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LANDSLIDES IN THE CARPATHIAN CURVATURE PALEOGENE FLYSCH. PARTICULARITIES

ABSTRACT: CIOACĂ A., *Landslides in the Carpathian Curvature Paleogene flysch. Particularities.* (IT ISSN 0391-9838, 1996).

The folded formations of the Curvature area Paleogene Flysch generate a particular morphology which shows up in the wide diversity of primary or secondary landforms. These landforms, the work of longer subaerial evolution and of present day neotectonic movements which accelerate erosion, depend on the varied resistance of sandstone rock to climate rather than on the narrow-folded structure itself. The relief being young, cement and granulometry are best revealed by landsliding which permanently maintains instability on slopes. As a consequence, most landslides entail an appreciable transfer of material from the slope to the valley, barring it and favouring the formation of small lakes behind the natural dams. This type of landslides has a high incidence on the landscape, as natural storage lakes usually lasting for more than one generation.

A few case-studies of the marginal flysch in the Curvature area (the lakes Ciocul Paltinului on the Bâsca Fără Cale River; Negru Lake on the Zăbala and a former lake on the Bâsca Rozilei, no longer visible today), formed by the landsliding in the Ruptura settlement area offer some information on the morphodynamical features of these landslides.

KEY WORDS: Landslides, Flysch, Curvature Carpathians, Rumania.

RIASSUNTO: CIOACĂ A., *Frane nel flysch paleogenico nel settore della Curvatura dei Carpazi. Peculiarità.* (IT ISSN 0391-9838, 1996).

Le formazioni flischoidi paleogeniche piegate dell'area di Curvatura dei Carpazi, generano una particolare morfologia che si evidenzia in una grande varietà di forme primarie e secondarie del paesaggio. Queste forme, che sono il risultato di una lunga evoluzione subaerea e di movimenti neotettonici attuali che provocano un'accelerazione dell'erosione, dipendono dalla variabilità di resistenza delle rocce arenacee più che dalla struttura fortemente piegata. La franosità mantiene permanentemente l'instabilità dei versanti. Come conseguenza, la maggior parte delle frane provoca un apprezzabile trasferimento di materiale dal versante ai fondivalle, causandone lo sbarramento e favorendo la formazione di piccoli laghi a monte di queste dighe naturali. Questo tipo di frane ha un'alta influenza sul paesaggio, poiché questi laghi rimangono per più di una generazione.

Alcuni piccoli casi studiati come il Lago Ciocul Paltinului sul Fiume Bâsca Făr Cale, il Lago Negru sullo Zabal ed un ex lago sul Bâsca Rozilei (non più visibile oggi), formati da fenomeni franosi nell'area di Ruptura, forniscono alcune informazioni sulle caratteristiche morfodinamiche di questi fenomeni gravitativi.

TERMINI CHIAVE: Frane, Flysch, Settore della Curvatura dei Carpazi, Romania.

THE CURVATURE CARPATHIANS

Because of the discordant disposition of major orographic linea against structural lines, the Curvature Carpathians [1] represent, from a morphogenetic viewpoint, the most intricate part of all flysch-underlain mountains. (GEOGRAFIA ROMÂNIEI, vol. III, 1987). The flysch sheets, remarkably parallel, fall into two large subnits: Cretaceous (the inner strip) and Paleogene (the outer strip). What distinguishes these two subunits is not only age of the respective formations, but also their particular structure and rock composition (MUTIHAC & IONESI, 1974). All in all, the Curvature mountain relief is the reflection of tectonic events: slow-going sinking on the inner flank, or reduced positive crustal movements and marked uplifting on the outer flank.

The Cretaceous flysch features by highest altitudes (Postavaru, 1799 m; Piatra Mare, 1883 m; Baiu, 1995; Ciucaş, 1954 m), engendering a corresponding orographic asymmetry. Since limestone formations prevail (limestones, conglomerates and sandstones with limestone cement) sinking and rock-and-soil falls have a higer incidence. The Paleogene flysch consists mainly of sandstone formations in alternation with argillaceous schists and with thin intercalations of limestone in the Negru Lake area). This lythological and structural aggregate is called the morphostructural unit of mountains developed on Paleogene flysch. In terms of grain size, mineral composition of particles and degree of gluing together, we distinguish at least two subunits: the Tarcău sandstone flysch and the Fusaru sandstone flysch. The former is responsible for sinking, sliding and gullying: the latter for landslides and mud flows. As a rule, the drainage network crossing the Paleogene flysch along one and the same valley, meets all such geomorphological processes; they are triggered by the different sandstone facies alternating with clay and marly schists. For exemple, the

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[1] The Curvature Carpathians correspond to the southern part of Eastern Carpathians.

