USING GIS FOR LANDSLIDES GRAPHICAL REPRESENTATION. CASE STUDY IN CORNĂŢEL (HÂRTIBACIULUI PLATEAU)

ROŞIAN GHEORGHE[1], HORVATH CSABA[2]

Abstract: - **Using GIS for Landslides Graphical Representation. Case Study in Cornăţel (Hârtibaciului Plateau).** This paper it's part of the present concern regarding the graphical representation of landslides. A very particular category of landslides is the glimee type. Of the territories in which they are frequently encountered, the Transylvanian Depression must be noted. Despite that these landslides are considered stable, since they occurred thousands of years ago, they were affected in time by various geomorphological processes. These include the recent (shallow) landslides, runoff on the slope, etc. For a correct graphical representation of both the old landslide and the current processes, which by their manifestation contribute to the genesis of new relief microforms, a GIS methodology was used. By using it, one can obtain both a graphical representation of various generations of landforms and can also make calculations allowing them to find out exactly their surface. This aspect has obvious practical connotations. As case study we used the landslide of Cornăţel, located in the south-western part of Hârtibaciului Plateau, an old glimee type landslide.

Key-words: glimee type landslides, graphical representation, distribution, GIS.

1. INTRODUCTION

The graphical representation of landslides components has been a matter of concern both for geomorphologists and cartographers. The obstacles arise when one has to perform the graphical representation of landforms belonging to different generations, as in the case of the old glimee type landslides. Of the territories in which they are frequently encountered, the Transylvanian Depression must be noted. Despite the fact that these landslides are considered stable, since they occurred thousands of years ago during the Holocene (Gârbacea, 2013), they were subsequently affected by various recent geomorphological processes.

[1] Babeş–Bolyai University, Faculty of Environmental Science and Engineering, 400294, Fântânele Street, No. 30, Cluj–Napoca, Romania; e-mail: georgerosian@yahoo.com
[2] Babeş-Bolyai University, Faculty of Geography, 400006, Clinicilor Street, No. 5-7, Cluj-Napoca, Romania; e-mail: hcsaba@gmail.com

To illustrate this, the landslide from Cornăţel was chosen as a case study. An old glimee type slip, located on the left side of the Hârtibaciu river valley, south of the town of Cornăţel (Viilor Hills). From a regional point of view, they are located in the southwestern part of the Hârtibaci Plateau (Figure 1), known as the Făgetului Hills (Pop, 2001), which in turn is a subunit of the Transylvanian Depression.

In order to picture the above, as a case study, the landslide of Cornăţel, an old glimee type landslide (Grecu and Josan, 1996), was used. This is located in the left slope of Hârtibaciu river corridor, in the south of Cornăţel village (Dealul Viilor). From this regional component perspective, they are located in the south-western part of Hârtibaciului Plateau, known as Dealurile Făgetului (Pop, 2001) which also is a sub-unit of the Transylvanian Basin.

