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USING GEOGRAPHIC INFORMATION SYSTEMS TO MONITOR THE AREAS AFFECTED BY MINING EXPLOITATION IN ORDER TO A SUSTAINABLE DEVELOPMENT OF THESE AREAS

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SUMMARY

Accomplishing a GIS involves research on underground geological structures, research on the exploitation of useful mineral deposits and their influence on land cover and the existing buildings on them, research on the stability of buildings affected by mines and also socio-economic analysis of these areas in order to a sustainable development and environmental protection.
Keywords: subsidence phenomenon; underground mining exploitation; surface; prognosis; GIS.

INTRODUCTION

Such studies are necessary in order to highlight and take corresponding measures regarding the protection of land and buildings from the surface thus reducing the subsidence damages caused by the movement of land surface and rock coverings over the environment and population in mining areas. Modern techniques and technologies currently used, such as satellite measurements or remote sensing, led to a significant increase in the accuracy of parameter calculations which describe the evolution and tracking of the subsidence phenomenon in time and prognosis of the influence of underground exploitation gaps from the mining basin on the land surface.

MATERIALS AND METHODS

For a certain point P(x, y, z) from the surface of a sinking area there are known the stages of this points as follows: ***INCIPIENT STAGE*** – where from the repaus the point will entering movement till it has the speed v_1; ***ACTIVE STAGE*** – where the sinking area may cross through all stages (sub critic -supercritical) and where we can anticipate a variation of the sinking speed around an average value; ***FINAL STAGE*** – where the sinking speed decreases continuously till stabilizing the terrain.

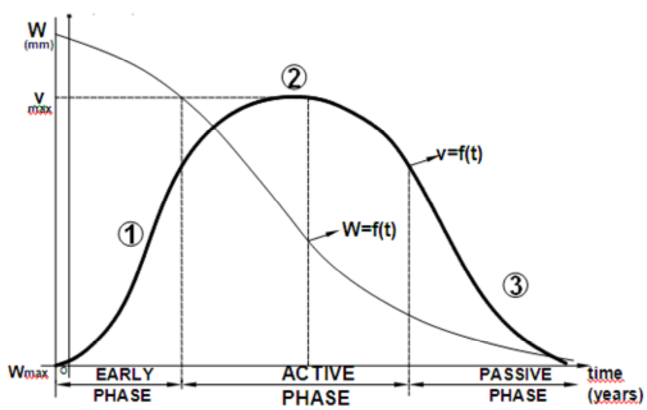

Figure 1. Evolution of W parameter and of sinking speed V

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.

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 2).

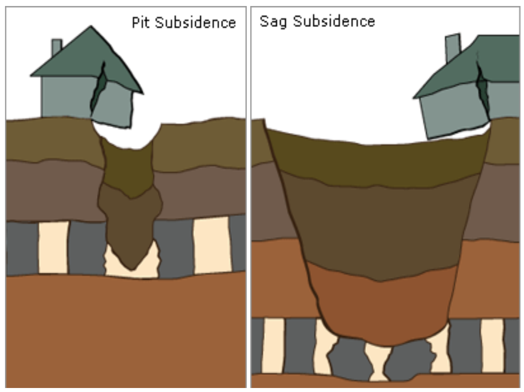

Figure 2. Examples of degradations

The phenomenon of displacement and deformation of earth surface has a great interest by its implications into the problems of environment protection and the protection of constructions existent at the ground. The researches made by present lead to establishing some links between the causes and effects of the displacement and deformation phenomenon establishing some prognosis of evolution on long and short term.

These prognoses are very important due to the fact that there can be made some future studies for a suitable development of the areas affected by the underground mining exploitations. The methods of approximating the curves that define the deformation and displacement phenomenon of the areas have been made after the observations made in long time in different mining areas. The monitoring phenomenon of displacing and deforming the areas is made permanently in active areas and also in conserved and closed mining areas because this phenomenon has a time development and the damages that can appear after the development can affect the surrounding environment and the existent constructions or the constructions that will be affected.

