as a result of the exploitation of seams 3 and 5 produced cracks, fissures and even cracks on the surface of the land, and cracks and crevices in the buildings.

At *the Petrila mine*, the surface subsidence is somewhat reduced, being 1032mm. This is due to the fact that, for the most part, the exploited space has been totally backfilled.

At *the Dâlja mine*, the maximum measured subsidence was 3814mm, caused by the method of exploiting several successive slices and several cuttings, but also by the high inclination (700) of seam 3, which would explain the contribution of some secondary phenomena to the development of subsidence, such as rock sliding, both from the roof and from the bedding of this seam.

At *the Livezeni mine*, the measured sinking bed is a composite bed, resulting from the exploitation of three coal faces. This sinkhole has an irregular (somewhat sinusoidal) shape because the four individual sinkholes (of each mined area) intersect, but also because the tracking station was located at the edge of the mined areas, an area where transverse deviations are maximum (924mm).

At *the Paroșeni mine,* the maximum submergence of the surface was 1638mm (in May 2015).

At *the Vulcan mine*, the phenomenon of displacement of the land surface is in the active phase, the exploitation being finished.

Both continuous and discontinuous subsidence phenomena were analyzed at *the Lupeni mine*. As for the continuous subsidence, it manifested itself by affecting some buildings even to the point of their destruction, and the discontinuous subsidence manifested itself by the appearance of sinkholes/pits determined by the overlap of three causes: the average exploitation depth (242-275m), the mining method in inclined slices with high-height undermined coal bank (15-35m) and the presence of normal faults near the mining panels, which led to the concentration of stresses on the corners of the pillars between the panels.

At *the Uricani mine*, the maximum dip measured was 170mm.

An important cause that led to the occurrence of subsidence phenomena in Valea Jiului was the exploitation of some safety pillars left in the exploitation perimeters to protect the objectives located in these perimeters.

Their exploitation led to the decommissioning of some industrial and civil constructions, the evacuation of the population from some perimeters being necessary, the destruction of some communication routes, led/leads to the drying up of some wells, the appearance of new springs and the accumulation of rainwater in the affected areas (e.g.in the Lupeni mining field, the total area of water accumulations is 2ha). The lands are removed from the economic circuit, no longer being suitable for the location of constructions or for agricultural crops, because the underground exploitations also cause the loosening of the rocks from the roof of the mining works, which has the main effect of the infiltration of water from the surface and the lowering of the hydrostatic level of the water table. The disappearance of fauna and flora in the affected areas was also reported. They were also affected approx. 70 individual peasant households, some blocks of flats in Petrila and a whole micro neighborhood of private houses in Lupeni were evacuated and demolished. Within the Livezeni mining field, several buildings in the area of influence and the access road to the Maleia valley were affected by cracking. In the Lupeni mining perimeter, following the exploitation of the Lupeni Sud mine (started in 1980), a continuous sinking was evident on the surface of the land, the affected area having a width of 50m and a length of 1km. As a result of the accumulation of rainwater, the mine became unsuitable and was closed in 1997. The access road to the Victoria quarry was also affected, and the exploitation of the safety pillar in the urban perimeter caused the degradation of 80 houses, which were expropriated and demolished.

The total area of extra-village lands affected by underground mining in Valea Jiului is 29.1ha, which were initially used as hay fields (19.2ha), pastures (8.4ha) and arable land (1.5ha).

Chapter 8 ***The comparative analysis of the impact of the mines in Valea Jiului on the environment before and after their closure***, at the beginning, makes some clarifications regarding the title of the thesis which, at first analysis, could be considered without substance, because it is known that the cessation of an anthropic activity, any it would lead to the elimination of environmental pollution.

So, the research/analysis of *the effects on the environment*, ***produced by the closing of the mines,*** could be summed up in a simple, but documented answer: yes, they are positive, indisputable.

In general, in the case of all stopped anthropogenic activities, *residual negative effects* more or less, over a certain period of time, depending on the self-purification/self-regulation capacity of the environmental components and the speed with which the rightful ones act to remedy these effects.

The ecological effects produced by the closure of mines are much more complex and call for a careful approach through, in most cases, long-term monitoring.

Underground, in the spaces affected by mining, abandoned after closure, physical-mechanical and chemical processes can occur, which are no longer controlled by humans and which, over time, can amplify and transmit to the surface.

Next, the impact of the closure of the mines in Valea Jiului on the quality of the surrounding environment (air, water, soil/land) is presented, comparing the results obtained from the analyzes carried out in the two stages (before and after the closure of the mines).

In the last 10-12 years, the closure of the majority of mines in Valea Jiului and the upgrading of some major sources of pollution (e.g. the Coroiești preparation), have contributed to an important

extent to reducing the impact of extractive activities on the environment (e.g. the significant decrease in the concentration of suspensions solids in the waters of the Jiu).

Among the environmental changes, land degradation currently has the most important consequences for human settlements and economic activities, especially through induced subsidence processes and the presence of tailings deposits with reduced stability.

The author of this thesis proposes her own method for establishing a Global Land Degradation Index (GLDI) affected by mining activities in a mining perimeter (mine) taking into account the entire analyzed area (in our case Valea Jiului) and makes a classification (in three houses) of this index. The calculation of the land degradation index caused by mining activities highlighted the fact that the most affected are the mining perimeters in the center and east of Valea Jiului, respectively Lupeni, Vulcan and Lonea, which also extend into the suburbs of Petrila settlements (Lonea colony, Cimpa), Jieț, Vulcan (north), Lupeni (east and north).

The chapter ends with the presentation of actions for the ecological reconstruction of the lands degraded by mining activities which, until now, had the purpose of covering them with vegetable soil, leveling and planting vegetation on the tailings deposits, ensuring the stability of the dumps and creating some lakes in the space of the former careers. An aspect that requires special attention is ensuring cooperation between the institutions that carry out the greening works, situations have been reported in which incorrectly carried out or unfinished works have endangered human settlements and economic objectives (e.g. the flooding of the Ștefan and Carolina neighborhoods in the municipality of Lupeni).

Chapter 9 ***General conclusions, personal contributions and recommendations*** summarizes what was presented in the other chapters, presents the author's personal contributions to the solution of the topic under study and ends with some recommendations addressed to those who are entitled to take care of the health of the environment in Valea Jiului.

The main contributions made by the author of the doctoral thesis consist of:

- Analysis of the mining evolution in Valea Jiului, paying more attention to its current situation;
- Analysis of the methods and procedures based on which decisions were taken to stop the activity of some mines;
- Analysis of the quality of the environment (air, water, soil/land) in two periods of existence of mining in Valea Jiului (before 2010 and after);
- Extensive documentation regarding the research carried out on environmental pollution in Valea Jiului before the start of the restructuring;
- Personal research on the quality of the environment in this area after 2010 (and as an employee of the Hunedoara County Environmental Protection Agency);
- Highlighting the impact produced by the closure of the mines on the environment with the residual ecological effects after this closure;
- Development of a method for evaluating the degree of land degradation by mining activities by proposing the use of a Global Land Degradation Index (GLDI).

Recommendation

- ✓ Reviewing some Activity Cessation Plans (PIA) and some Technical Projects for closing the mine and restoring the environment (PT), which proved to be inadequate for the situations in the field;
- ✓ More responsible controls on the part of the bodies empowered to verify how the conservation-closure and greening works of the land freed from construction were executed;
- ✓ Accelerating the process of greening the perimeters affected by mining activities;
- ✓ Diversification of ecological reconstruction solutions (not only covering with topsoil, leveling and planting vegetation) or natural vegetation.