ISSN 1454-9174

ANNALS
OF THE
UNIVERSITY OF PETROSANI

MINING ENGINEERING

vol. 18 (XLV)

UNIVERSITAS PUBLISHING HOUSE
Petroşani – ROMÂNIA, 2017

ISSN 1454-9174

Editorial office address: University of Petroșani, 20 University Street, 332006, Petroșani, Romania, Phone: (40) 254/54.29.94, 54.25.80, 54.25.81, 54.25.82, 54.97.49, Fax. (40) 254/54.34.91, 54.62.38, www.upet.ro, E-mail: ibol@upet.ro

CONTENTS

TIERED POWERED SUPPORTS IN LONGWALL FACES – NEW TRENDS IN THE THICK COAL SEAMS MINING

ILIE ONICA [1]
CRISTIAN HANNA [2]

Abstract: In this paper, a new concept concerning the powered supports used in longwall mining faces is presented, named "tiered powered supports", proposed for over 5-6m mining heights of the coal faces. Also, for these powered supports, are presented the technological process and are developed the kinetics and the kinetostatic analysis of these hyperstatic support units.

Keywords: *tiered powered support, longwall mining, thick coal seam, kinetics, kinetostastic*

1. INTRODUCTION

Preparatory workings volume reduction is an important way of increasing the mining efficiency of thick coal seams, mined with longwall faces. This advantage could be obtained by the vertical concentration of panel reserves, thus [7]: a) by using the top coal caving mining methods; b) by increasing the supports of the coal faces [4]. Note that, the second approach is the subject of this paper.

After the statistical analysis of several hundred longwall mining powered supports, it was obtained the following correlation between the masses *m* (in tones) and the maximum heights *Hmax* (in m) of the support units: $m = 2.8 \cdot 1.5^{H_{\max}}$, for $H_{\max} \geq 0{,}5$. Thus, the powered supports mass increases exponentially depending on the maximum height, and after 6-6.5m the powered supports must be conceptually revised [4], [10].

In order to surpass the critical height it is proposed a new conceptual type of support, named the tiered powered support (fig. 1). This type of support units results from superposing two support units of ordinary design and most of the components being maintained. A linking assembly "base-slide canopy" is supplementary built and it ensures a common mechanical structure and quasi-independent functionality at the level of each. Thus, each part (upper and lower) of the longwall face has independent

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equipment for cutting and hauling. Also, the transport preparatory working is disposed on the floor of coal seam and the ventilation working, under the roof.

Taking into consideration the previous constructive principle and doubling the mass and the height of every support, between 2 and 5m, there not being a critical height, is obtained a linear correlation between mass and the height of the supports: $m = 1 + 3.3 \cdot H_{\max}$ [4], [10].

From the viewpoint of designing these tiered powered supports there are two possibilities, namely: ether to couple two units already built, of the same type or of different types, realizing only the design of the “base-slide canopy” assembly and checking the whole structure for certain conditions or, in the second case, to design a new tiered support of certain configuration [4], [9], [10].

For to test this concept it is proposed in the year 1995,by I.Onica, in the working [4], a tiered support unit SMA-2E, by adapting the SMA-2 two leg shield supports unit, successfully used in Jiu Valley coal basin (fig. 1).

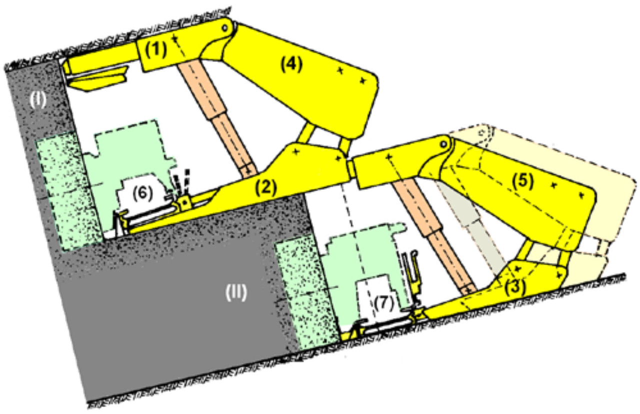


Fig.1. Tiered two leg shield powered support SMA-2E

(I) and (II) upper, respectively lower part of the support unit; (1)-upper canopy; (2)- base-slide canopy; (3)-lower base; (4)-upper shield; (5) –lower shield; (6), (7) –upper, respectively lower cutting machine - chain conveyor assembly

In the year 2013, in the paper [4], the Russian authors Mohnaciuk & Mîşliaev & Titov developed a tiered support, compact on the height of the coal face (fig. 2), similar to that of Fig. 1, which is a flexible support of the functional point of view, relative to the two steps of the coal face.

2. LONGWALL MINING TECHNOLOGY FOR THICK COAL SEAMS, USING THE TIERED POWERED SUPPORTS

Longwall mining technology using mechanized tiered powered supports type SMA-2E, from an organizational point of view, at the two front steps of the coal face level, is quasi - independent. Every coal front step it is equipped, along the coal face, with one armored face conveyor (AFC) and one double ended ranging drum shearer (DERDS).

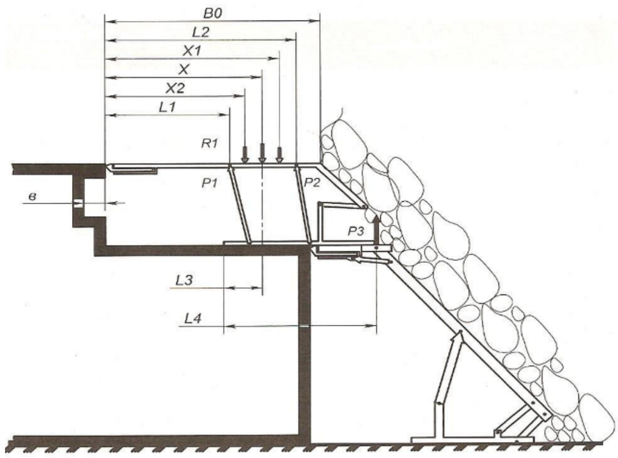


Fig.2. Compact tiered powered support
- after Mohnaciuk & Mîşliaev & Titov [4]

Longwall face preparation is achieved by a transport gallery, executed on the coal seam floor, in the lower step, and a ventilation gallery dug under the coal seam roof, at the upper step. It is preferred that the preparatory galleries with rectangular profile to be supported with the yielding steel sets and middle posts [5].

The main stages of the technological process of the longwall face [5], equipped with the tiered powered support units are the following:

Stage 0: the powered supports units and the conveyors, for the two steps, are advanced at the coal face limit;

Stage 1: in the upper step, the powered support units having the flipper canopies retracted, and the DERDS cutting the coal face; in the lower level, the AFC is at the coal face limit and the powered supports units are in the advanced position;

Stage 2: in the upper step, the unveiled roof is supported by the sliding canopies and the AFC is advanced; in the lower step, the support units and the AFC are in the stage 1 position;

Stage 3: in the upper step, the conveyor is positioned at the coal face limit, and the support units are relaxed, moved and positioned to the coal face, followed by the flippers canopies operation at the front position; the lower support modules remains in the stage 1 position and a cutting strip behind the upper module;

Stage 4: the AFC and the upper support modules is located as stage 3; in the lower step, the relevant support modules are advanced and the DERDS cutting the coal front;

Stage 5: in the upper step, the support and transport equipments remain placed as a stage 3; in the lower level, the conveyor is advanced at the coal face.

It should be noted that the coal face cutting made with these two DERDS is made bidirectional mode. Therefore, it is necessary that throughout the production cycle, upper shearer to advance the lower shearer. For this purpose, after the end of the coal cutting phase of the upper step, the upper shearer awaiting the lower shearer to ending the coal face cutting.

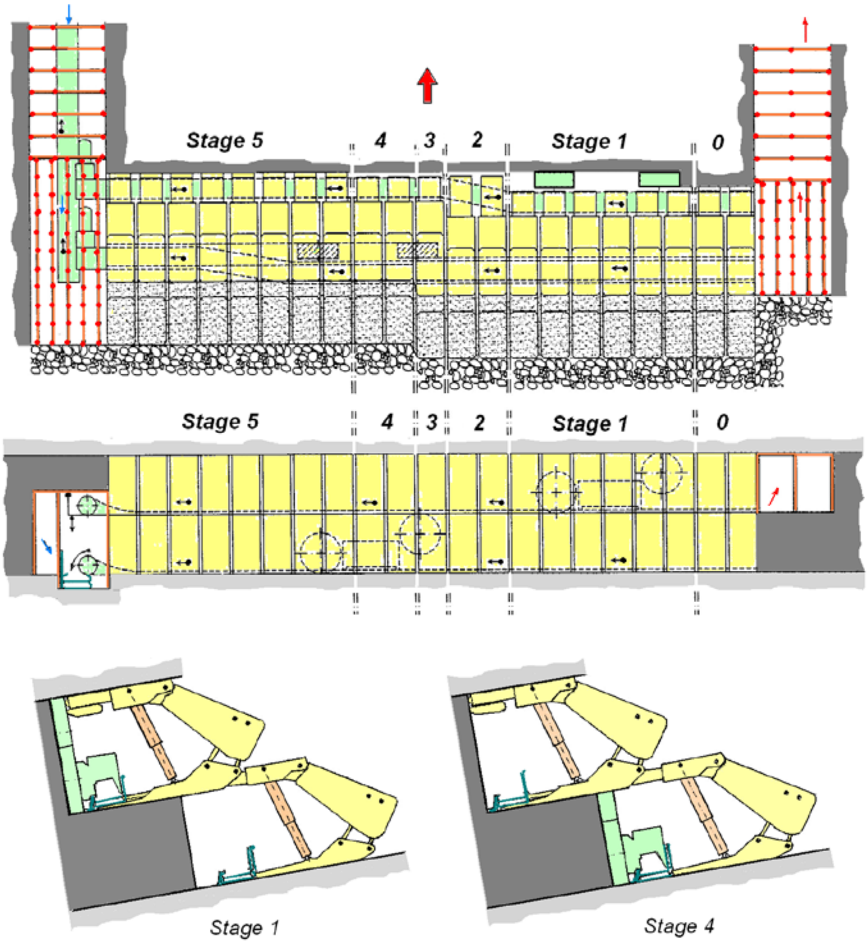


Fig.3. The main mining technological stages of the longwall coal faces, equipped with tiered powered supports SMA -2E

In order to ensure the stability of the coal face is recommended to use the tiered powered supports into longwall faces with descendent advancement. When the coal step has a pronounced tendency to sliding, can be attached to the lower subassembly a structural element, specific to support the coal face [5], [8]. Fig. 4 shows the stresses state, developed around the coal face equipped with tiered powered supports, obtained by finite element modelling [6], [8], [9].

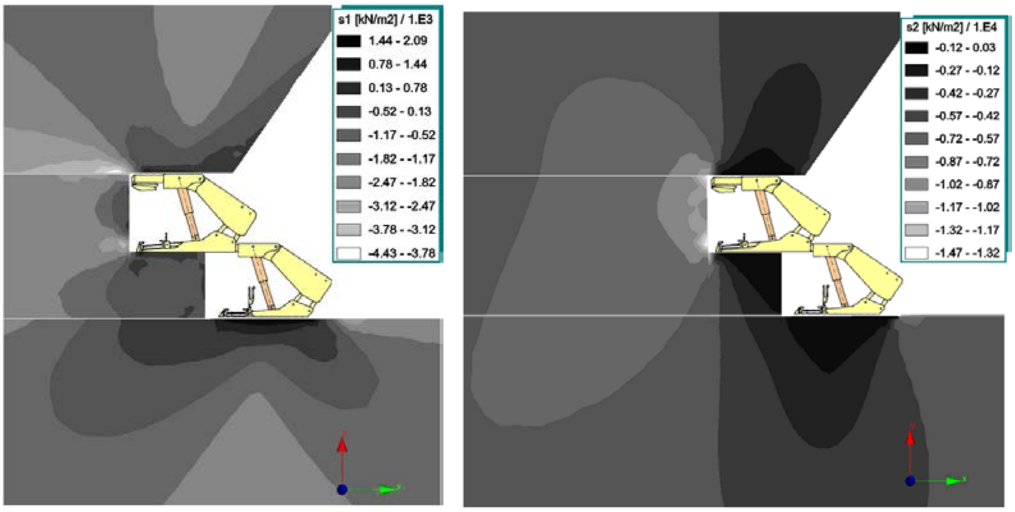


Fig. 4. The stress state developed around a longwall face equipped with tiered powered supports a) Maximum principal stress; b) Minimum principal stress

3. KINETICS OF THE TIERED POWERED SUPPORTS SMA-2E

To write the algorithm for kinetics analysis using the contour of vectors method (fig.5) [2], [11], with the expression of vector $\vec{l_i}$ by a scalar product between module l_i (size of elements of the quadrilateral mechanism) and his unit vector u_i defined by the angle θ_i, measured counterclockwise from the positive sense the axis *x*, according to fig. 2.

For closed contour $A_0A_1B_1B_0$ (quadrangle mechanism sides $A_0B_0=l_0$, $A_0A_1=l_1$, $A_1B_1=l_2$, $B_0B_1=l_3$), we can write the following general equation of contour closing:

$$\sum_{i=1}^{n} l_i \cdot \overrightarrow{u_i} = 0 \tag{1}$$

Equation (1) can be written in explicit form as follows:

$$\overrightarrow{u_1} \cdot l_1 - \overrightarrow{u_2} \cdot l_2 - \overrightarrow{u_3} \cdot l_3 + \overrightarrow{u_0} \cdot l_0 = 0 \tag{2}$$

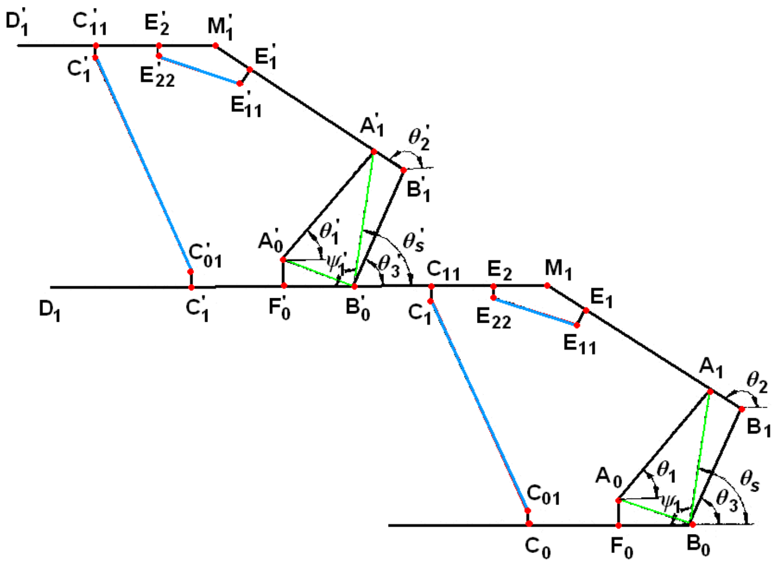


Fig.5. The algorithm schema for kinetics analysis using the contour of vectors method

We consider the vector $\overrightarrow{l_s}$ defined by the equation:

$$\overrightarrow{u_0} \cdot l_0 + \overrightarrow{u_1} \cdot l_1 = \overrightarrow{u_s} \cdot l_s \quad (3)$$

From equation (2) and (3) we obtain:

$$\overrightarrow{u_s} \cdot l_s - \overrightarrow{u_2} \cdot l_2 - \overrightarrow{u_3} \cdot l_3 = 0 \quad (4)$$

where:

$$l_s = \sqrt{l_1^2 + l_0^2 - 2 \cdot l_0 \cdot l_1 \cdot \cos(\theta_1 + \delta)} \quad (5)$$

$$\delta = \arctan \frac{Y_{A0} - Y_{B0}}{X_{B0} - X_{A0}} \quad (6)$$

$$\theta_s = \pi - \psi_1 = \pi - \arctan \frac{l_1 \cdot \sin\theta_1 + (Y_{A0} + Y_{B0})}{(X_{B0} - X_{A0}) - l_1 \cdot \cos\theta_1} \quad (7)$$

From equation (4) arising angles θ_2 and θ_3 expressions:

$$\theta_2 = \theta_s + \arccos\frac{l_s^2 + l_2^2 - l_3^2}{2 \cdot l_s \cdot l_2} \quad (8)$$

$$\theta_3 = \theta_s + \arccos\frac{l_s^2 + l_3^2 - l_2^2}{2 \cdot l_s \cdot l_3} \quad (9)$$

Knowing the angles θ_1, θ_2 and θ_3 and the lengths of quadrilateral mechanism l_1, l_2, l_3 and l_4, can determine the coordinates of the joints of the supporting quadrilateral mechanism of the upper support subassembly:

$$X_{A1} = X_{A0} + l_1 \cdot \cos\theta_1 \qquad Y_{A1} = Y_{A0} + l_1 \cdot \sin\theta_1 \quad (10)$$

$$X_{B1} = X_{B0} + l_3 \cdot \cos\theta_3 \qquad Y_{B1} = Y_{B0} + l_3 \cdot \sin\theta_3 \quad (11)$$

$$X_M = X_{A1} + l_4 \cdot \cos\theta_2 \qquad Y_M = Y_{A1} + l_4 \cdot \sin\theta_2 \quad (12)$$

$$X_D = X_M + l_{DM} \qquad Y_D = Y_M \quad (13)$$

The coordinates of the other important points of the lower step support can be calculated easily, knowing the coordinates of the points *M* and *D*. For the upper subassembly step support, knowing the coordinates of the points *B'₀* and *A'₀* ($X_{B'0} = X_M - MB'_0$ and $Y_{B'0} = Y_M$, respectively $X_{A'0} = X_{B'0} - B'_0 F'_0$ and $Y_{A'}0 = Y_M + F'_0 A'_0$), repeat the calculation algorithm shown above, to give results similar to those of equations (10),..,(13), for the pairs of coordinates, denoted by ('), of the joints of the quadrilateral mechanism of the upper step support: $(X_{A'1}, Y_{A'1})$; $(X_{B'1}, Y_{B'1})$; $(X_{M'}, Y_{M'})$; $(X_{D'}, Y_{D'})$. Also, similarly, can get the coordinates of the other points of the upper subassembly, knowing the coordinates of the points *F'* and *D'*.

4. KINETOSTATIC ANALYSIS OF THE TIERED POWERED SUPPORTS SMA–2E

The constructive structure of the tiered powered support SMA-2E, shown in the fig. 6 and subjected to kinetostatic analysis is a complex and hyperstatic structure [2], [4], [9], [10], [11].

This problem could be solved in two different ways:

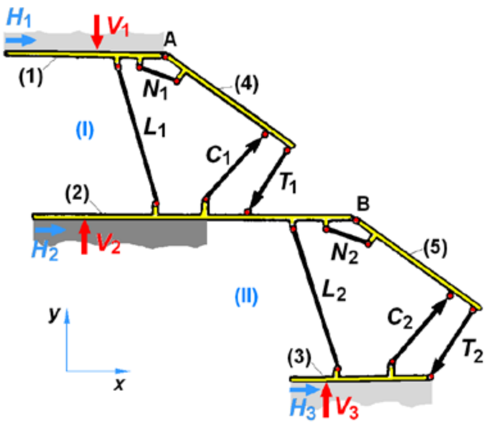


Fig.6. Calculus scheme of the tiered powered support SMA-2E
(1)-canopy; (2)-base-slide canopy; (3)-base plate; (4) and (5)-shields

a) by the calculus of the external maximum loadings, which characterise the load capacity of the powered support, and of certain connecting forces between the structural elements, for a certain constructive configuration of the support unit;

b) by the calculus of the main connecting forces between the structural elements, in the conditions of the maximum external loadings, required by the application conditions.

In the first case, it was used the Barczak & Garson methodology [1]. Because the complexity of the support structure, following completion of the equilibrium equations, written with this methodology, the problem becomes inextricable.

Taking into account the complexity of this constructive structure we tried to simplify this problem, for the limit conditions of the coal slope stability, when the support is into horizontal position and is loaded only from the roof direction (see fig. 6). Thus, the *simplifying hypotheses* are the following [4]:

-the support is loaded from the roof with a parabolic charge, maximum measured in the Jiu Valley coal basin, represented by the concentrated forces V_1 on the canopy (1), situated at a distance, from the top of this, at the 5/8 of the canopy length;

-V_2 for the “base-slide canopy”(2) and V_3 for the base plate (3), situated at 3/8 from its length, distance measured from the top of base; the reaction force V_2 is calculated for to maintain the coal slope face stability, respecting the condition that: $V_3=V_1-V_2$.

I In the previous conditions, there are written the equilibrium equations for every structural element (1),…,(5), shown in fig. 7, respectively for the forces in according with the x and y axis, $\sum F_x = 0$ and $\sum F_y = 0$; also, the i moment equations $\sum M_k^{(i)} = 0$, where i=1,2,..,5 and k is the referring connecting point of the moment equilibrium. Thus, resulting the following equations: $\sum M_A^{(1)} = 0$; $\sum M_{I1}^{(4)} = 0$;

$\sum M_B^{(2)} = 0$; $\sum M_{I2}^{(5)} = 0$ şi $\sum M_{I2}^{(3)} = 0$; where *A* and *B* are the hinge joints between the canopies and the shields and I_1 and I_2 are the instant rotation centres of the two lemniscate's bars.

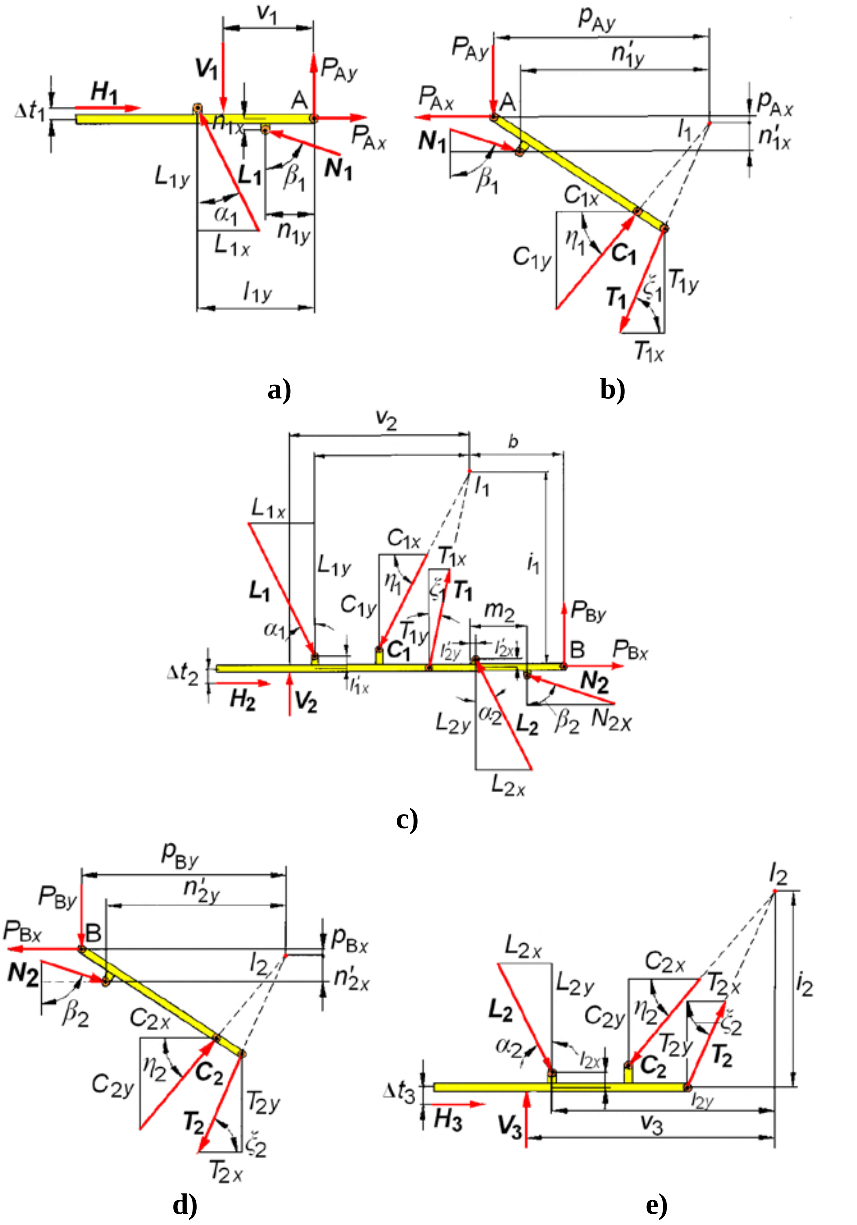


Fig. 7. Loading schemas of the main constructive elements of the tiered powered support SMA-2E

a) upper canopy; b)upper shield; c) base-slide canopy; d)lower shield; e) lower base

Finally, results an equation system with 15 equations and 15 unknown parameters, developed in the following:

$$H_1 - L_1 \cdot \sin\alpha_1 - N_1 \cdot \sin\beta_1 + P_{Ax} = 0 \quad (14)$$

$$-V_1 + L_1 \cdot \cos\alpha_1 + N_1 \cdot \cos\beta_1 + P_{Ay} = 0 \quad (15)$$

$$H_1 \cdot \Delta t_1 - v_1 \cdot V_1 + \left(\cos\alpha_1 \cdot l_{1y} - \sin\alpha_1 \cdot l_{1x}\right) \cdot L_1 + \left(n_{1y} \cdot \cos\beta_1 + n_{1x} \cdot \sin\beta_1\right) \cdot N_1 = 0$$
(16)

$$-P_{Ax} + C_1 \cdot \cos\eta_1 - T_1 \cdot \cos\xi_1 + N_1 \cdot \sin\beta_1 = 0 \quad (17)$$

$$-P_{Ay} + C_1 \cdot \sin\eta_1 - T_1 \cdot \sin\xi_1 - N_1 \cdot \cos\beta_1 = 0 \quad (18)$$

$$-P_{Ax} \cdot p_{Ax} - P_{Ay} \cdot p_{Ay} + N_1 \cdot \left(n_{1x} \cdot \sin\beta_1 - n_{1y} \cdot \cos\beta_1\right) = 0 \quad (19)$$

$$H_2 + L_1 \cdot \sin\alpha_1 - C_1 \cdot \cos\eta_1 + T_1 \cdot \cos\xi_1 - L_2 \cdot \sin\alpha_2 - N_2 \cdot \sin\beta_2 + P_{Bx} = 0 \quad (20)$$

$$V_2 - L_1 \cdot \cos\alpha_1 - C_1 \cdot \sin\eta_1 + T_1 \cdot \sin\xi_1 + L_2 \cdot \cos\alpha_2 + N_2 \cdot \cos\beta_2 + P_{By} = 0 \quad (21)$$

$$\begin{aligned} &V_2 \cdot v_2 - H_2 \cdot \left(\Delta t_2 + i_1\right) - L_1 \cdot \left[\cos\alpha_1 \cdot l_1 + \sin\alpha_1 \cdot \left(i_1 - l'_{1x}\right)\right] + L_2 \cdot \left[-\cos\alpha_2 \cdot l_{2y} + \right. \\ &\left. + \sin\alpha_2 \cdot \left(i_1 - l'_{2x}\right)\right] + N_2 \cdot \left[-\cos\beta_2 \cdot m_2 + \sin\beta_2 \cdot \left(n_{2x} + i_1\right)\right] - P_{By} \cdot b - P_{Bx} \cdot i_1 = 0 \end{aligned} \quad (22)$$

$$-P_{Bx} + C_2 \cdot \cos\eta_2 - T_2 \cdot \cos\xi_2 + N_2 \cdot \sin\beta_2 = 0 \quad (23)$$

$$-P_{By} + C_2 \cdot \sin\eta_2 - T_2 \cdot \sin\xi_2 - N_2 \cdot \cos\beta_2 = 0 \quad (24)$$

$$-P_{Bx} \cdot p_{Bx} - P_{By} \cdot p_{By} + N_2 \cdot \left(n'_{2x} \cdot \sin\beta_2 - n'_{2y} \cdot \cos\beta_2\right) = 0 \quad (25)$$

$$H_3 + L_2 \cdot \sin\beta_2 - C_2 \cdot \cos\eta_2 + T_2 \cdot \cos\xi_2 = 0 \quad (26)$$

$$V_3 - L_2 \cdot \cos\alpha_2 - C_2 \cdot \sin\eta_2 + T_2 \cdot \sin\xi_2 = 0 \quad (27)$$

$$V_3 \cdot v_3 - H_3 \cdot \left(\Delta t_3 + i_2\right) - L_2 \cdot \left[\cos\alpha_2 \cdot l_{2y} + \sin\alpha_2 \cdot \left(i_2 - l_{2x}\right)\right] = 0 \quad (28)$$

The unknown parameters of the equations (14),…,(28) are the following:

-the loadings of the hydraulic legs: L_1 and L_2;

-the loadings of the hydraulic ram between canopy and shields: N_1 and N_2;

-the forces from hinge joints *A* between the shield (4) and the canopy (1), respectively *B* between the shield (5) and the base-slide canopy (2): P_{Ax}, P_{Ay}, P_{Bx} and P_{By};

-the forces of the lemniscates bars of upper part of the support C_1 and T_1, respectively the lower part C_2 and T_2;

-the frictional forces developed between the structural elements (1), (2) and (3) and the surrounding massive (H_1, H_2 and H_3) that could be represented by the frictional angles $\varphi_i = \arctan(H_i / V_i)$, for i=1,2,3.

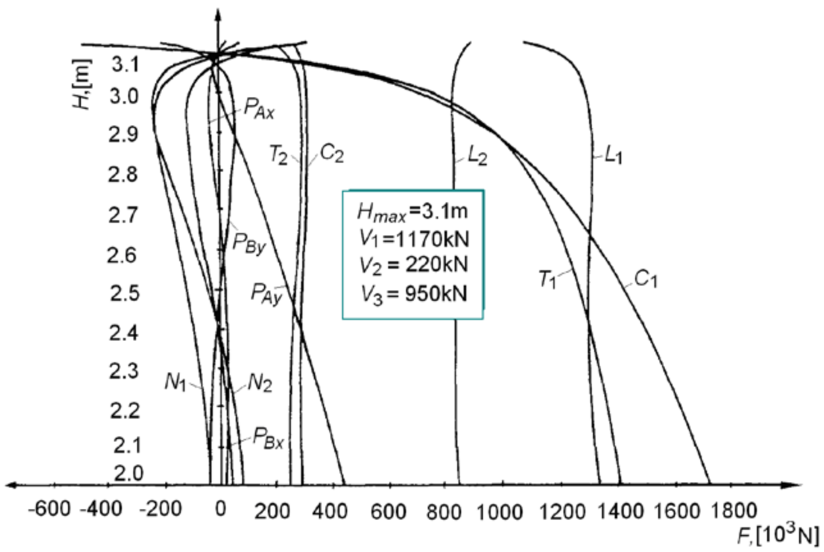
Kinetostatic calculation algorithm developed above for the tiered powered supports SMA-2E is subject of a computational program that follows a specific flow chart.

5. THE IMPLEMENTATION OF THE KINETOSTATIC COMPUTATIONAL PROGRAM FOR THE THICK COAL SEAMS GEO-MINING CONDITIONS OF THE JIU VALLEY BASIN

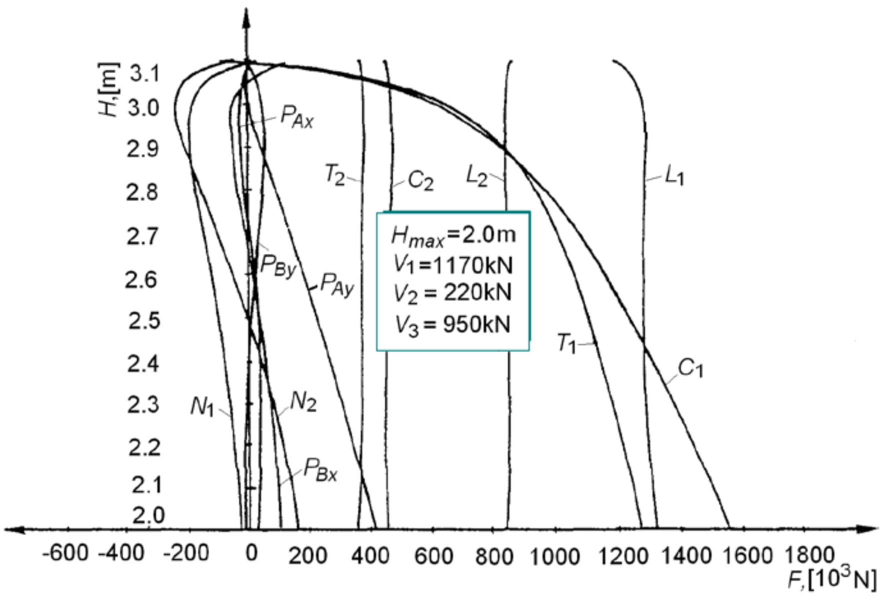
The previous algorithm is developed for the case of tiered powered support SMA – 2E, in the conditions of longwall faces existent in the coal seam no.3, Jiu Valley coal basin. The support canopy (1) is charged with a medium roof pressure of 0.3MPa, respectively a concentrated force of 1170kN at 1.7m from the top of the canopy, the base-slide canopy (2) with 0.14MPa or 220kN at the 0.4m and the base plate (3) with 0.26MPa or 950kN at 0.9m from the top of the base [4].

For analysing the powered support behaviour, in the previous conditions, it is taken into consideration the connecting forces variation, in the case where the lower part of the support is situated on the coal slope, firstly for 2m minimum height, and secondly for 3.1m maximum height, making variable the upper part of the support between H_{min}=2m and H_{max} =3.1m of support height. The evolution curves of the connecting forces, developed in the previous conditions, are represented in the fig.8. If it is analysed the maximum values of these forces, we can conclude that the forces developed into the support joints and the hydraulic elements is under the admissible values of these.

In *conclusion*, it is possible to transform and redesign the SMA-2 classical powered support, for the Jiu Valley geo-mining conditions, taking into account the “tiered support” concept, without making big structural modifications. Fig.9 shows a modified base of the upper substructure and the modified canopy of the lower substructure, for making the assembly “base-sliding canopy” of the tiered powered support SMA-2E.



a)



b)

Fig.8. The structural forces evolution depending on the height variation of the tiered powered support SMA-2E:

a) for the maximum height H_{max} of the lower part of the support;
b) for the minimum height H_{min} of the lower part of the support

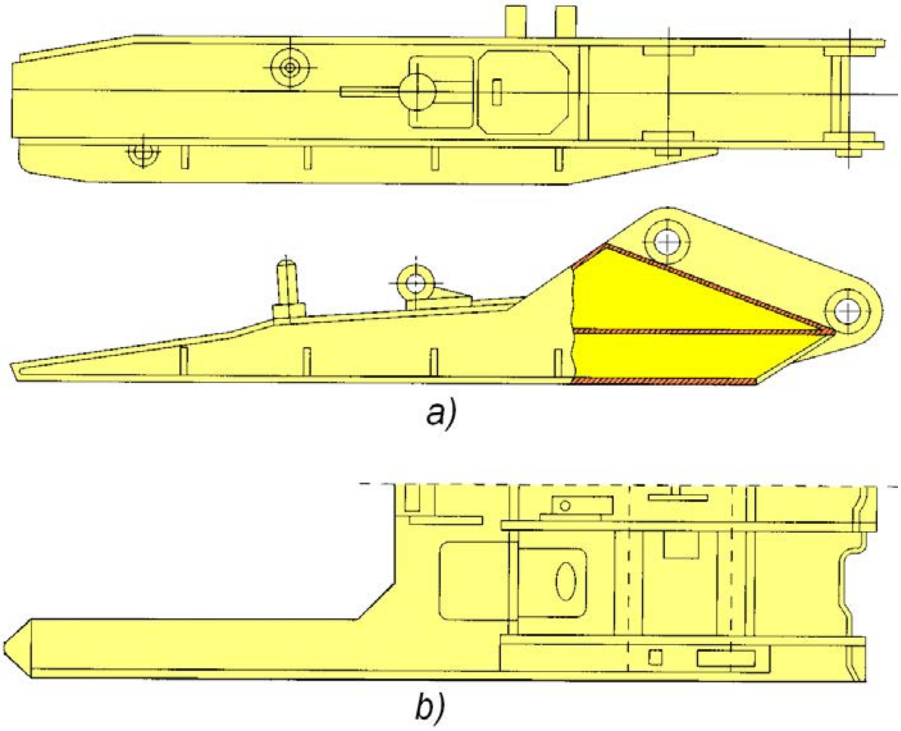


Fig. 9. The connection components between the upper and lower subassemblies
a)Base of the upper subassembly; b)Sliding -canopy of the lower subassembly

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DYNAMICS OF THE REACTIONS FROM THE BEARINGS OF THE PULLEY SHAFTS

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Abstract: The reactions from the bearings of the extraction pulley shafts are due to the burdens from the extraction cables that are transmitted through the pulley. The variation (dynamics) of these burdens is determined by the kinematics and the dynamics of the extraction installation and by the geometrical elements that define the position of the extraction machine in respect to the mine shaft. In this work, I present aspects regarding the dynamics (variation) of these reactions, during an extraction cycle and an analysis of the behavior of a tower of an extraction installation, in what regards the tensions and the deformities of the tower's resistance structure. For the exemplification of these aspects, the following extraction installation was studied: Auxiliary well no. 2, Maleia compound, Livezeni Mining Plant.

Key words: pulley shaft; size verification; design analysis

1. INTRODUCTION

The calculation the structure of the mining extracting towers is done taking into consideration all the unfavorable combinations practically possible of the different loads called groups of loads and are established taking into account in their form the compatibility of their acting simultaneously.

The loads are classified into: permanent, short term - temporary, long term - temporary, and exceptional.

In order to establish the state of strains and displacements from the structure of the tower due to the short term functioning loads transmitted through the extracting cables during an extracting cycle, it has been taken into study the tower of the extracting installation,, Auxiliary well no 2 "Maleia compound, Livezeni Mining Plant (fig. 1 and fig. 2), which has the general and working data presented as follows.

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Fig.1. Extracting installation
„ Auxiliary well no.2" Maleia
Livezeni Mining Plant south – west view

Fig.2. Extracting installation
„Auxiliary well no.2 " Maleia
Livezeni Mining Plant north – west view

2. THE INSTALLATION TAKEN INTO STUDY

The extracting installation which works on auxiliary well no.2, from Maleia E.M. Livezeni, which is destined [3] for the underground supply with materials and tools as well as for transporting personal which serves the pumping stations and used water removal from the underground at horizon 425 to the surface.

Fig. 3. The extracting installation
„ Puţ auxiliar nr.2 " Maleia
Livezeni Mining Plant south- west view

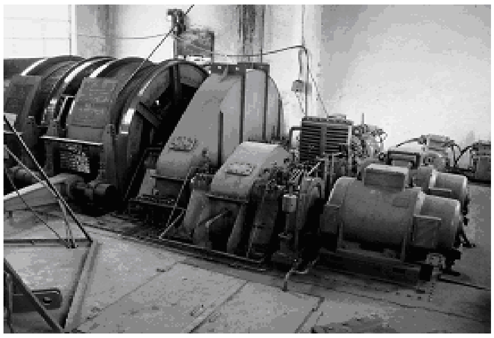

Fig. 4. The extracting machine
„ BAMERT 3000×900 UNGARIA " Maleia
„ Puţ auxiliar nr.2 " E.M. Livezeni

The extracting installation that supplies the well (fig. 3) is unbalanced and has an extracting machine type BAMERT 3000 900 HUNGARY (fig. 4) equipped with two asynchronous motors type MAF 61-8, (fig. 5), of 125 kW power and a nominal rpm of 730 rpm. The reducer of the machine (fig. 6) has two gears in separate cases power reducer (fig. 7) and rpm reducer (fig 8) with a transmittance ratio of 25.13 The extracting cables with diameters of Φ 34 mm and a mass (on a linear meter) of 4,28 kg/m on the left branch (from the extracting machine to the well) and Φ 34 mm and a mass 4,28 kg/m on the right branch are wrapped around the two extracting pulleys (fig. 9) of Φ 2500 mm with a mass (the pulley, the axel of the pulley and the bearing of the axel) of 2050 kg, laying on the tower at a height of 18,2 m (pulley axel).

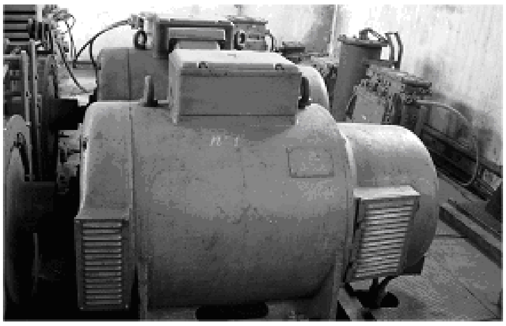

Fig. 5. Asyncrhronus motor type MAF 61 - 8

Fig. 6. Two gears reducer with separate cases

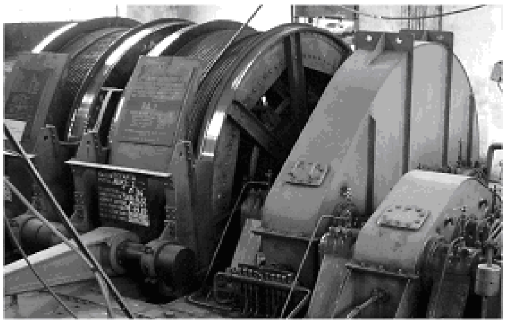

Fig. 7. Power reducer

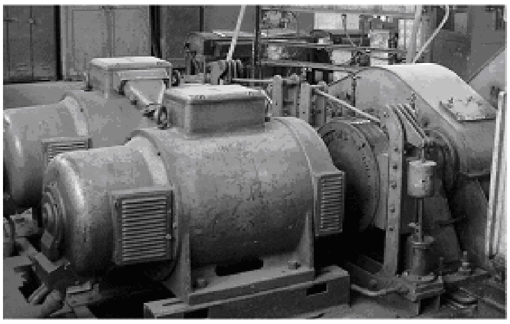

Fig. 8. Rpm reducer and auxiliary brake

The cables are wrapped in a two layers (rows) on each of the two wheels of the machine (fig. 10), from which one is fixed (fig. 11) and one is mobile (fig. 12) and which are hooked at one end by the exterior end (side) of them. The other end of the cables going through the extracting pulleys is hooked to the extracting vessel through the cable tie device DLC.

Fig. 9. Extracting pulleys

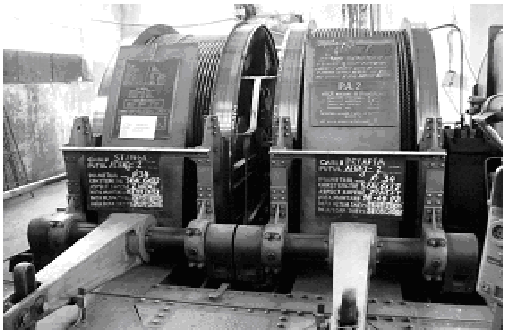

Fig. 10. Cable wrapping organ

Fig. 11. Fixed wheel

Fig. 12. Mobile wheel

Fig. 13. The tower

Fig. 14. Pulley platform

Fig. 15. Leading component

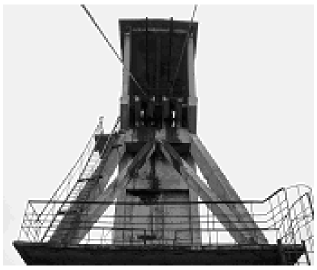

Fig. 16. Abutment

The extracting vessels are untipping cages with one level, with two trolleys per level having a mass (own mass plus D.L.C.) of 2781 kg. The mass of a trolley is of 650 kg, and the effective load is 1800 kg/trolley.

The tower (fig. 13) with a height until the pulley axel of 18,2 m. The structure of the tower is composed of the extracting pulley platform (fig. 14) sustained by the leading component (fig. 15) and the abutment (fig. 16) The extracting machine lies on the ground (at a height of 0.7 m to the 0 level of the well (well collar), sideways from the tower (well tower), at a distance (of the wheel axel), owards the vertical portion of the extracting cables which enter the well of 42m.

The length of the cable chord (the distance between the tangent points of the cable to the deviating pulley from the tower and the wheel of the extracting machine, in the central position of the chord (perpendicular on the wheel axel)), is for the left branch L_{cs} = 46,226m, and L_{cd} = 46,358m for the right branch.

The incline angles of the cables chords are $\beta_s = 34^0\ 04'\ 29''$for the left branch and $\beta_d = 29^0\ 44'\ 41''$, for the right branch, and the deviating angles (which are formed in the limit positions of the cable chord towards the interior side(interior angle) or exterior (exterior angle) of the wheel, over the central position of the chord) are: $\alpha_{e\ st}$ =19’29’’ and $\alpha_{i\ st}$=45’21’’ for the left branch and α_{edr}=31’53’’ and $\alpha_{i\ dr}$=32’46’’ for the right branch.

3. DETERMINING THE REACTIONS

Considering the elevator leaving the horizon 580 until it reaches the surface ramp (783 horizon) it has been taken into study the case of personal transport entering the underground when the left elevator full of personal is descending on the right wing (case 1); the right elevator is descending on the right wing (case.2). The kinematics elements for the cases taken into analysis are presented in fig. 17 and fig. 18.

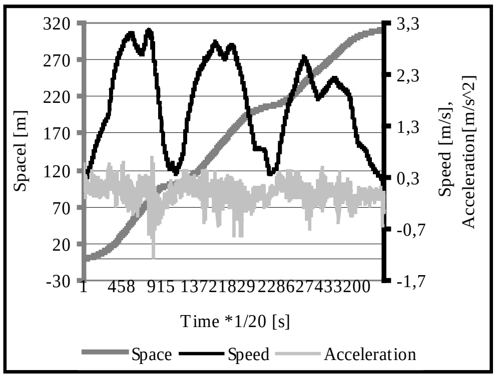

Fig. 17. Kinematic elements on the elevator left climbing personal entrance, case1

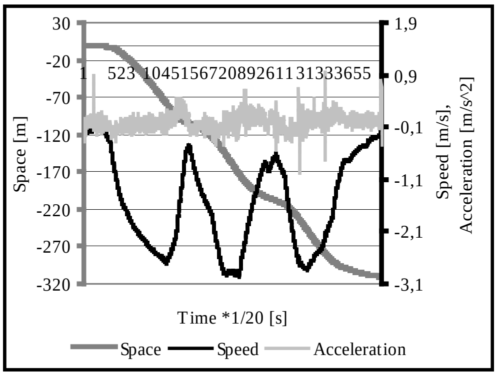

Fig. 18. Kinematic elements on the elevator left descending personal entrance , case 2

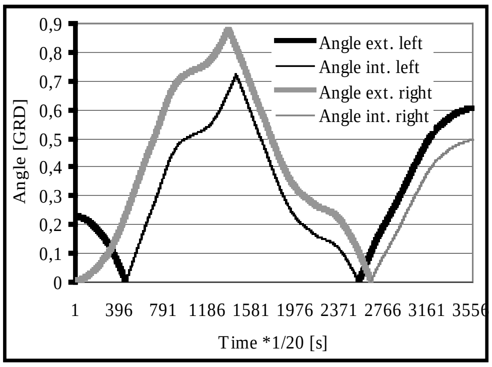

Fig. 19. Deviating angles for case 1 from fig. 17

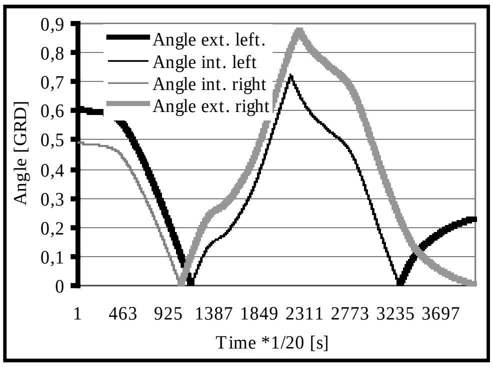

Fig .20. Deviating angles for case 2 from fig. 18

The calculation of loads has been done taking into consideration the statical, friction and dynamic forces [2]. In the calculation of loads it has been used the d'Alembert principle decomposing the efforts from the cable chords, in their touch points on the pulleys into components on three perpendicular directions which correspond to the axis system chosen in the discretization of the structure of the tower of the installation. The components of the efforts from the cable chords variate both because of the incline angles of the chords but also because of the deviation angles of them (fig. 19 and fig. 20).

Considering the following notation ,, a " the left bearing and ,,b " the right bearing, of each deviating pulley, there is presented the variation of the components of the forces on each pulley (fig. 21 and fig. 22) and the loads on the entire tower (fig. 23

and fig. 24), for each case taken into study.

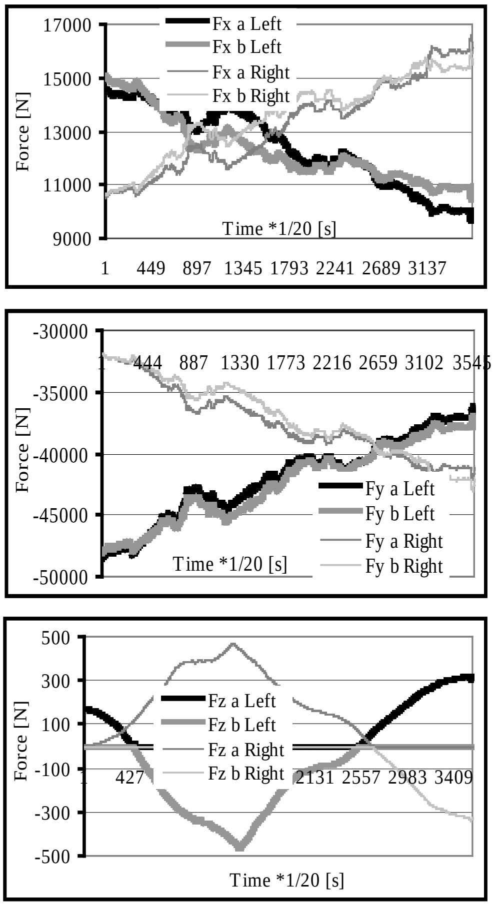

Fig. 21. Forces in the pulley bearings left and right case 1

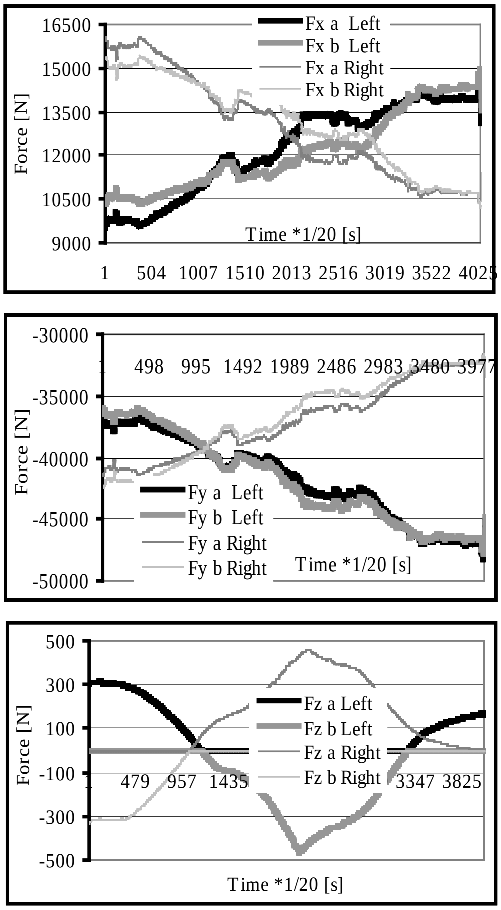

Fig. 22. Forces in the pulley bearings left and right case 2

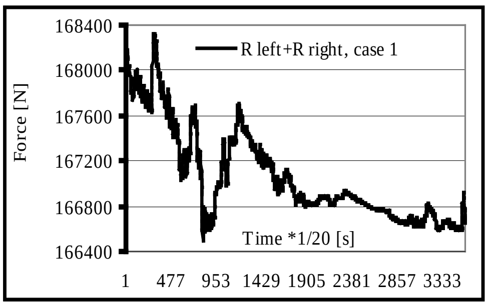

Fig. 23. Total loads when the elevator left climbing, right descending case 1

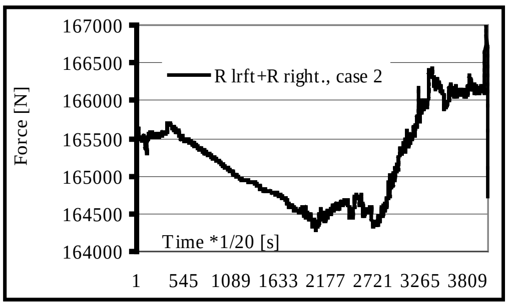

Fig. 24. Total loads when the elevator left descending, right climbing, case 2

4. STRAINS AND DISPLACEMENTS

Due to the complexity of the tower the most appropriate method of study is [1] that of the finite element. In order to analyze the state of strain and displacements with the method of the finite element and the tower structure has been modulated the geometrical and mechanical characteristics have been established and introduced into the calculation software. In the cases taken into study the mass of the tower has been calculated with the help of the software. In fig. 25 and 26 there are presented the strains and displacements for case 1, and in fig. 27 and 28 for case 2

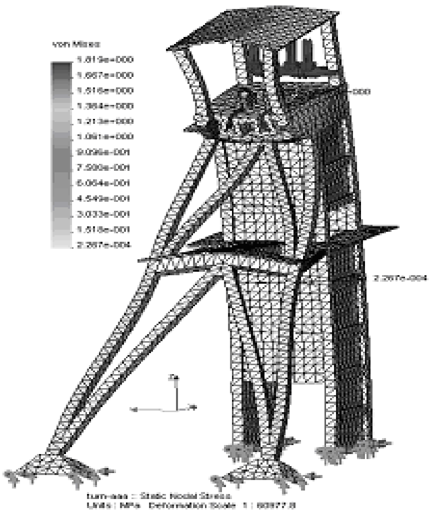

Fig. 25. Strains, case 1

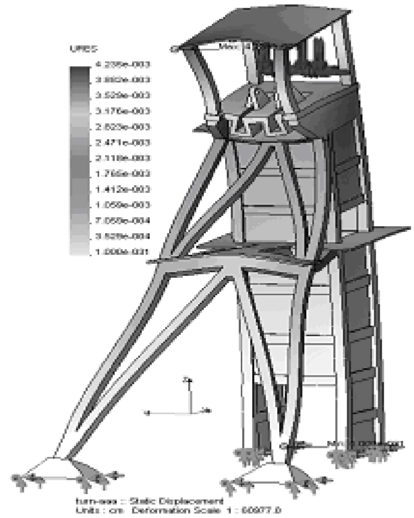

Fig.26. Displacements, case 1

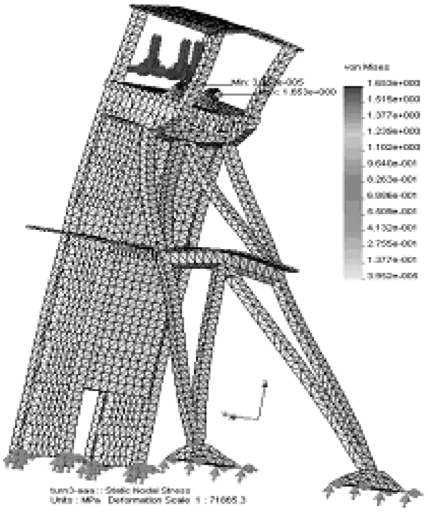

Fig. 27. Strains, case 2

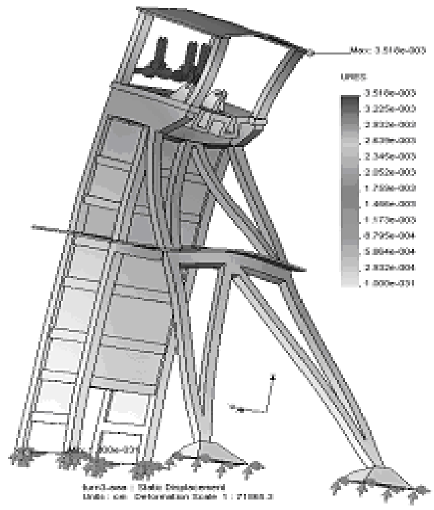

Fig. 28. Displacements, case 2

5. CONCLUSSIONS

There have been determined and localized the max values of strain and displacements from the tower structure, in order to establish the measuring points, in order to verify through experimental measurements the values obtained through numerical calculation Following these results there have been obtained information necessary in order to improve the maintenance of the extracting installations and to improve the existing system of repair and supply for this type of installations.

