BABEŞ-BOLYAI UNIVERSITY
FACULTY OF GEOGRAPHY

Doctoral Thesis
(Abstract)

GEOMORPHOLOGICAL DYNAMICS OF THE TORRENTIAL SYSTEMS IN THE SOMEŞ PLATEAU

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Table of Contents

Key words: dynamic geomorphology, direct erosion, headward erosion, accelerated erosion, intrinsic dynamics, flood, alluvial fan, rills, gullies, ravines, torrents, torrential systems, neotectonic movements, risks, hazards, management, torrential process.

1. Preliminary issues

The issues addressed in this paper are of general interest, not just specific to the geomorphological field.

Torrents represent distinct forms in the morphology of the Someş Plateau and their detailed geomorphological analysis (starting from the identification of the control factors up to the dynamic manifestation) represents a good starting point in elaborating some risk maps, but especially in choosing the best solutions for managing this phenomenon at the level of the entire analysed unit.

The working methodology is presented in the first chapter (as result of the harmonious combination of the methodological principles, work methods, and work techniques), which allowed to obtain relevant scientific results.

2. Geo-identity of the Someş Plateau

The Someş Plateau represents the north – north-western compartment of the Transylvanian Depression (Figure 1), the most extended and the most complex from morphostructural viewpoint.

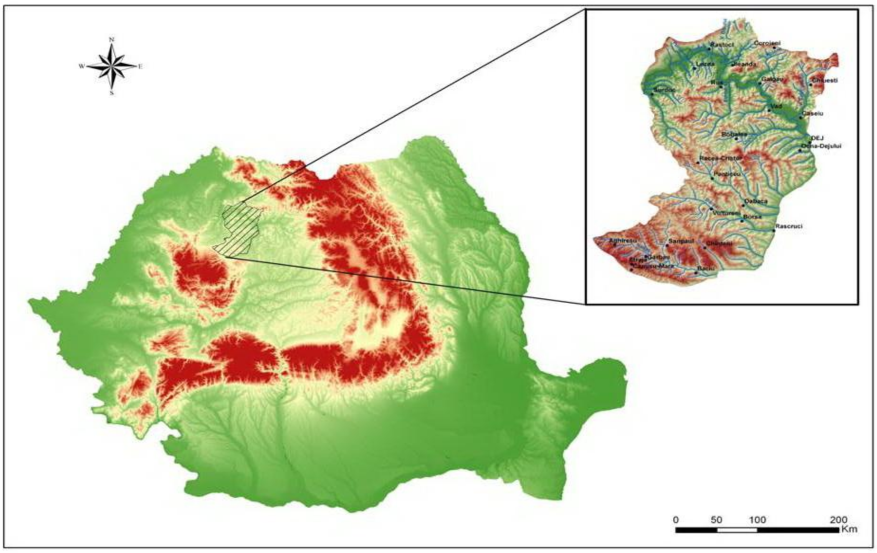

Figure 1. Location of the Someş Plateau within the Romanian territory

The analysis of the palaeogeographical evolution of the Someş Plateau (by means of the existing geological, geomorphological works and by studying the cartographic materials) represents a compulsory stage in understanding the context in which the torrential phenomenon emerged and developed. The current processes shaping the slopes (including torrentiality) act on the "memory" of the Pleistocene morphostructural system under the impulse of the human intervention and of the current temperate conditions.

In this region, intense erosion is the result not only of the combined action of the two neotectonic movements (the rise of the hilly compartment and the local subsidence of Jibou), but also of the friability of the geological formations.

3. Morphology, morphometry and hydrology of torrents

The understanding of the geomorphological dynamics in torrential systems requires a good knowledge of torrents as regards their morphology, morphometry and hydrology. Torrents are the result of the hydro-geomorphological balance, rainfall regime and relief representing the leading factors whose association creates a favourable context for the production of surface runoff and the quick concentration of waters in the torrent beds, triggering torrential phenomena. The difference in elevation dictates the magnitude of the evolution and the development of a torrent, the decrease in the potential difference leading to its self-annihilation. Torrents have a permanent tendency towards dynamic equilibrium, the existing disequilibrium tending towards a new stage of equilibrium, even during the increase of the formation.

