Morphostructure and Morphodynamical Processes in the Milcov Morphohydrographic Basin

Florina GRECU, Răzvan SĂCRIERU

Key words: vulnerability, Milcov, landslides, longitudinal faults, transversal faults, lithological contacts

Abstract. The present work aims at analyzing mainly the vulnerability to the imminent tectonically induced geomorphologic risk. The Milcov morphohydrographic basin is situated at the exterior of the Bend Zone –a highly tectonically active region. Most part of the observed area is of medium and high vulnerability in the present surface relief modelling processes, and tectonics is in a greater degree a preparatory factor than a triggering factor. In the internal Subcarpathian sector, major reactivation of landslides occured along longitudinal and transversal faults. The slopes are in continuous imbalance. The geological structure mirrors well the morphology of the landslides. In the medium sector, landslides occur mainly on lithological contacts. The inferior sector shows increased vulnerability to hydric and river bed processes.

Rezumat. Lucrarea de faţă îşi propune să analizeze cu precădere vulnerabilitatea la riscul geomorfologic iminent indus tectonic. Bazinul morfohidrografic Milcov este situat în partea externă a Curburii Carpatice – o regiune deosebit de activa din punct de vedere tectonic. Cea mai mare parte a arealului analizat se încadrează în clasa de vulnerabilitate medie şi mare la procese de modelare actuală iar tectonica reprezintă în primul rând un factor pregătitor şi mai puţin unul declansator. In sectorul subcarpatic intern importante reactivari ale alunecarilor de teren s-au produs in lungul faliilor longitudinale si transversale. Versantii se afla permanent intr-o stare de dezechilibru. Structura geologica se reflecta foarte bine in morfologia alunecarilor de teren. In sectorul mediu alunecarile de teren apar in special pe contacte litologice. Pentru sectorul inferior s-a observat o vulnerabilitate mare la procese hidrice si de albie.

Introduction

The Milcov morpho-hydrographic basin develops outher area of the Bend Zone. Within the Milcov river is a tributary of the Putna river (Fig. 1). The longitudinal profile extends over 84 km, between 1040 m altitude (springs), and 25m altitude to the Rastoaca confluence (Eastearn from Focsani). The geographical situation in the most active tectonic area in Romania and the most seismic active area in Continental Europe, as well as other external factors, is the condition for an intense geomorphological processes pattern.

The present work aims at analyzing mainly the vulnerability at the geomorphological, tectonically induced imminent risk. We thus evaluate the existence of vulnerability and, respectively, natural risk (Grecu, 2006, 2007) or biophysical vulnerability, which is the response of certain systems to the alterations of other systems from the environment, which they come in contact with (Birkmann, 2006, World Conference on Disaster Reduction; Hyogo Framework for Action 2005 – 2015”) (Grecu, 2009).

The tectonics and the stratigraphy of the basin (alternating pervious and impervious rocks) decisively influences the dynamics of the relief. Geologically, the Milcov basin and the entire Bend Zone have been subject to several research trends: the geological general analysis (Mateescu, 1927) the geology and the tectonics of the Neogene molasse (Paucă, 1942, 1952), the Milcov Strata (Macarovici, Motnas, Contescu, 1967), the geology of the Neogene deposits between the Milcov Valley and Putna (Cehlarof, 1998), the geological development starting with the Pliocene (Necea, Fielitz and Matenco, 2005), the tectonic characteristics of the Vallachian Phase (Hippolyte, Săndulescu, 1996), the subsidence rate of the Focsani Depression (Tărăpoancă, 2003), the present subsidence from GPS measurements (Hoeven van der et al., 2005).