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LABOR PRODUCTIVITY IN THE MINING SECTOR

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DIANA CORNELIA CSIMINGA [2]

Abstract: In essence, the fundamental purpose of all economic activities is to satisfy human needs as fully as possible. Depending on this desiderate, all activities in the mining sector are carried out. Probably, from the point of view of the peculiarities, no other branch of activity is outpacing the mining branch. Its own technological aspects (induced by the specificity of the processes through which an "agglomeration" of useful minerals, billeted under certain conditions in the earth's crust) is identified, researched and possibly "put into use", superimposed on the particular mode of use and / or the exploitation of more or less "finite" mining "products" determines even more extensive economic features. The labor force factor, to which the concept of labor productivity is linked organically, is characterized by both a quantitative dimension and a qualitative dimension. The quantitative dimension refers to the amount of work of a given nature provided in a given production process. This volume can be quantified by the number of units of time worked under certain well-defined conditions of the production processes. The qualitative dimension implies an individual approach and refers to the professional specialization of each job provider, to his / her qualification and production experience, as well as to the level of productivity. For mining activities characterized by a pronounced specificity of the conditions under which work is done, the use of this production factor raises a number of particular problems to management. Decisions on these, almost entirely, call for labor productivity.

Keywords: *useful mineral matter, deposit, labor force, mining branch, labor productivity.*

1. TECHNOLOGICAL AND ORGANIZATIONAL ASPECTS SPECIFIC TO THE MINING BRANCH

Normalization of work, as an instrument of managerial control, is a common domain of many researchers and practitioners with very different professional backgrounds. That is why we considered it necessary to present the technological and organizational features of the mining branch.

The definition of the activity of the mining branch is based on the fact that, in all these cases, people want to "abduct" something of nature! This "abduction" is

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expressed by the word extraction. That "something" that is extracted has some defining attributes: useful, rare, and exhaustible.

The utility attribute immediately accompanies the verb to extract: useful substances are extracted. Coal, for example, is useful for combustion-releasing energy, mainly in power and thermal power plants, whose products have utility that is no longer to be demonstrated but only evaluated against other alternatives to electricity; and thermal, which is neither simple nor achievable from one day to the next, nor at times unbearable.

The rarity attribute is harder to perceive. Useful mineral substances abducted by nature through mining are not something common to anyone. What is more useful as the air that nature offers us? Air is not a rarity, but it is a substance more than useful, it is the condition of life on the planet. The useful mineral substance is generally rare and must be sought. The search for the useful mineral substance precedes and accompanies its extraction. In terms of specialty, this search translates into the names of specific activities: prospecting, exploration, industrial conditions studies. In brackets, it is now acknowledged that the discovery of anomalies in the earth's nipples can no longer be the fruit of chance or amateur search through individual actions. Exploitation of useful minerals has become a sophisticated and costly activity. Only the usefulness of the useful substance can justify the costs and risks of the search.

A mining project involved exploratory work to figure out and calculate a volume of useful mineral that would justify the launch of the "abduction battle". Exploring should understand where the beneficial mineral substance is in the depths, what form and extension the bodies we call deposits, how much can be extracted, how the space bodies are placed in space, what is around them, etc. Exploration of a perimeter lasts for many years and when it comes to "positive results" (volume of exploitable reserves where applicable technologies can be applied and the amount that allows the development of an extraction capacity under acceptable economic efficiency) lies at the basis a mining project for the development of an operating unit.

The project already involves work to reach the first points of the underground from which the "attack" will start on portions, on the areas where it will be "kidnapped" for ten or even hundreds of years, the useful mineral substance to exhaustion or until it is found that the "battle" must be stopped. In terms of specialty, the project provides for opening works (surface wells with hundreds of meters of depths, mileage galleries, high-profile underground chambers, water collection basins, inclined planes, blind "wells"). All of these works are arranged and equipped to provide transport, circulation, water drainage, clean air flow to all points where people are, and the return of the air to the surface. None of the above mentioned can be seen from the surface, and at the entrance to the underground you can see them only partially. You have to be a specialist and have imagination to be able to see this huge set of works.

For the extraction of the useful mineral substance in a large part of a deposit (large surfaces, hundreds of meters or even kilometers - dimensions measured on two main lines of the section, on the direction and on the inclination) are delineated by other works attacked from the above-mentioned openings, smaller portions of the large portion of the reservoir that we were talking about above. This time, galleries, inclined planes, grooves, and other minor works are known as preparatory works. The last portion of the reservoir delimited by preparatory work, the transport function, the staff movement, the air circulation becomes, when these works have reached a certain stage, a decommissioning field in which there is a "ready-to-use" reserve. At this point, I really came to the basic work of a mine - the slaughter works. In the simplest, but fairly widespread way, a field of slaughter ready for exploitation was delineated by preparatory work as a parallelepiped. Such a diversion field is prepared to apply a technology that, in specialized language, is known under different names (relative to the type of useful mineral substance exploited). In summary, it can be said that by advancing (opening and training) hundreds and even thousands of meters, after years, we have come to construct all the necessary ways and to delimit, from a deposit, a "deposit "Which contains the reservoir reserve, which in the case of the said parallelepiped varies widely enough, from tens of thousands of tons to over one million tons, depending on the geometry of the field in which the preparation was made.

The picture of the specificity of useful minerals extraction processes is not outlined if we do not understand the concept of "exhaustible" that I mentioned above, when I said that something extravagant is extracted ("abducting").

The exhaustible nature of most useful mineral resources must be understood in two ways. The general meaning of the exhaustible character derives from the fact that the geological anomalies materialized in the underground bodies in which something useful is found (coal, oil, gases, metals) are extremely low in volume compared to the whole bark of the planet and are the result of some processes geological training that lasted at least several hundreds of thousands of years, and in most cases millions of years. For this reason, the extraction and consumption of the vast majority of useful mineral substances leads to the depletion of natural concentrations accessible to extraction and processing at acceptable costs. This is a great problem of planetary politics, in which man faces nature. However, this aspect of the exhaustible character is not considered in this paper. The particular meaning of depleting character must be perceived at all levels of the exploitation units. When we say exploitation units, we mean a mining field, a mining perimeter, a mining perimeter. At the level of each mentioned unit, part of the geological anomaly discovered as a resource of useful mineral substances, was transformed by mining works into reserves of different categories: in exploitation (at the level of slaughter fields), in preparation (both at the level of the which have not yet reached the reserve stage ready for operation, as well as at the level of the technological sectors in which several minefields are being prepared by means of joint mining works) and, finally, at the opening (at the perimeter level for the part of the reserves the perimeter which, in order to become accessible to the attack of the training works, requires the continuation of major opening or attacking new opening works: for access to new lanes, generally to new buildings, for extension to other blocks, for descending to the depth). In principle, the portion of the unopened reserves is less well known and requires the prior execution of geological research. This is, of course, exploration mining operations in perimeters under exploitation.

The particular exhaustible character that we were talking about makes each tonne extracted from the abode to zero, in a longer or shorter time, the ready reserve of the considered deviation field.

A frontier line of a slaughterhouse that at some point represents a production capacity ends its existence after several months, up to a few years later, and requires machinery transfer work, zone isolation and other work. The secret of production management in the case of mining operations is to ensure the completion of those preparatory works to ensure the entry into operation of new abatement fields. The life and efficiency of a mining activity depends on how the gaps between the three categories of work (cutting, preparation, opening) are kept under control until the perimeter reserves are exhausted if it is outlined.

2. GENERAL ASPECTS OF LABOR PRODUCTIVITY

Labor productivity expresses the efficiency of the production process from the point of view of labor costs: in the specialized works, the concept of labor expense and consumption of labor is used. For the sphere of this work, we considered the notion of labor consumption more appropriate, meaning that it is an expression in units of labor (number of personnel of the period, time units of time). It is the basic factor of the increase in production and synthetically expresses the living labor costs per unit of product or vice versa, the volume of production per unit of work spent.

In order to reflect concretely and multilaterally the quantitative and qualitative aspects that allow the determination of the influence of the various factors on which labor productivity depends, a system of indicators is needed. These indicators should refer to labor costs, production and technical and social conditions of the production process.

The rationale of the system of indicators of labor productivity can be thus expressed:

- the characterization of the absolute level of labor productivity, expressed in different units of measure;
- the evolution of labor consumption over time;
- Quantitative evaluation of the influence of factors with direct action on the increase of labor productivity;
-determination of labor force needs;
-Appreciation of labor needs in different activities and the main directions of efficient use of human resources.

Labor cost indicators are of overwhelming importance in terms of content and scope, and their adoption involves solving many problems, sometimes quite difficult.

The labor consumptions used in the calculation of labor productivity are generally expressed in actual, normed or planned quantities. Scope and how to group work-related consumption is a problem that resolves according to the purpose for which the labor productivity indicator is used. Work consumption may be limited to the workplace, to a certain category of staff or may involve more jobs and more staff by grouping them according to criteria that are consistent with the intended purpose.

It also presents a wide variety and expression of production used in the calculation of labor productivity: natural units, natural-conventional units, units of value, units of work, and so on. Expression of the quantity of production is determined, first of all, by the specificity of the activity and, obviously, by the aim pursued.

The labor productivity indicator generally expresses the ratio between two sizes: the quantity produced and the amount of labor consumed to obtain that amount of production. There are activities in which this simple relationship can be easily concretized. These include, for example, coal mining, electricity production, cast iron, steel, cement, etc. The study of work productivity variation for one and the same product executed by several homogeneous subunits allows to determine the causes that lead to differences and to substantiate some decisions to improve the situation.

The calculation of labor productivity in natural units can be done only in the case of homogeneous production. The productivity of work in natural expression expresses the reality most faithfully, but has a very limited sphere of applicability, being impossible to apply in the conditions of enterprises with a very wide diversification of production.

Expression of labor productivity in natural-conventional units is a variant of expression of labor output in natural units and is practiced in production units of the same kind, but with qualitative differences. This is also the case for useful mineral exploitation units.

Measuring labor productivity at enterprise level and possibly in a broader sphere (group of enterprises, branch, and economy as a whole) is only possible in terms of value. In this expression, the relationship numerator is evaluated on the basis of constant prices. Assessing output at constant or comparable prices is designed to mitigate the impact of possible price changes and inflation. In this way, the level of labor productivity expressed in value is influenced only by the internal factors of the production process.

Expression of production value for the purpose of calculating labor productivity at the level of a broad-based production system (sector, section, factory, plant, mine, quarry, enterprise, group of enterprises) has a broad meaning and scope refers to the entire activity of the system. In the past, economic practice has used several indicators to express the value of production (global production, global circulation, net production - to characterize the entire activity or production of goods, output used, and output sold and earned - to characterize only the activity refers to production destined for outsourcing). We will not insist on the content and limits of relevance of these indicators because mining activities do not justify a deepening of these issues. We will, however, come back to highlight specific aspects of these indicators in the mining sector.

An important aspect of the production value expression, irrespective of the indicator used, is the period of time the indicator refers to. Thus, the goods production indicator cannot serve for the calculation of labor productivity for large-scale enterprises, since according to the calculation method of this indicator it does not take into account the increase or decrease of the unfinished production stock and other products and services destined for internal consumption (tools, devices, verifiers, semi-products of their own production).

The volume of production can be determined in a variety of variants, depending on the level at which labor productivity is determined: labor productivity at sub-unit level, unit labor productivity, group of units (enterprise, company, and branch).

At unit level, labor productivity is calculated on the basis of the so-called finished (final) production data from its point of view. Multi-unit-level productivity indicators that produce products or services provide a medium value. Average productivity averages based on global production do not allow a real appreciation of labor productivity between different subunits; they also do not allow an accurate assessment of the efficiency of labor consumption in one subunit, compared to another.

3. VALUE INDICATORS OF LABOR PRODUCTIVITY IN THE MINING SECTOR

The production value expression for the purpose of calculating labor productivity is used at a complex production system level (sector, section, factory, plant, mine, quarry, and company) and uses prices to calculate various indicators: global production, cargo or production sold and collected.

Global production characterizes the entire volume of business activity and is obtained through a direct calculation of the multiplication of the quantity of products or services with comparable prices. Total production, calculated by the enterprise method, for industrial products and works that are executed from the customer's raw material includes the raw material brought by the customer at current billing prices of the period, thus not reflecting the conditions of constant pricing. The value of the global output of the period includes stock changes to unfinished production, tools, devices, verifiers and semi-finished products of their own production. The actual determination of labor productivity based on the global production indicator is only possible if, mainly, the nomenclature of the manufactured output, the structure of production and the consumption of raw materials and materials for the manufacture of the various products remain constant.

If the requirement stated in the previous phase is for a coal mining mine, instead of the manufactured output nomenclature, we should consider the mining, opening, preparatory, geological research and abstractions of the raw coal. The structure of production means the structure of the types of works mentioned. Consumption of raw materials, according to all known concepts, does not exist. Materials for the manufacture of various products should be considered as consumed for the purpose of performing the work nomenclature in the period-specific structure. None of the above is constant over time and consequently a value indicator of labor productivity calculated on the basis of the value of global output is not usable for comparisons between units and between time periods.

A simplification of the problem can be suggested and is easily accepted. A single product in the nomenclature shall be considered raw coal extracted or coals expressed in conventional units. Such production value indicators are very easy to calculate, the nomenclature is a single product and it is maintained throughout the life of the mine. With this simplification, however, we have only "discovered" another value indicator, the production of commodities.

The production of goods cannot be used for the calculation of labor productivity since, according to the calculation method of this indicator, it does not take into account the increase or decrease of the volume of reserves in the opening and in preparation, nor the change in the structure of coal production under the conditions in which processes are underway. This is equivalent to changing the structure of materials and materials consumed for production. These deficiencies particularly affect calculations over short periods of time, and for periods of years it has no value for mine management, and if taken into account would lead to totally erroneous conclusions because of the singularity of the conditions, in which the mine was managed, have undergone the main underground processes in each period of mine life. The life of the mine could be jeopardized if mining management were to maximize the production of goods on a monthly basis.

If many firms in manufacturing can base their assessments on past achievements, mining units cannot do this without great risks when comparisons relate to labor productivity expressed in units of value and production costs. When the benchmark of the past becomes unusable, there is the solution to fix a normative reference on other bases.

Net production is the indicator for which a particular interest in determining labor productivity has been shown. Carboniferous mining uses the concept of net production with two meanings. One is totally different from the net economic output: it is, in fact, an indicator of output in natural units (extracted coal) resulting from the correction of gross output for quality differences.

In the economic sense, net production (as a value indicator), as opposed to global production or commodity obtained by multiplying the quantities of products or services with comparable prices, is obtained by lowering material expenses (raw materials, fuel, energy, depreciation, services from outside, etc.) of global production calculated in current prices of the period. Significant volumes of works (openings, preparations, re-engineering, repairs, workshops) executed with internal forces are not reported and highlighted as current assets (when running from so-called investment funds) or as ongoing production). Efforts for such works are simply highlighted as production costs, so all material costs, including those for work in progress, are subtracted from global output to obtain net output. The size of this indicator, however, depends on the volume of labor consumption in all mine activities, but the only product included in the calculation of global production and implicitly net is the coal delivered, so the indicator is distorted by the structure of the works. In addition, the size of the indicator depends on the influence of taxes and differentiated pay policies.

At sub-unit level, global production may be confused with the final output of the unit. At the unit level, however, the sum of the global outputs of the subunits can no longer be confused with a final output due to the consumption of the production of some subunits by other subunits within the same unit. Independently of the value indicator used, without solving the price issue on the basis of which the value of the products and services is calculated and the value of the inputs being deducted, any assessment of the efficiency of labor consumption is not real.

Mining companies which have as their object the exploitation of energy coal have the peculiarity that at the level of the operating units and at the level of the companies they supply virtually a single product, energy raw material. This production, regardless of the mode of expression, involves the conversion of gross mining mass into conventional units (Gkal, Gf) or in value units using transformation coefficients or prices.

The calculation and analysis of labor productivity in natural units will be possible, at the same enterprise, and in case of expression in conventional or value units, provided that correct transformation coefficients are used (even the Gkal or Gf price can be considered a transformation coefficient).

4. CONCLUSIONS

In a synthetic form, the main conclusions that can be taken are the following:

- in the activities of the mining branch, the "nature" production factor has an entirely and wholly utilizable way: mining produces not only certain land plots, but natural agglomerations of useful minerals in the earth's crust (minerals deposits useful);
- in the mining sector, the mineral resource useful at the same time is a product and an object of activity (during the prospecting and exploration phases, the deposit is the product of the mining activities, so that later on during the development and exploitation phases, becomes their subject);
- knowledge of a mineral resource requires four stages: the identification and research of the deposit, the establishment of the technological characteristics of the useful mineral substances in the deposit, the elaboration of the technical and economic evaluation documentation of the possibilities for capitalization of the deposit, elaboration of the technical and economic documentation of the exploitation of the deposit);
- the labor productivity is linked to the labor force production factor, which implies a quantitative expression (volume of labor, of a certain nature, provided in a given production process), but also a qualitative dimension (the professional specialization of the work, skill level, experience);
- to be able to concretely and multilaterally reflect the quantitative and qualitative aspects that can determine the influence of the various factors on which labor productivity depends, a system of indicators is needed: these indicators must relate to labor costs, production and technical conditions, and social aspects of the production process;
- labor productivity is determined as the ratio between the volume of production and the associated work consumption. In the mining sector, for the measurement

of labor consumption, the so-called "job" (equivalent to the work done by a man during an exchange of labor) is generalized;

- the mode of expression of labor productivity is different: natural units, natural-conventional units or units of value (mining enterprises predominate in natural-conventional units: tons (with certain quality characteristics) / post);
- in the literature there is no particular approach to productivity, in which the research base is represented by the mining production processes;
- Productivity surveys have outlined two ways to approach its quantification: the aggregated approach, or the partial (component) approach. If the first approach has a clear theoretical dimension, the second approach has a distinct practical applicability (with implications in the design of productivity systems);
- in the activities of mining enterprises, the second approach to quantifying productivity is generalized;
- for the determination of labor productivity at the level of mining enterprise has an extended use the net production indicator (expression in conventional natural units, eg gig calorie, represents an extension of the mentioned indicator);
- in the Romanian enterprises there were no systematic researches on the quantification and the expression of the productivity of labor;
- the problem of productivity in the mining sector has received special attention: the elaborated normative and normative systems (for the particular conditions of exploitation of useful minerals in the different geographic areas of the country) have allowed the correlation between productivity and salaries to be substantiated.

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MATHEMATICAL MODEL OF OPTIMIZATION OF THE ORGANIZATIONAL STRUCTURES IN THE CASE OF ADOPTING THE MANAGERIAL REORGANIZATION DECISION OF A MINING SYSTEM

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GHEORGHE-FLORIN BUȘE[2]

Abstract: Organizational structure is an instrument that managers use to achieve the expected results by efficiently and efficiently capitalizing on resources. The analysis of the organizational structure involves trying to know what the basic units that make up any organization are and what relationships they keep between themselves and the outside. The paper addresses the main aspects of the methodology for improving managerial modeling. The authors of the paper emphasize the importance of a distinct requirement for managerial decisions under the dynamic market conditions and this is the reorganization and rapid adaptation to environmental flexibility. Using mathematical modeling, the authors analyze multiple options for complex modeling of production within the mining system and to produce an optimal and efficient variant.

Keywords: *organizational structure, mining activity, exploitation technology, mining product, production modeling, optimal and efficient variant*

1. INTRODUCTION

One of the major functions of the management is the organization that consists in allocating the resources of the organization in order to fulfill its strategic objectives and involves three successive activities: job breakdown (job specialization), combining positions to create departments and delegating authority.

The organizational chart is a graphical presentation of the organizational structure of the enterprise, which reproduces the components of the structure and their relationships.

Being a dynamic and complex element, the organizational structure requires continuous training based on realistic studies that are based on the concepts of managerial science.

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The organizational structure must be designed to enable the organization's strategy to be achieved. To this end, determining the organizational design will take into account, first of all, the key factors and critical objectives arising from the mission and overall strategy of the organization.

The process of analyzing and designing the organizational structure involves the following steps: analyzing the objectives of the enterprise; defining the activities and determining their content; designing divisions, grouping them and establishing relationships between them; the proper design of the organizational structure; the assessment of the functionality and the constructive aspect of the enterprise structure.
More complex technology requires a greater number of managers and hierarchical levels, leading to elongation of the organizational structure and increased coordination and supervision; the control time of first-line manager increases from single to mass production, decreasing to automated production; most managers in companies with high technological complexity also provide other administrative activities. The significance of these conclusions is that for each type of technology, the organizational structure presents specific aspects.

Analyzing the organizational structures of several mining enterprises, the following problems have been identified: most of the structures are of a linear-functional type with a heavy informational system and an authoritative decision-making process; decisions are taken exclusively at the level of higher management, which poses both positive and negative aspects.

The circulation of information takes place both vertically and horizontally in a specific way. Vertically, the information from executives to managers goes through a difficult and multi-level road.

The methodological system also did not have a development, the components of the decision-making process being the most used by the meeting, less the delegation and the participatory management. The methodological system contributes significantly to increasing the rationality and, implicitly, the efficiency of each management process, at its level being visible the tendency of professionalization of management.

This situation leads to insufficient scientific substantiation of higher-level decisions, on the one hand, due to the lack of service to an evolved decisional instrument and, on the other hand, due to insufficient information support. And the non-referral to modern management systems such as goal management, budget management, project management, etc. has a negative impact on the efficiency of management within the enterprise.

It seems unreal, but to date some businesses do not yet have specialized departments and sometimes very important activities in their structure, such as managerial planning and organization, legal service, marketing or staff management, are missing or insufficiently dimensioned. This causes the unclear definition of responsibilities, obligations, requirements, tasks between structural compartments (divisions), which are currently dealing with several problems at a time.

In most cases, the principle of flexibility is not taken into account when drawing up the organizational chart. Organigrams are sometimes static, while market flexibility is very high and requires companies to act as quickly, appropriately and efficiently as possible to environmental change. In a dynamic environment, businesses need to be prepared to cope with new market conditions and frequent changes to customer needs. Because the environment in which they operate changes so rapidly, they are forced to reevaluate and reassess their role in society. Businesses need to adapt, and adaptation needs to be faster than environmental change, only when it is effective.

It is necessary to create new organizational structures in several variants, which are subject to analysis based on a system of indicators and parameters in order to quantify the advantages and disadvantages offered by each variant of the structure. Then, under the new conditions, the enterprise can use these new model structures.

Modern affairs tend to move to flattened organizational forms to improve communication, to introduce the practice of delegation, and to increase the responsibility of each employee, with the elimination of unnecessary managerial levels. Among the disadvantages of flattening organizations is the discontent of managers at lower hierarchical levels who, seeing their ability to advance, are looking for other jobs. To work effectively, this type of organization needs talented managers.

The formal structure of an organization is called the organigram, and the informal one is called sociogram. One of the direct implications of the existence of these two types of structures within an organization is the existence of two types of leaders: formal or informal. From the point of view of the attributes of managers, the former exercise their authority (based on their formal position), the others exercise their influence (based on the social and communication skills).

The paper does not aim to describe the existing managerial concepts on the design and reorganization of managerial structures, but to demonstrate the necessity of their re-evaluation and reorganization depending on the changes in the environment.

2. MODERNIZING THE ORGANIZATIONAL STRUCTURE

Regarding the requirements for the modernization of the organizational structure, the specialists in the field of organizational management, mention that, synthetically, they can be presented in the form of the transition from the mechanistic type to the organic type [8]. Also, in the organizational structure of enterprises, there are several mutations that support the current functioning of organizations and facilitate their adaptation to business [3].

Mechanistic organization is the approach of the enterprise as a closed system, while the organic organization extends its scope to all the activities involved in achieving the objectives of the enterprise, being approached as an open, dynamic system. Particular attention is paid to taking into account the interaction between the environment and the organization of the firm and, implicitly, creating the conditions for producing creativity and promoting innovation.

A trend that will undoubtedly intensify is the amplification of the information dimension of the structural organization [2]. The basis for this evolution lies in the increasingly important role that information has in the modern business. Specialists confirm that there is a certain correlation between the ability of an enterprise to consume information and the level of productivity within it. Thus, posts must be treated not only as primary elements of the organizational structure, but also as transmitters and, at the same time, as recipients of information.

The opinion of the authors on the quality and efficiency of the organizational structure will be based not only on the analysis of the modified organizational chart but also on the functioning of both the organizational elements and the whole organization as an economic subject. The assessment of the effectiveness of the organizational structure, although complex and difficult, in the authors' opinion, can be focused on some evaluation criteria and indicators, expressing, on the one hand, the constructive side of the structural configuration, also called the structural static. Another part - the functionality of the organizational structure, also expressed as the "dynamics of the structure".

The first category includes: the cost of the structure (the weight of the administration expenses in the total expenses of the enterprise); the simplicity of the structure (characterized by the number of hierarchical levels and departments); share of functional departments (their staff) in total staff; staffing and remuneration fund; degree of organization, etc. The second category includes the non-quantifiable effects, mostly being the majority, expressing the level of realization of the modified set of objectives of the respective structure.

3. CASE STUDY: SYSTEMATIC ANALYSIS OF TECHNOLOGICAL FLOWS FOR CATEGORIES OF COMPLEX PROCESSES REPRESENTATIVE OF THE MINING INDUSTRY

3.1 Technological processes for the exploitation of coal deposits

The technological chain of any enterprise, from raw material to final product, involves at each stage certain efforts (costs) of it, after which certain effects (profits) are obtained. Each of the companies, meeting in this process, optimizes their activities in order to achieve maximum effects or minimum costs.

Production programs, developed separately from each enterprise, will not always constitute an acceptable program for the complex as a whole. As a rule, some businesses carry out their program in full, others - no. In this context it is important to highlight aspects of the economic potential as a whole. In the case of marginalization or favoring some producers, the economic potential of the complex is reduced.

The production situation described above can be examined and exemplified in a mathematical model using formalized language. We admit M1 and M2 producing raw material enterprises for the industrial complex A. Examples of such enterprises and industrial complexes may be the most diverse. The principles of effect-weighted effects in such complexes are described in [11].

In the literature there are presented technological chains for fields of activity in the agro-food industry [7].

The mining activity for the exploitation of a useful mineral resource consists of the whole of exploration, exploration, development, exploitation, preparation / processing, concentration, marketing of mining products, mine preservation and closure, including related environmental restoration and rehabilitation works [9].

Operation is the set of works executed underground and / or surface for extracting mineral resources, processing and delivering them in specific forms [10].

After completing the fundamental geological research stages and the exploration phase, which may take several years, the main stages of the mining activity are taken. The main phases are the opening, preparation and exploitation of the deposit, to which others are added, such as the construction of roads, the transport of the tailings and the useful minerals, its storage, the activity of the dumping, storage industrial waste, transport and equipment location, water evacuation, aeration if it is underground or dust reduction, if it is an up-to-date operation, staff transport, building construction and loading / unloading ramps, a well-defined order.

Mining is the amount of mining products extracted for processing and / or marketing by the holder.

Mining product is the product resulting from the operation of a deposit, delivered as such or in the form of sorts resulting from a process of processing / preparation for use as a finished product or as a raw material for the manufacture of another product.

A systemic analysis of the technological flows was then carried out for several categories of complex, continuously functioning, representative processes in the mining industry. The purpose of this analysis is to form a correct image of the technological process, of the functioning of the installations and the interrelations between the technological flows.

Coal is used as a primary source for the production of electricity and heat or in industrial processes.

Depending on the conditions of the deposit, the exploitation is done in underground mines or in quarries, applying the most appropriate exploitation methods and working technologies.

Thus, for the exploitation of the higher coal deposits, in the case of thin, medium, horizontal or low inclined thicknesses, the method of exploitation with frontal abates, in long poles in the direction or slope of the layer, is applied.

In the case of thick, high-inclined strata, the method of exploitation in horizontal slices is applied with the extraction of coal in strips or by mechanized complex fronts.

At low or medium slopes, the sloping slicing method is used with the extraction of coal in the long-beam absections [1].

Technological process is the totality of simultaneous or time-consuming operations required either to obtain a product (by extraction, processing) or to maintain or repair a technical system. The technological process can be achieved through different technologies. The technology indicates the essential changes in shape, structure and chemical composition necessary to achieve a product and is based on fundamental phenomena and characteristic laws.

For the development of a technological process, raw materials, energy resources and machinery are needed.

The technological process of exploiting a lignite deposit in the quarry comprises the following phases: extraction, transport and storage of sterile and coal.

Currently, the production processes in the lignite quarries are completely mechanized, which means that all the work phases are linked together, and the technical machinery for their mechanization is functionally (power and capacity) with the power and capacity of the main machine of the technological flow, which is the rotor excavator [4].

We will analyze some technological coal processing chains in different variants of the mining activity shown in figure 1.a) for quarries and figure 1.b) for mining.

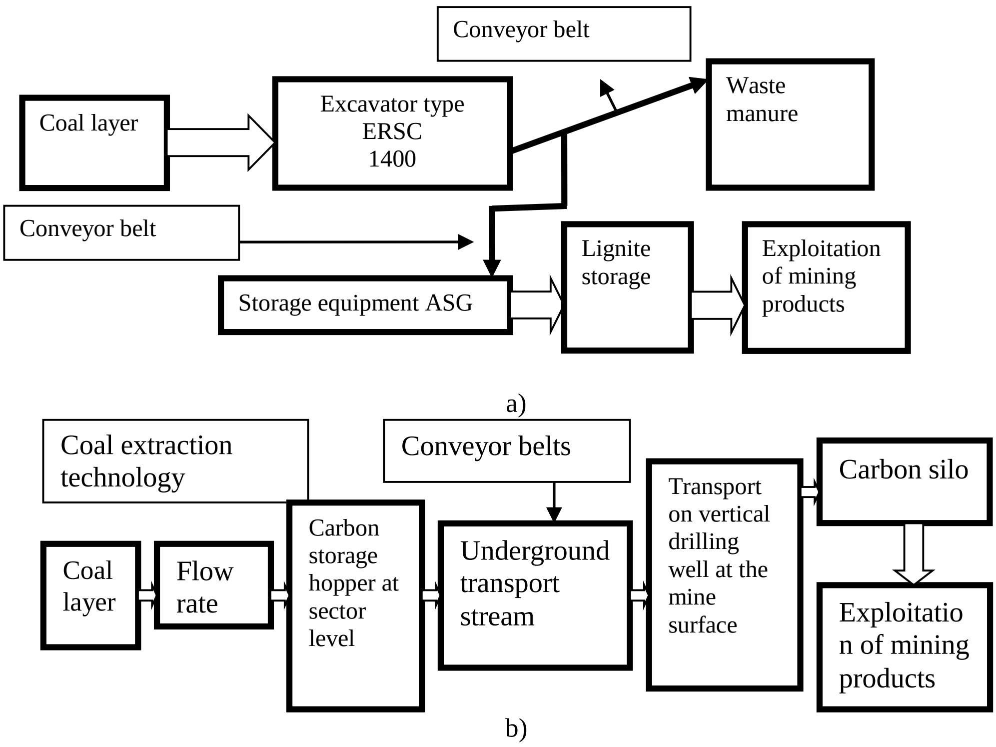

Fig. 1. Variants of technological chains within mining industrial complexes
a) Technological scheme for excavation and storage in the quarry
b) Technological scheme for exploitation, underground transport and storage at the surface of the mine

Mining is the amount of mining products extracted for processing and / or marketing by the holder.

Production involves the transformation of resources (capital, equipment, labor, information) into products or services. In the production process, managers are concerned about resource efficiency. On the basis of efficiency objectives, basic rules are laid down on how businesses need to use resources. These objectives are divided into two broad categories:

• minimizing the costs of achieving a certain level of production;

• maximizing output at certain costs.

The total consumption of inputs (expressed in cash) to obtain a certain amount of production is called the cost of production. The cost is expressed in money, because in order to acquire the factors, the producer companies pay certain amounts of money, that is, they spend. As a result, production costs are also known as production costs.

3.2 The mathematical model

Administrative relations between coal-producing enterprises and mining industry can be expressed through legal relationships such as:

- $M_1 \in$ A (the legal M_1 mining enterprise is part of the mining industry complex);
- $M_2 \in$ A (the legal M_2 mining enterprise is part of the mining industry complex);
- M_1 and $M_2 \in$ A (mining enterprises M_1 and M_2 are parts of the mining industry complex).

The industrial mining complex A may consist of the processing and commerce industry, and the coal mines, administrative, are separated. They produce coal for the mining industrial complex A based on price negotiation with or without sale-purchase contracts; the complex can be partly made up of mining enterprises (the rest of the mining and administrative enterprises do not belong to the complex), the processing and commerce industry.

The amount of coal required for the operation of the mining industrial complex A is p_0, mining enterprises M_1 and M_2 produce coal respectively in p_1 and p_2, restricted by the amount $p_1 + p_2 = p_0$, $p_1 \geq 0$, $p_2 \geq 0$.

Production costs of M_1 and M_2 mining enterprises will be C_1 and C_2, being production volume functions [5]:

$C_1 = C_1 (p_1)$, $C_2 = C_2 (p_2)$.

For example, cost features may be shaped [6]:

$$C_1(p_1) = \frac{30096 + 61{,}2p_1 + 0{,}42p_1^2 - 0{,}6p_1^3}{11 - 0{,}05p_1}; \quad p_1 \in (0, 219)$$

$$C_2(p_2) = \frac{6636 + 102{,}8p_2 + 0{,}2p_2^2 - 0{,}046p_2^3}{8{,}4 - 0{,}04p_2}; \quad p_2 \in (0, 219)$$

Case 1. Mining companies M_1 and M_2 belong to the mining industry A (M_1 and $M_2 \in$ A); $p_1 + p_2 = p_0 = 200$. Here, the mining industrial complex aims to develop the production program for M_1 and M_2 mining enterprises, for which the total C (p_0) costs (expenses) will be minimal.

The mining industrial complex solves the problem of mathematical modeling:

$C(p_0) \rightarrow min$, in conditions of: $p_1 + p_2 = 200$, $p_1 \geq 0$, $p_2 \geq 0$

The minimum value of the function was determined:

$C(p_0) = C_1(p_0 - p_2) + C_2(p_2)$

From the condition $\frac{dC(p_2)}{dp_2} = 0$, we determine p_2^* = 111, then

p_1^* = 200 - p_2^* = 200 - 111 = 89 (coal production units)

For the values p_1^* and p_2^* the costs will be minimum:

$C_1^*(p_1^*) + C_2^*(p_2^*)$ = 9976 (monetary units)

If the volume of coal production required for the mining industry A was produced by the M_1 mining company, the cost of the complex would have been:

$C_1(p_1) = C_1(200)$ = 14040 > 9976 (monetary units);

If the coal production volume required for the mining industry A was produced by the M_2 mining company, the cost of the complex would be:

$C_2(p_2) = C_2(200)$ = 12400 > 9976 (monetary units).

Let's examine the specific costs (per tone of coal):

$$\frac{C_1(p_1)}{p_1} = \frac{\frac{30096}{p_1} + 61{,}2 + 0{,}42p_1 - 0{,}6p_1^2}{11 - 0{,}05p_1}; \quad p_1 \in (0,\ 219)$$

$$\frac{C_2(p_2)}{p_2} = \frac{\frac{6636}{p_2} + 102{,}8 + 0{,}2p_2 - 0{,}046p_2^2}{8{,}4 - 0{,}04p_2}; \quad p_2 \in (0,\ 219)$$

From the conditions of cancellation of the first derivative: $\left(\frac{C_1(p_1)}{p_1}\right)' = 0$; $\left(\frac{C_2(p_2)}{p_2}\right)' = 0$,

We determine: p_1^* = 137; p_2^* = 93.

If mining companies M_1 and M_2 set their production programs exclusively for their own interests, then the minimum cost per unit of product (tone of coal) will constitute: $\frac{C_1(137)}{137} = 59{,}5$, $\frac{C_2(93)}{93} = 37{,}84$ (monetary units).

If mining companies M_1 and M_2 set the production program for the mining industry A, then the specific costs will constitute: $\frac{C_1(89)}{89} = 64{,}4$; $\frac{C_2(111)}{111} = 38{,}2$ *(monetary units).*

The unit-specific production costs increased by + 4.9 monetary units (64.4 - 59.5) for the M_1 mining and +0.36 monetary units (38.2 - 37.84) for the M_2 mining enterprise; at a total of 89 production units, this increase would have been +436.1 (4.989) and at 111 production units it would have been +39.96 monetary units (0.369111).

Finally, the total expenditure would have been higher by 476.06, which would have constituted 9976 + 476 = 10452 monetary units.

Case 2. The M_1 mining is an administrative component of the mining industrial complex A and the M_2 mining works under self-management conditions. The M_1 mining company can provide the productive activity of the coal mining industrial complex in the required amount of p_0 = 200 production units. In this case, production costs will be $C1$ (200) = 14040 monetary units.

If the mining industry A acquires coal from the mining company M_2 in the amount of p_2, then the expenses of the mining industrial complex A will be reduced by*:*

$$\Delta(x_2) = C_1(200) - C_1(200 - p_2) = 14040 - \frac{30096 - 61{,}2(200 - p_2) + 0{,}42(200 - p_2)^2 - 0{,}06(200 - p_2)^3}{11 - 0{,}05(200 - p_2)}$$

In order to reduce potential expenditures in volume 14040, raw material in the amount of (200 - p_2) is commissioned by the mining industry complex A for the M_2 mining enterprise. In this case, it will bear costs determined by function C_2 (200 - p_2). The optimal value is:

p_2^* = 111; p_1^* = 200 - 111 = 89 production units

If the M_1 mining company produced 200 units of coal, its cost would have been C_1 (200) = 14040; but the M_1 mining only produced = 89 production units, its expenditures constituted C_1 (89) = 5732 monetary units. Thus, the M_1 mining company incurred expenses at 14040-5732 = 8308 monetary units.

The mining company M_2, producing coal in the amount of 200 - 89 = 111 production units, did not bear the cost of 8308, but only 4244 monetary units.

The mining industrial complex can work in case 2 in several ways.

Case 1. Both p_1 and p_2 administrative coal producers belong to the mining industrial complex, the coal demand is 200 units of production, each coal producer has production capacities, respectively, 0 <p_1 <220; 0 <p_2 & lt; 210.

In this case, each of the M_1 and M_2 mining companies will produce optimal quantities: p_1^* = 89 production units with minimum expenses C_1^* = 5732 monetary units and p_2^*=111 production units with minimum expenses C_2^* = 4244. The total production costs of the mining industry related to the production of coal will constitute $C_1^* + C_2^*$ = 9976 monetary units. The total production costs of the mining industry related to the production of coal will be: $\frac{C_1(89)}{89} = \frac{9732}{89} = 64{,}4;\quad \frac{C_2(111)}{111} = \frac{4244}{111} = 38{,}2$ (monetary units)

Each of these specific costs determines the weighted specific costs of the mining industry:

$$\frac{64,4 \cdot 89 + 38,2 \cdot 111}{89 + 111} = 49,859 \text{ (monetary units)}$$

So, if both coal producers are part of the mining industry complex, productive activities are characterized by the following economic indicators:

• for the first M_1 producer: (89 production units, 5732 total expenditure units, 64.4 specific expenditure units);

• for the M_2 producer: 111 production units, 4244 total expenditure units, 38.2 specific expenditure units);

• for the industrial complex: (89 + 111) (5732 + 4244), 49,859) = (200 production units, 9976 total expenditure units, 49,859 specific expenditure units).

Case 2. The first M_1 coal producer belongs to the mining industrial complex, and the second M2. In addition, for some reasons (perhaps non-economic), the M_2 producer does not provide the coal mining industrial complex, ie $p_2 = 0$. The production capacity of the M_1 producer is $p_1 = 200$, the total raw material production will be:

$p_1 + p_2 = 200 + 0 = 200$ production units

The expenses of producers M_1 şi M_2 will be: $C_1(200) = 14040$; $C_2(0) = 0$.

Comparing the total expenses from the case 1: $C_1^* + C_2^*$ = 9976 with the total expenses from the case 2: $C_1^* + C_2^*$ = 14040, the difference being: $C_1(200)-(C_1^* + C_2^*)$ =14040-9976=4064.

Into the *second* mode the expenses increased with: $\frac{4064}{9976} \cdot 100\% = 40,7\%$

In case 2, the costs of a unit of raw material represent the value of: $\frac{C_1^*(89)}{89} = 64,4$ till 70,2, which means $\frac{70,2 - 64,4}{64,4} \cdot 100\% = 9\%$

Therefore, the mining industry complex does not like the exclusion of the raw material producer M_2 in its composition. If the M_2 coal producer was the administrative component of the mining industry, the production costs of the complex at a unit of raw material constituted 49,859, in case 2 these were of 70,2 units of currency, so they increased: $\frac{70,2 - 49,859}{49,859} \cdot 100\% = 40,8\%$

This is the price paid by the mining industrial complex for the removal of its M_2 coal producer (production process).

Case 3. M_1 coal producer does not belong to the industrial complex, is removed from the production process of the complex ($p_1 = 0$) and the coal producer M_2 belongs to the mining industry complex, having a production capacity of $p_2 = 200$ units. The production costs of the M_1 manufacturer will be C_1 (0) = 0; of the M_2 manufacturer will be C2 (200) = 12400 currency units. We compare the costs of Case 5 to Case 1: $C_2(200)$

- $(C_1^* + C_2^*)$ = 12400 - 9976 = 2424 monetary units, which increased with $\frac{2424}{9976} \cdot 100\% = 24{,}3\%$

Specific production costs in the case 3: $\frac{C_2(200)}{200} = 62$; compared to the case 1: $\frac{C_2(200)}{200} - \frac{C_2^*(111)}{111} = 62 - 38{,}2$, having an increase with $\frac{23{,}8}{38{,}2} \cdot 100\% = 62{,}3\%$.

Case 4. None of the two coal miners, administrative, belong to the mining industry A, each of these producers determines their optimum coal production, which is $\overline{p}_1^*$ respectively $\overline{p}_2^*$; $\overline{p}_1^* = 137$, $\overline{p}_2^* = 93$.

The production expenses will be $\overline{C}_1(137)$ = 8151,5; $\overline{C}_2(93)$ = 3519,12 (monetary units).

The production expenses: $\frac{C_1(137)}{137} = 59{,}5$, $\frac{C_2(93)}{93} = 37{,}84$

We compare the specific production costs of case 4 with those in case 1:

$\frac{C_1^*(89)}{89} - \frac{C_1^*(137)}{137} = 64{,}4 - 59{,}5 = 4{,}9$ or an increase of $\frac{4{,}9}{59{,}5} \cdot 100\% = 8{,}2\%$

$\frac{C_2^*(111)}{111} - \frac{C_2^*(93)}{93} = 38{,}2 - 37{,}84 = 0{,}36$ or an increase of $\frac{0{,}36}{37{,}84} \cdot 100\% = 0{,}95\%$

Specific weighted costs: $\frac{59{,}5 \cdot 137 + 37{,}84 \cdot 93}{137 + 93} = 50{,}74$ (monetary units)

Compared with Case 1, they increased by: $\frac{50{,}74 - 49{,}859}{49{,}859} \cdot 100\% = 1{,}85$

So, it is argued that the administrative inclusion of coal producers in the mining, economic, industrial complex is justified.

Case 5. The coal producer M_1 belongs to the mining industry complex A and the M_2 producer does not belong to this complex, each of these producers is not removed from the production process of the complex, $p_1 > 0$; $p_2 > 0$, the coal demand, $p_1 + p_2 = 200$. In this case, coal producer M_1 produces coal = 89 units (case 1) (per unit).

The second M_2 coal producer, even if the optimal quantity he would provide, is over 111 units, the mining industry favors the M_1 producer and the second one is 200-89 = 111 units of coal; expenses $C_2^*(111)$ = 4244, total expenses: $C_1^* + C_2^*$ =9976, specific expenses: $\frac{64{,}4 \cdot 89 + 38{,}2 \cdot 111}{200} = 49{,}859$.

In this case, the M_2 coal producer complies with the best interests of the mining industry.

Similarly, *Case 6* can be analyzed, when M_1 is not owned by the mining industry, and M_2 belongs.

Each coal producer is not removed from the complex production process,

$p_1 > 0$, $p_2 > 0$, $p_1 + p_2 = 200$.

In this case, the economic indicators coincide with those in case 1.

The results analyzed are presented in a systematic manner in Table 1.

Table 1. Operating variants of industrial complexes

Case 1	***Case 2***	***Case 3***
$M_1, M_2 \in A$, $p_1 + p_2 = 200$ $0 < p_1 < 220$; $0 < p_2 < 210$	$M_1 \in A$, $M_2 \notin A$, $p_1 + p_2 = 200$ $p_1 > 0$; $p_2 = 0$	$M_1 \notin A$, $M_2 \in A$, $p_1 + p_2 = 200$ $p_1 = 0$; $p_2 > 0$
$p_1^* = 89$; $C_1^*(89) = 5732$ $p_2^* = 111$; $C_2^*(111) = 4244$ $C_1^* + C_2^* = 9976$ $\frac{C_1^*(89)}{89} = 64,4$ $\frac{C_2^*(111)}{111} = 38,2$ $\frac{64,4 \cdot 89 + 38,2 \cdot 111}{89 + 111} = 49,859$	$p_1 = 200$; $p_2 = 0$ $C_1(200) = 14040$ $C_2(0) = 0$ $C_1(200) - (C_1^* + C_2^*) =$ $= 14040 - 9976 = 4064$ $\frac{C_1^*(200)}{200} = 70,2$ $\frac{C_1^*(200)}{200} - \frac{C_1^*(89)}{89} = 5,8$	$p_1 = 0$; $p_2 = 200$ $C_1(0) = 0$ $C_2(200) = 12400$ $C_1(200) - (C_1^* + C_2^*) =$ $= 12400 - 9976 = 2424$ $\frac{C_2^*(200)}{200} = 62$ $\frac{C_2^*(200)}{200} - \frac{C_2^*(111)}{111} =$ $= 62 - 38,2 = 23,8$
Case 4	*Case 5*	
$M_1 \notin A$, $M_2 \notin A$, $p_1 > 0$; $p_2 > 0$ $\overline{p}_1^* = 137$, $\overline{p}_2^* = 93$ $\overline{C}_1(137) = 8151,5$; $\frac{C_1^*(137)}{137} = 59,5$ $\frac{C_1^*(89)}{89} - \frac{C_1^*(137)}{137} = 64,4 - 59,5 = 4,9$ $\overline{C}_2(93) = 3519,2$ $\frac{C_1^*(93)}{93} = 37,84$ $\frac{C_2^*(111)}{111} - \frac{C_1^*(93)}{93} = 38,2 - 37,84 = 0,36$ $\frac{59,5 \cdot 137 + 37,84 \cdot 93}{137 + 93} = 50,74$	$M_1 \in A$, $M_2 \notin A$, $p_1 + p_2 = 200$ $p_1 > 0$; $p_2 > 0$ $p_1^* = 89$ $C_1^*(89) = 5732$ $p_2^* = 111$ $C_2^*(111) = 4244$ $C_1^* + C_2^* = 9976$ $\frac{C_1^*(89)}{89} = 64,4$ $\frac{C_2^*(111)}{111} = 38,2$ $\frac{64,4 \cdot 89 + 38,2 \cdot 111}{89 + 111} = 49,859$	

4. CONCLUSIONS

From the analyzes and calculations made above, the following conclusion can be drawn: mining industrial complexes can function efficiently if the economic interests of each producer of both coal and final products are second in relation to the finality of their activity.

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MONITORING SURFACE LAND DEFORMATION AND ANALYSIS OF DATA FOR LUPENI MINE

DACIAN-ANDREI FLOAREA [1]
ILIE ONICA [2]
DACIAN-PAUL MARIAN [3]

Abstract: *The paper refers to the study of the land deformation in time from the surface of the Lupeni Mine and the statistical analysis of the data obtained from the measurements through a profile function, specific to the Jiu Valley Mining Basin.*

Keywords: *monitoring, subsidence, horizontal displacement, coal seam, underground mining, profile function.*

1. INTRODUCTION

Underground mining of the coal seams from the Lupeni mining field has major implications in terms of stability of the land but also of the constructions from the surface. If, in the period before 1989, a large proportion of the landowners from the surface of the mining perimeters were expropriated, being possible to achieve monitoring alignments for measuring the surface subsidence for scientific purpose, after 1990, part of the lands expropriated have been rendered to former owners. In this situation, the mining units could no longer carry out alignments to measure the land subsidence for scientific purpose, they were done only to monitor certain objectives they were interested in (roads, land parcels etc.), often only when these subsidence phenomena were visible on the surface.

In the case of the mines from the Jiu Valley, the monitoring of the surface subsidence phenomenon as a result of the underground mining was done by classical topographic methods, the determination of the height of the points which form the monitoring station is done by means of the middle geometric leveling method [4], [5], [7], [8].

Each time a certain part of the points which formed the initial alignments disappeared and the analysis of the main parameters of the subsidence trough was based only on the data provided by a relatively small number of landmarks.

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In the following, there will be presented the alignments for monitoring the deformations of the terrain made for the Lupeni Mine as well as the main characteristics of the subsidence trough resulting from the processing of the data.

