UNDERGROUND MINING EXPLOAITATION INFLUENCE ON THE SUSTENABLE DEVELOPMENT OF JIU VALLEY MICROREGION

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Abstract: *The areas affected by the mining exploitations are mono-industrial and the appearance of potential directions for developing them are very linked to the results of the influence of these mining exploitations over the environment. The effects of the underground mining exploitations are the displacement and deformation of the terrain around the exploitation. To study the influence of this underground exploitation over the area is necessary for putting into evidence the phenomenon of displacement and taking the measures for protecting the objectives executed on the surface and the surface itself. So, the development of the infrastructure, the tourism, services, the implementation of different projects in order to have a sustainable development of Petrosani town must be made by analyzing very carefully the phenomenon of displacement and deformation of the terrestrial area under the influence of the underground exploitation. The Jiu Valley area that is intensely and forced industrialized, recorded during the last 40 years an excessively a port of population with different behaviors and customs is reflected into the social and economical situation of the county. This area contains 3 big towns: Petrosani, Vulcan and Lupeni, 3 small towns (Petrila, Aninoasa and Uricani) and only one big village, Banita, which contains three small villages. Into the context of a sustainable development of Jiu Valley in general and of Petrosani in particular we must take into account of many factors. One of the most important factors that influence the process of development is constituted in the subsidence phenomenon in Maleia - Livezeni are, which has a very high tourist potential and also into the other areas of Jiu Valley mining basin. The protection of the industrial, social and natural objectives from the surface of mining perimeter is made by dimensioning the safety (protection) pillars. In many cases it is put the problem to valor the reserves of useful mineral substance set into these safety pillars so putting into exploitation and introducing them into the economical circuit. In this situation there are made different studies in order to know the displacements and deformations of the terrains under the influence of mining exploitation of a rock situated under certain geological and mining and exploitation conditions.*

Key words: *Sustainable development, Jiu Valley, deformation, underground mining exploitations*

INTRODUCTION

The areas affected by the mining exploitations are mono-industrial and the appearance of potential directions for developing them are very linked to the results of the influence of these mining exploitations over the environment. The effects of the underground mining exploitations are the displacement and deformation of the terrain around the exploitation. To study the influence of this underground exploitation over the area is necessary for putting into evidence the phenomenon of displacement and taking the measures for protecting the objectives executed on the surface and the surface itself. So, the development of the infrastructure, the tourism, services, the implementation of different projects in order to have a sustainable development of Petrosani town must be made by analyzing very carefully the phenomenon of displacement and deformation of the terrestrial area under the influence of the underground exploitation.

MATERIAL AND METHODS

THE PRESENTATION OF JIU VALLEY MINING BASIN

Being situated along the Carpathians Mountains, which are a third of Romania, the Jiu Valley represents the gate to national park Retezat. Situated in the south of Hunedoara County and the south-west of Transylvania, in a depression of Meridional Carpathians, Petrosani depression called Jiu Valley is situated along the two Jiu Rivers (western and eastern Jiu).

Figure 1. Topography of Petrosani mining basin seen from the satellites

The coal basin of Jiu Valley (fig. 2) was divided in 16 mining perimeters: Lonea, Lonea Pilier, Petrila, Petrila Sud, Dâlja, Livezeni, Sălătruc, Iscroni, Aninoasa, Vulcan, Paroşeni, Lupeni, Bărbăteni, Uricani, Valea de Brazi and Câmpu lui Neag, from which 15 had mining activity (excepting Sălătruc).

THE SUSTAINABLE DEVELOPMENT OF JIU VALLEY MINING BASIN

The vision for a sustainable development is as follows:

The vision for many communities in Jiu Valley is to have healthy and sure models of sustainability. The vision of sustainability includes the management/hosting, infrastructure and services, including the utility of potable water comparable with the ones of size and function similar in European Union. Into a protected environment they will have an efficient transport and links of communication with the rest of the country and the resources of clean energy that is available. The community members will have opportunities acceptable for education, will take part to the economic process and will be able to imply into local government.