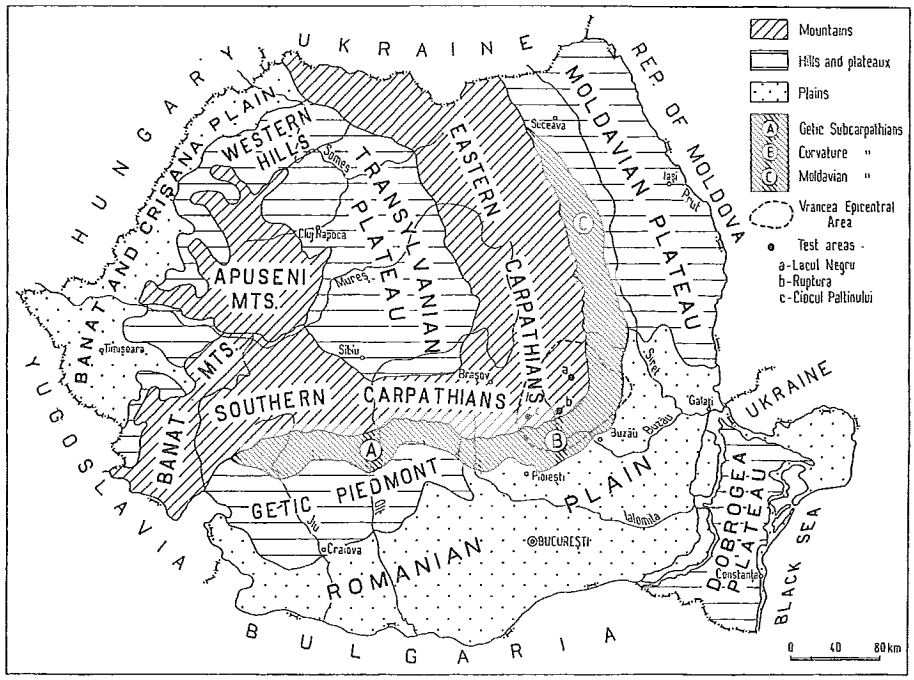

FIG. 1 - Location of studied cases within Romania's relief levels.

quartz grains from sandstones (psammites represent 70-80% compared to only 20-30 aleurites) readily becoming loose, the sinking and rock-and-soil fall of sandstone blocs (noticeable today in the masse of slided material) is very much facilitated. Moreover, the heterogeneous mass of landslides, also containing particles of sandstones and clay films, often forms an impermeable paste, which strengthened by sandstone blocs, is an ideal material for the formation of natural dams when the slide front rapidly reaches the valley. If the physical properties of the slided mass we would add the presence of some fixing elements (trees, wood clusters, narrow valley sectors, constructions and roads in mounds) we could easily account for the formation of smaller or larger storage lakes, some temporary (lasting for a few years) others of longer duration (one generation or more).

LANDSLIDES AND LAKES

Our investigations into the Curvature Carpathian Paleogene flysch were based on the Epoch Programme classification of landslide age (old landslides: Prequaternary and Pleistocene; historical landslides: old and recent; recent and present-day active). In the light of our dating possibilities (historical documents, local archive records, old maps, information supplied by aged locals), we focused on the recent landslides of the 19th and the 20th cc and the present-day active landslides. In line with the above programme we outlined the following situations, by type of activity: potentially reactive landslides (singular or episodic) and active landslides (occuring for the first time, intermittent, or continual). In view of the above, we consider these landslides associated with the formation of natural dams behind which the water of rivers keeps accumulating, is a major geomorphological risk. We may speak of a type of geomorphological risk specific to the Curvature Carpathian Paleogene flysch, where such phenomena are longlasting and have notable effects. The areas affected directly, or up the stream, being far more vulnerable, we studied the case of landsliding in the Negru Lake on the Zăbala Valley, Ciocul Paltinului Lake on the Bâsca Fără Cale Valley, or in the Bâsca Rozilei Valley, at Ruptura, where the landslide-formed lake is no longer visible today.

