Monitoring of Buituri Slag Dump, Hunedoara County in Relation with Environmental Protection

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Abstract

Detailed analysis of appearance and relief evolution in mining areas cannot be done without mining engineering concepts. Over time, researchers around the world have responsibly been involved in this matter necessary for the development of society, also with obvious implications and repercussions over the quality of life. The purpose of the scientific research detailed in this paper comprises in monitoring the slag dump from Buituri, Hunedoara County using space geodetic technology. Slag dump is the result of steel production activities carried out under the steel factory Arcelor Mittal Hunedoara S.A., formerly known as the steel factory Hunedoara - Siderurgica S.A. Therefore it was decided to conduct monthly topographic measurements to monitor possible dynamic changes that may appear in the context of continuous exploitation of the above mentioned slag dump. Monitoring possible movements is performed by comparing transversal and longitudinal profiles drawn based on zero measurement carried out on 20.05.2011, with the ones obtained after processing of the monthly measurements realized throughout the years 2011, 2012, 2013, 2014, 2015 and 2016. Also, for observing the displacements, comparative charts or tables with records regarding coordinates differences are studied. The issue of measuring and graphic representation of settlements, horizontal linear movements and landslides for structures such as slag or sterile dumps, requires further studies and interdisciplinary research, creating links between specialists in the fields of terrestrial measurements science and geology.

Keywords: *environmental protection, GNSS technology, monitoring, planimetric and altitudinal movements slag dump*

INTRODUCTION

In mining areas cannot study the evolution of the relief without mining in engineering concepts. Therefore researchers have studied this phenomenon have been responsibly involved in this matter necessary for the development of society, also with obvious implications. Mining and minerals processing activities have changed the dynamic of the evolution of spaces that are in relative balance. As a result, geomorphological elements will modify, new superficial formations are created and their physical-chemical processes are accelerated.

In the Deva-Hunedoara metropolitan area, three main types of dumps can be distinguished, classified by the origin and characteristics of the dumper material:

- **41 waste dumps**, resulting from uncovering or digging underground galleries located in close proximity to areas of extraction (Căoi – Vețel village, Valea Baniei – Ghelari village) (Fig. 1 and 2);
- **2 slag dumps**, that of Buituri located in northern part of Hunedoara City, on the right side of Cerna, the north-eastern extremity of the steel platform, namely that of Călan,

Fig. 1. Waste dump deposit from the former copper mine of Căoi (Vețel village)

Fig. 2. Waste dump deposit from Valea Banii (Ghelari village)

Fig. 3. Slag dump deposit from Buituri

Fig. 4. Slag dump of the career center Teliuc III

located in the flank of Perilor Hill, in the south-west industrial platform (Fig. 3 and 4);

- **3 career dumps:**

No.	The economic unit	The name of techno structure	Technical status
1	S.C. Talc-Dolomita S.A. Zlaști	Valea Nădrabului Dump	Active
2	S.C. Talc-Dolomita S.A. Zlaști	Zlaști Career Dump	Active
3	S.C. Talc-Dolomita S.A. Zlaști	Teliuc III Dump	Active

BACKGROUND

Hazards in mining areas can be classified into two main categories:

- hazards triggered by human activity: explosions in the mine galleries (USS in 1947, Romania: Vulcan in 2001, 2006 and 2010 Petrila);
- hazards triggered by natural factors: breakage or slippage of tailings dams caused by earth-

quakes (Chile in 1965, the Philippines in 1996 etc.) and rainfall (United Kingdom in 1966, USA in 1972, Italy in 1985, China in 1988, South Africa in 1994, Indonesia in 2000, Hungary in 2010, Canada in 2014).

The long and intense mining activity in the county of Hunedoara was not without sporadic manifestation of hazards. Faulty location of land-fills, upstream of human settlements and ignoring technical elements of construction by overfilling, above the maximum designed, have led to spills of slurry ponds or breaking over the crest slopes, Fig. 5. (Bălă, 2005; Bălă, 2007).

In general, considering the small values of displacements, to record these displacements is used high precision geometric levelling and the measurement processing is performed by rigorous methods using functional models from conditioned measurements and from indirect measurements. (Sălăgean *et al.*, 2015; Sestras *et al.*, 2015)

Fig. 5. Breaking of the tailings dam of the Certeju de Sus (source: www.adevărul)

The purpose of the scientific research detailed in this paper comprises in monitoring the slag dump from Buituri, Hunedoara County using space geodetic technology. Slag dump is the result of steel production activities carried out under the steel factory Arcelor Mittal Hunedoara S.A., formerly known as the steel factory Hunedoara - Siderurgica S.A.

Therefore it was decided to conduct monthly topographic measurements to monitor possible dynamic changes that may appear in the context of continuous exploitation of the above mentioned slag dump.

