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SPECIFIC FEATURES OF THE MASSIVE LANDSLIDES AT CORNĂȚEL (HÂRTIBACIU TABLELAND), RUMANIA

ABSTRACT: GRECU F. & JOSAN N., *Specific features of the massive landslides at Cornatel (Hartibaciu Tableland), Rumania.* (IT ISSN 0391-9838, 1996).

For the Hârtibaciu Tableland, the landslides, locally called *glimee*, represent a specific feature of the landscape because of the surfaces they cover (i.e. - maximum surfaces of 1,550 sq.km and average surfaces of 50-150 sq.km) and the height of the scarps (i.e. 60-70 m height on a 5 km distance). The largest area with *glimee* is to be found at the contact of Pliocene sands and shales with the Miocene rocks (shales, sands, sandstones or volcanic tuffs) or Sarmatian deposits. The location of these *glimee* shows a concordance of them with the dome or anticline structures. The sheets of underground waters are differently drained away by Pliocene and Miocene deposits and give lines of water springs on the medium or lower thirds of the slopes. The *glimee* lay in 5 rows grouped within 3 evolutionary stages. The oldest ones are situated in the lower part of the slope, the newest in the upper one.

KEY WORDS: Massive landslides, Slopes, Glimee (Tumuli), Transylvanian Tableland, Rumania.

RIASSUNTO: GRECU F. & JOSAN N., *Caratteristiche delle frane massive a Cornatel (Tavolato di Hartibaciu), Romania.* (IT ISSN 0391-9838, 1996).

Nel Tavolato di Hârtibaciu, le frane chiamate localmente *glimee*, rappresentano delle caratteristiche specifiche del paesaggio sia per la superficie che ricoprono (1550 km^2 la superficie massima, 50-150 km^2 quella media) sia per l'altezza della scarpata (60-70 m per una lunghezza di 5 km). Le più grandi superfici caratterizzate da *glimee* si trovano al contatto fra i depositi pliocenici permeabili e miocenici impermeabili. Esiste una concordanza fra la zona dove si trovano *glimee* e le strutture anticlinaliche o a domi. Gli scorrimenti si verificano in seguito all'oscillazione della falda freatica al contatto dei depositi miocenici e pliocenici e danno allineamenti di sorgenti nella parte medio-bassa del versante. Le *glimee* si trovano in cinque raggruppamenti e in tre stadi evolutivi. Le più vecchie sono situate nella parte inferiore della scarpata, mentre le più recenti nella parte superiore.

TERMINI CHIAVE: Frane, Versanti, Glimee (Tumuli), Tavolato Transilvanico, Romania.

The landslide area Cornățel-Nucet-Săcădate is situated in the S-W of the Hârtibaciu Tableland (and in the south of the Transylvanian Tableland) along the 45° 47° parallel. Sliding affects the southern and northern slopes of the Hârtibaciu-Olt interfluve, extending over three 3rd-and-4th order, secondary basins (Horton - Strahler classification system), namely Cornățel and Nucet in the Hârtibaciu basin, and Săcădate in the Olt basin. These areas have an amphitheatre-like layout. The massive landslides at Cornățel (glimee) are a characteristic landscape feature in the Transylvanian Tableland (fig. 1).

GENESIS AND EVOLUTION: FACTORS AND MODELS

The major factor responsible for the occurrence and dynamics of massive landsliding (glimee) in the Hârtibaciu Tableland is the geological substrate, e.g. the rock structure of surface deposits, mineral clays, the alternation of moist strata with different physico-mechanical properties and structure.

The Hârtibaciu surface deposits are of Upper Miocene, Sarmatian (Volhinian - Bessarabian) and Pliocene age. The position of the Hârtibaciu areas (and of the whole of the Transylvanian Tableland, as it were) against the tableland's geological substrate accounts for landsliding in three types of deposit: a) massive slides in Sarmatian deposits; b) massive slides in Pliocene deposits; c) massive slides at the contact of Pliocene patches with the Sarmatian (GARBACEA, 1964).

The widest glimee-affected areas, with a striking morphometry and morphography, occur in the Pliocene-Sarmatian contact zone (at Movile, Saschiz, Cornățel).