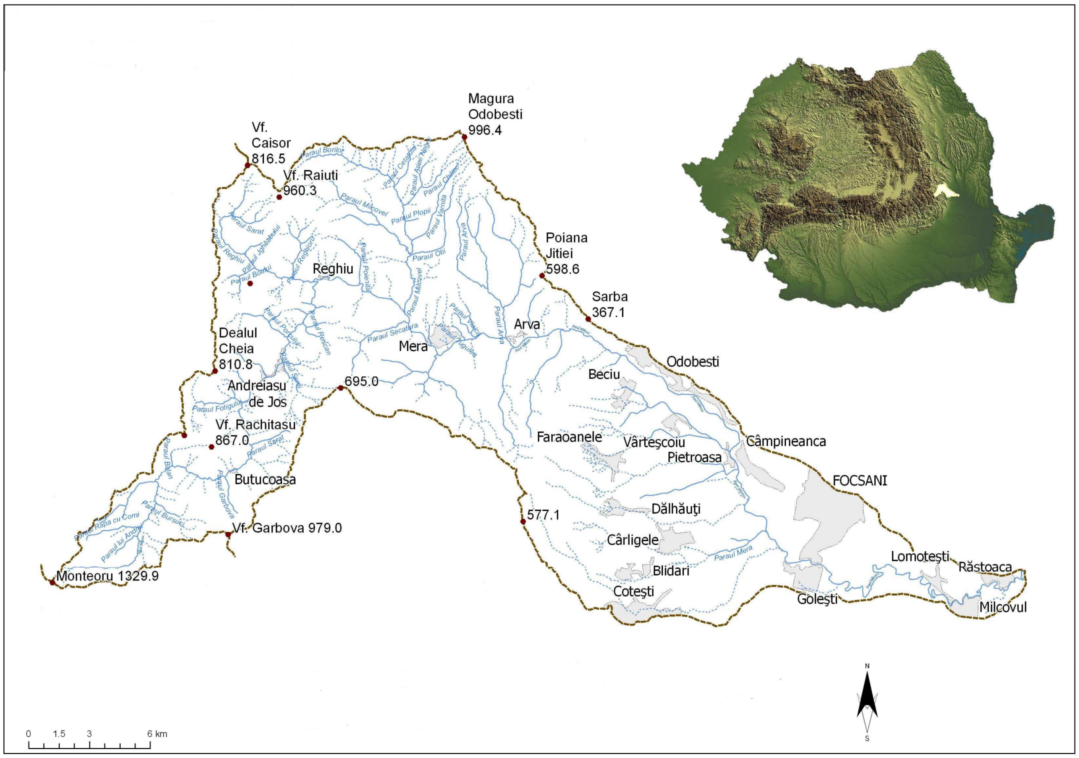

Fig. 1. **The Milcov hydrographic basin. Geographical setting in Romania**

The basic method is the geo - morphological one, field observation and mapping using topographic, geological or tectonic maps. Furthermore, in order to determine the degrees of vulnerability, special analytical, geomorphic (morphometric and morphographic) maps have been drawn.

The geological structure and the tectonic evolution as factors of instability

The present day morphodynamics is a consequence of the tectonical mobility of the region, manifested through plicative movements and earthquakes. Most of the analyzed area is placed within the high or medium risk class vulnerability to present shaping processes.

Structurally, it comprises three units: Paleogen flysch, Neogene molasse, and the foredeep area. The Paleogene flysch (marls, limestone grits, Kliwa sandstone, menilite schists and dysodile schists) appears as four anticlines on Eocene formations and two Oligocene synclinal bands alternate with the anticlinal Eocene bands (Mateescu, 1927). The Neogene molasse (sandstone, salt, saltbreccias, marls) are featured by the formation of thrust faults and the salt dyapir (Reghiu, Andreiaşu). There are also accumulations of natural gas in correspondence with the Casin-Bisoca Fault (The alive fires at Andreiasu). Five folds within the Pre-Sarmatian Miocene formations have been identified (Paucă, 1952). The foredeep area is situated Eastearn of the Caşin – Bisoca fault and comprises the Milcov Strata (Sarmatian – Pliocene) which have a flysch configuration due to the sedimentation speed being the same as the subsidence speed (Macarovici et al., 1967).

