INFLUENCE OF THE SEAM THICKNESS AND MINING DEPTH ON THE SURFACE DEFORMATION MODE AS A CONSEQUENCE OF UNDERGROUND MINING

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Abstract *The problem of surface deformation as a result of underground mining has occupied and still occupies an important place in the mining field scientific research. Solving this problem makes it possible to predict the effects of the underground mining on the surface and offers the possibility of taking appropriate measures to protect the civil and industrial objectives located in the area of influence of the extraction. This paper studies the way surface behaves as a result of the underground mining of a horizontal coal seam, under different conditions of mining depth and thickness of the seam. For this study, the analytical methods of prognosis were applied, namely the influence function method.*

Key words: *prognosis, influence function, subsidence, horizontal displacement, underground mining.*

1. Overview

The need to study the subsidence phenomenon has occurred with the development of mining and, in particular, with the transition from a predominantly surface extraction (open-pit) to underground mining [2], [3]. The subsidence phenomenon is still being studied and will be studied in the future as it is a topical issue grounded upon the need to protect surfaces and constructions from surface or underground mining works, communication paths, utility networks, etc. [6], [7], [18], [19], [20].

The magnitude of surface displacements and deformations is directly influenced by the mining depth and the seam thickness [9], [14], [15]. The more extracted seam is at a lower depth, the higher the maximum displacements on the surface, and the constructions located in the area of influence of the underground mining will suffer more significant degradation. Also, the higher the seam thickness the higher the maximum displacements [6], [9].

In order to study how the surface behaves in different conditions of depth and thickness of the extracted seam the influence function method was used [8].

2. Influence function method

The influence function methods (Figurea1) are based on the prognosis of the subsidence trough with the help of the influence area theory around the point of extraction [10], [11]. These methods can be applied to the extracted areas of different forms, but they are more difficult to calibrate and verify than the profile function methods [4], [5], [7].

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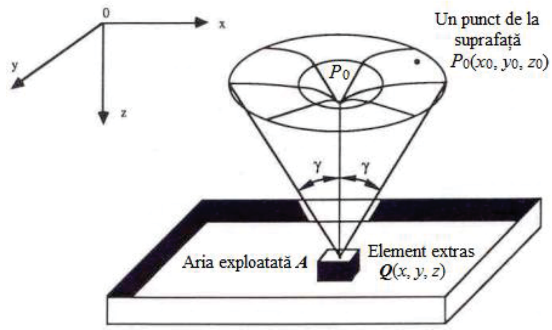

Fig. 1. *The influence of extracting the base element Q*

These are methods used to determine the influence exerted at the surface by the partial elements of the extracted area.

Different forms of influence functions were obtained by several researchers of subsidence events including - Bals 1932 Bayer, 1945; Sann 1949 Knothe 1957 Kochamanski 1957 Ehrhardt and Sauer 1961; Brauner 1973; Zich 1993, etc. [6], [8], [11], [17].

In our case, for the surface deformation prognosis due to underground mining, the influence function method developed by Knothe (also known as Knothe-Budryk method) was applied.

This method is based on the Gaussian distribution of probabilities. According to this method, the math function is [11]:

$$k_z = \frac{1}{R^2}\left[e^{-\left(\frac{\pi x^2}{R^2}\right)}\right] \quad (1)$$

3. Analysis of mining depth influence on the surface

In order to analyze the behavior of the surface at the variation of the mining depth, there has been considered the extraction of a single panel, located on a horizontal coal seam, with a thickness of 10m, under different depth conditions, namely: H = 100 m, 200 m, ..., 900m. The longwall face was supposed to have a length of 100 m and the third dimension of the excavation (panel length) has been chosen so as not to affect the way that surface moves in the area of interest.

Following the calculations, the subsidence and horizontal displacement were predicted for all 9 cases studied.

Figure 2 shows the subsidence curves predicted by the influence function method and Figure 3 shows the curves of the predicted horizontal displacements.