South-east of Cornățel (the Dărâmat Peak) the Sarmatian is built up of schistose marls, sands with gravels and conglomerates, and numerous spherical gritstone concre-

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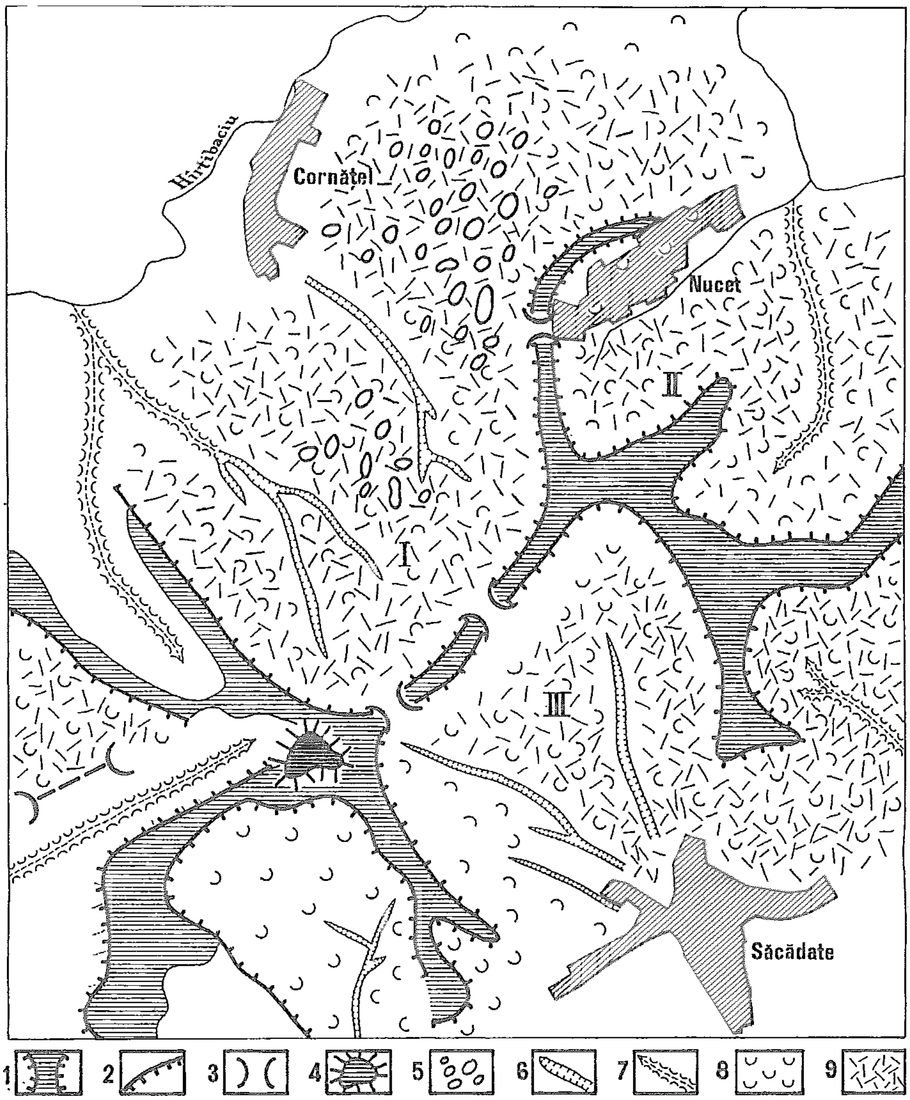

FIG 1 - Slope evolution - Cornățel type (I - Cornățel; II - Nucet; III - Săcădate): 1) landslide interfluves; 2) scars; 3) landslide saddles; 4) outliers; 5) tumuli; 6) small valleys; 7) gully erosion; 8) landslides; 9) landslide glacis.

tions. On the slope facing the Olt River (north of Săcădate settlement) the Sarmatian also contains blackish schistose marls, gray sandy marls and dolomite limestone in the form of variously-sized beds or lenses. There is a 1 m-deep layer of sandy-marls intercalated in this complex. East of the Cornățel landslides, at depth between 26 m and 66 m the Sarmatian layer underlies the Pliocene. It consists of sand-intercalated compact marls and two layers of dolomite limestone followed by a ca 1 m-thick hard gritstone layer (at depth between 66 m and 67 m). The thickness of the Pliocene patches overlying the Sarmatian is varied and fairly reduced (26 m at Ilimbav). These patches are represented by Lower Pontian sands, presumably because the upper strata had been removed by erosion. The Pliocene consists of a lower sand horizon, a complex of intermediate marls and the upper sands horizon. North of the Hârtibaciu River, at Hamba, the Pontian is 730 m thick. The upper sands complex (378 m thick) consists of eight sand beds in alternation with seven marly beds (bed thickness runs between 10 m and 40 m) (VANCEA, 1960).