Tectonics are primarily a preparatory factor, rather than an initiating one. Earthquakes of over 6 or 7 degrees are the exception (ex. 1940, 1977, 1986, 1990) which prodeced the landslides in Andreiasu de Sus and Titila area. The most significant reactivations have taken place after rainy periods (for example, July 2005). The tectonic factor played an essential part in relief evolution through the shaping of the hydrographic network and the marked slope dynamics.

The Neogene molasse englobes a series of crushed synclinal (Raiut-Titila, Ursoaia-Rachitasul) with a tendency towards scaling (Paucă, 1952). Locally there are dyapir salt structures (Andreiasu, Reghiu). Such a complex tectonic structure is a consequence of longitudinal and transversal faults, appeared since Moldavian (Miocene) and Valachian

(Pleistocene) tectogenesis. Major faults (e.g. Caşin – Bisoca) have formed during the Miocene. The high number of faults is due to the modification in the stress field. The direction of compression changed from NW-SE to N-S during middle-Tortonian time (Hippolyte & Săndulescu, 1996).

The longitudinal faults in Jghiaburi – Butucoasa, Lunca, Prahuda area are reversed faults oriented from North to South. The transversal faults are mainly strike-slip faults and are oriented from West to East and are less evident: the Raiuti Fault, the Farcasei Fault, the Andreiasu Fault, the Reghiului Fault, the Titila Fault. These lead to a discontinuity in the linear-longitudinal relief structures and the formation of smaller and dynamically different compartments.

The Neogene molasse comprises Miocene formations between the marginal fault of the flysch in the west and the Caşin – Bisoca Fault to the east. This includes the Aquitanian (salt and salt breccias), the Burdigalian (mainly sandstone and marls), the Badenian (the Rachitasu sandstone, grey marls, the Slanic ash tuff) having a lithology with a high potential for slope processes.

The vulnerability to geomorphological processes

The geomorphological processes with direct and rapid response to earthquakes are the gravitational ones.

Concerning slope instability we observe:

- the occurence of microlandforms and old material deluvial, which are disturbed and reactivated even by minor earthquakes;
- the landslides mouvement or the separation of material masses from the slope following seismic shock.

Both situations are significantly influenced by the restrictive factor of the vegetal cover features.

The most affected area by slope processes within the neo-tectonic and masive deforestation conditions is the upper Milcov basin, upstream from the Milcov-Reghiu confluence. The distribution of landslides depends on the Milcov Valley, as well as the tributary basins.

The Milcov Valley in this internal Subcarpathian sector follows two major longitudinal fault lines: Jgheaburi – Butucoasa and Casin – Bisoca. The slopes of the Milcov Valley are affected by old and deep landslides (Fig. 2). Reactivations of such landslides may be observed on the two slopes of the Milcov River between Rachitasu and Andreiasu de Jos. Further there also appear gully processes (left slope). Subsequent to the year 1960 the versants have been protected by forests (black pine, silvester pine) which presently have reached their maturity. At the same time, transversal hydrotechnical works has been conducted on the majority of affluent courses, thus ensuring the slope stability (Săcrieru, 2008 a).

Fig. 2 **Landslides on the Caşin Bisoca fault**
(Photo: Grecu, September 2008)

Most part of the lower basin of the Roşoiu stream is affected by the landslides along two longitudinal faults. The land degradation is also related to gullies. Due to ample forest and hydrotechnical works subsequent to the year 1963, we estimate a diminished vulnerability to landslide processes.

In the Upper basin of the Pârâul Sării, within the areas of Andreiaşu de Sus and Titila (Fig. 4), we estimate a high vulnerability to landslides due to the placement between two important tectonic lines: the Caşin Bisoca fault (east) (Fig. 3) and the axis of the Răiuţ Titila synclinal (West). The upper course of the Pârâul Sării developed along the reverse fault of Andreiaşu and landslide occured on the entire slope. Thus the areas between built area and also the arable land, orchards, pastures and hay-fields. On the lower course the marked instability is due to the presence of a salt dyapir. This featuring the areas where reactivations of landslides occured after July 2005. Also there have been mudslides upstream from the confluence with Milcov, at Eastern of Andreiaşu de Jos.