RESULTS

This research was made in Hunedoara County, Petrosani Mining Basin where it is

Livezeni Coal Mine.

The topographical alignments for surveying the displacements and deformations of the terrain from the surface contain the following types of landmarks:

Main linking landmarks – are the topographical points that are contained into the triangulation network of the mine. These points must be placed into stable areas and should exist during all period of the measurements;

Supporting landmarks (end marks) – are points that belong to each alignment being situated outside the areas influenced by the mines and constitute the beginning and the end of the surveying alignments;

Working landmarks (mobile marks) – are the marks located at certain distances, between the supporting marks;

The distance between the working marks is linked to the exploitation depth H so as follows: 5 m – for $H \leq 50$ m; 10 m – for H = 50 ÷ 100 m; 15 m – for H = 100 ÷ 200 m; 20 m – for H = 200 ÷ 300 m; 25 m – for H = 300 ÷ 400 m; 30 m – for $H \geq 400$ m.

There will be made simultaneous three stages of measurements: Measuring the vertical displacements; Measuring the longitudinal horizontal displacement; Measuring the transversal horizontal deviation.

Due to the fact that the sinking phenomenon is a dynamic one that will have three phases (starting phase, active phase and silence phase), the frequency of the measurements will be different in the three phases. During the extinction phenomenon, the measurements will be made at every 6 months. It is considered that the phenomenon is extinguished, so that after two consecutive measurements made at every 6 months, the vertical displacement has a value smaller than 1 mm. In the present the surveying of the displacement and deformation of the field from outside the mine under the influence of Livezeni Mine it is made by using a surveying station formed from 50 marks. The topographical observations have been executed at every 3 months starting with 2001. This surveying station (Figure 4) furnishes information regarding the displacement and deformation of the field surface.