It follows that the Miocene and the Pliocene deposits, in which permeable sands and impermeable wet marly-clay strata keep alternating, are prone to landsliding.

Since clay minerals show the highest concentration, while the percentage of iron oxides in Sarmatian and Pannonian deposits is reduced, the physical-mechanical properties of these deposits register significant variations when in contact with water (increased plasticity, and depleted shearing-stress resistance) (MATEI, 1983). In addition, the weathering processes affecting sedimentary deposits show up in the enrichment of the argillaceous factors in montmorillonites; the depth at which these processes act with maximum intensity depends on the permanent fluctuation of the underground water level.

The spread of glimee-affected areas and the tectonics of surface deposits on the anticline and syncline flanks is rather concordant. As a rule, the widest areas seem to follow the direction of strata inclination (tab. 1). In these geological conditions, heavy rainfall is the major landslide-triggering factor (GRECU, 1983; 1992).

TABLE 1 - Morphometrical data about the hydrographical basins in the area affected by 'glimee'

Location of the basins	Size - Order	Total area (basin) sq.km.(S)	The area covered by glimee (% S)	Age of the surface layer
Hârtibaciu (Bărcuț)	4	34.5	12.4	Miocene (Rodbav Dome)
Sărătura (Țeline)	4	24.5	4.9	Miocene (Daia-Țeline Anticline)
Hârța (Ghijasa)	4 and 5	50.0	5.0	Pliocene (Buia - Ghijasa Anticline)
Valea Morii (Movile)	4	39.0	23.0	Mio/Pliocene(Daia-Țeline Anticline)
Albac (Merghindeal)	5	11.0	4.4	Mio/Pliocene (Dealu Frumos Anticline)
Androchiel	4	23.0	1.04	Mio/Pliocene (Ilimbav Dome)
Cornățel - Valea Șerbilor	3 and 4	9.0 (V. Șerbi)	—	Mio/Pliocene (Anticline Cașolț-Săcădate)
Hârtibaciu-right-left	6	1042	3.07	Miocene and Pliocene

The local particularities of landslides are related to the way in which general potential triggering factors and the underground water sheet regime are associated. The imbalance of the Cornățel and Movile slopes was enhanced by the presence and evolution of Pliocene patches correlated with very moist periods. In a first stage, the contact zone between the Pontian and the Sarmatian lay in the lower section of the slope. Under favourable conditions (of underground water flow presumably coupled with the deepening of the Hârtibaciu river) one-two rows of mounds began detaching and sinking-sliding over very small distances. As the Pontian-Sarmatian contact zone was shifting to the central part of the slope, a new glimee sequence set in during the Quaternary. In a final, recent stage, the Pontian-Sarmatian contact line moved up the slope. These evolutive stage, corroborating the results of sporo-pollinic analyses (MORARIU & *alii*, 1964), were dated to the Pleistocene (the oldest ones) and to the Early Holocene (the youngest ones towards the scarp).

SLOPE DYNAMICS

The Cornățel landslides occur on the left side of the Hârtibaciu, in the perimeter of the Hârtibaciu settlement. Maximum altitudes range between 595 m (Codrul Hill, 6th-order interfluve) and 564 m (Viilor Hill, 4th-order interfluve). The Hârtibaciu thalweg lies at 400 m (abs.alt), altitudinal amplitude reaching about 195 m and 164 m, respectively along a distance of 1.7 km (slope declivity 16.4‰).

The N-W landslide-affected slope is deforested. In point of evolution stage and morphology two areas can be outlined on the slope (fig. 2):

– The *southern half*, in a more advanced evolution, with a balanced slope profile and flat mounds (fig. 3), is of a landslide glacis-type subjected to the action of torrential organisms. The median section of the slope, in Curmătura basin, has been fixed by plum and apple-tree orchards.