2. ANALYSIS OF LAND AND OBJECTIVES DEFORMATION FROM LUPENI MINE

In order to monitor the ground deformation phenomenon as a result of the underground mining of the coal seam no. 3, an alignment was made consisting of a total of 14 points, arranged in a length of 665m (Figure 1) [2], [3].

Because during the monitoring period of the phenomenon (September 2009 – March 2013) a large part of these points disappeared, to determine the subsidence trough only the points existing at the date of the last measurement were taken into account.

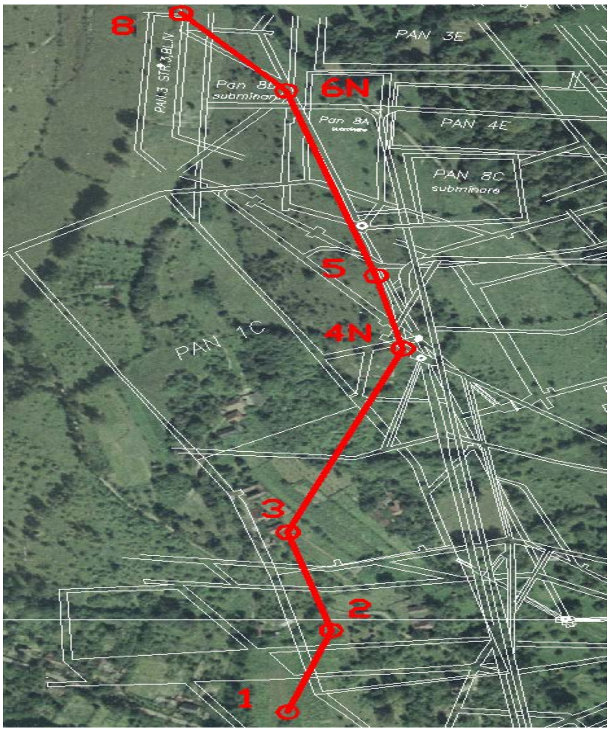


Figure 1. The subsidence monitoring alignment at Lupeni Mine

Seam 3, block IV, was extracted by collapse of the rocks from the roof, with the help of the mechanized complexes (Panel 1C), and top coal caving longwall mining (Panel 3, Panel 3E, Panel 4E, Panel 8A, Panel 8B and Panel 8C), the total height of the excavated space being between 25m and 30m.

It should be noted that the measurements made on the alignment points were performed at irregular intervals (6 months, 3 months and 5 months).

As a result of the data obtained from the field measurements, the maximum subsidence of the land was 3 483mm (in March 2013).

The development of the subsidence trough over time, based on the measurements made, is shown in figure 2. Also, the evolution over time of the maximum subsidence obtained from the processing of the data collected in the field is shown in figure 3.

For the statistical approximation of the subsidence trough generated by the underground mining of the seam no. 3 in panels 1C, 3, 3E, 4E, 8A, 8B and 8C, corresponding to Block IV, a profile function has been used, of form [7], [9], [10], [11]:

$$W(x) = a \cdot x^b \cdot e^{-c \cdot x} \quad (1)$$

where: *x* is the distance measured from the limit or the subsidence trough to the reference point.

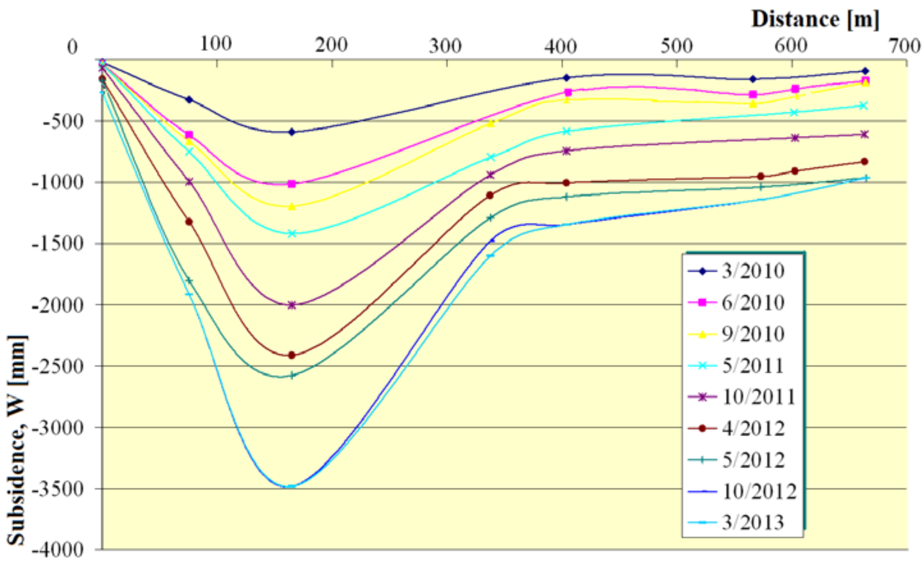


Figure 2. The graph of surface subsidence resulted from measurements at Lupeni Mine [2], [3]

The values of the regression coefficients *a*, *b* and *c* for the case of Lupeni Mine, calculated under the conditions of maximum subsidence, are: $a = -3{,}765 \cdot 10^{-1}$; $b = 2{,}202$; $c = 1{,}207 \cdot 10^{-2}$; and the determination coefficient of function (1) is: $R^2 = 0{,}992$.

Using this profile function, the maximum calculated subsidence is 3 431mm, in relation to the measured one, which is 3 483mm – where from the high value of the determination coefficient, which tends to 1.

In figure 4 is shown the graph of the profile function (1), as compared to the maximum subsidence resulted from the processing of the data collected from the field. Also, the time evolution of the maximum subsidence resulted from the processing of the measured data, compared to the maximum subsidence resulted from the use of the profile function, is presented in figure 5.

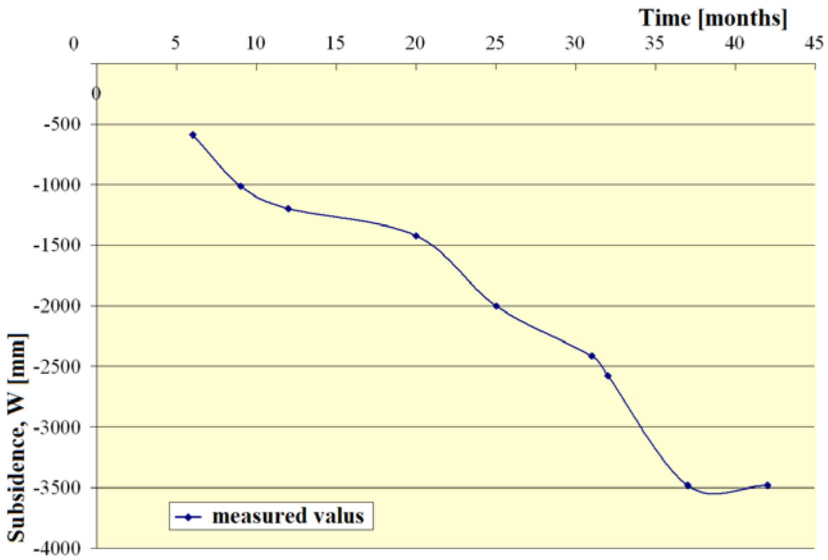


Figure 3. The evolution in time of the maximum measured subsidence at Lupeni Mine [2], [3]

In the literature [1], [6], the subsidence phenomenon resulted as a consequence of the underground mining, depending on time, it is described as being composed of three phases, namely: the initial phase, which may take several days; the main phase, which can last from a few months to a few years (depending on the speed of operation); the final or residual phase, the duration of which may last from several months to several years (Fig. 6).

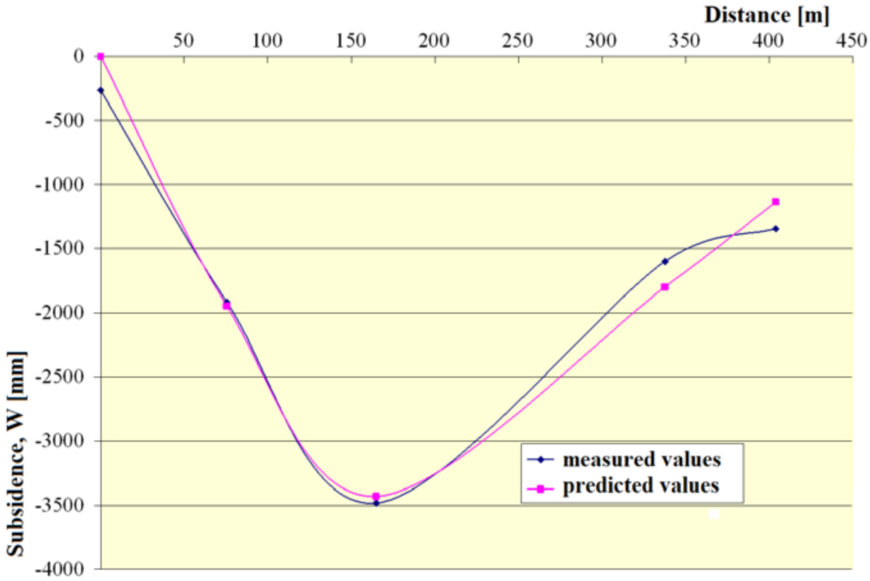


Figure 4. The maximum measured subsidence and the maximum predicted subsidence at Lupeni Mine [2], [3]

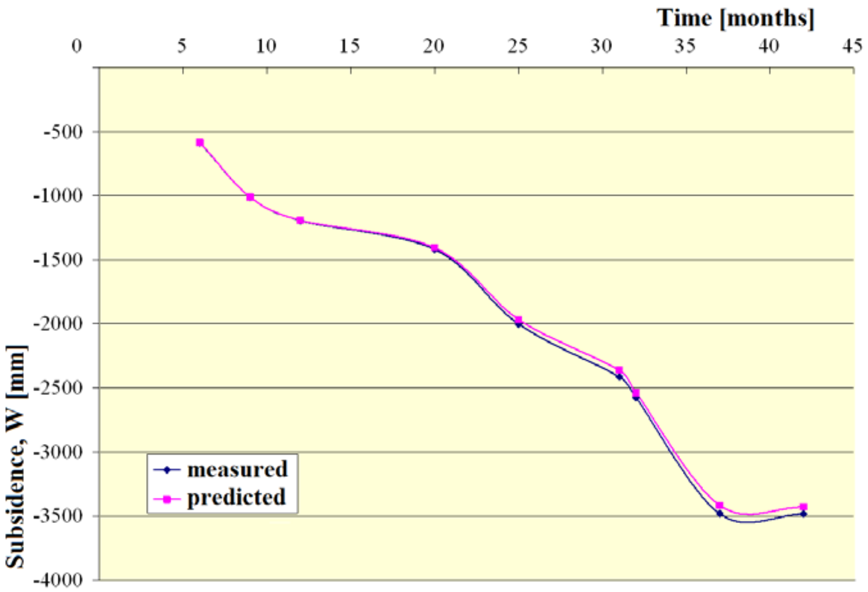


Figure 5. The evolution in time of the maximum measured and predicted subsidence at Lupeni Mine [2], [3]

From the graphical representation of the evolution in time of the maximum subsidence (Fig. 3) it can be noticed that this monitoring station was made at the moment when already the subsidence phenomenon had begun his manifestation, being in the second phase, namely the main phase of the subsidence phenomenon. During this period, the speed of the surface subsidence calculated as the ratio between the benchmark subsidence and the time interval between two measurements is 142mm/month, in the first period of monitoring of the phenomenon and 181mm/month in the last period.

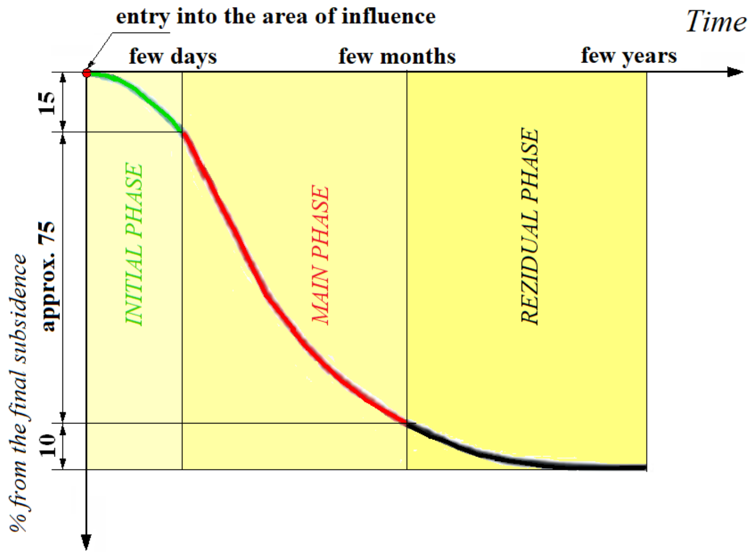


Figure 6. Phases of subsidence phenomenon [1]

It can also be noticed that during the periods September 2010 – May 2011 (the period between month 12 and month 20 of monitoring), October 2012 – March 2013 (the period between month 40 and month 45 of monitoring), the subsidence speed is significantly reduced from 142mm/month in the first monitoring period to 27mm/month, which can lead us to the erroneous conclusion that the phenomenon has entered in the final phase (extinguishing phase).

In order to ensure that the underground mining not to affect the objectives from the surface, a series of major safety pillars were drawn so that, regarding the industrial and civilian objectives of major importance (hospitals, schools, compressor station, degassing station, etc.), they not to be affected by the underground mining. Regarding the individual civilian constructions, they were affected by the underground mining, but they have not been carefully monitored from the part of Lupeni Mine, after 1989, she was only pleased to compensate people who suffered damage due to underground mining.

Some of the effects of the land subsidence phenomenon on the constructions situated in the area of influence of the underground mining of the coal seams located in the perimeter of Lupeni Mine, are presented in figure 7.

Figure 7. The influence of underground mining on some constructions, in the case of Lupeni Mine [2], [3]

As can be seen in images from figure 7, most of the affected buildings (residential houses) are with one level, made of brick walls, on monolithic concrete foundations or river stone and are over 50 years old.

Due to the differentiated displacements of the surface, generated by the underground mining, the movement have propagated through the foundation of buildings, to their superstructure, initially causing traction and shear cracks, which have gradually progressed over time in the separation of plasters, horizontal, vertical and diagonal fractures, until the structural elements are completely broken down.

3. THE INFLUENCE OF THE TIME FACTOR CONCERNING THE SURFACE SUBSIDENCE AT LUPENI MINE

After analyzing the evolution in time of the subsidence resulted from the processing of the measured data in situ and represented by the profile function (1) and of the determination of all the coefficients *a*, *b* and *c* related to this functions, the simple regression analysis of these regression coefficients was performed, depending on their evolution over time.

The graphical representation of the evolution in time of the regression coefficients value are shown in figure 8 and is defined by the following functions [9], [10]:

$$a_{(t)} = -a_1 \cdot \ln(t) + a_2 \tag{2}$$

$$b_{(t)} = -b_1 \cdot \ln(t) + b_2 \tag{3}$$

$$c_{(t)} = -c_1 \cdot \ln(t) + c_2 \tag{4}$$

Where: t is the time; a_1, a_2, …, c_2 – the regression coefficients of the logarithmic function.

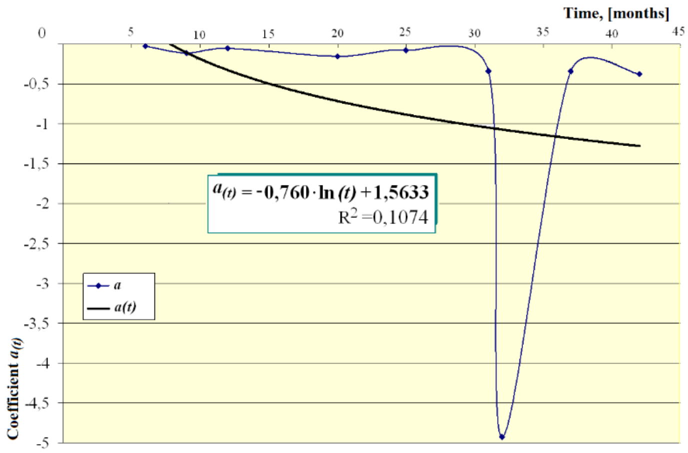
From the analysis of the functions (2), (3) and (4) it is found that:

- The time evolution of the three coefficients is non-linear, and the functions that best approximate their evolution in time are the logarithmic ones;
- The logarithmic regression functions of the coefficients *a*, *b* and *c* are time dependent on their pairs of corresponding regression coefficients (a_1, a_2), (b_1, b_2) and (c_1, c_2).

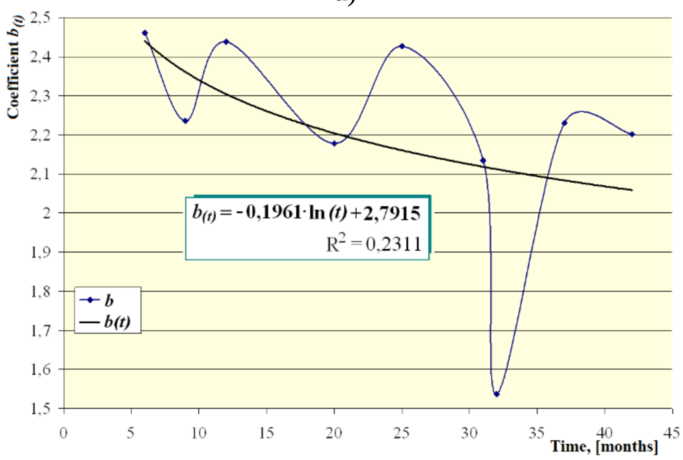
Consequently, the new predictive function within time *t* of the subsidence, which takes into account the distance *x* measured from the limit of the subsidence trough, has the form [9], [10]:

$$W(x,t) = \left(-a_1 \cdot \ln(t) + a_2\right) \cdot x^{-b_1 \cdot \ln(t) + b_2} \cdot e^{\left(-c_1 \cdot \ln(t) + c_2\right) \cdot x} \tag{5}$$

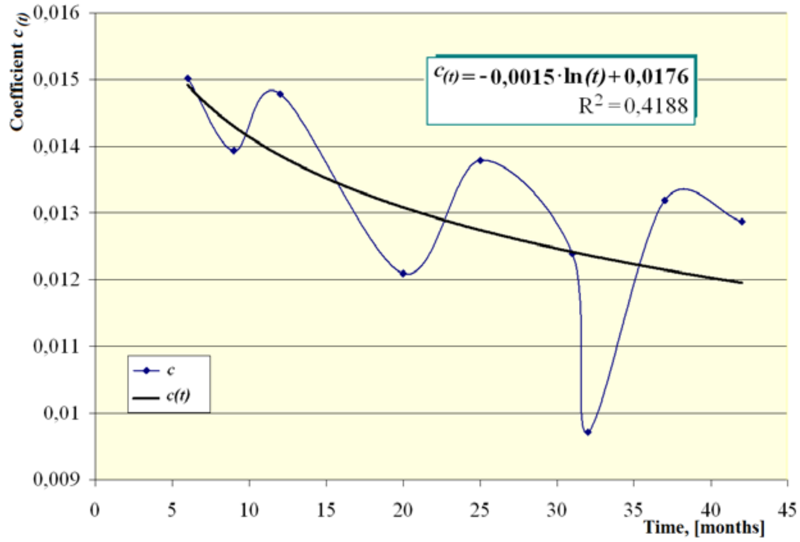
Where: *x* is the distance measured from the limit of the subsidence trough to the reference point; *t* – time.



a)



b)



c)

Figure 8. Comparative graphical representation of the time evolution of the parameters *a*, *b* and *c* and graphs of their logarithmic regression functions

The value of the coefficients a_1, a_2, b_1, b_2 and c_1, c_2 for function (5) for the Lupeni Mine is shown in table 1.

Table 1. The values of the regression coefficients of function (5) [2], [3]

Coefficient	Value	Coefficient	Value	Coefficient	Value
a_1	0,7601	b_1	0,1961	c_1	0,7601
a_2	1,5633	b_2	2,7915	c_2	1,5633
R^2	0,1074	R^2	0,2311	R^2	0,4188

The value of the average determining factor of the function (5) is $R^2_{med} = 0{,}982$

.

Using this new profile function (5), for the prognosis of subsidence at Lupeni Mine, the maximum calculated subsidence is 3 433mm, compared to the measured one, which is 3 483mm – resulting an extremely good estimate of the subsidence measured in time.

The comparative graphical representation of the predicted subsidence curves, calculated with profile function (5) and of the subsidence measured in time, is presented in figure 9.

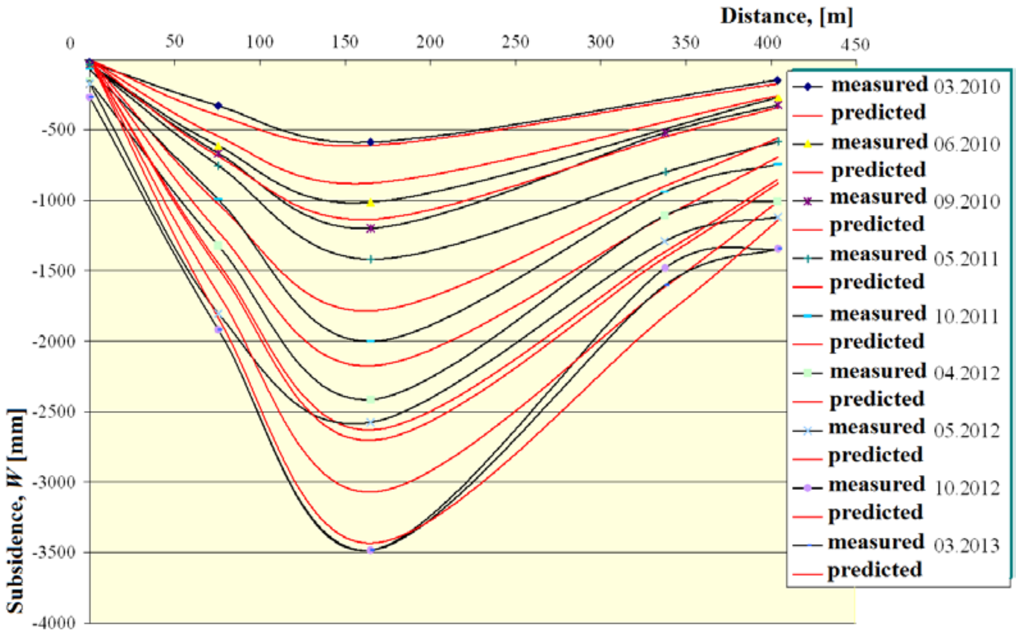


Figure 9. The comparative graph of measured and predicted subsidence with the new profile function [2], [3]

4. CONCLUSIONS

The monitoring of the surface terrain deformation phenomenon, in the case of Lupeni Mine was performed on certain routes (established according to the interest of the mine), by topographical methods (middle geometric leveling and/or trigonometric leveling). The maximum measured subsidence was 3 483mm.

The statistical mathematical approximation of the measurements performed over a period of time, was accomplished by a profile function, for the prognosis of subsidence, specific to the Jiu Valley mining basin, which estimated very well the measurements performed over time, namely a maximum subsidence of 3 431mm, for the case of Lupeni Mine.

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3D FINITE ELEMENT MODELING OF THE LAND STABILITY AFFECTED BY THE UNDERGROUND MINING OF THE COAL SEAMS FROM THE JIU VALLEY

DACIAN-ANDREI FLOAREA [1]
ILIE ONICA [2]
DACIAN-PAUL MARIAN [3]

Abstract: *This paper refers to the analysis of surface deformation generated by the underground mining of the coal deposits, using 3D finite element modeling. Are taken into account the extraction methods with longwall mining, with the collapse of the rocks from the roof and with top coal caving, in several extraction sequences of the coal face.*

Keywords: *numerical modeling, finite element, subsidence, horizontal displacement, coal seam, underground mining.*

1. INTRODUCTION

Since the 19th century, the railway companies from the Ruhr mining basin carrying out leveling measurements have noticed that as a consequence of the underground mining of the coal there is a lowering of the railway level, the results of these measurements being recorded in various reports. Such reports were also drafted in countries with underground mining activity (Belgium, France, etc.) and formed the basis for further research of the phenomenon of displacement and deformation of the ground as a result of the underground mining [1], [2]. This phenomenon also felt its presence in one of the most important mining basin of Romania, the Jiu Valley mining basin [5], [8], [14].

The phenomenon of deformation and displacement of the ground has been a major problem of the underground mining and has been studied by many researchers in the field, with the result that this is a very complex phenomenon, generated by an amalgam of factors (physical-mechanical characteristics of rocks, mining factors, factors of geometry of deposits, disturbing factors, etc.) [10], and its prediction is specific to each case [6], [7].

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The main objective of this paper was to obtain a more accurate prediction of the surface subsidence phenomena and implicitly the effects it has on the surface objectives by using a numerical method of analysis, namely the finite element method in 3D. We mention that the validation and calibration of these numerical models was carried out under the conditions of Lupeni [3] and Paroseni [1], [2] mines.

The influence of the underground mining on the surface was analyzed under the conditions of longwall mining method, with the collapse of the surrounding rocks (Fig. 1) and with top coal caving (Fig. 2) [10], [12].

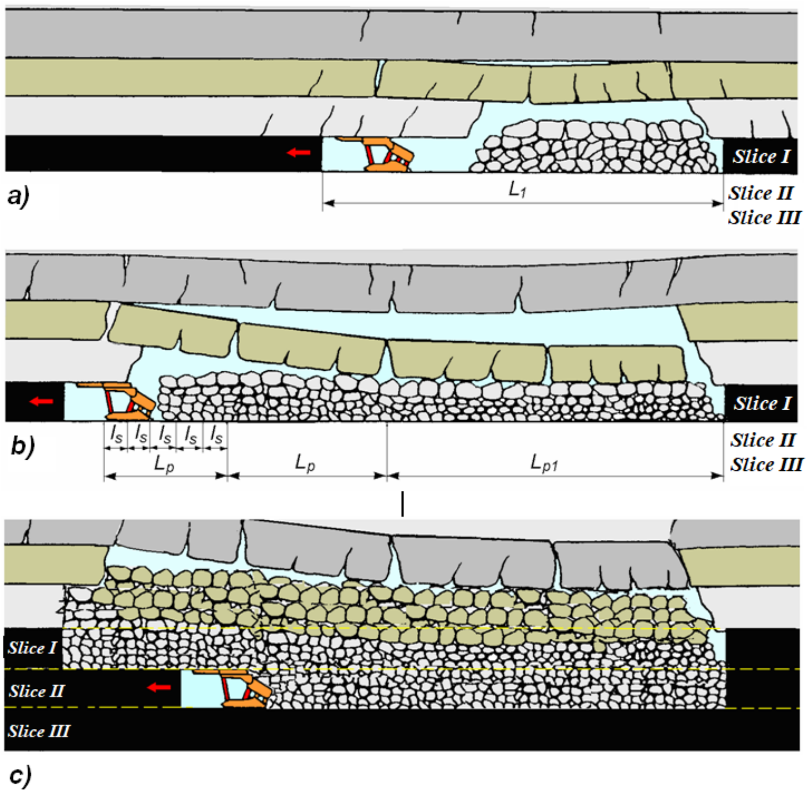


Figure 1. Sequential collapse of the rocks from the roof under the conditions of mining the first slice: *a*) first collapse of the direct roof; *b*) periodic collapse of the direct and principal roof; *c*) collapse of the rocks from the roof under the conditions of mining the 2nd and 3rd slice (adaptation after Peng & Chen [15])

L_1 – first step of collapse of the direct roof; l_s – the primary step of collapse of the direct roof;
L_p – the secondary step of collapse of the principal roof (main roof);
L_{p1} – the first secondary step of collapse of the main roof

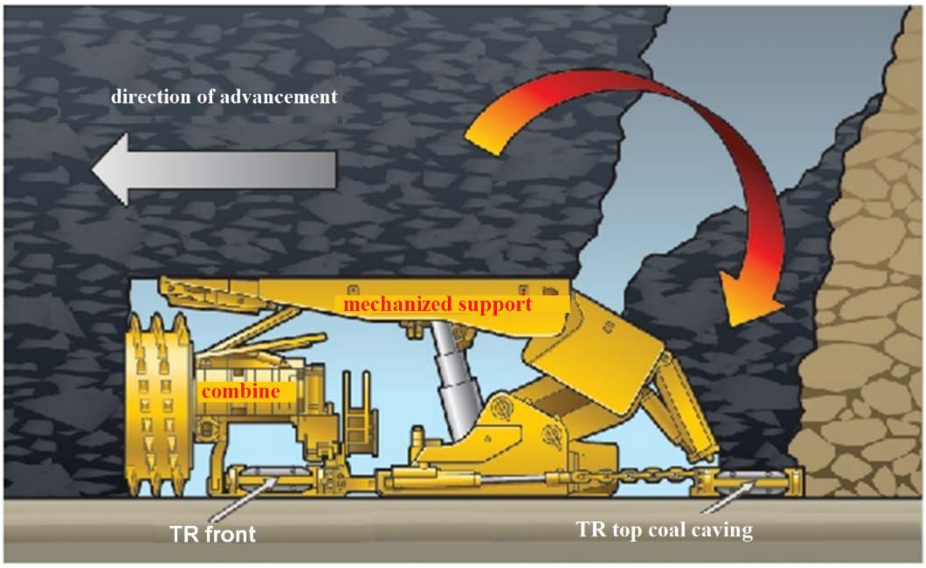


Figure 2. Complex-mechanized longwall mining and top coal caving [17])

2. DESCRIPTION OF THE MODELS WITH FINITE ELEMENT

The purpose of the researches undertaken in this chapter was to study the behavior of the constructions located on the surface of the coalfields in the Jiu Valley, by extracting a thick seam, with low inclination, in the case of different systems of mining the inclined slices. To achieve this goal the 3D finite element modeling was used, with CESAR-LCPC software, version 4 and the processor CLEO 3D.

The modeling of the field subjected for mining, considered continuously, homogenous and isotropic, was performed for the conditions of a thick seam of horizontal coal, with an average thickness of 9m, respectively 8m, at an average depth of H = 300m, measured from surface – the most common depth of the thick coal seam no. 3, in the low inclined areas from the Jiu Valley (e.g. Paroseni, Lupeni or Livezeni mining fields). As it results from the finite element modeling, following the sensitivity analysis of the various parameters, performed in works [6], [7], [16], the inclination of the seam within the range of 18^o – 20^o has no major influence on parameters of the surface subsidence (Fig. 3); in this way, for the simplification of the model generation by the "extrusion" operation, it was preferred to represent a horizontal deposit.

For the result to be significant, seam no. 3 with a thickness of 9m (Fig. 5. a-d) and respectively 8m (Fig. 5. e-f) was imagined to be mined in the final phase in a panel with a total extinction of X_{ca} = 400m and a longwall with a length of l_{ab} = 150m.

Under the above mentioned conditions, the extraction of seam no. 3 was simulated, with a thickness of 9m, in three inclined slices, with high/thickness h_{ex} = 3m, mined in successive order, from top to bottom (Fig. 5. a-c) and extracted all over the entire thickness between the bed and the roof (Fig. 5. d). Also, the thickness of 8m was considered to be divided into two slices with a height of h_{ex} = 4m, mined in descending order.

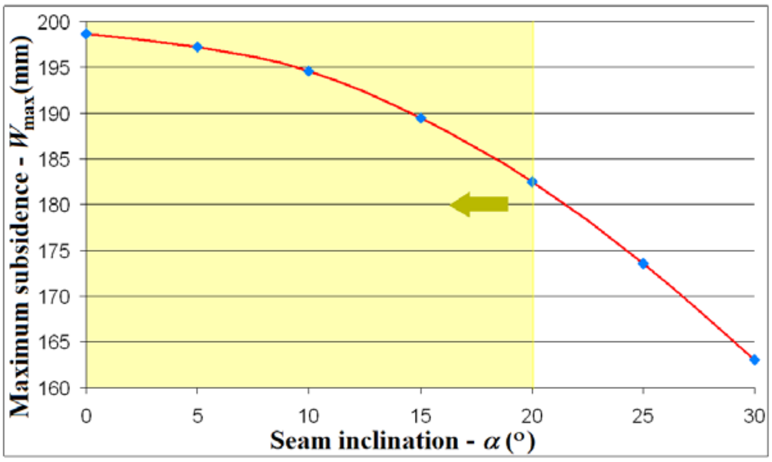


Figure 3. The influence of the variation of seam inclination angle on the maximum subsidence [6], [7]

Although in the modeling hypothesis it was simplistically considered that the surrounding rocks and the coal are continuous, homogeneous and isotropic environments, methods and technologies with longwall, in retreat / with pillars, were considered as guiding the mining pressure by total collapse of the rocks from the roof (the cases represented in the schemes of figures 5. *a*-*c*, *e* and *f*) and with top coal caving (case from figure 5. *d*) [10], [12].

As can be seen in figure 5, in several computational models, were captured 12 phases / sequences of extraction of the longwall face, starting from the attack gallery from point *A* to the stopping / disassembling point of the face *B*, and for each extraction system schematized in figure 3, respectively, for X_{ca} = 50m, 100m, 140m, 170m, 190m, 200m, 210m, 230m, 260m, 300m, 350m, 400m.

Due to the symmetry of the model after the vertical plane *z*0*x*, oriented to the forward direction of the longwall face, in order to reduce the size of the model and implicitly the calculation time, a symmetrical model was adopted after this sectioning plane (Fig. 4). Finally, a model with the dimensions of *X* = 2500m, *Y* = 500m and *Z* = 409m was obtained [9], [11], [13].

As for the representation of the massif, this was obtained by the meshing in plan of a model with triangular finite elements and through their sequential "extrusion" after the *z* axis, have resulted volumetric finite elements in the form of triangular prisms, with the height disposed after this axis [9], [11], [13].

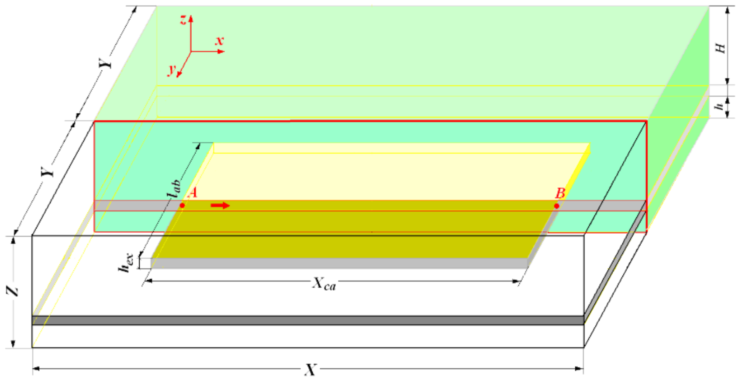
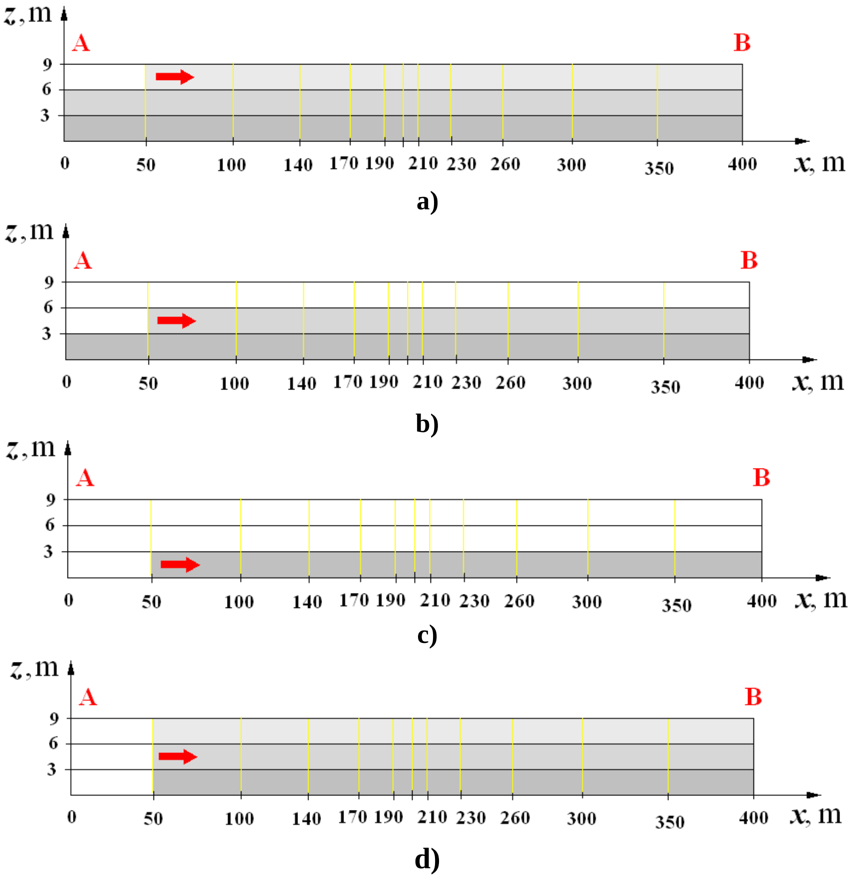


Figure 4. The schematic diagram of the 3D symmetric model with finite elements for the analysis of the influence of underground mining of a thick seam with low inclination on the surface [1], [2]



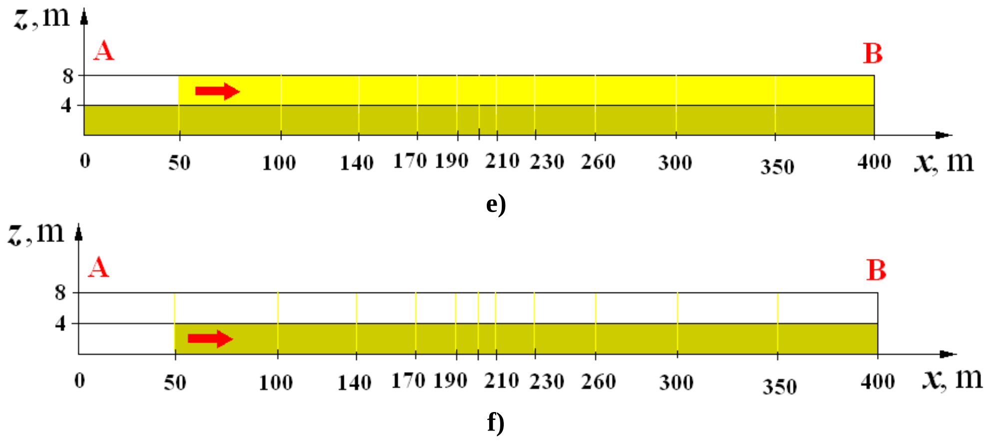


Figure 5. Variants of the modeling of the extraction by longwall mining of a thick coal seam, with low inclination, from the Jiu Valley mining basin [1], [2]

a) extraction of the first 3m slice, with the collapse of the rocks from the roof; *b*) extraction of the second slice of 3m, with the collapse of the rocks from the roof; *c*) extracting the third slice of 3m, with the collapse of the rocks from the roof; full extraction of the 9m seam, with top coal caving;
e) extraction of the first 4m slice, with the collapse of the rocks from the roof; *f*) extraction of the second slice of 4m, with the collapse of the rocks from the roof

The generation of the model with base finite elements (from which particular models were derived) was based on the following constitutive elements: 23 712 knots and 40 843 volume elements.

To implement the boundary conditions of the model, the following restrictions were imposed: for the lower limit, the movement along the *z* axis was blocked, and for the lateral limits, the movements along the *x* and *y* axes was blocked – maintaining the freedom of movement for the other directions and for the surface.

With regard to the constitutive laws of the materials used in the model, given the very large dimensions of the models, in order to reduce the calculation time, the hypothesis of elastic behavior was chosen. This choice was determined by the fact that from similar models made by Marian [6] and Ștefan [16], using both the elastic and elastic-plastic laws for the rock mass, were obtained some results with insignificant differences. Therefore, in these models, the following characteristics were adopted for the rock mass: the average apparent density $\rho_r = 2\,663$ kg/m^3, Young modulus of elasticity $E_r = 1{,}511 \cdot 10^6$ kN/m^2 and Poisson ratio $\nu_r = 0{,}19$. In the calculation it was used a “Phase” load of the model, using the MNCL module of the CESAR software. The model was loaded in the initial phase geostatic, with some average vertical tensions at the face level $\sigma_z = \gamma_r \cdot H$ =0,02663·300 = 8MN/m^2 and some horizontal tensions $\sigma_x = \sigma_y = k_{ox} \cdot \sigma_z = k_{oy} \cdot \sigma_z$ =0,33.8 = 2,64MN/m^2 [9], [11], [13].

3. ANALYSIS OF LAND DEFORMATIONS AS A RESULT OF UNDERGROUND MINING

It is mentioned from the beginning that, as a result of the calculations, the presence of the building in the model has no influence on the evolution of the parameters of the subsidence trough, respectively on the surface deformation.

The analysis of surface behavior following the interpretation of the results obtained from the calculations made on the finite element models synthesized in figure 5 are presented below.

3.1. Mining in slices, with longwall mining and collapse of the rocks from the roof

It is analyzed by means of two models with basic finite elements, in 3D, different, comprising the extraction in 12 sequences of a coal seam: 1) in the first basic model, a 9m thick seam, extracted in 3 successive slices, 3m thick, with a longwall face of 150m long and guiding the mining pressure by the total collapse of the rocks from the roof (Fig. 5. *a*, *b* and *c*); 2) In the second basic model, a seam of 8m thick, extracted in two successive slices, with a thickness of 4m each (Fig. 5. *e* and *f*).

3.1.1. Extraction of the first 3m slice (from the 9m seam) and 4m (from the 8m seam), by longwall mining and the collapse of the rocks from the roof

a) Slice I, of 3m – seam of 9m

In the case of extraction of the first slice (see Fig. 5. a), the maximum horizontal displacement *u*, at the point where the excavated space has a directional length of 50m and is at a distance of 150m from the axis of the building, has a maximum value of 6.8mm, continuing its development until the full extraction of the panel, where it reaches 129.6mm (Fig. 6). From the analysis of the graphical representation it can be observed that the horizontal displacement has a strongly increasing evolution.

Regarding the vertical displacement *w*, it reaches the maximum value of +469.5mm when the first slice is fully extracted, and at the point where the extracted space has a length in the direction of 50m, the subsidence is 23mm (Fig. 7). The extension of the subsidence trough along the *x* axis (the forward direction of the longwall face), starts from 408 and reaches a maximum of 1 134m in the case of full extraction of the first slice.

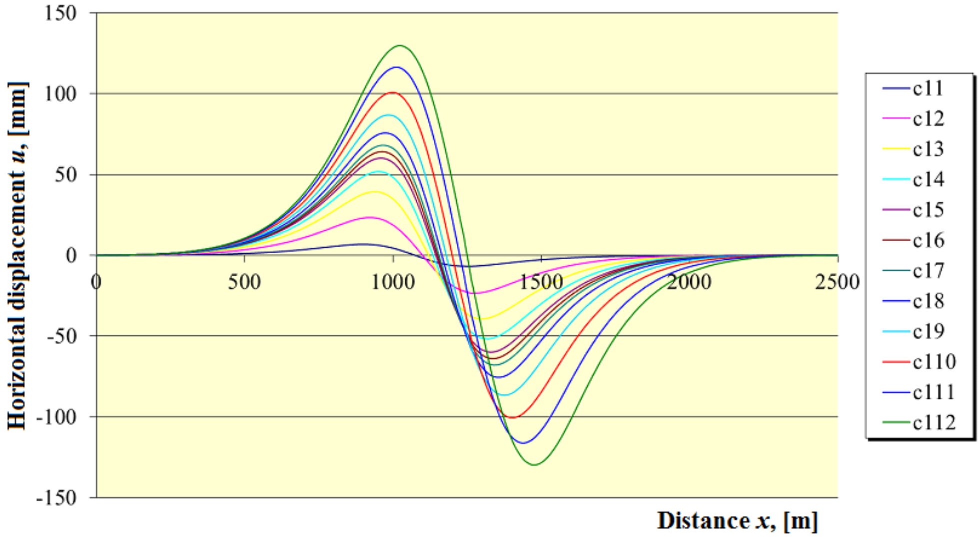


Figure 6. The evolution of the horizontal displacement in the case of the extraction of the first slice, of 3m [1], [2]; cij: i – slice number (i = 1); j – extraction sequence (j = 1, 2, …, 12)

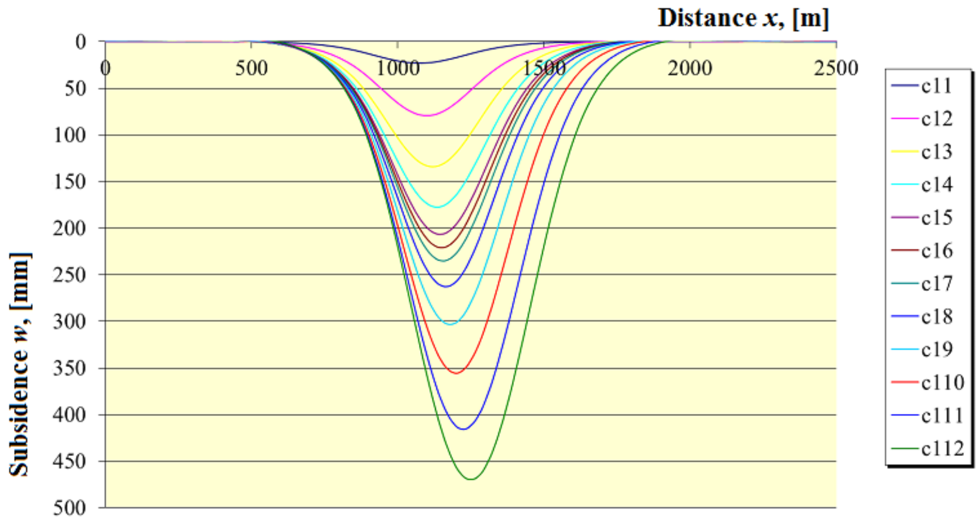


Figure 7. The evolution of the subsidence in the case of the extraction of the first slice, of 3m [1], [2]; cij: i – slice number (i = 1); j – extraction sequence (j = 1, 2, …, 12)

b) Slice I, of 4m – seam of 8m

In this situation (see figure 5. e), the maximum horizontal displacement is 130mm, when the extraction of slice I is finalized, and at the point where the extracted space has a length of 50m (the longwall face is within a distance of 150m from the building's axis) has values ranging from -6.9mm ÷ +6.9mm, (Fig. 8).

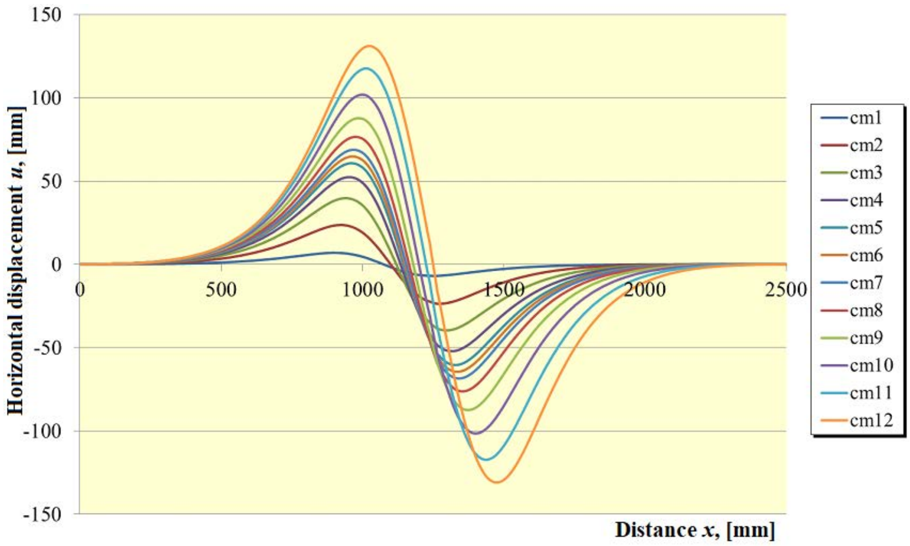


Figure 8. The evolution of the horizontal displacement in the case of the extraction of the first slice, of 4m [1], [2]; cmj: j – extraction sequence (j = 1, 2, …, 12)

The vertical displacement reaches a maximum of 417mm, when the first slice is fully extracted, and for an extension of the extracted space of 50m (the first extraction simulation stage) subsidence is 23mm (Fig. 9).

The extension of the subsidence trough, along the *x* axis, for all 12 extraction simulation stages, is 440 m, for X_{ca} = 50m and reaches a maximum of 1 134m in the case of full extraction of the first slice, for X_{ca} = 400m.

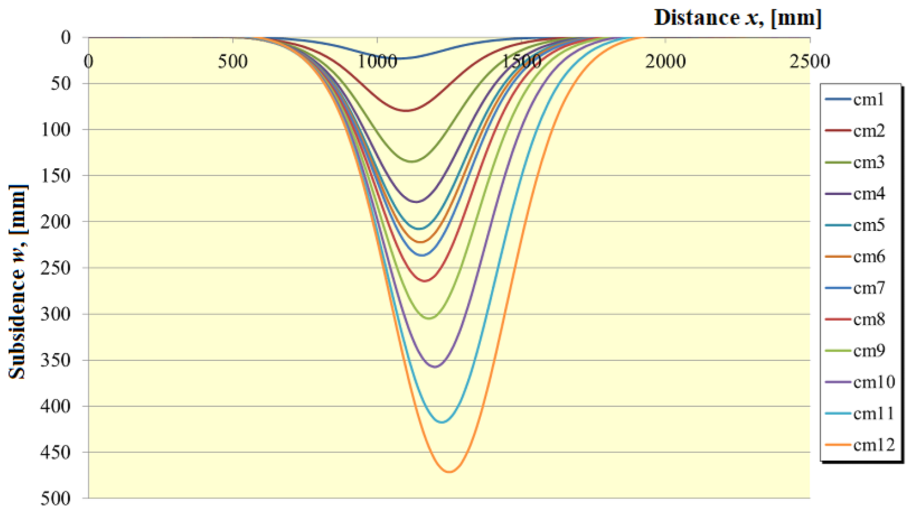


Figure 9. The evolution of the subsidence in the case of the extraction of the first slice, of 4m [1], [2]; cmj: j – extraction sequence (j = 1, 2, …, 12)

3.1.2. Extraction of the second slice of 3m (from the 9m seam) and 4m (from the 8m seam), by longwall mining and the collapse of the rocks from the roof

a) Slice II, of 3m – seam of 9m

In the case of the extraction of the second slice, the horizontal displacement, schematically represented in figure 5. b is in the range of -133.4mm +133.5mm (Fig. 10), but its evolution is no longer so pronounced as in the case of the first slice. This highlights the fact that at the time of the extraction of the first slice, there is an increased stress relief of the rocks massif in the roof.

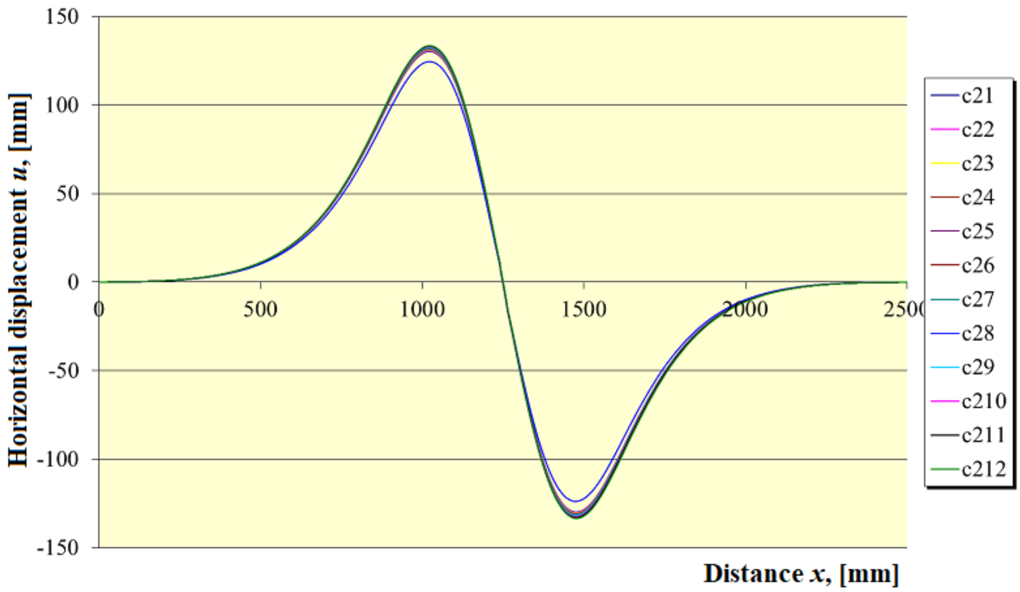


Figure 10. The evolution of the horizontal displacement in the case of the extraction of the second slice, of 3m [1], [2]; cij: i – slice number (i = 2); j – extraction sequence (j = 1, 2, …, 12)

The vertical displacement in this case reaches a maximum value of -482.7mm when the second slice is fully extracted (Fig. 11) and the size of the subsidence trough along the *x* axis is maintained at 1134m.