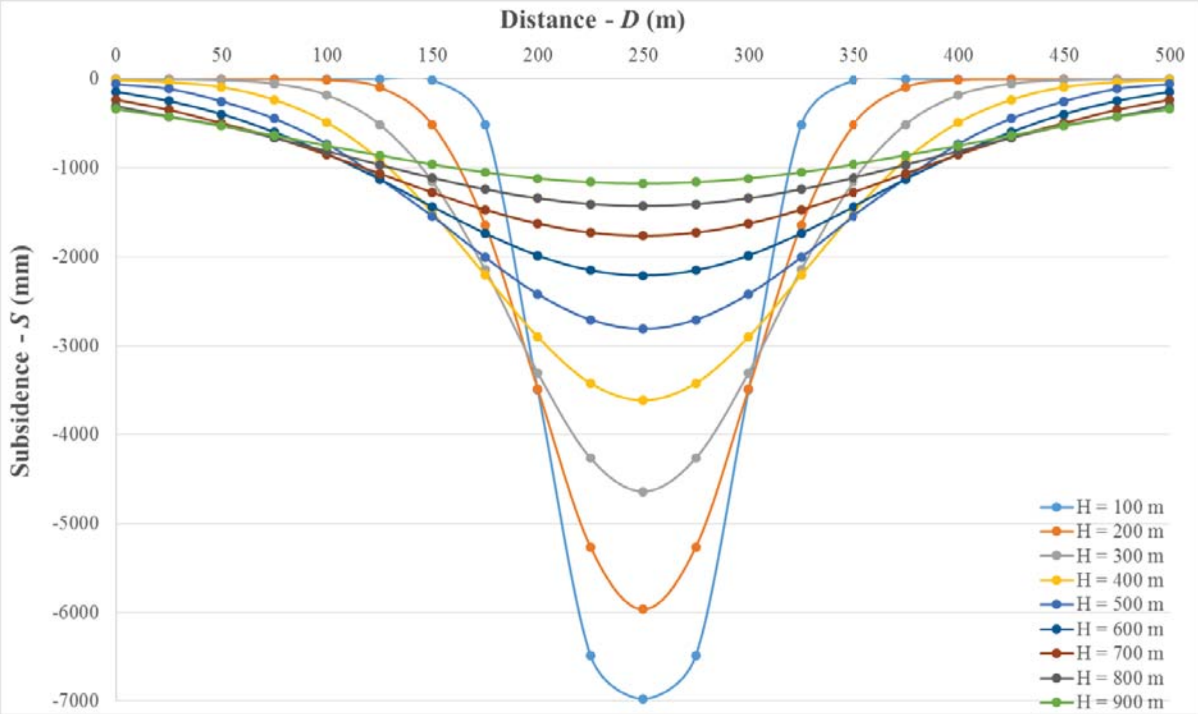

Fig. 2. *The influence of the mining depth on the vertical displacement of the surface*