– The *northern half*, is in an earlier stage of evolution, with numerous mounds that decrease in relative and absolute height downslope (fig.4). A great many springs drain the microdepressions between mounds, meadows or crop cultures occurring over limited areas.

The glimee-affected region appears to be stabilized, yet sliding may set in anytime. The original interfluve has in part been destroyed by the scarp. The slopes lying on the opposite side, partly connected on a secondary interfluve (sliding interfluve) preserve outliers from the primary interfluve and saddles (JOSAN & GRECU, 1981). The steps of the sunken scarp in the central portion of the slope are an indication that the process is ongoing.

The slope is modelled by torrential organisms deepened by 1.5 - 2 m into the slided deluvium. Due to the geological substrate, they tend to become elongated at the top. There are some small areas in which deep erosion, and sheet wash are kept under control by plantations.

DYNAMICS OF MASSIVE LANDSLIDES (GLIMEE)

There are five rows of glimee grouped by three stages of evolution: in the upper section of the slope - 2 rows, in the median section - one row, and in the lower section - two rows. The slope facing the scar is very steep, the opposite one dipping down mildly. Glimee asymmetry within one and the same evolutionary stage and the presence of wider longitudinal depressions (between mound rows belonging to successive stages) accounts for successive stagewise land movement. The early stage was marked by regressive sinking and sliding movements (upslope) which subsequently progressed downslope. The recent glimee (450 m long, 200 m wide and 30-45 m high maximum values) occurring in the mound row closer to the scarp (stage III) are slightly elongated in shape, running parallel to the scarp and perpendicular to the direction of movement (fig. 5). The roundness indicator is 2.25 (at the base 1.25) and close to unity toward the foot of the slope (tab. 2). The scarp is subjected to sheet wash, sinking, landsliding, and gullying with a small, steep coluvial-deluvial-proluvial slope forming at its base.

