

METHODS OF DETERMINATION OF A POINT WHERE A GALLERY BREAKS THROUGH A DEPOSIT

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Abstract: The problems of underground mining are based on the realization of a stable and precise underground topographic base made under optimum conditions, fulfilling the required conditions can be solved using the vector methods presented in Chapter 6, solving based on analytical, trigonometric and graphical processes. The introduction of an information system for solving the problems of mine penetration in the conditions of using a spatial reference system in optimal conditions of realization of the underground topographic networks of support represents an important contribution in the selection, programming and determination of elements of breaking of mining works performed in optimal conditions , efficient, accurate and economical.

Keywords: gallery, mining topography, mining works, deposit, determination

1. Introduction

The most important part of the mining topography, in the mining operations, consists of mining strikes works. The paper contains the topographic calculation of a mining work to determine the point where a gallery breaks through a deposit.

These works must meet certain conditions related to local conditions, deposits and surrounding rocks (geometric, tectonic, etc.) as well as technical conditions of production processes (technical and technological), extraction works. These issues included references to the spatial location of the deposits and the mutual correlation between them.

In these problems, some assimilations of principle are made as follows:

- The galleries will be reduced to their axes, so they will be assimilated to some vectors similar to the vectors in plan and space or curves;
- Layers and pylons will be assimilated to the mathematical planes in space, so they will be determined by the usual mathematical elements - points, straight and vectors.

2. Materials and Methods

One of the methods appropriate to the representation of mining works and geological formations is the vector method. The vector is the geometric element of representation characterized by direction, sense, origin and size.

In the vector representation method, the mines and deposits are approximated by some vectors because their geometrical elements are direction, inclination, and magnitude.

Mining strikes occupy a particular importance in topographic activity. Mining works that are carried out through mining penetrations must always meet conditions imposed by

geological factors and miners, solving them by different ways (analytical, trigonometric, graphical, geometric).

These types of problems are useful in designing horizontal, sloping, vertical, and minimal mining.

These issues are grouped so that solving is unique, such as:

- the intersection of mining works with strata;
- intersections of strata;
- intersections between mining works,
- problems that are reduced to straight and plane intersections in space.

The elements of definition that characterize mining are:

- a point $P_1 (x_1, y_1, z_1)$ on the axis of a gallery;
- θ_1 axis orientation and
- φ_1 axis declination

So, the defining elements of a straight line: $D_1 [P_1 (x_1, y_1, z_1), \theta_1, \varphi_1]$.

The equation of a straight line passing through a point of direction and inclination is shaped:

$$(D_1) \frac{x - x_1}{\alpha_1} = \frac{y - y_1}{\beta_1} = \frac{z - z_1}{\gamma_1} = \lambda \quad (1)$$

where:

- $\alpha_1, \beta_1, \gamma_1$ - are the right-wing directors of the straight line:
- $\alpha_1 = \pm \cos \varphi_1 \cos \theta_1$;
- $\beta_1 = \pm \cos \varphi_1 \sin \theta_1$
- $\gamma_1 = \pm \sin \varphi_1$
- λ = parameter

The unitary vector $\overline{\rho}_1$ of D_1 , which characterizes the straight-line direction, has the following form:

$$\overline{\rho}_1 = \alpha_1 \cdot \overline{i} + \beta_1 \cdot \overline{j} + \gamma_1 \cdot \overline{k} \quad (2)$$

where $\overline{i}, \overline{j}, \overline{k}$ - are vector vertices of the vector $\overline{\rho}_1$ correspondent to the axis x, y, z.

Considering other straight line D_2 the angle ω between the two straight lines is given by the following relation:

$$\cos \omega = \alpha_1 \alpha_2 + \beta_1 \beta_2 + \gamma_1 \gamma_2 \quad (3)$$

or

$$\cos \omega = \cos \varphi_1 \cos \varphi_2 \cos (\theta_2 - \theta_1) + \sin \varphi_1 \sin \varphi_2 \quad (4)$$

A plan (Q) is individualized by a point $P_0 (x_0, y_0, z_0)$, the orientation θ_P , which is the orientation direction of a horizontal plane and the slope of the plane, which is the angle of inclination of the highest slope, so the plan (Q) is given by: $[P_0(x_0, y_0, z_0), \theta_P, v]$.