The Negru Lake slides are of recent date (1979). They began on the left side of the valley, affected by older such processes, periodically reactivated. This makes us assume that, in the historical past, storage lakes of different sizes, did form on the same site. In effect, the junction area upstream the dam formed in 1970, loks like a narrow plain branched out along the Zăbala and the Valea Mare valleys with obvious fluvio-lacustrine deposits. From the lake which in 1970 measured nearly 1, 000 m in length on the Zăbala and 600 m on the Valea Mare, there remained only 600 m on the Zăbala and 350 im on the Valea Mare in 1984. The intense gullying which had carried the slided material, silted the lake, so that in 1995 what remained of it was and ovoidal pool in the confluence area, long of 263 m and wide of 70 m, one-third covered with a water vegetation (fig. 2, a).

Another interesting aspect in the that the slide steps lie over the strips of different rocks traversed by the landslide. Here again, there are three geomorphological risk classes (low, moderate, and high) but foreseeable effects involve only the road running parallel to the Zăbala and the forest areas surrounding the slide (CIOACĂ, 1985).

In the upper and median sections, a 2-3 m delevelling is the outcome of the resistance put up against erosion by the Paleogene limestone plate (0.2-0.4 m) cropping up among the slided materials. In-between the median and the lower

sections, there is a thin Paleogene limestone strip (0,10-0.25 m), a temporary landing for part of the sandstone material transported by the upstream active surface slides. This sandstone strip is undermined by the springs of the Grosu Straia horizon (sandstone-limestone flysch), a supply source for the huge mass of sliding material.

A peculiar case is the landslide in the Ruptura settlement area, on the southern slope of the Podul Calului Mts. (fig. 2, b) marked by vast slidings which often reach the Bâsca Rozilei channel-bed forming momentous natural dams with temporary lakes emerging behind them. The study of the Ruptura slide was prompted by the morphodynamic particularities of this slide and its effects on the Bâsca Rozilei bed, on the road along it and on the hamlet located on the body of the slide. Some of these effects are documented in the archives of Păltiniș Church and in local place-names. The oldest records (1870) tell of a landslide that had destroyed part of the Vâsc village homesteads and dammed Bâsca Rozilei stream. The lake that formed behind the dam covered not only the stream bed but also the lower terrace cropland, so that people would rebuild their houses higher up on the alluvial fan formed on a leftside tributary of the Bâsca in front of Vasc village. This hamlet was given the name of Balta[2] because the waters of the lake formed behind the dam bordered it to the north. The road running on the right bank of the Bâsca Rozilei stream could be reached by crossing the slide-formed dam itself. At the same time, part of the scattered homesteads of «Pe Ruptură» hamlet, lying in the immediate neighbourhood of the scar, were severly affected by its reactivation, which indicates that the sliding mass moved down the slope. Since then, the hamlet went by the name of Ruptură, with mass movement going on intermittenly and making people abandon some of their homesteads. In 1923, the heavy summer rainfalls led to huge water amounts accumulating in the brittle rocks, so that by early autumn the first sliding coluvia fissured numerous houses and the local church. The documents kept at Păltiniș Church tell how the icons of Ruptură Church were brought there, and how the wood the church had been made from, was sold. What was left of it were its foundations and the plant-cover of its yard. Some aged locals recount how a mulberry - tree, which had stood in front of the church-gate, began sliding slowly downstream (by nearly 400 m - fig. 2 b) in 1990, already withered, it was cut down.