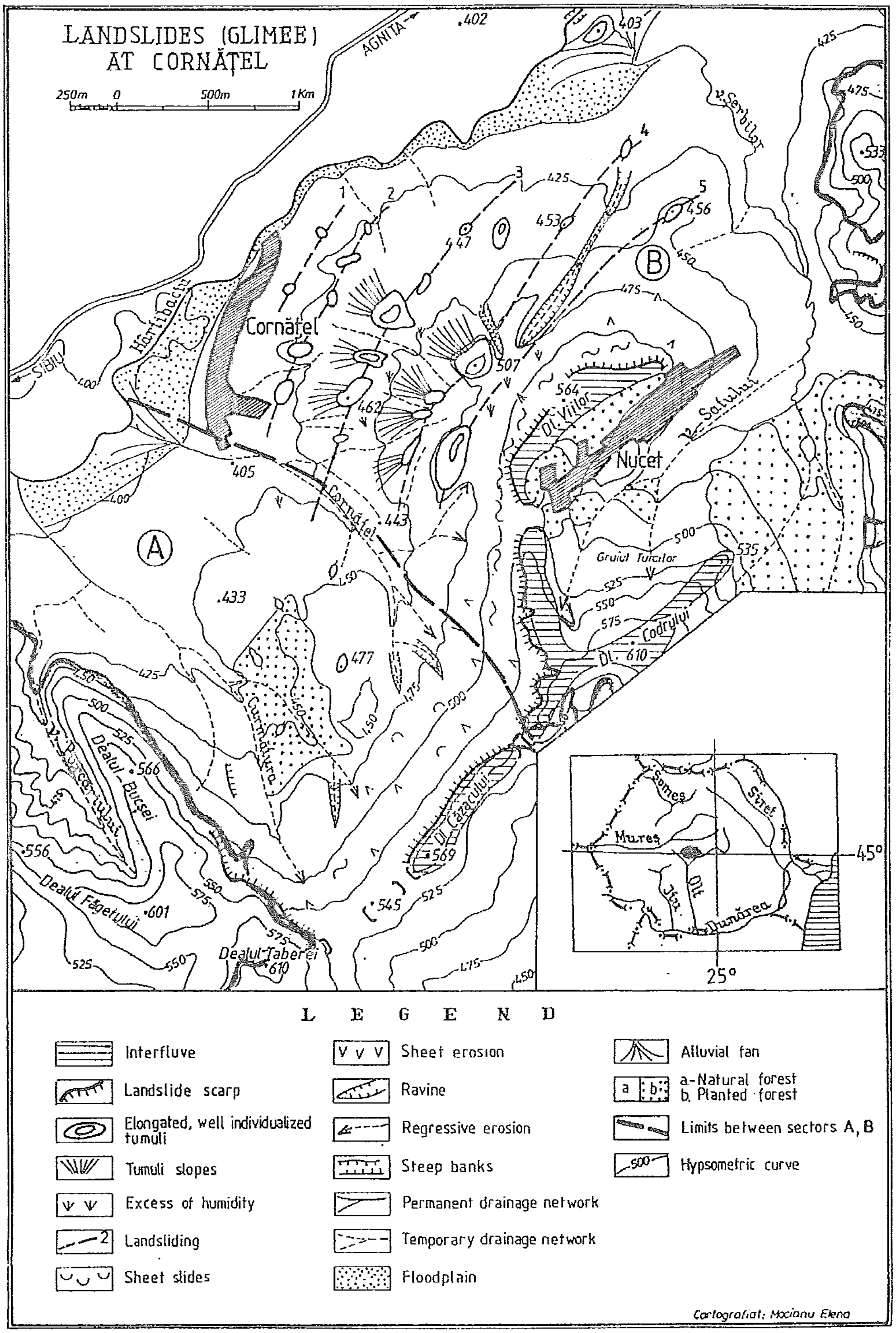

FIG. 2 - The geomorphological map of landslides from Cornăţel.

TABLE 2 - Morphometrical data of individual 'glimee'

Stage of evolution	Length (m)	Width (m)	Height (m)	Roundness index (at the basis)
III	450	200	30 - 35	2.25
II	250	200	15 - 20	1.25
I	100	100	under 5-10	1.00

According to morphometric evidence the current shape of massive landslides is the result of mass movement on the slope along time and of subsequent modelling processes, which affected all and every glimee. The sliding mass is being fragmented both in the course of its movement and afterwards, under the impact of torrential organisms.

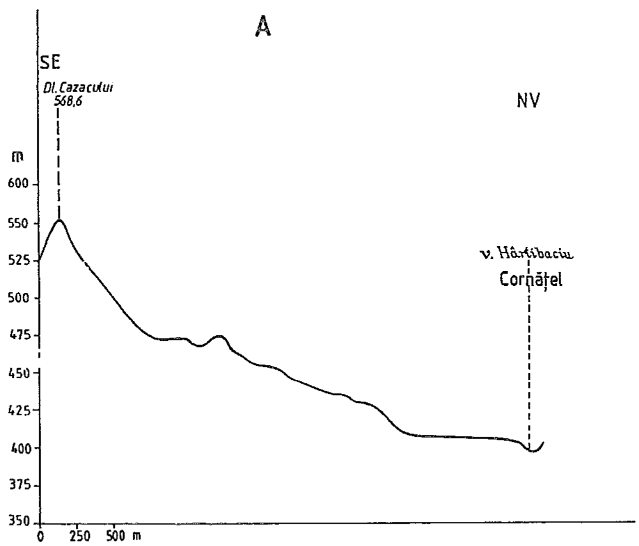

FIG. 3 - Cross-section through lanslides - sector A .

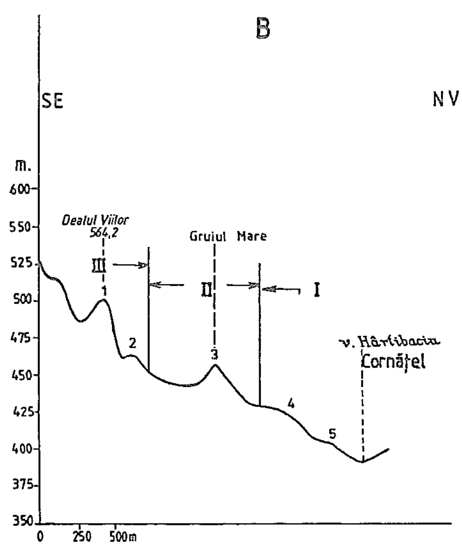

FIG. 4 - Cross-section through lanslides: 1-5, enumeration of landslides from newest to oldest; I, II, III, stages of evolution.

