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MIHAELA DINU (*)

THE RELATIONSHIP BETWEEN LANDSLIDES AND SLOPE EVOLUTION IN THE VÂLCEA SUBCARPATHIANS, RUMANIA

ABSTRACT: DINU M., *The relationship between landslides and slope evolution in the Vâlcea SubCarpathians, Rumania.* (IT ISSN 0391-9839, 1996).

The Vâlcea SubCarpatians are an example of a hilly region on the outer part of the Carpathians where many types of landslides can be observed. The old generation of landslides of Pleistocene age covers a large area. The present generation is the outcome of natural factors and anthropic activity. Usually both of them work together for changing the slope profile.

KEY WORDS: Landslides, Slope evolution, Vâlcea SubCarpathians, Rumania.

RIASSUNTO: DINU M., *Il rapporto tra frane ed evoluzione dei versanti nei SubCarpazi di Vâlcea, Romania.* (IT ISSN 0391-9838, 1996).

I SubCarpazi di Vâlcea sono un esempio di regione collinare della parte esterna dei Carpazi, dove si possono osservare numerosi tipi di frane. La più vecchia generazione di frane, di età pleistocenica, copre una vasta area. La generazione attuale è il risultato dell'interazione fra fattori naturali ed azione antropica. Generalmente le due generazioni contribuiscono insieme al cambiamento del profilo del versante.

TERMINI CHIAVE: Frane, Evoluzione dei Versanti, SubCarpazi di Vâlcea, Romania.

INTRODUCTION

The hilly region between the Topolog and the Bistrița Vâlcii rivers, which goes by the name of the Vâlcea SubCarpathians (fig. 1-A), is part of the SubCarpathians, a major relief unit in this country, featuring by the sharpest slope dynamics in Rumania. A subdivision of the Getic SubCarpathians, the region is well represented in the present relief. It evolved within the drainage basin of the Olt River, which together with lithology and structure, stamped a specific modelling style.

The constitution of rocks in this SubCarpathian sector reveals the whole succession and diversity of the Getic Depression sedimentary deposits, from the Eocene to the Villafranchian. The strips of these deposits, extending down to the Getic Piedmont in the South, are of variable width and increasingly younger age (fig. 1 B). The Neogene molasse formations form a monocline with a Southward inclination, gradually folding toward the central part of the Getic Depression. Major tectonic lines, running almost parallel to the margin of the Carpathian crystalline bloc, are Est-West oriented.

Landforms stretch up from 200 m (at the junction of the Bistrița and the Olt rivers) to 1,067m (Fața Mare Hill), the amplitude being 867 m. Slope declivity is often under 45° on marly-clay-sands and over 45° on conglomerates and Eocene sandstones. Because marly-clay and sandy-clay rocks are prevalent, mass movements are quick to develop, the Vâlcea SubCarpathian slopes undergoing a rapid evolution. Such an evolution is enhanced by a young landscape (outcropping of Mio-Pliocene structures from under the Villafranchian piedmont cover), which subjects landforms to continuous change in an attempt to adjust to the geological structure (BADEA & BALTEANU, 1982). The neotectonic movement, of different rate and intensity, which continued from the Quaternary to the Present, had permanently stimulated slope modelling, contributing along the time to the evacuation of materials from drainage basins.

The morphoclimate of the region is rich in precipitations which, during May-June (frequently in association with snow melting), accumulate in the porous formations, thus triggering (with a lagtime) landslides.

LANDSLIDES AND SLOPE EVOLUTION

Landslides represent the main category of mass movements, being particularly well-represented in the SubCarpathian region. The yare the main feature of the present-