The process of sustainable development is a very complex one and must imply the analyze of all economical, social and environmental factors.

Into the followings we analyzed the most important factors that influence the process of sustainable development of Petrosani.

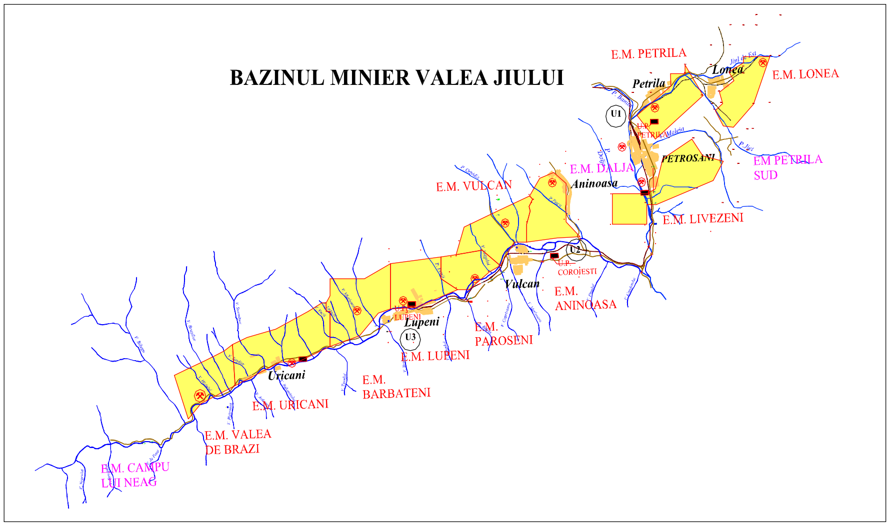


Figure 2. Map of mining parameters from Jiu Valley mining basin

RESULTS AND DISCUSSIONS

***THE INFLUENCE OF THE PHENOMENON OF SUBSIDENCE OVER THE* SUSTAINABLE DEVELOPMENT OVER PETROSANI**

Into the context of a sustainable development of Jiu Valley in general and of Petrosani in particular we must take into account of many factors. One of the most important factors that influence the process of development is constituted in the subsidence phenomenon in Maleia - Livezeni are, which has a very high tourist potential and also into the other areas of Jiu Valley mining basin.

The protection of the industrial, social and natural objectives from the surface of mining perimeter is made by dimensioning the safety (protection) pillars. In many cases it is put the problem to valor the reserves of useful mineral substance set into these safety pillars so putting into exploitation and introducing them into the economical circuit. In this situation there are made different studies in order to know the displacements and deformations of the terrains under the influence of mining exploitation of a rock situated under certain geological and mining and exploitation conditions.

To determine the values of the displacement and deformation parameters is made by using direct and indirect measurements that are grouped into the following methods:

- Geodesic measures;
- Topographical measures;
- Photogrammetric measures.

To study the displacement phenomenon is made by using the data obtained over the displacement of a group of points from the field that are displaced together with the terrain in movement. The marks that materialize the points in movement are called *working marks* and the stable marks are called *supporting marks*. All the working and supporting marks that are used for supervising the displacement of the ricks constitute a *station for observation the displacements.*

The displacement of the points is observed by topographical periodic measurements for determining their successive positions.

