# INDIRECT ASSESSMENT OF RIVER-TORRENTIAL EROSION BY MEASURING THE ERODED VOLUM CASE STUDY: THE REGHIU STREAM

***NICULAE LUCICA*** [1]

**ABSTRACT**. **Indirect assessment of river-torrential erosion by measuring the eroded volum (flow). Case study: The Reghiu Stream**. The landform, as a whole, is the basic component of the environment and evolves as an open system controlled by two categories of components, in a close relationship of dynamic interconditioning**.** The endodynamic components are stable and they define the relief physiognomy: hypsometry, the gradient and length of the slope, lithologic conditions and the drainage density. The exodynamic components, with high spatial and temporal mobility, control the flow of matter and energy within the hydrographic basin, the solar energy, the rainfalls, the temperature, the plant cover, and the anthropic activity. The volume of eroded material of a hydrographic basin will set the relationship between the present physiognomy of the landform and the flow of materials carried and discharged. The quantitative evaluation of the erosion in a hydrographic basin, specific to a certain region, will deal with the parameters reflecting the intensity of the morphogenetic processes over a specified period of time**.** The Reghiu Stream, a left-side tributary of the River Milcov, drains varied landforms, developed on geological formations with different physical properties; moreover, it manifests a regressive erosion, weaker than the Zabala River (they used to have a common evolution during the geological past), and the interfluve is very narrow – there are few facts which lead to the conclusion that the erosion is differential, depending on the local conditions of shaping**.**

**Keywords:** hydrographic basin, eroded volume, thalweg, morphogenetic process, initial landform and present landform**.**

## 1. INTRODUCTION

The volume of the eroded relief belonging to a certain unit or to another well-defined system (the morphohydrographic basin), explains, to a smaller extend, the intricate relationships settled over the ages between the endodynamic and exodynamic components of the geomorphologic system, which is, in fact, the relationship between the present outline of the relief and the alluvia carried or discharged within that system. The quantitative evaluation of the erosion of one or more hydrographic basins in a particular area exhibits some significant parameters,

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which deal with the intensity of the morphogenetic processes over a longer period of time (millions of years, in general).

What adds to the morphodynamics of a region, where the stream load has been discharged from, are the thalwegs of the main and secondary rivers. The most noticeable phenomenon specific to the thalweg is its shape (Rădoane, 2003). The graphic representation of a thalweg shows the distribution of the distances along the river depending on the height of the relief. It is the most conspicuous feature and it persists regardless the climacteric conditions in which it has evolved the size of the river or the rock of the riverbed. Furthermore, with regard to the base level evolution, on the bottom of the profile, we may establish the degree to which the riverbed thalweg deepens, closely connected to its shape (Lesenciuc, 2001).

## 2. THE ANALYSIS OF THE VOLUME OF THE ERODED LANDFORM OF THE REGHIU HYDROGRAPHIC BASIN

This study applies the method of calculating the volume eroded by the fluvial-torrential valleys and branched ravines. It has proved rather difficult to determine the exact geometrical form of the cross-section of such valleys (a calculation artifice usually applied to spaces with morphologic and tectonic uniformity), i.e a space with fierce dynamic, such as the Sub-Carpathians in Vrancea Region**.**

The volume of the relief removed from Reghiu hydrographic basin is quantitatively given by the difference between the initial volume and the present one.

We will apply this indirect method to previously mentioned hydrographic basin, obtaining interesting results.

The hydrographic basin of the Reghiu Stream is located in the Sub-Carpathians of Vrancea and it is the affluent of the River Milcov on its left side. It displays a very sinuous hydrographic network, even irregular in some parts. The basin was carved on sedimentary formations consisting of sandstone, schist, conglomerates, clay, with salt and plaster bands, deposited during the Oligocene-Miocene Age. The basin is crossed by a strike-fault in the central-eastern part, from South-East to North-West.

The actual river route of the Reghiu is a consequence of a complex process of reorganizing the hydrographic network, dominated by activities of regressive and lateral catchment; thus, a series of initial routes (seven, actually) of the Putna and its main tributaries could be recomposed. Two of these routes include the current thalweg of the Reghiu, as follows: - The Naruja Stream – The Reghiu Stream – The Milcov Stream,-The Peticul Stream (upper course)-The Zabala-(between Paltin and Prahuda Villages), - The Ox Valley - The Reghiu – The Milcov. There are evidence to support these:

- the narrow interfluve between the thalweg of the Naruja and the Reghiu (approximately on the alignment of villages Naruja and the western part of Podul Stoica), the distance is only 631,732 m

- the conspicuous asymmetry between the thalwegs of the Zabala and the upper course of the Reghiu (the latter literally “hanging” 140 m above the Zabala thalweg) (Fig. 1);