(*) *Institute of Geography, 70307 Bucharest (Rumania).*

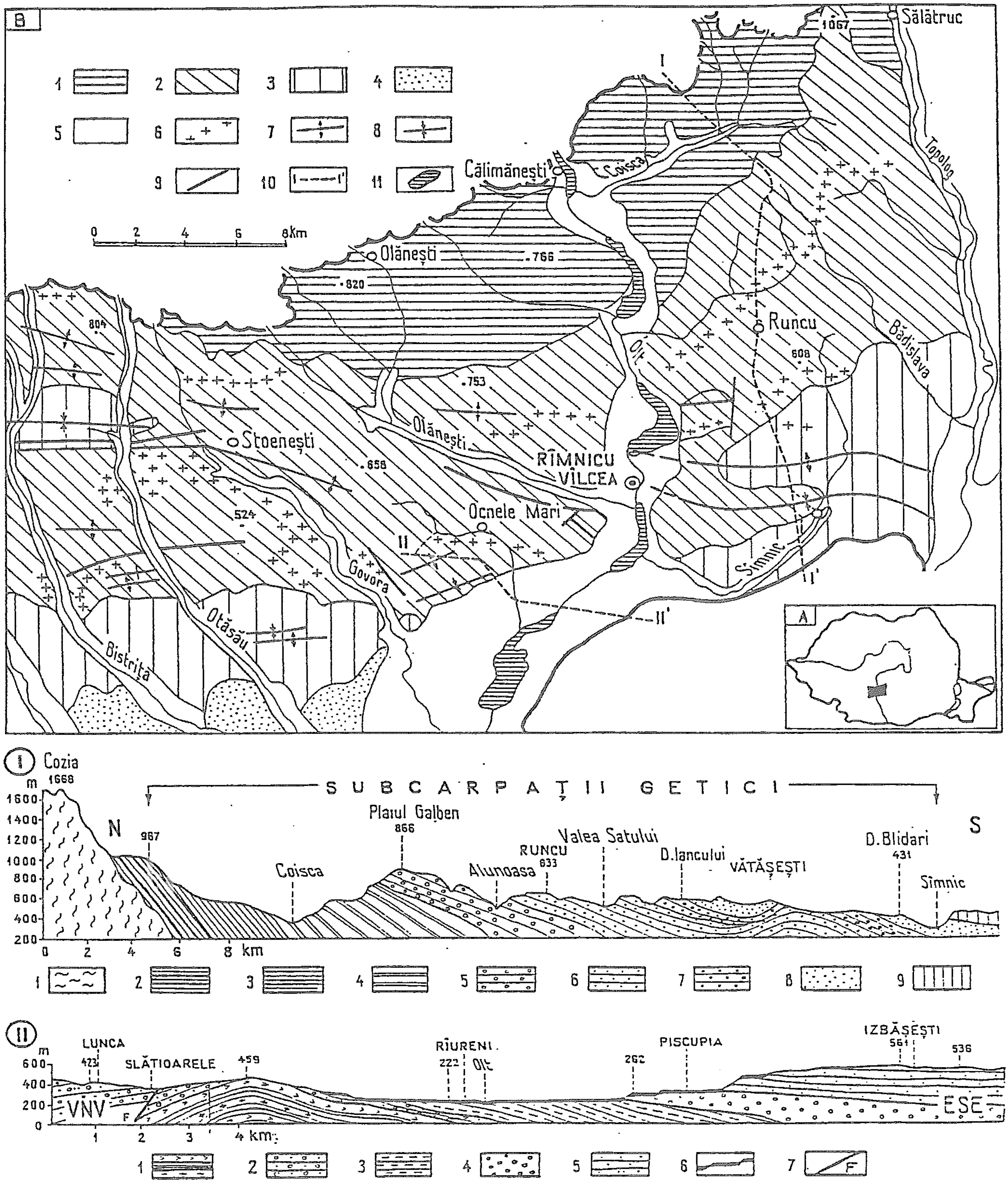

FIG. 1-A) Location of the Vâlcea SubCarpathians; B) Geological map. Legend: 1) Paleogene; 2) Miocene; 3) Pliocene; 4) Pleistocene; 5) Holocene; 6) Tuff; 7) anticline; 8) syncline; 9) fault; 10) profiles; 11) reservoirs.
Profile I-I': Length profile on the interfluve between the Olt and the Topolog rivers: 1) Cozia gneiss; 2) Upper Cretaceous; 3) Eocene; 4) Oligocene; 5) Burdigalian; 6) Baddenian; 7) Tortonian; 8) Sarmatian; 9) Meotian; 10) Pontian: 11) Dacian; 12) Villafranchian.
Profile II-II': Cross section on the Olt river, South of the Râmnicu Vâlcea: 1) Tortonian; 2) Sarmatian; 3) Lower Pliocene; 4) Villafranchian; 5) Pleistocene; 6) Holocene; 7) fault.

day modelling in the Vâlcea SubCarpathians, having a multitude of forms. While other denudational processes unfold continually causing small quantities (per time and surface unit) of material to be transported, landslides occur at random in time and space, but with visible effects on slope morphology. They develop suddenly, are difficult to prognosticate and prevent and incur great damage.

