MONITORING THE MINIER SUBSIDENCE PHENOMENON IN VALEA ARSULUI AREA - VULCAN MINING EXPLOITATION

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***Abstract**: The mining subsurface phenomenon is known as a particularly complex process, in time and space, referring to the displacement and deformation of the terrestrial surface as a result of the underground exploitation of various deposits, leading to a negative impact on the environment in time and more. The topo-geodetic monitoring of the subsidence phenomenon resulting from the exploitation of mining deposits has been, is and will always be a concern of the specialists in the field of engineering sciences, offering reliable results of studies on the establishment of measures for the protection of the civil and industrial objectives, and of human life. This paper presents the results obtained from the study of the topo-geodesic monitoring of the mining subsidence phenomenon for the Vulcan mining perimeter, Hunedoara County, Romania.*

***Keywords:** monitoring, subsistence, diving, topographic measurements.*

1. Introduction

Most of the time, the mining of stratiform deposits leads to the movement and deformation of rocks in the roof, affecting civil and industrial buildings, flora and fauna, and sometimes even human life, with a negative impact on the environment.

The elements that characterize and appreciate from a qualitative and a quantitative point of view the subsidence phenomenon resulted from the exploitation of the mining deposits are constituted by components of the diving bed, which are used in obtaining the maximum submergence, the size used in calculating the parameters necessary for the analysis and the extensive study of this phenomenon.

In order to determine the components of the diving bed, among the most accurate methods one can find the topo-geodetic measurement methods built according to monitoring marks for the movement and deformation of the terrestrial surface.

This paper aims to present the monitoring of the mining subsurface phenomenon in the perimeter of the mining Vulcan, in the Arsului Valley area from the Vulcan locality, Hunedoara County, Romania, and the presentation in a diagram form of the results obtained following the monitoring of three consecutive measurements cycles realized during two months in 2018.

In the picture below (Figure 1) one can observe the tailings dumps existing in the studied area together with the new anthropic lake formed in the area of the electricity network poles, which in turn are affected by the underground coal mining works, these details representing a small part of the negative effect of the subsidence phenomenon as a result of the stratiform exploitation of the studied area.

Fig.1. The negative effects of the subsidence phenomenon as a result of the exploitation of coal deposits - Vulcan Mining - Arsului Valley, Vulcan Town, Hunedoara County, Romania

2. The geographic location of the objective studied

Vulcan mining exploitation is among the few mining coal mines currently in operation in the Jiu Valley mining basin. Located in south-western Romania, at the Southern Carpathians poles, the locality of Vulcan is geographically located at 45° 23' north latitude and 23° 17' east longitude.

The mining perimeter covered by the present paper is located in the administrative territory of Vulcan, Hunedoara County in Romania, more precisely north of the city of Vulcan, at the end of the street bearing the name of the place, namely the Arsului Valley. In the image below (Figure 2), an area zoning is displayed, where the location of the area studied can be observed.

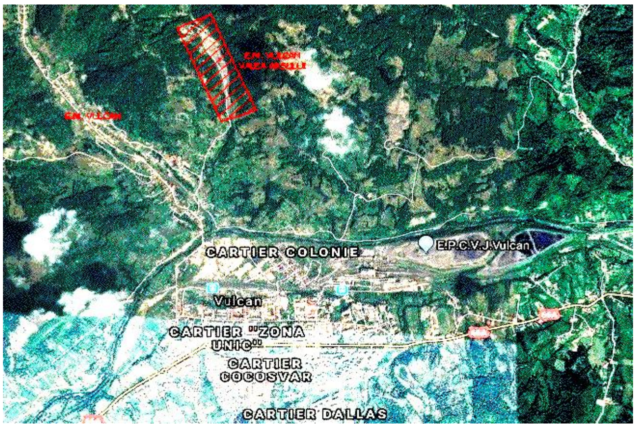

Fig. 2. Area plan of the area studied - Arsului Valley within the mining area Vulcan, Vulcan, Hunedoara County, Romania

3. Topo-geodetic methods and means used

The first studies and researches on the monitoring of the subsidence phenomenon as a result of the exploitation of stratiform deposits within the perimeter of the Arsului Valley - E.M. Vulcan were made in the beginning of 1981, due to the apparition of a water crater accumulated as a result of the mining subsidence phenomenon, and since then the area has been studied and researched by different specialists in the domain.

