DETERMINING TRAKING STATIONS FOR THE DRY SALT EXPLOITATION METHOD TIME BEHAVIOUR

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Abstract. After the exploitation of useful minerals, the rocks around the remaining spaces tend to occupy them, due to the pressures that arise. Existing displacements may extend, affecting the terrestrial surface and edifices existing in the recess area. In order to determine the magnitude of these manifestations and evaluate their evolution, it is necessary to establish a network of points (the tracking station) for observations to be made through topographic methods for the determination of the movement elements before the extraction of the useful mineral substance.

Keywords: tracking, topographic methods, tracking stations, subsidence.

INTRODUCTION

In relation to the other mineral deposits, the salt deposits in our country are of great size, which makes the effects of their exploitation manifest on surfaces proportional to the dimensions of the void that forms.

Based on the geomechanical characteristics of the salt, the depth of the exploitation is between 243÷286 m for the Praid deposit and 337÷340 m for the deposit at Tg. Ocna - Trotuş mine, resulting in an average depth of exploitation of 300m (Hirian and Georgescu, 2009).

In order to extract salt through the dry procedure, the method of exploitation used in the salt mines in the country is with small square rooms, consisting in the extraction of salt from the rooms between which the safety pillars are left, also square shaped. The size of a pillar-room assembly is 30 m regardless of the operating depth, but the camera's side is counter proportional to the operating depths - with values of 18m and falling to 12 m deep, while the pillar side is directly proportional to the depth and has values from 12 m and reaches 18 m. The height of the room and the pillars is between 7m and 10m (Hirian and Georgescu, 2009).

In the ceiling of the first operating horizon a safety pillar is left, whose thickness is determined by the nature and way of water circulation on the back of the salt mass, the thickness of which is generally 30 m. The pairs of successive horizons have a thickness of 8÷10m. At the Ocna Dej salt mine, due to the presence of an aquifer layer with a pressure of 20 atmospheres in the bed of the lens shaped reservoir, a safety pillar was provided at the 20m hearth (Atudorei et al., 1971). The small squares exploitation method provides a 30-40% exploitation rate for mines situated at depths of 100-500m.

The arrangement of the chambers and pillars can be seen in Fig. 1. The movement of the rocks and the dimensions of the affected area are influenced by the depth of the salt deposit, its size and shape, and the dimensions of the exploited space, as well as:

- the geomechanical characteristics of the salt deposit and those around it;
- the tilting the salt bed;

- the land relief;
- the deposit's tilting in relation to the topographical surface's tilting;
- the tectonic, geological and hydrological conditions of the salt deposit area;
- a series factors that derive from the geo-mining ones (Ortelecan et al., 1999): the sinking factor „a”, the exploited area size factor „λ”, the depth factor „k”, the time factor „t” and the influence factor „e”.

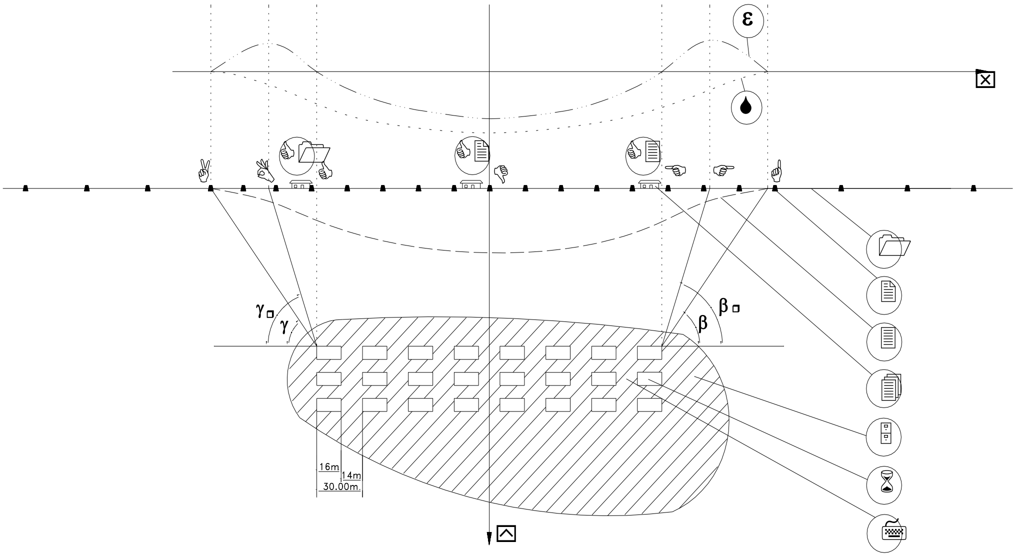

Fig. 1 Dry salt exploitation - the area of influence

Fig. 1 representing the following:

8. terrestrial surface;
9. tracking station landmark;
10. sinking layer;
11. surface showing construction;
12. salt deposit;
13. small square chamber from the exploited area;
14. inter-chambers pillar;

γ – upstream limit angle;
γ_r – upstream breaking angle;
β – downstream limit angle;
β_r – downstream breaking angle;
S – subsidence curve (sinking);
ε – longitudinal deformation curve.