Findings indicate the existence of several dynamic cycles of activating slidings. One can even speak of seasonal cycles. Reactivation of old slides over the past 150 years in the Eastern Carpathians (ICHIM & *alii,* 1984; SURDEANU, 1988) and in the Curvature SubCarpathians (BALTEANU, 1983) has been recorded roughly every 30 years.

Two major generations of landslides are reported for the Vâlcea SubCarpathians (DINU, 1991).

The old generation of landslides (Pleistocene) are very deep and cover the hillslopes above the 200-240 m terrace level. The mere fact that they are spread throughout the SubCarpathian regions, speaks about their slope modelling during the Quaternary. This assumption is confirmed by the presence of large landslide monticles (deep slides), partly destroyed by erosion or recent sheet slide. The monticles occur in the upper section of slopes and on summits, being disseminated largely in the marly-clay strip of the Chiciura Hill (between the Sâmnic and the Sâmnicel rivers, covered with forests), the Lacul Frumoasei Hill (covered with pastures), on the summits between the Olăneşti and the Govora rivers (covered with forests and pastures), on the summit between the Otăsau and the Bistriţa valleys (covered with pastures). The slope appears to be widly dipping, because both the monticles and the depressions between monticles are intensely altered by other processes (yet not changing their form completely).

Present landslides represent smaller reactivations of older or fresher, historical and contemporaneous sliding deluvia. There is a large variety in shape: from furrows to lenticular nest they may acquire vast proportions, affecting the entire slope.

Present landslides are triggered by natural causes (mainly rock type and water), but human activity did much to accelerate their occurence (many settlements which developed 4-5 centuries ago have been considerably extending).

The size of the slide, its shape, type of material moved, mode of transport, all play an important part in shaping the relationship between slides and slope evolution. As far as the thickness of moved deposits and the volume of material transported are concerned, one may identify three types of slides in the Vâlcea SubCarpathians (tab. 1).

TABLE 1 - Type of landslides in the Vâlcea SubCarpathians.

	Length/m	Width/m	Depth/m	Inclination	Shape	Landuse	Slope profile	Type	Movement
Sheet slides	25-50	1.5-15	1-1.5	>5°	linear irregular elongated	pastureland hayfield orchard farmland	linear convex concave inclined	lenticular	translational
Medium deep slides	25-75	5-25	1.5-10	>5°	linear irregular elongated	pastureland hayfield orchard farmland	linear convex concave inclined	lenticular	translational rotational
Deep slides	25-250	5-40	5-15	>5	monticles irregular	pastureland hayfield orchand farmland forest settlements	step-like concave inclined	monticle ripple	translational rotational

Sheet slides (superficial) are most frequent; they are directly related to land use. Wherever the upper part of the slope is used as pasture, hayfield or as orchard, sheet slide develops in the immediate vicinity of the watersheds (the hilly zone of Ianculesti, Blidari, Lacul Frumoasei, Stoenesti), overlying older monticles. In the convex slope area, where the cover of surface deposits is thinner, sheet slide reaches the bottom rock itself. In the concave area of slopes, and on the glacis formed at their feet, where the weathering crust is thicker, the slides tend to cover a larger area (along the Olt river and its main tributaries).

Sheet slides have been found in very diverse situations: on old and very deep monticles as in the hills of Măgura, Runcu, Lacul Doamnei, Ocnele Mari and Govora; in the convex sectors of steep slopes (Cheant Hill); in the concave sectors of steep, overwet slopes of the valley basins of Coisca, Sâmnic, Muereasca, Cacova and Govora; on junction glacies between the Olt waterplain and its terraces, or between the waterplain and the slopes; at the foot of slopes undermined by small ephemeral streams (tributaries to the mainstreams); on deforested structural surfaces (sometimes on areas where the forest is scarce) used as pasture, hayfield or as orchard, more extended between the Topolog and the Olt and between the Otăsau and the Bistriţa Vâlcii valleys; on materials piled up at the base of cuestas all-over the area of monocline structures; in the folded zone, especially in the portion of Ocnele Mari-Govora anticline, where sheet slide is connected with the dissolution of salt. Sheet slides are a landmark of present-day relief modelling in all the depressions, in the Olt passageway and in the passageways of its main tributaries. They affect also some arable lands (Tigveni, Muereasca, Pausesti-Maglasi, Govora-Sat), village hearths (Rădăcinesti, Runcu, Feteni, Pausesti Otăsau) and sometimes the recently afforrested slopes (the upper basin of the Sâmnic and the Tulburoasa).