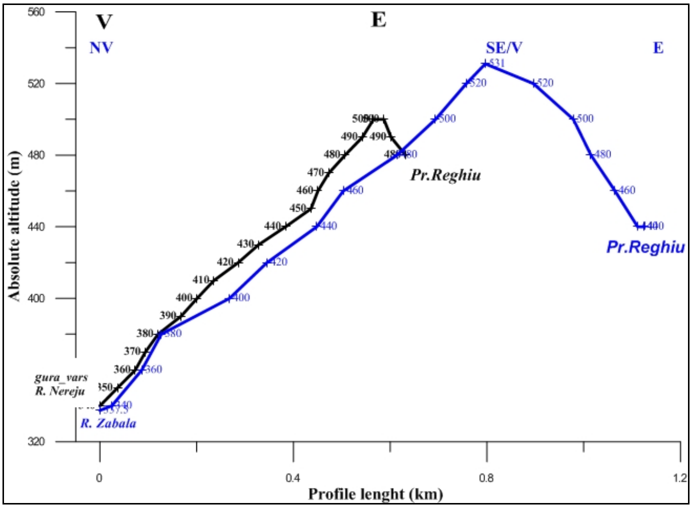


*Fig. 1. Transverse profile between rivers Zăbala, Putna and The Stream Reghiu*

– the presence of a 890-m high floor on the southern branch of Magura Raiut, covered in coarse alluvium of gravels, disposed horizontally. According to many authors, the top floor of the Reghiu Hill is the high terrace of the neogenic area of Vrancea. Its position varies compared to the neighbouring river beds: 545 m above the Zabala, 580 m above the thalweg of the Putna and approximately 500 m from the Milcov. Both the gravel and the position of the floor prove that there were west-east river courses at 880 – 900 m altitude, perpendicular on the alignment of the western hills and on the line of the creases. The western hills were not yet defined, as their present peaks partially influence the interfluves which used to divide the west-east water courses.

## 3. METHODOLOGY

To calculate the eroded volume we subtract the volume of the present landform from the volume of the initial landform, and we follow various stages:

- the demarcation of the hydrographic basin
- the hindcast of the contour line of the initial topographic surface (Hi) where the depression (deepening) of the valley network of the Reghiu Stream basin commenced (closely related to the neighboring basins due to a common evolution in the geological past) (Grecu, 1998); It actually means plotting some linear outlines to connect the valley mouth (level zero) to the peaks of the watersheds (remains of the initial topographic area); subsequently, by interpolation, the junction of the initial contour lines are identified, by associating into contours with

same value. The orientation of such contours considers the beginning of a major unity pre-existent in the actual basin (for example, the inception of a versant of a valley, superior in value to the existent one) (Fig.2).

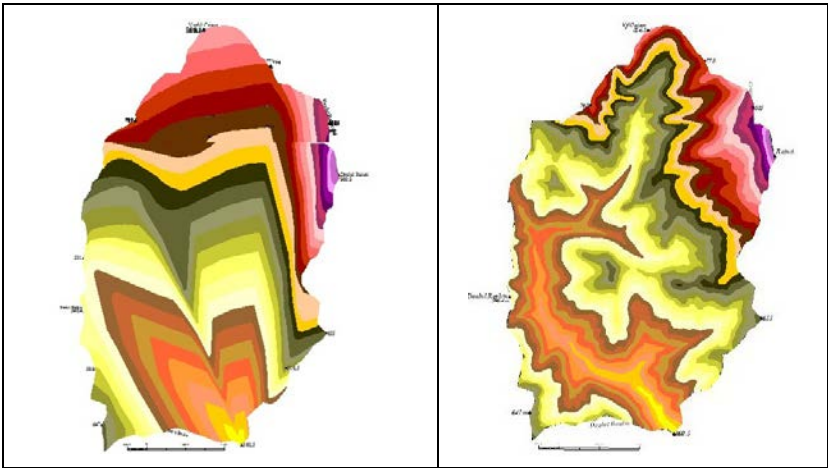

***Fig. 2. The original cathment area of The Reghiu Stream (left) and the current surface catchment area of The Reghiu Stream (right)***

- the calculation of the initial landform volume (Vri) and the present one (Vra), by summing up the partial landform volumes (Vrp) between the surface of the contour line (Sc) and the accumulated relative height (DHc) estimated in comparison with the minimum altitude on the thalweg**.**

The table has the following columns:

- column 1- hypsometric intervals (absolute altitudes, m), corresponding to the contour lines on the topographic map of the present and initial landforms;
- column 2-surfaces (square m) between the contour lines of the present landform (Sra) and the initial one (Sri);
- column 3 relative height (ΔHc), calculated for each hypsometric interval; they result from the accumulation of the hypsometric intervals (present and initial);
- column 4- values of the partial volumes of the landform (cubic m), calculated for each hypsometric interval (present and initial)
- column 5- cumulated values of the partial volumes of relief (present and initial)
- total eroded volume (Vter) resulted from the difference between the volume of the initial landform and volume of the present landform;
- specific eroded volume (Vser) which is the report between the total eroded volume and the surface of the basin. (Popescu, 2002)

The data shown in the table chart “The Morphometric Analysis of the Hydrographic Basin of the Reghiu Stream” are illustrated by the cumulative hypsometric graph (Fig.3), both for the initial and the present surface (Table 1). Furthermore, there are some morphodynamic differentiations on hypsometric floors, and a differentiated intensity of the erosion.

***Table 1. The morphometric analysis of the hydrographic basin of the Reghiu Stream***

| Hyps. Inter. (m) | actual landform | | | | initial landform | | | |
|---|---|---|---|---|---|---|---|---|
| | surfaces ($m^2$) | relative height (ΔHm) | Partial volume values ($m^3$) | The values of cumulated volumes ($m^2$) | surfaces ($m^2$) | relative height (ΔHm) | Partial volume values ($m^3$) | The values of cumulated volumes ($m^2$) |
| 360.5-380 | 59587.11 | 19.5 | 1161948.60 | 1,161,948.60 | 41891.00 | 19.5 | 816874.50 | 816874.5 |
| 380-400 | 184059.93 | 20 | 3681198.52 | 4,843,147.12 | 139175.30 | 20 | 2783506.01 | 3600380.51 |
| 400-420 | 259380.41 | 20 | 5187608.27 | 10,030,755.39 | 224918.39 | 20 | 4498367.72 | 8098748.232 |
| 420-440 | 383144.29 | 20 | 7662885.82 | 17,693,641.20 | 321877.51 | 20 | 6437550.18 | 14536298.41 |
| 440-460 | 494805.76 | 20 | 9896115.19 | 27,589,756.40 | 396348.32 | 20 | 7926966.36 | 22463264.77 |
| 460-480 | 644542.99 | 20 | 12890859.82 | 40,480,616.22 | 517171.75 | 20 | 10343435.02 | 32806699.8 |
| 480-500 | 760217.68 | 20 | 15204353.63 | 55,684,969.84 | 621283.62 | 20 | 12425672.37 | 45232372.16 |
| 500-520 | 847906.33 | 20 | 16958126.57 | 72,643,096.41 | 697564.49 | 20 | 13951289.82 | 59183661.98 |
| 520-540 | 877249.02 | 20 | 17544980.30 | 90,188,076.71 | 760689.60 | 20 | 15213792.08 | 74397454.06 |
| 540-560 | 896562.36 | 20 | 17931247.29 | 108,119,324.00 | 752784.79 | 20 | 15055695.89 | 89453149.95 |
| 560-580 | 891109.73 | 20 | 17822194.56 | 125,941,518.56 | 1044177.49 | 20 | 20883549.79 | 110336699.7 |
| 580-600 | 1054566.60 | 20 | 21091332.02 | 147,032,850.58 | 592912.80 | 20 | 11858256.00 | 122194955.7 |
| 600-620 | 738615.83 | 20 | 14772316.60 | 161,805,167.17 | 1287170.91 | 20 | 25743418.26 | 147938374 |
| 620-640 | 679343.34 | 20 | 13586866.70 | 175,392,033.87 | 674384.57 | 20 | 13487691.46 | 161426065.5 |
| 640-660 | 539265.99 | 20 | 10785319.83 | 186,177,353.70 | 898417.75 | 20 | 17968354.93 | 179394420.4 |
| 660-680 | 662567.78 | 20 | 13251355.53 | 199,428,709.23 | 661503.08 | 20 | 13230061.62 | 192624482 |
| 680-700 | 275389.73 | 20 | 5507794.54 | 204,936,503.77 | 558058.08 | 20 | 11161161.59 | 203785643.6 |
| 700-720 | 368771.91 | 20 | 7375438.21 | 212,311,941.98 | 608703.33 | 20 | 12174066.56 | 215959710.2 |
| 720-740 | 298814.34 | 20 | 5976286.77 | 218,288,228.75 | 601414.08 | 20 | 12028281.66 | 227987991.8 |
| 740-760 | 381824.84 | 20 | 7636496.79 | 225,924,725.54 | 494367.47 | 20 | 9887349.45 | 237875341.3 |
| 760-780 | 330386.87 | 20 | 6607737.36 | 232,532,462.90 | 421706.19 | 20 | 8434123.70 | 246309465 |
| 780-800 | 214694.58 | 20 | 4293891.63 | 236,826,354.53 | 346814.12 | 20 | 6936282.40 | 253245747.4 |
| 800-820 | 171508.10 | 20 | 3430161.94 | 240,256,516.47 | 250550.72 | 20 | 5011014.46 | 258256761.8 |
| 820-840 | 129074.71 | 20 | 2581494.17 | 242,838,010.64 | 95579.91 | 20 | 1911598.12 | 260168360 |
| 840-860 | 98139.43 | 20 | 1962788.51 | 244,800,799.15 | 130434.42 | 20 | 2608688.38 | 262777048.3 |
| 860-880 | 75870.16 | 20 | 1517403.10 | 246,318,202.25 | 73124.80 | 20 | 1462496.02 | 264239544.3 |
| 880-900 | 46326.99 | 20 | 926539.88 | 247,244,742.14 | 154835.14 | 20 | 3096702.88 | 267336247.2 |
| 900-920 | 28995.94 | 20 | 579918.74 | 247,824,660.87 | 38802.66 | 20 | 776053.17 | 268112300.4 |
| 920-940 | 17423.97 | 20 | 348479.47 | 248,173,140.34 | 105186.13 | 20 | 2103722.59 | 270216023 |
| 940-960 | 13551.91 | 20 | 271038.19 | 248,444,178.53 | 26987.08 | 20 | 539741.57 | 270755764.6 |
| 960-960.3 | 7536.68 | 0.3 | 2261.01 | **248,446,439.54** | 2491.00 | 0.3 | 747.30 | **270756511.9** |
| | **12431235.29** | | | | **13541326.50** | | | |
| specific volume eroded: 22310072,33*$10^3$ $m^3$/12,431=1794712.6*$10^3$/$km^2$ | | | | | | | | |