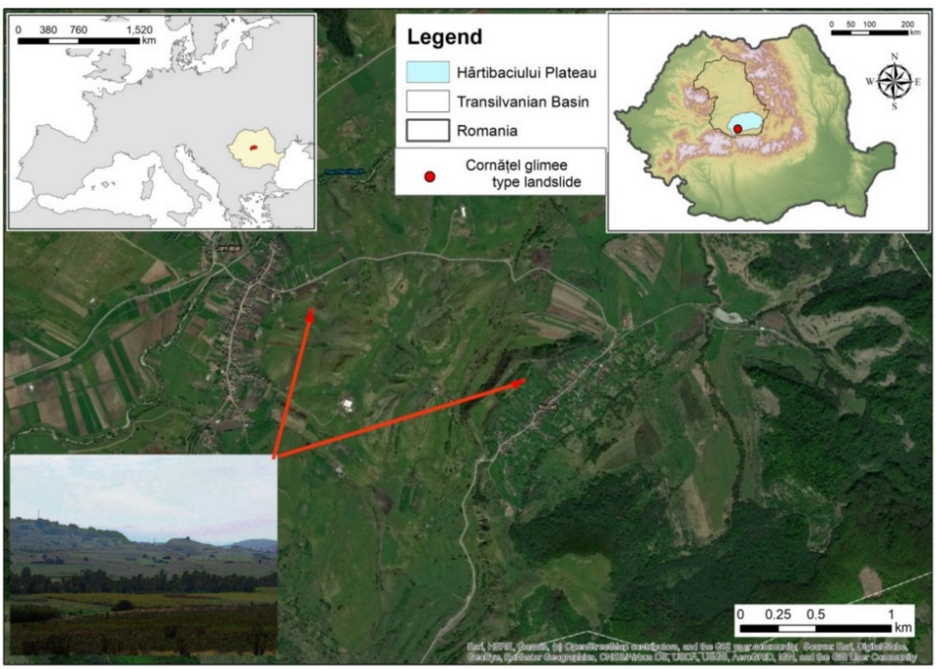

Fig. 1. Study area, Cornățel glimee type landslide location

Regardless of the viewpoint from which they are approached, glimee type landslides are one of the specific elements of the Transylvanian geomorphological landscape, both by their frequency and amplitude, as well as by their role in the evolution of the slopes. At the same time, due to their production mode and residual effects in the overall morphology, they were rightly considered catastrophic moments in the evolution of slopes (Jakab, 1981). One of the main problems encountered in the study of the glimee was the one represented by the determination of their age and correlated with it, the climatic conditions that forced changes of such magnitude to the substrate. The existing studies indicate several favourable time intervals for this type of landslides, from the Late Glacier to the Sub-Atlantic, with the possibility that some of them may have occurred during the Eemian period (Pendea, 2005).

The old age of the landslide body has caused it to be affected over time by current geomorphological processes, which has determined the existence of several landform generations.

For a correct graphical representation of both the old landslide and the current processes (superficial landslides, ravines, etc.), which by their manifestation contribute to the genesis of the new relief's micro-landforms, a GIS methodology must be used.

2. METHODS AND RESOURCES

By the specific marks introduced in the Transylvanian geomorphological landscape along with the complexity of the evolution of the affected sites, one can ascertain that the glimee type landslide topic has not been yet exhausted. This is supported by the possibility of using new methods to highlight the reality in the field. In this context, the present study is part of the glimee type landslides graphical representation concerns through GIS techniques.

The first objective cartographic representation of the glimee type landslides of the Transylvanian Basin was made in 1964 by V. Gârbacea and it was related to the Saschiz landslides. The graphical representation proposed by the above-mentioned author is distinct by the enlistment of the morphological components included in this type of landslide, namely: scarp, basins (between mounds and between the scarp and the landslide body), and row of mounds. The actual geomorphological processes are also enlisted as small size landslides (enlisted on mounds), and under the name of recent landslides (enlisted on slope surfaces adjacent to glimee type landslides) therefore, unaffected by the main landslide). The cartographic methodology proposed by V. Gârbacea in 1964 is further used not only by the already mentioned author in his studies undertaken with various collaborators (Buz et al., 1986; Morariu et al., 1965 etc.) but also by other authors that were researching graphical representation of glimee type landslides (for instance, Josan, 1970; Grecu, 1992, Buzilă and Muntean, 1997; Roşian, 2009 etc.).

The graphical representation of glimee type landslides, subsequent to the mapping conducted by V. Gârbacea in 1964, does not bring significant value to it, given that the current geomorphological processes that affect various elements of the initial landslide, are either not represented or this is made by dot symbols which do not provide any information about their spatial expansion. For this very reason, studies as the present are considered as being necessary, as they are designed to provide information about how much of the surface of glimee type landslide really is stable, and how much is unstable, that is to say, how much is affected by the current geomorphological processes.

In order to map the landslide component from Cornăţel, a GIS methodology was used. It consisted in using a specific GIS software (Esri ArcMap), by which, based on the existing information from field analysis, ortophotoplans and topographic maps, the landslide components were vectorised. Also, we have conducted some field observations, where landslide components could not be precisely charted by the ortophotoplans, the GPS measurements where used; the information collected from the field was then downloaded and included in a GIS software for data processing.

Subsequently, in order to complete the landslide map from Cornăţel, each of the landslide components was graphically represented. In order to determine the surface of the landslide components and the weight of the various landslide components spatial statistics functions where used.