Medium-deep and deep slides, (tab. 1) have the greatest spread and diversity of forms. Using a classification by form and shape, resulting from their genetic complexity, we would list mound or monticle slides, step-like slides or pseudoterraces under simple forms, and valley slides and slide slopes under complex forms (TUFESCU, 1966).

The deep slides (old and recent) affect the majority of slopes developed on marly-clay rocks with intercalations of sands and tuffs. These slides are translational and rotational. Likewise sheet slides, they occur in pasture lands and hayfields, but they are more widespread in the settled perimeters (the villages of Rădăcinesti, Dângesti, Feteni, Fundatura), on farmlands on slopes (Vlădesti, Păusesti Otăsau, Frâncesti) and below the forest belt (400-800 m high hills). The fact that they occur in highly diverse conditions is an argument in favour of the idea that sliding is a normal process for the rhythmical evacuation of deluvia from the Sub-Carpathian slopes (BALTEANU, 1983).

Although apparently deep slides are relatively stabilized, being the outcome of an older (Pleistocene) evolution, they are actually evolving, though at a slower pace, preparing a new cycle of reactivations. As a proof of it stand the inclined trees on monticles and the rounded (blunt) monticles subjected to (surface and deep) erosion or to recent sheet slides (upper basin of the Sâmnic, Magura Hill, Ocnele Mari Hills, Govora Hills). Monticular slides occupy various sections of the slope: the upper part of the drainage basin source area up to the summits (Valea Mare, Alunoasa, Glâmboaca); the median part above the highest (200-240 m) Olt terrace level (Crucea Mierlei, Piscu Mare); in many cases, materials brought from the slope during several reactivation phases accumulate at the foot of the slope in the form of thick slided deluvia.

There are few active deep slides and they affect smaller areas than the fixed ones. They can reactivate deluvia and the rock in situ. More numerous are the medium-deep slides, dominant in the Muereasca, Govora, Otăsau and Bistrița valleys (fig. 2).

One of the active deep slides occurred at Păusesti Otasau, on the left side of the Otăsau (DINU, 1991), during 1981 (fig. 3). It affected the upper section of a cuesta slope

