Analele Universității din Oradea, Seria Geografie, Tom XIX, 2009, pag 27-32

THE ESTIMATION OF THE SLIP PLANE AT THE COLȚI-ALUNIȘ LANDSLIDE (BUZĂU MOUNTAINS, ROMANIA) USING GROUND SURFACE DISPLACEMENTS MEASUREMENTS

Mihaela CONSTANTIN[1], Marta C. JURCHESCU[2],
Kazunori FUJISAWA[3], Koji ISHIDA[4]

Abstract: ***Abschätzung der gleitfläche der Colți-Aluniș rutschung (Buzău Gebirge, Rumänien) mit hilfe von verschiebungsmessungen an der geländeoberfläche.*** Die Colți-Aluniș Rutschung befindet sich im Sibiciu Einzugsgebiet, in den Buzău Gebirgen, und gefährdet die Straße, die die Siedlungen Colți und Aluniș verbindet. Die Rutschung wurde von den heftigen Regenstürmen des Zeitraumes Mai-August 2005 ausgelöst, die viele geomorphologische Naturgefahren in den Bogenkarpaten verursachten. Der Artikel legt das Ergebnis der Abschätzung der Rutschfläche dar, anhand Daten aus den Messungen mit einer Totalstation von Mobilpfahlbewegungen. Drei Datenreihen wurden für die Abschätzung der Rutschfläche benutzt und 14 mögliche Einsatzdatenkombinationen wurden analysiert, mit Hilfe eines Programms das von Public Works Research Institute (Tsukuba, Japan) entwickelt wurde. Die Methode besteht in: der Teilung der Rutschmasse in mehreren Blöcken; der Annahme dass der Rutschkörper steif ist; der Vorraussetzung dass die Bewegungsvektoren parallel zur Rutschfläche sind; Polynomkonstruktionen für die entsprechenden Blöcke und der Abschätzung der Rutschflächenform durch die Verknüpfung der Polynome. Das Ergebnis der Abschätzung der Rutschfläche anhand dieses Programms ist ähnlich mit dem Ergebnis der Abschätzung aus Bohrungsdaten. Der Unterschied zwischen den zwei hier angewandten Methoden wird auch diskutiert.

Schlüsselwörter: Rutschung, Geländeoberflächeverschiebungen, Abschätzung der Rutschfläche, Buzău Gebirge, Rumänien

Introduction

The Colți-Aluniș landslide occurred in the Sibiciu basin (Buzău Mountains, Curvature Carpathians) after heavy rainfall (total cumulative rainfall during May-August - 528.2 mm) in the summer of 2005. The landslide is located on deposits of Paleogene flysh in Kliwa facies represented by an alternation of sandstones, clays and shists (Fig. 1, Fig. 2). The landslide is one of rotational type. The scarp has a length of 258.0 m, the average landslide width being of 111.0 m. The length of the different landslide blocks varies between 116.0 m on Block 3 and 133.0 m on Block 1. The landslide affects the road on an approximate length of 300.0 m.

According to the geomorphic and morphodynamic characteristics the landslide body was divided into 4 blocks (Fig.1) (Constantin et al., 2009).

[1] Institute of Geography, Romanian Academy, Str. D. Racovita 12, 023993, Bucuresti 20, Romanania; email:mihaela.constantin@gmail.com
[2] Institute of Geography, Romanian Academy, Str. D. Racovita 12, 023993, Bucuresti 20, Romanania; email: marta_jurchescu@yahoo.com
[3] Public Works Research Institute, Tsukuba, Japan, 1-6 Minamihara, Tsukuba, Ibaraki,3058516, Japan; email: fujisawa@pwri.go.jp
[4] Public Works Research Institute, Tsukuba, Japan, 1-6 Minamihara, Tsukuba, Ibaraki,3058516, Japan; email: k-ishida@pwri.go.jp