The most active sector of the slide today is the lower one (over 600 m wide) which goes down to the Bâsca waterplain. The many moist areas of the median part represent a permanent supply source for the water layer here, and the active sliding bed that is being formed steadily changes this section's chaotic morphology. With gully erosion deepening on the sides of the slide, and on the Ruptura valley banks, the slided mass is sectioned into several groups with a distinct dynamics each: a large alluvial fan in the west, at the mouth of a slide valley; its material is being permanently evacuated, so that the accumulations pile up and trigger catastrophic events. In the east, however, the slide-carried mass of rock stagnating, it becomes compressed, suddenly triggering the movement of large quantities of material and endangering the circulation on the highway. Although they use to remake it, it is far from being properly consolidated, so that it is highly undulated and deviated toward the valley side; successive road fragments and cover materials are visible in the profile section of the bank, indicating the recent episodic evolution of the slide. This sector also shows active micro sheet-wash, small monticles, sliding coluvia through compression of moving material, microdepressions filled with water or with a hydrophile vegetation, and 2-3 m-high slopes formed along the tracks which erosional material is evacuated through.

The recent most slidings which barred a valley in the Curvature Carpathian Paleogene Flysch, forming the Ciocul Paltinului and the Funicular lakes on the Bâsca Fără Cale Valley, occured on the lower step of the Buzău Mts. - the Zmeuret - Monteoru. Their geology is dominated by an alternation of narrowly folded and faulted Paleogene sandstones and shales, lying in the vicinity of the internal (Cretaceous) flysch. And altough the steep slopes are afforested, nevertheless erosion processes and slidings do develop. Slidings entail important masses of material (sandstone blocs framed in a sand - clay mould produced by the disaggregation of the Fusaru sandstone) and shales in rainy periods, or in the wake seismic shocks, and are running fastly downslopes.

After the March 4, 1977 earthquake (M = 7.2), huge amounts of material from either slope, inclusive of a marginal section of the righthandside valley forest, reached the Ciocul Paltinului point, barring the valley almost instanteneously, and the lake that formed was 1,000 m long. after de dam remained settled at 632 m alt., the lake, still in place today, shrank to 872 m in length and 322 m in width in its central section where it is 2.2 m deep because the landslide-formed slopes are mild and rather symmetrica (fig. 2, c). Given the configuration of the dam and its permanent supply with materials from the two active neighbouring slides, the lake is assumed to last for several generations (we could assimilate in with Roșu Lake in the Bicaz Valley, which formed in 1837 after a heavy rainfall period, and is still in place today). Which is not the case of the Funicular Lake, formed in 1982 and situated 1.3 km downstream the Ciocul Paltinului Lake, given that the transport capacity of the Bâsca Fără Cale River is greater tham the rate of material carried by the landslides down the slope. Therefore, in less than one generation, the dam is supposed to destroyed.

CONCLUSIONS

In the morphostructural mountainous unit developed on Paleogene flysch outside the Curvature Carpathians, the relative homogeneity of sandstone and shale alternations makes mass movement an extensive phenomenon even on afforested slopes. The presence of rather narrow valleys, bordered by steep slopes, is a favourable background for landsliding and the accumulation of slope materials into the valley, liable to forming natural dams anytime. The lakes developed behind these dams have often af-

[2] In romanian «*Balta*» means little lake and «*Pe Ruptură*» on breaking off.