3. RESULTS AND DISCUSSION

Although the landslide from Cornăţel doesn't represent the largest area affected by glimee landslides, and it's not even the most publicized one, we choose this area for several reasons: good preservation of the site, easy identification of the landslide components (Figure 2), the presence of current geomorphological processes, accessibility etc. It is however an excellent case study, the landslide affects the entire profile of the slope.

The aim of this study is the graphical representation of the current geomorphological processes within the glimee type landslides with the help of GIS techniques. To achieve this aim, a detailed geomorphological map was realized (Figure 3). On this map were represented both the overall landslide components as well as the current geomorphological processes affecting them, resulting in a specific morphology.

Within the overall morphology of the landslide from Cornăţel, there are several distinct elements such as: scarp, the depressionary alignment between the scarp and the first row of mounds, the mounds and the front of the landslide (Figure 3).

The scarp has a length of 2200 m and is in the form of a precipice with a slope of 60-70 m. The scarp is currently active providing material through the superficial slides and splash erosion etc. (Moldovan, 2012)

The transition from the scarp and the several rows of mounds is done through a **depressionary alignment** within which there are several lakes currently silting. The lake basins collect water in the heavy rainfall season. Compared to the micro-basins located between the glimee type rows, the depressionary alignment it's better developed and expanded in size.

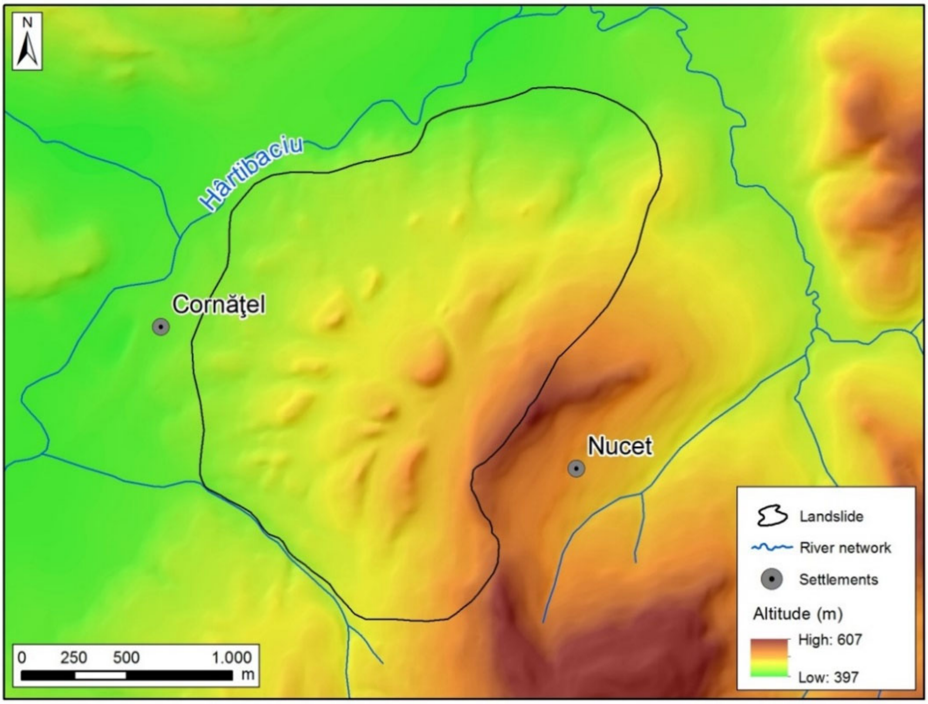

Fig. 2. The digital elevation model of the field

The row of mounds complex. On the bottom of the separation line, as a result of landslides, there are three parallel rows of mounds. Most of the mounds are covered by grass, except for some of them in the first and second row where there are some without vegetation because of recent active geomorphological processes. The largest correspond to the mounds located in the 1st and 2nd row which have relative altitudes of 30-45 m.

The front of landslides is represented by the first rows of mounds that nowadays can no longer be fully recognised as the front of the landslides is prolonging almost intangibly to the meadow. It is possible that the flattening of the front of landslides might have been rendered also by anthropogenic factors.