Glimee-affected slopes are unstable, subjected to sinking and sliding, sheet wash and run off (fig. 6). The differences of altitude found within one and the same genetic stage are rooted in the distinct evolution of each massive landslide. There are some regions (e.g. at Movile), where the lower part of recent glimee presents a step, a kind of basement, attenuated by masses of land moved from the upper part of the slope, the slope itself tending to develop a balanced profile (fig. 7).

Summing up we would say that the Cornățel landslides could be viewed as a typical area of glimee-modelled slopes.

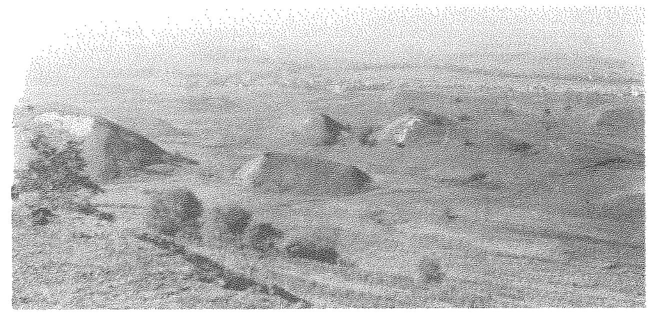

FIG. 5 - Tumuli slope and size.

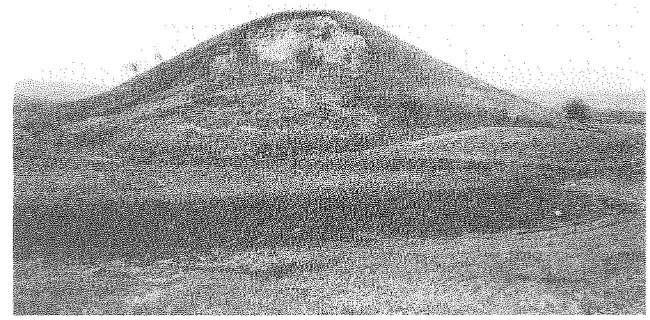

FIG. 6 - The dynamics of the tumuli.

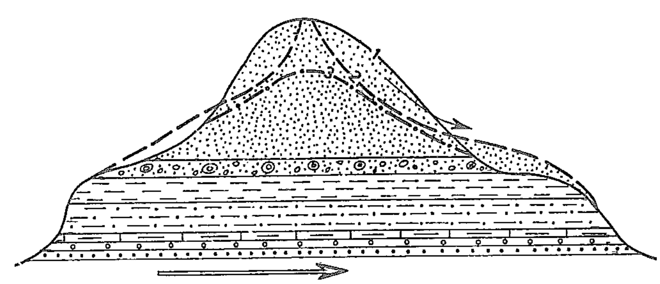

FIG. 7 - The evolution of tumuli sliding and falling: 1, the initial profile of the slope; 2, 3, the profile that formed by successive evolution of the slope.

REFERENCES

GÂRBACEA V. (1964) - *Alunecările de teren de la Saschiz (Podișul Hârtibaciului).* Studia Univ. Babeș-Bolyai, Series geol-geogr., VIII, 1, Cluj.

GRECU F. (1983) - *Alunecările de teren de la Movile (Podișul Hârtibaciului.* Ocrotirea mediului înconjurător, 27, 2.

GRECU F. (1992) - *Bazinul Hârtibaciului, Elemente de morfohidrografie.* Edit. Academiei, București.

JOSAN N. & GRECU F. (1981) - *Contribution a la connaissance des processus de versant du Plateau de Hârtibaciu (Depression de Transylvanie).* Rev. Roum. Geol. Geophys., Geogr., Geographie, 25, 2.

MATEI L. (1983) - *Argilele panoniene din Transilvania.* Edit. Academiei, București.

MORARIU T., DIACONEASA B. & GARBACEA V. (1964) - *Age of land-slidings in the Transylvanian tableland.* Rev. Roum. Geol. Geophys., Geogr., Geographie, 8, 149-157.

VANCEA A. (1960) - *Neogenul din Bazinul Transilvaniei.* Edit. Academiei, București.