MEASURING THE PARAMETERS THAT INFLUENCE THE PHENOMENON OF DISPLACEMENT AND DEFORMATION OF THE GROUND AT MINA LIVEZENI

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Abstract: *The phenomenon of displacement and deformation of the surface land, continues to present a wide interest in the implications of environmental problems and protection of existing construction area. The researches in this direction have led to the conclusion that the observations made in the areas affected by underground mining can be done short-term forecasts, medium and long forecasts about the phenomenon analyzed. These forecasts have been particularly important in the sense that future studies can be made for sustainable development of areas affected by underground mining. Throughout the duration of the existence of a mining the topography is an important component. Topo-geodetic methods to study modern methods of tracking the movement of the land surface in the mining areas is a prerequisite for evidence the phenomenon in the future. The paper presents a synthesis of process-time tracking of the sinking land in the process of operating the E.M. Livezeni.*

Key words: *monitoring, surface deformation, subsidence, displacement.*

INTRODUCTION

In Romania, the research of the phenomenon of displacement of the land surface under the influence of groundwater exploitation is largely confined to topographic measurements in tracking stations and interpreting the results. Surveying is carried out using total stations and levels and rarely using GPS technology, and to forecast the main parameters of the bed dipping is applied in either of the following methods.

Studying the phenomena that occur in the process of displacement and deformation of the earth's surface under the influence of underground mines is of particular importance for the delimitation of hazardous areas and for the security of deposits and construction and rely on direct topographical observations.

These phenomena are not studied sufficiently in our country and as such, at the majority of deposits there are not set rules for protection of surface construction and mining, according to various data mining geological conditions.

MATERIAL AND METHODS

Livezeni perimeter mine is located in the eastern part of Petrosani basin and it is comprised of perimeters Petrosani and Petrila South to the north, Sălătruc to the south , Dâlja and Iscroni to the west, Lonea to the east.

Figure 1. Access to the mining area

For an area proposed for tracking movement of the terrain in the Livezeni mining area under the influence of underground exploitation is through a tracking station consisting of 50 landmarks. The total length of this station is 1485.9 m. The arrangement of the milestones was achieved along the road which makes access to tourist areas of the Parang Mountains.

Topographical observations were made once in 3 months since 2001. This tracking station provides data on the movement of the terrain from the operation layer 3 block VI A, panels (3-4), 5 and 6 (Figure 2).

Layer 3, related to these three panels, was operated in tilt slices (about 2.5 m thick) with long complex mechanized fronts (SMA P2H mechanized support, combines 2K52-MY and and armored personnel carrier TR-7) and directing the pressure by total collapse of roof rock.

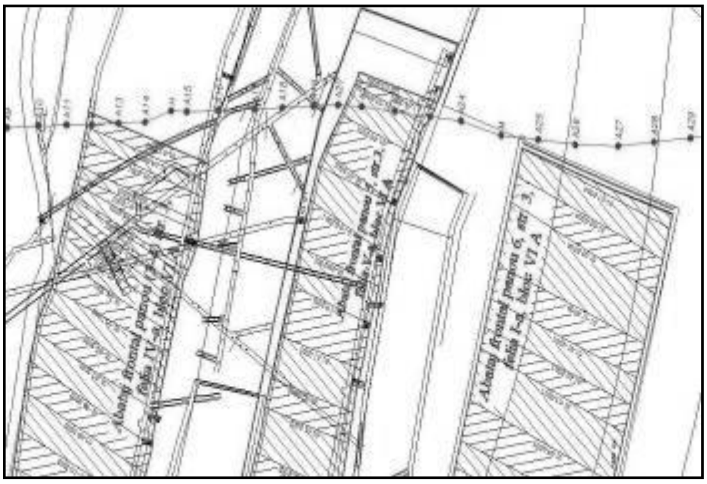

Figure 2. Surface movement tracking station at land mine Livezeni

Maximum sinking measured in this tracking station is 924mm.

The disadvantage of this tracking station is that it is located on the outskirts of the 3 stopes, an area where cross deviations tend to the peak.