The equation of a plane Q containing the point $P_0 (x_0, y_0, z_0)$ and is perpendicular to a given straight line whose cosine directives are α, β and γ equivalent to α_P, β_P and γ_P is given by the relationship:

$$(Q): \alpha_P (x - x_0) + \beta_P (y - y_0) + \gamma_P (z - z_0) \quad (5)$$

In which:

$$\begin{aligned}\alpha_P &= \pm \sin v \sin \theta_P \\ \beta_P &= \pm \sin v \cos \theta_P \\ \gamma_P &= \cos v\end{aligned}$$

These principles underlie the mining topography problem solving.

3. Results and Discussion

Methods of solving the problems of mining topography

The most important mining problems are the penetration problems that arise in the case of mining projects or the expansion of existing ones in all the underground working phases concerning the opening, preparation and exploitation of the deposits with useful mineral substances, by the way of solving, provides graph-analytical documentation that implements the projected elements.

Breaking a deposit with a mining work (Determining the point where a gallery breaks through a deposit)

The axis of the gallery is represented by the right D_0 given by:

- points P_{104} and P_{209} :
- orientation $\theta_{209-104}$, noted with θ_0 :
- declination $\varphi_{209-104}$, noted with φ_0 .

and the deposit is given by the Q plane defined by:

- point $P_1(x_1, y_1, z_1)$:
- orientation θ_P :
- declination v .

It is determined the point $P(x_P, y_P, z_P)$ where the gallery will penetrate the plane of the deposit.

Analytical solving

For the straight line D_0 there are known: $P_{104}(x_{104}, y_{104}, z_{104})$, $P_{209}(x_{209}, y_{209}, z_{209})$. It is calculated θ_0 and φ_0 .

Write the equation of the straight line that passes through P_{104} and has the orientation θ_0 and the declination φ_0 :

$$\frac{X - X_{104}}{\alpha} = \frac{Y - Y_{104}}{\beta} = \frac{Z - Z_{104}}{\gamma} \quad (6)$$

$$\alpha = \cos \varphi_0 \cos \theta_0$$

$$\text{where : } \beta = \cos \varphi_0 \sin \theta_0$$

$$\gamma = \sin \varphi_0$$

The equation of the straight line can be written in the parametric form:

$$\begin{aligned} X &= X_{104} + \lambda\alpha \\ Y &= Y_{104} + \lambda\beta \\ Z &= Z_{104} + \lambda\gamma \end{aligned} \quad (7)$$

The parametric equation of the plan has the following form:

$$\alpha_p(X - X_{P_1}) + \beta_p(Y - Y_{P_1}) + \gamma_p(Z - Z_{P_1}) = 0 \quad (8)$$

where: $\begin{cases} X_p = X_{104} + \lambda\alpha_{104} \\ Y_p = Y_{104} + \lambda\beta_{104} \\ Z_p = Z_{104} + \lambda\gamma_{104} \end{cases}$

where: $\lambda = \frac{\alpha_p(X_{P_1} - X_{104}) + \beta_p(Y_{P_1} - Y_{104}) + \gamma_p(Z_{P_1} - Z_{104})}{\alpha\alpha_p + \beta\beta_p + \gamma\gamma_p}$

By replacing λ into the parametric equation of the straight line, there are obtained the coordinates of the point P(x_p, y_p, z_p) where the gallery squeezes the plane of the deposit.

