

## PERFORMING A G.I.S. IN THE AREAS AFFECTED BY THE UNDERGROUND MINING EXPLOITATIONS

Mihai Valentin HERBEI, Ph. D. Eng., mihai\_herbei@yahoo.com

Octavian HERBEI, Prof. Ph. D. Eng., University of Petrosani - Faculty of Mining

Roxana Claudia ULAR, Univ. Assist. Ph. D. student, Eng.

**Abstract:** In many life fields it appears more stringent the necessity that in a certain space, a certain region the analyze of some information should be linked to geographic environment. This group of duties needs to be performing spatially the information, which, due to the huge quantity of data to be managed is very great today without using the possibilities offered by the informatics. The result of this created the basis and contributed to the development of geographical information systems – G.I.S. The area affected by the mining exploitations are especially the mono-industrial areas that need a permanent monitoring and on long term in order to protect the environment for a sustainable development of them from all points of view.

### 1. Introduction

The purpose of this research is accomplishing a GIS in the city area of Petroșani, a system that allows visualization, examination, handling, exploring of different areas from the studied perimeter with the purpose of finding effective rehabilitation solutions or development of this area taking into account the real status from the field.

In order to accomplish a decisional informatics system for sustainable development of the areas affected by the underground mining exploitations in the case of Jiu Valley Mining Basin and in particular the city of Petroșani, the steps followed were the ones outlined below.

### 2. Implementing the GPS support network of the Jiu Valley Mining Basin

The network consists of 23 points (Fig. 1), 9 of which are old points and 14 are new points, support network which has been checked and compensated. This network has been executed for the entire Jiu Valley Basin also including the studied area.

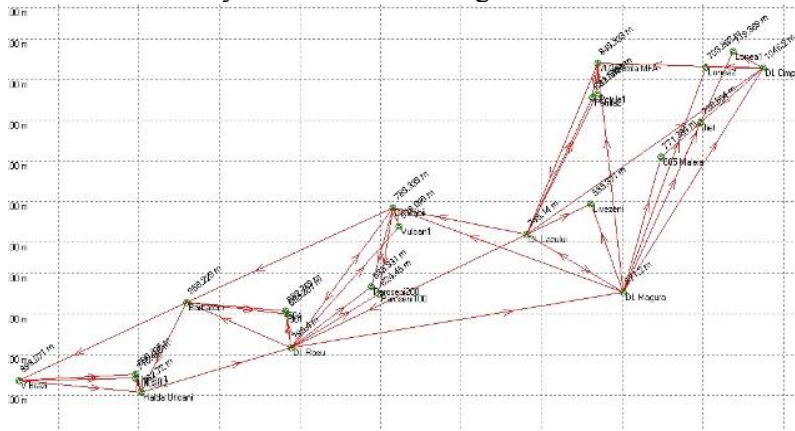


Fig.1. GPS Network of the Jiu Valley Mining Basin

### 3. Monitoring the subsidence phenomenon in the area of Petroșani City

The decisional process regarding the affected areas will take into account the parameters of the subsidence phenomenon, parameters which have to be obtained through surveying and then monitored permanently on a medium and long term. The parameters influencing the phenomenon of displacement and deformation of the land surface have been calculated taking into account several measurements performed at different time frames, measurements which will be continued also in the future. Studying the displacement phenomenon is based on the data obtained during the displacement of a group of points placed adequately in the field, in order for these to displace along with the surface of the land in motion.

The corresponding graph is the following :