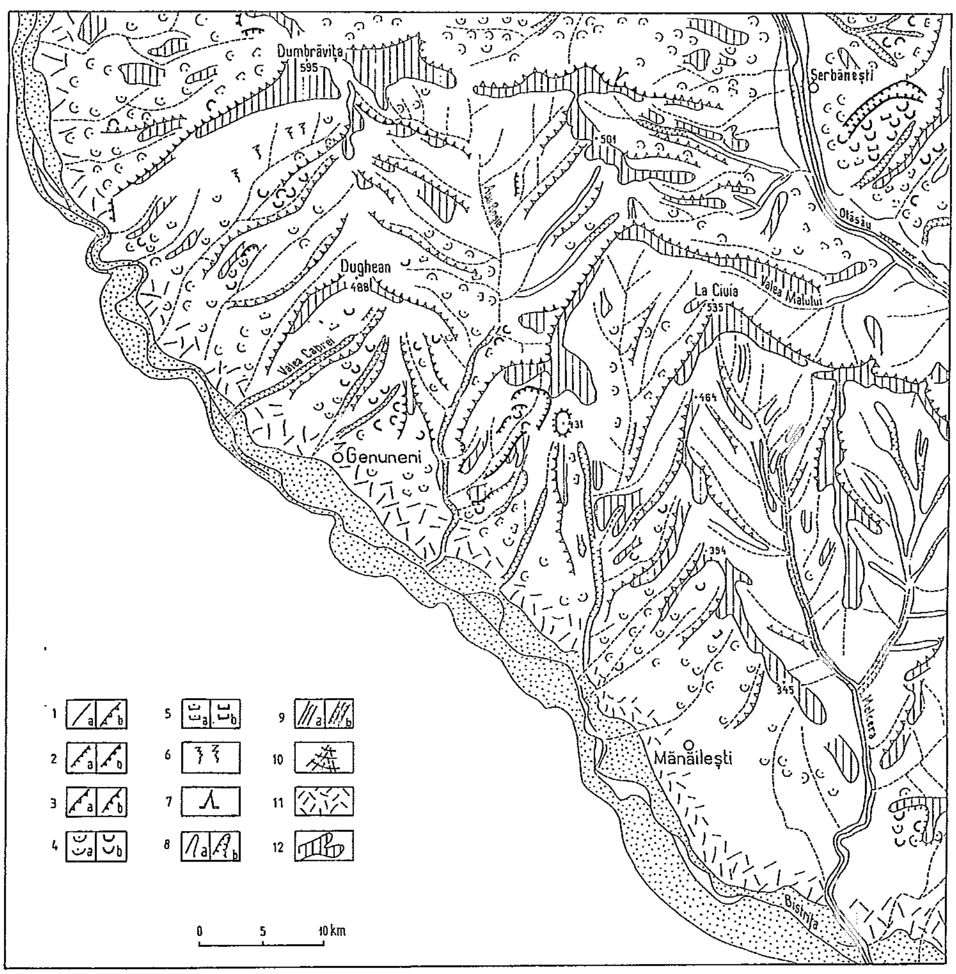

FIG. 2 - Șerbănești area, geomorphological sketch: 1) scarp under 2 m, (from numbers 1 to 5 a: fixed, b: active); 2) scarp from 2 to 10 m; 3) cuesta; 4) sheet slides; 5) deep slides; 6) sheet wash; 7) gully; 8) ravene, a: fixed, b: active; 9) banks a: stable, b: active; 10) alluvial fans; 11) glacis; 12) flat or slightly dipping summits.

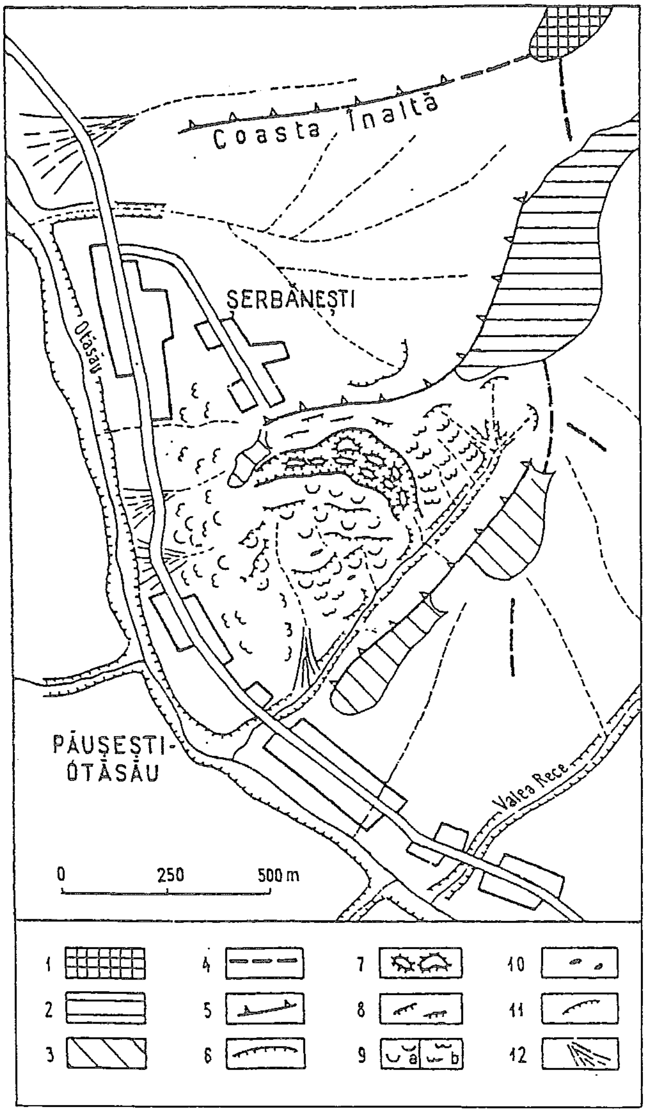

FIG. 3 - Păuşeşti Otăsău (Serbăneşti) recent deep slide: 1) 450-500 m level; 2) 375-425 m level; 3) 275-325 m level; 4) interfluve; 5) cuesta; 6) escarpment; 7) monticles; 8) scarps; 9) a: medium-deep slides, b: sheet slides; 10) temporary lakes; 11) banks; 12) alluvial fan.

(Baba Floarea Hill, 534 m) and was triggered largely by the heavy rainfalls during May 1981. After a long period with drought (from January till April, under 50 mm/month) the heavy rainfalls occurred during May, June and July (between 115-200 mm/month). The equilibrium broke at the contact of the Pliocene (fine-grained sands with thin shale intercalations) with the Miocene (marls, clays, sands, tuffs). The sudden ounset of the slide was associated with the formation of a huge, ditch-like depression with a curved trajectory, concaving toward a gully source area on the side of the Otăsau. The ditch is 350-400 m long, 40-60 m wide and 8-15 m deep. Inside it one can still see the monticles left by the slided and fallen material, initially pointed in shape and with the old structure fairly well visible (fig. 4). The shape of these monticles is subject to permanent change, as is their height, which is declining. The surface cover, together with the slided rocks, altered the initial slope profile (from linear to step-like), deregulating the entire drainage network. The thalweg of the gully and some tributaries were barred by the rotational slide. That covered almost the entire length of the opposite slope. In the depressions, emerged behind the main ripple and along the former stream course, waters began accumulating and the sectors of some deregulated streams became apparent.