Fig. 3. **The Milcov Valley along the Casin-Bisoca fault**
(Reghiu-Scruntar) (Photo: Grecu, September 2008)

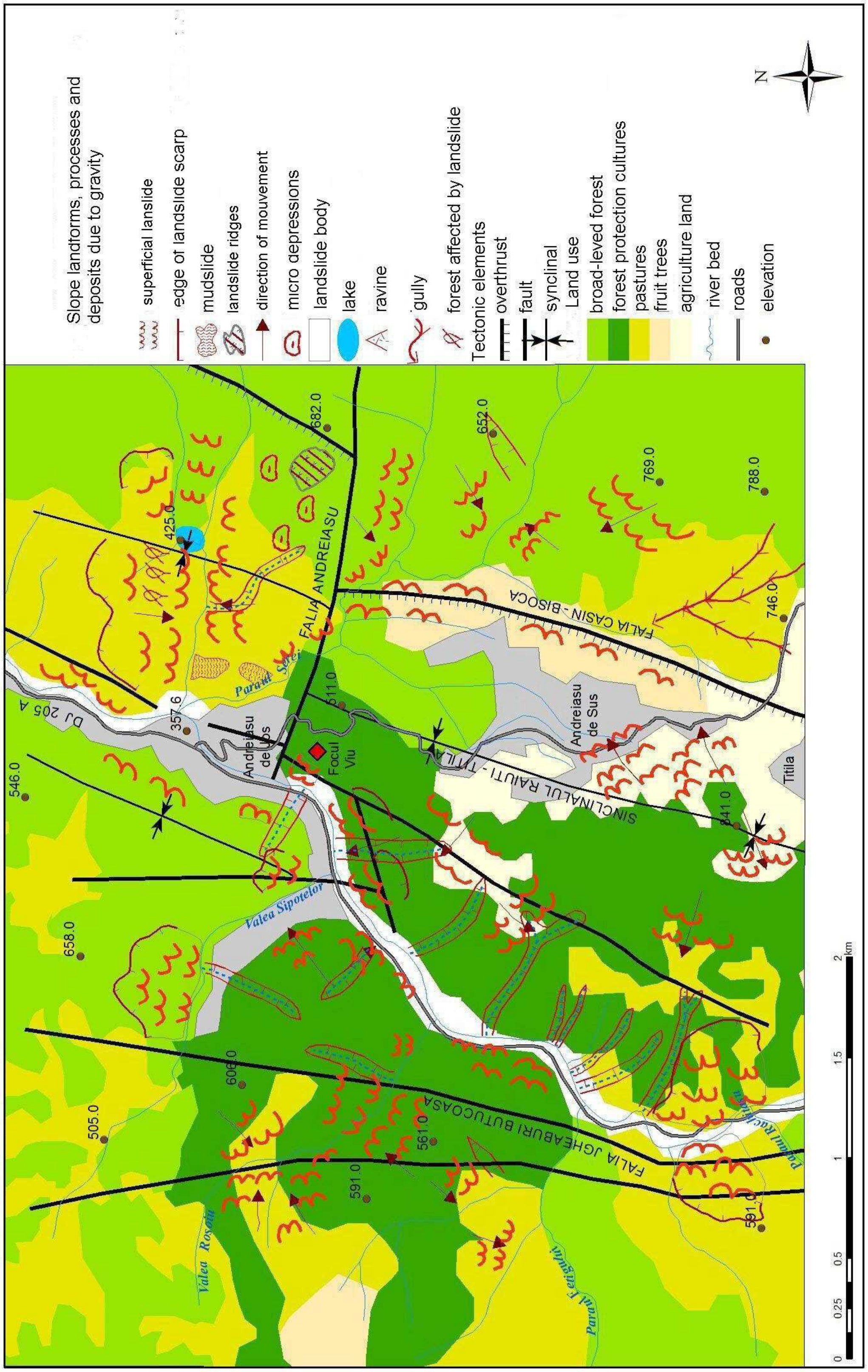

Fig. 4. **The Andreiaşu de Jos-Titila perimeter. The geomorphological map**
(Săcrieru, 2008 c)