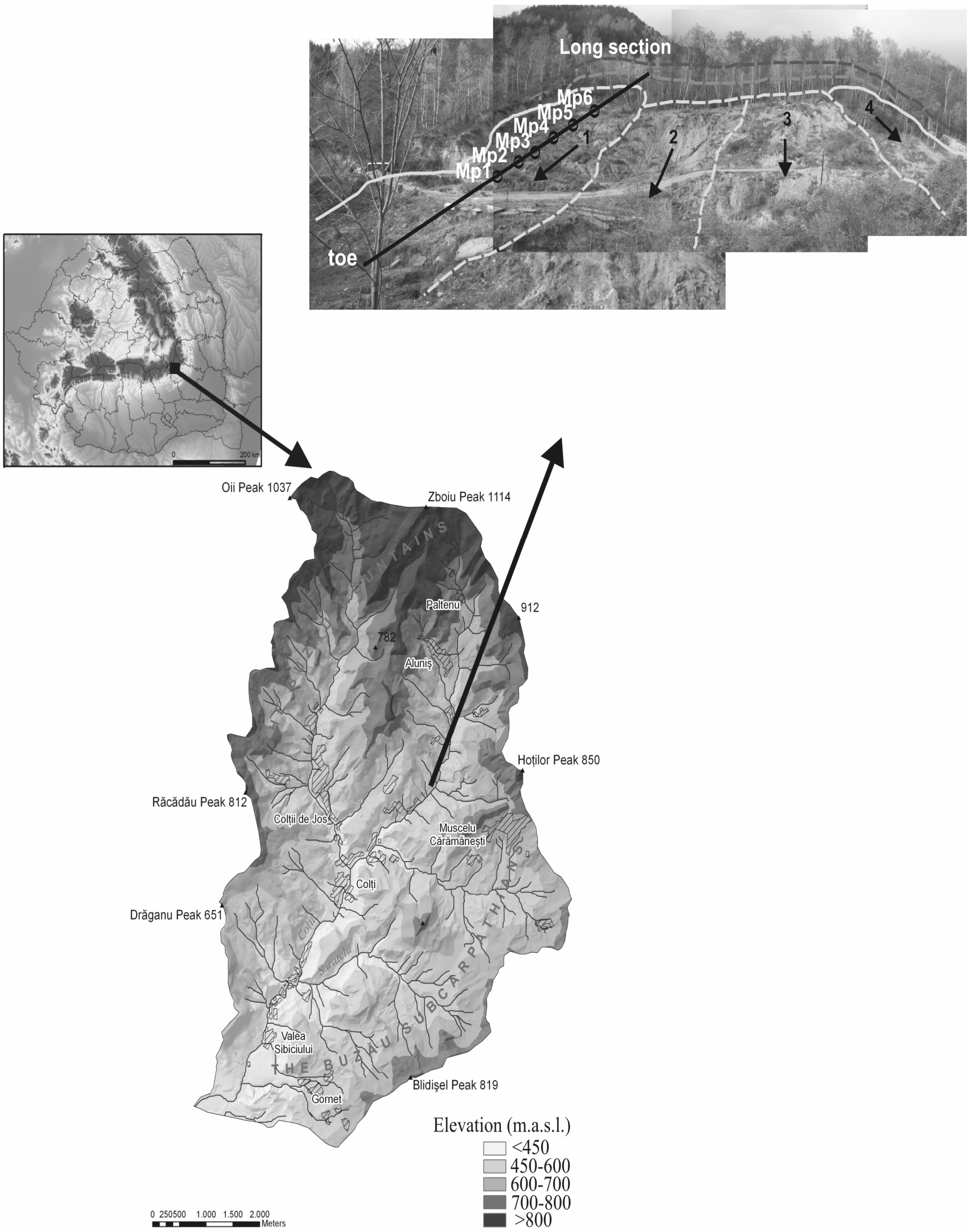

Fig.1 The location of the Colţi - Aluniş landslide in the Sibiciu basin (Buzău Mountains, Romania)

In November 2007, mobile piles were set up on Block 1 in order to assess the slip plane position using ground surface measurements and the program proposed by Public Works Research Institute, Tsukuba. Six transversal alignments of mobile piles (each at a distance of approximately 10 m) were set up.

Three data sets obtained from measuring the movements of mobile piles set up on the longitudinal section using a Sokia SET 310/510/610 total station were analyzed.

The result obtained using the program of estimation was finally compared with the result of the slip plane estimation using borehole data.

Geologic and geomorphic setting

The Sibiciu basin covers parts of two relief units represented by Ivănețu Summit (Buzău Mountains) and Buzău Subcarpathians (Fig.1) (Constantin, 2006). The Buzău Mountains in the Sibiciu basin consist of flysh deposits, NNE-SSW oriented, distributed into two facieses of Paleogene deposits (Dumitrescu et al., 1970): the facies of Colți (Pg1+2) represented by sandstones, clays and marls and the Kliwa facies, represented in the region by sandstones interbeded with clays and shists (lt-ch). The Buzău Subcarpathians consist of Neogene deposits represented mainly by clays, marls and sands (Fig.2).