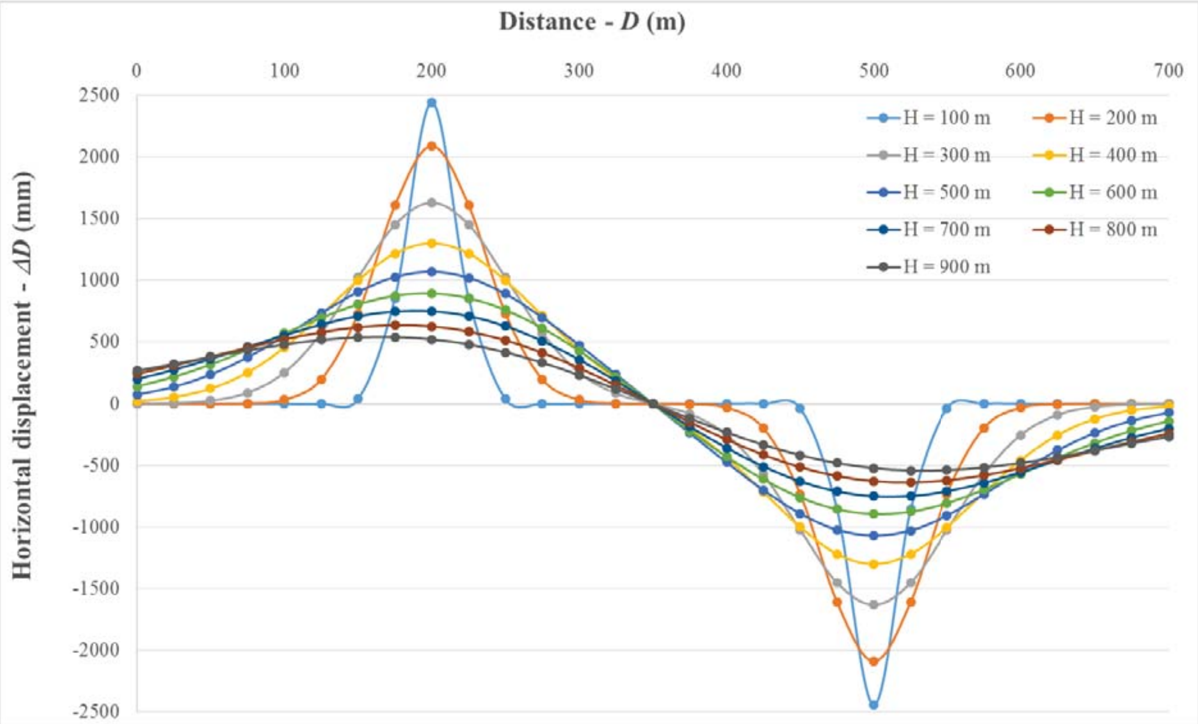

Fig. 3. *The influence of the mining depth on the horizontal displacement of the surface*

By analyzing the charts of subsidence and horizontal displacements, we can see that, in the case of small mining depths, there are smaller areas affected on the surface, but the damages produced are more significant (as the movements are more significant). Otherwise, at great mining depths there are larger areas on the surface affected, but the displacements are lower.

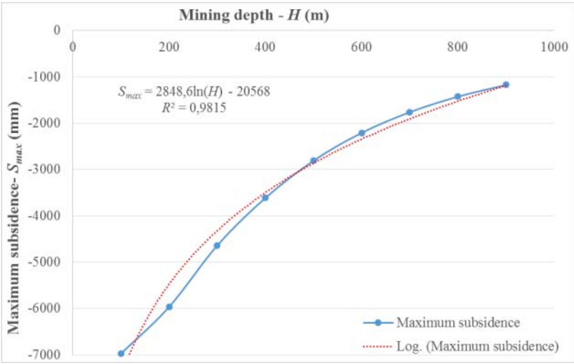

Fig. 4. *The variation of maximum subsidence depending on mining depth*

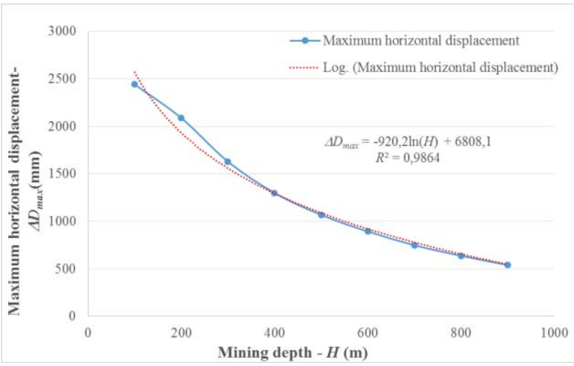

Fig. 5. *The variation of maximum horizontal displacement depending on mining depth*

Figures 4 and 5 illustrate graphically the influence of the mining depth on the developed mode of maximum subsidence and maximum horizontal displacement.

As one can observe, both maximum subsidence and maximum horizontal displacement increase significantly (almost logarithmically) as the mining depth decreases. It is also noteworthy that under the analyzed conditions, at a small mining depth (below 200 m) in the center of the subsidence trough, a significant portion of the surface is in the almost zero horizontal displacement area (see Figure 3).

4. Analysis of the influence of seam thickness on surface

In order to study the influence of the coal seam thickness on the surface, the same mining conditions were analyzed as in the previous case, but the mining depth was considered constant (and equal to H = 300m) and different thicknesses of the extracted seam were analyzed, m = 2m, 4m, ..., 20m.

As in the previous case, subsidence and horizontal displacement were predicted, graphically represented in figures 6 and 7.

Regarding the influence of the extracted seam thickness on the surface movements, let's observe that both the maximum subsidence and the maximum horizontal displacement increase linearly with the increase of the extracted seam thickness. This is graphically represented in Figures 8 and 9.