In order to eliminate this inconvenience herein, the monitoring of the displacement of the ground surface was carried out by the GNSS technology - RTK method.

To follow the movement of the terrain using GNSS technology - the method RTK – on the general plan of the mine (see Figure 3), where the exploited areas are to be highlighted, the alignments have been designed after which it is wished to conduct the following of the phenomenon of subsidence and the distance between the trace points.

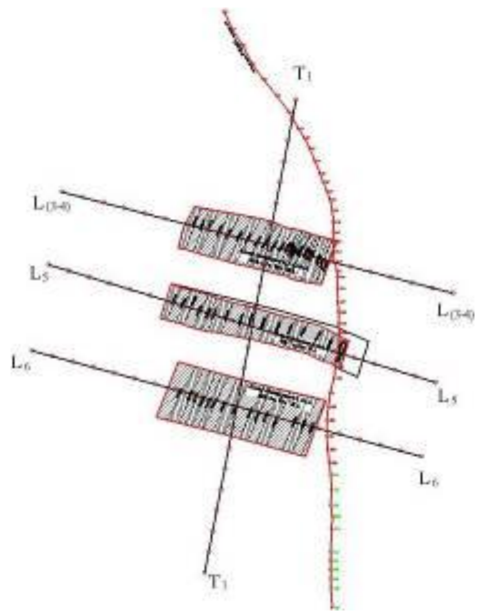

Figure 3. Designing alignments tracking of the movement of the area

Thus, they designed four alignments tracking namely:

- An transverse alignment T1 - T1 consisting of 24 tracking benchmarks, the distance between them is about 50m;

-3 Longitudinal alignment L (3-4) - L (3-4), L5 - L6 and L5 - L6 arranged in the center part of each panel in the advancing direction of the front of the stope. These alignment are formed of 20 marks each, the distance of which is also of about 50m.

The coordinates forming alignments tracking were read and were placed points with corresponding coordinates in the GPS memory (memory card).

By staking program (09 Stakeout) at the base measurement, which was held on **15.09.2010**, the points forming these alignments have been mapped, while measuring their share. Coordinates and share of these benchmarks are summarized in **Table 1.**

RESULTS AND DISCUSSIONS

Table 1

Table of coordinates and tracking elevation benchmarks at the base measurement

Transverse Profile $T_1 - T_1$			
Nr. reper	X	Y	Z
1	375529,114	435417,541	813,216
2	375538,635	435466,726	811,893
3	375548,131	435515,964	795,149
4	375557,638	435565,193	799,481
5	375567,139	435614,422	803,846
6	375576,639	435663,651	795,831
7	375586,140	435712,880	792,691
8	375595,641	435762,109	800,041
9	375605,142	435811,338	812,193
10	375612,736	435850,685	817,361
11	375622,262	435900,048	830,794
12	375631,789	435949,411	828,216
13	375641,315	435998,774	822,361
14	375649,932	436043,421	812,056
15	375659,426	436092,616	806,008
16	375668,920	436141,811	802,093
17	375678,415	436191,007	800,319
18	375687,909	436240,202	787,848
19	375697,403	436289,397	786,493
20	375706,898	436338,592	781,541
21	375716,392	436387,787	777,104
22	375725,886	436436,982	774,613
23	375735,380	436486,178	765,842
24	375744,875	436535,373	760,541

Longitudinal Profile $L_{(3-4)} - L_{(3-4)}$			
Nr. reper	X	Y	Z
25	375193,558	436317,278	816,231
26	375242,043	436304,651	818,913
27	375290,529	436292,024	819,461
28	375339,015	436279,397	818,643
29	375387,501	436266,769	814,241
30	375435,986	436254,142	812,014
31	375484,872	436241,515	814,136
32	375532,958	436228,888	807,164
33	375581,443	436216,261	799,469
34	375629,929	436203,634	797,846
17	375678,415	436191,007	800,319
35	375726,900	436178,379	788,168
36	375775,386	436165,752	787,414
37	375823,872	436153,125	783,141
38	375872,358	436140,498	775,933
39	375920,843	436127,871	779,848
40	375969,329	436115,244	790,010
41	376017,815	436102,616	805,411
42	376066,300	436089,989	808,661
43	376114,786	436077,362	822,812