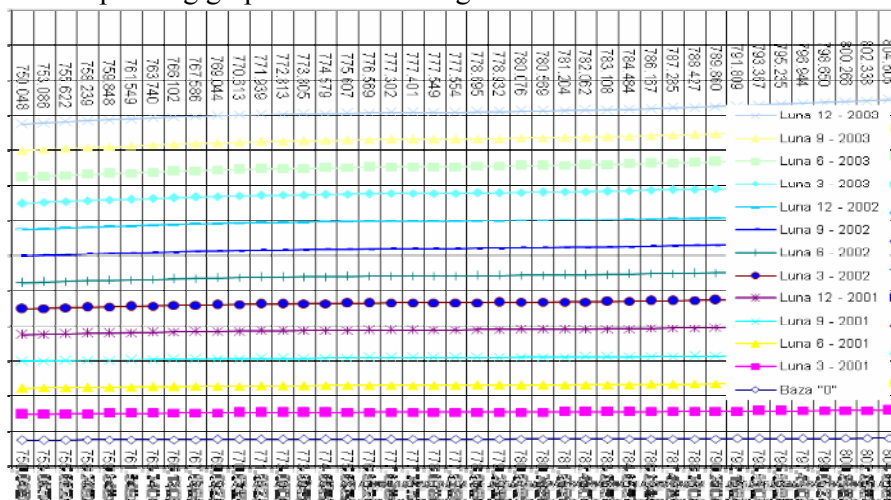


Fig. 2 Elevation graph of the traced points

After determining the final results it results that the subsidence process in the studied area is active and it must be motorizes in future.

#### 3.1. Adjusting the experimental data with the help of regression and correlation analysis

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:

1. **INCIPIENT STAGE** – where from the repaus the point will entering movement till it has the speed  $v_1$ ;
2. **ACTIVE STAGE** – where the sinking area may cross through all stages (sub critical -supercritical) and where we can anticipate a variation of the sinking speed around an average value;
3. **FINAL STAGE** – where the sinking speed decreases continuously till stabilizing the terrain.

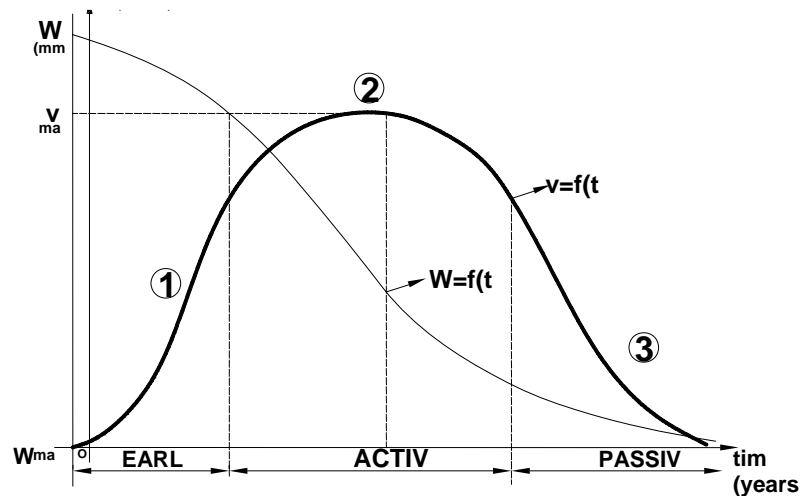


Fig. 3 Evolution of  $W$  parameter and of sinking speed  $V$

In correspondence with these stages of the point from the ground it will exist a topic behaviour of the sinking parameter  $W$ . As a value, from 0 – moment when the effect is not come yet, toll  $W_{ma}$  we can observe a continuously behaviour even if the fluctuations of speed are discontinuously from a year to another.

In order to obtain a good prognosis we must chose regression functions of the three areas of development. These functions must have different behaviours during the extrapolation period.

So, we looked for functions  $W(t)=f(t)$  that must have different behaviour at extrapolating the values.

- For the (1) are the tendency of decreasing the speeds to zero:

$$W(t) = a_1 \exp(-b_1 t) \quad \text{exponent}$$

where:  $a_1, b_1$ - coefficients determined by regression;  $t$  – time in months from the first measurements;  $W(t)$  – depended variable (sinking), [m].

- For the (2) are the constant tendency of the speeds around an average value:

$$W(t) = a_2 \exp(-b_2 t^2) \quad \text{squared exponent}$$

where:  $a_2, b_2$  – numeric coefficients;  $t$  – time (months);  $W(t)$  – sinking, [m].