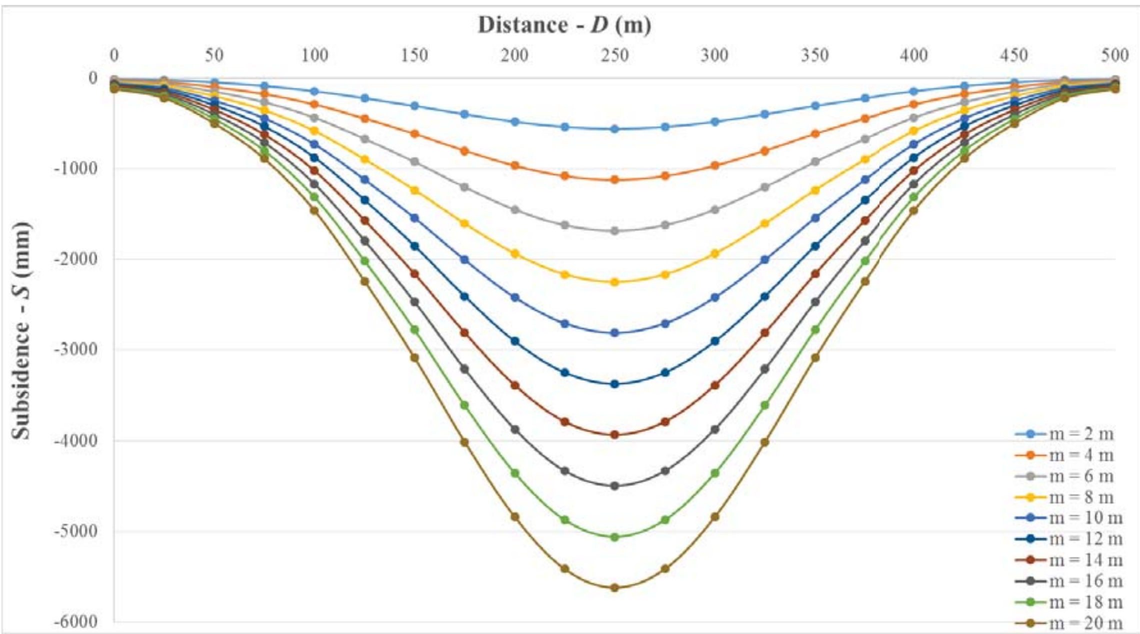

Fig. 6. *The influence of the seam thickness on the vertical displacement of the surface*

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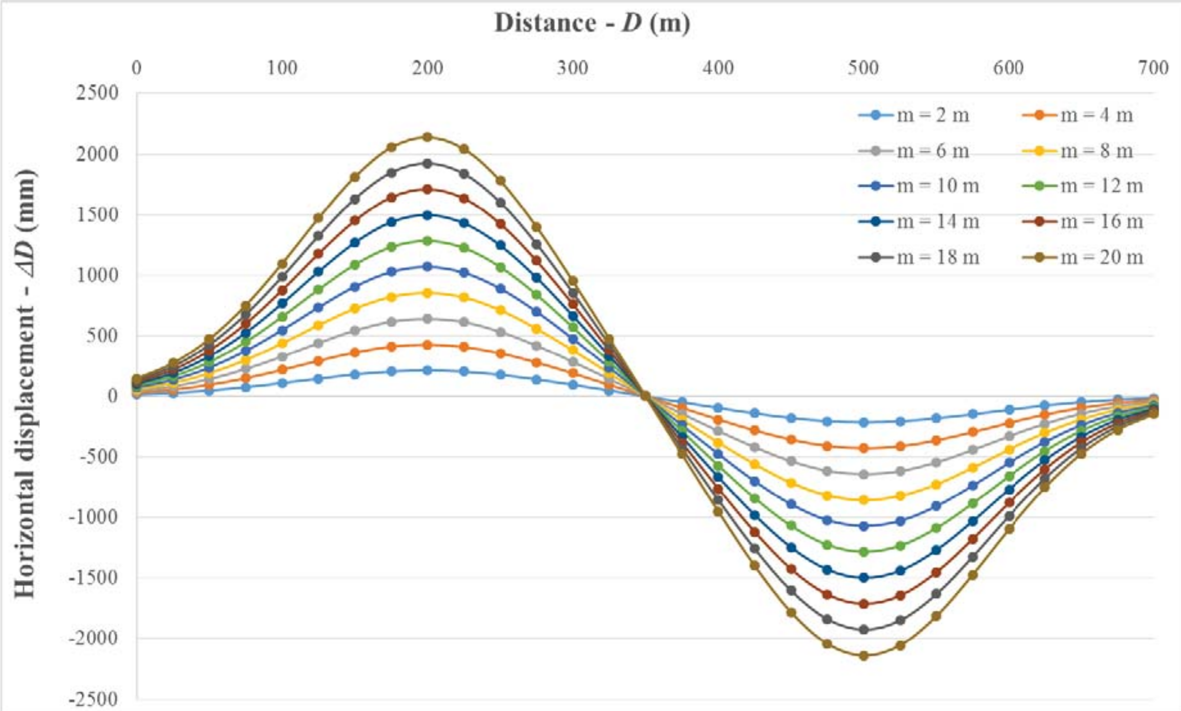