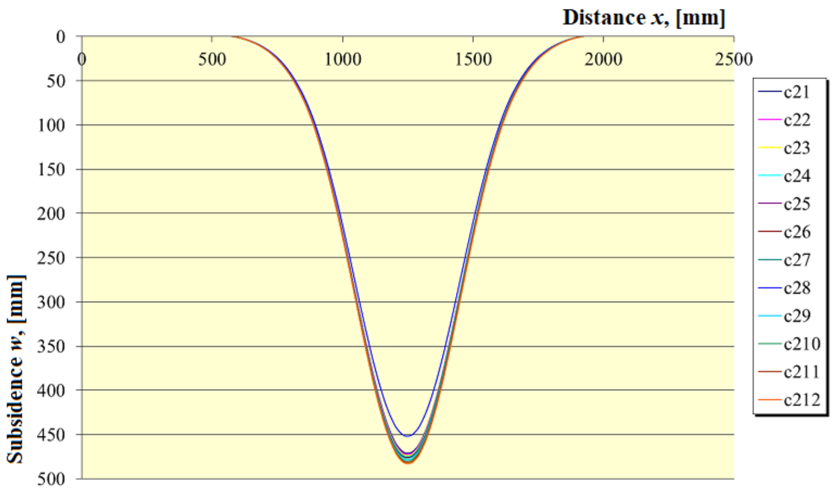


Figure 11. The evolution of the subsidence in the case of the extraction of the second slice, of 3m [1], [2]; cij: i – slice number (i = 2); j – extraction sequence (j = 1, 2, …, 12)

b) Slice II, of 4m – seam of 8m

In the conditions of extraction of the second slice, with a height of 4m, for a seam thickness of 8m (Fig. 5. f), the maximum horizontal displacement for an extension of the extracted slice of X_{ca} = 50m is 7.5mm; continuing its development until the full extraction of the panel, where it reaches a maximum of 133mm (Fig. 12).

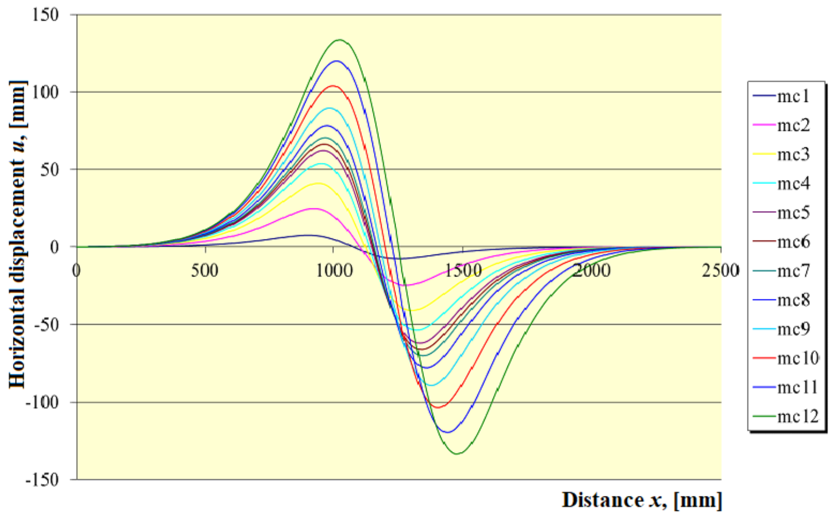


Figure 12. The evolution of the horizontal displacement in the case of the extraction of the second slice, of 4m [1], [2]; mcj: j – extraction sequence (j = 1, 2, …, 12)

Regarding the vertical displacement, it reaches the maximum value of +482mm when the second slice is fully extracted, for X_{ca} = 400m, and in the phase where the extracted space has a length in the direction of 50m, the subsidence reaches the value of 25mm (Fig. 13).

The size of the subsidence trough, measured after the *x* axis of the finite element model, starts from 450m, for X_{ca} = 50m and reaches a maximum of 1 134m, in the case of integral extraction, for X_{ca} = 400m.

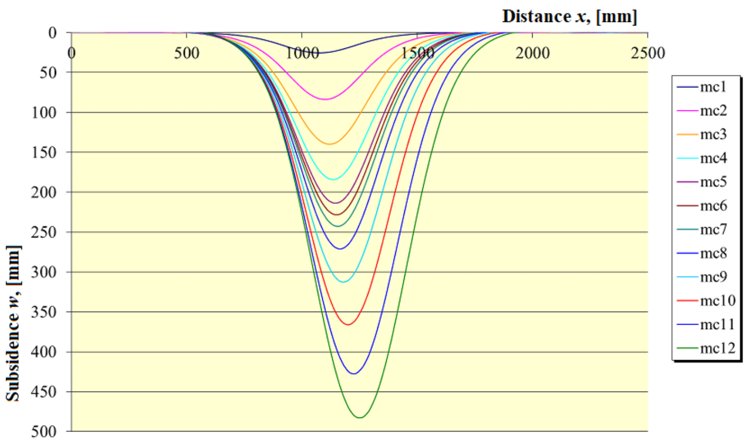


Figure 13. The evolution of the subsidence in the case of the extraction of the second slice, of 4m [1], [2]; mcj: j – extraction sequence (j = 1, 2, …, 12)

3.1.3. Extraction of the third slice of 3m (from the 9m seam), by longwall mining and the collapse of the rocks from the roof

Following the extraction of the third slice, according to the schematic diagram from figure 3. c, the horizontal displacement is in the range of -136mm + 136mm (Fig. 14), and the maximum subsidence reaches 491mm (Fig. 15).

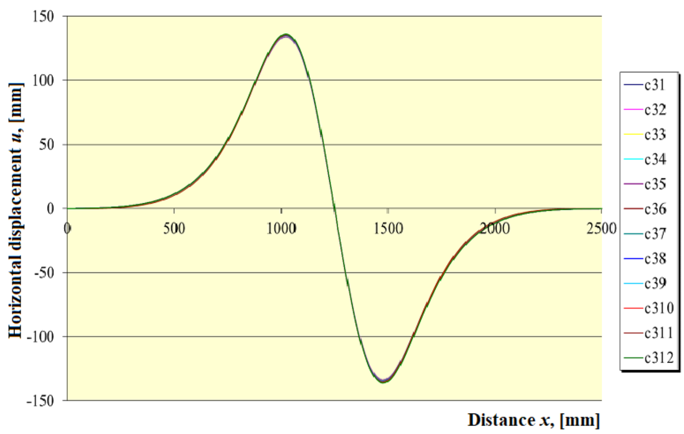


Figure 14. The evolution of the horizontal displacement in the case of the extraction of the third slice, of 3m [1], [2]; cij: i – slice number (i = 3); j – extraction sequence (j = 1, 2, …, 12)

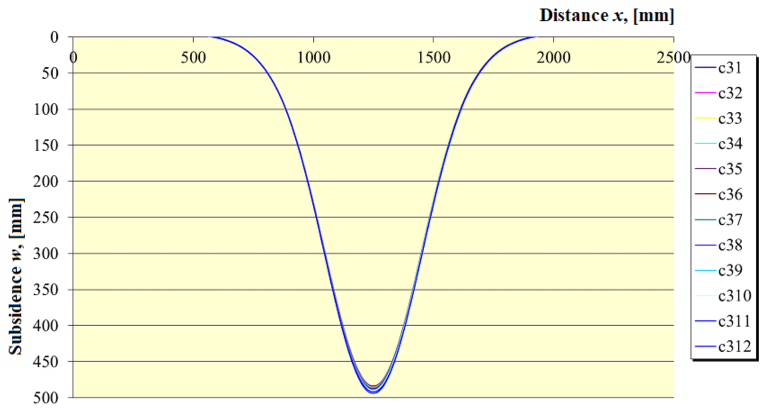


Figure 15. The evolution of the subsidence in the case of the extraction of the third slice, of 3m [1], [2]; cij: i – slice number (i = 3); j – extraction sequence (j = 1, 2, …, 12)

3.2. Full extraction of the 9m seam, by longwall mining and top coal caving

The base model contains a coal seam of 9m thick, fully extracted by longwall mining and top coal caving of 150m long. The longwall face has a height of 3m and the top coal caving is of 6m height. The analysis of surface deformation is performed in 12 sequences of extraction of the panel [12]. In the case of the finite element modeling of the underground mining by longwall mining and top coal caving, schematized in figure 3. d, the maximum horizontal displacement, at the point where the extracted space has a length in the direction of X_{ca} = 50m (the longwall face is located at 150m from the building's axis) has a value of 8mm; continuing its development until the full extraction of the panel where it takes values between -136mm +136mm, for X_{ca} = 400m (Fig. 16).

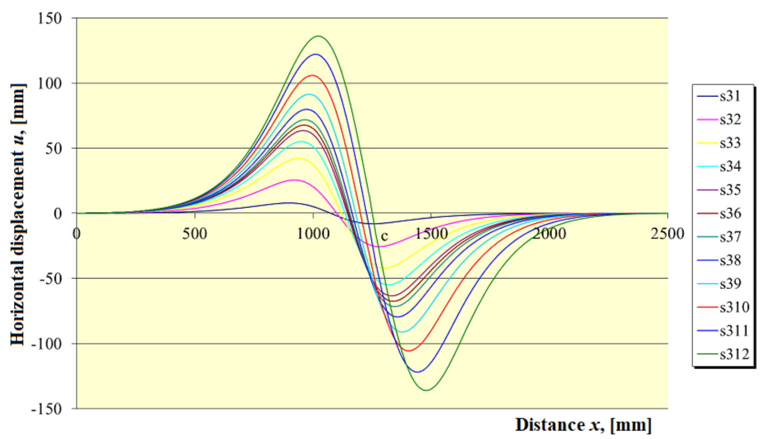


Figure 16. The evolution of the horizontal displacement in the case of the extraction by top coal caving; sij: i – number of levels of the building (i = 3); j – extraction sequence (j = 1, 2, …, 12)

Under the same conditions, the vertical displacement reaches a maximum value of 491mm, at the time of full extraction, for X_{ca} = 400m, and at the point where the extracted space has a length in the direction of X_{ca} = 50m, the subsidence is 27mm (Fig. 17).

The size of the subsidence trough, measured along the *x* axis of the model, for the first extraction simulation phase, starts from 483m and reaches a maximum of 1 134m in the case of integral extraction.

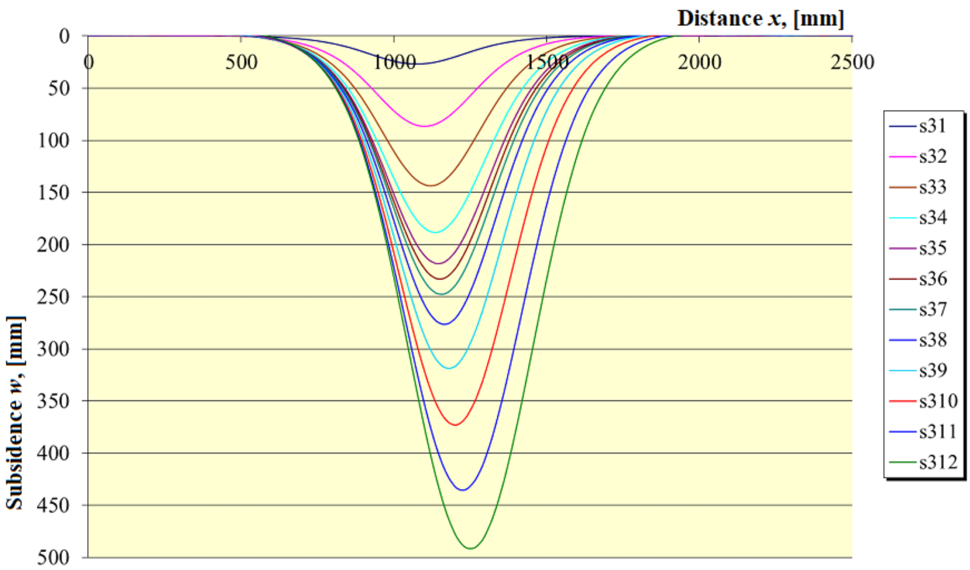


Figure 17. The evolution of the subsidence in the case of the extraction by top coal caving; [1], [2]

sij: i – number of levels of the building (i = 3); j – extraction sequence (j = 1, 2, …, 12)

3.3. Comparative analysis of surface deformation according to the extraction method and the seam thickness

From the surface behavior analysis, depending on the extraction systems taken into study, it can be concluded that the minimum horizontal displacement, situated within the range of -129.6mm +129.7mm, is produced under the conditions of underground mining of the thick seam in slices with a slice thickness of 3m, with the collapse of the rocks from the roof, and the maximum horizontal displacement is in the range -136mm +136mm (Fig. 18) and occurs both in the case of underground mining by top coal caving and in the case of extraction of the third slice, with a thickness of 3m.

Regarding the vertical displacement of the surface, it can be said that, in the situation of extracting the first slice of 3m thick, it has a minimum value of 469.5mm, the maximum of 491mm (Fig. 19) is generated in the situation of underground mining by top coal caving or after the extraction of the third slice of 3m.

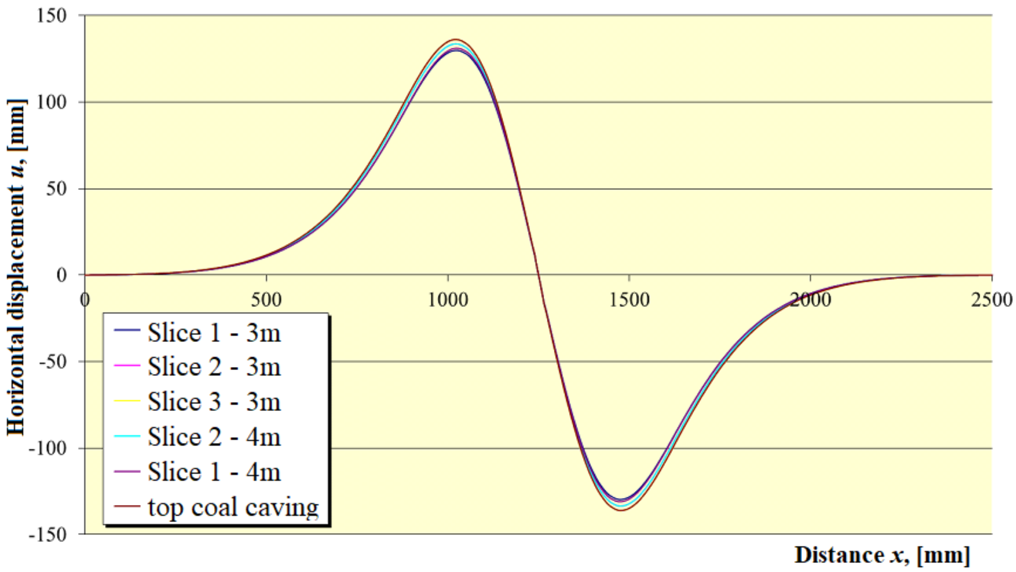


Figure 18. The evolution of the horizontal displacement according to the extraction method and the seam thickness [1], [2]

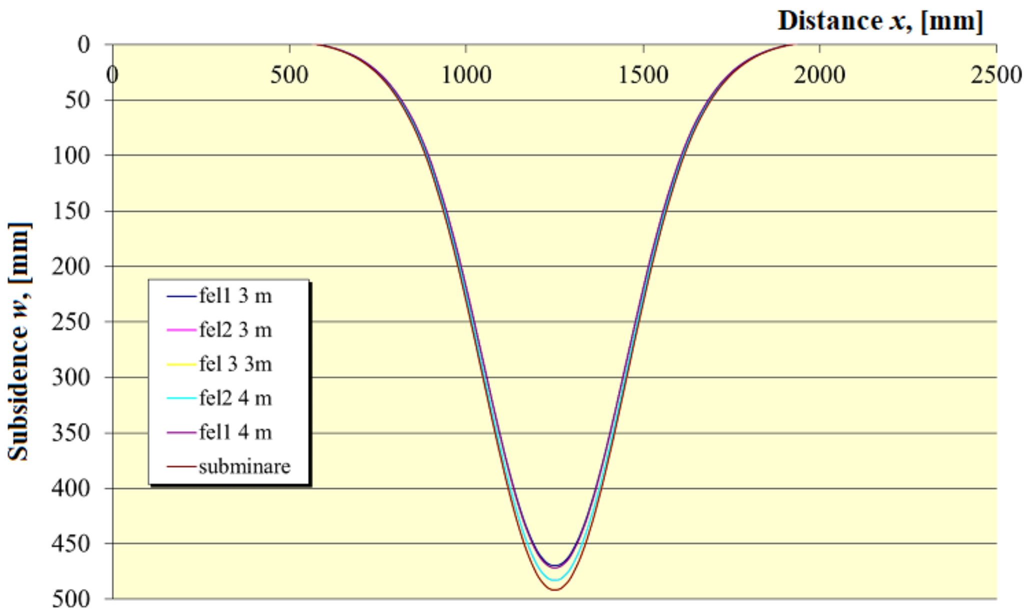


Figure 19. The evolution of the vertical displacement according to the extraction method and the seam thickness [1], [2]

4. CONCLUSIONS

The purpose of the research made in this paper is to analyze the behavior of the surface, as a result of finite element modeling in 3D, in the area of influence of the underground mining of a thick coal seam, with certain systems and different sequences of extraction of the seam.

In order to achieve the objectives of the research, it was made a 3D finite element modeling, using CESAR-LCPC software, version 4 – the CLEO-3D processor, of a deposit containing a thick horizontal coal seam, with an average thickness of 9m, respectively 8m, at an average depth of H = 300m.

Simulation of the extraction of the seam by longwall mining, with a panel width of 150m and a length of 400m, was analyzed for 12 sequences of extraction of the panel, by applying the following systems of extraction: a) the 9m thick coal seam is extracted in 3 successive slices with a thickness of 3m and directing the mining pressure through the total collapse of the rocks from the roof; The 8m thick coal seam is extracted in two successive slices of 4m each, with the directing of the mining pressure by the total collapse of the rocks from the roof; c) the 9m thick coal seam is fully extracted through longwall mining and top coal caving.

Due to the very large dimensions of the models (X = 2 500m, Y = 500m and Z = 409m), in a simplified way, the environments of the models were considered to be continuous, elastic and isotropic, and the loading of the models was made geostatic.

From the analysis of the surface deformations under the influence of the underground mining of the thick coal seam, it has resulted that the expansion of the subsidence trough, along the x axis, for all 12 stages of simulation of the underground mining, is between 440m for X_{ca} = 50m and 1 134m for the full extraction of the first slice, for X_{ca} = 400m.

The evolution of the horizontal displacement u is accentuated to the extraction of the first slice, regardless of the thickness, reaching $\pm$ 129.6mm.

In the case of extraction of the second slice, the horizontal displacement u is in the range of -133.4mm + 133.5mm, but does not show an equally accentuated evolution as in the as in the case of extracting the first slice, due to a strain relief of the rock mass at the time of extraction of the first slice.

After the comparative analysis of the surface deformation, depending on the extraction method and the seam thickness, has resulted that both, subsidence w (491mm) and horizontal displacement u (-136mm +136mm) have an increasing evolution more accelerated in the case of underground mining by top coal caving, compared to the extraction method in slices.

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DETERMINATION OF RISK COEFFICIENTS FOR FACTORS THAT GENERATE LANDSLIDES AT THE COUNTY LEVEL

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NICOLAE DIMA [2]

Abstract: The stability state of terrains depends on the presence and interaction of permanent factors that determine the emergence and development of the landslides. Determination of the influencing factors that exist at a point in time offers the possibility of identification of risk areas and estimation of the probabilities of occurrence on the basis of which the planning, designing and putting into practice measures to combat the landslide tendency is realized.

Keywords: *landslides, risk areas, influencing factors.*

1. FACTORS THAT INFLUENCE THE OCCURRENCE AND DEVELOPMENT OF LANDSLIDES

The studies regarding the occurrence and development of landslides follow the estimation of the value and geographical distribution of K_i risk coefficients (i = a … h) and specification of the potential group (low, medium or high) and establishing a probability level of landslide occurrence, which will lead to the identification, localization, delimiting and thematic map representation of areas exposed to the landslide hazard.

The landslide hazard maps include isolines with a planar geographic distribution of landslide probability values or of probabilities of exceeding for different specific destructive characteristics which generate damages.

Evaluating the landslide occurrence probability of a mountainside is determined based on the eight factors of influence: a – lithology, b – geomorphology, c – structure, d – hydrology and climate, e – hydrogeologic, f – seismic, g – forestry, h – anthropic.

The influence of each factor upon the state of equilibrium of a mountainside is expressed through a coefficient K_i (i = a … h), the value of which is contained in the interval [0, 1]. The factors of influence taken into consideration do not act with the same

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intensity upon the mountainside stability, the factors being considered as having a major role being lithology and geomorphology while the other 6 factors have a secondary influence. The evaluation of the coefficients afferent to the 8 factors that influence the stability of mountainsides is made on the basis of existing documentary materials and information obtained through measurements.

2. THE STRUCTURE OF DATA USED TO CREATE THE NATURAL HAZARD MAPS

In order to create the hazard maps the following categories of data are collected and centralized:

a) Data characteristics regarding the medium of production of natural hazard phenomena: the digital terrain model, interest areas limits, the geographic localization of the phenomenon, vegetation, land use, pedology, hydrography, geology, hydrogeology, climate.

b) Data regarding the related the triggering or attenuation phenomena for hazard production when a landslide occurs: hydrology, precipitation, registered maximum flow rate, subsidence, subsidence type, subsidence occurrence reduction potential, earthquakes (intensity, construction regulations), land improvements works, development works in the hydrographic basins.

c) Anthropic data regarding the technical infrastructure created in the range of hazard manifestation: road and railroad infrastructure, hydrotechnical defense works or other use works (piscicultural, irrigation or navigation developments), characteristics of constructions regardless of destination.

The structure of the graphical and attributive data bases used for the delimitation of risk areas is oriented on the delimitation of elements specific to the influence factors and contains:

-Communication paths: roads, railroads, etc., polygon type graphical entities;

-Territorial administrative units, polygon type graphical entities;

-Polyline type graphical hydrographic entities for the rivers not registered in the land register and polygon type for rivers registered;

-Vegetation, polygon type graphic entity;

-Relief units, represented as contour lines, polyline type graphic entity.

-Soils, polygon type graphical entity.

The data can be obtained from different sources, respectively existing maps and plans, orthophotomaps, statistical data provided by the National Statistical Commission. *Open source* data can also be used (Google Street, Google Satellite, Google Terrain, SRTM, etc.) that can be imported and managed through the *open source* type applications (QGIS, SAGA GIS, etc.)

3. DETERMINATION OF RISK COEFFICIENTS FOR FACTORS THAT GENERATE LANDSLIDES AT THE LEVEL OF THE OLT COUNTY

Taking into account the characteristics of natural and anthropic factors corresponding to the Olt County, the following values for influencing factors have been determined:

a) Lithology factor

The lithology characteristics of geological formations that crop out on the county territory, to which are added the geomorphological characteristics, the climatic particularities and precipitation regime, in the case of areas with varied sizes, induce the high value of landslide probabilities, that lead to them being categorized in the group of areas exposed to hazards and landslides. These kinds of areas are found in the mountainsides of torrent valleys on the right side of the Oltet, the mountain foothill area ridges that dominate the right side terrace of the Olt, north of the Oltet and at the starting point of the Bolovanu, Cungrea Mica and Plapcea valleys.

The values attributed to the K_a risk coefficient are as follows:

-0.80 (high probability) for deluges, sands, gravel and clay;

-1.0 (very high probability) for deluges, clays, sands, gravels from areas affected by landslides.

b.) The geomorphological factor

The landforms of the county are affected by the present geomorphologic processes, principally the erosion of mountains (water run-off, gully formation and landslides). The planar areas of foothill fields and terrace bridges are affected by the suffusion processes, and in the valley mountainsides the presence of side erosion is remarked that induces local cave-ins and small landslides.

The risk coefficient K_b values depending on the particularities of the terrain are as follows:

-0,09 (reduced probability) for the basically horizontal areas;

-0,20 (medium probability) in the case of slopes under 5^o;

-0,50 (medium-large probability) for $5 – 9^o$ slopes;

-0,80 (high probability) for slopes of $10 – 15^o$ and affected by gully formation;

-0,90 (very high probability) for slopes over 15^o, with a high degree of gully formation, in some areas affected by landslides.

c.) The structural factor

The south side of the Olt County is contained inside a major tectonic unit – The Moesic Platform, inside which the main share between plicative and disjunctive tectonics, is represented by the second group, otherwise characteristic of platforms that induce an advanced fracturing.

The main fault lines have an E – W direction in which the fault line group associated with the Craiova – Bals – Optasi lifted area that is individualized in the shape of a horst that descends in successive steps both towards the north as well as the south. On the general background of a small value tilt of the sedimentary deposits of the platform, the existence at the local level of relatively large tilts is explained by the position of the deposits on the sides of the blocks with dislocated vertical displacements that are quite intense.

The main fractures are accompanied by more or less developed systems, by secondary fractures with amplitude and extension that are direction variable.

The risk coefficient K_c, are as follows:

-0,30 (medium – large probability) for sedimentary formations from inside the platform areas

-0,50 (medium – large probability) for the sedimentary formations from the external flank of the foredeep.

d.) Hydrologic and climatic factor

The Olt hydrographic network is characterized by the Danube River and its three main tributaries, Olt, Vedea and Calmatui. The Danube forms the southern border of the county on approximately 50km, between Ostrovul Papadia and upstream of Ostrovul Calnovat having a basin area of 624.900 km^2. The average multi-annual flow varies between 5.576 and 5.640 m^3/s with maximum values in the period March – May, and minimum values at the beginning of fall, August – October. The maximum flow was evaluated at 16.800 m^3/s.

The Olt River crosses the county territory on a length of 145 km having as right-sided tributaries the Beica, Oltet and Teslui valleys, and left-sided tributaries Darjov and Iminog. The minor riverbed is wide and has numerous meanders, and the major riverbed is intensely alluvial and contains local meadow terraces, levees and lacustro-marsh microdepressions. Also noted are frequent processes of high amplitude lateral erosion.

The multiannual flow varies between 160m^3/s at the county entrance and 190m^3/s at the river mouth. The maximum flow values are registered in the period April – June, and minimum values in November – January. The maximum flow level was evaluated at 3.700 m^3/s (Stoenesti). The Vedea River crosses the county, with its superior basin, on a length of 100 km, until the confluence with the Tecuci stream. The source area of the Vedea River is the Cotmeana Plateau. The left tributaries are Vedita and Cotmeana, and on the right side the valleys of Plapcea and Dorofei.

The multi-annual average flow is 5.5 m^3/s, with a maximum of 850 m^3/s. The average daily flow values are registered in the June – August period. Situated inside the Olt County area there also exist 40 lakes.

The annual average temperature varies between 11,0^{o}C in the south (Corabia) and 10,0^{o}C in the northern extremity.

Average temperatures of 22 – 23^{o}C were registered for the month of July in the central area (Slatina, Caracal), respectively 20 – 21^{o}C in the northern part of the county.

Regarding precipitation, the annual average quantities, which rise from south to north, vary between 500 and 700 mm.

Winds indicate, through their mode of manifestation, an interference of air currents from west and east (the North-Eastern Wind and South-Western Wind). The average annual frequencies are registered between 12,0% and 18,5%, and the annual average speeds have values from 2 to 5 m/s.

The afferent risk coefficient K_d values, are as follows:

-0,30 (medium probability) in the southern half of the county;

-0,50 (medium – high probability) in the northern half of the perimeter.

e.) The hydrogeologic factor

Widespread and high productivity aquifers appear in the gravels and sands developed between the Olt River and the Vedea River. The direction of water flow is towards the south – south – east, in accord with which a decrease in the value of hydro contour levels is remarked from 150 in the north to 70 in the south. The aquifers are 40 - 50 m deep in Piedmont Oltet and Piedmont Cotmeana, 20 - 30 m in the Leu - Rotunda field, and in the Olt and Danube terraces reach 5 - 10 m.

The groundwater aquifers in the terraces are manifested on the surface through springs, and the alluvial ones generally have free surface hydro-structures, the Darjov valley, between Brebeni and Valea Mare and Vedea in the Vitanesti-Potcoava area sometimes locally can be under pressure. In the Olt and Danube meadows the groundwater horizons have a depth of up to 3 m, generating excess soil moisture. The aquifers in the Danube meadow are discontinuous, with a local character.

Total mineralization is generally between 500 and 1300 mg/l, with low values of 500 mg/l only in the areas of Calui and Ganeasa - Doba and over 1300 mg/l south of the Lungesti and Valea Mare area. The total hardness (in hydortimetric degrees) is between 15 and 40 (between Bals and Piatra Olt).The K_e risk coefficient has the following values:

-0,50 (medium – large probability) for areas with temporary springs at the base of mountains in periods of precipitations;

0,80 (high probability) in the case of areas with permanent emergences at the base of mountains with the presence of the phreatic in the immediate approach of the surface.

f.) The seismic factor

The seismic hazard from Romania is due to the Vrancea subcrustal seismic source and other seismic surface sources (Banat, Fagaras, Dobrogea, etc.). The Vrancea source is decisive for the seismic hazard from approximately two thirds of the territory of Romania, while the surface sources contribute more to the local seismic hazard. The areal contained inside the Olt County falls within the macro area with 7_1 seismic magnitude – M.S.K. scale (Medvedev-Sponheuer-Karnik) according to S.R.11.100/1_{-93} „Seismic Zoning of Romania”. Compared to the Norms and Regulations for the antiseismic engineering of constructions $P_{100\text{-}92}$, appendix A “Seismic zoning of the Romanian territory from a calculus parameter point of view” it is situated in area D of seismic intensity (equivalent seismic level of 7), having the seismic coefficient K_8 – 0,16 and corner period T_c – 1,5 sec., with the exception of the northern extremity of the county where T_c – 1,0 sec. According to norm $P_{100\text{-}1\,/\,2004}$ – “Zoning of the territory of Romania in terms of control period (corner) T_c of the response spectrum”, the eastern side of the county is characterized by a_g – $0{,}20_g$, and the western side a_g – $0{,}16_g$ and T_c – 1,0 sec, with the exception of the northern extremity where T_c – 0,7 sec.

For the entire area of the county that is situated in the level 7 MSK seismic intensity area (Medvedev – Sponheuer - Karnik), the risk coefficient K_f has the value 0,70 (high probability).

g) Forestry factor

On the largest part of the Olt County, the natural vegetation has been replaced with agricultural crops. The forest steppe areas, being the largest one, occupies the central and southern part of the plain and is generally constituted from forests with species of oak trees, small patches of meadows and shrubs.

Presently the areas occupied by forests amount to approximately 11% of the total county area.

The K_g risk coefficient has the following values:

-0,20 (medium probability) in cases where the degree of forest vegetation coverage exceeds 60%;

-0,50 (medium – high probability) for areas of which the degree of coverage with tree vegetation is situated between 20 and 60%;

-0,80 (high probability) for areas of which degree of coverage with forest vegetation is under 20%.

h.) Anthropic factor

The industrial development of the county has generated growth in the urban areas (Slatina, Bals, Caracal) which has generated the realization of ample urban construction works consisting of water and sewage networks, road and railroad networks, works that have determined a large volume of excavations, factors that combined with the deforestation and hydroenergetic developments on the Olt (accumulation lakes), constitute factors favoring the triggering of landslides. Based on criteria from Appendix C to the methodological norms regarding the elaboration mode and landslide risk map contents – H.G. 447/2003, each polygonal area has been attributed a value of the risk coefficient K_h, corresponding to the defining elements of the anthropic influence factors, respectively: municipality- 0,80, city- 0,50/ rural locality- 0,30/agricultural terrain- 0,40/orchard- 0,20 vineyard- 0,30/unproductive terrain- 0,01/unaffected areas- 0,10/single railroad- 0,30/double railroad- 0,60/national road- 0,70.

For the Olt County, the K_h risk coefficient has the following values:

-0,30 (medium probability) for the areas in which constructions are far apart and where there are only roads of local interest;

-0,70 (high probability) for areas occupied by buildable areas constituted from buildings that are not very large and where preponderantly locally important roads are present;

-0,90 (very high probability) occupied by important localities with utility network and crossed by county or national roads.

In order to calculate the average hazard coefficient K_m, corresponding to each polygonal area (the areas of administrative territories) delimited by overlaying the 8 maps corresponding to each of the eight factors the following formula was used:

$$K_m = \sqrt{\frac{K_a \times K_b}{6}\left(K_c + K_d + K_e + K_z + K_p + K_h\right)} = 0{,}29$$

Following the calculation of the influence coefficients, their geographical distribution and establishing the degrees of potential (low, medium, high), to which corresponds a certain probability of occurrence of landslides, through the intersection of the areas corresponding to each factor and applying the mathematical Km value from the calculus formula of the average hazard coefficient, for each newly generated polygon, results the hazard thematic map for landslides.

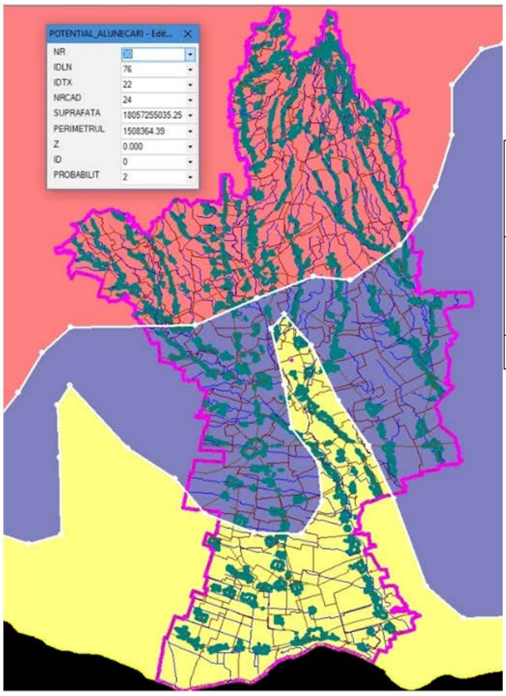
The general map with the geographic distribution of the average hazard coefficient in GIS system, synthesizes the following categories of areas:

-0,00-0,30 (medium probability) for areas situated in the major riverbed of rivers, or at the upper part of the forms of relief;

-0,31-0,50 (medium-high probability);

-0,51-0,80 (high probability);

-0,81-1,0 (very high probability);



Legend:

Potential of landslide occurrence	Landslide probability	Conventional symbol (color)
Low	Zero	
	Very small, tends towards zero	
High	High	

Fig.1. Digital GIS basemap with macrozoning the potential risk for landslides in Olt County

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THE ALTERNATIVE USE OF VARIOUS MEASUREMENT METHODS FOR SURFACE MOVEMENT TRACKING

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Abstract: The tracking of surface movement over time can be accomplished by various modern or classical measuring methods performed successively at different time intervals. Irrespective of the method used, the results of the measurements must allow the extraction and interpretation of the characteristic dimensions defining surface movement, providing sufficient data to be precise for use in assessing the present conditions and estimating the trends regarding the future evolution of the phenomenon.

Keywords: *surface movement tracking, LIDAR, photogrammetry, GPS, metadata.*

1. TRACKING SURFACE MOVEMENT USING DATA OBTAINED THROUGH VARIOUS MEASUREMENT METHODS

The movements can be determined and estimated from the values and conditions of the initial observation, the periodic measurement and the quantification of the factors that influence the evolution of the surface movement until the phenomenon ceases. Irrespective of the measurement method, the implementation of a movement tracking project on a surface, requires going through some phases which involve the usage of specific technical equipment in certain execution conditions. Each measurement method has advantages and disadvantages, the construction of accurate prediction models can only be achieved by using combined methods of analysis and by analyzing as much data as possible through various methods.

Schematically, the phases of a surface monitoring project while using different measurement methods are as follows:

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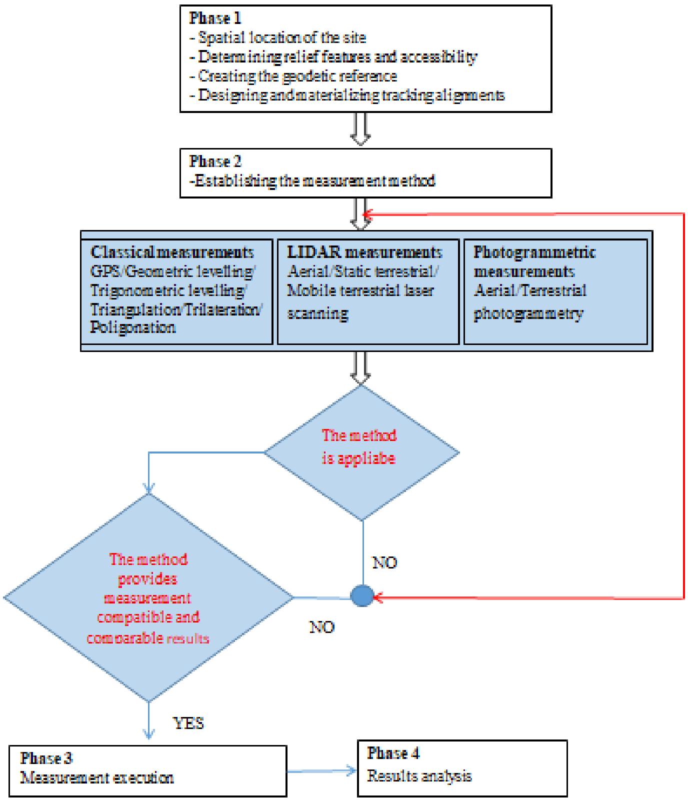

Fig. 1. The phases of a surface movement tracking project when alternative usage of various measurement methods

Considering the fact that in the affected areas, beside the classic tracking measurements there are also various aerial photography projects, LIDAR scanning, topo-cadastral measurements, etc., it is required to create a common database for these areas to integrate all the different sources measurement results.

According to current requirements, geospatial databases are accompanied by metadata that allow both the identification of the source of the data and also give information about the quality, organization, access rights and user segment to which they are intended.

Information on data content refers to general classification elements, source and identification. Data quality information refers to precision, accuracy, homogeneity, how the standard was approved, who did the verification, who recommends them, etc. Data organization includes the structure of the geospatial data, reference systems, version, edition, date of creation, date of last edit, etc. The reference system includes data about the datum, the cartographic projection, etc. The segment for which the data can be used is directly related to the availability and the mode of data distribution, including details of the covered area, the format in which the data can be delivered, the order and delivery mode, price, etc.

2. SURFACE MOVEMENT TRACKING ON THE BORE FIELD IN OCNELE MARI, VÂLCEA COUNTY

The proposed methodology for surface movement tracking on the bore field in Ocnele Mari, Vâlcea County, is based on the alternative usage of several measurement methods, as follows:

-aerial laser scanning, aerial photography and GPS measurements, which were made in 2013;

-aerial photography and GPS measurements, which were made in 2015;

-mobile terrestrial laser scanning and GPS measurements which were made in May and December, 2017.

For the comparison of the measurement results, a 3m x 3m trapezoidal concrete control surface, used as a reference, was placed in the vicinity of the bore field.

Within each measurement session, the corners and the center of the control surface were redefined using GPS measurements, while the differences between sessions were used as a reference for calibrating the results obtained by LIDAR scanning and aerophotography, and for tracking vertical movements in the study area.

The evaluation of the results obtained using the four measurement methods was realised with the control surface points for each measurement session. Horizontal movement tracking was performed by comparing the horizontal difference between the level curves generated on the basis of the digital terrain model.

2.1 Aerial Laser Scanning, Aerophotography and GPS Measurements phase, 2013

The following equipment was used in 2013 for aerial laser scanning, aerial photography and GPS measurements:

-2 RIEGL Q560i laser scanners;

-Ultracam Lp photogrammetric camera;

-IMU model IGI class II d,256 Hz;

-mobile GPS, mounted on Novatel OEM4/OEMV;

- static ASHTECH ProMark 200 GPS;

-processing programs: AeroOffice,GrafNav,RIProcess,Terrascan, Ultramap;

- Râmnicu Vâlcea ROMPOS reference station (code VLC1).

The surface control coordinates and the precision of determination are shown in the table below.

Table 1. Surface control coordinates

No.	X_stereo70	Y_stereo70	Z_MN75	RMS_XY	RMS_Z	Average no. of sattelites	PDOP	HDOP	VDOP	TDOP
176	399046.1136	442815.6587	280.196	HSDV:0.012	VSDV:0.015	10	1.100	0.500	0.900	0.500
182	399042.9064	442815.3868	280.1752	HSDV:0.011	VSDV:0.011	10	1.100	0.500	0.900	0.500
197	399044.5804	442814.0167	280.1771	HSDV:0.005	VSDV:0.012	10	1.100	0.500	0.900	0.500
221	399043.1984	442812.4502	280.1576	HSDV:0.006	VSDV:0.014	10	1.100	0.500	0.900	0.500
227	399046.1524	442812.584	280.1849	HSDV:0.012	VSDV:0.015	10	1.100	0.500	0.900	0.500

The root mean square error obtained from the post-processing of the kinematic trajectories has the following values: RMSx=0.0209 m RMSy=0.0287 m, RMSz=0.0498 m.

Considering that transformation points implemented in the Transdat program were used to transform ETRS89 system points into the 1970 Stereographic System to eliminate the elevation errors caused by the continuous improvement of the program, the ellipsoidal elevation was used for the calculations.

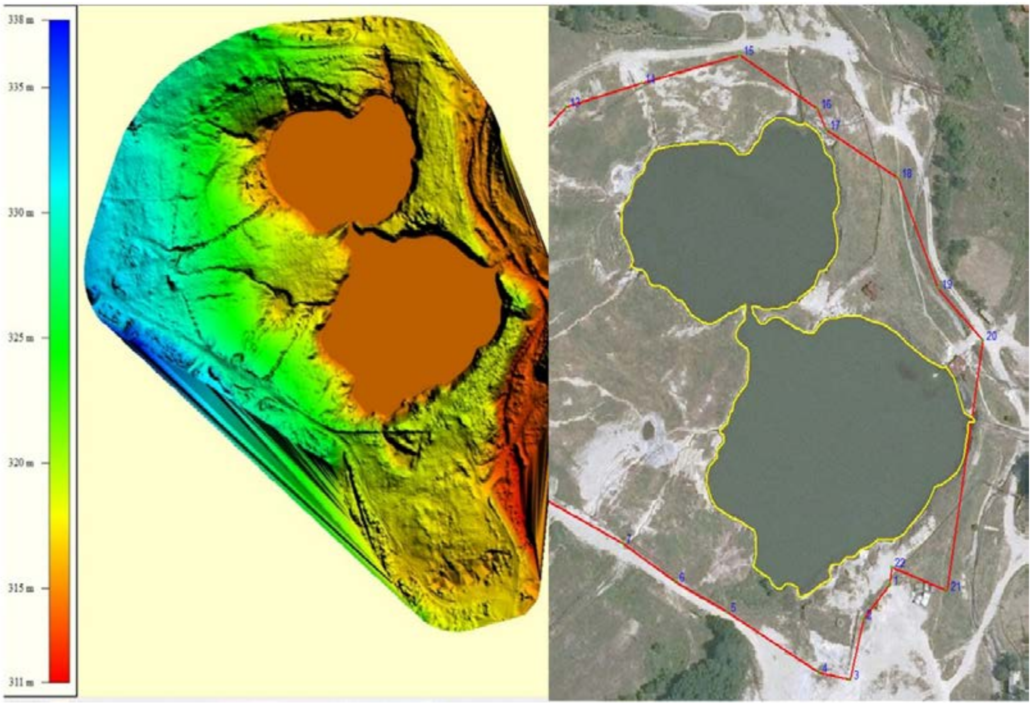

Fig. 2. The Digital Terrain Model, the orthophotomap and the control points, June 2013

2.2 The aerophotography and the GPS measurements executed in 2015

The following equipment was used in 2015 for aerial photography and GPS measurements:

-Ultracam Lp photogrammetric camera;
-IMU model IGI class II d,256 Hz;
-mobile GPS, mounted on Novatel OEM4/OEMV;
- static ASHTECH ProMark 800 GPS;
- processing programs: AeroOffice,GrafNav,RIProcess,Terrascan, Ultramap;
- Râmnicu Vâlcea ROMPOS reference station (code VLC1).

The pictures were taken on 19.04.2015 with a 13cm/pixe resolution.

The Digital Terrain Model was generated from 1 point/pixel images. When checking the model using the control surface, there was a -0.659 m height difference. In conclusion, the DTM generating softwere uses a rather inaccurate interpolation algorithm and therefore the process does not provide sufficiently precise results for a competent assessment. Concerning the analysis performed by the comparison of common elements identified on the images obtained in June, 2013 and April 2015, there are no significant changes, the shape of the lake being slightly different in the north-east.

Fig. 3. *The Digital Terrain Model, the orthophotomap and the control points (yellow contour - 2013, green contour-2015*

To improve accuracy, it was chosen to determine the coordinates of the control surface by stereorestitution. To identify a point element on stereograms, it takes about 1.5-2 pixels, resulting in a planimetric accuracy of +/- 0.20 m-0.26 m.

Since the photogrammetric method does not provide sufficiently precise results, it has been chosen to determine by GPS measurements both the control surface elements and circular points around the lakes.

The altimetric differences are presented in the table below.

Table 2. Surface control coordinates

No.	X_stereo70	Y_stereo70	H_ETRS89_2013	H_ETRS89_2015	Difference 2013-2015
176	399046.11	442815.6587	317.677	317.631	0.046
182	399042.91	442815.3868	317.656	317.611	0.045
197	399044.58	442814.0167	317.658	317.617	0.041
221	399043.2	442812.4502	317.638	317.595	0.043
227	399046.15	442812.584	317.666	317.623	0.043
Average					0.0436

2.3 Mobile Terrestrial Laser Scanning and GPS measurements executed in 2017

The following equipment was used in May and December 2017 for Mobile Terrestrial Laser Scanning and GPS measurements:

- VMX-250 mobile laser scanning system, that incorporates two RIEGL VQ-250 laser scanners, an IMU Applanix POS Lv, a Trimble GPS and four CS 6 digital cameras;

The system provides the following precisions:

-Absolute position precision: 20-50 mm;

-Relative position precision: 10 mm;

-Angular precision : ROLL :0.0050 /PITCH :0.0050 /YAW: 0.0150

-ASHTECH ProMark 800 GPS used for static measurements;

-Processing programs: Pospac MMS 8.01,RIProcess,Terrascan,GlobalMapper;

-ROMPOS reference station- Râmnicu Vâlcea (code VLC1) ;

-ROMPOS Control Station- Horezu (code HORE).

Scan parameters have been set to achieve a density of 1000 points / m^2.

The processing of the kinematic trajectories was done with the Pospac MMS 8.01 program, the processing option being In Fusion Single Base. The root mean square error obtained from the post-processing of the kinetic trajectories for the May 2017 measurement session has the following values: RMSx = 0.0148 m RMSy = 0.0183 m, RMSz = 0.0441 m, being comparable to the 2013 measurements.

The root mean square error obtained from the post-processing of the kinetic trajectories for the December 2017 measurement session has the following values: RMSx = 0.0141 m RMSy = 0.0138 m, RMSz = 0.0352 m, being comparable to the 2013 measurements.

The classification of the points for obtaining the digital terrain model (ground class) was done with the Terrascan program.

The average elevation height measured using the control surface points for the two sessions is 0.014 m.

The average elevation height measured in the control area between June, 2013 and December 2017, is shown in the table below.

Table 3. Centralized table with altimetric values in the control surface points

No.	**H_ETRS89 2013**	**H_ETRS89 2015**	**H_ETRS89 May2017**	**H_ETRS89 December2017**	**Difference H_ETRS89_2013-H_ETRS89_December2017**
176	317.677	317.631	317.573	317.559	0.118
182	317.656	317.611	317.553	317.539	0.117
197	317.658	317.617	317.554	317.54	0.118
221	317.638	317.595	317.536	317.522	0.116
227	317.666	317.623	317.563	317.549	0.117
					0.1172

According to the results presented in the table it can be assumed that the area of the study shows the phenomenon of diving, the average annual rate being 0.0293 m.

3. CONCLUSIONS

The studied case illustrates how to obtain and use data achieved by using alternatively different measurement methods in the study of surface deformation by simply finding a common reference to allow estimation and comparison of the results. A resulted from the measurements data analysis leads to the conclusion that, in order to allow the proper use of the information, a computer system is needed to enable the work with the geospatial data obtained.

Once created, this information system can be upgraded and expanded nationwide for all mining areas, ensuring:

- creating a national database with information on the mining objectives in the conservation and closure process, with the possibility of extending to active mines;
-monitoring of the environmental issues and mining processes;
-providing decision support for emergency management;
- timely identification and detection of critical situations;
-evaluation of the effects of mining activity on the environment;
-determining the causes of production and measuring effects.

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RESEARCH ON THE DISPERSION OF POLLUTANTS FROM SOLID FUELS COMBUSTION

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Abstract: Fossil fuel combustion in stationary and mobile sources is widespread anthropic activity, responsible for loading the atmosphere with a complex of gaseous and solid organic and inorganic pollutants. The following pollutants can be present: acid gases (sulfur dioxide and trioxide, nitrogen oxides, carbon mono and dioxide), powders (ash and soot) and some organic volatile compounds (hydrocarbons - predominantly methane, organic acids). The ashes by burning coal contain a number of metals such as: As, Cd, Pb, Mn, Hg, Ni, V. The models currently used in Romania to calculate pollutant concentrations are based on Gaussian solutions of diffusion equation. This paper presents the dispersion of pollutants using the ARIA IMPACT software. These models can be applied to momentary and continuous point sources, linear and surface sources. The models are applicable for one or more sources.

Keywords: *pollution, measures for reducing pollution, mathematical model*

1. INTRODUCTION

The development of the electricity sector, a strategic sector essential for economic and social development of Romania must be achieved, first, closely related to the overall development of Romania, and taking into account the varied but limited primary energy resources of Romania as well as submitting to the sustainable development principles. In the context of ”Romania's strategy for energy for 2007-2020” approved in 2007, Romania's energy policy objectives focus on secure electric energy supply, improving energy efficiency, environmental protection and respecting consumer rights. The dual relationship between environmental protection and economic development must create that balance, enabling the objectives of sustainable development. As a result, measures and appropriate decisions to reduce drastically the amount of toxic emissions released through smokestacks into the environment are required, protecting in this way, both national ecological heritage and that of neighboring countries. This is the purpose for which it was developed "The convention for the avoidance of trans boundary pollution", which was also joined by Romania.

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2. POLLUTANT DISPERSION IN THE ATMOSPHERE. CASE STUDY - CEN HD ELECTROCENTRALE PAROSENI

2.1. Pollutant emissions

The direct impact of pollutants discharged into the atmosphere from a source shall take place in areas relatively close to it, over distances of a few tens of meters to several kilometers, depending on the physical parameters and the power of the source. When the source is located in a densely populated urban area the most important factor exposed to direct pollutants is the human factor who takes over noxae from the atmosphere by inhalation. Also vegetation (ornamental and protective), surface water (drinking water reservoirs) and soil are affected.

Currently, in Romania, in STAS 12574-87 there are established ambient air quality conditions so that the maximum permissible concentrations of pollutants do not exceed the threshold of harmfulness and protect people, flora and fauna in the surrounding area of thermal power plants, and not only against the harmful effects of these substances.

The problem of environmental pollution is considered solved at large combustion plants if the smokestack height is properly sized providing a range of spread of pollutants, so that their concentration at ground level should be less than the limits allowed by law. ISPE designed a normative act, PE 229/84, which establishes the methodology for calculating the smokestack height and the concentration of SO_2 and particulate ash.

Currently, this way of solving it is considered inappropriate because from the enormous amount of pollutants removed annually through smokestacks, some spread around pollution sources, remaining in that country, but another part is carried out by air and water across borders. The valuation calculations of the pollutants (CO, SO_2, NOx) dispersion based on Gaussian distribution show that often the cumulative effect of multiple sources generates overruns of imissions at ground or certain heights levels, both close to sources and distant (trans boundary pollution).

In both cases the polluting effect is amplified over time, especially for persistent noxae, forming so-called gas sources (generating harmful effects).

The dispersion of pollutants in the atmosphere is a complex phenomenon that is the subject of numerous theoretical and experimental research. The dispersion of pollutants in the atmosphere is determined by the turbulent diffusion phenomena and by the air masses transport.

The environment in which the diffusion process is conducted is the atmospheric air, pollutant emitted being therefore most affected by phenomena occurring within the Atmospheric Boundary Layer (ABL). In the study of pollutant dispersion in the atmosphere the effect of two processes is analyzed:

- The actual dispersion under the effect of wind and other meteorological parameters;

- The dispersion of pollutants in the atmosphere, complex process that depends not only on meteorological factors, but also geographic factors, specifics of the source etc.