- For the (3) area the increasing tendency of the speeds to a maximum value:

$$W(t) = a_3 t^3 + b_3 t^2 + c_3 t + d_3 \quad \text{polynomial type}$$

where:  $a_3, b_3, c_3, d_3$  – numeric coefficients.

#### 4. Accomplish a G.I.S. in Petrosani area in order to have a sustainable development in this area

The sustainable development means to have healthy and sure models of sustainability. This includes the management, the infrastructure and its services including the facilities of drinking water comparable to the ones from the European union. In a protected environment they will have an efficient transport and links of communication with the rest of the country and will have available resources of clean energy. The members of this community will have acceptable opportunities for education, will take part to the economic process and they will be able to implicate themselves into the local government.

For this application I used the software ArcGIS 9.2 made by ESRI company and this application allowed me as follows:

- To create the geo-spatial data bases
- To modify, complete and update the GIS recourses
- To make thematic maps.
- To make analyses and interrogations specific to this project
- To build some reports based on geo-spatial data.

The most important feature of a GIS consists in its capacity of making spatial analyzes so to use the spatial data in order to obtain reports regarding the studding area.

These spatial data are worked based on some specific algorithms by using own operations.

The spatial analyzes are useful for evaluating, making prognosis, interpreting and understanding. The spatial analyzes are **modularly ones**. In GIS there are 4 main types of spatial analyze as follows: spatial superposition and continuity analyze, surface analyze, linear analyze and raster analyze.

The spatial analyze helps us to extract the significant data distributed spatially and that will be worked. So, we can obtain data associations, which can be characterized or which lead to previsions or to understanding the phenomena. The operations can be made directly on the layers together with their attributes.

The result of a spatial analyze is to allow to be interrogated the attributes and to generate some new date by using the existent ones.

The main spatial operations are as follows:

- Operations from a single layer
- Operations from multiple layers
- Statistic analyze
- Network analyze
- Analyzing the areas – making the digital model of the field

Into the presented application it was defined a series of layers as follows: water network, phone network, underground works, exploited area, GPS network, waters, road, constructions, proprieties.

The data brought to the GIS working environment can be manipulated in different purposes. The data manipulation is made as follows:

- a) **Finding again;**
- b) **Modifying the data structure;**
- c) **Interrogating and analyzing.**

a) **Finding again the data (Fig. 4) consists in:**

- ✓ Selecting a data category;
- ✓ Selecting the graphic data or attribute data by using graphic windows, circle, polygon;
- ✓ Selecting the graphic data