4. Control factors of torrentiality in the Someş Plateau

Geology, topography, climate, vegetation, soils, human factor, time represent the control factors of torrentiality in the Someş Plateau, which determine the changes and the feedback relations at the entry into the torrential geomorphological system.

The longitudinal profiles of the torrential valleys in this unit correspond (in terms of genesis and evolution) to a sequence of the geologic time (i.e. geomorphological time), being the expression of the co-working between the control factors: initial relief, climate (extremes, average precipitation), geology (great extension of the friable rocks, alternation of hard and soft rocks, tectonic movements) etc.

Climate represents one of the independent variables of the torrential geomorphological system, with great impact in the development of the torrential geomorphological processes by the regime and the variations of precipitation and temperature, generating floods.

Relative altitude represents a very good indicator of the intensity of torrential processes, as well as of the evolution trend of the torrential formations. The highest frequency of these formations corresponds to the Someş Corridor, being correlated with the areas of maximum energy highlighted in the following sectors: Căpâlna – Gâlgău – Dăbâceni (north of the Someş Corridor) and Rus – Vad (in the south).

Out of the total area of the Someş Plateau (2,621.4 km²), only 749.9 km² are covered by forest. Forests are preserved in patches, forest soils standing testimony of the former forest cover. A high degree of forested areas is highlighted on the slopes bordering the Someş Corridor, the presence of the forest cover having impact in slowing down the torrential processes, despite the high value of the relative altitude. However, at unit level, the degree of slope forests remains very low (Figure 2), fact reflected in the high density of the sheet and gully erosion.

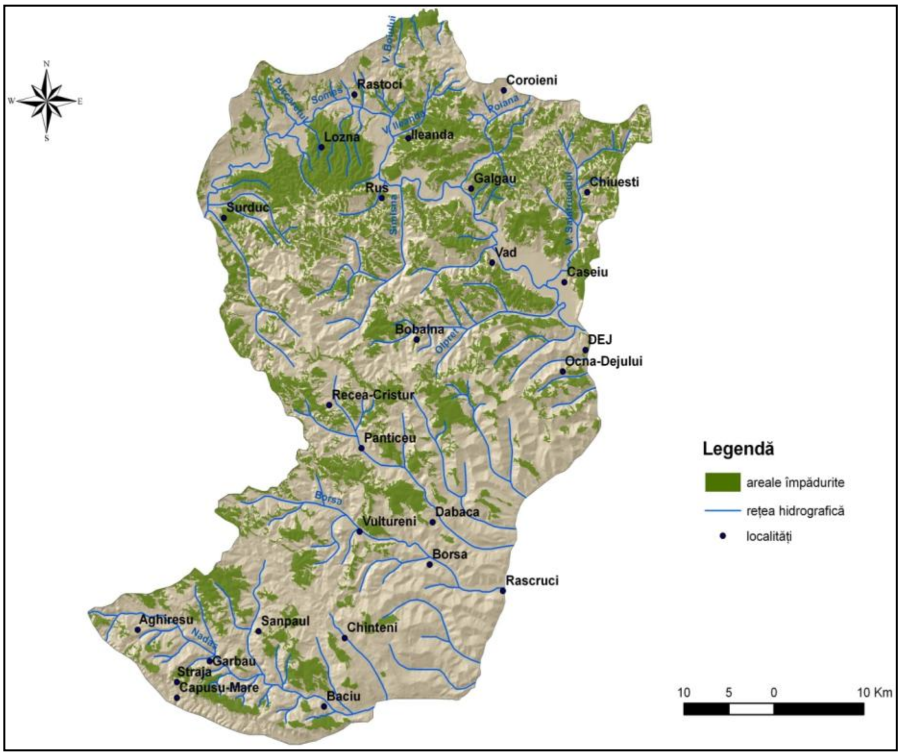

Figure 2. Forested areas in the Someş Plateau

The high frequency of defective works applied to lands, overgrazing, erased or quasi-erased woodcutting, etc., without taking into account the implications upon the erosion processes in the basin, represents a part of the causes that favour the rapid concentration of runoff, the development and the progress at an intense pace of the torrential processes, as well as the association with other slope processes (landslides, rock falls etc.).