Longitudinal Profile L5 - L5			
Nr. reper	X	Y	Z
44	375160,302	436144,959	785,711
45	375208,403	436130,341	799,104
46	375256,504	436115,722	800,101
47	375304,606	436101,104	806,210
48	375352,707	436086,485	811,811
49	375400,809	436071,867	817,014
50	375448,910	436057,248	830,010
51	375497,011	436042,630	837,151
52	375545,113	436028,011	830,551
53	375593,214	436013,392	825,414
13	375641,315	435998,774	822,361
54	375689,417	435984,155	815,108
55	375737,518	435969,537	804,016
56	375785,620	435954,918	798,383
57	375833,720	435940,300	791,161
58	375881,822	435925,681	787,403
59	375929,924	435911,063	788,012
60	375978,025	435896,444	797,531
61	376026,126	435881,826	807,136
62	376074,228	435867,207	813,151

Longitudinal Profile L6 - L6			
Nr. reper	X	Y	Z
63	375121,232	435942,517	774,261
64	375169,623	435929,399	774,618
65	375218,014	435916,399	774,618
66	375266,405	435903,163	798,105
67	375314,796	435890,046	795,281
68	375363,187	435876,928	793,826
69	375411,578	435863,809	796,361
70	375459,969	435850,692	799,350
71	375508,360	435837,574	803,150
72	375556,751	435824,456	806,626
9	375605,142	435811,338	812,193
73	375653,533	435798,220	816,355
74	375701,924	435785,102	830,104
75	375750,315	435771,984	819,261
76	375798,706	435758,867	797,840
77	375847,098	435745,749	795,032
78	375895,488	435732,631	805,836
79	375943,879	435719,513	817,461
80	375992,270	435706,395	833,931
81	376040,661	435693,277	841,018

To capture the movement of land , the second measurement was performed after *6 months*, on **19.03.2011**.

Table 2

Table of coordinates and the benchmarks of tracking elevation at the second measurement

Transverse Profile $T_1 – T_1$			
Nr. reper	X	Y	Z
1	375529,184	435417,538	813,210
2	375538,695	435466,713	811,872
3	375548,111	435515,952	795,063
4	375557,678	435565,206	799,339
5	375567,159	435614,413	803,678
6	375576,649	435663,641	795,625
7	375586,12	435712,871	792,449
8	375595,621	435762,115	799,745
9	375605,162	435811,355	811,874
10	375612,776	435850,679	817,044
11	375622,232	435900,063	830,479
12	375631,719	435949,426	827,903
13	375641,355	435998,792	822,052
14	375649,932	436043,433	811,755
15	375659,416	436092,655	805,709
16	375668,96	436141,818	801,815
17	375678,45	436191,004	800,053
18	375687,913	436240,214	787,6
19	375697,424	436289,384	786,277
20	375706,839	436338,588	781,344
21	375716,356	436387,781	776,953
22	375725,871	436436,996	774,511
23	375735,355	436486,162	765,768
24	375744,849	436535,352	760,527

Longitudinal Profile $L_{(3-4)}$ - $L_{(3-4)}$			
Nr. reper	X	Y	Z
25	375193,546	436317,269	816,214
26	375242,031	436304,635	818,868
27	375290,515	436292,001	819,369
28	375339,008	436279,369	818,511
29	375387,511	436266,778	814,088
30	375435,968	436254,155	811,827
31	375484,847	436241,503	813,937
32	375532,934	436228,890	806,930
33	375581,429	436216,243	799,221
34	375629,914	436203,665	797,589
17	375678,439	436191,016	800,053
35	375726,906	436178,391	787,917
36	375775,399	436165,758	787,192
37	375823,882	436153,160	782,952
38	375872,343	436140,432	775,768
39	375920,826	436127,841	779,723
40	375969,347	436115,256	789,921
41	376017,807	436102,632	805,349
42	376066,311	436089,981	808,626
43	376114,792	436077,349	822,803