The Lingura Valley (Păpăluga) catchment is mostly affected by landslides. These are complex and deep landslides. Between the landslide ridges there are microdepressions with lakes and small surfaces of water, mostly silted. A landslide (Fig. 5) occured in the springs area along the Andreiaşu transversal fault and the area of separation near the Caşin Bisoca fault.

We assess the Andreiasu de Jos – Focul Viu area as a particularly mobile area, especially due to the intersecting of the longitudinal faults with the transversal Andreiasu fault. Thus slopes and riverbeds are dynamic state (Fig. 6 and 7). This mobility is acentuated and permanently mantained by frequent earthquakes (sometimes daily). As regards of small hydrographic basins the landslides on both slopes obturate riverbeds transforming them into successions of pools and incised thalwegs. There are numerous examples, both in the upper and middle basin. The disafforested area on the left side of the Milcov is the most affected.

There apears consequently the permanent action of eartquakes on the slope morphodynamics with paroxymal pulsations at high magnitude earthquakes.

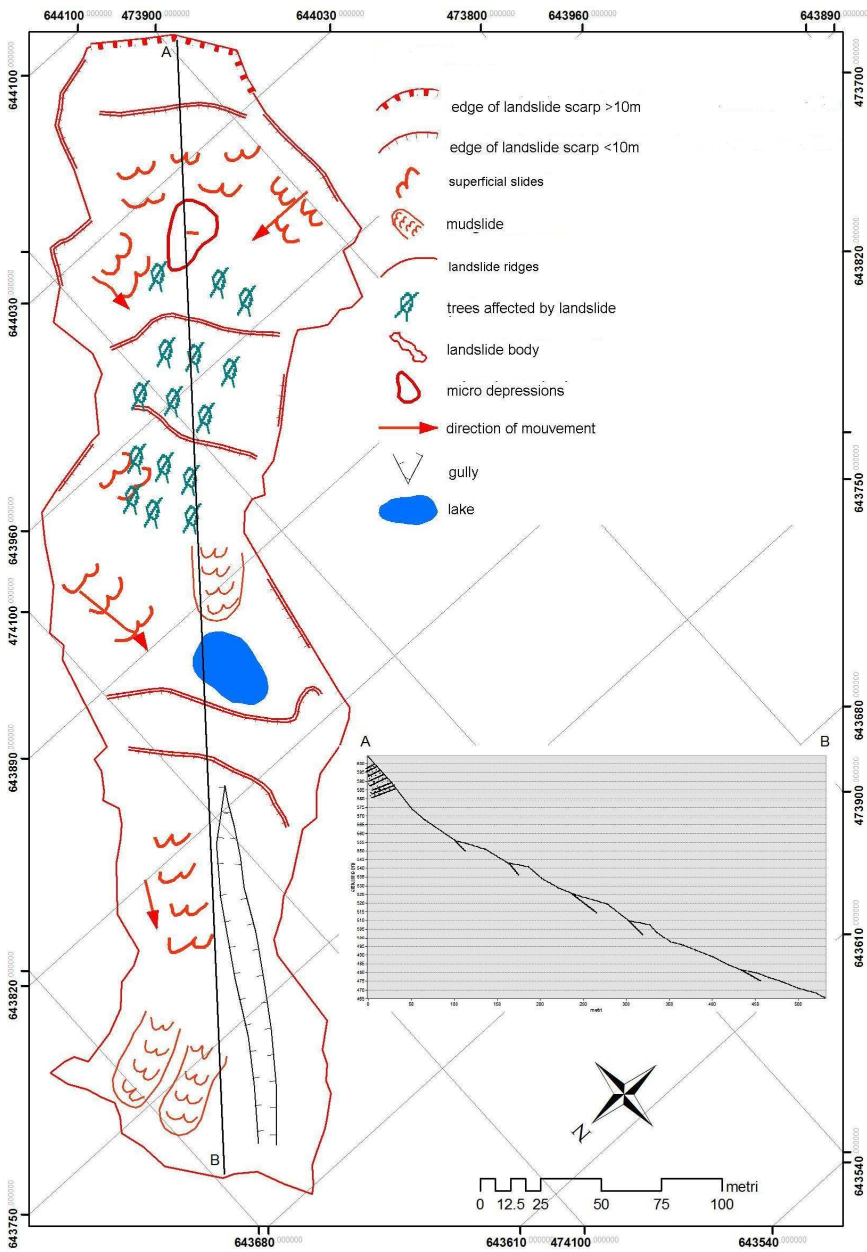

Fig. 5. **The Păpăluga slide. Geomorphologic outline and longitudinal profile**
(Săcrieru, 2008 c)

The medium sector (the Mera depressions and the external subcarpathian hills), is featured by numerous lythological contacts and a density of over 3 km/km^2 in the upper catchments and extended areas along the Milcov, show a medium and high vulnerability to slope processes. In numerous situations landslides have advanced regressively on the slope, affecting the interfluves, the watershed being under the innitial one. This is the case of the afluents of Milcovel on the right, especially the southern i watershed of the Tulburea Valley, afforested slopes.

For the Mera depression the lithological factor is essential in innitiating landslides. The Upper Pliocene formations are the most prone to mass slides on versants. The overhumid clays, highly contractile, with a low resistance to shearing, become a lubricant determining landslides on strata with less than 10^0 inclination. Due to the high hydrostatic pressure of underground waters, they engage fine particles of sand, determining a suffusion process followed by complex landslides. (Zamfirescu et al., 1975).