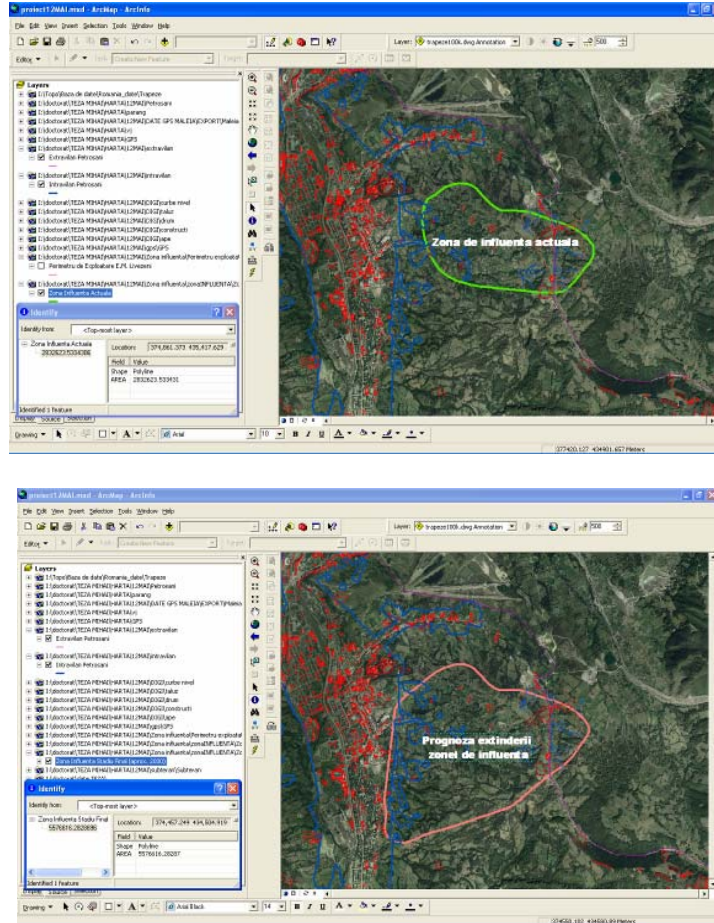


Fig. 4. Marking and foreseeing the present influence and future area for the next 20 years regarding the Livezeni mining area

**b) Interrogating and analyzing the data (Fig. 5)**

When it is put into service the system that contains the geographic data, it was able to be interrogated by using some simple questions: *Who is the owner? What is the distance between 2 points?* etc. or there can be used some analytic questions: *Where are some proper areas for building a house? Which is the area with prognosis influence? If a new access road is built, how it will be affected by the mining area? , How many building are there in the influence area of the mining exploitation? etc.”*

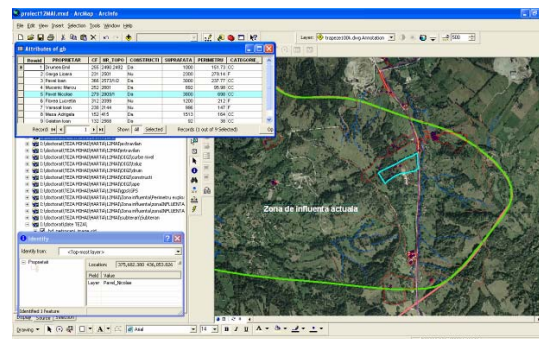


Fig. 5. Identifying the proprieties from the influence area

c) Showing the data (Fig. 6) and generating the reports has the following processes:

- Creating, memorizing, finding again, generating the structure;
- Libraries of conventional signs as points, lines, surfaces having the possibility to generate, edit, insert the new signs;
- Libraries of writing characters having the possibility to generate, edit, insert the new characters, styles;
- Possibility to represent the same frame of some data with different locations, different scales;
- We associate to the attributes some conventional signs, colours, texts;
- Insert the legends.

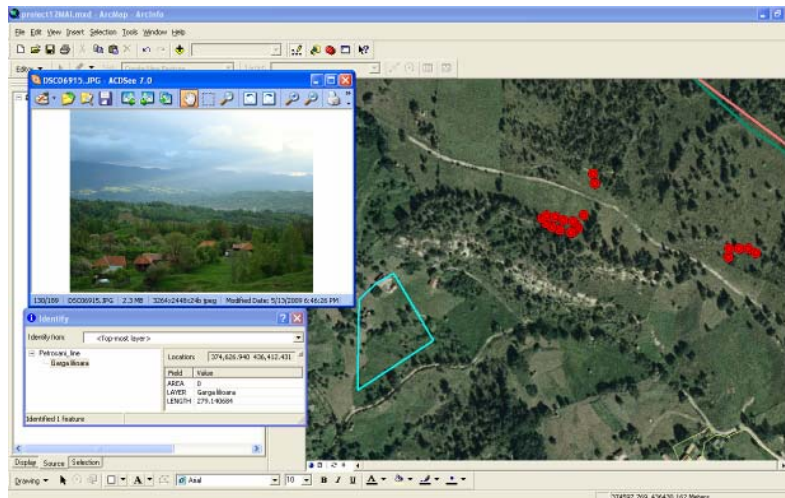


Fig. 6. Visualize some proprieties affected by Livezeni mining exploitation

## 5. Generating and interpretation the DTM for the Jiu Valley Mining Basin – Hunedoara County - Romania

The interpolation methods type triangulation one after whom it is obtained a TIN structure (**Triangular Irregular Network**) (Fig. 6), are also multiple. Interpolation methods such as triangulations, when it is obtain a TIN (**Triangular Irregular Network**) (Fig. 7) are also multiple. The best one is *Delaunay Interpolation* that allows to be obtained some perfect triangles inside a circle so the distance between the points from the picks of the triangle is always minim. For each triangle there are memorized the coordinates and attributes of the three picks, topology and slope and declination direction of the triangle surface.