In many cases, to ensure the stability of the area, both during the exploitation activity and its cessation, it must be known the direction of action and intensity of deformation processes and the displacement of rocks. (Farcaș *et al.*, 2015)

In processing the geodetic observations, based on the type of measurements made, are used mathematical models appropriate for indirect measurements and conditioned measurements of same precision or of different precision. (Ortelecan *et al.*, 2014; Vele *et al.*, 2014)

As a result of extracting a volume of useful minerals from a deposit, the state of stress and strain from the massif changes the form. This has the effect of destroying the stability of surrounding rocks, so fractured rocks from the excavation contour are set in motion. (Sălăgean *et al.*, 2016)

MATERIALS AND METHODS

The perimeter occupied by the slag dump (Fig. 6) serves as a storage area for over 30 million cubic meters of blast furnace and steelworks slag. Currently, the landfill is exploited for slag, bark of cast iron and other ferrous debris.

Therefore it was decided to conduct monthly topographic measurements to monitor possible dynamic changes that may appear in the context of continuous exploitation of the above mentioned slag dump.

An initial number of eighteen points that are subject to monitoring has been imposed. Because of the fact that most of the geodetic benchmarks have been destroyed, due to meteorological conditions or continuous operations carried out in the slag dump, only six points on the site of the operation of the company SC SLAG PROCESSING SA HUNEDOARA have been monitored. The topographic works started in 2011 (Fig. 7); in 2016 the aim is to determine the displacements of five points staked out by concrete benchmarks.

Topographic measurements were realized using South S82 GNSS Rover (Fig. 8) together with Carlson SurvCE software for the processing stage. In order to accomplish the monitoring of the slag dump, measurements were effected by stationing in each of the five points. Once the GPS was installed on the point whose coordinates are to be determined, the required settings have been

Fig. 6. Slag dump location near the city of Hunedoara

Fig. 7. Sketch of the network points and measurement zero

Fig. 8. South S82-V GNSS Rover

performed and then, the operator had to proceed to the measurement process.

RESULTS AND DISCUSSIONS

Monitoring possible movements is performed by comparing transversal and longitudinal profiles drawn based on zero measurement carried out on 20.05.2011, with the ones obtained after processing of the monthly measurements realized throughout the years 2011, 2012, 2013, 2014, 2015 and 2016. Also, for observing the displacements, comparative charts or tables with records regarding coordinates differences are studied.

The results obtained from processing these measurements can be observed in the graphical tables shown below (tab. 1).

The first step for creating the 3D model is importing the surveyed points and drawing them

into the CAD environment. For instance, when using AutoCAD software, ProfLT and TopoLP can be used to achieve longitudinal profiles and cross sections (Fig. 11 and 12).

Based on the cycles of measurements realized for the studied objective, the following conclusions emerge:

- the maximum horizontal and vertical displacements have been recorded for points 9 and 11 because they were destroyed in 2014 and then replaced;
- maximum height differences have been recorded for points 9 and 11 for the same reason mentioned above;
- by comparing the values of the determined displacements with the attention and alarm values, these values do not fall within the normal tolerances accepted for the phenome-

Tab. 1. Height differences, expressed in millimetres, recorded year on year starting with measurement zero

No. point	Measurement zero 20.05.2011	Measurement 17.09.2012	Measurement 16.09.2013	Measurement 19.09.2014	Measurement 15.09.2015	Measurement 14.01.2016
2	477795.161	0	no longer follows			
8	478149.827	-0.002	0.02	0.039	0.078	0.027
7	478074.348	-0.006	-0.023	0.001	0.029	-0.028
10	477997.117	-0.331	-0.343	-0.317	-0.382	-0.31
9.1	477958.618	-4.949	-4.965	-13.353	-13.29	-13.382
11	477919.455	0.167	0.166	-47.994	12.012	-48.035

Fig. 9. Evolution of the height values of the network points starting with measurement zero

Fig. 10. Evolution of horizontal displacements of network points starting with measurement zero

Fig. 11. Transverse profile obtained for measurements realized in 16.01.2011

Fig. 12. Longitudinal profile obtained for measurements realized in 16.01.2011

non of settlement, leading to the conclusion that the dump represents a danger to the surrounding areas.

CONCLUSION

Movements and changes in the structure of the slag dump have been determined as the result of the monthly study realized upon the benchmarks installed in the perimeter of interest. Due to

modernization of techniques and technologies in the field of engineering geodetic, observations of the movements of a structure are permitted using modern surveying techniques and tools.

An eloquent example is represented by the case of the slag dump from Buituri, Hunedoara County presented in the present scientific research, as geodetic satellite technology application facilitates monthly measurements. Considering that

exploring the area under study is difficult, as the dump is being constantly exploited, the GPS receiver represents the optimal convenient solution.(Bălă, 2006)

The number of points collected in a short interval of time is very high, enabling the correct interpretation of the results.

The issue of measuring and graphic representation of settlements, horizontal linear movements and landslides for structures such as slag or sterile dumps, requires further studies and interdisciplinary research, creating links between specialists in the fields of terrestrial measurements science and geology.

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