Longitudinal Profile L5 - L5			
Nr. reper	X	Y	Z
44	375160,314	436144,938	785,690
45	375208,421	436130,321	799,052
46	375256,508	436115,715	800,017
47	375304,615	436101,101	806,065
48	375352,722	436086,468	811,622
49	375400,801	436071,856	816,809
50	375448,902	436057,242	829,767
51	375497,006	436042,639	836,877
52	375545,121	436028,035	830,266
53	375593,233	436013,382	825,115
13	375641,302	435998,765	822,052
54	375689,411	435984,139	814,822
55	375737,514	435969,526	803,749
56	375785,616	435954,910	798,173
57	375833,711	435940,316	790,983
58	375881,809	435925,692	787,249
59	375929,918	435911,055	787,891
60	375978,036	435896,462	797,428
61	376026,141	435881,831	807,068
62	376074,233	435867,202	813,135

Longitudinal Profile L6 - L6			
Nr. reper	X	Y	Z
63	375121,218	435942,502	774,252
64	375169,632	435929,379	774,601
65	375218,011	435916,391	774,581
66	375266,412	435903,154	798,050
67	375314,785	435890,032	795,192
68	375363,191	435876,917	793,673
69	375411,583	435863,821	796,165
70	375459,990	435850,677	799,119
71	375508,368	435837,552	802,884
72	375556,735	435824,434	806,324
9	375605,128	435811,326	811,868
73	375653,553	435798,229	816,036
74	375701,945	435785,134	829,807
75	375750,352	435771,940	819,016
76	375798,729	435758,897	797,639
77	375847,090	435745,778	794,864
78	375895,471	435732,654	805,713
79	375943,894	435719,534	817,368
80	375992,279	435706,399	833,886
81	376040,637	435693,264	841,001

Parameters that influence the phenomenon of displacement and formation of the earth's surface were calculated for transverse profile T1 -T1, presented in the following table:

Table 3

Parameters takeover of observations transverse profile T1-T1

SINKING $S_i = H_i^0 - H_i^K$ [mm]	TILTING $I_{i,i+1} = (S_{i+1}-S_i)/D_{i,i+1}$ [mm/m]	CURVERTURE $K_{i,i+2}=(I_{i+1}-I_i)/(D_{i,i+2}/2)$ [mm/m²]	RADIUS $R_i = 1/K_{i,i+2}$ [m²/mm] sau [km]	HORIZONTAL MOVMENT $D_{i,i+1}^x = \Sigma (D_{i,i+1}^K - D_{i,i+1}^0)$ [mm]	SPECIEFES THE HORIZONTAL DEFLECTION $\varepsilon_{i,i+1}=(D_{i,i+1}^K-D_{i,i+1}^0)/D_{i,i+1}^0$ [mm/m]			
S	I	K	R	D*	ε	D^K	D^0	D^0
-6	-	-				[mm]	[mm]	[m]
-21	-0,29941	-		11,718	0,234	50.098,041	50.098,323	50,098
-86	-1,29623	-0,01989	-50,282	25,823	0,281	50.145,335	50.131,230	50,131
-142	-1,11690	0,00358	279,610	-10,129	-0,717	50.138,583	50.174,536	50,175
-168	-0,51857	0,01193	83,797	15,260	0,507	50.137,446	50.112,057	50,112
-206	-0,75792	-0,00477	-209,477	18,136	0,067	50.137,256	50.134,380	50,134
-242	-0,71803	0,00080	1.256,788	22,830	0,094	50.137,446	50.132,751	50,133
-296	-1,07704	-0,00716	-139,654	8,102	-0,294	50.137,446	50.152,174	50,152
-319	-0,45874	0,01233	81,089	-10,293	-0,367	50.137,446	50.166,840	50,156
-317	0,04991	0,01128	88,677	8,493	0,469	40.073,124	40.054,308	40,054
-315	0,03978	-0,00022	-4.460,881	1,085	-0,147	50.273,755	50.281,163	50,281
-313	0,03978	0,00000	-335.273,061,382	8,650	0,150	50.273,945	50.266,380	50,266
-309	0,07956	0,00079	1.263,723	-15,254	-0,475	50.273,755	50.297,858	50,298
-301	0,17594	0,00201	496,745	-1,798	0,296	45.470,950	45.457,495	45,457
-299	0,03992	-0,00285	-351,326	-26,417	-0,491	50.102,735	50.127,363	50,127
-278	0,41914	0,00757	132,128	-4,501	0,438	50.102,735	50.080,820	50,081
-266	0,23950	-0,00359	-278,915	10,766	0,215	50.103,906	50.093,140	50,093
-248	0,35926	0,00239	418,366	1,901	-0,177	50.102,735	50.111,600	50,112
-216	0,63869	0,00558	179,306	23,222	0,426	50.102,735	50.081,414	50,081
-197	0,37922	-0,00518	-193,096	29,482	0,125	50.102,925	50.096,885	50,097
-151	0,91811	0,01076	92,973	27,082	-0,048	50.102,735	50.105,135	50,105
-102	0,97799	0,00120	836,761	3,462	-0,471	50.102,735	50.126,366	50,126
-74	0,55884	-0,00837	-119,535	34,814	0,626	50.103,717	50.072,366	50,072
-14	1,19753	0,01275	78,447	39,912	0,102	50.102,925	50.097,826	50,098