So it was determined the heights of points from the surveying station. Their schedule is as follows:

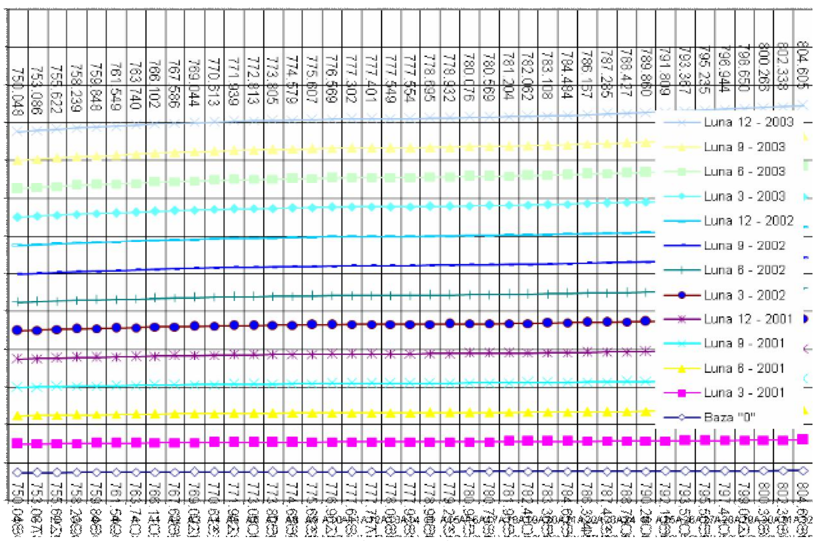


Figure 3.Skedule of heights for surveying points

The deformation and displacement parameters are as follows:

- ***Surface sinking (S_i)***

It represents the decrease of the level of area in report with the initial level of the same area with the relation: $\mathbf{S_i = H_i^* - H_i}$ [mm]

where: H_i^* = height of the mark from zero measurement; H_i = present height of current mark.

- ***Surface declination (I_i)***

It represents the declination of an area – part between two surveying points – from the surface over the initial position. It is determined with the report between the differences of the sinking of two consecutive marks of observations and the horizontal distance between them as follows:

$$I_i = \frac{S_{i+1} - S_i}{d_{i,i+1}} \quad \text{[mm/m]}$$

where : S_i = sinking of current mark; S_{i+1} = sinking of next mark; $d_{i,i+1}$ = horizontal distance between the two marks.

- ***Horizontal displacement (D^*_i)***

It represents the horizontal component of the displacement vectors of the points. It is the displacement in horizontal plan of a point situated into an area under exploitation influence.

It is determined with the difference between the current distance and the same distance measured initially as follows:

$$\mathbf{D^*_i = D_{i,i+1} - D_{0i,i+1}}$$

where: $D_{i,i+1}$ = horizontal distance between the two marks at current measurement $D_{0i,i+1}$= horizontal distance between the same marks at zero measurement.

- ***Horizontal deformation (ε_i)***

It is defined as longing (+) or shorting/compression (-) of a distance between two observation marks when the deformation is positive or negative. There are in fact the longings and compressions along the observation part and they are calculated as follows:

$$\varepsilon_i = \frac{D^*_i}{D_0}$$

where: D^*_i = horizontal displacement; D_0 = initial horizontal displacement.

- ***Curving ray* (R)**

The curving ray (R) is determined by the sucession in time of the deformations:

$$R_i = \frac{d_{i-1,i+1}}{\Delta I_i}$$

- ***Surface curve* (C)**

It is inverse over the curving ray and it is defined as a limit of the report between the convergence angle of the tangents into in neighborhood points and the distance between them.

$$C_i = \frac{1}{R_i}\left[km^{-1}\right]$$

The parameters that influence the phenomenon of displacement and deformation were calculated depending on many measurements at different intervals of time, which will be made also in the future.

Table 1

Determination of displacement and deformation parameters

Pct.	**S_i** [mm]	**S_{i+1}-S_i** [mm]	**I_i** [mm/m]	**D_{i+1} –I_i**	**$D_{i, i+2}$**	**R_{i+1}** [m/mm]	**C_{i+}**	**D_i** [mm]	**ε_i**
A	0	+10	0,373204	-0,517137	47,638	-92,118	-0,010855	118	+4,4038
1	+10	-3	-0,14933	0,585283	41,235	70,453	0,014938	-263	-11,3227
2	+7	+9	0,44135	-0,76363	39,200	-51,554	0,01939	-18	-0,8826
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮

These parameters were represented into the figure 4 resulting that the phenomenon of subsidence is active and it need to be monitories in order to be protected the environment.