Fig.7. *The influence of the seam thickness on the horizontal displacement of the surface*

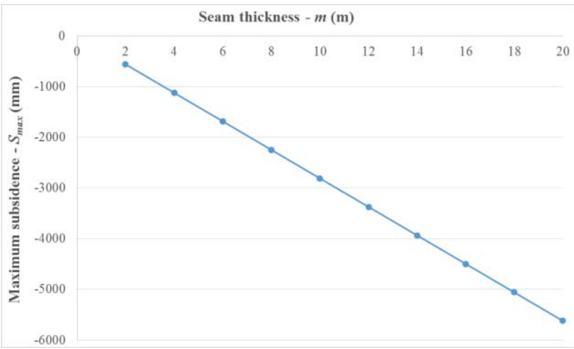

Fig. 8. *The variation of maximum subsidence depending on extracted seam thickness*

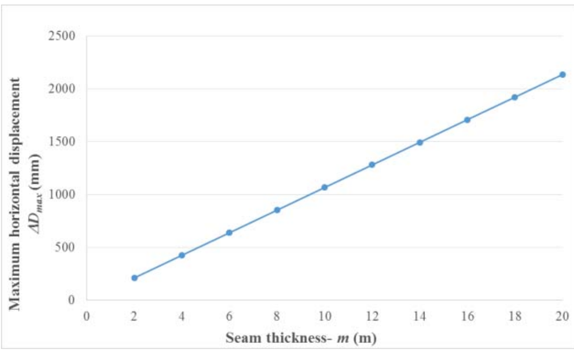

Fig. 9. *The variation of maximum horizontal displacement depending on extracted seam thickness*

The dimensions of the subsidence trough are also influenced by the extracted seam thickness but to a much lesser degree than the mining depth.

5. Conclusions

The influence function method is a particularly useful method for predicting the main parameters that define the subsidence trough.

In this paper we analyzed how the mining depth and the extracted seam thickness influence the movement of the surface.

Thus, it was analyzed the influence on the surface of the underground mining of a horizontal seam, with a thickness of 10 m (for the first analyzed case, the analysis of the influence of the mining depth) at different mining depths. For the second case, a similar situation was analyzed, but the mining depth was kept constant and various thicknesses of the extracted seam were analyzed.

As a result of this analysis it was found that both factors (i.e. both the mining and the seam thickness) have a strong influence on the size of the surface movements.

Both maximum subsidence and maximum horizontal displacement increase significantly in the case of low mining depths. It can also be observed that these parameters increase linearly with the increased thickness of the seam.

Regarding the dimensions of the subsidence trough, from the graphs shown, it can be noticed that in the case of large mining depths, the dimensions of the subsidence trough appeared on the surface increase significantly. On the dimensions of the subsidence trough, it can be seen that the seam thickness has a lesser influence, the subsidence trough rising relatively little with the increase of the seam thickness.

References

1. Fissgus, K.G.,
Ingineria subsidențelor în minerit, Editura Universitas, Petroșani, 2011;

2. Floarea, D., Marian, D.P., Onica, I., Cozma, E.
Necessity of Following up the Land Surface Deformation for Closed Mining Areas, Proceeding of the 15th International Multidisciplinary Scientific Geo-Conference & EXPO - SGEM 2015, Sofia, Bulgaria, June 16-25 2015, ISSN: 1314-2704.

3. Floarea, D., Onica, I., Cozma, E., Marian, D.P.
Necessity of Subsidence Phenomenon Monitoring in the case of Sustainable Development of Jiu Valley Coal Basin Conditions, Annals of the University or Petrosani – Mining Engineering, Vol. 15, 2014.