The lower sector, of glacis type and plain, is mainly affected by hydric and riverbed processe, Upstream from Câmpineanca the Milcov river meanders significantly, as a consequence of active subsidence (Grecu et al, 2007).

Floodplain processes activated after the increas in discharge from 12-18 July 2005 manifested differently from one sector to another. Around Odobesti town, the lateral erosion is the geomorphological with the greatest impact at the riverbed level (Săcrieru, 2008 b). In the lower sector, the alluvionation from the minor riverbed has exceeded tens of centimeters. In Goleşti, for example, a 1,2 m stratum of fine alluvions was deposited, at an absolute maximum debit of 724 m^3/s. Flooding has produced significant material damage, especially along the access ways and national roads.

Conclusions

The natural hazards within the Milcov basin are usually complex, the triggering factors being of geological nature (neotectonical, seismic, petrographic) and climatic, to which we can add deforestation and other anthropic factors.

Earthquakes are a permanent cause of the geomorphologic processes because they gradually decrease the slope stability.

Depending on the intensity and frequency of the processes affecting the risk elements, the vulnerability is medium to high on the Milcov catchment, with local differences. Generally it is a adjacent risk, with an occurence probability dependent on earthquakes of more the 6 degrees Richter, but with continuous quantitative accumulations.

The corelation between the prediction and the occurence of earthquakes is extremely important on the reduction of the impact on the population, through the possibility of informing. The estimated magnitude and the present day earthquakes in Vrancea in February 2005 show us a good prediction, usually the actual magnitude being lower than the predicted one. Comparatively, for the earthquakes from he seismic areas of Europe and Asia, the corelation degree between the figures mentioned in February 2005 is over 0,70 (Grecu, 2006, 2008).

Fig. 6. **Slided rock son a fault slope** (Photo: Grecu, September 2008)

Fig. 7. **The influence of microstructure in slope drainage system. Reghiu** (Photo: Grecu, September 2008)

REFERENCES

BIRKMANN, J. (ed.), 2006, *Measuring Vulnerability to Natural Hazards, Towards Disaster Resilient Societies*, United Nations University Press, Tokyo, Japonia.