The 3D visualization (figure 5) is a preferred way for visualizing in order to understand the present terrain of any area. This can be made by using techniques that use frame methods or by transforming the 3D representation into 2D one. In order to be more real the image based on information it is added the primitive value. This way of map helps us to increase the visual model and to have a live detail.

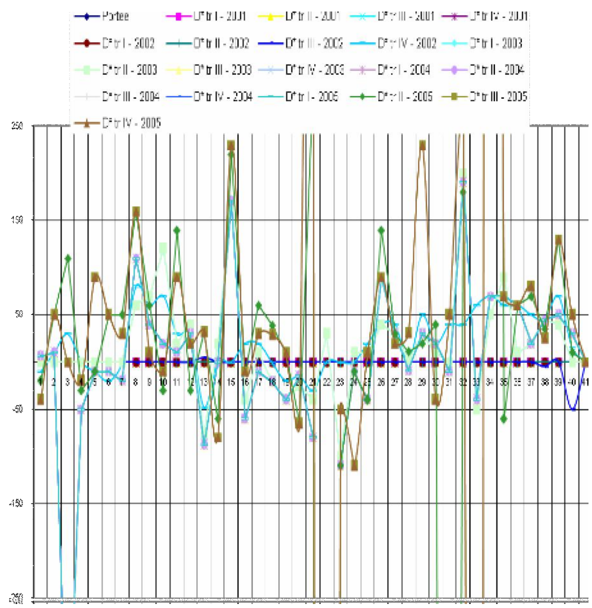


Figure 4 Schedule of parameters that influence the subsidence phenomenon

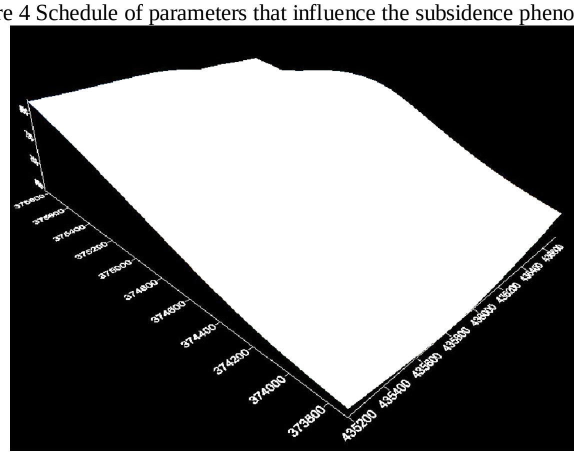


Figure 5. 3D Model for Jiu Valley mining basin and Livezeni mining perimeter

SURVEYING THE STABILITY OF THE TERRAINS AND CONSTRUCTIONS FROM THE SURFACE

After the underground mining exploitation, at the surface it may appear some types of degradations of the terrains and constructions:

- Degradation of the pavages and constructions base
- Horizontal and vertical displacements in report with construction terrain;
- Breakings into the terrain;
- Breakings into construction faces;
- Breakings into portant and non-portant walls.

In order to consolidate the constructions there may be applied different solutions that can be made individuals and in group depending on the degree of construction degradation.

In order to be able to protect the objectives from the surface and also a series of mining workings situated into the covering rocks it is necessary to leave parts of unexploited rock under these called safety pillars. To protect the exploited area with safety pillars (temporarily or definitively) represents one of the way for directing the mining pressure.

As definitively safety pillars there are also the pillars necessary for protecting the mine wells or other mining works and also the industrial, social and natural objectives over the mining perimeters (buildings, roads, railways, etc.).