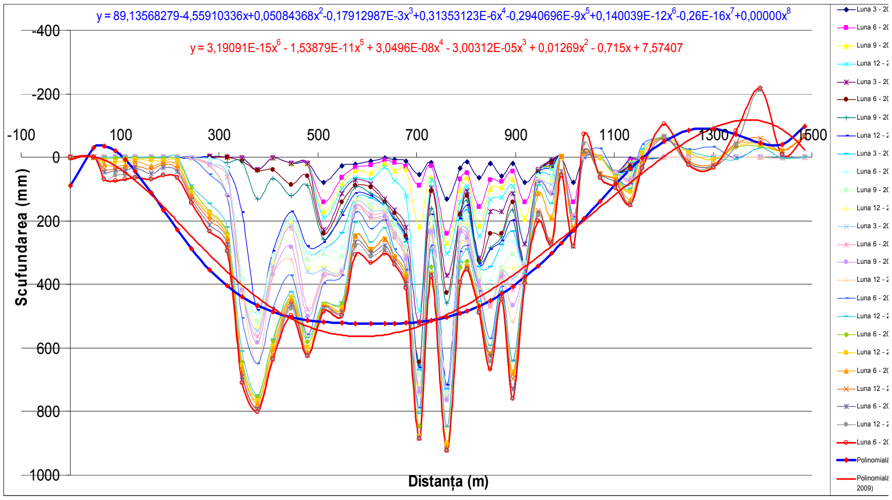

Figure 3. Profiles of the time sinking at Livezeni Mine

Figure 4, Example of landmarks

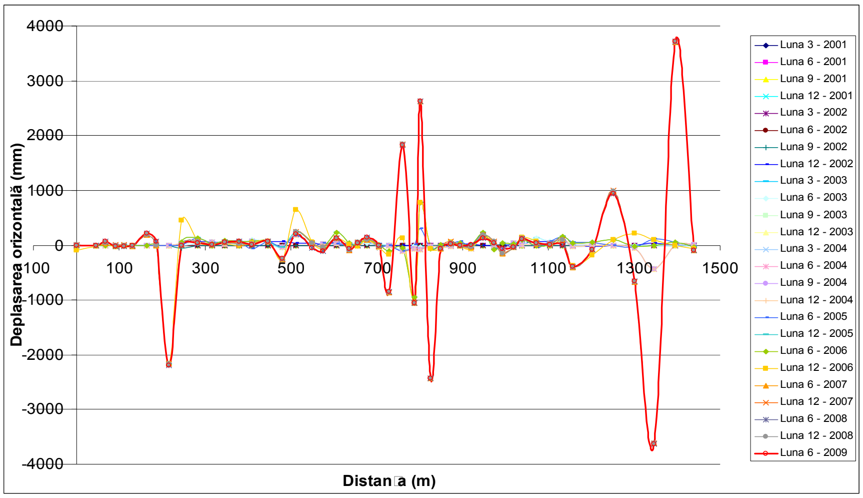

Figure 5. Profile of horizontal displacements in time at Livezeni Mine

The sinking bed from the fig. 6 is a composed bed, resulted after the exploitation of the 3 working fronts. This sinking bed has an unregulated shape (as a sinuous) due to the fact that the 3 individual sinking beds (of each space exploited in part) is intersected but also that the surveying station is placed at the margin of the exploited spaces, where the transversal deviations are at maximum.

Into Figure 6 it is represented the sinking measured into the Livezeni Station, resulting an apparent sinking bed (as an effect of field displacement). Into the Figure 7 it is represented a surveying station of the displacement and deformation of the surface, formed from a longitudinal profile L1-L1 and 2 transversal profiles T1-T1 and T2-T2 situated over the exploited space.

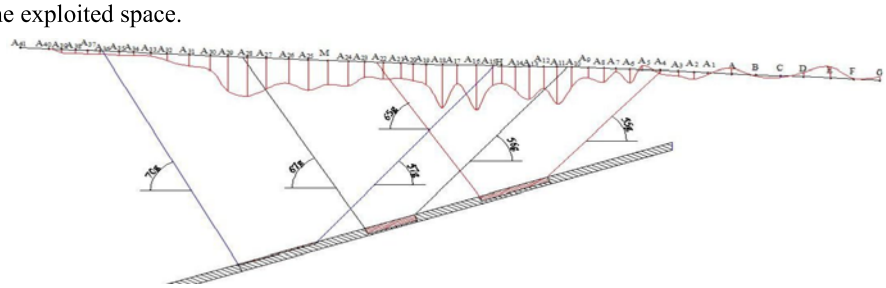

Figure 6. Representing of sinking bed

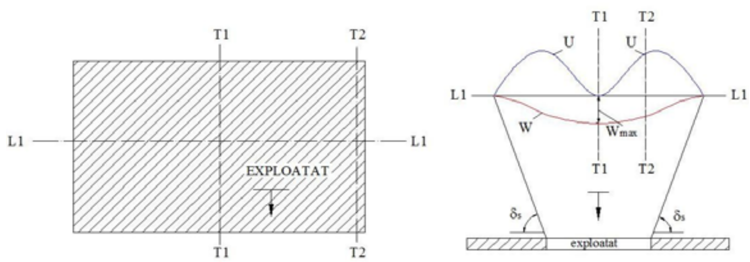

Figure 7. Representing a surveying station of the field displacement and deformation

From the above figure we can notice that the transversal profile T1-T1, situated into the center of exploited space, it is appear some transversal deviations that tend to zero and over the transversal profile T2-T2, situated at the margin of the exploited space, it action some transversal deviations that tend to maximum value. Even if the transversal deviations that act over this profile are approximate equal in all points situated inside the exploited space, the difference of leveling between the level of each point from the basic measurement and their level of final measurement is nor the same because the field level is different (Figure 8).