Trigonometric solving

The points P_{104} and P_1 are into the same horizontal plan. The following relations give the straight-line orientation θ_{104-P} and its length:

$$\begin{aligned} \tg \theta_{104-P} &= \frac{\Delta y_{104-P}}{\Delta x_{104-P}} \Rightarrow \theta_{104-P} = \arctg \frac{\Delta y_{104-P}}{\Delta x_{104-P}} \\ \tg(\theta_{104-P} + 50^{\circ}) &= \frac{\Delta x + \Delta y}{\Delta x - \Delta y} \end{aligned} \quad (9)$$

If the tangent value is greater than 2, the relationship is used:

$$\ctg(\theta_{104-P} + 50^{\circ}) = \frac{\Delta x - \Delta y}{\Delta x + \Delta y} a = \frac{\Delta x_{104-P}}{\cos \theta_{104-P}} = \frac{\Delta y_{104-P}}{\sin \theta_{104-P}} \quad (10)$$

As we know: the orientation of the straight θ_0 , the orientation of the plane θ_p and the orientation of the straight θ_{104-P} can calculate the angles:

$$\begin{aligned} \alpha &= \theta_0 - \theta_{P-104} \\ \beta &= \theta_p - \theta_0 \\ \gamma &= \theta_{104-P} - \theta_p \end{aligned}$$

For validation: $\alpha + \beta + \gamma = 200^{\circ}$

The distance $S_{104,P}$ is calculated with the following relation:

$$S = S_{104-P} = \frac{a \sin \beta t g v}{t g \varphi_{104-209} + \sin \alpha t g v} \quad (11)$$

Using the distance we calculate the coordinates of the point P:

$$\begin{cases} x_P = x_{104} + S \cos \theta_{104-209} \\ y_P = y_{104} + S \sin \theta_{104-209} \\ z_P = z_{104} + Stg \theta_0 \end{cases} \quad (12)$$