Land use and the modification of the vegetation cover structure represented primordial causes that favoured sheet and gully erosion. This can be seen clearly from the large area of degraded lands in the Someş Plateau (62,683.2 ha).

The greatest share belongs to sheet erosion, which, at the level of the Cluj and Dej Hills, affects 15,131.4 ha, and at the level of the Şimişna-Gârbou Hills affects 10,624 ha, subunits in which forests cover very restricted areas. The areas of land affected by gully erosion (rills, gullies, ravines) are lower compared with those affected by sheet erosion, being of 2,166.2 ha in the Cluj and Dej Hills and of 1,533.4 ha in the Şimişna-Gârbou Hills.

Geology represents another independent variable of the torrential geomorphological system. The lower relative altitude (about 100 m) in the Cluj and Dej Hills, combined with the high friability of rocks, has generated torrents with large cross sections, at the level of each morphological unit. Exceptions occur in the case of torrents that have suffered geological constraints in their development, constraints imposed by the presence of Eocene tuff and limestone.

In the Şimişna–Gârbou Hills, the prevalence of Miocene formations (consisting of clays, with intercalations of sandstones, kaolin sands, conglomerates) have created a geological background favourable for torrential processes because of the low resistance to erosion of the existing rocks, besides the above-mentioned variables.

The Purcăreț-Boiul Mare Plateau highlights torrential rills, deepened in the Oligocene sediments and, subsequently, in the Eocene limestone in the base. Some of them disappear in the limestone, emerging at lower altitudes. In addition, the presence of limestone and sandstone thresholds have forced some torrents (such as the Scandicu torrent) to shape a klisura-like channel that ensures the transport of the material from the catchment basin, suspended and extended in area, towards the sector of lower slope gradients.

In the Sălătruc Hills, the friability of the Miocene deposits (carbonate clays, sands, gravels) has allowed the torrential formations to evolve quickly, developing large cross sections (the Runc torrent, south of the village of Gostila, the Cupşoara torrent, west of Chiuieşti), while the Dej tuff generates steep slopes and frequent slope breaks in the longitudinal profiles of the previously-mentioned torrents.

The geologic substratum influences both the torrential morphodynamics and the evolution of the forms in the valley complex. In the hard rocks, the evolution of torrents is a more reduced one, being the morphodynamic response given by the resistance of the respective strata to erosion. The typical morphology of the Usturiş, Răpău, Chejd torrents can be mentioned, where the emergence of hard rocks (limestone, tuffs) have conditioned constraints in the evolution of torrents, clear delimitations between some morphological parts of the torrents, as well as a typical physiognomy (suspended catchment basin, drain channel, which, on certain sectors, has the form of local petrographic scarp).

5. Torrential phenomenon in the Someş Plateau

The chapter highlights the place of the torrential process in the context of current slope processes, the spatial manifestation of the torrential phenomenon, the inventory of degraded lands (by gully erosion, sheet erosion and landslides, processes that coexist and complete each other on large areas) in the geographical unit under consideration, as well as of the torrent dynamics in the area.

Torrential valleys are the answer of the genetic-evolutionary process. The change of the rapport: vertical erosion – lateral erosion – accumulation reflects the evolutionary stage of the torrent, imprinting the overall morphology of valleys.

The active forms of these torrential modelling formations (rills, gullies, ravines, torrents) appear frequently in the four subunits, in response to the large amounts of precipitation that allow the formation of floods, relative attitude, friability of rocks, changes in vegetation cover structure, etc.

Torrents with complex geometry (classical model) present the highest frequency in the entire unit, the northern slopes of the Dej Hills and the Şimişna-Gârbou Hills (towards the Someş Corridor) being the most affected by vigorous torrents proper, as result of the high relative altitude, whose brutal manifestation is illustrated by the materials transported by debris flows and deposited in the outlet section (Photo 1).