MATERIAL AND METHOD

In order to determine the area of influence of the exploited field on the terrestrial surface and the existing objectives, the tracking station is situated on the surface in the part located above the exploited area. It consists of landmarks arranged on longitudinal and transverse alignments in relation to the exploited area, as well as connecting points represented by points in the support zone of the area. In order to obtain conclusive results, the location of the connecting parts and the alignment points, it should be taken into account that their existence is ensured for the entire period of observation and that the reference and support points located outside the diving bed are located in stable areas so that the observations are not affected by any movements .

Depending on the extent of the exploited area, the affected area as well as the existing relief, the tracking station may be composed of one or more transverse alignments and one or more longitudinal alignments. The arrangement of parallel and perpendicular alignments on the direction of the deposit is made at a distance of up to 50m between two alignments (Ortelecan et al., 1999).

Support bands (end markers of alignments located outside the affected area, 3-4 on each side) will be spaced 40-50m apart.

The speciality literature (Ortelecan et al., 1999) recommends that the location of the support points in relation to the position of the space to be exploited should start where the value of the vertical displacement is null and the following calculation relations are indicated:

- on the deposit direction, upstream of the exploited area

$$D_1 = H_1 \cos\theta \frac{\cos\delta_1}{\sin(\delta_1 - \theta)} \quad (1)$$

- on the deposit direction, downstream of the exploited area

$$D_2 = H_2 \cos\theta \frac{\cos\delta_2}{\sin(\delta_2 + \theta)} \quad (2)$$

- upstream

$$D_3 = H_3 \cos\varphi \frac{\cos\gamma}{\sin(\gamma - \varphi)} \quad (3)$$

- downstream

$$D_4 = H_4 \cos\varphi \frac{\cos\beta}{\sin(\beta + \varphi)} \quad (4)$$

For equations (1) – (4) the following were used :

- D_i – the distance from surface correspondent of the exploited area to the first support point;
- H_i – the limit depth of the exploited area on said direction;
- θ, φ – the tilting angle of the terrain with the direction, respectively leaning of the deposit;
- δ_1 , δ_2 – the limit angle of the deposit direction upstream respectively downstream of the exploited area;
- γ , β – the limit angle upstream, respectively downstream.

The positioning of work marks in the alignments is determined by the depth of exploitation, relief, tectonic disturbance or other disturbing factors. The profile of the diving bed and the characteristic curves is obtained, the more precisely as the number of marks is larger, and the observations are made in high precision conditions. At the same time, it has to be taken into account that too many work marks lead to increased accumulations of errors and, implicitly, lower precision.

Relying on practice-based data, the distance between work marks was determined in relation to the operating depth (Table 1).

Table 1

Crt. No.	Exploiattion depth [m]	Distance between work marks [m]
1	up to 50	5
2	50 ÷ 100	10
3	100 ÷ 200	15
4	200 ÷ 300	20
5	300 ÷ 400	25
6	over 400	30

We use the same tools and the same working methodology in each measurement cycle. With the help of the data obtained, in both the horizontal and the vertical plan, the position of each mark in the tracking station and the connecting links are determined. The configuration of a tracking station is shown in Fig. 2.

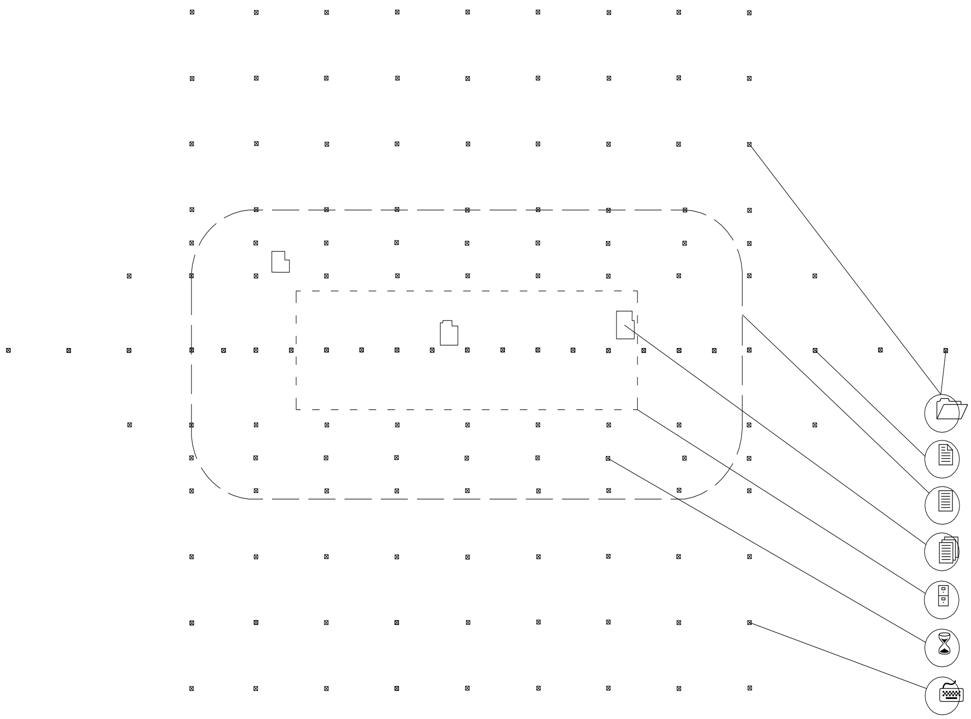

Fig. 2 Traking station

Fig. 2 presents:

1. support marks;
2. longitudinal alignment mark;
3. the limit of the sinking layer;
4. a construction located inside the sinking area;
5. surface projection of the exploited space limit;
6. work marks;
7. transverse alignment mark.

RESULTS AND DISCUSSION

In order to evaluate the stability of the connecting elements, the observations made in each cycle will be processed in a first step considering the network of points as a free network (Ghiţău, 1983) and after determining the stable points, the displacements of the marks in relation to the previous cycle measurements and in relation to the initial (basic) cycle (Arsene, 2014). The values obtained are used to complete the alignment sheet and to draw up the characteristic diagrams. The alignment sheet contains the plan of the alignment marks with the number and position relating to the other alignments and targets, the data on the position of each of the reference marks in the original measurement and the data for the current cycle. The following parameters are calculated by means of :

- Δy_i – the longitudinal displacement, calculated as the difference between the horizontal distance from the ending mark of the alignment and the reference *i* determined in the base cycle and the horizontal distance between the same reference markss determined in the current cycle;
- $\Delta d_{i,i+1}$ – the variation of the length of the interval, calculated as the difference between the longitudinal displacement of the reference *i* and that of the reference *i + 1* in the current cycle;
- $\varepsilon_{i,i+1}$ – the longitudinal deformation represented by the ratio between the variation of the length of the interval between the *i, i + 1* marks in the current cycle and the horizontal distance between the two marks in the initial cycle;
- S_i – subsidence (sinking), established as the difference between the share of the *î* mark in the current cycle and the base cycle;
- $\Delta S_{i,i+1}$ – the difference in sinking, obtained as the difference between the subsidence of the two adjacent marks, in the current cycle;
- $S'_{i,i+1}$ – the slope of the interval, represented by the ratio of the sinking difference between the *i, i + 1* marks in the current cycle and the horizontal distance between the two marks in the initial cycle;
- $\Delta S'_{i,i+1}$ – tilting variation, determined as the difference between the slopes of two successive intervals, in the current cycle;
- v_i – the sinking speed per period, determined as the ratio between the subsidence of the mark *i* and in the current cycle and the number of days (months) from the previous cycle to the current cycle.

Characteristic diagrams as follows:

- subdidence (sinking) diagram *S*;
- longitudinal displacement diagram Δy;
- longitudinal deformation diagram ε;
- tilting of the S' interval diagram;
- variation of the $\Delta S'$ tilting diagram.

The alignment sheet and the characteristic diagrams are drawn for each alignment in each observation cycle. The obtained scores are compared with those in the previous cycle / cycles to see the evolution of the displacement phenomenon.

CONCLUSIONS

Monitoring the effects of mining activity on the surface through tracking stations allows attainment of data by which the parameters of displacement and deformation of the surface are determined and the characteristic curves are obtained, leading to the determination of the limit angles and the place where the subsidence will be at its maximum. All this makes it possible to trace the shape of the diving bed (layer) and determine its dimensions.

From the analysis of the shape of the diving bed and the characteristic diagrams, the conclusions can be drawn:

- in the case of horizontal or low slopes deposits (≤ 10°) and slightly rugged relief, the place where the maximum subsidence is recorded corresponds to the middle of the exploited area ;
- if the deposit is inclined, the maximum subsidence shall be recorded upstream of the middle of the exploited area; it was observed from practical data that the ratio between the horizontal distance between the upstream edge of the diving and the diving site and the one between the downstream edge of the diving bed and the maximum diving site has a value of 0.458 in the case of a tilting slope deposit of 34°, respectively of 0.250 in the case of a deposit with an inclination of 60°;
- the terrestrial surface moves to a point of maximum subsidence, which leads to the occurrence of compressions in the central area of the diving bed and tensions at its limit, the transition zone from compression to tensions being above the edges of the exploited area;
- on the same vertical line there are: the maximum subsidence point, the maximum compression point and the null longitudinal displacement point;
- the maximum tension points, where cracks occur in the field, determine the boundaries of the breaking zone (characterized by the breaking angles β_r, γ_r, δ_r);
- the constructions situated on the edge of the diving bed (the areas between points A - C or E - G, or near them, Fig. 1) will be more affected than those located in the middle of the exploited area, except in the case of a layer crash in the covering one above the exploited area.

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