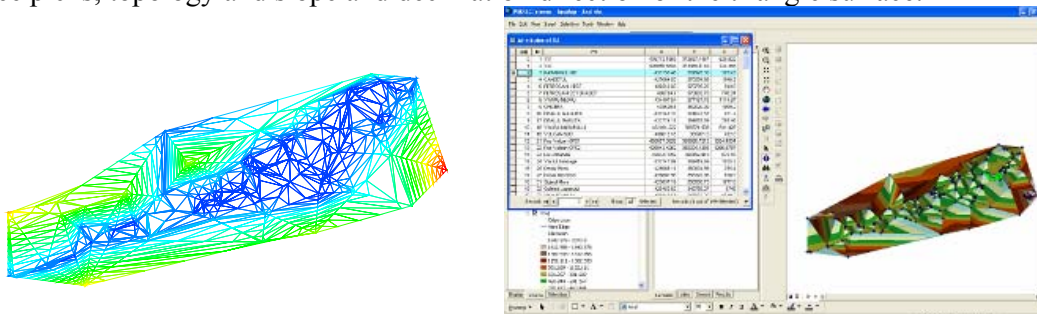


Fig. 7. Elaboration of TIN structure

Three dimensional visualization (Fig. 7) is the preferred way of visualization to comprehend the actual terrain of any place. This can be achieved by techniques using wire frame models or rendering from a 3-D plane to a 2-D plane. For added realism, image based information is added to the rendered primitives. This kind of texture mapping serves to increase the visual appeal and increase the vivid detail. This is popularly known as *draping*, and leads to a greater understanding of patterns in the image and how they relate to the shape of the earth's surface.

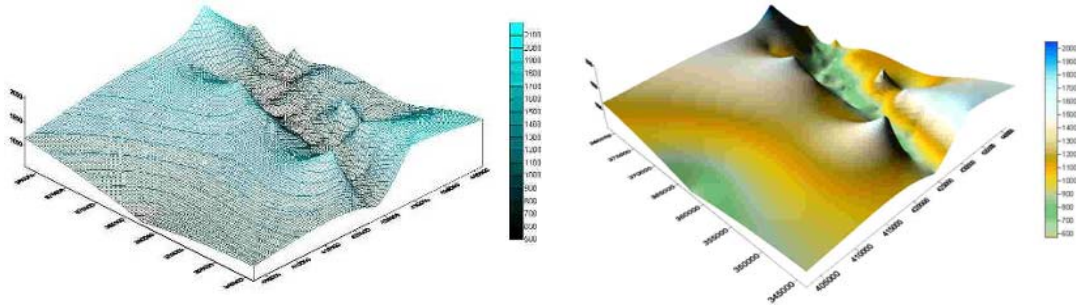


Fig. 8. The 3D model (Wireframe model and Surface model)

### 5.1. DTM Interpretation

The analysis of DTM's to extract terrain parameters is termed **DTM interpretation**. The extraction can be performed by either visual analysis or quantitative analysis (interpretation). The analysis can be grouped into *general geo-morphometry* or *specific geo-morphometry*. General geo-morphometry deals with quantification of general surface characteristics such as **slope, gradient or aspect**. The concept of measuring **slope** from a topographic map is a familiar one for most professionals in the landscape planning/surveying professions. Slope is a measurement of how steep the ground surface is. The steeper the surface the greater the slope. Slope (Fig. 8) is measured by calculating the tangent of the surface. The tangent is calculated by dividing the vertical change in elevation by the horizontal distance. If we view the surface in cross section we can visualize a right angle triangle. Slope is normally expressed in planning as a percent slope which is the tangent (slope) multiplied by 100:

$$\text{Percent Slope} = \text{Height} / \text{Base} * 100$$

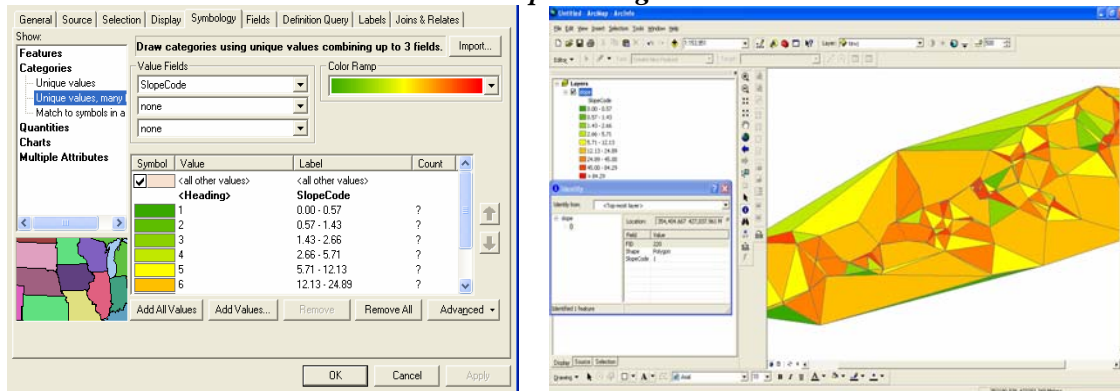


Fig. 9. The measuring of slope using ArcGIS software

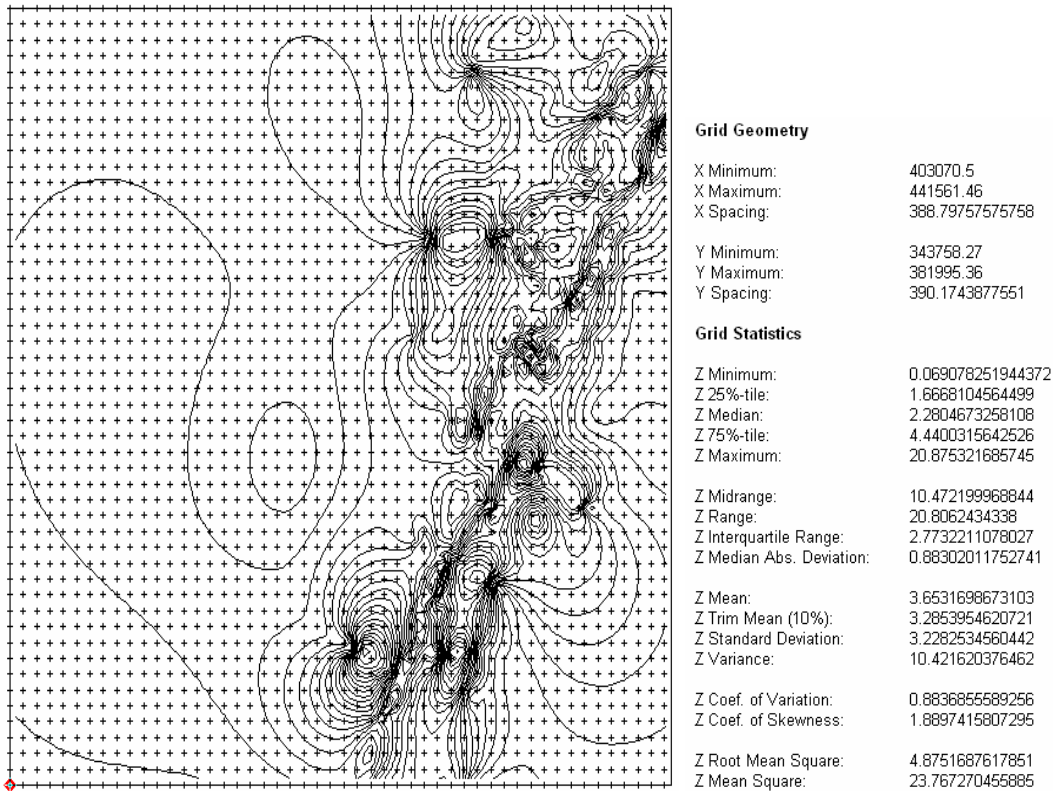


Fig. 10. The map of Slope and Grid Information using Surfer Software

**Slope** is an attribute to define surface and comprises **gradient** and **aspect**. When written in the form of a mathematical equation *gradient* (usually calculated in degrees) refers to the first vertical derivative of altitude and represents the rate of change in its magnitude over distance. Similarly *aspect* is the first horizontal derivative of the altitude and represents the direction of the slope. The **curvature** (convexity / concavity) of the terrain can be determined by the second order derivatives. Curvature of the surface helps define the movement of masses. The formulae for calculation are mentioned below:

$$Gradient = \sqrt{\left(\frac{\Delta z_x}{\Delta x}\right)^2 + \left(\frac{\Delta z_y}{\Delta y}\right)^2}$$

$$Aspect = \tan^{-1} \left( \frac{\frac{\partial f}{\partial x}}{\frac{\partial f}{\partial y}} \right)$$

$$Curvature = \sqrt{\left(\frac{\partial^2 f}{\partial x^2}\right)^2 + \left(\frac{\partial^2 f}{\partial y^2}\right)^2}$$