We consider that the points A and B that belong to a profile of surveying the displacement and deformation of the field there are three possibilities of calculation of a correction as follows:

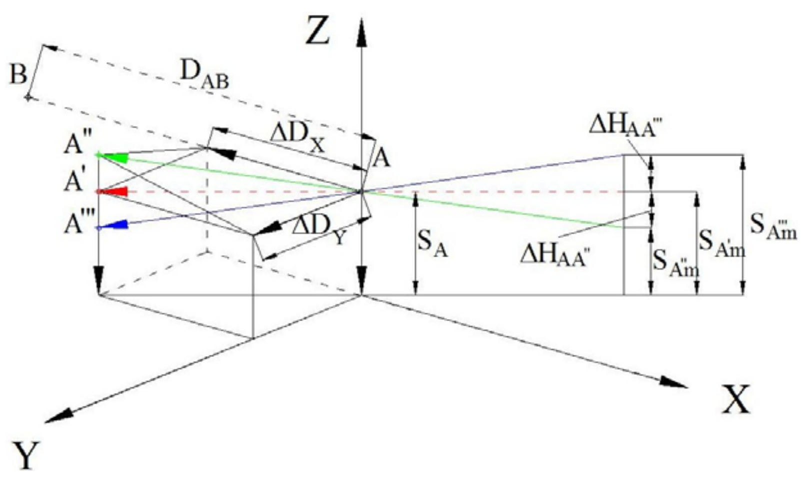

Figure 8. Displacement and sinking of point A

where: D_{AB} – distance between points A and B; ΔD_X – displacement after X axis (horizontal displacement); ΔD_Y – displacement after Y axis (transversal deviation); S_A – displacement after Z axis (real sinking of point A); $S_{A`m}$ – sinking measured into point A; $S_{A``m}$ – sinking measured into point A``; $S_{A```m}$ – sinking measured into point A```; $\Delta H_{AA``}$ - difference of initial leveling between point A and point A``; $\Delta H_{AA```}$ - difference of initial leveling between point A and point A```;

Because the displacement can be up to several meters we can consider that the displacement in point A is equal to the displacement in the location where it was displaced. (A`, A``, A```), meaning $S_A = S_{A`} = S_{A``} = S_{A```}$.

In **the first case**, point A having the height H_A has moved to location A` whose initial height is equal to the height of point A. In this case, there is no correction because the slope of the terrain is zero, meaning that the measured displacement is equal to the real displacement.

$$S_A = S_{A`m} \quad (1)$$

In **the second case**, point A having the height H_A has moved to location A``. In this case the measured displacement is smaller than the real displacement ($S_{A``m}<S_A$) resulting the need of a correction equal to the initial level difference between point A and point A``( $\Delta H_{AA``}$).

$$S_A = S_{A``m} + \Delta H_{AA``} \quad (2)$$

In the third case, point A having the height HA has moved to point A```, the measured displacement is bigger than the real displacement (SA```m>SA) resulting the need of a correction equal the initial level difference between location A and location A``` (ΔHAA```)

$$S_A = S_{A```m} - \Delta H_{AA```} \quad (3)$$

If the number of determination is low, present them in text. If there are many repetitive data, these can be given in tables or graphs, but present only representative determination and not variation on the same theme. For series of graphs that look alike, only one illustration will be enough, and for the reset, please describe the phenomenon in text.

DISCUSSION

The date acquired from the field correlated with the date acquired from analogical support has been correlated with spatial databases regarding the studied area using ArcGIS software. In the following figures are some examples of query analysis regarding the studied area.