Photo 1. Materials transported by debris flood (south of the village of Chizeni)

All five models of torrents (linear, bifurcated, with funnel–shaped basin, convergent, and classical), identified by Hosu (2009) for the Someş Corridor, can be generalized to the entire area of the Someş Plateau.

In the Cluj and Dej Hills, the lowest relative altitude and the friability of the Miocene formations have favoured the areal development of catchment basins. Where hard rocks are present (tuffs and limestone), the areal development of basins is small, the distinction being made by the drainage channel (e.g. Postelicilor torrent).

The changes at the level of control factors generates adjustments of the longitudinal profile of torrents, a situation profoundly revealed in the attainment of the optimal form, so that energy consumption for the transit of water and sediments is minimal. Local base levels are the expression of the emergence of hard rocks along the torrential bed, highlighting the evolutionary stage of the torrential formation. By comparing the longitudinal profiles of the Pociu (Figure 3) and the Cetan valleys (Figure 4), their different development into various geological formations can be clearly noticed.

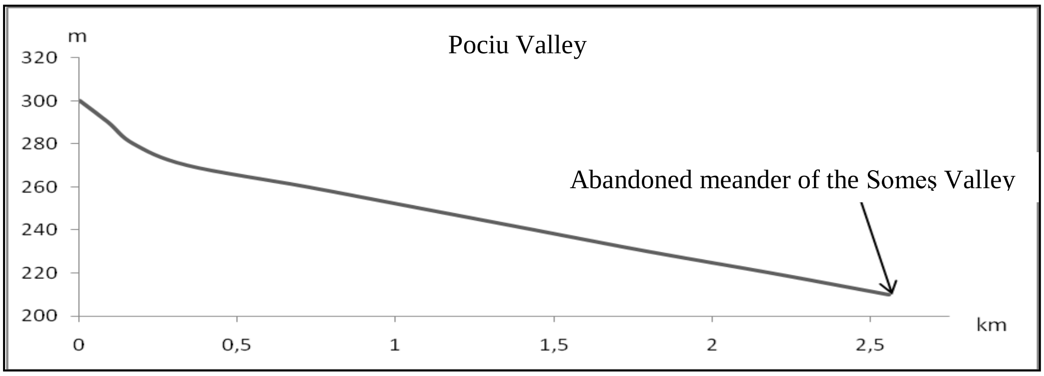

Figure 3. Longitudinal profile of the Pociu Valley, south of the village of Buzaş

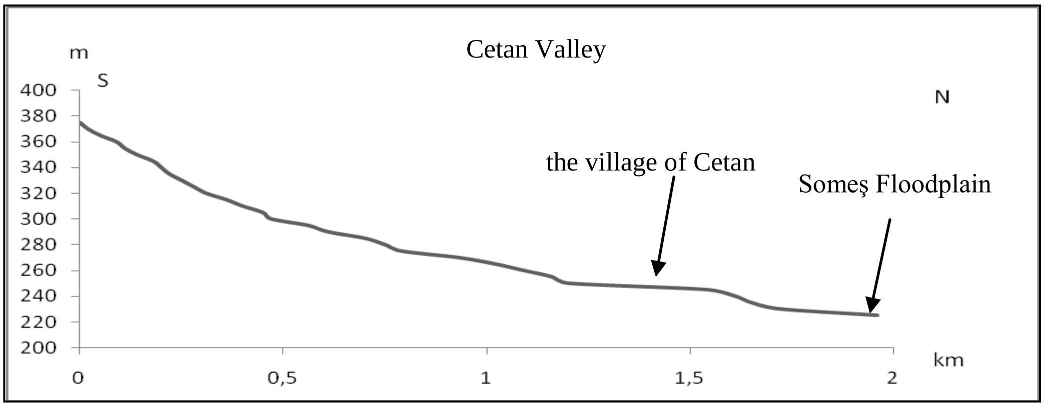

Figure 4. Longitudinal profile of the Cetan Valley, south of the village of Cetan

In the case of Cetan Valley, the numerous slope breaks are the expression of coarse conglomerates and marly sandstones of the Hida strata that have greater resistence to erosion, unlike the geometry of the longitudinal profile of the Pociu Valley, shaped in a less hostile lithological context represented by yellow sandstones with intercalations of pressed yellow sands (Buzaş strata).