On this basis we have drafted separate graphs for each parameter.

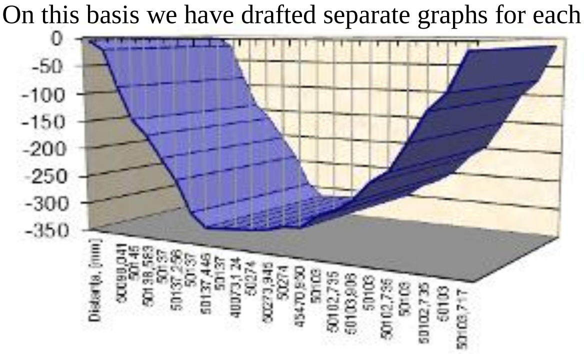

Figure 4. Sinking, [mm]

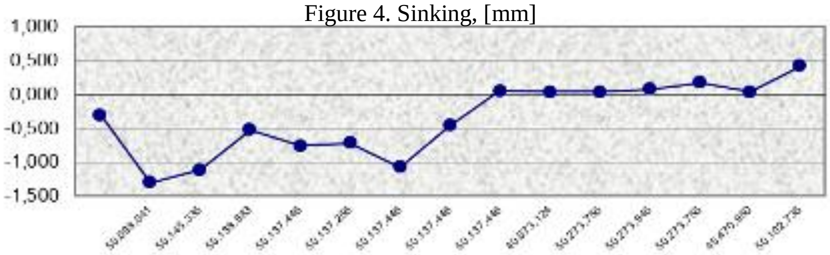

Figure 5. Tilting, [mm/m]

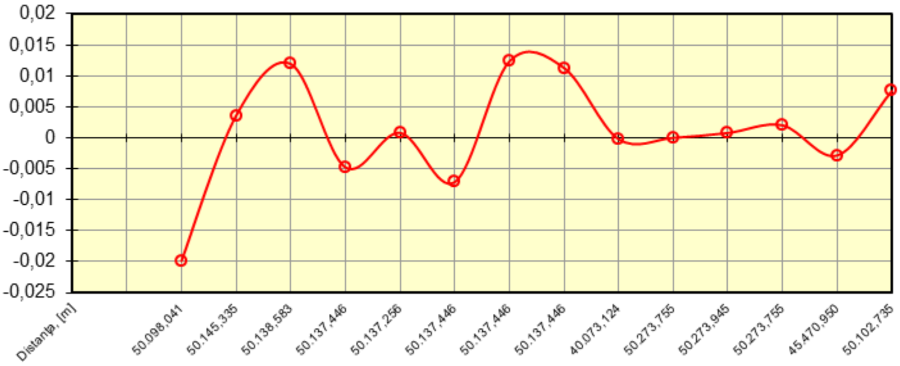

Figure 6. Curverture, [mm/m²]