The dispersion of these agents has been studied very much and based on the research conducted and the achieved results, a number of authors have established different laws and formulas for calculating the concentration of harmful substances in various points. Until now however, there hasn't been found a general method for calculating the area of air pollution using the height and distance of the contamination source.

Formulas known until today are based on local research each including certain coefficients that vary widely from one another, both in number and value.

Smokestacks of industrial installations are the most important sources of emission of pollutants into the surrounding atmosphere. Their location and height are factors that influence a lot the area of contamination; the higher a source (smokestack), the greater the dispersion; height depending on certain rules of construction, cost, maximum speed of pollutant output, circulation, etc. Pollutants discharged on the smokestack have some kinetic energy and form a jet in the vertical direction. This effect is reinforced by the upward forces that arise due to gases that have a much higher temperature than the surrounding atmosphere. By mixing with ambient air there is created an equilibrium temperature where by the exchange of impulses with the environment, the jet is canceled. The dispersion and transport of pollutants in the atmosphere are complex and difficult to study processes. The study of pollutant interaction with the environment, where the dispersion occurs, is made taking into account all factors influencing its evolution in time and space.

The main meteorological factors affecting air pollution are:

- Horizontal wind (speed and direction);
- Geostrophic wind in the free atmosphere;
- Friction with the ground forces that alter geostrophic wind;
- Local winds (breezes, mountain-valley winds);
- Atmospheric stability: stability classes are a simple way to characterize the turbulent atmosphere that affects the dilution of the atmosphere;
- Height of the mixture;

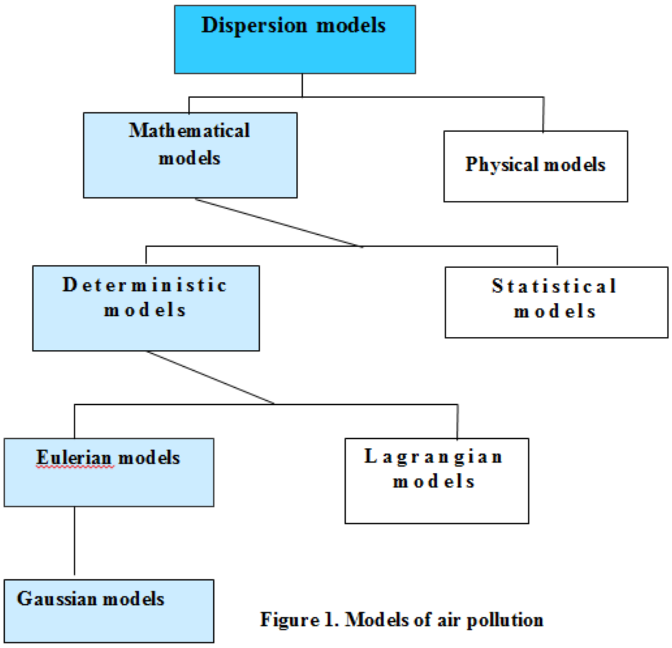

Figure 1. Models of air pollution

The models currently used in Romania to calculate pollutant concentrations are based on the Gaussian solutions of the diffusion equation (Fig. 1) (Racoceanu C. -2011). These models can be applied to the following types of sources: momentary and continuous point sources, linear sources and surface sources. The models are applicable for one or more sources.

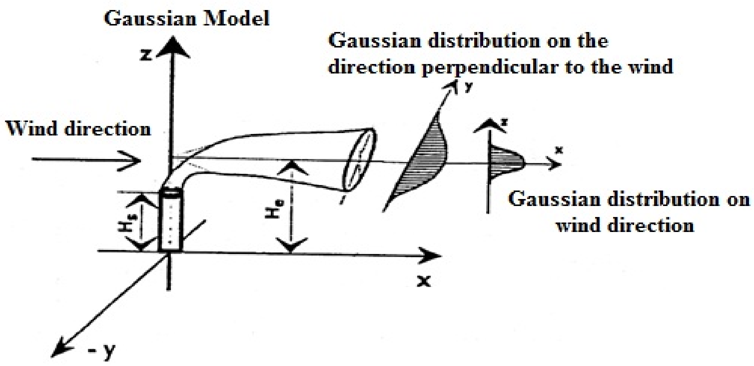

Fig. 2. The Gaussian model for the dispersion of pollutants

The concentration of a pollutant (CO_2, SO_2, NO_2, CO) produced by a momentary and continuous point source, a linear source, or a source surface with the height h (Fig. 2) is given by the equation:(Ciolea D., 2004, J.H.Seinfeld, 2006)

$$c_i(x,y,z) = \frac{Q}{2 \cdot \pi \cdot \overline{u} \cdot \sigma_y \cdot \sigma_z} \cdot e^{-\frac{y^2}{2\sigma_y^2}} \cdot \left(e^{-\frac{(z-h)^2}{2\sigma_z^2}} + e^{-\frac{(z+h)^2}{2\sigma_z^2}} \right) \quad [1]$$

Where: c_i - concentration of contaminant (kg / m^3);

- Q - the emission of the pollution source (kg / s);
- h - the actual height of the source (m);
- u - average wind speed (m / s)
- σ_y, σ_z - parameters of diffusion determined according to the distance x, (m).

Table 1 shows existing installations being implemented at Electrocentrale Paroseni for retention, disposal and dispersion of pollutants in the air.

The specific noxae from fuel combustion in boilers, according to the National Pollutant Emission Guidelines, are: CO_2, CO, CH_4, N_2O, NO_x, SO_x, As, Cd, Cr, Cu, Ni, Pb and powders.

Table 1. Installations for retention, disposal and dispersion of pollutants in the air at S.E. Paroseni

Pollution source	**Emission point**	**Pollutant**	**Treatment equipment**	**Proposed or existent**
IMA 2	Dispersion chimney H = 160 m Dv = 7 m	Powders	3 electrofilters	Existent
		SO_2	-	Desulphurization plant – in progress
		NO_x	NO_x burners	Existent

Table 2. Emission points and possible pollutants being emitted into the air for IMA

Process	**Emission point**	**Pollutant**	**BAT**
Fuel combustion in boilers	IMA 2	CO_2 NO_x CO Powders CH_4 SO_x As, Cd, Cr, Ni, Pb, Hg	**Reduction of SO_2 emissions** - solid-fuel with a sulfur content below 0.9% - Combustible gas desulphurization **Reduction of NO_x emissions** - improve performance burners and other primary measures - supporting measures to reduce NO_x emissions - reduce dust emissions **Modernization and electrostatic refurbishment other measures** - proper dimensioning of dispersion chimneys - preheating combustion air - combustible gases resulting from production processes to steam.

Table 2 shows the pollutants that are possible to be emitted into the atmosphere and the best techniques that can lead to reducing air pollution. No emissions to air shall exceed the limits specified in Table 3, after achieving the measures contained in the action plan, according to the transitional period.

Table 3. – IMA 2 functioning

Thermic power	**Pollutant**	**Measured average value, mg/Nmc**	**VLE mg/Nmc according to HG. 541/2003**
IMA 2 587 MWt			Furnace for burning solid fuel
	Powders		100
	SO_2	2.200	532 – beginning from 31.12.2010
	NO_x		600 – beginning from 01.01.2016

2.2. Drawing the maps of dispersion of pollutants emitted in the combustion installations of Electrocentrale Paroseni

Description of the dispersion model used

ARIA IMPACT is the new user-friendly software developed by ARIA Technologies adapted to the needs of industries, consulting companies and local and regional administrations responsible for analysis and assessment of air pollution. It is a gaussian model explicitly designed for evaluating the long-term impact of emissions from industrial sites, vehicular traffic and diffuse sources. The system is designed for decisionmaking purposes providing the possibility to simulate consequences of increased emissions or implementation of proposed actions to reduce them.

ARIA IMPACT simulates long-term operation by using meteorological time series covering several years, representative for the site. The software accounts for temporal variation of emissions allowing a realistic and dynamic description of source operation over time. The simulation yields results that can be compared with regulatory norms of air quality as well as basic elements for complete evaluation of health risks.

Calculation model used is Gaussian Cartesian, to calculate the long, medium and short term immissions from industrial centers, car traffic and diffuse sources. Aria Impact calculates the dispersion of two types of pollutants:

- non-reactive chemical gas (ex. aerosoli precum SO_2 şi NO_x);
- powders, that are subject to sedimentation and deposition processes in the examined areas.

The program is able to consider multiple individual sources of pollution, realizing the simultaneity for each pollutant separately. The model takes into account the evolution of the concentration of pollutants in the smoke and the change of the direction due to meteorological factors. In addition to those presented when the wind blows in the study area at low intensities, the program uses a Gaussian model for low wind speeds, calculating the concentrations of pollutants at ground level. The calculation is based on the following hypotheses:

- the turbulences are uniform in the lower layers of the atmosphere;

- the measurements made to the analyzed site are representative for the whole field of study;
- pollutants densities are close to that of air;
- the vertical component of wind is negligible compared with the horizontal one;
- stationary regime, eg the smoke is considered to instantly reach steady state conditions for each series of weather conditions used in the calculation of pollutant dispersion.

Generally, these assumptions can lead to over estimation of analyzed pollutants, but they allow the user of the modeling dispersion software to quickly view the characteristic parameters of pollution in an area of 1.0 to 50.0 km.

ARIA IMPACT ground-level pollutant outputs concentrations as iso-lines or colored areas superimposed on a map of the studied site. With this mathematical model one can calculate both the average annual concentrations of pollutants and hourly concentrations or daily (percentile) and their spatial distribution in the analyzed area. The annual iso-lines for sulfur dioxide, oxides of nitrogen in the atmosphere, dust suspension, for year 2015 are shown in figures 3,4,5.

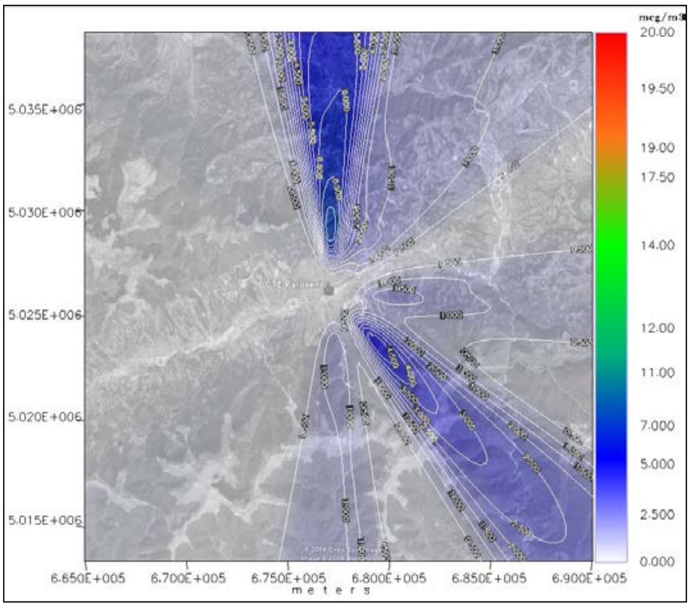

Fig 3. Annual concentration of SO_2

Maximum annual concentration of SO_2 is 7,39 µg/m3.

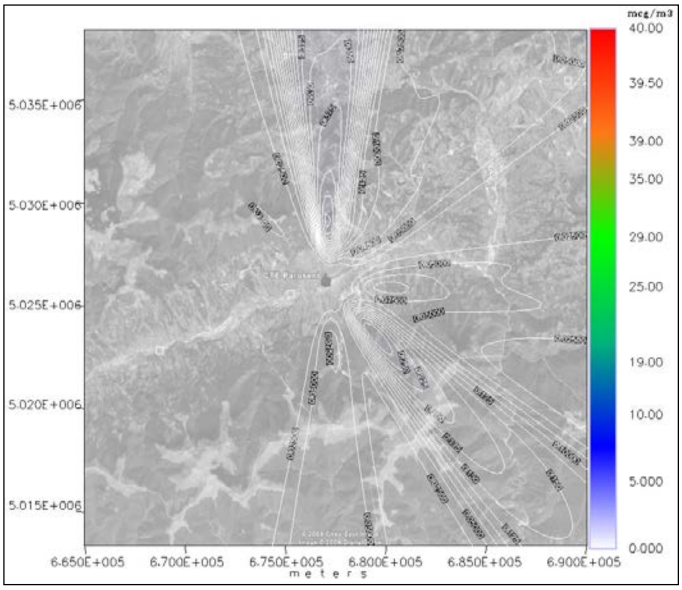

Fig. 4. Annual concentration of NOx

Maximum annual concentration of NOx is 0,46 µg/m3.

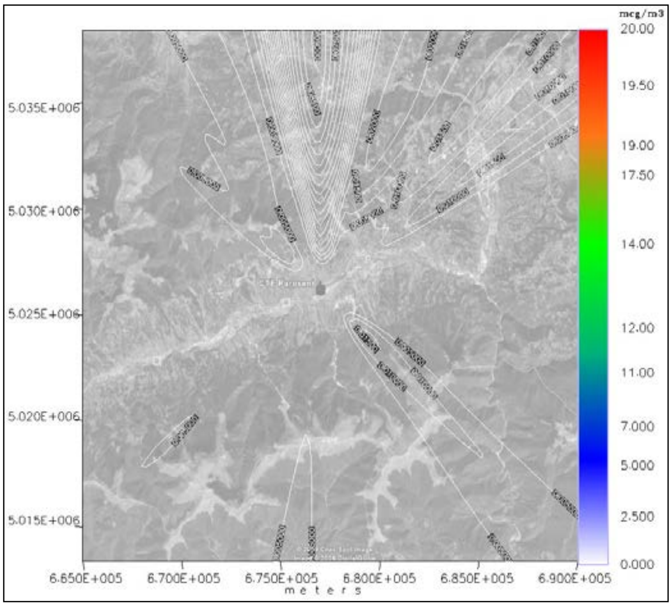

Fig. 5. Annual concentration of PM

Maximum annual concentration of PM is 0,09 µg/m3.

3. CONCLUSIONS

The direct impact of pollutants discharged into the atmosphere from a source occurs in areas relatively close to it, over distances of a few tens of meters to several kilometers, depending on the physical parameters and the power source.

As a result, the necessary measures and appropriate decisions, as to reduce drastically the amount of pollutants removed by chimneys in the environment, protecting in this way both the national and ecological heritage of the neighboring country, are to be taken.

By upgrading Group 4 there is ensured the continuity in functioning of the energy group, in terms of safety, efficiency and environmental protection.

The upgrading of Group 4 included use of Best Available Techniques to reduce NOx by installing advanced burners with low NO_x, reducing the amount of emissions below the European environmental requirements, and by the modernization of electrostatic precipitators. For the future, a flue gas desulphurization station is to be achieved and to replace the current evacuation of ash and slag hydromixture with a new technology - dense slurry.

Monitoring of emissions is done online, using a system that has equipment for flue gas analysis: O_2, SO_2, NO_x, CO, CO_2 and powders, ensuring the transmission of the data remotely, giving the possibility of monitoring and storing them.

The models currently used in Romania to calculate pollutant concentrations are based on Gaussian solutions, allowing them to be applied to momentary and continuous point sources, linear sources and area sources.

It appears that in the period under review and for the values analyzed: sulfur oxides, nitrogen oxides, particulate matter, there was no exceeding of the limit imposed by Order No. MAPM. 592/2002.

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TRANSFERENCE OF THE OLD TOPOGRAPHIC MAPS FROM ANALOG FORMAT TO DIGITAL

DACIAN-PAUL MARIAN [1]

Abstract: Old topographic maps are a particularly important database. For this reason it is necessary to preserve them in optimal conditions and in an accessible form. Preservation of old maps by transferring them into a digital format, involves scanning and storing them in a raster format or, for easier future use, digitizing and keeping them in a vector format. In this paper is shown a way of transfer in digital format of a topographic contour map.

Keywords: *map, digitization, analog format, digital format*

1. GENERALITIES

A map, is a reduced, conventional and generalized representation of the terrestrial surface, based on mathematical principles and certain scale, taking into account the sphericity of the earth [5].

Old topographic maps are one of the most accessible sources of data acquisition with regard to surface configuration. If is necessary to know the surface configuration at a given time in the past, the old topographic maps constitute the only source of information. For this reason, keeping them in good and easily accessible conditions is very important. Extracting data from topographic maps can be done by manual, semi-automatic or automatic digitization [4].

For example, in the case of this paper, has been chosen for semi-automatic digitization a map with level curves (contour map) from 1982, drawn at a 1:2000 scale in the Jiu Valley 1958 projection (Fig. 1).

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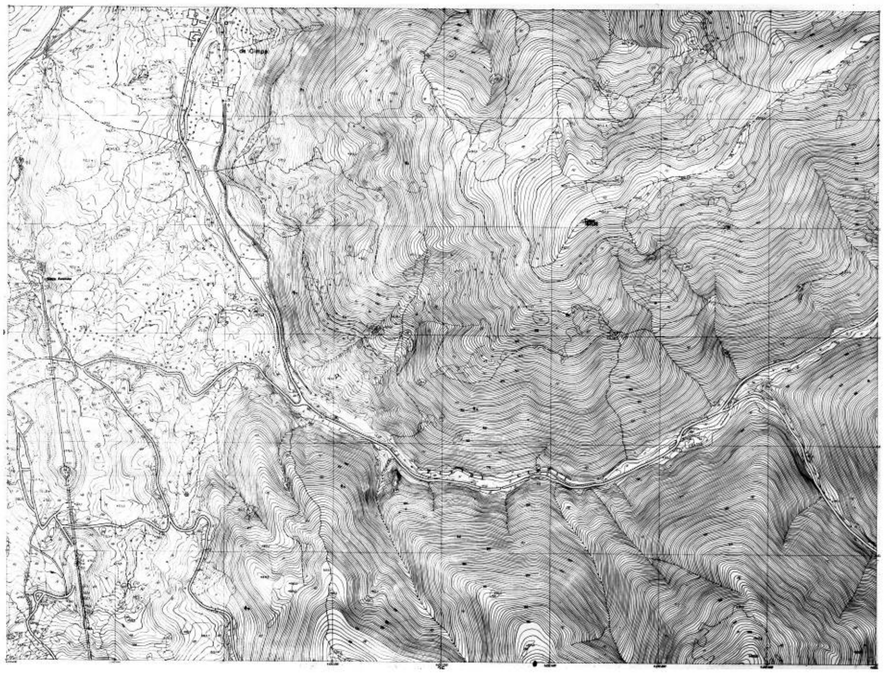

Fig. 1. Map selected to be transferred in digital format

The map chosen for digitization is located in the Cimpa area, Petrila town, Hunedoara county, Romania (Fig. 2).

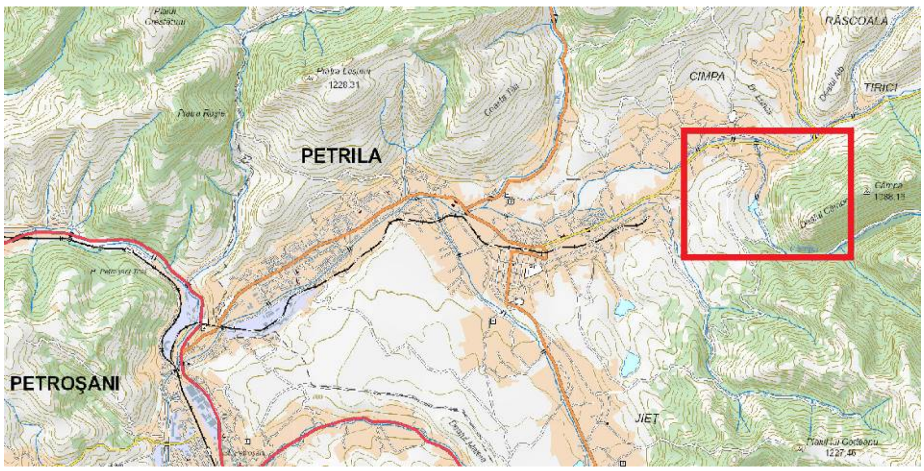

Fig. 2. Geographical location

To transfer this map in digital format, the Autodesk software package was chosen, namely: AutoCAD Civil 3D and AutoCAD Raster Design [1], [2].

2. PREPARING THE MAP FOR DIGITIZATION

For the transition of the old topographic maps from analog format to digital, it is necessary to digitize all the details that are on the map [6], [8].

Digitizing means the process of copying the level curves (or other details) from the raster format, using a polyline that stores in each vertex the *X* and *Y* position of the point located on the digitized level curve. In the end, the elevation of the digitized level curve is attached to the created vectors.

Before proper digitization, it is necessary to prepare the raster image.

First, the map was cleaned (dust and other impurities was removed) after which it was scanned at the highest possible resolution. The raster image, obtained from the scan, was imported into the AutoCAD program using the Raster Design module, accessing the command RASTER → INSERT (Fig. 3).

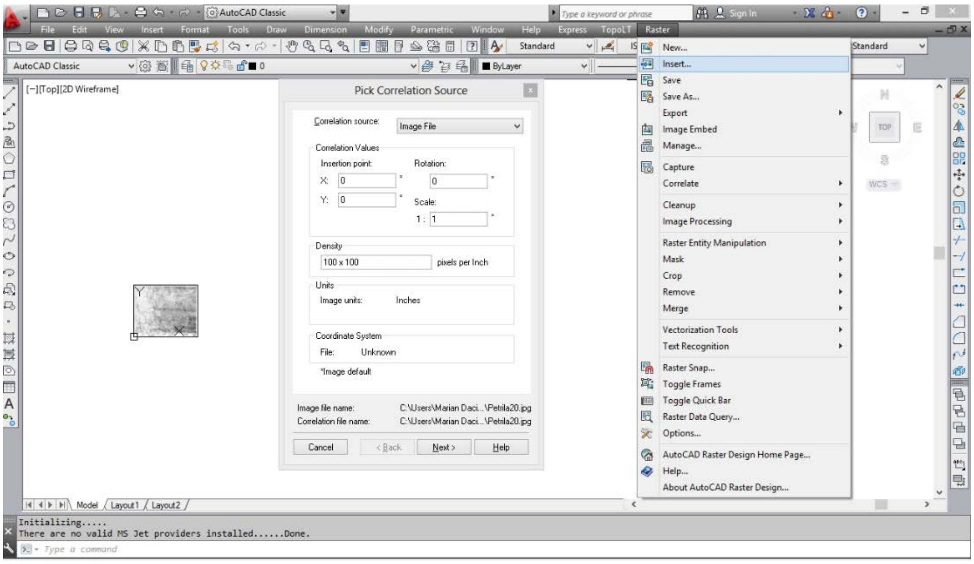

Fig. 3. Inserting the map in AutoCAD

The program requires the insertion of some parameters for inserting the raster image (insertion point coordinates, photo rotation angle, scale, measure unit, density of points per measure unit). In the case of new photograms (orthophotographs) the program automatically recognize these parameters and place the image automatically on their real coordinates.

For old maps, these parameters must be entered manually, if they are known. If they are not known, the map is inserted manually on random coordinates, then the raster image is manually georeferenced [7].

Georeference is the assignment of real coordinates and, where appropriate, spatial extentions in order to locate on the terrestrial surface the mapped area. These coordinates can be: geographic coordinates (latitude and longitude) or rectangular coordinates (*X* and *Y*) depending on the projection which will be used.

So, after the approximate positioning of the raster image (on temporary coordinates), was made a simple georeference of the image on its real coordinates (read from the corners of the grid) by a translation, rotation and scaling of the raster image.

After this simple georeference (due to the fact that the raster image underwent some minor changes from the scanning process) it is necessary to perform a precision georeferencing using several known points. For this purpose, the intersections of the grid lines were used (so that the corners of the grid drawn on the raster image overlap perfectly over the corners of the real grid).

This operation was performed using the RASTER → CORRELATE → ROBBERSHEET command (Fig. 4), the program requesting to indicate the overlapping points (this is done by selecting them manually on the screen).

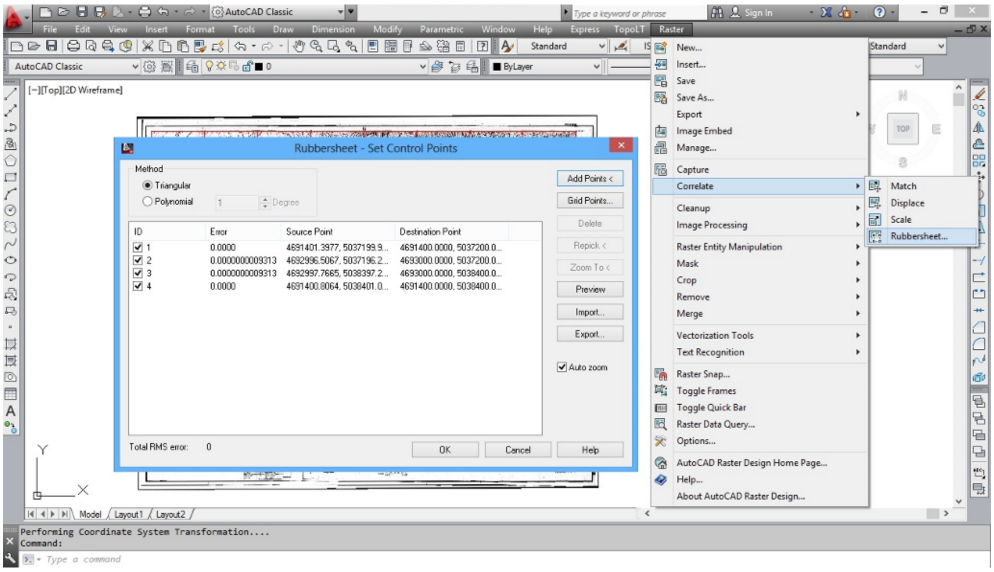

Fig. 4. Precise georeference of the raster image

At this moment the raster image is placed on the real coordinates in the Jiu Valley 58 reference system and digitization of the level curves can be started.

2. THE PROPER DIGITIZATION OF THE LEVEL CURVES

The digitization of the level curves can be done in two ways namely:

- Manual digitization, using a 3D polyline (by manual tracing with the cursor of the contour of the level curve, after which for the 3D polyline is given the elevation of the level curve);

- Semi-automatic digitization using the features provided by AutoCAD Raster Design.

For semi-automatic digitization of the level curves, in order to achieve the Digital Elevation Model, the image must first be converted from a color image (or grayscale) to a bitonal image. This is done by using the RASTER → IMAGE PROCESSING → CHANGE COLLOR DEPTH command, then selecting the BITONAL option from the command box. Following the transformation of the raster image will result a black and white image, the details on the map being represented by white and the background will be black (Fig. 5).

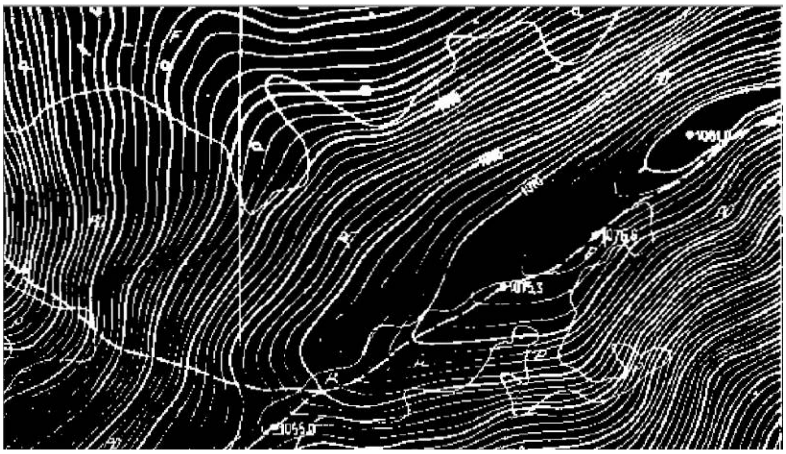

Fig. 5. Raster image transformation in a bitonal image

If necessary, the color of the raster image can be reversed using the RASTER → CLEANUP → INVERT command, resulting the image from figure 6.

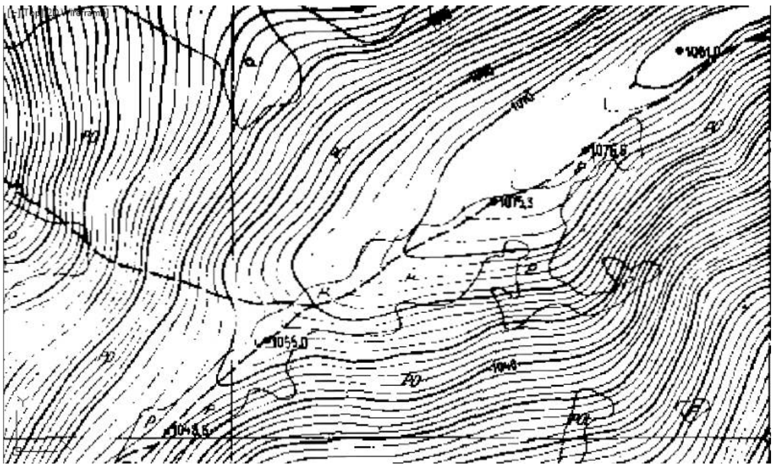

Fig. 6. Bitonal image color inversion

At this point, the semi-automatic digitization of the level curves can begin. This process proves to be particularly useful, especially if the scanned raster image is of great clarity. It can be called a semi-automatic operation because the vectorization is done by pressing on each line. To do this, go to the RASTER → VECTORIZATION TOOLS → CONTOUR FOLLOWER (Fig. 7).

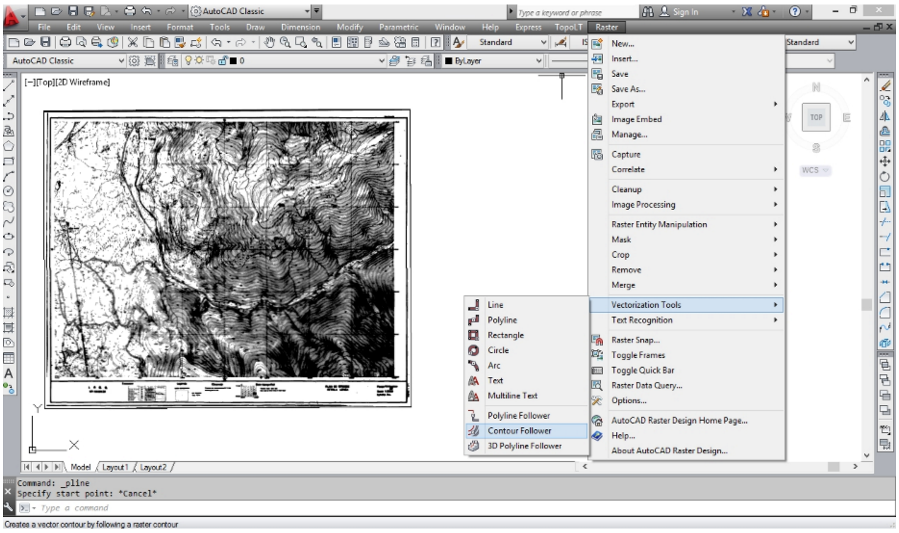

Fig. 7. Bitonal image color inversion

After accessing the command, the program prompts you to select a point on the level curve. After selecting that point, the program followed with a 3D polyline the respective curve to the point where the level curve is interrupted (Fig. 8), or if there is a closed contour, a closed polyline is drawn.

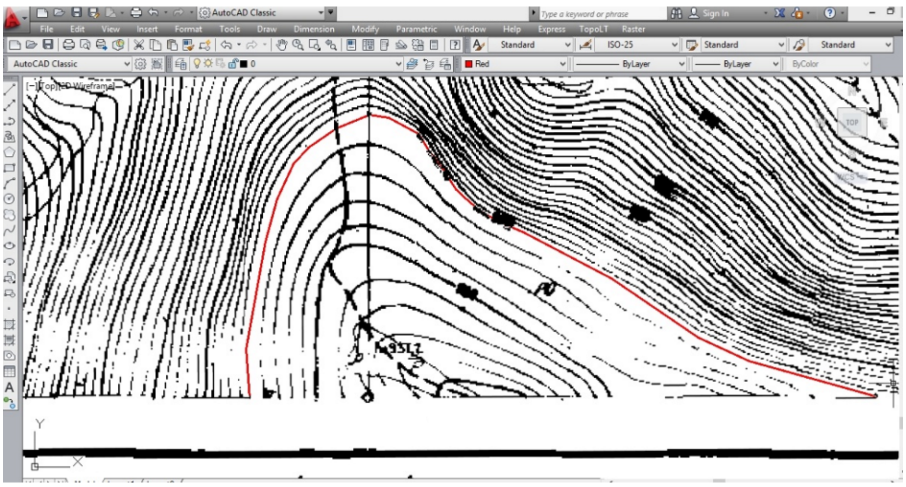

Fig. 8. Semi-automatic vectorization of the level curves

If the level curve is interrupted at a certain point, the program requires the next point to be used to continue vectorization, or there is the possibility to continue the vectorization manually.

At the end (when the vectorization of a level curve ended) the program asks us to specify the elevation of the level curve (Fig. 9).

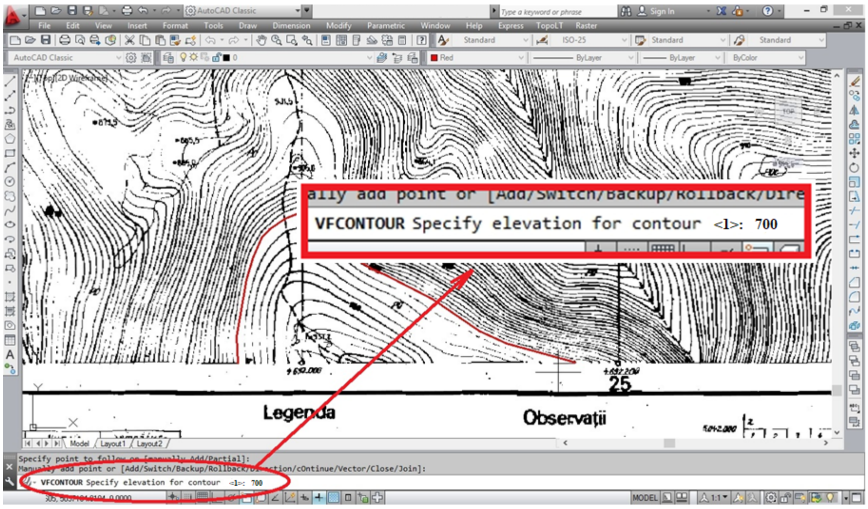

Fig. 9. Specifying the elevation of the vectorized level curve

From figure 9 it can be seen that after specifying the elevation of the level curve the program traces a vector polyline instead of the level curve from the raster image. Similarly, all of the curves in the selected raster image were done resulting a digital contour map in vector format (Fig. 10).

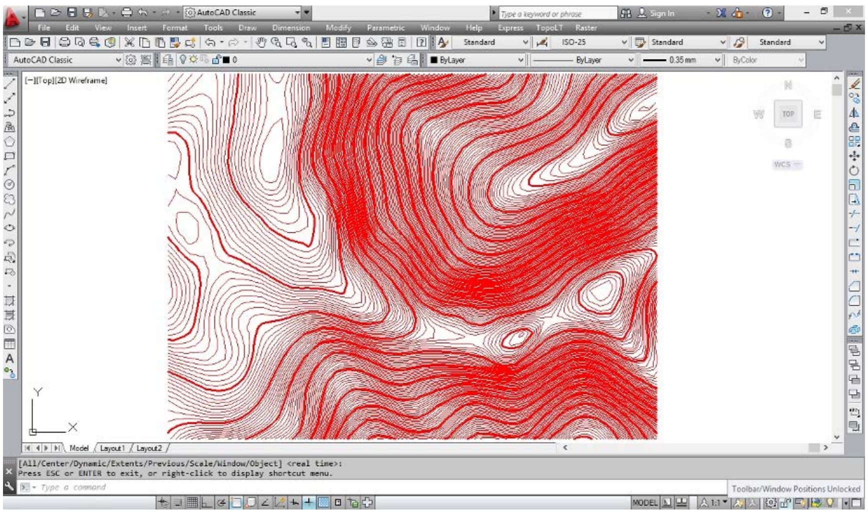

Fig. 10. The vectorized shape of the level curves

Three layers were used for each type of level curve (for main, normal and intermediate level curves).

Since each level curve was associated with its own elevation, the result is a 3D contour map (Fig. 11 – 12) particularly useful for generating a DEM.

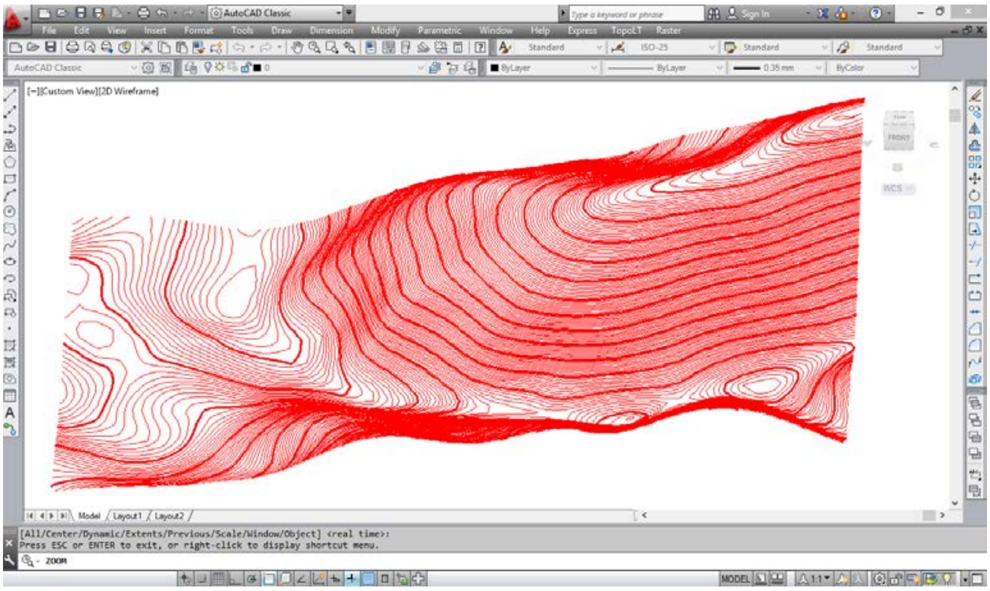

Fig. 11. 3D view of the resulted map

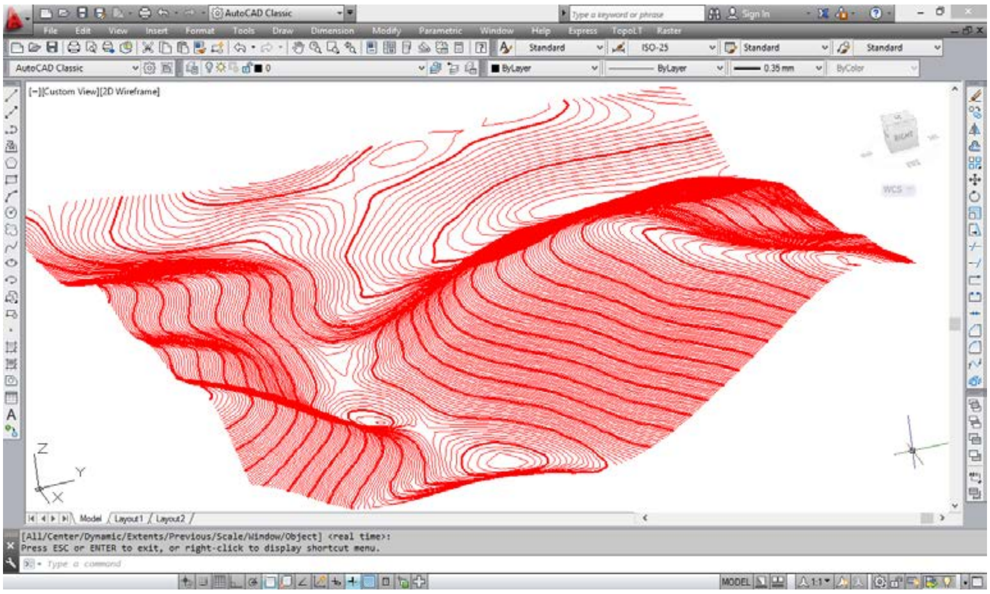

Fig. 12. 3D view of the resulted map

3. CONCLUSIONS

The digitization of old maps is particularly useful not only for their preservation (and keeping in a digital form), but also due to the fact that based on them certain studies can be carried out such as:

- Determination of excavation or dump volumes (applicable in particular to open pit mining, making the difference between the pre-operational situation and the current situation – or at a given time);
- Analysis of surface movement as a result of underground mining, making the difference between the pre-operational situation and the current situation (since the level curves taken from the old maps may have certain errors, the method can be applied in the case of underground mining of thick seams, where total subsidence appeared at the surface is considerable.
- Surface movement due to landslides, etc.

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GENERATION OF DIGITAL ELEVATION MODEL BASED ON A CONTOUR MAP AND ITS SUBSEQUENT USE

DACIAN-PAUL MARIAN [1]

Abstract: Digital terrain models have known a wide applicability in the last period due to the development of the computing technique, of the instruments and methods of measuring and representing the land surface. Currently, digital terrain models are widely used in many areas of activity, providing a powerful tool for monitoring, analyzing and controlling the land.

Keywords: *map, digital elevation model*

1. GENERALITIES

Terrestrial surface modelling is the process by which a natural or artificial surface is graphically represented by one or more mathematical equations, taking into account specific problems related to the representation of the Earth or portions of this.

When talking about the digital model of the terrestrial surface we're dealing with three types of elevation models: DSM (Digital Surface Model), DEM (Digital Elevation Model) and DTM (Digital Terrain Model) [3], [4].

A DSM is a 3D representation of the surface with all the objects on it (either natural - such as trees - or artificial, buildings, bridges etc.).

A DEM is a 3D representation of the surface in which all the objects on it are removed. DEM data files contain the elevation of the terrain over a specific area, usually at a fixed grid interval over the surface.

A DTM is a 3D representation of the surface consisting of X, Y and Z coordinates stored in a digital form. It includes not only heights and elevations but other geographical elements and natural features such as rivers, ridge lines, etc. A DTM is effectively a DEM that has been augmented by elements such as breaklines and observation other than the original data to correct for artifacts produced by using only the original data [1].

Generating DEM refers to the way the data are acquired, the proper realization of the model through different interpolation methods as well as the choice of the data representation structure. The DEM construction, for the case presented, consists in the creation of a continuous surface by the interpolation method, starting from the land data obtained from old topographic maps [8].

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Interpolation methods are diverse, the most common being: linear interpolation and triangulation. There is no universal interpolation algorithm which is good for all the applications, but each method of interpolation has a number of advantages and disadvantages to be taken into account when choosing it [5], [7].

2. GENERATING THE DIGITAL ELEVATION MODEL

To generate the DEM in this paper was used the AutoCAD Civil 3D software. To do this, a *.dwg* contour map file was selected, and with the help of the above mentioned program, in a first step, a new surface has been created with the desired features. This can be done by right-clicking on the SURFACE menu and choosing CREATE SURFACE command (Fig. 1).

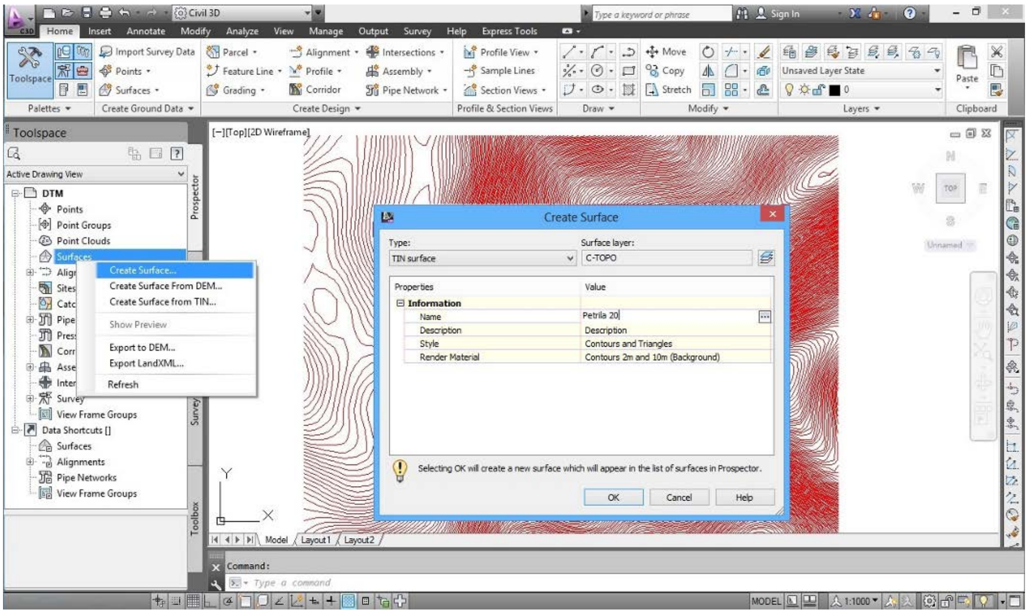


Fig. 1. Creating a new surface in AutoCAD Civil 3D

In the following, the created surface must be associated with some elements that define it (points, lines, level curves etc.). In this case, we will associate to the created surface the level curves from the *.dwg* fine. This is done by selecting the new created surface from the SURFACE menu (on the left – TOOLSPACE), then right-clicking on the desired item (in our case CONTOURS) and selecting ADD option from the DEFINITION submenu (Fig. 2).

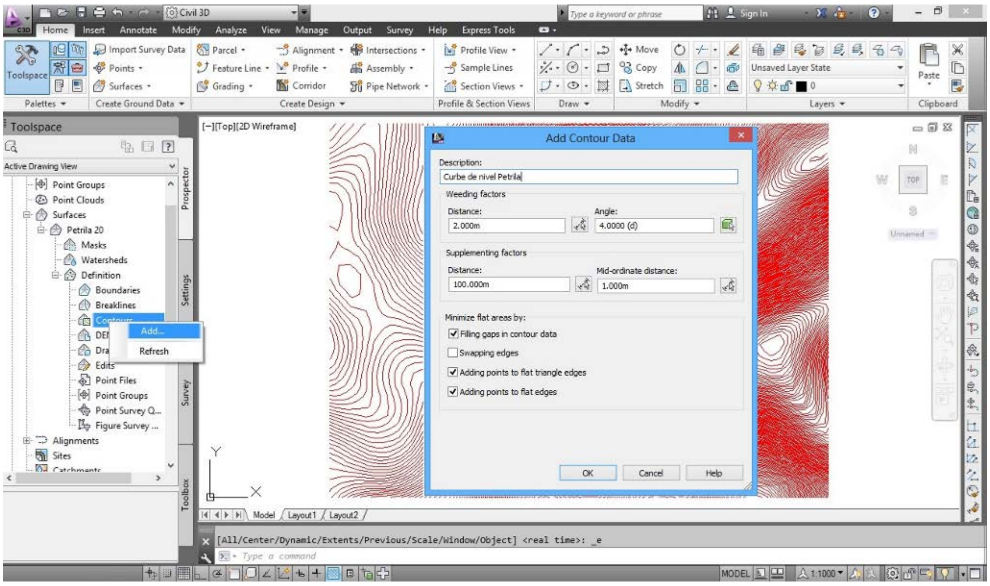


Fig. 2. Associating the level contours with the new created surface

After this association, when the OK button is pressed, the program creates a new surface (or rather it creates the Digital Elevation Model) with the selected features. The generated digital model is in the form of level curves and triangles as shown in figures 3 and 4.

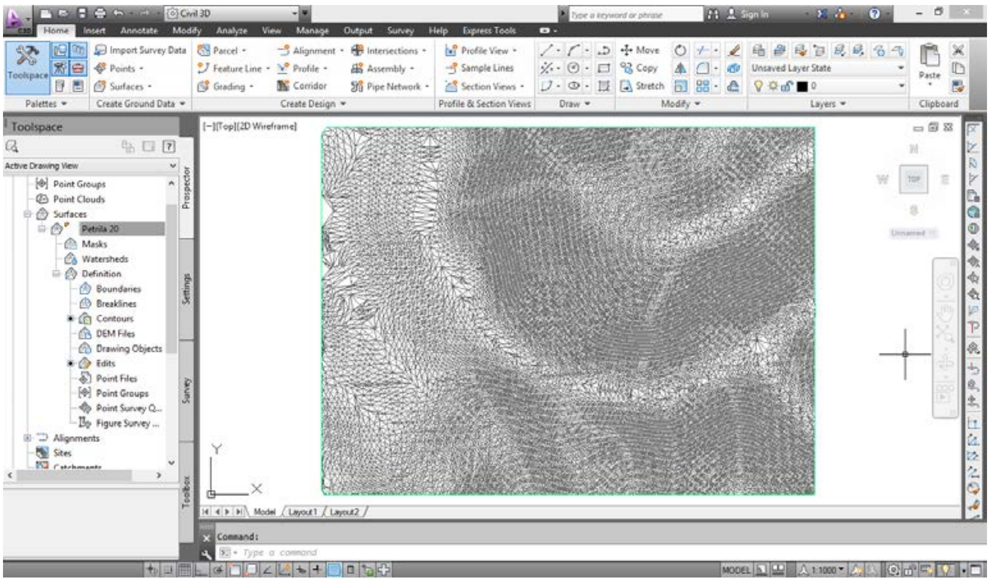


Fig. 3. Shape of the Digital Elevation Model

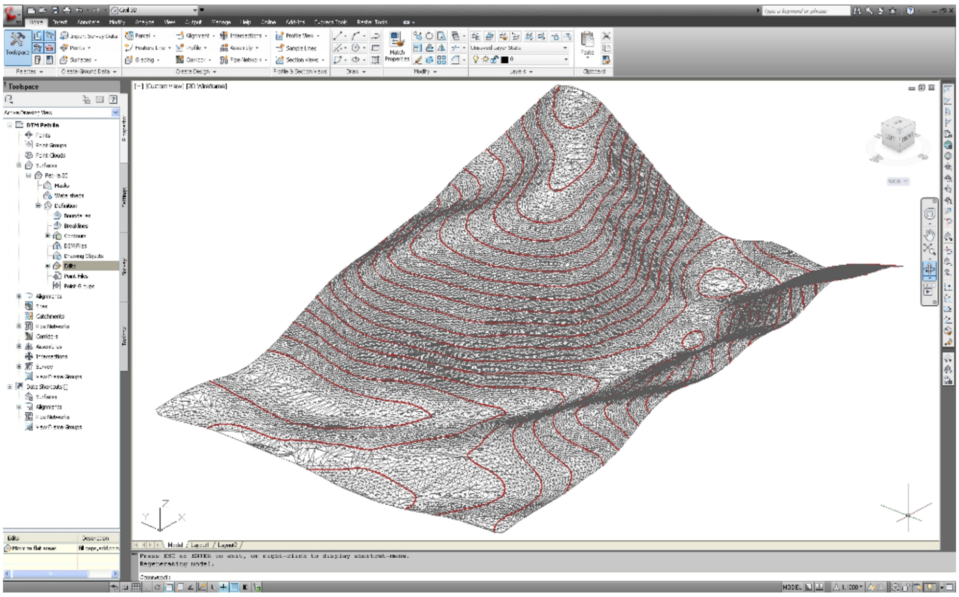


Fig. 4. 3D shape of the Digital Elevation Model

Also, beside the triangle and level curves models, other types of surfaces can also be created such as: level curves with certain density or hypsometric models. To change the surface type, select the created model and from the displayed menu select the SURFACE PROPERTIES command after which, from the window that appears, chose the desired surface model (Fig. 5).

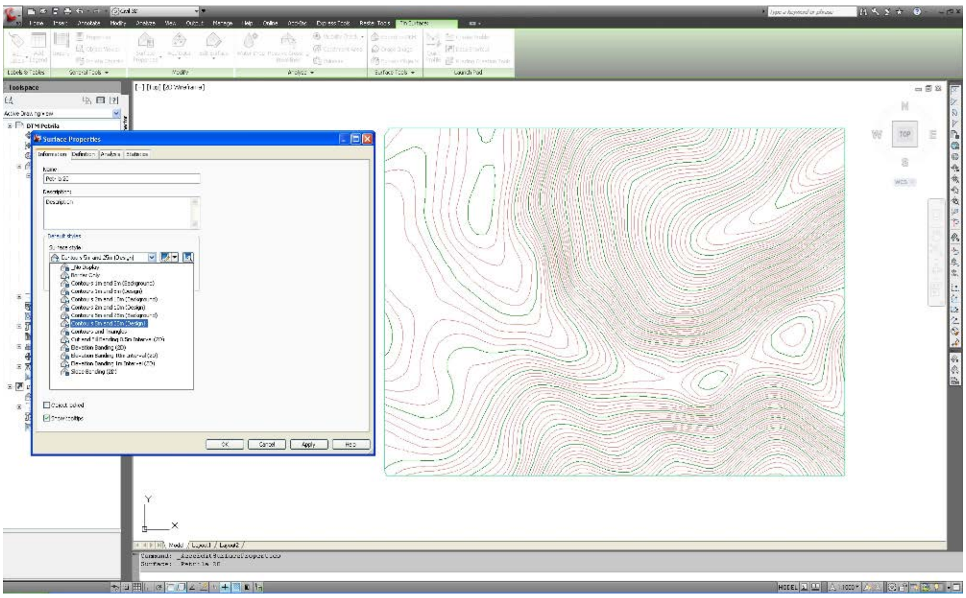


Fig. 5. Digital Elevation Model in the form of level curves

On these types of models you can place heights on the desired level curves (by selecting the surface and choosing the ADD LABELS command – Contour Single / Multiple / Multiple at Interval – as shown in figure 6), the slope of the terrain can be determined (at any point after a certain direction or between two points, via the ADD LABELS – Slope command, as shown in figure 7), or the high of intermediate points can be determined (using the ADD LABELS – Spot Elevation command, figure 8).