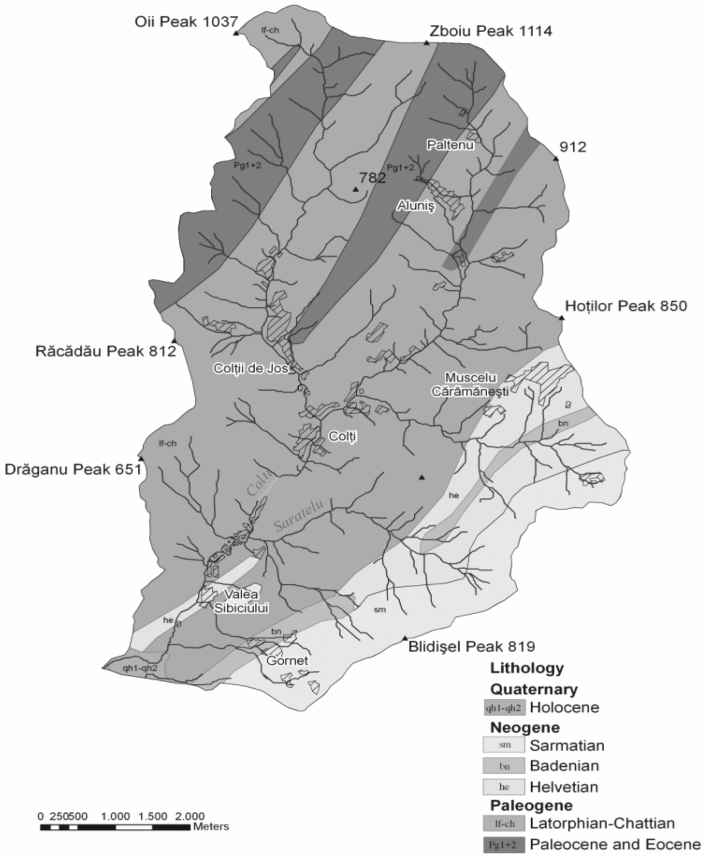

Fig. 2. The geologic map of the Sibiciu basin

The drainage density in the basin has values of 5-6 km/km^2 in Buzău Mountains and 3-4 km/km^2 in Buzău Subcarpathians. The presence of landslides in the basin is associated with the 12-24^{0}and 6-12^{0}slope classes covered by pastures and orchards.

The Colți-Aluniş landslide occurred after heavy rainfall in the summer of 2005 on a slope developed on Kliwa facies (Fig.1, Fig.2). After geomorphic observations the landslide was divided into four blocks according to the morphodynamic features (Fig.1). Block 1 appears to be very active and has a 64.0 m long scarp, an average width of 38.0 m and a length of 133.0 m. The slide elevation ranges from 500.0 to 465.0 m throughout

Block 1, the difference in elevation being of 35 m. The slope angle ranges from 0 to 33^0 with an average slope angle of the displaced slide mass of 16.7^0. The main scarp and other two minor scarps, as well as the depletion zone can be easily noticed on the geologic engineering cross-section (Fig. 3). The landslide toe is slightly above the Sibiciu River (Constantin et al., 2009).

Based on geomorphic observations and boreholes information a geologic engineering cross-section was also elaborated (Fig.3).