4. Floarea, D.A., Onica, I., Marian, D.P.
Monitoring Surface Land Deformation and Analysis of Data for Lupeni Mine, Annals of the University or Petrosani – Mining Engineering, Vol. 18, 2017.

5. Floarea, D.A., Onica, I., Marian, D.P.
3D Analysis with Finite Elements of Land Stability Affected by Underground Mining, Within Paroseni Mining Perimeter, for the Location of a main Gas Pipeline, Mining Revue, Vol. 24, no. 1, 2018.

6. Marian, D.P.
Analiza stabilității terenului de la suprafață sub influența exploatării stratelor de cărbuni cu înclinare mică şi medie din bazinul Văii Jiului, Teză de doctorat, Petroşani 2011;

7. Marian, D.P.
Urmărirea topografică şi analiza deformării suprafeței terenului afectat de exploatarea subterană, Editura Universitas, Petroşani, 2012 ISBN 978-973-741-264-5.

8. Marian, D.P.
Analysis of Surface Behavior as a Result of Underground Mining of two Coal Seams, Mining Revue, Vol. 23, No. 4, 2017.

9. Marian, D.P., Onica, I., Cozma, E.
Sensibility Analysis of the Subsidence Parameters at the Variation of the Main Geo-Mining Factors, Mining Revue, Vol. 17, no. 3/2011.

10. Marian, D.P., Onica, I., Marian, R.R., Floarea, D.A.
Surface subsidence prognosis using the influence function method in the case of Livezeni Mine, Mining Revue, Vol. 23, no. 1/2017.

11. Marian, R.R., Marian, D.P.
Prognosis of surface deformation by the influence function method in terms of Paroseni mine (Romania), Mining of Mineral Deposits, Vol. 12 (2018), Issue 2, pp. 63-67, ISSN 2415-3443.

12. Marian R.R., Marian D.P., Onica I.
3D Finite Element Analysis of Deformation of Buildings Located in Areas Affected by Underground Mining, Proceeding of the 18th International Multidisciplinary Scientific Geo-Conference & EXPO - SGEM 2018, Sofia, Bulgaria, ISBN 978-619-7408-37-9, ISSN: 1314-2704

13. Onica, I., Cozma, E., Marian, D.P.
Analysis of the Ground Surface Subsidence in the Jiu Valley Coal Basin by using the Finite Element Method, Proceeding of the 11th International Multidisciplinary Scientific Geo-Conference & EXPO - SGEM 2011, Sofia, Bulgaria, June 19-25 2011, ISSN: 1314-2704.

14. Onica, I., Cozma, E., Marian, D.P.
Ground Surface Deformation using the Finite Element Method, in Conditions of the Longwall Mining of the Coal Layer No. 3-Livezeni Mine, Mining Revue, Vol. 17, No. 1, 2011.

15. Onica, I., Marian, D.P.
Ground surface subsidence as effect of underground mining of the thick coal seams in the Jiu Valley Basin, Archives of Mining Sciences, Vol. 57, no. 3, Poland 2012, ISSN:0860-7001;

16. Onica, I., Marian, D.P.
Aplicații ale metodei elementelor finite în analiza stabilității terenurilor și structurilor subterane, Editura Universitas, Petroşani, 2016;

17. Onica, I., Cozma, E., Marian, D.P., Ștefan, N.
Prognosis of the Maximum Subsidence and Displacement of the Ground Surface in the Jiu Valley Coal Basin, Proceeding of the 14th International Multidisciplinary Scientific Geo-Conference & EXPO - SGEM 2014, Vol. III, Sofia, Bulgaria, June 17-26 June 2014.

18. Ortelecan, M.
Studiul deplasării suprafeţei sub influenţa exploatării subterane a zăcămintelor din Valea Jiului, zona estică, Teză de doctorat, Universitatea din Petroşani, 1997.

19. Popescu, G., Marian, D.P.
Surface Subsidence Monitoring using GPS Technology-Rtk Method-at Livezeni Mine, Mining Revue, Vol. 18, No. 2, 2012.

20. Vereș I.S., Marian D.P., Fissgus K.G, Ștefan N.
Finite Element Analysis of Surface Subsidence for Establishing the Location of a Gas Pipeline, Modern Technologies for the 3rd Millennium (23-24 Martie 2017 Oradea, România).

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