In the case of Cristorului, Cărbuniştea (Figure 5), Chicerei Seci, Bădeşti, Satului torrents, etc., situated in the central area of the Dej and Cluj Hills, despite de lower relative altitude, the steep slopes and frequent slope breaks are characteristic along the longitudinal profile, imposed by the tuffs peculiar to the Badenian formations that come into contact with the Hida formation, leading to an increased differential erosion.

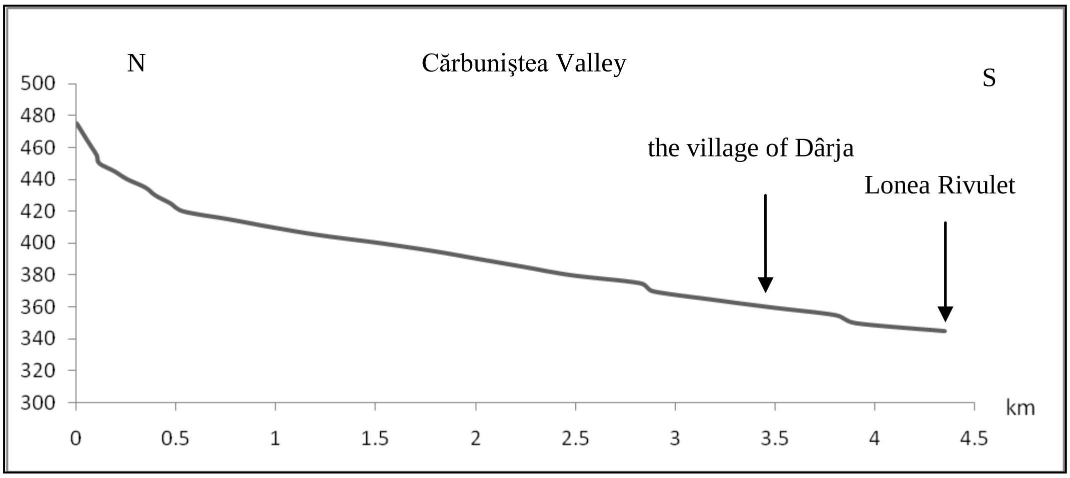

Figure 5. Longitudinal profile of the Cărbuniştea Valley, north of the village of Dârja

A similar situation occurs in the southern part of the Cluj and Dej Hills, where the presence of Eocene limestone hinders the areal development of the catchment areas, generating steep longitudinal profiles at the level of valleys (Cozopăi Rivulet – Figure 6). The presence of the Eocene limestone band delimits the catchment areas towards the drainage channel, giving them a suspended character (Postelicilor torrent, Răpău Rivulet).

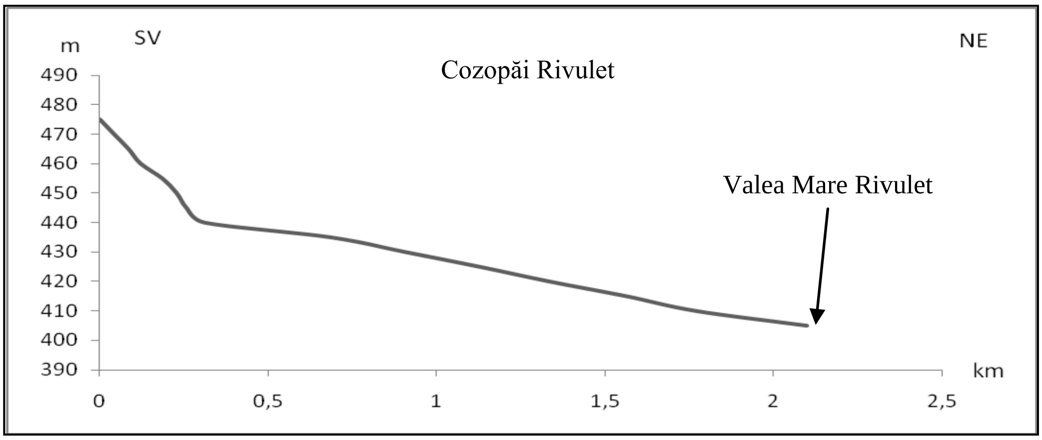

Figure 6. Longitudinal profile of the Cozopăi Rivulet, north of the village of Sânpaul

Geological constraints are no longer maintained at the level of drainage channels, where sandstones, sands and marls of the upper Oligocene series (Chattian-Aquitanian) have allowed the development of broad valleys.