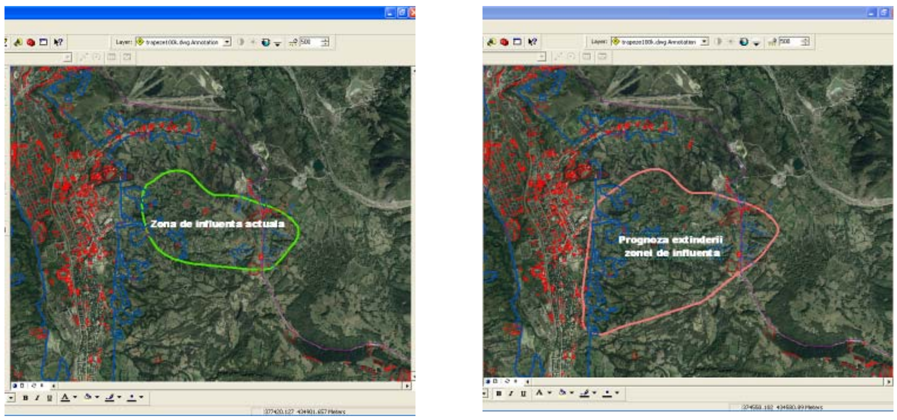

Figure 9. The actual influence area and the prognosis of future area of influence for the next 20 years - Petrosani mining area

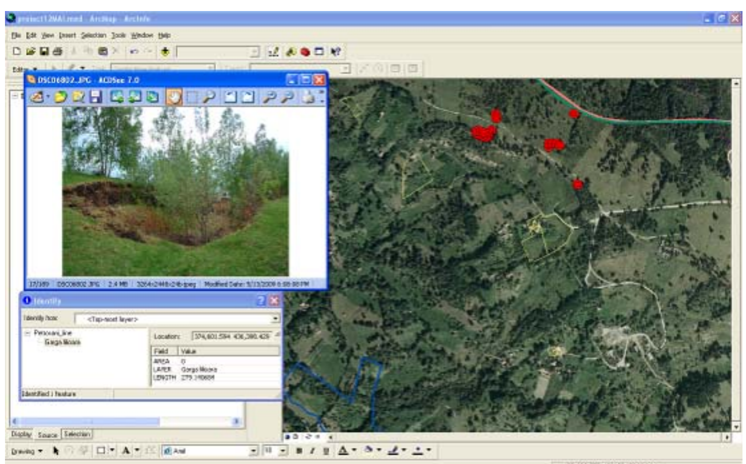

Figure 10. Marking and representing of the most affected areas

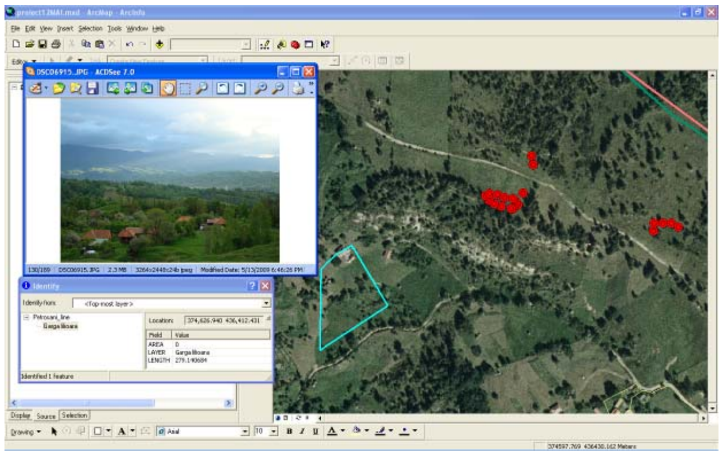

Figure 11. Visualizing of some affected properties

CONCLUSION

The digital map correlated to different databases offers the possibility to analyze the studied area, Petrosani area. The analyses are the base for the decisional process for making and implementing some feasible projects for developing the area from all points of view. This GIS of Petrosani can be applied in different areas affected by mining exploitation in Jiu Valley or any other mining areas in order to implement some project regarding their sustainable development.

REFERENCES

1. Dima N., Pădure, I., Herbei, O., "*Mining topography*", Corvin Publishing, Deva, 1996 p 410.
2. Herbei O., Herbei M., "*Geographic Information Systems. Theoretical and applications*", Universitas Press, Petroşani, 2010, p 216.
3. Herbei, O., "Determining the parameters of deforming the terrain surfaces and researching the constructions from the surface under the influence of underground exploitation for the mineral rocks", Doctorate thesis, University of Petrosani, 1995, p 220.