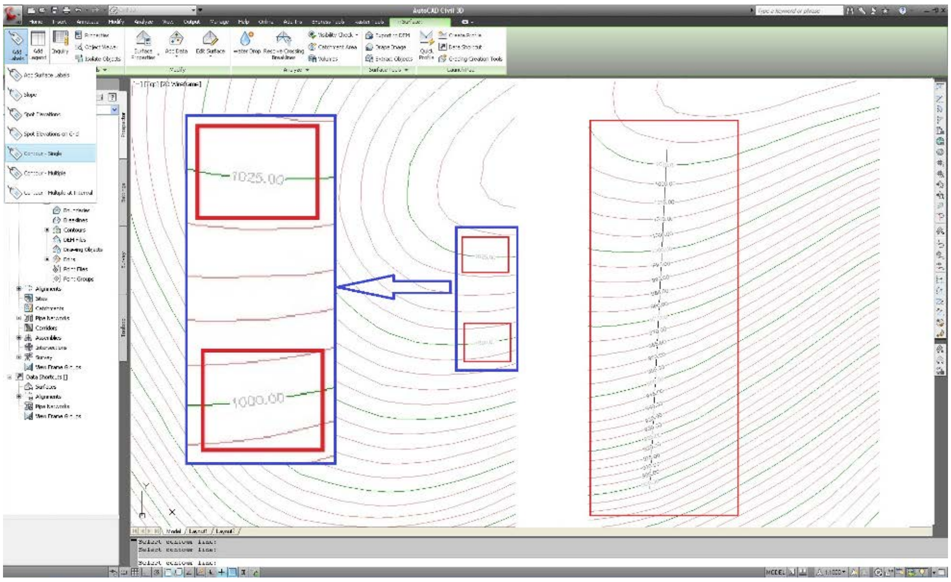


Fig. 6. Positioning the heights on the level curves

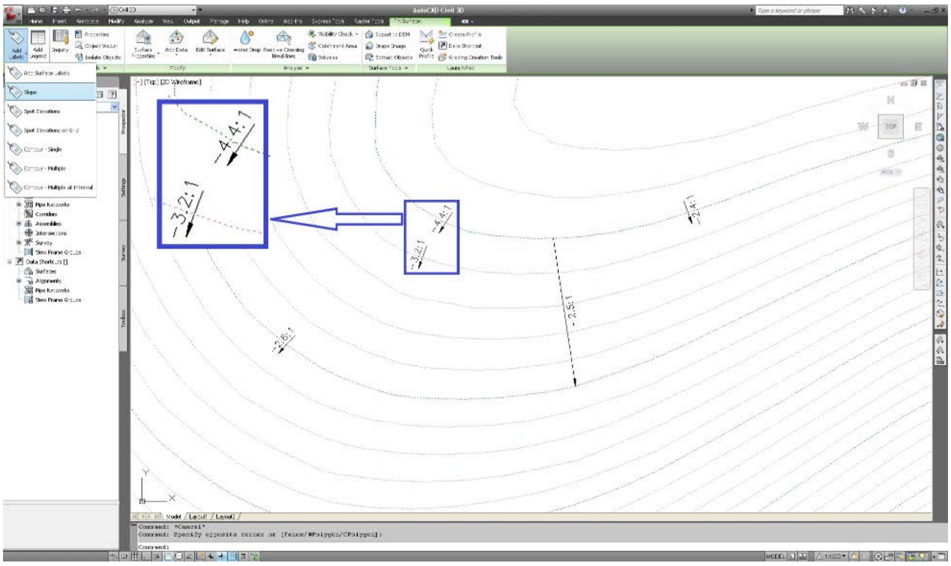


Fig. 7. Display of the land slope

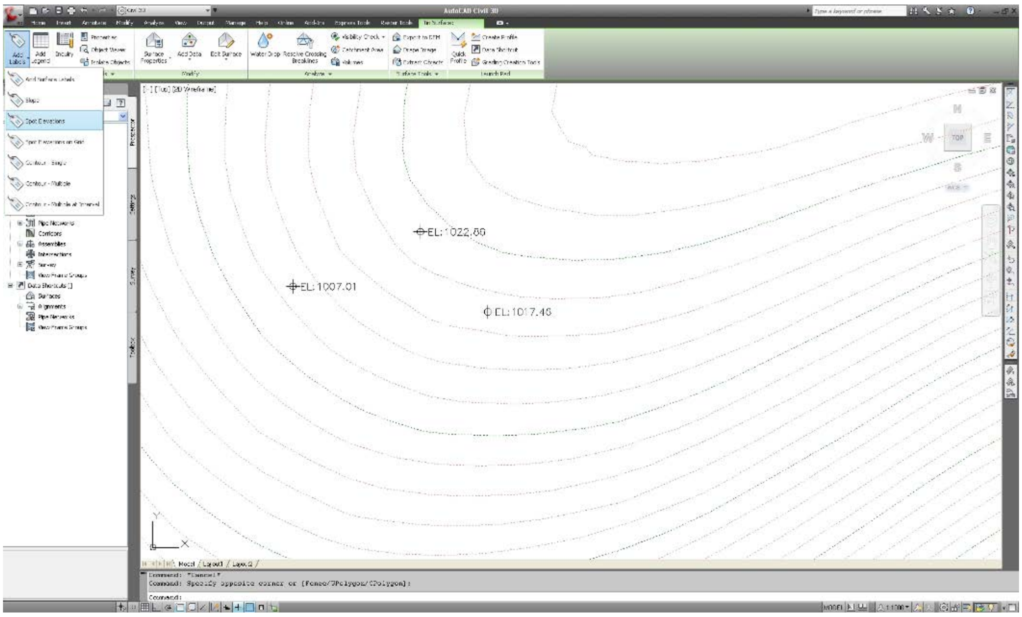
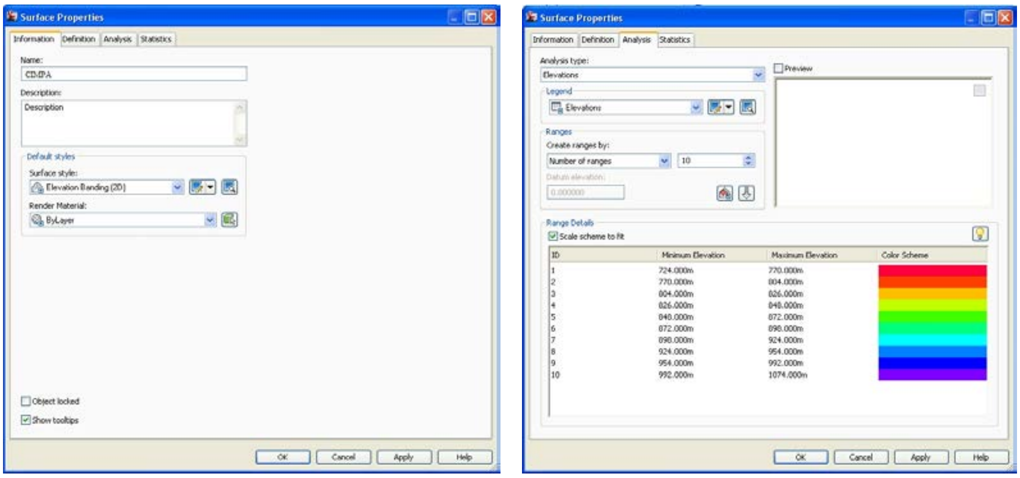


Fig. 7. Determining the height of intermediate points

To make hypsometric models (see figure 9), from the window that appears when pressing the SURFACE PROPERTIES command, choose the ELEVATION BANDING (2D) option in the INFORMATION menu (Fig. 8 a) and the number of intervals / colors is selected from the ANALYSIS menu (Fig. 8 b).



a) b)

Fig. 8. Achievement of hypsometric models

To display the legend on the hypsometric model select the model and choose ADD LEGEND (Fig. 9).

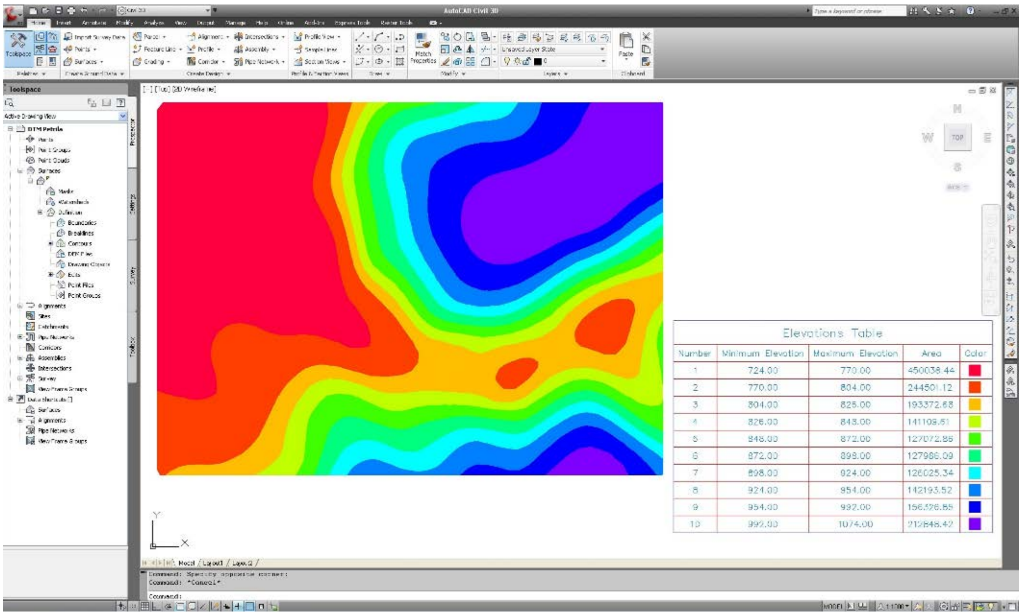


Fig. 9. Surface representation in the form of hypsometric models

3. OVERLAPPING AN ORTHOPHOTOMAP OVER DEM

To improve the Digital Elevation Model (and to make it easier to locate certain objects), an orthophotomap or a topographic map can be overlapped over the created model [2].

For this, the orthophotomap is inserted into the AutoCAD program using the Raster Design module and the RASTER → INSERT command.

Because the orthophotomap is much larger than the required area (i.e., the orthophotomap is larger than the old map from which the level curves were taken - as seen in figure 10) it should be cut. The RASTER → CROP → RECTANGULAR REGION command can be used to crop the orthophotomap, after which the surface that is desired to remain is selected (Fig. 11).

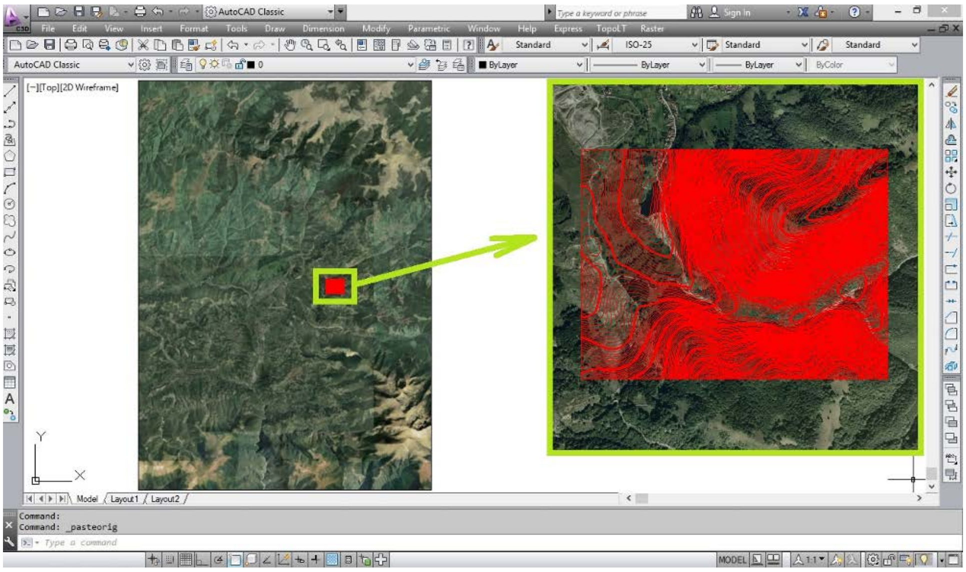


Fig. 10. Importing the orthophotomap on the real coordinates

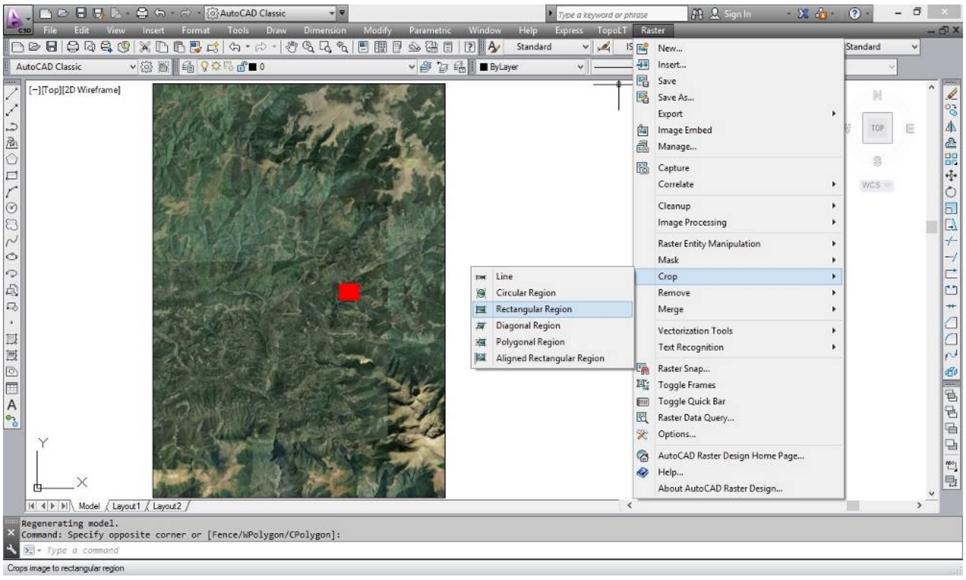


Fig. 11. Cropping raster images in AutoCAD Raster Design

At this point, the orthophotomap has the same dimensions as the digitized surface (Fig. 12) and it can be overlapped over the previously generated DEM. Now the raster image is located at the base elevation (zero) and the DEM is located on the real elevation, given by the level curves (Fig. 13).

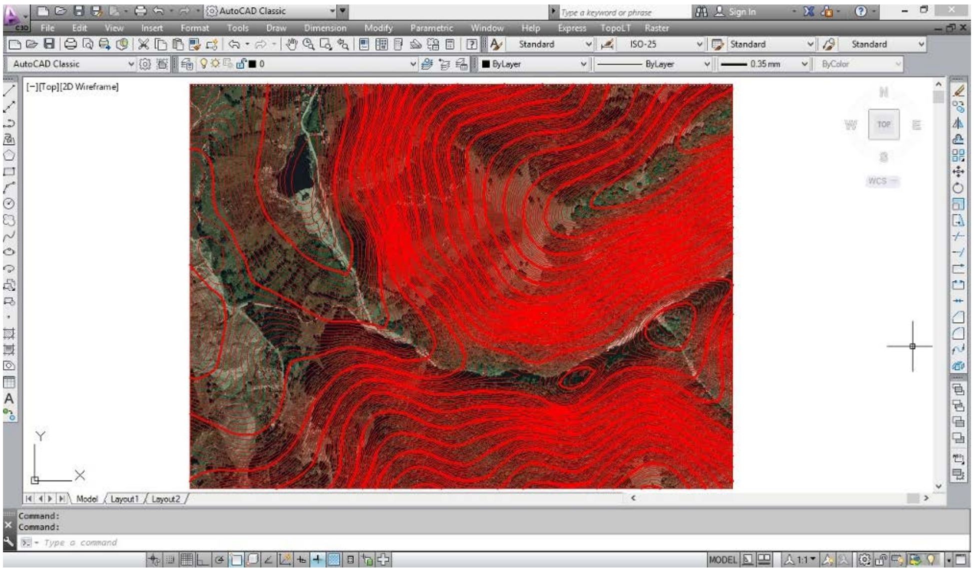


Fig. 12. The cropped raster image

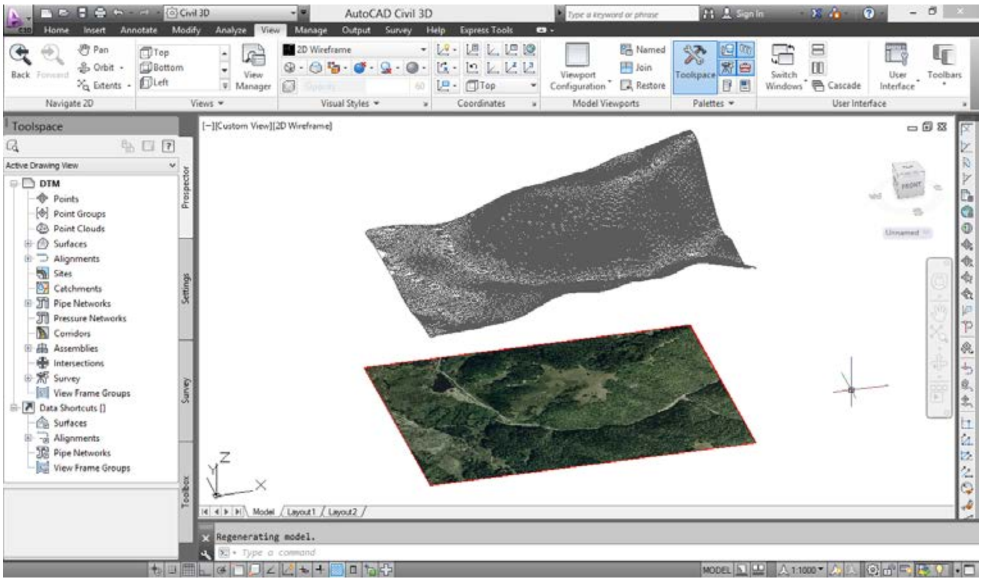


Fig. 13. The elevation difference between the orthophotomap and the DEM

To overlay the orthophotomap over the DEM, select the DEM and from the popup menu (Tin Surface CIMPA) select the DRAPE IMAGE option (Fig. 14). After pressing the OK button, the image is overlapped over the DEM resulting a realistic DEM (Fig. 15).

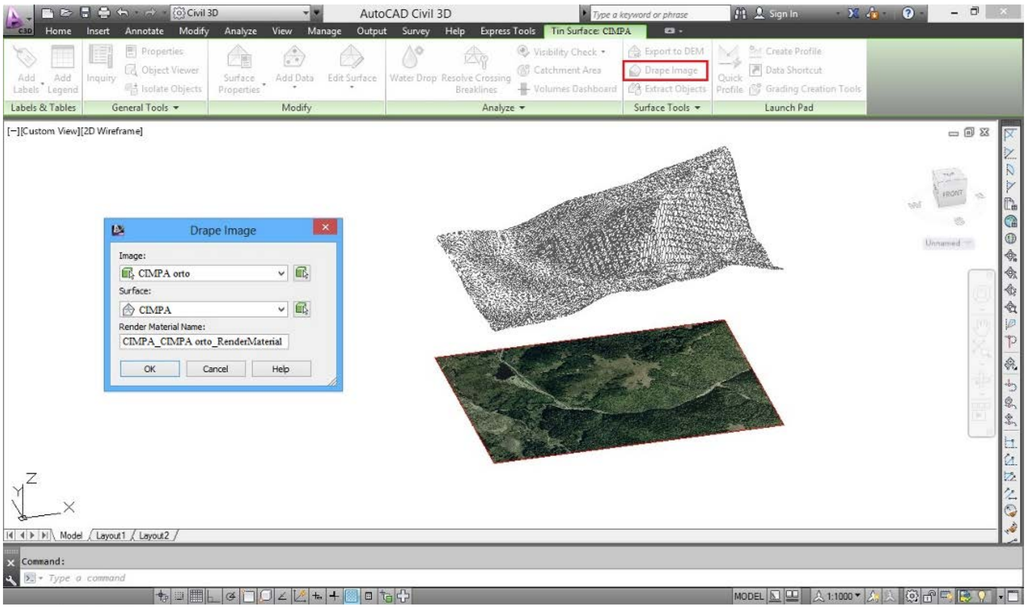


Fig. 14. Drape Image option window

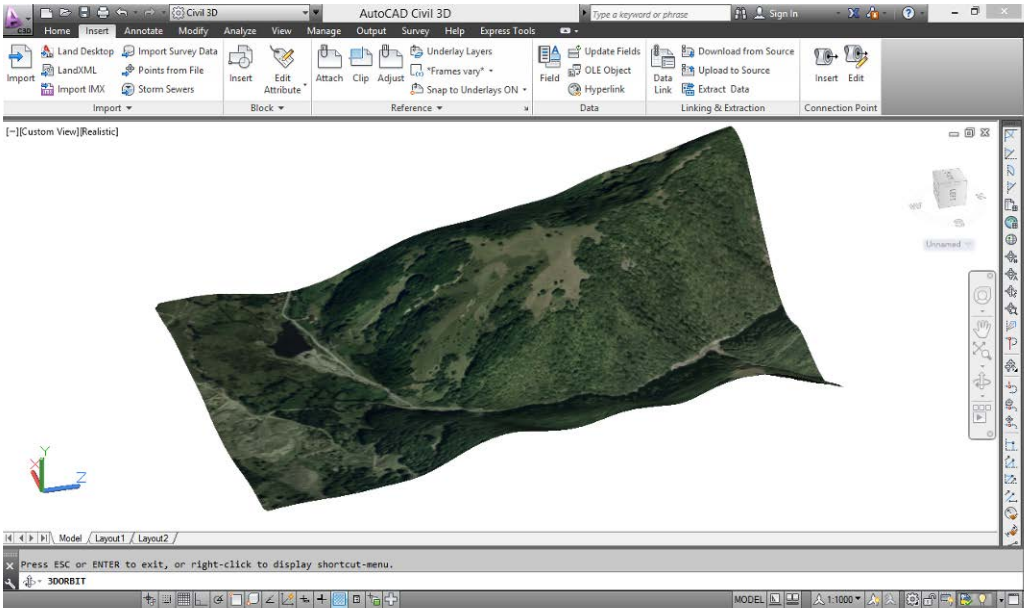


Fig. 14. DEM after overlaying the orthophotomap

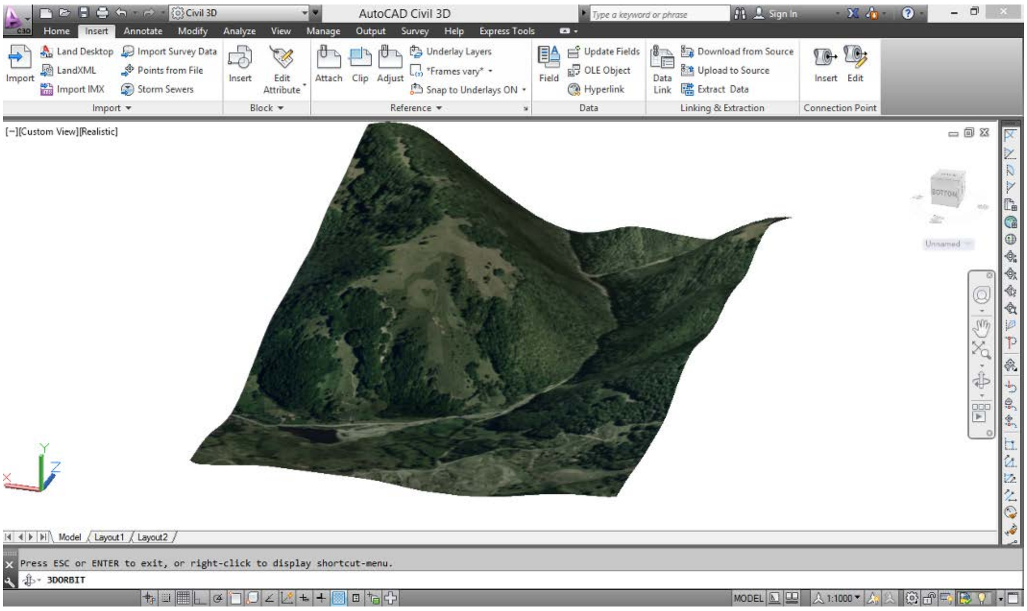


Fig. 14. DEM after overlaying the orthophotomap

4. PERFORMING SOME ANALYSIS BASED ON DEM

The realization of such surface models is particularly useful, not just for the purpose of better visualization of the surface but also due to the fact that, based on them, different surface analyzes may be performed. Among these we mention: creating profiles after certain directions; water flow models; visibility models; volume calculation etc. [6], [7].

To create profiles (or vertical sections on the surface), it is necessary to draw a polyline of sectioning (irrespective of its elevation), after which the surface is selected, the Quick Profile command is accessed, is selected the line after which the vertical profile is made and is chosen the position where the profile will be drawn (Fig. 15).

If the position of the line where the section is made changes the created profile is automatically changed (Fig. 16).

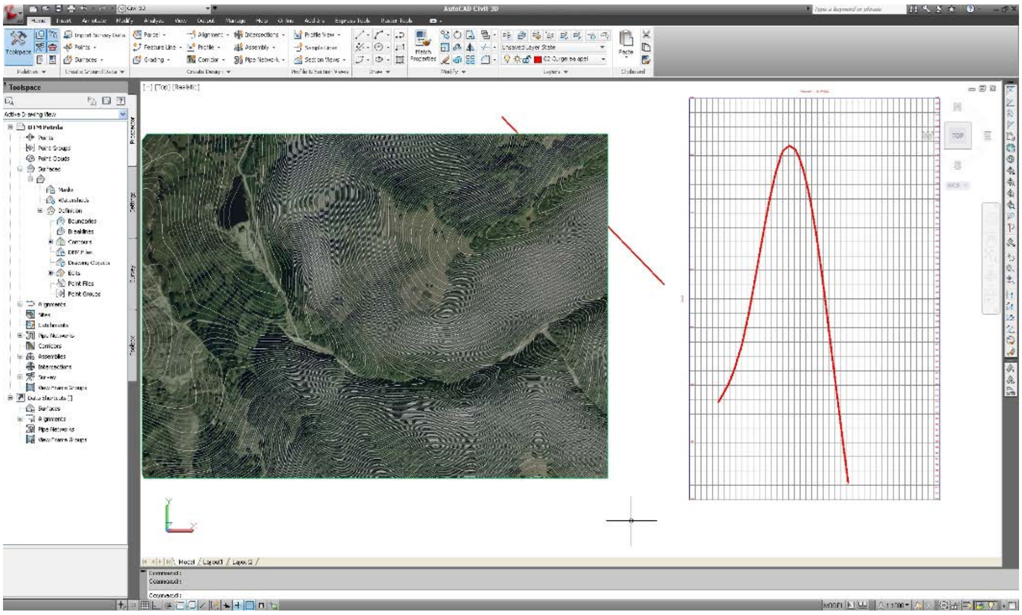


Fig. 15. Creating vertical profiles after surface

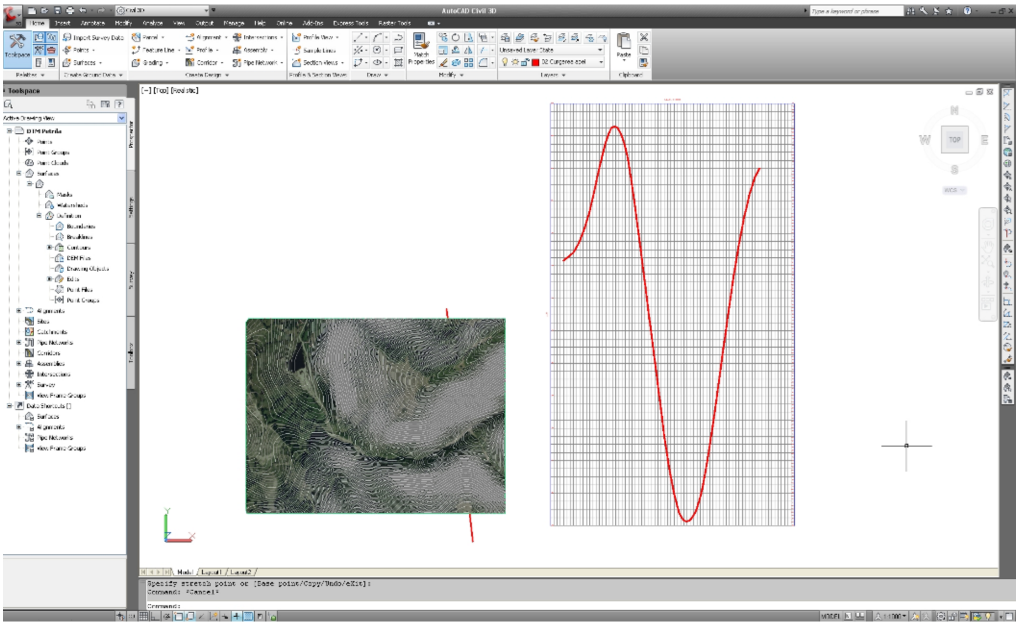


Fig. 16. Creating vertical profiles after surface

The determination of the water flow directions is done using the Water Drop command, then it is chosen the point or points from which the water flow direction is to be determined (Fig. 17).

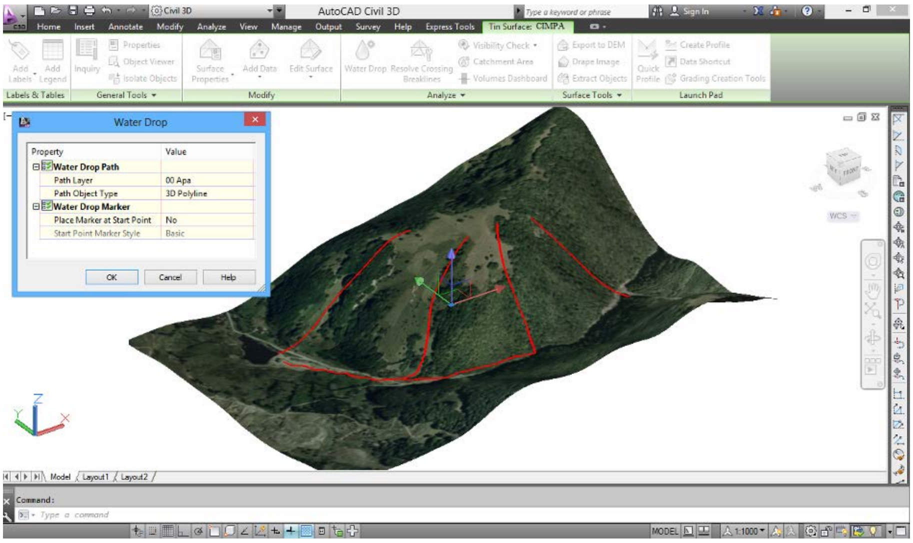


Fig. 17. Water Drop analyze

To create visibility models, the surface will be selected and from the Analyze menu the desired option is selected (Point to Point, Zone of Visual Influence, Check Sight Distance). The choice of Zone of Visual Influence (Fig. 18) is especially useful if it is desired to place topographical points, signaled by various methods, in certain areas. To do this analyze, the Zone of Visual Influence is selected, is indicated the place where the point will be placed and the height of the signal (marked in figure 18 with blue – X) and the visual radius.

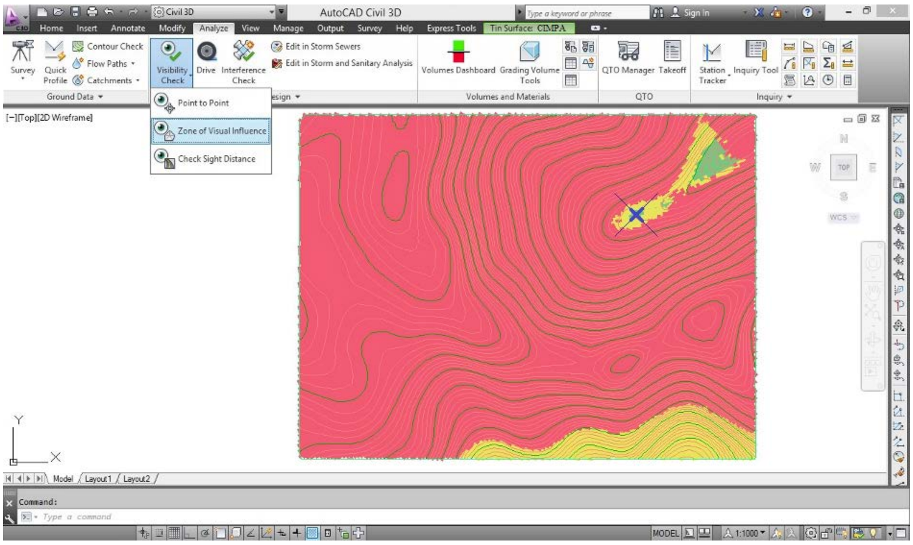


Fig. 18. Zone of Visual Influence analyze

After the model is generated, 3 zones will appear:

- Green area – with maximum visibility (where from the whole signal is visible);
- Yellow area – with partial visibility (where from only a part from the signal is visible);
- Red area – where from the signal cannot be seen.

5. CONCLUSIONS

This paper aims to present how to achieve a Digital Elevation Model using as database the level curves obtained by digitizing an old topographic map. For this purpose, specific programs developed by AUTODESK were used, namely: AutoCAD Civil 3D and AutoCAD Raster Design.

The DEM finds its applications in several areas, especially in civil engineering, topography and geodesy, geophysics, geography, archaeology etc., the main applications being:

- Visualization of the land surface;
- GIS;
- Surface analysis;
- Rectification of the aerial photographs and satellite images;
- Extracting land parameters (making water flow models and land movement);
- Engineering and infrastructure design.

The main disadvantage of a DEM is that it contains nothing but elevation information. While, for the purpose of a general view, accurate location of objects on the DEM, by referring to the characteristics of the terrain, can be difficult. One way to improve the DEM is the overlapping of orthophotomap or topographic maps over it.

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Scientific Reviewer:
Assoc. Prof. PhD. Eng. Ioel VEREȘ
UNIVERSITY OF PETROȘANI

THE ACCURACY OF GPS COORDINATE MEASUREMENTS, CASE STUDY FOR PORTABLE DEVICES

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NELU ȘTEFAN[2]

Abstract: There are various statistical methods of describing specifications for the accuracy of a GNSS receiver and it can seem confusing or misleading the meaning of such statistics. The purpose of this paper is to introduce some of the most commonly used accuracy measures, and their relationships to one another, based on a series of positioning measurements made with a portable GNSS receiver.

Keywords: *Positioning accuracy, GNSS, GPS, portable receiver*

1. ACCURACY AND PRECISION

Accuracy and precision are often used to describe the how good is the position acquired by GPS receiver. A distinction should be made between accuracy and precision. Accuracy is the degree of closeness of an estimate to its true, but unknown value and the precision is the degree of closeness of observations to their means. Figure 1 illustrates various relationships between these two parameters. The true value is located at the center of the circles.

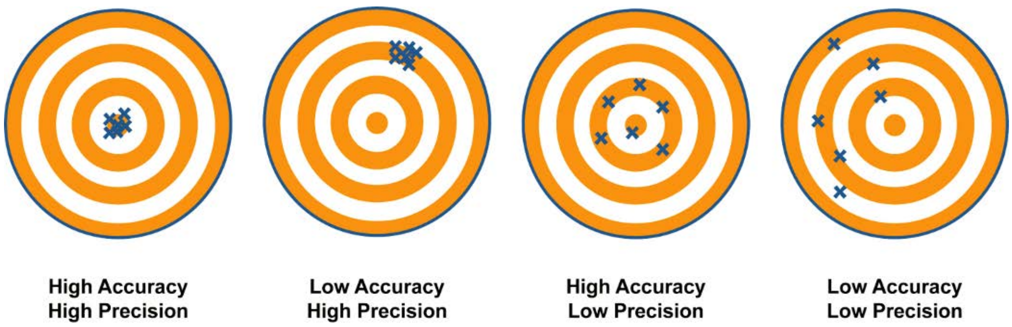

Fig. 1. Accuracy versus Precision

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2. ACCURACY MEASURES

The uncertainty in position can be expressed as the probability that the error will not exceed a certain amount. Under the assumption that position errors follow the normal (or Gaussian) error distribution (for arguments sake, there are only random errors being propagated into the position results), this probability can be related to the magnitude of the sample standard deviation:

$$\sigma_x = \pm\sqrt{\frac{\sum_{i=1}^{n}(x_i - \overline{x})^2}{n-1}} \tag{1}$$

For example, in the case of a linear (one-dimensional) accuracy measure, one standard deviation (one sigma) would correspond to a 68.27% *confidence interval.* That is, it is assumed that: (a) the mean value of an infinitely large sample of position results is the correct result, and (b) the standard deviation of this sample defines the interval on either side of the mean (or correct) quantity that contains 68.27% of all the results. 31.73% of the results will therefore be outside this range, and if the one sigma quantity is taken as the *accuracy measure,* then 68.27% of the results will be deemed acceptable and the remainder will be outside the accuracy "specification". The probability of the result being in the interval two standard deviations on either side of the mean is 95.45%. In general, the 95% confidence level is taken as the measure of adequate accuracy, and this corresponds to 1.96 standard deviations (but is generally approximated by two standard deviations, or two sigma). The probability corresponding to three sigma is 99.73%, which is inclusive of almost all position results. Vertical uncertainty can be expressed in this one-dimensional form.

This concept can be extended to two dimensions, so that areas can be constructed corresponding to distinct error probabilities such as 50%, 95%, etc. These zones are centered at the correct or true position. In general these zones are elliptical in shape, and they are known as **error ellipses**. However, the error ellipse constructed from the standard deviations of the two dimensional quantities (for example, east and north position components), and the correlations between these two quantities, contains only 39% of the position results and the error ellipse's axes are generally inflated by a factor of approximately 2.45 to create the 95% error ellipse. Surveyors are well acquainted with the concepts of error ellipses. (In three dimensions, the error figure is an **error ellipsoid**.)

2.1. Distance root mean square (DRMS) error

Traditionally navigation users have expressed horizontal position uncertainties in the form of circles and 3-D position uncertainties as spheres. This simplification of the error distribution requires the definition of the **Distance Root Mean Square**

(DRMS) error, which can be determined for the 2-D case from the horizontal component standard deviations σ_E and σ_N:

$$DRMS = \sqrt{\sigma_E^2 + \sigma_N^2} \tag{2}$$

$$2DRMS = 2\sqrt{\sigma_E^2 + \sigma_N^2} \tag{3}$$

The probabilities described by 1.DRMS and 2.DRMS are defined as the typical 68.27% and 95.44% values respectively, associated with the 1-dimensional distribution. (2.DRMS refers to TWICE the distance root mean square.) *These probabilities are not constant, but are dependent on the geometry of the position solution*. For example, if the geometry of the solution is very poor then the 95% error ellipse is very elongated, and the probability associated with an error circle of radius 2.DRMS may not be 95%. Conversely, if the error ellipse is almost circular, then the probabilities of the ellipse and the circle are also almost identical. In the case of GPS it has been found that the probability associated with the circle of radius 2.DRMS ranges from 95% to 98.5%.

In the 3-D case the equivalent accuracy measure is the **Mean Radial Spherical Error (MRSE)** and it involves three standard deviation quantities, σ_E, σ_N and σ_z:

$$MRSE = \sqrt{\sigma_E^2 + \sigma_N^2 + \sigma_z^2} \tag{4}$$

The probability associated with the sphere of radius MRSE is 61%.

2.2. Circular Error Probable (CEP)

An alternate measure for the horizontal accuracy is the **Circular Error Probable (CEP)**, sometimes also referred to as the "Circle Error Probability" or "Circle of Equivalent Probability". This defines the radius of a circle inside which there is a *50% probability* of the position being located. CEP can be calculated with the following expression:

$$\mathrm{CEP} \approx 0.59 \cdot (\sigma_E + \sigma_N) \tag{5}$$

How is CEP related to horizontal DRMS? There is no exact relation, but an approximate relation defined for GPS is:

$$\mathrm{2DRMS} \approx 2.45 \cdot \mathrm{CEP} \tag{6}$$

In the 3-D case the equivalent accuracy measure is the **Spherical Error Probable (SEP)**, and the associated probability is also 50%:

$$\mathrm{SEP} = 0.51 \cdot (\sigma_E + \sigma_N + \sigma_z) \tag{7}$$

There is another accuracy measure for the 3D case, the **90% Spherical Accuracy Standard (SAS90)**, that is the radius of the sphere centered at the true position, containing the position estimate in 3D with a probability of 90%:

$$SAS90 = 0.833 \cdot (\sigma_E + \sigma_N + \sigma_z) \tag{8}$$

If the accuracy performance of a positioning system is not known a priori, then the radius of the 95% confidence interval zone, as well as for other probabilities, has to be determined empirically from a large sample of positioning results. On the other hand, if the positioning system controllers wish to guarantee a certain level of accuracy performance, then the quantity must be specified a priori and all effort applied to reduce the level of total error in the system so that 95% of position results are within the specified zone.

3. PRACTICAL STUDY FOR CONSUMER PORTABLE GNSS RECEIVERS

The practical study was realized in Petrosani, Romania, at a point that was chosen so that it allows a relative good view of the sky, although it is in an urban area. The measurements were made with a GNSS (Global Navigation Satellite System) receiver contained in a Smartphone with Android operating system, so the results are similar with any consumer handheld GNSS receiver, even if it is a dedicated receiver (such as Garmin, Magellan or Lowrance), or other device with integrated GNSS sensor (such as a smartphone with GPS sensor). As measuring software I used the free software "Mobile Topographer" by StgrDev, because it has some useful surveying tools for the calculus of the geodetic coordinates in various coordinate systems, and also it has the feature for averaging the coordinates over time in order to get better readings.

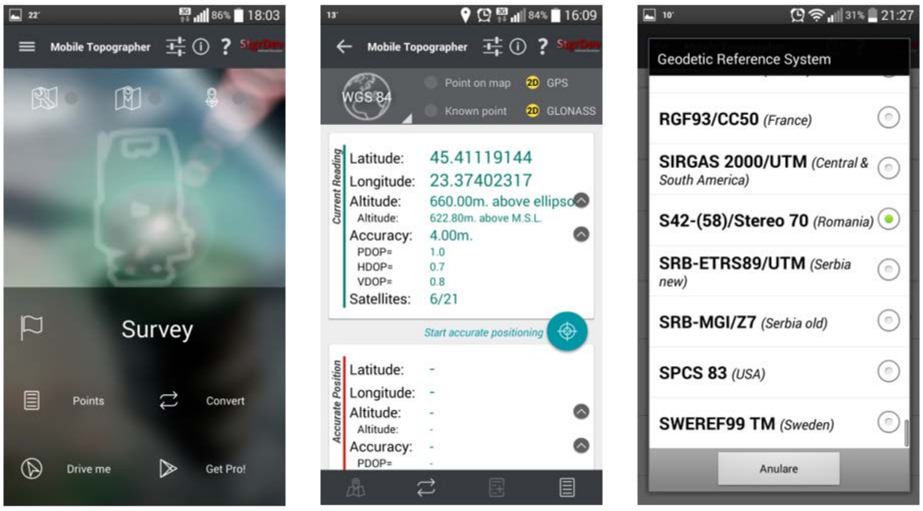

Fig. 2. left: the Mobile Topographer app interface, middle: the Survey module, right: setting the geodetic reference system

The practical measurement procedure: the receiver was positioned over the measuring point and after a short period of time the averaging feature was started by pressing the "Start accurate positioning" button. The duration of each measurement was 50 to 60 seconds, until the shown accuracy of the averaged position was less than 1 meter, sometimes even less than 0.5 meter. The measurements were made so that the time between two successive measurements was at least 3 hours, in order to have different satellite geometry for each measurement. Practically the measurements were made over a period of several months twice a day, the first measurement in the morning and the second measurement in the afternoon or evening.

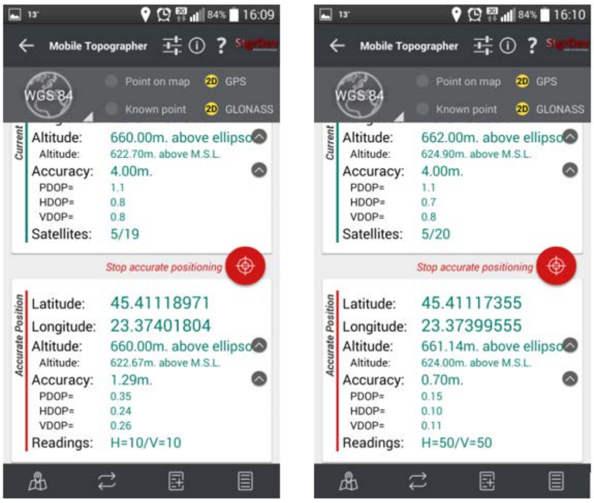

Fig. 3. left: accuracy increase after 10 readings, right: accuracy after 50 readings

There were made a series of 100 measurements as described above, and the resulting geographical coordinates were converted into the Romanian national geodetic reference system which is the "Stereographic 1970" projection system in order to represent the results overlayed on an geo-referenced aerial survey photography and to provide an easier way to make further accuracy calculations on measured quantities expressed in meters instead of degrees. The point coordinates were exported in csv format, so that they can be imported in a spreadsheet in order to calculate the different types of accuracy.

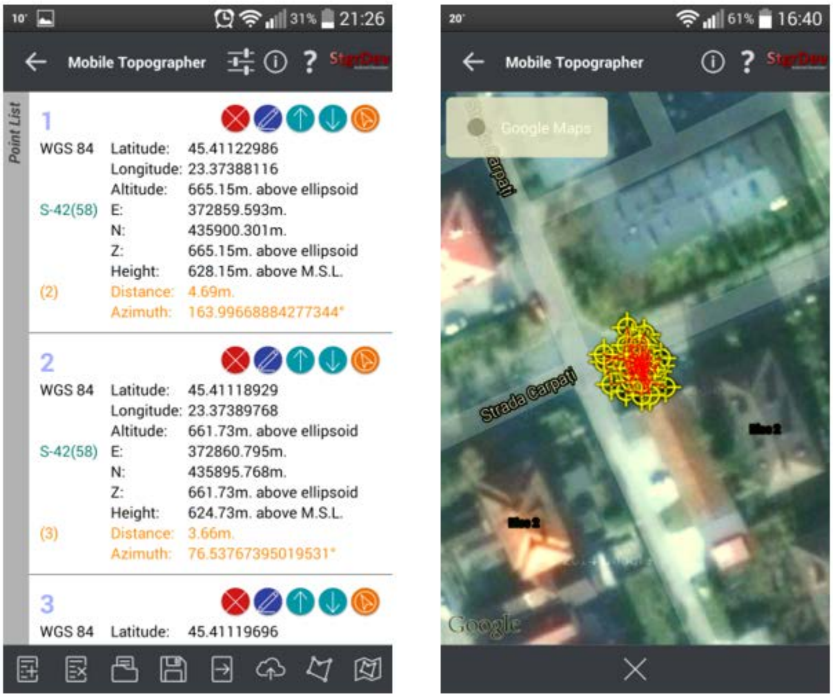

Fig. 4. left: list of measured points, right: scatter-plot within Mobile Topographer

From that series of 100 measurements were calculated the mean values of the coordinates and the sample standard deviations for each axis of coordinates, Easting, Northing and Height above mean sea level (MSL). The results are as follows:

Table 1. Mean values of the coordinates and standard deviations

Mean values of the coordinates (Romanian "Stereographic 1970" projection system)	Sample standard deviations
Easting = 372866.15 m	σ_E = ± 2.03 m
Northing = 435899.26 m	σ_N = ± 2.87 m
Height = 616.28 m	σ_z = ± 5.93 m

Fig. 5. Aerial view of the scatter-plot (red points)

Using these values of the standard deviations for the horizontal coordinates we can draw the 1σ, 2σ and 3σ error ellipses.

Table 2. Error ellipses elements

Error ellipse	Probability	Semi axis in East direction	Semi axis in North direction
1σ	39%	2.03 m	2.87 m
2σ	86%	4.07 m	5.74 m
3σ	99%	6.10 m	8.60 m

The circular errors for the 2D accuracy are as follows:

Table 3. Circular errors

Accuracy type	Probability	Relation	Error value (Radius of circle)
DRMS	65 – 68%	$\sqrt{\sigma_E^2 + \sigma_N^2}$	DRMS = 3.52 m
2DRMS	95 – 98%	$2\sqrt{\sigma_E^2 + \sigma_N^2}$	2DRMS = 7.03 m
CEP	50%	$0.59 \cdot (\sigma_E + \sigma_N)$	CEP = 2.89 m

For the 3D case the spherical errors are as follows:

Table 4. Spherical errors

Accuracy type	Probability	Relation	Error value (Radius of sphere)
MRSE	61%	$\sqrt{\sigma_E^2 + \sigma_N^2 + \sigma_Z^2}$	MRSE = 6.90 m
SEP	50%	$0.51 \cdot (\sigma_E + \sigma_N + \sigma_z)$	SEP = 5.53 m
SAS90	90%	$0.833 \cdot (\sigma_E + \sigma_N + \sigma_z)$	SAS90 = 9.03 m

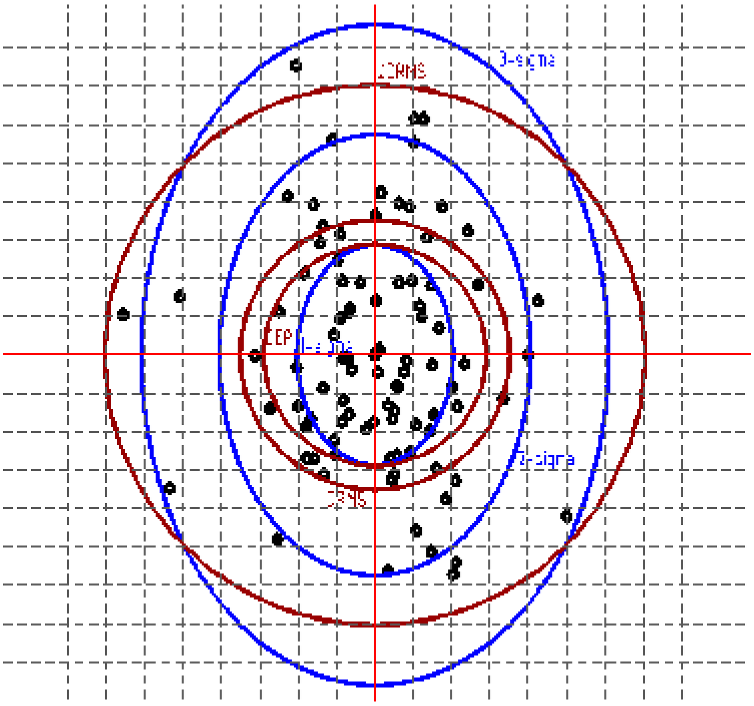

Fig. 6. Rings and ellipses of accuracy used to describe GNSS horizontal point positioning accuracy

4. CONCLUSIONS

Comparing the accuracy shown by a portable GNSS receiver with the results obtained in this experiment we can say that the shown accuracy of the device is most likely the CEP accuracy, with an associated probability of 50%. This means that half of the readings are inside the CEP circle, but it also means that half of the readings are outside this circle. In order to get a better confidence of the readings (95% probability), it would be advisable to consider the 2DRMS accuracy, by multiplying the displayed CEP accuracy with a factor of 2.45 (2DRMS ≈ 2.45 · CEP). In this way we can be sure that 95% of the readings are nearer than the 2DRMS distance to the true position of the point.

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Scientific Reviewer:
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POSSIBILITIES OF USING TERRESTRIAL MOBILE LASER SCANNING SYSTEMS IN SUBTERRANEAN ENVIRONMENTS

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Abstract: The growing number of LiDAR scanning solutions offer an alternative to classical methods of measurement that are often used underground, the results obtained being comparable from an accuracy point of view but when work duration and degree of detail are taken into account, laser scanning is increasingly superior. Compared with other methods of remote sensing, the methods of laser scanning can be easier to use in order to perform subterranean measurements due to the fact that the fulfilment of lighting and visibility conditions is no longer necessary, only site access for crew and equipment being a prerequisite for mission execution.