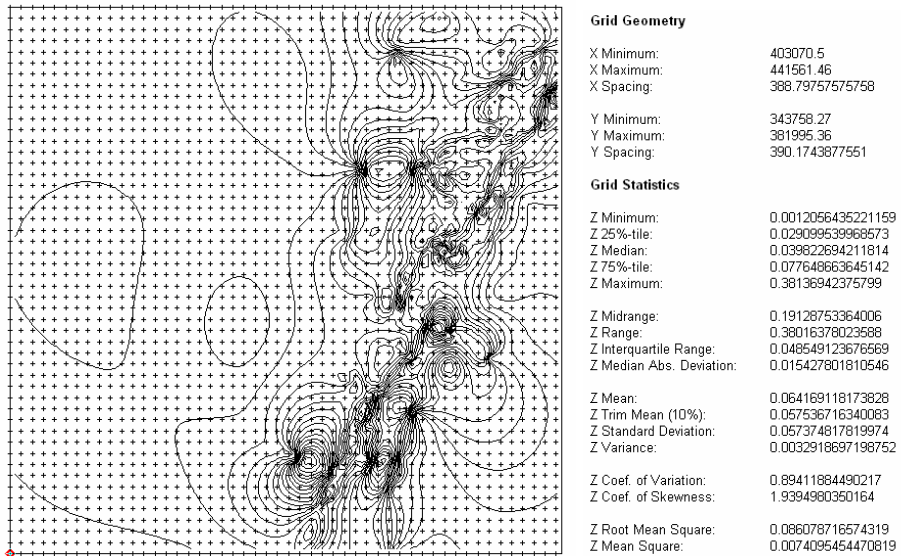


Fig. 11. The map of Gradient and Grid Information using Surfer Software

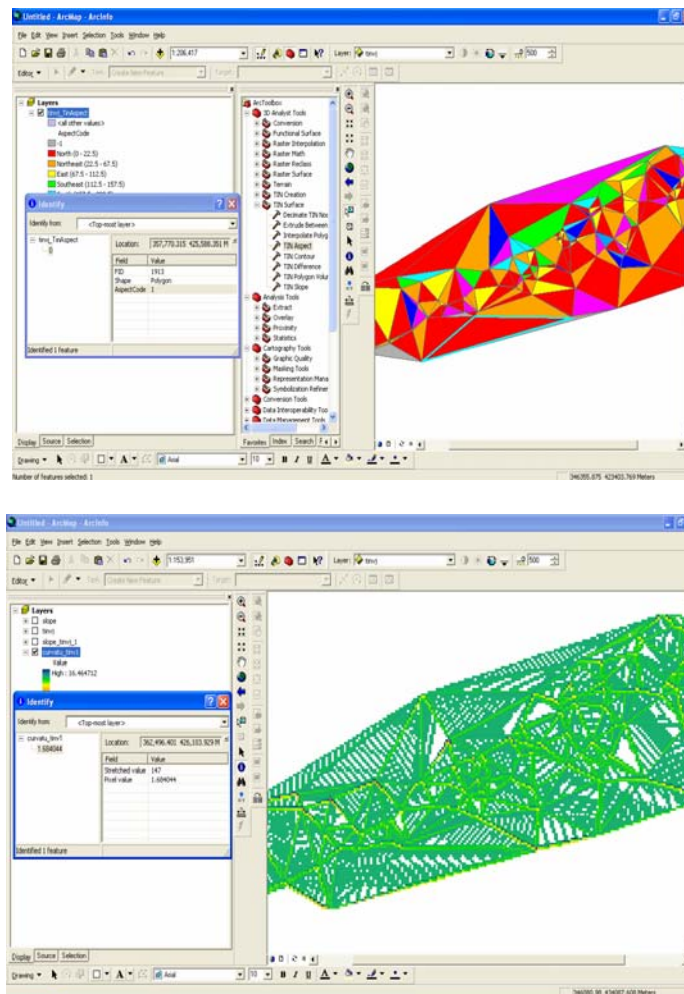


Fig. 12. The calculation of the aspect and curvature using ArcGIS software

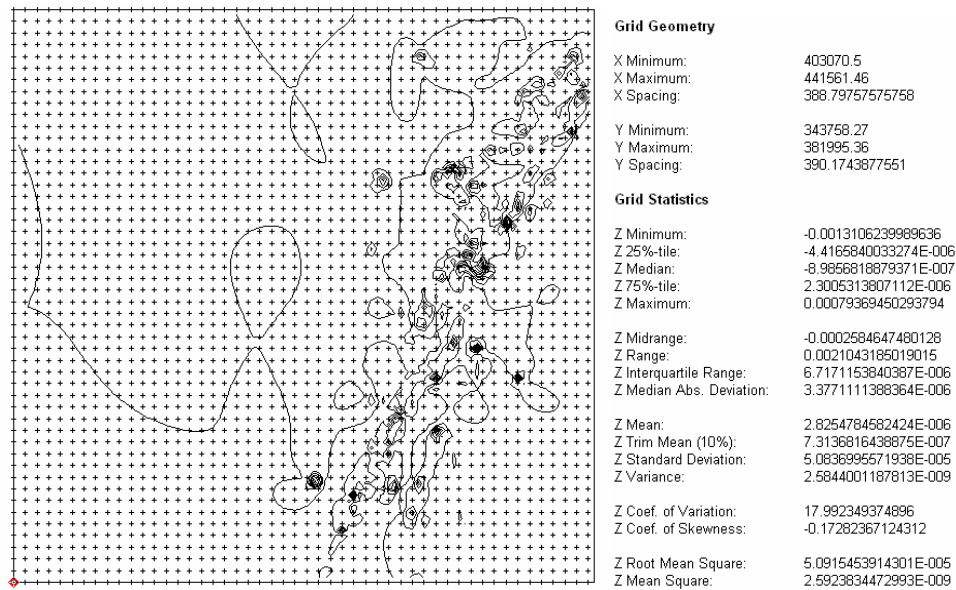


Fig. 14. The map of Curvature and Grid Information using Surfer Software

## 6. Conclusions

The digital map correlated to different databases offers the possibility to analyze the studied area, Petrosani area. The analyzes 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. To make this application included automatically also the generation of the digital model of the terrain for the studied area. So, in this way, it can be understood and interpret ate the shape and features of the studied area depending on the users needs.

## 7. References

1. Băduț, M., *GIS – Geographic Information Systems – Practical fundamentals*, Blue Publishing House, 2004
2. Dima N., Pădure, I., Herbei, O., *Mining topography*, Corvin Publishing House, Deva, 1996
3. Dima, N., Herbei, O., *General topography and elements of mining topography*, Universitas Publishing House, Petrosani, 2005
4. \*\*\* *Manual of geodesic engineer*, Technical Publishing House, Bucharest 1974