The landslide area is of 3,558 km^2. Of this amount 0,430 km^2 is represented by the scarp, 0.486 km^2 by the mounds (mounds are also included in the body of the landslide, but they have been separately dealt with because of the specific morphology) and 2,642 km^2 by the body of the landslide.

Along with the major landforms, already listed, there are some smaller landforms which are due to the current geomorphological processes. Thus, one can observe some recent landslides (0,190 km^2), splash erosion (0,006 km^2), gully erosion (0,009 km^2), lakes (0,010 km^2) (Figure 3) etc. It is important to highlight that these landforms overlap most of the original landslide components.

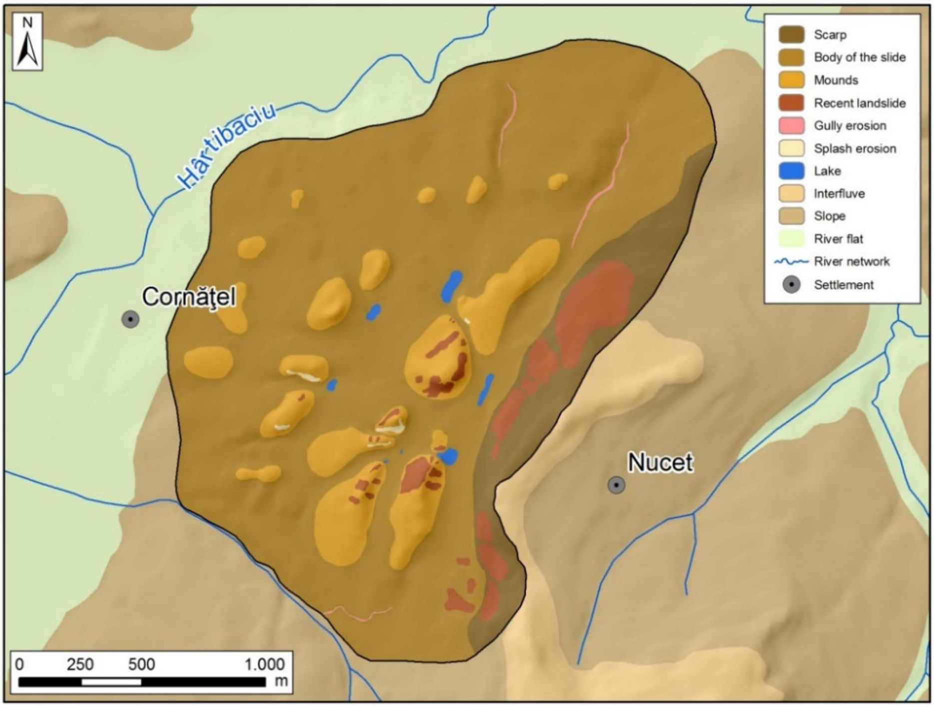

Fig. 3. Cornățel landslide and components map

These recent geomorphological processes are favoured also, along with the land use (pasture), by the presence of Sarmatian geological formations in which marl clays, sands and tuffs compositions prevail.

In this context, it should be emphasized that even if generally speaking, the glimee type landslides are considered as being stable, at the detail level, within the scarp or mounds, the current geomorphological processes lead to instability.

Within the Cornăţel landslide, of the 33 recent landslides, eight are located in the scarp (0,141km^2), three on the body of landslide (0,010km^2) and 22 on the mounds (0,039km^2). Also, the five splash erosion areas (0,006 km^2) are on the mounds of glimee, ant the three gully erosions (0,009 km^2) affect directly the body of the landslide.

The presented data show that at the Cornăţel glimee type landslide the most affected, by curent geomorphological processes, is the scarp (32.7%), followed by mounds (9.25%) and then the rest of the body of landslide. If we were to consider the mounds along with the rest of the body of the landslide, which in a broad way is the body of the landslide, it results that this is affected by the recent geomorphological processes on a 2.5% of its surface. For the entire landslide, calculations indicate that 5.76% (0,205 km^2) of its surface is affected by the recent geomorphological processes.

The results emphasize that even if they are considered as being stable, glimee type landslides are affected by recent active geomorphological processes, which indicate further progressed within the actual geomorphological conditions.