Keywords: *LIDAR, mobile laser scanning*

1. ANALYSIS REGARDING THE POSSIBILITIES OF USING LASER SCANNING SYSTEMS IN SUBTERRANEAN ENVIRONMENTS

Regardless of the scope of work, the equipment for technical measurement development follows the general tendency of reduction of the time necessary for data collection and automation of extraction and subsequent processing if data.

With regard to the equipment and geospatial data collection methods for the mining sector there is a rapid growth of data obtainment technologies for above ground mining but which have a low degree of applicability in the case of subterranean mining.

Modern methods of geospatial data acquisition have their applicability also in the domain of subterranean mining but it is known that in order for an optimal functioning and obtaining accurate data certain requirements must be fulfilled that cannot be ensured in above ground environment, as follows:

- the majority of modern measurement equipment are based on using GPS technology that cannot be used underground;
- the measuring methods based on LiDAR technology can be used only in certain cases (salt extraction operations, scanning of mining objectives where extraction

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activities have ceased) in other situations use of these is made difficult due to the subterranean work conditions (limited access, intensive workflow, dust, humidity, etc.).

The new technologies are not focused on developing equipment and measurement methods usable underground, there existing only studies and research regarding the identification of methods through which the existing equipment can be adapted to be also used in this domain.

However the development of subterranean measurement equipment will only accentuate in the near future concomitantly with the development of indoor positioning systems. Presently there exist interior positioning procedures based on the combination of spatial position determination offered by sensors (LiDAR, video cameras) and the methods of correction transmitting (laser rays, radio waves, ultrasounds, wi-fi, etc.), thus being obtained positioning accuracies of up to 1 meter.

Laser technologies are presently used in the subterranean environment with increased frequency. The equipment that use this technology input the returns received from the laser beams making possible to obtain the distance and direction data, in the case of total stations, or the numerical model of a surface, in the case of laser scanning. Obviously this equipment can be restrictively used in the subterranean operations where there is a danger of explosion.

Modern total stations are provided with ATR (Automatic Target Recognition) systems and an actuator system for automatic tracking of reflective targets, robotic guidance and data transmission systems, offering the possibility of measuring and sending the coordinates in real time, with millimeter level accuracy.

The static scanning method is preponderantly used in the case of LiDAR scanning, the equipment in this case being installed in a fixed point. In the case of scanning mining works the possibility of translating the resulting point cloud from the scanner coordinate system to the cartographic coordinate system must be ensured. The principle used for georeferencing the data is similar to the principle of traverses and consists of creating a network of points of which the coordinates are determined in the desired projection system, consisting of support points that will be stationed with the scanning equipment and control points. The support and control points are generally marked with different strips that have a distinct reflectivity compared to the rest of the surfaces and permit the visual identification of points. The support point placement must be designed depending on the LiDAR sensor scanning range in order to create an overlap area, as these points are usually placed in this area.

Mobile laser scanning is applied less in subterranean environments due to the fact that the cinematic positioning accuracy is in general conditioned by the use of GPS technology. However until presently there have been realized some terrestrial mobile laser scanning measurements for linear underground objectives (tunnels), still the majority of these have been executed for demonstrative purposes.

2. EXECUTION OF TERRESTRIAL MOBILE LASER SCANNING MEASUREMENTS IN THE OCNELE MARI SALT MINE

The salt extraction mining works performed at Ocnele Mari, Valcea County, are currently taking place at two horizons: horizon 210 and horizon 226, using the small chamber mining methods.

For the opening of the deposit, the oblique directional adit method of opening was used, this method being applicable for the following reasons:

- The possibility of development near a heap in which to store the resulting material resulting from the mining works;
- The possibility of creating and adequate space for depositing materials necessary for mining work execution;
- The area of operation is not affected by landslides of avalanches;
- The area is safe from eventual flooding due to snow melting, torrential rainfall, river levels rising;
- The landform allows the placement of the mine enclosure for the main adit.

The equipment used to execute the measurements is the VMX-250 type with the following integrated components:

a) Two RIEGL VQ250 model laser scanners, with the following main technical characteristics:

- effective measuring rate: greater than 300.000 measurements / second / scanner;

- maximum measurement range: 500m for a pulse repetition rate of 100kHz or 75m for a pulse repetition rate of 600kHz;

- minimum measurement range: 1.5m. This parameter is very important given the fact that measurement is taking place in subterranean tunnels;

- scan speed larger than 2 x 100 lines / second / scanner;

- accuracy: 10mm;

- precision: 5 mm;

The scanning mechanism is a rotating one; ensuring a 360^o scan angle.

b) The integrated INS/GPS system composed of an Appanix 200Hz inertial unit and TRIMBLE GPS, capable of the following performance:

- absolute positional accuracy: 20 – 50mm;

- relative positional accuracy: 10mm;

- angular accuracy: ROLL: 0.0050 / PITCH: 0.0050 / YAW: 0.0150;

c) DMI (distance measurement indicator) that is connected to the system control unit.

The equipment is used for trajectory determination when the GNSS signal reception is lost with the processing software capable of obtaining the trajectory based on the measured distance and inertial measurements.

The data acquisition and monitoring software (RiAcquire) is developed by the equipment manufacturer and allows the operator to configure and monitor the equipment, define the scanning parameters, observe in real time details regarding the positioning and navigation systems and also evaluate the quality of acquired data.

The scan project management is realized from the acquisition stage, where a standard folder structure is generated that is later used for the processing stages.

Also in order to determine the control points used to adjust the point cloud, Spectra Precision SP80 GNSS Rovers were used in tandem with a Sokkia SET 630R total station.

3. EXECUTION STAGES DESCRIPTION

Before the scanning measurements took place there were measured 11 control points out of which 8 were placed inside the tunnel.

The points were determined using the closed traverse method using two station points positioned at the tunnel entrance, the coordinates of which were obtained using static GPS measurements. The horizontal accuracy of control point determination is +/- 0.01m and the vertical accuracy is +/- 0.04m. In order to visually identify the control points in the point cloud these have been pre-marked with retro-reflective targets. By applying an option to visualize the point cloud by intensity in the LiDAR processing software, the control points are distinctly visible as compared with the rest of the points. System initialization was made at the entrance and exit point of the tunnel, and an alignment route being taken in which the kinematic GPS system was fully functional.

To determine the kinematic GPS trajectory in the calibration area the ROMPOS ground reference stations recording were used from Ramnicu Valcea (VLC1) and Horezu (HORE).

The scanning was performed at a pulse repetition rate of 100 kHz, while the speed of the vehicle was maintained at a relatively constant value of 20kmph. The access to the tunnels resulted in the immediate loss of GPS signal with the automatic initialization of the VMX-DMI distance measurement system. The measurements took place on May 2017.

The kinematic trajectory processing was made in the POSPAC MMS version 8.1 software using both the <IN-Fusion PPP> processing solution, based on using the precise trajectories (Precise GPS Ephemeris, Precise GPS Clock, Earth Rotation Parameters, Ionosphere Model P1-C1 DCB), as well as the <IN-Fusion Single base line> based on the differential processing method (DGPS), depending on the ground reference station recordings. In the end the DGPS method was preferred, with the Ramnicu Valcea base station used as reference and Horezu being used as control station. The POSPAC MMS software processes trajectories in both directions (trajectory start – trajectory end and trajectory end – trajectory start) using optimizing algorithms based on the Kalman filter. This algorithm functions recursively using the previous estimations and corrections in order to calculate the current position starting from the premise that the measurements follow the Gauss function model of probability density. This Gaussian shape is illustrated in the accuracy estimation graph generated by the POSPAC MMS software following DGPS processing.

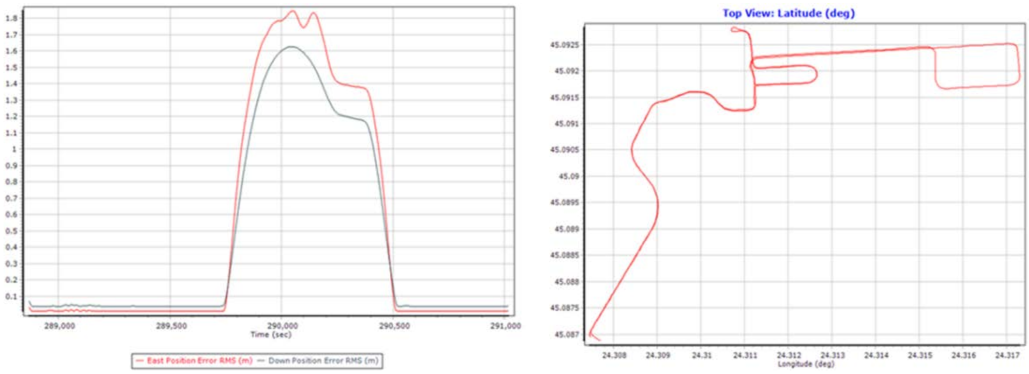

Fig. 1. Trajectory and horizontal and vertical accuracy estimation graphs

The average root mean squared error obtained following the processing of the kinematic trajectories has the values: RMSx = 1.491 m RMSy = 1.383 m, RMSz = 1.241 m.

The data processing was performed with the scanning manufacturer's software RiProcess, RiAnalyze, RiPrecision and was conducted in the following stages:

a) Analysis of the records for reconstituting the echo signal, estimating the number of target objects, wavelength, echo amplitude and intensity (signal) for each target object,

b) Conversion of data from the scanner Cartesian coordinate system in a coordinate system chosen by the user, keeping the data referring to echo amplitude and intensity (of signal) for each target object detected.

c) Visual data analysis. In this stage the data is analyzed to check for density, data uniformity evaluation, identification of data recorded accidentally and surfaces that can be used for calibration.

For the salt mine scanning project the average point density was 19.451 points / m3.

d) Data calibration. In the case of LiDAR data an internal calibration and external calibration is performed. The internal calibration consists in distance offsetting (eccentricity) between the equipment components according to the manufacturer's technical specifications and the installation specifications, relative to the inertial unit reference points following the coordinate system axis defined.

The external calibration is the process of eliminating the differences between the alignment angles caused by the coordinate axis and different tilts of the two laser scanners. The offset parameters of these differences are calculated in the calibration protocol of the equipment and can be directly applied but due to the fact that changes can occur over time it is necessary to periodically update the tilt angles and positions.

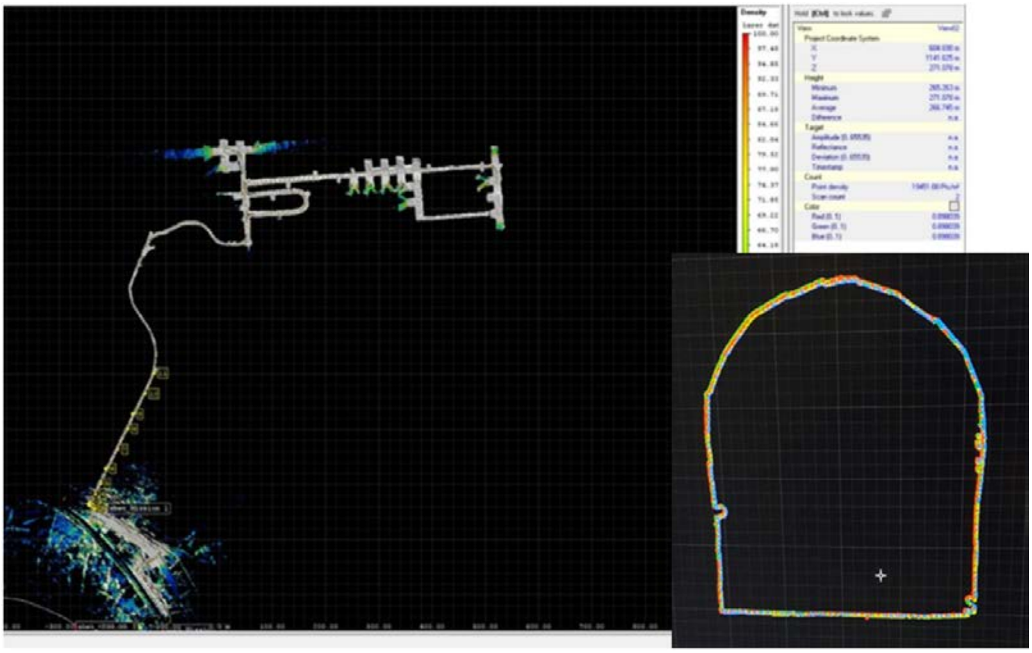

Fig. 2. Analysis of data in RiProcess (point density and cross-section)

e) Selecting the calibration algorithm and the actual external calibration. The laser data comes from two different scanners placed in two different positions and there are portions of the route that have been traveled in both directions, therefore it is necessary to eliminate the coordinate differences between points that describe the same surfaces.

f) Establishing the calibration tolerance. The process is stopped when the root mean squared error of the differences between the surface points used for calibration is lower that a certain threshold. For the present project the admitted error was 0.0163.

g) The point cloud offset to control points. This is realized by constraining the scanned data to control points. In order to perform the offset to control points the route was divided into distinct sections, each section containing two control point.

Following the offset differences have resulted in the control points according to the following table:

Table 1. Differences in control points

Point no.	X	Y	Z
4	0.084	0.03	0.03
5	0.084	0.028	0.046
6	0.101	0.029	0.076
7	0.148	0.085	0.154
8	0.205	0.158	0.226

9	0.196	0.16	0.286
10	0.13	0.152	0.306
11	0.186	0.101	0.451
Average	0.14175	0.092875	0.196875
STDEV	0.049871	0.059297	0.147522

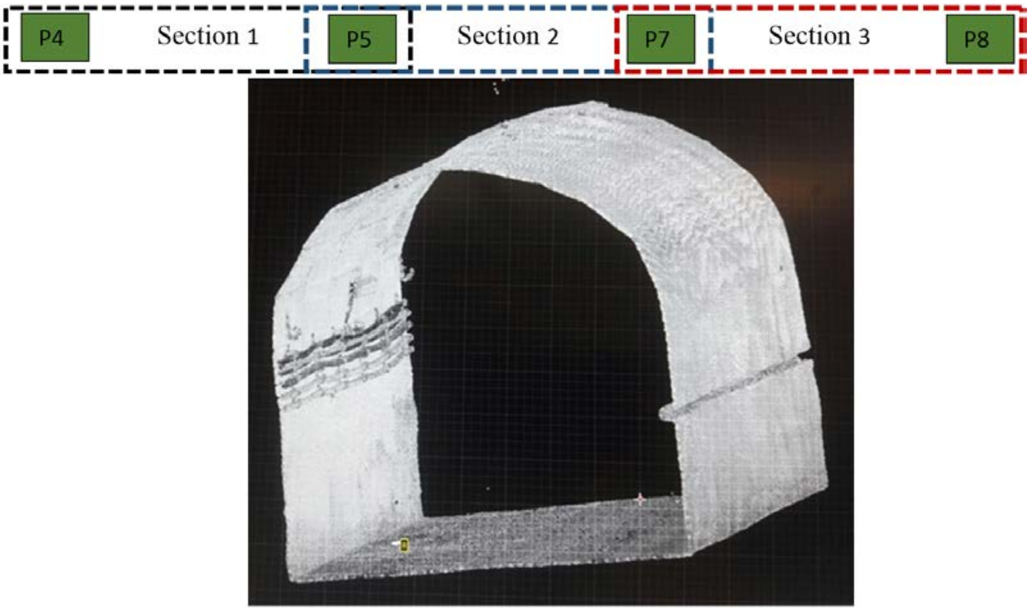

Fig. 3. Diagram of control point positioning and cross section for control point no. 8 after offset

h) Data export.

The data has been exported in .las format, georeferenced in UTM 35 coordinate system and ETRS89 ellipsoidal height.

4. CREATING A GRAPHICAL DATABASE

The .las LiDAR data files occupy a memory space of approximately 4.5 GB for each scanner. Taking into account the high point density, for an easier maneuverability, the data was separately exported for each scanner.

The point cloud itself represents a database that can reorganized by grouping the points based on interest classes (classification), in the present case the possible classes being represented by the access point, tunnel walls / mining chambers and other kind of elements.

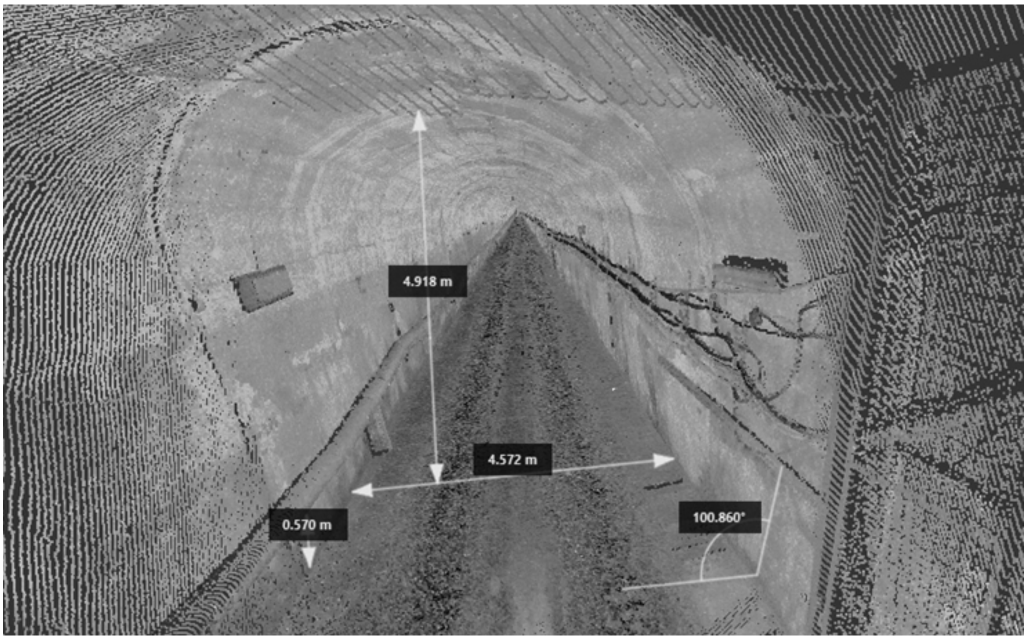

Fig. 4. Example of dimension data extraction from the point cloud (Autodesk RECAP)

The vast majority of laser points define the shape of mining works, there are buildings and other constructions only in the recreational area, and therefore point classification has been performed only for the surface that defines the access point. This surface has been used for the longitudinal section of the salt mine.

The point classification and "ground" class creation that define the access point was performed using the TerraScan software, an application that runs inside Bentley Microstation. The stages are as follows:

- A new project is created in Microstation, and the workspace seed3d.dgn is selected
- The Terrascan application is launched and the .las file is imported;
- The .las file is divided into standard sized sections;
- The application predefined classification algorithms are used. There is an option to classify "by tunnel section" for this specific case.

In order to use this procedure tunnel cross sections are created, the points being classified depending on their position relative to the cross-section contour.

- The point export in ASCII format with .txt extension containing the x, y, z coordinates separated by space (example 399415.067 446235.946 228.392).

Obtaining the vector type linear data from the point cloud can be realized by using the Autodesk RECAP 2016 and Autocad Civil 3D 2016 software.

In order to perform this task, the .las format data is imported in Autodesk RECAP and exported based on sections or as a total project with the *.rep file extension.

The data in .rep format can be attached to a project created in Autocad Civil 3D in which polyline or polygon type vectorial data can be created, alignments can be defined, sections or surfaces can be generated.

For a simplified graphical representation of mining works a surface model can be generated using equidistant cross-sections extracted from the point cloud. The necessary stages to execute this are as follows:

- The spline curve/ 3D polyline is built for the mining works route using the “ground” class points,
- Equidistant cross-section sectors are generated on the polyline alignment. For a fast generation of the sectors the PointSense Plant (FARO) application can be used in the Autocad Civil 3D environment using the <define multiple slice> command, selecting the alignment/ curve, and selecting the equidistance between sections;
- The vector form of the cross-section sectors is created;
- The <loft> command is used to create surfaces between cross-sections;

This method is only an approximate representation of the mining works that offer the advantage of occupying a small memory space and allow a fast maneuverability and 3D viewing. For a more precise and realist rendering of the mining works the data provided by the high density point cloud must be used as fully as possible from which the vector data can be extracted depending on project necessities. Working with large sized data (from the occupied memory space viewpoint) does not constitute a major impediment because the current hardware allows working with large volumes of data or an objective can be divided into multiple sections of smaller dimensions, adapted to the available hardware resources.

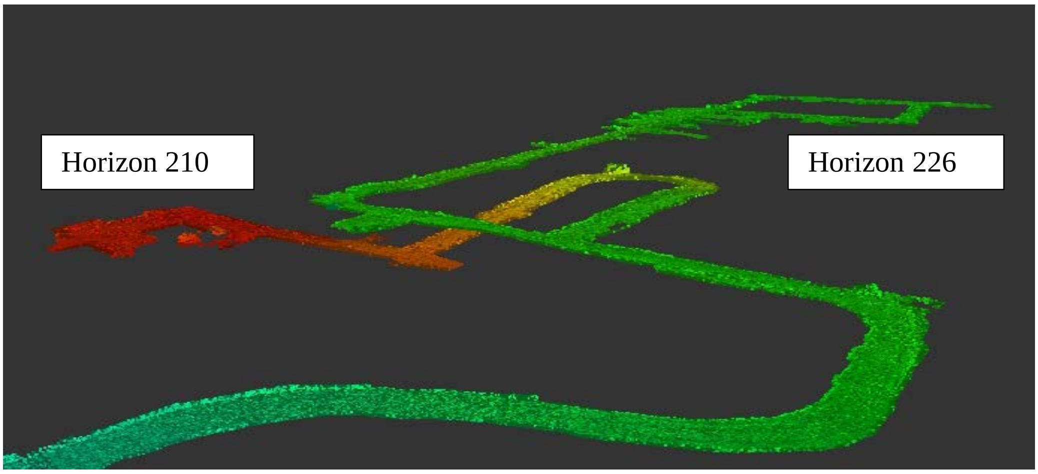

Fig. 5. *Digital surface model (ground class) Ocnele Mari salt mine*

5. CONCLUSIONS

The increasing number of LiDAR scanning solutions offers an alternative to classical measurements that are predominantly used in a subterranean environment, the obtained results being compatible from an accuracy viewpoint but from an execution period and degree of detail perspective, laser scanning is superior. In the present case study, the laser scanning measurements performed ensure an average density of over 19000 points / m^2, a centimetre level accuracy for all three axes and the execution time was 40 minutes (11:09 AM – 11:50 AM).

Compared with other remote sensing methods, the laser scanning methods can be easier to use for executing measurements underground due to the fact that it is no longer necessary to assure lighting and visibility conditions, and only the issues related to site access for equipment must be resolved. The relatively simple workflow described in the project allows the rapid extraction of three dimensional detailed topographic data, with an immediate applicability in the activities of designing, extending, monitoring and documentation of subterranean mining work progress, evaluating the stability of works, etc.

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POSSIBILITIES OF PROCESSING GEOSPATIAL INFORMATION SPECIFIC TO THE MINING SECTOR

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Abstract: The technological process of the last years that has taken place in the area of geospatial data collection sensors has determined a parallel development of techniques and methods of calculation destined for processing, analyzing and distribution of data. The current processing and management possibilities of descriptive information with spatial repartition find their applicability also in the mining sector.

Keywords: *GIS, geospatial data, topology.*

1. GENERAL CHARACTERISTICS OF DATA APPLICATION USED FOR PROCESSING GEOSPATIAL INFORMATION

The data and descriptive characteristics with spatial repartition are processed and stored in a geographical informational system which determines that presently the equipment and applications destined to obtain and manage the data be oriented towards the following aspects:

- continuous development of sensors and methods of obtaining geospatial data, this presupposing the identification of new methods of data collection or adapting the existing methods so that they are applicable in as many domains as possible;

-continuous development of data applications so that the geospatial data is processed, updated and quickly distributed towards the interested users;

-development of processing algorithms so that the data can be converted from a cartographic system to another or a common format that can be managed by as many applications and handled simultaneously by as many different users.

The present measuring methods allow the acquisition of a large volume of data in a short period of time therefore data processing applications must develop algorithms of ingesting and processing of data as well efficiently managing the memory space.

The geospatial information data processing applications currently in existence offer global management functionalities and utilities created and adapted for a certain field.

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From the viewpoint of creating and managing graphical data, the present software products use two methods of database organization:

- taking the shape of a unique database, in which all graphic elements of a project are found in a single file. This method of representation is mainly used by CAD type software (for example the applications created by Autodesk, Bentley, etc.)
- under the structure of multiple databases, in this case distinct files are created for graphic elements, point, line, polyline) and attributive tables associated with the graphic elements. This method of representation is mainly used by GIS type software (ArcGIS, Mapsys, etc.). Regardless of the mode of graphic database organization, applications must allow the representation of all elements that define a mining objective in each operating phase.

2. PROCESSING GEOSPATIAL DATA SPECIFIC TO THE MINING SECTOR

GIS programs in the mining sector are applicable especially for performing mining cadaster works. Due to the fact that mining cadastre is integrated into the general cadastre the informational structure must be a common one. In the case of Romania, the table structure and format of data specific to general cadaster was established by the National Agency for Cadastre and Land Registration, the .xml format being used in order to represent data (.cpxml for usual cadastre works and .cgxml for general cadastre works).

The graphical database is formed out of polygon type layers containing the administrative territory boundary, the cadastral sector limit, the plot limit, the parcel limit, immovable properties, building limits. These are represented in the .xml file through planimetric coordinates of contour points that define the polygons.

The attributive database is formed by tables that contain the data regarding addresses (immovable property address and owner address), buildings, property deeds, immovable property, individual units, parcels, owner, and registration.

The current applications used for 3D representation contain general spatial visualization and graphical representation functions but also ensure the possibility of running multiple functions specific to a certain domain.

For the domain of mining there exist specific applications that run under the dedicated software of the main manufacturers, for example AutoCad Civil 3D, Mine Cycle Survey while TerraModeler runs as an application inside Bentley Microstation, etc.

In GIS type applications, the 3D graphical representation functions are used for virtual modelling of the real three-dimensional space, the realization of spatial analysis being possible their results finding their applicability including in the mining sector.

For example a three-dimensional complete representation of an area where a mining objective is to be developed allows the efficient placement of the infrastructure elements and mining works.

From the viewpoint of 3D representations the most challenging problem is creating a three-dimensional topology. If in the case of creating two-dimensional topologies between the two-dimensional graphical element (point, polyline, polygon) and the unique identifier a *one to one* relation is created, in the case of three-dimensional topologies each body must be deconstructed into surfaces and a topological connection must be created between each body and surface that it consists of. From a physics and logic viewpoint this process presupposes the creation of supplementary index tables that however require new organization rules and a database size at least three times greater. The database increase in size implicitly presupposes the decrease in work speed even for simple search and location operations. Also a simple modification of the shape a of three-dimensional body implies the remaking of the topological spatial relations of membership and neighboring and the complete update of the index table, these operations that require a large amount of time and resources. These are the reasons for which the majority of actual topologies are realized in a two-dimensional space and the elements necessary for three-dimensional representation are attached in the attribute table. Therefore data management is made at the two-dimensional level, existing only representation and/or visualization functions in the three-dimensional system.

3. MANAGEMENT OF MINING WORKS IN A GIS ENVIRONMENT

To fulfill the requirements of representation and management of data specific to the mining sector the data applications must contain functions and complex procedures that allow the 2D and/or 3D representation of mining works of any kind (CAD functions), but also offer an environment that permits the creation and management of geospatial data (GIS functions).

The applications used to represent the mining works significantly simplify their designing. For comparison we approach the issues of designing a mining project of minimal length between two existing works.

These types of projects ensure the connection between two mining works and are named as drilling works and junction works.

According to the criteria that form the basis for selecting the ore extraction mechanisms it is taken into consideration that the total lengths of the works of opening, preparing and extraction have values that are as small as possible. Therefore from a topographic viewpoint it should be pursued that the mining works have a minimal length. Under consideration are two mining works G1 and G2 between which a minimal length mining work must be executed. In the designing phase of the project the two points must be determined, P and P1 that will constitute the drilling ends. In order to fulfill the minimal length requirements the line that starts from point P from the G2 mining work plane must perpendicularly cross the G1 mining work plane in point P1.

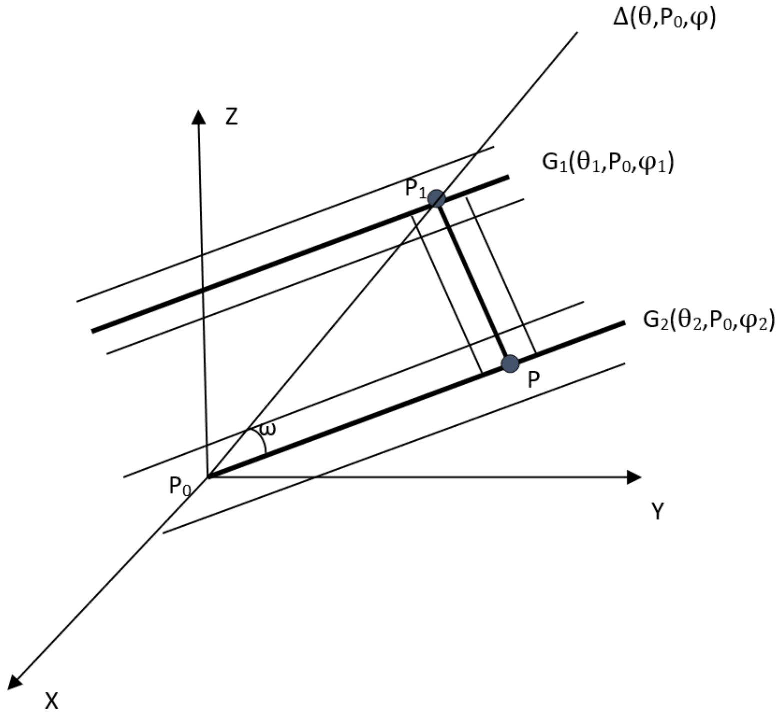

Fig. 1. Elements of designing a minimal length mining work

The coordinates of point P (*x, y, z*) are obtained from the following formulas:

$x = x_0 + P_0P\alpha_2,\ \alpha_2 = \cos\theta_2 \cos\varphi_2$

$y = y_0 + P_0P\beta_2,\ \beta_2 = \sin\theta_2 \cos\varphi_2$

$z = z_0 + P_0P\gamma_2,\ \gamma_2 = \sin\varphi_2$

$P_0P = P_0P_1 \cos\omega,\ \cos\omega = \alpha\,\alpha_2 + \beta\,\beta_2 + \gamma\,\gamma_2$

$P_0P_1 = \sqrt{(x_0 - x_1)^2 + (y_0 - y_1)^2 + (z_0 - z_1)^2}$

$\alpha = \cos\theta \cos\varphi$

$\beta = \sin\theta \cos\varphi$

$\gamma = \sin\varphi$

The angle θ is obtained from formula $\operatorname{tg}\theta = \frac{y_1 - y_0}{x_1 - x_0}$

The angle φ is obtained from formula $\operatorname{tg}\varphi = \frac{z_1 - z_0}{\sqrt{(x_0 - x_1)^2 + (y_0 - y_1)^2}}$

The distance P_0P is obtained by replacing the P_0 coordinates in the equation of the plane that goes through point P_1 and is perpendicular to G_2.

$P_0P = (x_0 - x_1)\,\alpha_2 + (y_0 - y_1)\,\beta_2 + (z_0 - z_1)\,\gamma_2$

The minimal length work is executed from point P_1 with the orientation elements θ_0 and φ_0, and determined by the formulas :

$\operatorname{tg}\theta_0 = \frac{y - y_1}{x - x_1}$

$$\text{tg } \varphi_0 = \frac{Z - z_1}{\sqrt{(x-x_1)^2 + (y-y_1)^2}}$$

By using the facilities offered by the CAD type data software the problem is easily solved by using basic commands. Thus, if the elements from figure 1 are represented in Autocad, in order to draw a perpendicular line from point P and determine the coordinates of point P_1 it is sufficient launch the <OSNAP> function prior to creating the line and using the <Perpendicular> mode when drawing. After drawing the perpendicular line between point P and gallery G1 point P_1 is created at the intersection between the two perpendicular lines by selecting the <Intersection> option from <Object snap mode> and entering the <Point> command after which the point is selected and properties table selected where the newly created coordinates are shown.

To estimate and track the mining work excavation process of minimal length in a GIS environment it should be borne in mind that, besides the progress of the works, the unit cost and the total costs related to the execution of the mining work must be highlighted.

The implementation steps are as follows:

a) The layer for the mining work, e.g. the <GALLERY> layer, is created.

b) The graphical representation of the work is established and created. This can be of the polyline type, where distinct segments are created marking the progress of the works, spatially overlaid over the designed alignment or polygon, in which case the projected horizontal size of the mining work is represented.

c) The topology is constructed. The vector elements included in the corresponding graphic layer present a series of distinctive spatial features (unique graphic identifier, start and end coordinates, length of a line, perimeter, and surface of a polygon) that represent basic geometric attributes and are generated when the topology is created.

d) the attribute table afferent to the graphical entities in which the fields are defined is created:

- <ID_Segment_project> - represents the unique identifier of a section of the project, defined as an integer type numerical data;

- <Project_TYPE> - represents the work type (shaft, well, etc.), defined as alphanumeric data of a character set type;

- <Section> - represents the constructive type of a cross section (trapezoidal, rectangular, cylindrical, etc.), defined as an alphanumeric data of a character set type. The character set can optionally define a path to a graphical image of the section, so that the section can be directly visualized.

- <Support> represents the constructive type of support, defined as an alphanumeric data of a character set type;

- <Work_segment_length> - represents the length of a section/segment from the work executed in a certain interval of time, defined as a real number data type;

- <Cumulative_work_length> represents the sum between the work segment lengths executed previously and the current segment length, defined as a real number data type

- <Project_work_length> - represents the total length of the project according to the execution design, defined as a real number data type;

- <Start_date> - represents the commencement date of the work in the respective segment, defined as a calendar data type.

- <End_date> - represents the finalization date of the work in the respective segment, defined as a calendar type date.

- <Unit_cost> - represents the cost of extracting a meter of mining work expressed in lei / m, defined as a real number data type;

- < Work_cost> - represents the project cost on the date work progress evaluation, defined as a real number data type. It is determined as a product between <Cumulative_work_length> and <Unit_cost>.

- <Estimated_cost> - represents the total estimated cost determined in the designing phase of the mining work, defined as a real number data type.

e) Data is entered into the attribute table fields. In addition to the data tables, the geographic data management software automatically create fields or index tables, operation logs, access rights, etc.

The relational structure of data organization allows the execution of operations specific to classical databases, namely searching, filtering according to certain criteria, ordering and aggregation of data.

f) Query and spatial analysis operations are created for generating thematic maps and extracts in table format.

The previously described stages represent the basic operations, which can be accomplished by the majority of existing GIS applications, including *open source* applications.

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Scientific Reviewer:
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AN ELEMENTARY METHOD TO DETERMINE THE PARAMETRIC EQUATIONS OF THE EARTH ROTATION ELLIPSOID

TEODOR RADU [1]

Abstract: The transition from the general Cartesian equation of the earth rotation ellipsoid to the parametric equation represents an exam subject for students of any faculties of geodesy. The present paper represents a method of obtaining this parametric equations which can be explained highschool seniors in applied mathematics courses.

Keywords: *earth rotation ellipsoid, parametric equations, tangent, normal*

The ground rotation ellipsoid is obtained by rotating the ellipse passing through the points B, C, B', C' around the axis Oz (Fig 1).

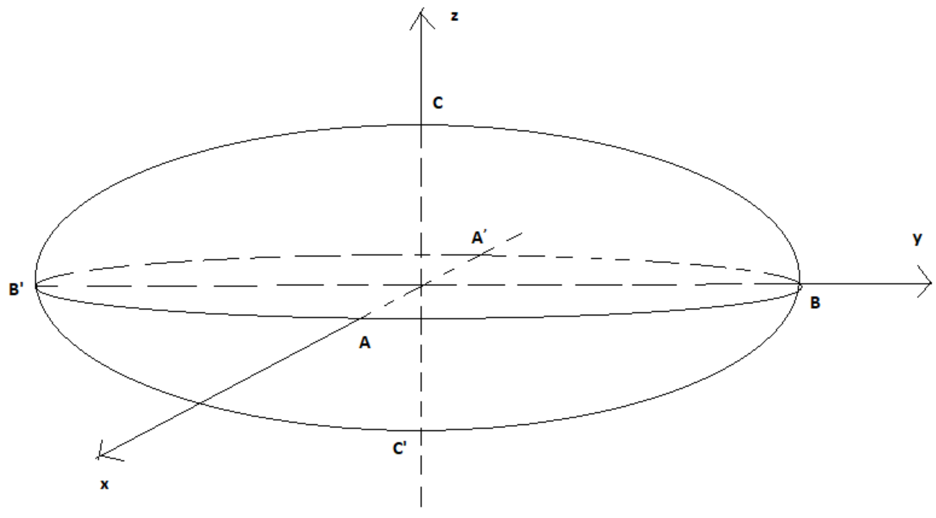

Fig. 1.

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Noting the earth rotation ellipsoid with $\mathcal{E}$, we will have: $\mathcal{E} \cap Oy = \{B, B'\}$, where $B(0, a, 0)$ and $B'(0, -a, 0)$;$\mathcal{E} \cap Oz = \{C, C'\}$, where $C(0,0,b)$ and $C'(0,0,-b)$; $\mathcal{E} \cap Ox = \{A, A'\}$, where $A(a, 0,0)$ and $A'(-a, 0,0)$.

We consider $a > b$.

The general formula of an ellipsoid passing through $A(a_1, 0,0)$, $B(0, b_1, 0)$, $C(0,0, c_1)$ is:

$\frac{x^2}{a_1^2} + \frac{y^2}{b_1^2} + \frac{z^2}{c_1^2} = 1$, where $M(x, y, z)$ is a on the ellipsoid.

Considering that $a_1 = b_1 = a$ and $c_1 = b$, we obtain:$\frac{x^2+y^2}{a^2} + \frac{z^2}{b^2} = 1.$

As we know, the point $M(x, y, z)$ with Cartesian coordinates can be represented as point $M(\varphi, \lambda)$ with geographical coordinates where φ is the angle made by the normal to the ellipsoid in point *M* with the xOy plan and λ can be considered the value of the angle $\measuredangle(AOM_1)$ where $M_1$is the *M* projection on xOy plan (Fig. 2).

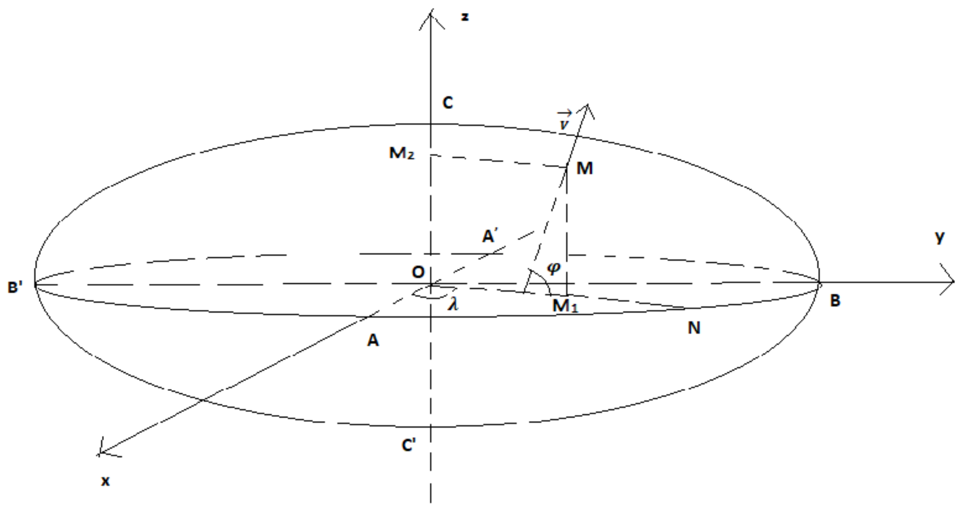

Fig. 2.

It is easy to observe that $OM_1^2 = x^2 + y^2$ and noting $OM_1 = r$ we will have: $r^2 = x^2 + y^2$.

In this conditions, replacing $x^2 + y^2$ in the ellpsoid equation we will have: $\frac{r^2}{a^2} + \frac{z^2}{b^2} = 1.$

We consider OM_1 as an axis with the origin in O noted with Or and we can intersect the earth rotation ellpisoid with the plan generated by this axis and point M.

We get through the section an ellipse with semi-axis $ON = a$ and $OC = b$ (Fig. 3).

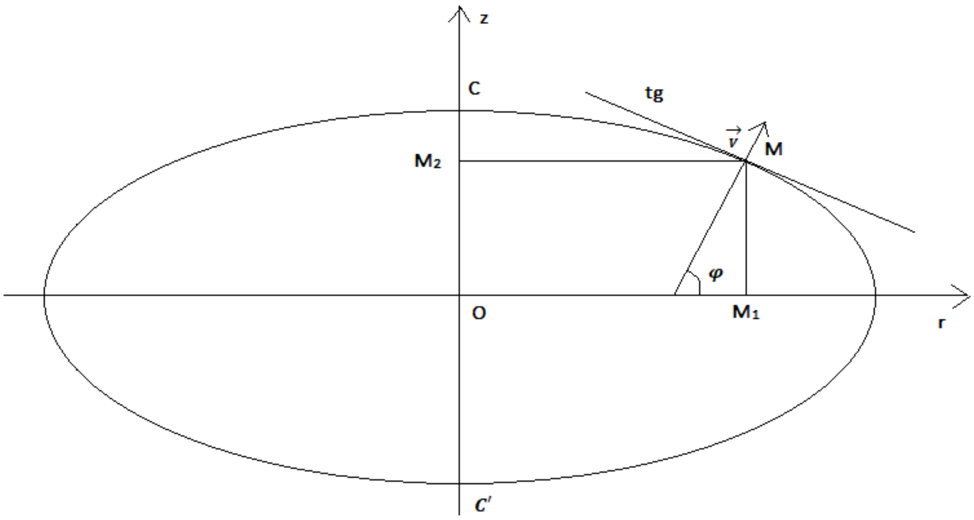

Fig. 3.

We will have $N(a, 0)$ și $C(0, b)$ and so the ellipse equation will be: $\frac{r^2}{a^2} + \frac{z^2}{b^2} = 1$, where $M(r, z)$ is a point on the ellipse.

Further, we consider $M(r_0, z_0)$ a fixed point on the ellipse.

The tangent line equation in M to the ellipse will be:

$$tgM: \frac{rr_0}{a^2} + \frac{zz_0}{b^2} = 1 \Leftrightarrow \frac{zz_0}{b^2} = 1 - \frac{rr_0}{a^2} \Leftrightarrow z = -\frac{b^2}{a^2}\frac{r_0}{z_0}r + \frac{b^2}{z_0}$$

Noting m_1 as slope of the tangent line (a line in rOz), we will have:

$$m_1 = -\frac{b^2}{a^2}\frac{r_0}{z_0}$$

We note m_2 as slope of the normal $\vec{v}$ in point M to the ellipse and because $\vec{v} \perp tg$ we will have $m_1 \cdot m_2 = -1$

In conclusion $m_2 = \frac{a^2}{b^2}\frac{z_0}{r_0}$ and because $m_2 = tg\,\varphi \Rightarrow z_0 = \frac{b^2 r_0 tg\,\varphi}{a^2}$.

Replacing z_0 in $\frac{{r_0}^2}{a^2} + \frac{{z_0}^2}{b^2} = 1$ we obtain

$a^2r_0^2 + b^2{r_0}^2(tg\ \varphi)^2 = a^4$, and so $r_0^2 = \frac{a^2}{a^2+b^2(tg\ \varphi)^2} = \frac{a^4(\cos\varphi)^2}{a^2(\cos\varphi)^2+b^2(\sin\varphi)^2} \Leftrightarrow$

$$r_0^2 = \frac{a^2(\cos\varphi)^2}{1-(\sin\varphi)^2+\frac{b^2(\sin\varphi)^2}{a^2}} = \frac{a^2(\cos\varphi)^2}{1-e^2(\sin\varphi)^2}.$$

We have $r_0 = \frac{a\cos\varphi}{\sqrt{1-e^2(\sin\varphi)^2}}$ where $e^2 = \frac{a^2-b^2}{a^2}$ is the first eccentricity of the ellipse.

Replacing $r_0 = \frac{a\cos\varphi}{\sqrt{1-e^2(\sin\varphi)^2}}$ în $z_0 = \frac{b^2r_0\sin\varphi}{a^2}$, we obtain $z_0 = \frac{a(1-e^2)\sin\varphi}{\sqrt{1-e^2(\sin\varphi)^2}}$.

Considering $M(x_0, y_0, z_0)$ as a point on the ellipsoid, we will have $x_0 = r_0\cos\lambda$ and $y_0 = r_0\sin\lambda$ (according to Fig 2) after projecting point M_1 on Ox an Oy axis.

In the end, the following equations are obtained:

$$x_0 = \frac{a\cos\varphi\cos\lambda}{\sqrt{1-e^2(\sin\varphi)^2}}$$

$$y_0 = \frac{a\cos\varphi\sin\lambda}{\sqrt{1-e^2(\sin\varphi)^2}}$$

$$z_0 = \frac{a(1-e^2)\sin\varphi}{\sqrt{1-e^2(\sin\varphi)^2}}$$

Which means that we obtained the Cartesian coordinates of point $M(x_0, y_0, z_0)$ depending on the geographical coordinates of the same point $M(\varphi, \lambda)$.

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Scientific Reviewer:
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SOME OF THE 19TH CENTURY REGULATIONS ON THE INTRODUCTION OF THE HISTORICAL CADASTER WITHIN TRANSYLVANIA, BANAT AND BUCOVINA AND THEIR MODERNITY

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Abstract: The introduction of the systematic cadastre in the second half of the nineteenth century into the historical provinces inhabited by the Romanians within the Habsburg Empire (from 1867 the Austro-Hungarian Empire was made on the basis of regulations for the application of Imperial Patentes, called instructions issued since 1824. These so called Instructions contain regulations on the technical and legal aspects of the cadastre and have been uniformly applied throughout the empire. The instructions detail the attributions of each staff category responsible for their application as well as the way of drawing up the entire cadastral documentation. The key staff member of the entire scaffolding of the cadastre remains the military surveyor, called geometer. He is situated between the upper levels of the state structures and the communities to which the cadastre is addressed. The result of their application was the systematic and complete cadastration of the mentioned provinces, providing a uniform and fair basis for the taxation of land and buildings, as well as a framework for economic development in the second half of the 19th century.

Keywords: *systematic, stable cadastre, instructions for cadastre introduction*

1. SUMMARY

The introduction of the systematic cadastre in the second half of the nineteenth century into the historical provinces inhabited by the Romanians within the Habsburg Empire (from 1867 the Austro-Hungarian Empire was made on the basis of regulations for the application of Imperial Patentes, called instructions issued since 1824. These so called Instructions contain regulations on the technical and legal aspects of the cadastre

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and have been uniformly applied throughout the empire. The result of their application was the systematic and complete cadastration of the mentioned provinces, providing a uniform and fair basis for the taxation of land and buildings, as well as a framework for economic development in the second half of the 19th century.

The introduction of the cadastre the nineteenth century into the Habsburg Empire, which included at that time the historical provinces of Transylvanian, Banat and Bucovina, ,was an important element of modernization of society. The model of the mentioned cadastre adopted in the 19th century originates in the "Centesimo Milanese", the Milan cadastre, whose first works started on April 17, 1720, in a festive setting. Taking into account its efficiency and modernity was taken over by Napoleon Bonaparte's regime, then in Belgium, following the Netherlands, Bavaria, Luxembourg, Rhine, Westafalia, the cantons of Vaud and Geneva, and also throughout the Habsburg Empire, being here the most modern cadastral system of the 19th-century.

After a series of tax reforms introduced by the Empress Maria Theresa in the Habsburg Empire, in 1748 and then in 1756, continued by her successor, the Emperor Joseph II, in 1785, it became apparent that a unitary and fair tax system is necessary for the whole empire. In 1806 Emperor Francis I assign a commission to create a universal, uniform and stable cadastral system, valid for the whole empire. For this purpose, in 1810, a Commission was set up to regulate the land tax system which was to be established as a result of cadastral works based on military triangulation work already carried out. The Imperial Patent of 23.12.1817 issued by its works, according to which each locality should be surveyed, parcel by parcel including even non-productive lands. This Imperial Patent was followed by the Instructions for the application of articles 8 and 9 of it, regulation published in 1824.


Instruction
zur
Ausführung der zum Behufe des allgemeinen Catasters
in Folge des 8ten und 9ten Paragraphes
des
Allerhöchsten Patentes vom 23. December 1817
angeordneten
Landes-Vermessung.
Wien.
Aus der kaiserlich-königlichen Hof- und Staats-Aerarial-Druckerey.
1824.

Fig. 1

This document inaugurates a series of such regulations, called instructions, during the nineteenth and early twentieth centuries that largely maintain its principles and methodology. The next ones are those issued in 1856, 1865 in German and those issued in 1869, 1904 and 1910 in Hungarian .Thus, the Instructions issued in 1824 lay the foundations of an institution that will remain known as the Franciscan Cadastre or Stable Land Cadastre.

This work sums up of the principles and working methodologies set forth by the Instruction from 1824 and which are kept by subsequent regulations. Pursuant to the purpose established by the Imperial Patent, the first Instruction formalizes a pyramidal network of state structures subordinated to the Imperial Finance Ministry. At beginning the authority responsible for introducing the systematic cadastre was designated the aforementioned committee but in the next instructions the state authorities responsible for the introduction of systematic cadastre were General Direction of the Land Tax. According to the Instruction from 1824 at the level of each province of the empire a committee would be responsible for setting preparatory measures for the introduction of the cadastre on the basis of annual plans. These include taking over and adapting triangulation works[1] already carried out as well as describing the boundaries of the province where the cadastre is introduced.

With the purpose to cover technical issues, provincial directorates and sub-directorates were created, having subordinated territorial inspectorates with inspectors and sub-inspectors, the latter having the task of coordinating and controlling the teams of technicians and cadastral engineers (geometers). The geometers body is organized on classes; promotion from one class to another is based on evaluation grids.

Alongside these structures, a separate headquartered in Vienna direction for triangulation works has been created and also a Calcul Bureau with directors and sub-directors at each provincial level. A separate detail instruction was given to the geometers of this direction. The staff of these structures is responsible for the graphical triangulation and the establishment and description of the provinces boundaries, as well as for the transmission of the coordinates of the triangulation points to the geometries carrying out the cadastral works, the latter being attributed to a geodetic specialist: the so-called graphical triangulator.

According to the document's view, triangulation works as a basis for measurements, it offers the possibility of joining surveying records, individual measurements in a totality, maintaining them between boundaries and also providing orientation, ensuring the possibility of verifying surveying works through the existence of verifiable points, reducing the accumulation of inevitable errors. For each Viennese square mile (57 532 225 sqm), it is necessary to determine at least three triangulation points (in mountainous regions of at least two). The graphical triangulator has the task of drawing sketches specifying the graphically determined triangulation points. These points must coincide with consistently visible landmarks: towers, geodesic pyramids,

[1] The cadastral works, mentioned by the Instruction of 1824, were based on the first military survey performed 1763 to 1787, termed as the "Josephinishe Aufnahme.", but without any geodetic survey. For this purpose the Liesganig triangulation was used and supplemental surveys using plane table and alidade. About 4500 map sheets were drawn up based on Vienna Klafter System where 1 Zoll = 400 Klafters = 7586 meters. The cadastral surveys in Transilvania, Banat, and Bucovina, were performed based on the second military triangulation carried out 1806-1829, consisted of few main chains, both in the western part of the Habsburg Empire and also a chain along the Carpathian Mountains to Transylvania. In 1806 was established the Vienna datum, based St. Stephan's Tower, having the origins expressed in the Ferro system ($\Phi_{\circ}$= 48° 12' 34.0" North, $\Lambda_{\circ}$= 34° 02'15.0" East of Ferro. (Ferro is in the Canary Islands which is 17° 39', 46.02" West of Greenwich.). Prior to the beginning of cadastral surveys the Walbeck ellipsoid where a =6,376,896 meters and 1/f = 302.78.

massive single trees, etc. It is recommended that part of the determined points should be as far as possible on the border line between localities.