From the upper section of the slope the material moved on the gully tributaries, the scarps of which were reactivated (2-10 m). The whole movement-affected slope can be viewed as a fully evolving sliding slope. Sheet slide was reactivated along the monticles and deep erosion became very intense. The slide destroyed three homesteads that stood above the road, itself covered by slope-washed material. Damage was caused also to the farmland on the slope.

There are situations when actual sliding slopes are formed (Lacul Frumoasa Hill on the left side of the Sâmnic Valley at Popeşti, on the left side of the Buleta Valley, on the left side of the Stancioiu Valley). On these slopes there is a step-like display of elementary forms: a) sliding rock-and-soil falls in the upper part, shaping the scarp of corniche and the deep depressions; b) a wide diversity or sliding types in the median section associated with gully erosion, wrenching processes and maximum soil moisture; c) sliding-rock and soil falls (the undermining of the slope by lateral erosion) associated with sinkings, flows, gullying in the lower section, where, in time, a sliding glacis begins forming, with a tendency to extend up-slope.

Valley landslide, a name first given in Romania by MIHĂILESCU (1940), are the result of complex processes which, starting from an ensemble of lateral source areas, are drawning the whole valley and its ramifications. These slides fill the majority of small, ephemeral subsequent valleys which intersect marly-clay and sand horizons (very comon on the Eocene deposits, at the Northern contact with the mountains). Unlike in the permanent network, materials here are evacuated intermittently.

CONCLUSION

The present-day modelling of the region is a complex process begun in the Pleistocene and continued through the Quaternary to the Present. Modelling processes are not isolated, they are associated with similar or different categories of processes (more obvious than in any other relief units). So, slopes undergo several types of mass movements and erosion processes, adjoined in space or superposed in time. In some cases, certain processes become dominant (usually sliding or deep erosion); certain relief-destructive processes might have induced an alternative evolution. It would be fairly difficult to establish with precision which of these processes was fundamental in modelling the slopes. However, what is certain, is the fact that mass movements, sliding, flowing, sinking, rock and soil falls, did prevail during some periods of time.

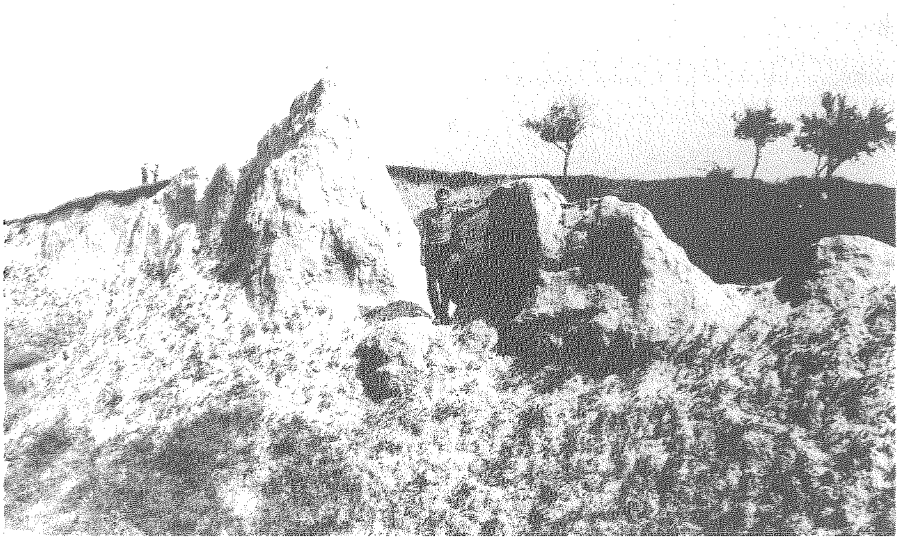

FIG. 4 - Păusesti Otăsău recent deep-slide: monticles inside the ditch.

Presently, a combination of mass movements and gullying is assessed to be responsible for the rate of slope change and destruction, significantly influencing all the other landscape components, as well.

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