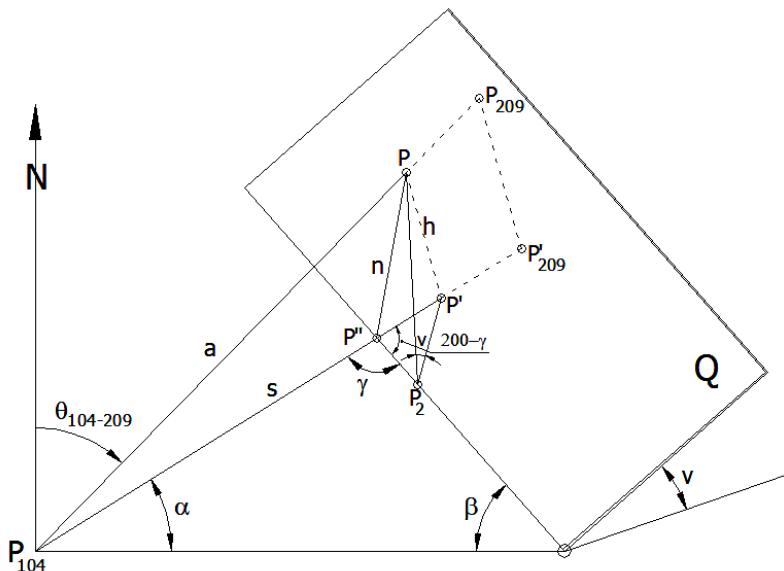


Fig. 1. Spatial representation

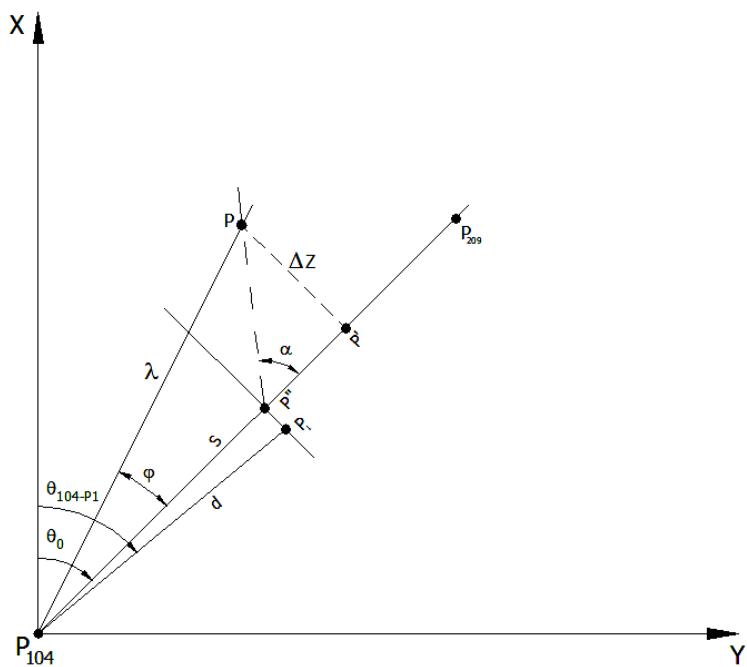


Fig. 2. Graphical solving

The following is the algorithm in the pseudo-code that underlies the program in Microsoft Excel that solves the problem presented above.

```

 $D_5 \leftarrow 28672$ 
 $D_6 \leftarrow 75083$ 
 $D_7 \leftarrow 449,5$ 
 $D_9 \leftarrow 110$ 
 $D_{11} \leftarrow 15$ 
 $D_{15} \leftarrow 28610$ 
 $D_{16} \leftarrow 75125$ 
 $D_{17} \leftarrow 450$ 
 $D_{19} \leftarrow 15,25$ 
 $D_{21} \leftarrow -10$ 

 $M_4 \leftarrow \cos\left(\pi * \frac{D_{19}}{200}\right) * \cos\left(\pi * \frac{D_{21}}{200}\right)$ 
 $N_4 \leftarrow \sin\left(\pi * \frac{D_{19}}{200}\right) * \cos\left(\pi * \frac{D_{21}}{200}\right)$ 
 $Q_4 \leftarrow \sin\left(\pi * \frac{D_{21}}{200}\right)$ 
 $M_7 \leftarrow \sin\left(\pi * \frac{D_9}{200}\right) * \sin\left(\pi * \frac{D_{11}}{200}\right)$ 
 $N_7 \leftarrow -\cos\left(\pi * \frac{D_9}{200}\right) * \sin\left(\pi * \frac{D_{11}}{200}\right)$ 
 $Q_7 \leftarrow -\cos\left(\pi * \frac{D_{11}}{200}\right)$ 

 $N_9 \leftarrow \frac{M_7 * (D_5 - D_{15}) + N_7 * (D_6 - D_{16}) + O_7 * (D_7 - D_{17})}{M_4 * M_7 + N_4 * N_7 + O_4 * O_7}$ 
 $N_{11} \leftarrow D_{15} + N_9 * M_4$ 
 $N_{12} \leftarrow D_{16} + N_9 * N_4$ 
 $N_{13} \leftarrow D_{17} + N_9 * O_4$ 

% point of punching
 $D_{24} \leftarrow N_{11} ; \% x$ 

```

	A	B	C	D	E
1					
2					
3	Elementele caracteristice ale stratului				
4	Punctul P_o				
5		X _o		28672	
6		Y _o		75083	
7		Z _o		449,5	
8	Orientarea directiei stratului				
9		Q _P		110	
10	Inclinarea stratului				
11		V		15	
12					
13	Elementele caracteristice ale lucrarii miniere				
14	Punctul P_1				
15		X ₁		28610	
16		Y ₁		75125	
17		Z ₁		450	
18	Orientarea directiei lucrarii				
19		Q		15,25	
20	Inclinarea lucrarii				
21		f		-10	
22					
23	Punctul de strapungere				
24		X		28643,284	
25		Y		75133,129	
26		Z		444,573	
27					

Fig. 3. Calculation template

4. Conclusions

The programs developed for all the existing situations in the mining activity in the field of penetration are accessible to any user, the program developed in Excel takes over the known elements in the analyzed space, the elements determined by the use of the different types of measurements and the elements characterizing the mining carried out by the penetration under the precision conditions high, efficient and in optimal and increased safety conditions.

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