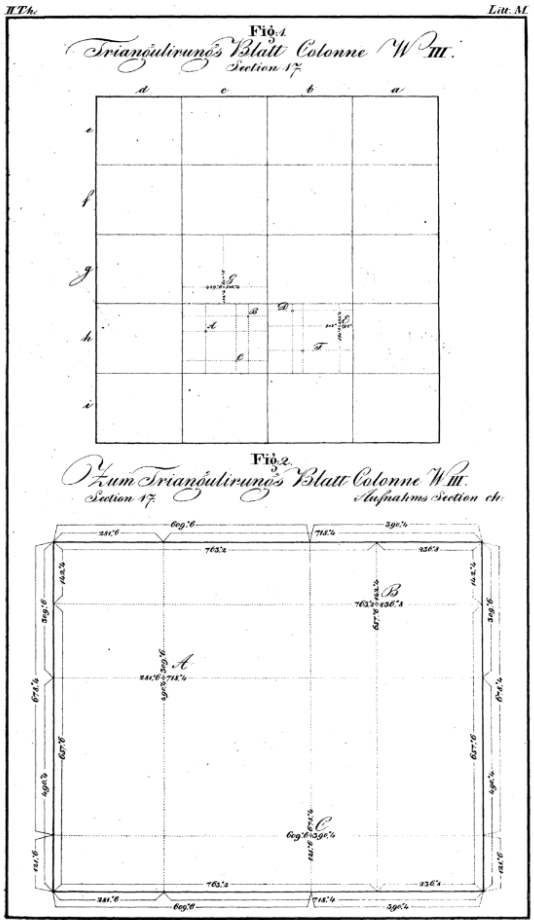

Fig. 2

Both the geometers performing the cadastral works and those responsible for triangulation works must program their activity in two fieldwork campaigns, summer one from April to October and a winter campaign from October to April.

The work flow of triangulation and cadastral surveys was strictly controlled by a system of periodic reports, with monthly, semestrial and annual frequency. The works will be carried out on the basis of well-defined annual plans, which will be pursued through the mentioned reporting system.

The cadastral works of a municipality begin with the determination of the boundary of the locality, usually made after the graphic triangulation works. The geometer specially designated for this work draws up the prescribed documentation by the cadastral instruction where the main points on the boundary between localities, the neighbors and other significant aspects are described. The work of boundary delineation is assisted by the representatives of the local authorities for whom the cadastre is carried out as well as those of the neighboring localities. The cadastral instructions describe also a procedure to be followed in case of disputes regarding the establishment of boundaries between localities.

Field surveys are carried out by geometers accompanied by assistant geometers and auxiliary staff, usually consisted of three persons in charge of transporting instruments, performing triangulation point signaling works, etc. The surveying works are generally performed by military geometers belonging to the officers' or non-commissioned officers' body. Together with the owner participation at the detailed surveying works, trustworthy people of the community are designated to confirm the boundaries of both the individual plots and of the locality.

The instruction specifies which instruments are commonly used for surveying works: the topographic plate, theodolite, the level, the chain, the compass, and the drawing kit, the integrity and precision of everyone must be examined periodically or at the beginning of each work session.

The instruction of 1824 and the next ones elaborate how the cadastral surveying should be performed and how to represent them on maps. Parcels have to be surveyed with all the field details: constructions, fittings, the category or categories of land use of every parcel, types of crops. Soil quality is not taken into account during the surveying works. Areas with different use categories within a parcel are delimited as distinct subparts. Similarly, the yards together with the buildings form the distinct sub-parcels. For small buildings such as sheds, huts, small wooden houses, cabins, surveying works and their representation on maps are not required. Public buildings such as churches, monasteries, hospitals form special plots. If plots with the same owner are intersected by permanent details, for example rivers, streams, public roads then they form distinct plots, but if they are intersected by details such as trails, water drains, irrigation channels are considered as one plot. The very small parcels in relation to the map scale are not represented, but they must be mentioned in the protocol (report) drawn up after performing the field surveying.

Fig. 3 Instruction from 1856. Color code and conventional signs used on cadastral maps

Forests are divided into plots according to the owner and the natural boundaries. If large forests have previously been surveyed by forest engineers, their works will be taken into account in new cadastral works after a prior check. Enclaves inside forest areas are recorded as distinct plots according to the land use category. Rocks, grooves are recorded separately if they exceed the area of 100 squares fathoms

All public roads are considered as special plots. Rivers, lakes and waterways are treated as distinct plots. Unoccupied areas of the riverbed are included in the river special parcel as well as floodplains around it. Unused or unproductive lands are also considered as individual plots.

Detail procedures to be followed by geometers for topographical surveys are also specified in different particular cases for strip ground and parcels, with special regard when the field details allow only a limited use of optical instruments. In this regard the instruction presents the procedures to be followed for the surveying works within the built areas, the geometers having to determine the dimensions of the block and of the more important buildings within it and after drawing an abbreviated sketch of the block area, the other topographic details are obtained by graphical means. Particular attention is paid to localities with more than 600 houses.

Drafting of maps is carried out during the winter campaign and must include all parcels with the significant topographical details. Each plot is colored according to a color code corresponding to the land use categories. Inside the parcel, besides the cadastral number assigned to each parcel or sub-parcel with the Arabic numerals, the name of the owner is mentioned and, where appropriate, the house number in the built-up areas. Numbering usually starts with the church plot. Once the maps have been drawn up, correctness and accuracy are checked and redraws are made with a red line.

Surface calculation for small areas is done by geometric methods by dividing the plot sketch into simple geometric figures, triangles or trapezes but in case of large areas by using glass engraved gilded plates.

After completion of the maps, land registers with cadastral numbers shall be made, stating the name and first name of the owner, the land use category ("genus").

Detailed instructions are given also on how to draw up detail and synthetic reports on each hierarchical level of the staff responsible by introducing the stable cadastre.

The geometer must finally produce a complex documentation that mainly includes:

- The layout of basic map of the locality;
- Parcel/land register);
- Building register);
- The alphabetical index of the owners;
- Final description of the locality boundaries;
- Land book;
- List of unknown owners;
- Surface calculation protocol (register);
- List of involved authorities

The instruction for cadastral works as a result of the Instruction issued in 1824 did not produce immediate effects within the Habsburg Empire territories inhabited by Romanians. However, its principles and the main technical methods have been maintained and developed in subsequent regulations for the introduction of the systematic cadastre.

Thus the 1856 and 1865 Instructions issued for the application of the Imperial Patents of 23 December 1817 and that of 20 October 1849 takes over and develops the provisions of the Instruction of 1824.

The introduction of the cadastre into the Romanian provinces of the Habsburg Empire was mainly based on the provisions of the 1856 Instruction.

Taking into account the Maramureş County case, on the basis of the preserved archival material, it can be noticed that between 1856-1864, all the localities both on the left and the right border of the Tisa river were surveyed, following the principles introduced by the instructions from 1824 and 1856 and complex documentation resulted, including cadastral maps, parcel and land registers, land books and wealthy land sheets.

Fig. 4 Sketch of Iapa village-today district of Sighet town

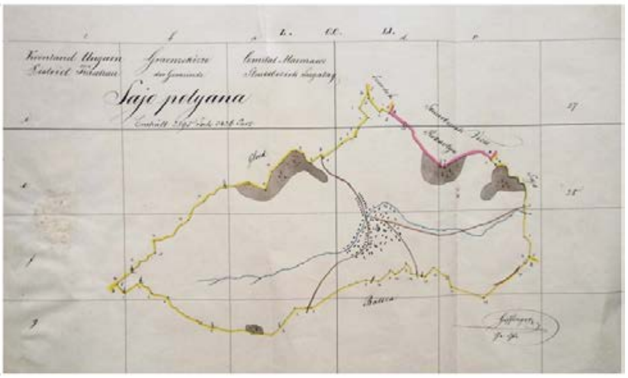

Fig. 5 Boundaries of Sieu Village, Maramureș county

The cadastral works were performed according to the instructions starting with the triangulation graphical works, establishing the positioning of the locality boundaries in relation to the geographic coordinate system.

A technical documentation regarding the delimitation of the boundaries of every surveyed locality was drawn up, in the presence of the local authorities describing the main point sand specifying the neighbors.

Fig. 6 Cadastral map sheets from Sighet town and Iapa village

The cadastre works were carried out in a record time, if we take into account their complexity, thus drawing up the documentation provided by the instructions: map carton sheets, registers and land books. The works carried out during this period are the basis for the land book in use today, at least as regards the calculation of the parcel areas.

In conclusion, through the use of clear and flexible working principles and methodologies specified in the mentioned instructions, the cadastre of the territories of the Romanian historical provinces: Transylvania, Banat and Bucovina, was performed with an accuracy that is acceptable even today, being at that time a support for their economic and social development. The resulting material can still be used today in the general cadastre introduction works.

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EVOLUTIONS AT THE ENTERPRISE'S LEVEL: FROM MENTENANT SYSTEM TO TOTAL MAINTENANCE

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FERENC KORONKA [2]
DIANA CORNELIA CSIMINGA [3]

Abstract: The technological component of the modern enterprise is defining not only for its classification in a certain field of activity but also for its economic and financial performance. In the evolutionary context of the substitution of the labor factor by the capital production factor, the importance of the technological side has grown to become decisive in the long term perspective of the success and performance of the enterprise. Maintaining technology at certain operating parameters, streamlining this process, integrating into a unitary management system have become priorities and even challenges of top management. The modern industrial enterprise has become more and more valuable to the resource called time. Performance, regardless of its nature, if it is not obtained in a certain temporal context, becomes no longer important. This is the only way to explain the increasing importance attached to maintenance activity, linked, in the most general way of defining, to the passage of time. Maintenance should not be understood as a specific activity by which components of machinery, equipment, plant are maintained for as long as possible, but rather as a specific (but generalized) activity by which the effects of a set are removed greater detrimental factors, not only related to proper functioning, but also degraded by defined or predefined operation within clear time coordinates. Thus, the modern enterprise has moved from the verb "to maintain" to the verb "to continue to exist". However, this shift implied major changes in the way we understand and relate to maintenance work.

Keywords: *maintenance, maintenance system, maintenance management, total maintenance.*

1. THE CONCEPT OF MAINTENANCE

Maintenance is the activity that includes all the measures and actions taken on a machine or equipment (equipment) in order to avoid accidental stopping of the machine or equipment in case of an accidental stop. Maintenance-specific actions are

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maintenance, revision and repair, with the goal of maintaining reliability or periodically restoring it to an acceptable level.

The time required to carry out the maintenance activity is the maintenance time. It has the following structure:

- the fault location;
- time of preparation for intervention;
- diagnostic time;
- time to buy the necessary interventions;
- time for the intervention itself;
- test and sample time.

Maintenance time, plus non-operating logistics time and non-operating time for organizational reasons determines the inactivity time of the machine or machine. Based on service and maintenance times, the availability of the machine or machine (equipment) can be calculated

$$D = \frac{T_F}{T_F + T_M} \tag{1}$$

where:

D – availability of the machine or machine (equipment);

T_F – running time;

T_M – maintenance time.

The availability value may vary in the range [0; 1]. From an economic point of view, the value of availability should be as close as possible to 1. This means that the maintenance time is as low as possible (compared to operating time). Such a situation can be achieved by reducing the preparatory times (through anticipated actions) in the maintenance time structure, providing easy and immediate access to the replaced or adjusted parts, reducing the time required to replace or adjust (they can be made immediately or very easy).

2. TYPES OF MAINTENANCE SYSTEMS

The way maintenance activities are organized determines several types of maintenance systems:

- corrective maintenance;
- the current maintenance;
- periodic maintenance;
- the planned maintenance;
- palliative maintenance.

Corrective maintenance includes all measures taken and actions taken by the manufacturer, that is, the recipient of machinery, equipment or installations, the content of which concerns:

- improving constructively the machine, machine or plant by redesigning parts or sub-assemblies that do not meet the practical requirements (it exhibits rapid wear, high consumption, uncomfortable operation, high noise, strong vibrations, etc.);

- functional improvement of the machine, machine or plant (when operating below guaranteed parameters);

- removing deficiencies that are specific to the reliability and maintenance of the machine, machine or plant.

As a rule, this type of maintenance system is specific to the warranty period of the new product or the warranty period granted after a capital repair (and which is established on the basis of a prior agreement between the contractor and the owner).

Current maintenance includes those actions and measures aimed at maintaining the machine, machine or plant reliability at an acceptable level during the scheduled period, determining the degree of wear and tear of overloaded components during operation, and establishing a revision period, all in order to increase economic efficiency. This type of maintenance system is based on:

-cleaning and removing impurities and pollutants which may affect the correct operation of the machine, machine or plant;

- proper lubrication and lubrication of the machine, machine or plant;

- the daily routine of the machine, machine or plant running behavior (in order to detect eventual malfunctions and avoid accidental malfunctions).

Periodic maintenance shall be based on the manufacturer's maintenance technical recommendations, the maintenance subsystem's recommendations and the observations resulting from the current operation of the machine, plant or plant. This maintenance system is mainly based on actions to prevent defects rather than removing them. Preventing defects with a certain probability involves knowing the rhythm and wear degree of the parts, knowing the outcome of the previous interventions, establishing the replacement time, based on this knowledge, deducting the need for materials and spare parts, estimating the maintenance time and qualification necessary to carry out the intervention. Regular functional maintenance requires a rigorous maintenance periodic (daily, weekly, monthly, etc.), which consists of checking and revisions, replacing the used parts, followed by the functional adjustment, so that the machine, the machine or the plant will operate design parameters for a new time period.

The operations specific to the type of periodic maintenance system are:

- periodic inspection (involves measuring the main functional parameters and estimating the degree of wear in order to anticipate the fault);
- partial revision (performed as a result of periodic inspection, being a planned, well-prepared intervention, involving the replacement or repair of used or defective components);
- general revision (which aims at the detailed verification of functional subassemblies, operational safety and precision, having the character of a planned intervention).

Planned maintenance is based on the planning of interventions in relation to their complexity as well as the complexity of the machine, machine or plant. The specific interventions of this type of maintenance system are:

- repairs as required (in the case of accidental breakdowns or breakdowns) that do not comply with a particular planning and eliminate the closest planned intervention;
- -requirements based on findings occurring when the machine, plant or plant no longer meets functionally, technically or technologically, requiring immediate intervention (although no accident or accidental failure occurred);
- rigidly planned repairs, which involve background intervention as planned, even if the machine, machine or plant is technically, technologically and functionally satisfactory;
- technical repairs and repairs, which are planned and may have the character of technical revisions, current repairs or capital repairs.

Palliative maintenance includes the system of actions and maintenance and repair measures for machines, machinery and installations that are out of use but are maintained in operation either due to their conforming characteristics or due to economic considerations (eg lack of funds necessary to acquire new machinery, equipment or installations). Typical of this type of maintenance system are actions and measures that provide an improvement in the condition of the masts, machines, installations, but without eliminating the cause that caused the accident or accidental shutdown.

3. TOTAL ENTERPRISE-LEVEL MAINTENANCE

At the enterprise level, the maintenance of machines, machinery and installations can not be viewed in isolation, but only in close relation, interdependence with the entire technical and technological activity, with significant effects on the economic and financial results of the enterprise.

Since the early 1980s, maintenance as a distinct activity within the enterprise has begun to become a standardization process that, as time passes, becomes more and more extensive. This process takes into account both maintenance operations and activities as well as the context in which they take place, not even the parties involved in this process being ignored. It has thus become possible in the 2000s to talk about the concept of "total maintenance". This concept can be adequately emphasized only by the categories of requirements it entails, namely:

- machinery, plant and equipment requirements: from this point of view, there is a possibility that they can perform their functions either within the normal operating period or in a specific operational context;
- operator requirements: From this point of view, it is possible for machinery, equipment and installations to operate at predetermined parameters either within a certain time frame or through a set of technical and / or qualitative specifications.

- requirements on the overall work of the company and its result of this view have highlighted it be possible to achieve maximum efficiency of operation of machinery, equipment and facilities during their entire life cycle technology without harming the environment.
- In close connection with this concept of total maintenance, the company-specific maintenance responsibilities could be identified, namely:
- security in operation of machines, equipment and installations (reliability, availability, security, maintenance);
- continuation of the expenses generated by the maintenance activities and their efficiency;
- the total cost of using different machines, equipment and plant at the enterprise level;
- management of operational risk (global, enterprise and individual, by category of machinery, equipment and plant);
- management of the workforce involved in the maintenance activities and the efficiency of its use;
- use the effects of environmental maintenance activities and reduce their impact.

3. CONCLUSIONS

Maintenance has become increasingly important at the enterprise level. This has become the object of a dedicated management subsystem, integrated with the enterprise management system. An efficient enterprise-level management system must allow at least:

- improving maintenance planning;
- development of maintenance-specific maintenance programs;
- diagnosing defects of machines, equipment and installations;
- rapid and accurate evaluation of the categories of resources needed for maintenance activities;
- systematic analysis of the causes of defects;
- optimal dimensioning of maintenance-specific maintenance stocks.

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INTEGRATING THE MAINTENANCE MANAGEMENT INTO THE ENTERPRISE MANAGEMENT SYSTEM

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Abstract: The decision-making component has a privileged position in the architecture, functionality and performance of the management system of any business. No other organizational element has such a pronounced managerial specificity and so great an impact on all business plans and results. As a result, most management authors view the decision as the essential element of the management process and the specific tool for expressing managers. In essence, the qualitative level of the way an enterprise is run is best expressed through the results achieved by the elaborated and applied decisions. The decision is the "resistance piece" of management, its most dynamic expression, through which it expresses its functions in full. The technological dimension of the enterprise's activities has become a determining factor in a competitive and free-market economy. The economic and financial performance of the enterprise is crucial in the competition to maintain and gain new market shares that are essential for the future development of the business. The organization's internal organization from a technological point of view cannot ignore the issue of maintenance. In order to be effective, the business process characteristic of this enterprise subsystem must be integrated into the global decision-making process, but without altering its specific character.

Keywords: *decision, management, management system, maintenance, enterprise, maintenance system.*

1. MANAGEMENT DECISION

Of the multitude of attributes that are only of the human species, the most representative is probably man's ability to make decisions. In fact, the whole range of conscious, rational actions by which man rises above the animal kingdom is based on the decisions he takes. Decisions are present in all our daily activities, whether they concern personal life or the manifestation of man (the individual) as an element integrated in the various organizations.

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Many specialists, both Romanian and foreign, have tried to define the decision. The result was a multitude of definitions, simpler or more complex, shorter or more elaborate. Analyzing the views of different specialists and reporting to the data provided by decision-making practice leads to the conclusion that the decision is "the chosen path of action to be pursued in order to achieve one or more objectives" [7]. This simple definition highlights the elements that the decision necessarily implies:

- the objective (set of objectives);
- the variants (alternatives, paths) possible to follow in order to achieve the objective (set of objectives) assumed;
- the choice or selection (the conscious process through which one of the previously identified action variants is chosen).

When a man's decision does not influence other people, we have to deal with the so-called personal decision, and when the decision concerns the activity of a community, an organization, we are dealing with the so-called management decision). The management decision is the "result of the rational process that chooses from the many alternatives, variants or possible solutions that best fit the goal or the proposed goal of the organization" [9].

The management decision is the main outcome of the management process. Even though, through the approach style and the methods of solving, the issue of personal decisions is sometimes approaching that of the management decisions, there are obvious elements of the latter that distinguish it from the first, namely:

- the complexity and the higher difficulty (the management decision always involves at least two persons: the decision-maker, the executor, the one who applies or transposes the decision into practice or the consequences of the decision);
- in the elaboration and implementation of the decision, the characteristics of the groups or the enterprise, as well as the interests, the training, the motivation and the potential of the affected, in one way or another, of the decision (the management decision has direct influences at the level of the groups, not affecting only the condition, behavior, actions and results of a single individual);
- the decisional decision (management decision always determines direct and / or indirect economic, technical, financial, human and other direct effects, at least at the level of a company's compartment, or even on it, as a whole).

The importance of management decisions derives precisely from the effects they can generate. Obviously, in an enterprise, the entire managed system translates in reality the orders received from the leading system. If these orders (and the solutions that generated them) are good, the overall result of the business will be good, and if the chosen solutions are mediocre, the results cannot exceed them in quality. However, the importance of management decisions may be greater or less in relation to the nature of the decision, the type of decision, the level of management, the scope, the dimensions of the influenced system, the possible implications for the enterprise, etc.

In management practice, the management decision takes either the form of decision-making or the form of the decision-making process. Decision-making occurs in decision-making situations of reduced complexity or repetitiveness, when the variables involved are well known by the decision-maker, and there is no need for information gathering and analysis. Decision-making (which predominates in enterprise) is consumed in a very short period of time (seconds or minutes), based on the experience and intuition of managers. The decision-making process is specific to relatively complex decision-making situations, involves a relatively large amount of time (days, weeks or even more), involves collecting and analyzing a certain amount of information, and usually consulting more people before making a decision.

2. TYPOLOGY OF DECISIONS

Management literature presents a large number of criteria against which decisions can be classified. With all this diversity and despite the fact that each recognized author has his / her own view on the importance of decision classification criteria, in each paper, the first criteria taken into consideration are those related to the elements of a decisional matter, namely: the decision maker, alternatives or alternatives available to the decision maker, decision criteria, decision-making restrictions, nature states, and time. From this approach, we have adopted the following fundamental criteria for classifying decisions [9]:

- decider (the person or group of people who choose from the set of possible alternatives the one considered the best), in relation to which we distinguish individual decisions and collective decisions (group);
- the number of alternatives or alternatives that the decision-maker has at his disposal, in relation to which we distinguish decisions with two alternatives (yes or no, be or not to be, do or not do), decisions with a finite number of alternatives (where there will be a choice between several solutions available) and decisions with an infinite number of alternatives (where the best solution will have to be chosen without knowing all the possible ones);
- the number of decision criteria ("instruments" with which alternatives are compared), in relation to which we distinguish between one-dimensional or one-dimensional decisions (where the choice of the best alternative is based on a single criterion) and multi-dimensional or multidimensional on multiple criteria);
- the rules of choice (existence or lack of rules of choice between variants), in relation to which we distinguish planned decisions (which presuppose the existence of very precise rules of choice of selection procedures), unscheduled decisions (which assume that the decision-maker has to establish rules of choice, in which case two different decision-makers can make different decisions without saying that one of them has been wrong) and semi-programmed decisions (which presuppose the existence of certain rules, but without excluding the lack of personal decision of the decision-maker);
- the nature states (expressed by the totality of objective factors that can alter the outcome of the decision independent of the decision-maker), in relation to which we differentiate decisions in certainty (the consequences of which are fully known), risk decisions (the probabilities of the consequences are known) and decisions under non-determination (probability of consequences are unknown);

- the time horizon to which the decision refers, in relation to which we distinguish between short-term decisions (under 1 year), medium-term decisions (3-5 years) and long-term decisions (over 5 years);

- the influence of time on the decision-making problem, in relation to which we distinguish static or time-based decisions (a single choice at a certain moment of the management process) and dynamic or sequential decisions (which consist of a succession of decisions, from the other and to be analyzed in the form of a decision-making assembly);

- the decision-making process (which assumes that in managerial practice the analysis and logic are intertwined with the intuition, experience, talent, flair, temperament and personality of the decision-maker), in relation to which we distinguish intuitive decisions (based on the philosophy that decision-making is an art and not a science) and analytical decisions (based on the theory that the solution to a decision-making problem can only be achieved through a rational selection and / or choice process).

The above issues do not exhaust the issue of classifying decisions. By combining the criteria itself, there are an appreciable number of types of decisions, such as:

- individual, uni-central decisions with finite number of alternatives;
- collective, multi-criteria, with finite number of alternatives, at risk;
- collective decisions, with infinite number of alternatives, unscheduled, in certainty, etc.

3. DECISIONAL SITUATION

The decisional situation is defined by "all the information necessary for the decision maker to adopt the optimal alternative, which will lead to the achievement of the previously set objectives" [10]. As component elements, "the decisional situation consists of the set of uncontrollable variables, the set of controllable variables and the set of result indicators" [10].

3.1. The number of uncontrollable variables

Adoption of a management decision occurs at a time when the environment presents a certain situation, with certain characteristics and with a certain tendency for evolution, more or less predictable. The set of parameters by which the decisional environment is defined and characterized and which cannot be influenced by the decision-maker is known as the set of uncontrollable variables. The decision-maker can at most know the uncontrollable variables, describe them, quantify them, predict their future evolution, analyze their influence on alternatives and objectives, but cannot change their values.

The category of uncontrollable variables is:

- parameters characterizing the natural environment (climate, relief, geological and mining conditions, all factors influencing investment decisions in the mining sector, which is why these decisions acquire an obvious feature in relation to investment decisions in other branches);

- parameters that characterize the environment of the enterprise (economic, social, technological, competition, political, legislative);

- the previous decisions adopted at higher levels of management and which have already begun to be translated into reality.

The totality of the values that uncontrollable variables have at a given moment define a situation of objective conditions or a state of nature.

3.2. The plurality of controllable variables

The totality of the values that characterize alternatives or variants of a decisional problem is the set of controllable variables. From the point of view of the decision maker, the controllable variables constitute the set of parameters that can be adopted and modified at will, within certain limits, as far as they are known and in accordance with the states of nature. In fact, by combining in certain ways the values of the controllable variables, the alternatives or the variants of a decisional problem are defined. Identifying alternatives, assessing their consistency with the state of the environment, and quantifying the effects of their implementation is a process that, for some decision-making issues (such as most decision-making issues regarding the use of mineral deposits) ample and complex.

3.3. The plurality of result indicators

Result indicators express quantitatively and qualitatively the consequences that can be achieved when implementing the decision, representing functional dependencies on both the uncontrollable variables and the controllable variables. Result indicators are therefore dependent variables, which characterize both the extent to which the objectives are achieved and other consequences of the application of the decision.

In mining management decisions, the most common output indicators are: production volume, production quality, opening and / or preparation mining volume, unit costs, capital expenses, operating and maintenance costs, profit (loss) .

A decision problem may have one or more objectives, and the consequences of the decision can be expressed by a greater or lesser number of outcome indicators. Both the system of objectives and the result indicators are characterized by the existence of certain contradictions materialized in the fact that an alternative better meets certain objectives and less well others. Because of this, a decision-making problem arises in order to achieve a compromise between the positive and the negative consequences, between the efforts and the results.

"The set of consequences that are taken into account simultaneously and correlated when the decision-maker analyzes and compares the different alternatives with each other in order to adopt the optimal variant is the decision criterion" [10].

Formalized, the decision criterion expresses the structure of the set of output indicators taken into account when comparing alternatives.

The complexity of many decision-making situations in mining businesses requires the use of several decision criteria. Among these, as will be shown in a future paragraph, a privileged position is spent on expenses and / or costs.

4. DECISION-MAKING PROCESS

The decision-making process is the set of rational actions that the decision-maker carries out from the time of the decision-making process, to the implementation of the chosen solution and the assessment of the extent to which it has led to the achievement of the enterprise's objectives. The attempts to stage the decision-making process have resulted in different systematizations, both in terms of number of stages and their designation. However, common elements are not lacking because, in essence, the process of decision-making is suggested by the management process itself, with its functions (from forecast to control).

In the most well-known concepts, the stages of the decision-making process are the following [10]:

- recognition and analysis of the problem, identification of the applicable solutions, collecting and analyzing the information, choosing the optimal solution, implementing the decision;
- establishing a diagnosis, identifying alternative solutions, analyzing and comparing alternatives, choosing the plan to follow;
- incertitude, definition and analysis of the problem, development of alternatives, verification;
- recognition of the problem, preliminary observations and analysis, development of applicable solutions, testing and analysis of proposed solutions, development of the right solution, testing of the chosen solution, achieving a smart compromise, implementation of the plan;
- awareness of the problem of decision making, diagnosis, recognition of critical issues and problem definition, identification and analysis of available alternatives, assessment of the likely consequences of available alternatives, choice of the best alternative, acceptance of the alternative by the organization;
- identifying the problem, gathering information, developing alternatives, evaluating alternatives, choosing an alternative, implementing the decision, controlling and evaluating the results of the decision.

5. MAINTENANCE MANAGEMENT

In order to formalize the decision-making process specific to the maintenance of machinery and plant in an enterprise, the objectives of this activity need to be precisely identified. In the most general cases at the enterprise level, the maintenance activity has the following objectives:

- maintenance of the state of operation of all machines and installations;
- avoiding accidental stops and removing the possibility of damage occurring;
-application of a maintenance system that generates a security state by avoiding accidents;
- efficiency of maintenance costs;
- reduction of operating expenses at enterprise level;
- forming and specific training of the staff involved;
- dependence of the specific maintenance and reliability indicators;
- appropriate application of specific management methods and techniques, generating superior decisional outcomes;
- reducing risks of injury to staff.

In order to achieve all these objectives, it is necessary to clearly identify the elements of the maintenance system, represented by:

- the machines and installations in the enterprise's patrimony (their technological characteristics, operating rules, revision, maintenance and repair, technical books, industrial designs, technical and economic indicators of operation);
- spare parts, fuels, lubricants, materials (technical characteristics, wear, necessary stocks);
- technological sheets and maintenance, maintenance and repair programs (necessary operations to be performed, necessary materials, necessary tools and equipment, working conditions, execution deadlines, necessary personnel, testing procedures);
- suppliers of spare parts, materials, equipment, installations, machines (reliability, reliability, quality, prices);
- programming of effects diagnosis;
- personal involved (qualification, expertise, availability);
- absolute and statistical evidence of maintenance activities.

The main tasks of the maintenance subsystem are:

- planning and organizing the maintenance activity of the machines and installations of the enterprise;
- optimization of maintenance at the enterprise level;
- taking maintenance at the enterprise level;
- providing technical assistance in order to solve some special technical problems;
- development of documents specific to maintenance activities;
- providing and updating maintenance-specific maintenance documentation;
- cooperation with other involved departments within the enterprise;
- optimization of the supply process with spare parts, fuels, lubricants, materials;
- organizing the personnel activities specific to the field of maintenance;
- realizing and managing a system for recording, calculating and tracking maintenance-specific technical indicators.

6. CONCLUSIONS

The modern enterprise operates in a dynamic competitive environment. The company's performance is appreciated, in almost all situations, only in financial terms. In order to adapt to the changing external environment, but also in order to make more efficient use of resources, the company needs to develop its own management system, including all its activities. Management activities address the whole system of production factors that the enterprise uses. The technological component of the production system has become more and more important in the context of technical developments that have forced development based on the capital production factor. The management of technology, of the technical capital that the enterprise possesses has become essential for financial performance. In this context, maintenance management has become an essential component of the enterprise management system.

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SOCIAL-ECONOMIC INFLUENCES OF MINING SYNCOPES IN THE JIU VALLEY OVER THE MEMBERS OF THE COMMUNITY

FELICIA ANDRIONI[1]

Abstract: The article illustrates the main social and economic repercussions of the mining decline over the community members in the Jiu Valley, Hunedoara county after the events of December 1989. The research method used is the analysis of the documents of certain specialty studies in the literature from which we extracted relevant conclusive aspects that highlight the fact that the syncopes of mining in the area have negatively influenced the community both economically and socially.

Keywords: *Community, Social, Economic, Mining, Effects, The Jiu Valley, Decline.*

1. INTRODUCTION

Mining is a traditional, historic occupation, attested since 2000 years ago when the Romans came here to extract gold and base metals from the underground mines opened in the Transylvania mountains (13). After the opening of mines in Romania and the consecration of this occupation the mining communities have developed, focused on mining production outlets.

In the last 27 years, Romania has undergone an extensive process of socio-economic transformations generated by the industrial restructuring process, which was based on legislative or operational documents such as the Mining Law no.85 / 2003, The Mining Industry Strategy, approved by the Government Decision HG no.615/2004, The 2008-2020 Mining Industry Strategy, Romania's Mining Strategy for 2017-2035 (12, 13). On the basis of these national regulations, in the context of Romania's alignment to European legislation, along with its integration into the large European family in 2007, the operational closure of most of the mines led to the destructuring of Romania's industrial and economic segment, to the loss of jobs for the active population, to the collapse of living standards of all the members of the mining communities, to the lack of alternative jobs resulting in the increase of the external migration phenomenon, the amplification of population's social problems in the mining communities. Despite the fact that the mining areas benefited, between 1999 and 2015, from various sources of

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financing through the EU non-reimbursable funds or World Bank to support the mining reform, the industrial restructuring in Romania has generated economic and social effects which seriously affected the life quality of the communities from the mining areas.

As a result of becoming a member of the European Union in 2007, Romania agreed and promoted institutional and sectoral reforms in the Accession Agreement. Within these changes, one closely analyzed the role of mining in the Romanian economy and its long-term contribution to the sustainable development process, on the one hand, and on the other hand, one took into consideration the pressures to modernise its industrial sectors, in line with the global and European trends (13). Keeping in mind the importance of the mining industry in the national economy as a whole, it was necessary to carry out analyses and forecasting studies (6) to substantiate and develop viable socio-economic policies on the population level.

2. BRIEF HISTORY OF MINING IN THE JIU VALLEY

A first record of the coal deposit in the Jiu Valley was made in 1782, and the first prospecting works began in the Jiu Valley in 1835 when the large reserves of coal in this area (15) were highlighted. The first works for the start of operations in the Jiu Valley began in 1840, with Petroşani, Vulcan and Petrila areas (11). According to the document *Brief history of mining in the Jiu Valley* (15), in 1859 the second mining enterprise in the Jiu Valley basin was established at Vulcan. In the same year they started the works for the opening of the "Deak" mine, which became the Petrila mine later on. Between 1867 and 1868, in the Petroşani mining field, they began excavating the "eastern" gallery that opened the "Petrosani East" mine in the upper part. Due to the problems created by exploitation and transport, the mine closed in 1937. In 1869, it was the beginning of the opening works at the Lonea mine. After this date, the mining activity intensified and more and more new mines appear on the map of the Jiu Valley. In 1980, the opening of the Aninoasa mine took place, during which a gallery was opened at the "Dâlja" horizon. The opening of these mining operations until 1900 attracted the attention of larger companies from Austria, Germany and Hungary, and after the association of small entrepreneurs, the infrastructure began to develop. The interwar economic crisis closed the Vulcan East and Vulcan West mines in 1931, which are reopened after the Second World War. The interest in the Jiu Valley coal peaked in the 1970s during the Communist era when the coal industry became one of the main components of the national energy system as a result of the global oil crisis and the cessation of Iran's delivery of crude oil to Romania. The mining industry generated an increase in the life quality of the members of the Jiu Valley community; in 1989, and one recorded over 60000 active persons in the Jiu Valley mines. The interest in the Jiu Valley coal began to decline after 1990 and production along with it, the decline of this mining region being manifest after 1996, when massive restructuring began in the Jiu Valley, and the towns built during the communist era began to decline (11). Currently, there are only two mines in the Jiu Valley, the remaining four mines are in the process of closure.

Starting with 1990 and the transition to the market economy, the restructuring of the mining industry was developed in the following directions: The decreasing or ceasing of the production activity; The technological restructuring of production; The organizational and managerial restructuring; The personnel restructuring (5). The economic restructuring of the countries in transition to the market economy is accompanied by major changes on the work market structural, occupational, or regarding the work statute, which display characteristics generated by the economic structure, the economic performance and potential, the degree of training and the possibilities of work force improvement (17, p.237).

3. CHARACTERISTICS OF THE JIU VALLEY COMMUNITY AFFECTED BY THE DECLINE OF MINING

Based on the analysis of specialised studies in the field of the Bell (2009), Dale (2002), Krausz and Stegar (1999), Hirghidus and Andrioni (2017); Radu (2015), Stegar (2007), Warwich and Littlejohn (1992), the authors identified for the mining community three distinctive features thereof: a) shaping a strong occupational identity profile of the mining communities; b) declining economic, financial, family, social and moral resources among the mining community; and c) measures taken to combat the negative effects of the reduction / closure of mining operations. These characteristics are briefly presented below:

a) Shaping a strong occupational identity profile of the mining communities

The social identity of individuals is influenced by work and social practices that have been practiced in communities over several generations. In certain case studies on communities affected by mining restructuring in various countries, Radu points out that the miners' perception of their own status is reflected in the selected development strategies for the restructuring of the local economy (3), perception illustrated by the idea that in former mining operations, one must create jobs compatible with the previous employment of the labour force.

Mining "unites people around a common identity, as there exist the consciousness of an identity dominated by pride and glory" (16, p.25) which is based on the dual experience of the miners of hardness, difficulty, danger, on the one hand, and friendship, solidarity and closeness, on the other hand (21); once this identity is taken away from the members of the community, the latter are thrown into a state of community anomy (2). The lack of identity generates conflicts and riots among the community. This may be one of the explanations of the Jiu Valley's miners' uprisings throughout history (in 1929, 1977 and post-December “Mineriade” / miners’ marches and riots).

The occupational identity among the Jiu Valley mining communities was reflected not long ago in the status of man as family head who provided the family income, the woman being assigned the status of housewife and homemaker in the family's administrative activities and the role of raising and educating children. This situation changed along with the massive restructuring of the mining segment in the area, and in the context of an increasingly limited number of jobs for men, the role of women in the family has become more important, as their status changed, the many women ensure he family income, following the migration to other European countries.

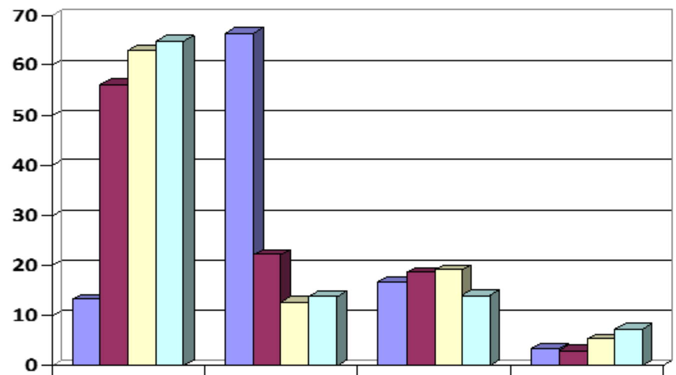
b) Declining economic, financial, family, social and moral resources among the mining community

Given the drastic reduction of the mining segment, implicitly the diminishing of resources and the economic downturn, the mining communities affected by restructuring were named by Johnstone and Lionais exhausted communities. Exhausted communities are defined as areas that have lost part of their economic rationality as space, while maintaining strong attachments and social relationships related to a place (9, p.219)

In the Jiu Valley, like in other mining communities in Romania, the members of the mining community, due to their attachment to the personal and professional space where they lived manifested resistance to the departure trend in the area (16, p.31). Also, within the deindustrialised mining community in the Jiu Valley there is a process of moral degradation in the context of the growing needs and shortages of community members. The absence of job alternatives in the area and implicitly the increase in unemployment generate a higher incidence of alcohol consumption among the community members, an increased incidence of depression on the individual and collective level, an increase in the phenomenon of family violence on the background of the intra-family relationship deficit and alcohol consumption.

In this aspect, the study *Alcohol Consumption Culture in the Jiu Valley Mining Milieu*, realized by Hirghidus and Andrioni in 2017, show how an "alcohol culture" was formed in the mining environment of the Jiu Valley; make up a "portrait" of the alcohol consumer by detailing the deformations on human level, also, and analyse the consequences of alcohol consumption on family and society. The target population was represented by the 843 miners who live and work in the Jiu Valley. Excessive alcohol consumption often leads to violence within the family (as admitted by 69.6% of respondents), but also within society (as 73.5% of respondents declare). A high percentage of the surveyed subjects, 83.5%, know enough cases of families that have broken up because of excessive alcohol consumption. The attitude of accepting alcohol consumption as a normal fact is also reflected in the assertion that "drinking a glass of alcohol a day is not a tragedy." (7, p.9). The perception of miners who responded to the sociological questionnaire (figure 1) is that in working conditions similar to those in which they work, drinking alcohol is the same for 66.5%. The image of "strong people" also emerges from the comparison with other categories of employees, as follows: miners consume more alcoholic beverages than those working in less difficult working conditions (56.2%), than other employees working for the State (62.9%), than the employees working in the private sector (64.8%).

The conclusions of this study confirm the idea that “a certain tradition of alcohol consumption has formed over time in the mining milieu. This tradition only takes into account the so-called beneficial consequences and does not take into account the serious negative consequences (deterioration of health, deterioration of the family environment, danger to children in alcoholic families)” (7, p.11).



	more	the same	less	NO
employees working in similar conditions	13,3	66,5	16,8	3,4
other categories of employees working in easier conditions	56,2	22,1	18,6	3,1
other categories of employees working for the State	62,9	12,7	19,1	5,3
other categories of employees in the private sector	64,8	13,8	14,1	7,3

Fig. 1 – Miners consume alcoholic beverages in comparison with other categories of employees... (%)

Source: Hirghidus, Andrioni, 2017, p.4. (7).

The evolution of the capitalist economy lays its mark on communities by exhausting their resources, also. Thus, the results of the researches highlighted by Stegar (2007) on the level of the unemployed population in Jiu Valley (2001) and on the level of the beneficiaries of minimum guaranteed income (2002, 2004) confirmed that there was a decline in the living standards of the community members generated by the progressive diminishing of the resources, recording a continuous worsening of the quality of life situation of the respondents. Thus, the progressive deterioration in the quality of life can be noted "from 67% in 2001 to 79% in 2002, maintained at 70% in 2004; the opinion that life has improved is insignificant in weight but justifiable for those who have never had a job – and thus they have had any income - the social aid received may be seen as progress compared to the previous situation” (19, p.139).

c) *Measures taken to combat the negative effects of the reduction / closure of mining operations*

The characteristics of the measures adopted to mitigate the negative effects of the closure of mining operations are important to be known in order to better understand the features of the mining community under consideration. The literature presents a variety of measures taken to combat the negative effects of mines closure. On the local level, according to Radu, may be viewed from the perspective of the mining company, of the public institutions and of the community members. These subsystems have different perspectives and interests that may not coincide. Thus, if the public institutions aim at maintaining or expanding the local economic base, the mining company must adapt to the market conditions in order to survive or become stable, so the company will try to restructure, modify labour costs, or obtain other profit sources. On the other hand, individuals are looking for stable economic conditions, and unemployment and job search implicit migration are sources of negative stress (16, p.59).

The development strategy of the mining industry promoted before 1989 was based on the concept of self-subsistence in the provision of mineral resources to the economy in order to reduce imports. (12)**.** The situation created after 1989 imposed the support of the mining sector by the state, which required a great budgetary effort. In the period 1990-2007, the state spent on the national level, for the support of the mining sector, the sum of 6,156.4 million US dollasrs, as shown in table 1:

Table 1 Allocation of state budget funds to support the mining sector (1990-2007)

Specification	**Value (US million dollars equivalent)**
Subsidies	4,125.2
Social transfers	316.9
Capital allotments	1714.3
Total	6156.4

Source: Ministry of Economy, Commerce and Relations with the Business Environment (12)

One can see in the table above those subsidies, social transfers and other capital allocations have been allocated to support the mining sector in Romania and implicitly in the Jiu Valley. In spite of these measures, the sudden fall in the economy of the mining regions affected by the restructuring of the sector could not be diminished, the operating losses registered in the 17 years were in the amount of 1729,4 (12), a sum almost equivalent to the capital allocations used, and the social problems in these regions have increased.

Despite the measures adopted by the government for the period 2008-2020: reviewing the legislative framework in the mining sector with a view to improving it; the subsidies and assigned transfers, the professional reconversion of the population, the non-reimbursable financing measures allocated to mining areas, the effects of these measures on the members of the community were not the expected ones, the reality in this area revealing an increased incidence of social and economic problems of the community.

In the study conducted by Krausz and Stegar carried out in 1998 among a sample of 857 laid off persons registered at the local employment agencies in the towns of Petroşani, Vulcan and Lupeni, study targeting the layoffs of mining personnel in the Jiu Valley, one could remark, in the post-layoff situation in the Jiu Valley, that more than half of the respondents expressed their dissatisfaction with the dismissal caused by the failure to fulfill their plans and the finding that their life is in a serious situation or much worse than before (10, pp.46-53). "In 1998, almost half (45% of the total) benefited from a maximum of 12 compensatory salaries, and the link with the private sector was very weak, only 13% being able to mention it, and most of them occasionally worked for entrepreneurs and only 14 persons (1.6%) incorporated a private firm. The main difficulties mentioned by the respondents in terms of privatisation were: lack of money (34.79%), lack of knowledge (13.22%), lack of courage (13.22%), lack of facilities (10.66%), insecurity of work in a privately owned company (11.40%) "(19, p. 99).

4. SOCIAL AND ECONOMIC IMPLICATIONS OF THE MINING DECLINE OVER THE MEMBERS OF THE COMMUNITY IN THE JIU VALLEY

The Jiu Valley is associated with coal mining. The Jiu Valley located in Hunedoara County includes a series of cities Lonea, Petrila, Petroşani, Aninoasa, Vulcan, Lupeni, Uricani, all of which are mining centres. Jiu Valley is a monoindustrial specifically area. The radical reform in the Romanian economy, mainly in such cost – ineffective sectors as mining, was massively based on personnel reduction. In the Jiu Valley, this started with Ordinance no. 22/1997, whose effect was the laying off of almost half of the employees. In 2006, the number of employees in CNH was approximately 4 times smaller than in 1997. Reductions continued throughout the years, the most recent being the one in 2010, when, on grounds of Special Ordinance no. 116/21.12.2006, modified and completed, approximately 1,600 employees in mining were laid off (17, p.237).

The impacts of these economic measures are currently being felt in full, amplified by the lack of alternatives for ensuring jobs for unemployed. Successive stages of economic restructuring operated in the Hunedoara County and implicitly in the municipality Petrosani lack of alternative investments that have generated a continuous major negative impact among the population. Economic consequences have been reflected on the social, accentuation deficiencies damaging quality of life in the area. These accumulated negative aspects induce an economic and psychological discomfort to the individual, family and community level (1, p.26).

Following other analysis of the perception of the Jiu Valley inhabitants regarding different aspects of family life quality, as a result of an empirical study that is part of an extensive research based on a survey conducted on 500 families in the towns of the Jiu Valley, namely: Petroşani, Petrila, Aninoasa, Vulcan, Lupeni and Uricani achieved by Schmidt in 2012, the subjects under investigation appreciated the Jiu Valley as a problematic area. On the whole, they consider that the most serious problems are the following: poverty, unemployment, corruption, downsizing, criminality and child abandonment (tables 2 and 3).

Table 2. The most serious problems of the Jiu Valley (%)

Problem of the Jiu Valley	**Cumulated choices**
Poverty	74,2
Unemployment	54.4
Corruption	31.6
Downsizing	21,4
Criminality	9,8
Child abandonment	8,2

Source: Schmidt, 2012, p.265 (18)

The subjects identify the poverty specific to the whole area as the most serious in the hierarchy of family problems. The financial problems, job instability and unemployment are the permanent problems of the inhabitants of the area. Other questions revealed that most of the population considered that life before 1989 was good to very good. For almost half of the population, material conditions between 1990-1997 was appreciated as good to very good, with a significant decline after 1997 and deep dissatisfaction nowadays.

Table 3. The main problems of the family in Jiu Valley (%)

The main problems faced by the families in the Jiu Valley*	**Cumulated choices***
Financial problems	87,4
Job instability	67,8
Unemployment	50
Lack of dwellings	37,2
Medical problems	36,4
Lack of leasure time	20,2

Source: Schmidt, 2012 (18) * Differences up to 100% (in small proportions) represent the „other/others" choice.

The author concluded in this study that the Jiu Valley inhabitants desperate and discouraged by their present situation, may still have the power to hope that the Jiu Valley will offer new jobs and improve the existing ones in the future, so that unemployment will no longer represent the stigma we are all bearing at this moment, but this hope is automatically shadowed by the justified fear the low living standard, the poverty specific to the region and the continuous growth of prices, (including household expenses) will lead to a worsening of the situation, with possible medical effects. If today these people ignore, or play down the importance of medical problems, they will end up by being painfully aware of it (18, p.268).

One of the most pressing issues highlighted in various studies is poverty. Poverty implies a low income level of the Jiu Valley population leading to a limitation of access to education, health and the lack of certain facilities.

As a result of the current economic situation, the lack of job alternatives, the registered unemployment rate, and the undeclared unemployment in the Jiu Valley, many members of the community do not have the necessary resources to meet the fundamental needs. The poverty is the lack of resources needed to meet the subsistence needs or the inability to meet those needs considered to be minimal for an individual, this poverty being considered absolute if individuals in a community cannot afford the minimum subsistence level. Definitely from the perspective of social functioning, poverty can be defined in terms of the minimum conditions that are necessary for a normal functioning of the individual within the community of the Jiu Valley. Not only simple individual survival, but the existence of those means that provide the person with complete participation in social life, the fulfilment of the roles that he or she has, participation in the minimal formative activities that give an individual enough chances to develop through his or her own effort, all represent some important traits of this perspective. A form of poverty is the relative one which, in Townsend's view (1993), refers to the relative level of people's needs and aspirations that depend on the general development degree of a particular society. "Establishing the poverty line is a problem, the poverty line being the level of money incomes under which a person may be considered poor. Each country has its method of establishing the poverty threshold", (20, pp. 33-36).

Relative poverty is expressed by the percentage ratio between the number of poor people with an equivalent available income per adult lower than the threshold set at 60% of the minimum guaranteed income for the population (4, p.67). In the Jiu Valley, the relative poverty rate and the poverty rate by age groups and by gender is illustrated in Tables 4 and 5.

Table 4. Relative poverty rate by age groups in the Jiu Valley

Age groups, years of age	**Total persons**	**Poverty rate: people below the poverty threshold / total persons, %**						**6-year average**
		2010	***2011***	***2012***	***2013***	***2014***	**2015**	
0-17	*23088*	*31,3*	*32,9*	*34,6*	*32,1*	*32,0*	*29,9*	***32,1***
18-64	*83046*	*19,2*	*21,0*	*21,0*	*21,5*	*21,3*	*21,1*	***20,8***
$\geq$ 65	*14600*	*16,7*	*14,1*	*15,4*	*15,0*	*14,7*	*14,3*	***15,0***
Weighted average within the entire population	***120734***	***21,2***	***22,4***	***22,9***	***22,7***	***22,5***	***22,0***	***22,3***

Sources: INS, 2015 (8), Davidoiu, 2017 (4).

Table 5. Relative poverty rate by genders in the Jiu Valley (processing apud *INS*)

Genders	Total persons	Poverty rate: people below the poverty threshold / total persons, %						6-year average
		2010	2011	2012	2013	2014	2015	
Male	*59475*	*21.0*	*22.3*	*22.6*	*22.9*	*22.6*	*21.7*	***22.2***
Female	*61259*	*21.4*	*22.5*	*23.2*	*22.5*	*22.4*	*22.3*	***22.4***
Weighted average	***120734***	***21.2***	***22.4***	***22.9***	***22.7***	***22.5***	***22.0***	***22.3***

Sources: INS, 2015 (8), Davidoiu, 2017 (4).

At present, the population of the cities of the Jiu Valley (Petroşani, Petrila, Vulcan, Lupeni, Uricani, Aninoasa) are hardly surviving the precarious economic situation generated by the decline of the area's mining since 1997.

The problems faced by the Jiu Valley population in recent years are caused by the layoff of miners who cannot find jobs, by the rise in unemployment, by the migration of the active population in search of work and by poverty. During these past years, the situation of the unemployed persons has considerably degraded: the conditions for employment allowance were restricted, the selectivity of the labour market hardened, the opportunities for getting a job were reduced. The individuals who lost their job belong to diverse social layers, and for each there are special rights and obligations, as regards incomes and especially the job search (14, p.235).

According to the National Institute of Statistics (INS), the number of unemployed persons in 2015 in the Jiu Valley is presented in table no.6

Table 6. Number of unemployed persons in the Jiu Valley

Locality	Number of unemployed persons	Total population	Percentage in the total population, %
Petroşani	*1513*	*37160*	*4.07*
Lupeni	*843*	*23390*	*3.60*
Vulcan	*946*	*24160*	*3.91*
Petrila	*905*	*22692*	*3.98*
Aninoasa	*116*	*4360*	*2.66*
Uricani	*230*	*8972*	*2.56*
Total	***4553***	***120734***	***3.77***

Sources: INS, 2015 (8), Davidoiu, 2017 (4).

5. CONCLUSIONS

The existence of coal resources in the area has laid its mark on the socio-economic development of the Jiu Valley, turning it into a mining-specific mono-industrial area. The restructuring of the mining sector has significantly influenced the social and economic development of the area, its social and economic impact being considerable both on the level of the local community and on the level of the related economic activities in the area.

The main effects of mining sector syncopes over time have been felt both in the mining area and in the area of societies that have economic ties with it, especially by increasing the unemployment rate and, as a result, lowering the standard of living of the area's inhabitants. The social effects have become more and more serious over time, all the more so as the measures to combat the negative effects of mining closures are poor and deficient.

The most important social implications on the community members in Jiu Valley, in the last years, following the closure of state institutions are: lack of employment alternatives, poverty, the number of families with many children who have a minimum source of subsistence, alcoolism, domestic violence, migration phenomenom.

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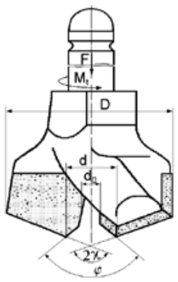

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