6. Management of torrential phenomenon in the Someş Plateau

Torrent planning represents a necessity in mitigating hazards and risks. Torrents fall into the category of risk phenomena, by favouring the production of flood and because of the brutal manifestation of their discharge, often producing negative effects, difficult to assess. A good example is the impact of the torrential flow upon the county roads 109, near the village of Borşa, and 109 E, between the villages of Chizeni and Fodora (Photo 2).

Although the financial efforts necessary for planning the torrential basins are significant, they are much lower compared to the value of the damage produced in a given period. It can be considered that torrent planning in this unit represents a link in the chain of the sustainable development throughout the region.

A. B.

Photo 2. A. Effects of the incapacity of the tubular bridge to handle the volume of water drained through the ravine (west of the village of Borşa, Cluj County); B. Material transported during a torrential flood over the county road 109 E (between the villages of Chizeni and Fodora)

Given the friability of the substratum, the large amount of material transported by the flow, etc., only certain methods of placing the transverse hydrotechnical works at the level of torrent beds are required (generally) in the Someş Plateau (slope compensation method, tiered works method, downstream target defense method)

The Cetan torrent planning model (south of the village of Cetan) is based on the downstream target defense method, especially because the village of Cetan is located in the discharge sector of the torrent. According to this method, transverse and longitudinal hydrotechnical works are concentrated in the lower part of the torrential stream. Given the geological conditions in which this torrential organism has developed, the profile of the torrent bed, etc., the suggested solutions have in view the achievement of four transverse works to reduce the flow and the amount of transported alluvial material.

The Ciurgăuaşu ravine planning model (west of the village of Borşa) is meant for the lands where gully erosion combines with landslides on large areas. Besides the top protection facilities aiming at stopping the development of gully erosion (collecting ditches, inclined canals, outlets, thresholds, etc.), a special importance will be given to transverse works at the level of the ravine bed (thresholds, gratings, and cross bars) to limit the negative effects of the concentrated flow, as well as the collecting drains on landslides and slopes. In case these anti-erosion works will not be sufficient, they will have to be doubled by protective plantations (acacia) on the lands affected by landslides and on those surrounding the ravine.

Conclusions

In the analysed unit, climate, geology, topography, vegetation, as well as human factor (by land use and vegetation cover change), create a very favourable context for the manifestation of torrential processes and the development of torrential formations. The friability of rocks, the relative altitude, etc., offered by the Someş Plateau, have determined the development of some vigorous torrents that have shaped the slopes intensely (by erosion), evolving up to the formation of some micro-depressions (Luminişu, Bădeşti, Poienița, etc.).

The torrential process is the answer of the mutual interactions and conditionings between erosion, transport and accumulation, each of them representing a main facet of this unique process. Within torrential formations, erosion takes place both directly and regressively. The force that gives a strong dynamics to the entire torrential process is represented by flood, whose level is essential. Its action depends very much on the strength of materials and the morphometric elements. The energy dissipation of the torrent is achieved where the amount of deposited materials oppose a sufficient resistance against transport.

The torrent resists as long as it has intrinsic energy which is related to water and strength of materials.

The management of the torrential phenomenon in the Someş Plateau represents the practical side of the present research. The planning of the torrential hydrographic basins, through its multiple beneficial effects (economic, social, etc.), represents a link in the chain that leads towards a sustainable development of the entire unit under consideration. The functional reintegration of the lands affected by torrential processes into environment depends on the combined and complete implementation of works (transverse, longitudinal, slope runoff regulation, afforestation), so that the final result is maximum, with as little financial efforts as possible.

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