4. CONCLUSIONS

For an objective graphical representation of the old landslide and the current processes, which with their appearance contribute to the genesis of new microforms, GIS methodology was used. By using this, besides of a graphical representation of various generations of landforms, one was able to make calculations that allow finding their exact surface. These aspects have an obvious practical connotation.

The results of this study are represented by a detailed geomorphological map, in conjunction with its interpretation, at general and statistical level.

The existence of a slope affected by old landslides, which resulted in several rows of mounds, which in turn are affected by current geomorphological processes, is nothing more than the overlapping of different generations of landforms resulting from the same geomorphological process.

Briefly, this leads to the conclusion that a slopes affected by glimee type landslides, continues its development under the favourable conditions of the current geomorphological conditions by forming new slips and new scarps on the old mounds and scarp.

The presented example helps depict the role played by the geomorphological processes represented by massive glimee type landslides in shaping the slopes in the Transylvanian Basin in order to reach the state defined as the dynamic balance. In this case, compared to other type of slope evolutions in the Transylvanian Basin, the actual processes have no longer affected new land surfaces, but they have developed at the level of the old forms, resulting in overlapped generations of landforms.

REFERENCES

Buz, V., Ciangă, N., Diaconeasa, B., Gârbacea, V., Idu, D. P. (1986), *Alunecările de teren de la Pădureni (Ţop),* Proleme de Geografie Aplicată, Intreprinderea Poligrafică Cluj, Cluj-Napoca, pp. 15 - 21.

Buzilă, L., Muntean. L. (1997), *Alunecările de teren de la Şaeş (Podişul Hârtibaciului),* Comunicări de geografie, Bucureşti, pp. 36 - 38.

Gârbacea, V. (1964), *Alunecările de teren de la Saschiz (Podişul Hârtibaciului)*, Studia Univ. „Babeş - Bolyai”, Cluj-Napoca, seria Geologie-Geografie, vol. VIII, fasc. 1, pp. 113 - 121.

Gârbacea, V., (2003), *Relieful de glimee*, Editura Presa Universitară Clujeană, Cluj-Napoca, 259 p.

Jakab, S. (1981), *Modelarea versanţilor din Dealurile Târnavelor prin alunecări de teren,* Lucrările Conferinţei Naţionale pentru Ştiinţa Solului Braşov, Publicaţiile Societăţii Naţionale Române pentru Ştiinţa Solului, Bucureşti, pp. 23 - 33.

Grecu, Florina (1992), *Bazinul Hârtibaciului. Elemente de morfohidrografie*, Editura Academiei Române, Bucureşti, 168 p.

Grecu, Florina, Josan, N. (1996), Specific Features of the Massive Landslides at Cornăţel (Hârtibaciu Tableland), Rumania. Geogr. Fiz. Dinam. Quat., 19/1996.

Josan, N. (1970), *Alunecările de teren de la Romaneşti-Paucea,* Lucrări Ştiinţifice, Seria A, Oradea, pp. 97 - 103.

Moldovan, Monica-Loredana (2012), Glimeele din Transilvania – studiu geomorfologic, Teză de doctorat, Universitatea Babeș-Bolyai, Facultatea de Geografie, Cluj-Napoca.

Morariu, T., Gârbacea, V., Călinescu, Maria, (1965), *Alunecările de la Bozieş, (Câmpia Transilvaniei),* Comunicări de geografie, vol. III, Bucureşti, pp. 37 – 42.

Pendea, Fl., (2000), *Model de evoluţie morfo-pedogenetic al unui subsistem de versant în Holocen,* Studia Univ. „Babeş-Bolyai" Cluj-Napoca, Seria Geographia, an. XLV, nr. 2, pp. 37 - 45.

Pop, Gr., (2001), *Depresiunea Transilvaniei*, Editura Presa Universitară Clujeană, Cluj-Napoca, p. 274.

Roşian , Gh., (2009), Evoluţia versanţilor afectaţi de alunecări masive de tip glimee. Studiu de caz: versantul drept al Văii Secaşului Mic (Sectorul Tău - Secăşel), Geographia Napocensis, an III, nr. 1, pp. 33 - 40.