CEHLAROV A., 1998, *Studii mineralogice şi litologice ale depozitelor neogene dintre valea Milcovului şi valea Putnei, cu privire specială asupra acumulărilor de celestină de pe pârâul Valea Sării – judeţul Vrancea*, Teză de doctorat, Universitatea din Bucureşti.

GRECU F., 2006, 2009, *Hazarde si riscuri naturale*, ed.III,IV, Ed. Universitară, 222 p., 302 p.

GRECU F., 2008, *Geomorfologie dinamică*, Ed. CREDIS, 232 p.

GRECU F, COMĂNESCU L, GHERGHINA A., GHITĂ C., SĂCRIERU R., VĂCARU L., 2007, *The geomorphological processes and forms developed by quaternary deposits in the Romanian Plain (Est of river Olt)*, in Carpatho – Balkan – Dinaric Conference on Geomorphology, Book of Abstracts , ISBN: 978-963-9632-13 – 4.

HOEVEN, van der A.G.A. et al., 2005, *Observation on present-day tectonic motions in the Southeastern Carpathians: Results of the ISES/CRC-461 GPS mesurements*, Earth and Planetary Science Letters, **239**.

HIPPOLYTE J.C., SĂNDULESCU M, 1996, *Paleostress characterization of the "Wallachian phase" in its type area (southeastern Carpathians, Romania),* Tectonophysics, 263.

MATEESCU S., 1927, *Cercetări geologice în partea externă a curburii sud-estice a Carpaţilor Români*, An. Instit. Geol. Rom., XII.

MACAROVICI N., MOTAS I.C., CONTESCU L., 1967, *Caracteres stratigraphiques et sedimentologiques des depots sarmato-piocenes de la Corboure des Carpates Orientales*, An. St. Univ Al. I. Cuza Iaşi, **XII**.

NECEA D., FIELITZ W., MATENCO L., 2005, *Late Pliocene – Quaternary tectonics in the frontal part os the SE Carpathians: Insights from tectonic geomorphology*, Tectonophysics 410.

PAUCĂ M., 1942, *Asupra reţelei hidrografice şi morfologiei regiunii de la Curbura de SE a Carpaţilor*, Revista Geografică Română, **V**, Fasc. **I-II**.

PAUCĂ M., 1952, *Depozitele miocene presarmaţiene din regiunea de Curbură a Carpaţilor*, An C.G. **XXIV**, Bucureşti.

SĂCRIERU R., 2008 a, *Importanta lucrarilor hidrotehnice transversale din albii pentru dinamica reliefului in bazinul Milcov. Studiu comparativ bazinele Arva si Valea Rea,* Comunicari de Geografie, XII,Universitatea din Bucuresti, Facultatea de Geografie.

SĂCRIERU R., 2008 b, *Vulnerabilitatea la eroziune laterala pe cursul inferior al raului Milcov*, Lucrari si rapoarte de cercetare, **II**, Universitatea din Bucuresti.

SĂCRIERU R., 2008 c, *Bazinul morfohidrografic Milcov. Studiu geomorfologic*, Teză de doctorat, Universitatea din Bucureşti.

TĂRĂPOANCA M., BERTOTTI, G., MAŢENCO, L., DINU, C., CLOETINGH, A., 2003, *Arhitecture of the Focsani Depression: A 13 km deep basin in the Carpathians bend zone (Romania)*, Tectonics, vol. **22**.

ZAMFIRESCU F. et al., 1975, *Procesele de sufoziune – facor principal în declanşarea alunecărilor de mare amploare din bazinul Râmna (Vrancea),* Lucrările Colocviului naţional de geomorfologie aplicată şi cartografie geomorfologică, Iaşi.

University of Bucharest
Faculty of Geography
Departement of Geomorphology-Pedology