Given that the initial marks used in the monitoring of the mining subsidy were partly destroyed, others disappeared; the topo-geodetic measurements necessary for the realization of the present case study were made starting with the R5, R6, R7 level markers, materialized at the base of concrete pillars belonging to the electric power network. The monitoring marks in the area of influence were set at the base of the LEA pillars crossing the area of influence.

Once the stable elements were identified in the area, that can be used to monitor the mining subsidence phenomenon (concrete, pillars, etc.), these were marked with paint, as it can be seen in the picture below (Figure 3). On the concrete pillars located in the tracking area four tracking marks were painted, one at the base and the remaining from 50 cm in 50 cm, the last mark being 1.5 m from the base of the pillar. In this way, it was intended for the measurements to be also made if the base landmark pillar is covered by tailings or water.

Fig. 3. Marking of monitoring marks for the subsistence phenomenon

For the determination of the values measured for the plan-metric values, a total station with a 5" precision, using the polar co-ordinate method, was used as instrument, and a NI025 level was used to determine the measured values for the altimetric values using the geometric middle level method, starting from the R19 levelling index, having the elevation Z = 621,135m, embedded in the Chorine extractor machine, thus determining the altimetry of all the points marked in the field, their numbering starting from R0 and closing the alignment of the tracking track on the embedded mark in the R41 construction. In Figure 4 one can see the centralized situation of the values obtained and the calculations made after the measurements.

The values determined after the first topo-geodetic measurement cycle on 06.07.2018 served and will continue to serve as a reference for future measurements to be made.

The monitoring of the subsidence phenomenon in the present case study was performed quarterly on the R5, R6 series, keeping track of the evolution over time on the new alignment of the R7-B1-B2-B3-S10-S-12-S13- S15 (red continuous line). Due to the fact that the mark on the S11 pillar is surrounded by water, it was not possible to carry out specialized measurements on it.

Figure 5 shows an extract from the topographic plan in which the monitoring line of the subsidence phenomenon of the area studied is represented.

E.M. VULCAN

Centralizer diving measurements

Nr. Meas.	Data	Characteristic	POINTS								
			R7	B1	B2	B3	S10	S12	S13	S14	S15
0	06.07.2018	X	433733.84	433800.73	433811.19	433892.57	433924.32	434022.40	434076.65	434129.76	434185.25
		Y	366038.58	366038.53	366035.95	366017.33	366027.64	365996.14	365997.99	365991.85	365980.36
		Z	634.186	633.527	633.629	632.233	631.041	631.568	631.848	632.168	634.091
		$D_{i,i+1}$	43.92	66.90	10.78	83.48	33.39	103.01	54.28	53.46	56.67
1	·11.09.2018	X	433733.836	433800.732	433811.194	433892.566	433924.32	434022.4	434076.649	434129.757	434185.247
		Y	366038.577	366038.534	366035.951	366017.328	366027.636	365996.136	365997.992	365991.849	365980.361
		Z	634.186	633.526	633.627	632.231	630.94	631.511	631.837	632.166	634.09
		dX crt									
		cum									
		dY crt									
		cum									
		dZ crt	0.000	-0.001	-0.002	-0.002	-0.101	-0.057	-0.011	-0.002	-0.001
		cum	0.000	-0.001	-0.002	-0.002	-0.101	-0.057	-0.011	-0.002	-0.001
		Di - i+1									
		dD crt									
		cum									
2	16.11.2018	X	433733.836	433800.732	433811.194	433892.566	433924.32	434022.4	434076.649	434129.757	434185.247
		Y	366038.577	366038.534	366035.951	366017.328	366027.636	365996.136	365997.992	365991.849	365980.361
		Z	634.186	633.523	633.622	632.215	630.854	631.501	631.819	632.165	634.088
		dX crt									
		cum									
		dY crt									
		cum									
		dZ crt	0.000	-0.003	-0.005	-0.016	-0.086	-0.010	-0.018	-0.001	-0.002
		cum	0.000	-0.004	-0.007	-0.018	-0.187	-0.067	-0.029	-0.003	-0.003
		Di - i+2									
		dD crt									
		cum									

Fig. 4. Centralizer of topo-geodetic measurements performed to monitor the subsidence phenomenon