The temporarily safety pillars called also floor pillars are let on, under or around the main preparation workings in order to support the face coal workings and also the preparation ones. The most used criteria for protecting the safety pillars is the *critic angle criteria* based on the relation between the declination angle of the pillar β and the specific admitted deformation ε_a , represented into the table 2 for four categories of objectives.

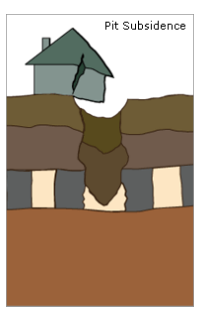
If the deformation is greater than 12 mm/m, the buildings cannot be used anymore because they have suffered walls breakings and other main destructions.

Table 2

Critic angle criteria for four categories of objectives

Category	**Admitted deformation $\varepsilon_{a,\ mm/m}$**	**Pillar angle β,°**	**Destruction characterization**	**Objective**
I	0,01-1,5	54	Invisible breakings	Wells, industrial objectives, roads, railways, bridges, hospitals, rivers, lakes
II	1,5-3,0	58	Visible breakings of 2-5 mm	Oil pipes, blocks with more than 2 floors, transforming stations, high tension lines, industrial structures and for agriculture
III	3,0-6,0	62	Open fractures of 10-20 mm	Secondary roads and railways, underground works, Airports
IV	6,0-12,0	66	Open fractures >10-20 mm	Temporary buildings, agriculture and forest terrains

The technical and mining measures that are imposed in order to protect the buildings foresee especially to be used different methods of exploitation of the useful mineral substance and using the safety pillars for protecting the objective from the surface (Figure 6)



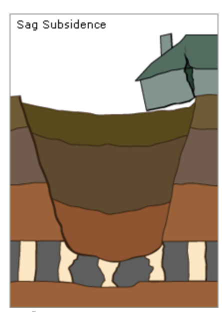


Figure 6 Exemples of degradations

STATISTIC ANALYZE OF THE SUBSIDENCE PHENOMENON INTO JIU VALLEY MINING BASIN

To make the calculation for foreseeing the subsidence phenomenon and dimensioning the safety pillars cannot be made without knowing the limit angles of sinking and the angles of maxim sinking. The size of the surface that is affected by the movement of whole rock over the size of exploited space is limited by planes that together with the horizontal one make some angles called sinking angles (β_s , γ_s , δ_s) breaking angles (β_r , γ_r , δ_r) depending on the height of exploitation, on nature and mechanical features of the rocks into the places where the breaking lines defined by the breaking angles come through the surface appear breaks (Figure 7).

The prognosis of the deformation and displacement phenomenon of the terrestrial surface was based on the values of the sinking angles (figure 8) that are between 60-70 grades.

From the observations made on the sinking it results that the rock and the surface suffer displacements and deformations, resulting compression and traction efforts. Among more important factors that influence the displacement and deformation process of the terrain we can mention as follows:

- Physical and mechanical features of covering rocks
- Rock tectonic
- Hydrological and geological conditions
- Declination and measure of exploitation layers
- Exploitation methods
- Method for directing the pressure of surrounding rocks
- Dimensions of exploited space
- Exploitation depth

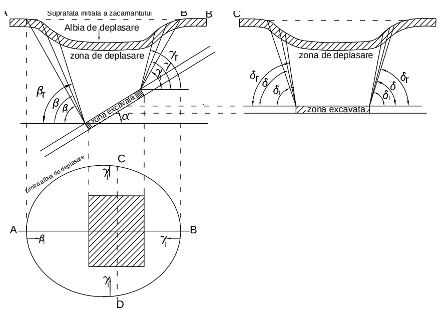


Figure 7 Sinking angles

CONCLUSIONS

The sustainable development of a mining area as Jiu Valley in general and Petrosani town in particular cannot be made without studying the influence of the underground exploitations over the environment and constructions from outside. These are the most important factors that influence this process. So it is necessary to b made a statistic analyze of this phenomenon and to miniaturize permanently the areas from the earth surface in order to protect them.

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