Figure 7. Radius, [m² / mm]

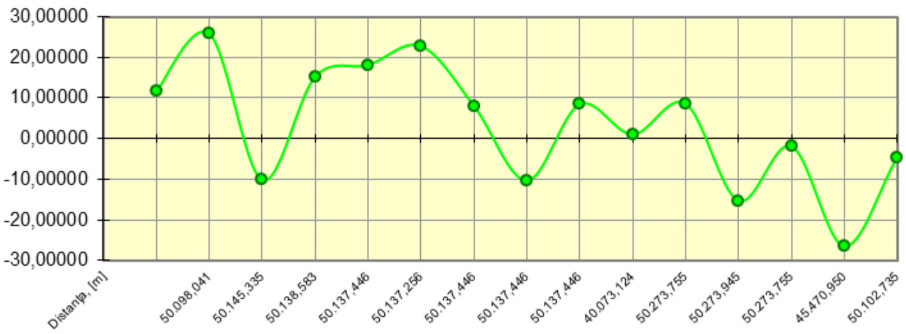

Figure 8. Horizontal movement,[mm]

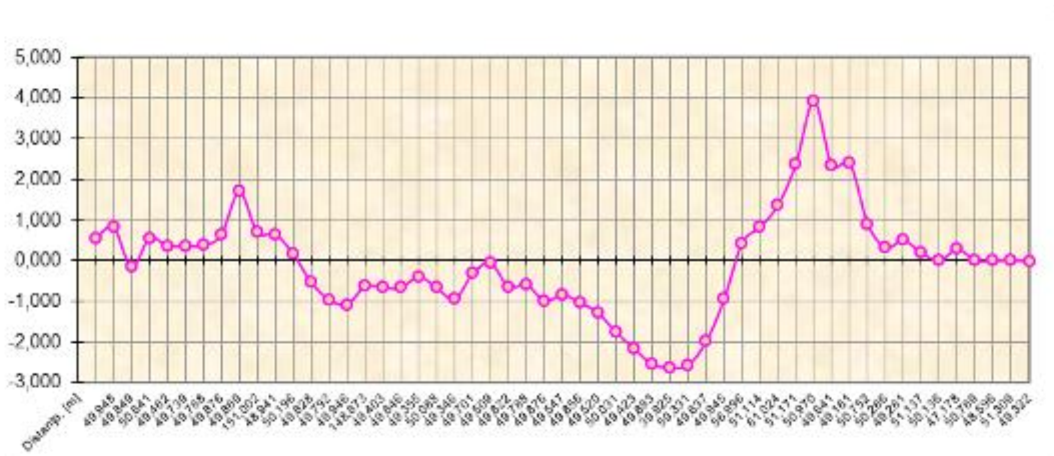

Figure 9. Specifies the horizontal deflection, [mm/m]

The graphics parameters that influence the phenomenon of subsidence

CONCLUSIONS

In this case, the following of the movement and deformation of ground surface at Livezeni mine is achieved through parallel alignment with the direction, respectively the inclination of the exploited layer and as much as possible in center gap resulting from the operation.

In these alignments there were performed two measurements (base measurement and a second measurement carried out after 6 months to capture the movement of the land), using GNSS technology RTK measurement method.

This method of monitoring the phenomenon of subsidence can be easily applied in places where the ground level allows. The method can also be applied using a total station but how to perform the measurements is more complicated.

Although RTK method is easy to apply, it has some disadvantages (cons GPS technology) among which, perhaps the most important are: high purchase price of this technology, slightly lower precision than the classical methods (leveling, etc.).

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