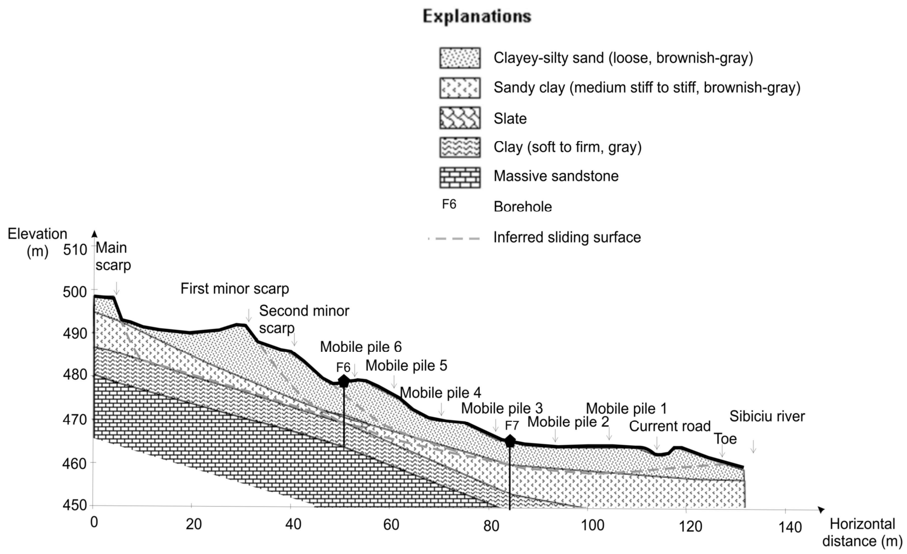

Fig. 3. The geologic engineering cross-section of Block 1 (Constantin et al., 2009)

The slide mass consists predominantly of fine silty-sands with inclusions of schists and sandstones. The sliding surface comprises three geologic materials (i.e., sands, sandy-clays and grey clays). The sliding surface intercepts the sandy-clay layer at a depth of 6.5 m in borehole F6, and the grey clays at a depth of 11.5 m in borehole F7 (Constantin et al., 2009). The drainage of Block 1, which appears to be the more active one affecting the road, is the Sibiciu River located at the toe of the slide. The movement of the slide is caused by the rain and snow melt water which infiltrates through the sandy layer, the sandy-clay and grey clay layers. The inferred sliding surface in Fig. 3 is based on the information from boreholes (F6 and F7) and the examination of the main and secondary scarps.

In order to estimate the slip plane of Block 1, three data sets of mobile piles displacements measurements were analyzed using the method proposed by Landslide Research Team, PWRI, Tsukuba.

Methodology of slip plane estimation

The method developed by PWRI consists in (Asai et al., 2006; Ishida et al, 2007**;** Takechi et al., 2008):

- dividing the sliding mass into several blocks;

- the use of displacement vectors at measurement points on the ground surface along the main profile line of the landslide considering them to be parallel with the slip plane (Fig. 4);

- constructing polynomials for respective blocks and estimating the shape of slip surface by connecting the polynomials;

- setting up the appropriate divide line and underground border point (the point of intersection of different slip plane shapes) according to the estimated slip plane shape based on field survey.

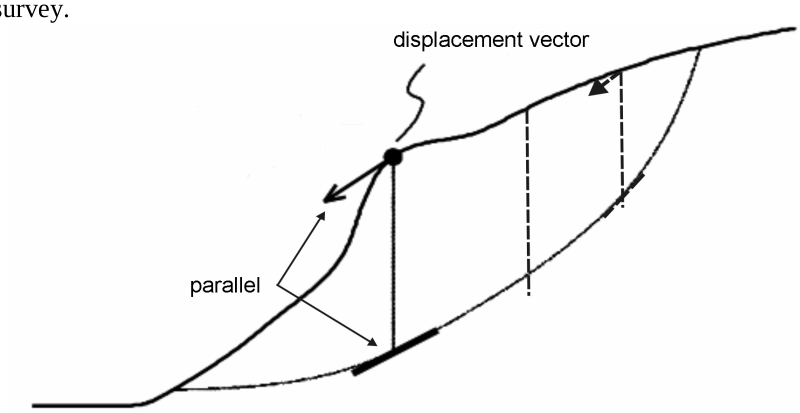

Fig. 4. The assumed conditions to calculate the slip plane using polynomials

The input data of the program are (Ishida et al., 2007):
- ground surface profile and coordinates of measurements points;
- displacement vector at a measurement point on the ground surface;
- coordinates of points of deformation at the head and toe of the landslide.

Results

In the processes of estimating the slip plane using the program proposed by PWRI, Tsukuba, 14 different situations were analyzed: using all mobile piles and two blocks divide lines; using all mobile piles and three blocks divide lines; using all mobile piles, three block divide lines, the setting of the underground border point; use the coordinates of Mp6, Mp4, Mp3, Mp1, the coordinates of toe or head, one block divide line and the setting of the underground border point.