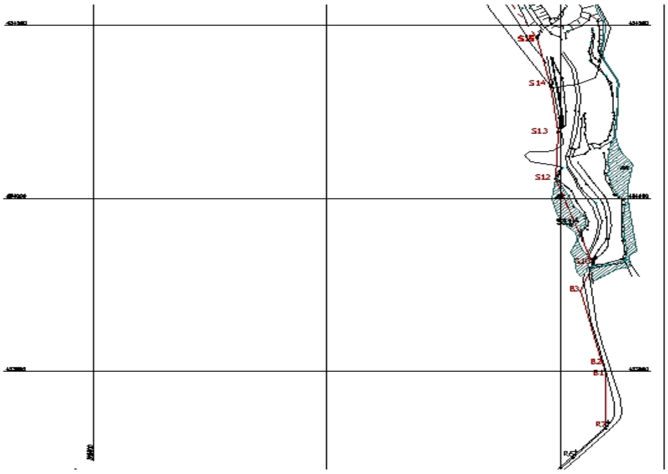

Fig. 5. Extract from the topographic plan made to monitor the mining subsistence phenomenon

4. Results

The results obtained in the present case study, referring to the topo-geodetic measurements carried out over three time periods, are highlighted in the present paper in the form of a diagram shown in Figure 6 below, where the diving values can be observed on the monitored alignment contains the references R7-B1-B2-B3-S10-S12-S13-S14-S15. Noteworthy is that of all of the nine landmarks monitored, the S10 landmark has the highest values for the altimetric dive value, fact which shows that one can predict that the point of maximum sinking of the alignment will be the S10 point.

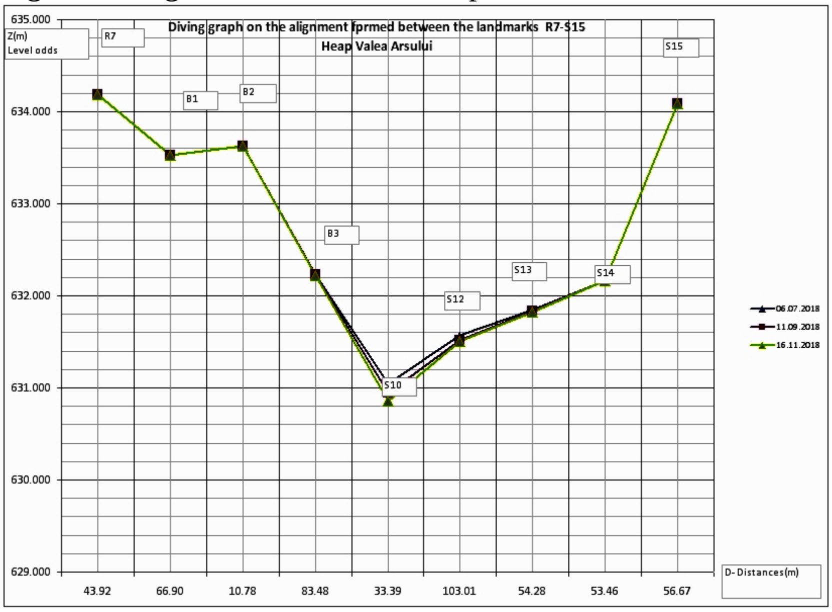

Fig.6. Diving graph on the alignment monitored – Arsului Valley, Vulcan Mining, Vulcan, Hunedoara County, Romania.

5. Conclusions

Starting from the research realized and the results obtained in the various stages of the case study, one can conclude that the subsidence in the central area of the alignment monitored, keeping in mind the terrestrial relief, can be caused not only by the ongoing underground exploitation, but also by the surface geology and / or meteorological conditions over time.

The position of the S10 landmark, located in the centre of the area considered unstable and affected by the subsidence phenomenon at a fairly high rate, can indicate that, over time, the geological structure of the land surface can extend beyond the mining perimeter affected by the subsidence, an explanation would be that the elastic behaviour of some sedimentary rock formations can determine the extension of the mining subsidence phenomenon, including outside the mining galleries.

As previously stated, the centreline of the tracking alignment on the vertical component shows a maximum sinking value of the S10 landmark of 0.187m / 4 months, which results in the conclusion, that during a year the sinking of S10 will be 0.561m / year, thus one can assert that the mining subsidence phenomenon in the studied area is still in the active phase.

At the same time, one considers it extremely important that all the points around the area, considered unstable, show a constant tendency for slow sinking.

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