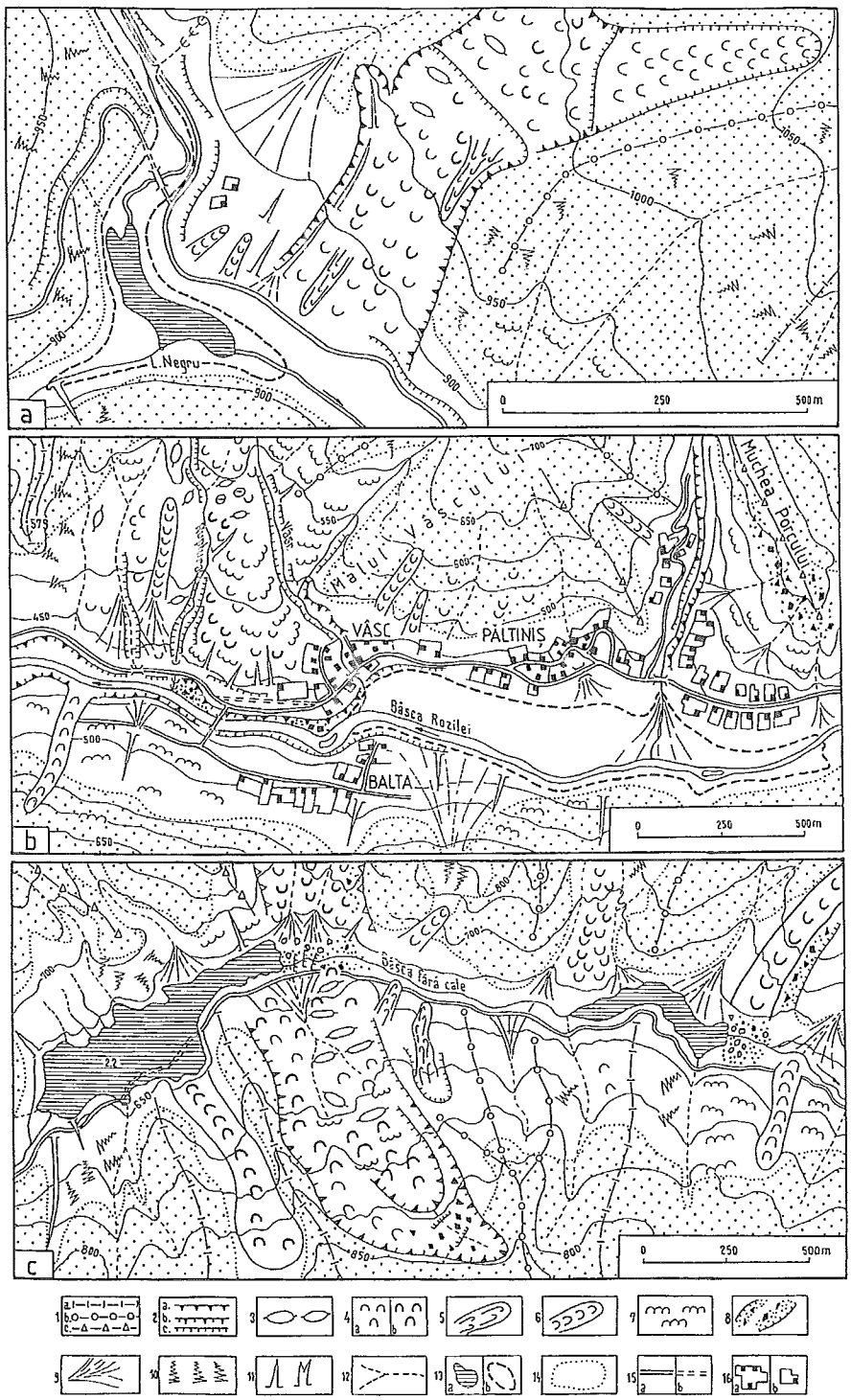

FIG. 2 - Geomorphological sketch of studied landslides: (a, Negru Lake; b, Ruptura settlement; c, Ciocul Paltinului Lake): 1) mountain summits (a, step-like; b, rounded; c, pointed); 2) sharp delevellings (a, over 10 m; b, 5-10 m; c, under 5 m); 3) monticles; 4) landslides (a, stabilized; b, active); 5) mud flows; 6) sliding valleys; 7) solifluxions; 8) rock-and-soil falls; 9) alluvial fans; 10) sheet wash; 11) gullies; 12) small fixed valleys; 13) lakes (a, present area; former area-reconstruction); 14) forests; 15) roads (a, not affected; b, affected by landslides, or flooded by lake waters); 16) tightly-grouped settlements (a) and scattered homesteads (b).

fected the roads and the scattered mountain homesteads. Since these geomorphological processes have negative effects upon the region's economy, broadening the area of investigation is an imperative necessity. Similar case-studies applied to different structural and petrographic conditions could lead to the outlining of a geomorphological risk category specific to the Curvature Carpathian area.

REFERENCES

CIOACĂ A. (1985) - *Consideratii asupra reliefului structural din Subcarpatii Vrancei.* Studii si cercetări de Geologie, Geofizică si Geografie, Séria Geogr., T.32, 71-72.

GEOGRAFIA ROMÂNIEI, vol. III (1987): *Carpatii Românești și Depresiunea Transilvaniei.* Ed. Academiei, 185-210.

MUTIHAC & IONESI B. (1974) - *Geologia României.* Ed. Tehnică, 183-186.