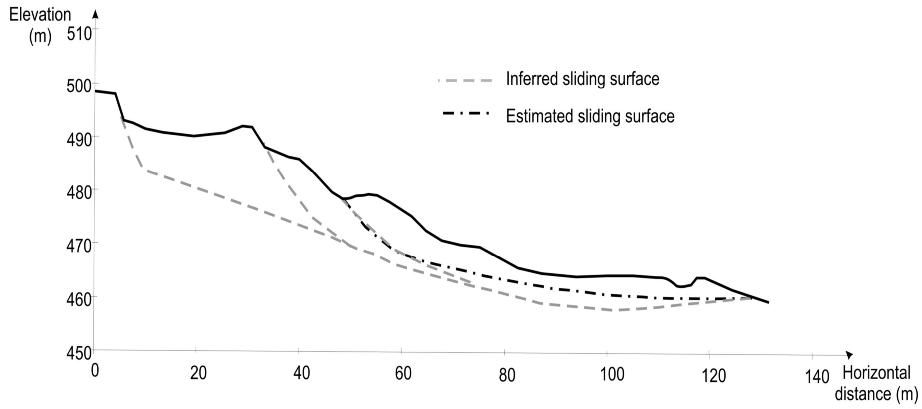

Fig. 5. The comparison between calculated slip plane and slip plane obtained from borehole data

The situation which considers the coordinates of Mp6 (mobile pile 6), Mp4 (mobile pile 4), Mp3 (mobile pile 3), Mp1 (mobile pile 1) and toe, the usage of one block dividing line and the setting of the underground border point seems to be very close with the position of slip plane estimated from borehole data.

A vertical difference of 3.3 m (Fig.5) between the two slip planes was obtained in the borehole F7 and in the lower part of the landslide. This is a subject of discussion since data from a borehole located down slope of F7 would offer more detailed information about the position of slip plane inferred from boreholes.

The method depends on personal judgment about parameters taken into consideration in the 14 trials analyzes (Takechi et al., 2009).

Conclusions

The deep-seated Colți-Aluniş landslide has a complex geomorphic and geologic engineering characteristic which draws our attention from many points of view. One of them was to estimate the slip plane using the program proposed by PWRI in order to be compared with the slip plane obtained from boreholes stratigraphy data.

The results seem to be reliable except the middle part of the landslide. The difference between the two estimations is questionable since in that part of the landslide the borehole data down slope of F7 are missing.

We also consider that the method has the advantage of being easy to be applied soon after the landslide occurrence, thus giving the possibility to estimate the slip plane position, to take emergency measures rapidly and consequently reduce the damages.

Acknowledgements

The present study was partly supported by the Ministry of Education and Research through the grant in aid PNII-IDEI_367 (2007-2010) funded through The National University Research Council of Romania (CNCSIS). We thank to Daniel Ciupitu and Laurențiu Niculescu for taking the measurements with the Total Station. The cooperation with Public Works Research Institute, Landslide Research Team, Tsukuba, Japan through the Agreement between Institute of Geography, Romanian Academy and Public Works Research Institute (2007-2011) is fully appreciated.

REFERENCES

Constantin, M. (2006), *Prognoza alunecărilor de teren. Abordari actuale*, Ed. AGIR, 99p.

Constantin, M., Trandafir, A.C., Jurchescu, M.C., Ciupitu, D. (2009), *Morphology and environmental impact of the Colți-Alunis landslide (Curvature Carpathians, Romania)*, Environmental Earth Sciences, Ed. Springer, DOI 10.1007/s12665-009-0142-1

Dumitrescu I, Săndulescu M, Bandrabur, T., Sandulescu, J. (1970), *The geologic map of Romania, scale 1: 200,000. Covasna*, Com.Geol. Inst.Geol., Bucureşti

Ishida, K., Fujisawa, K., Kojima, S., Tanaka, H. (2007), *Estimation Method of Slip Surface by Ground Surface Displacement*, AGU Fall Meeting 2007, Abstract H11C-0664

Asai, K., Fujisawa, K., Tanaka, H., Takeishi, A. (2006), *Examination of estimation method of slip surface by ground surface displacement at the early stage of landslide*, Proc. of the 45th Conference of the Japan Landslide Society, pp.393-394

Takechi, K. Takeishi, A., Fujisawa, K, Ishida, K., Kuda, T., Okuda, S., Chiba, S., Kodama, H., Yamashita, T., Fukui, K., Ikei, H., Yokoyama, N., Itoh, K., Ishizaka, S. (2009), *An Improved Method for Estimating Slip Surface of Landslide Through Ground Surface Displacement*, AGU Fall Meeting 2008, Abstract H43I-08