The data of the hypsometric graph (Fig. 3) tell about the relative massiness coefficient of the landform, which express the degree of the vertical fragmentation of the relief. In addition, the method allows a global evaluation of the volume of the eroded material in report to the entire hydrographic basin, and on its hypsometric floors, as well.

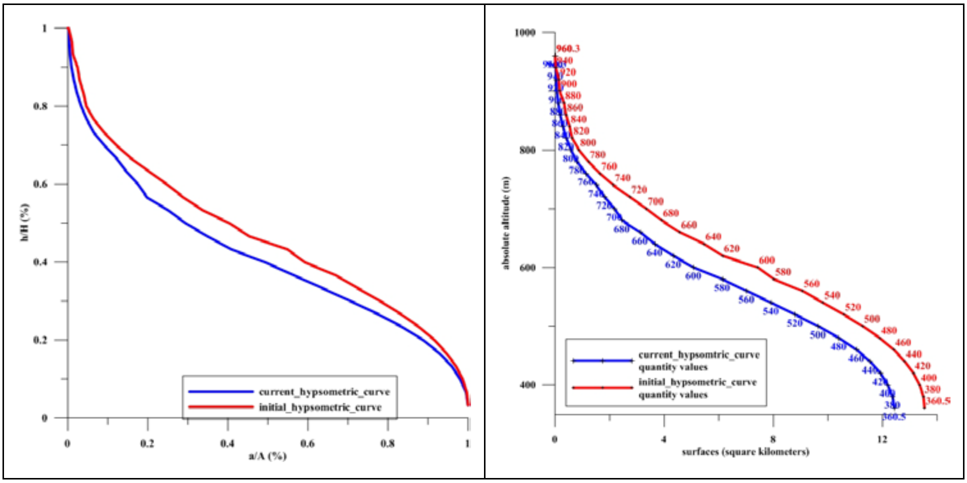


***Fig. 3. The hypsometric graph of The Reghiu Stream: percentage values (left) and metric values (right)***

To assess the erosion only measuring the thickness of the dislocated material means to follow some stages, the first two of which are identical to those of the first method, as follows**:**

3- dividing the hydrographic basin into modules with constant surface;

4- calculating the average altitude of the present landform (Hmed) for each charted surface;

5- finding the thickens of the eroded material (Ger) of each surface;

6- calculating the volume of the eroded material (Ver) for each unit of surface (S);

7- Finding the total eroded volume (Vter) by summing up the partial volumes (Ver) of each unit of surface**;**

This method helps identifying differences that occur inside the basin (petrographic, tectonic, changes of the local level, etc) (Fig. 4).

In addition to this, it allows mapping isolines of the thickness or the volume of the eroded material by the interpolation of the values of the surface units.

The sum of the negative volumes of the contour lines is a more direct approach in evaluating the eroded material in the hydrographic basins.

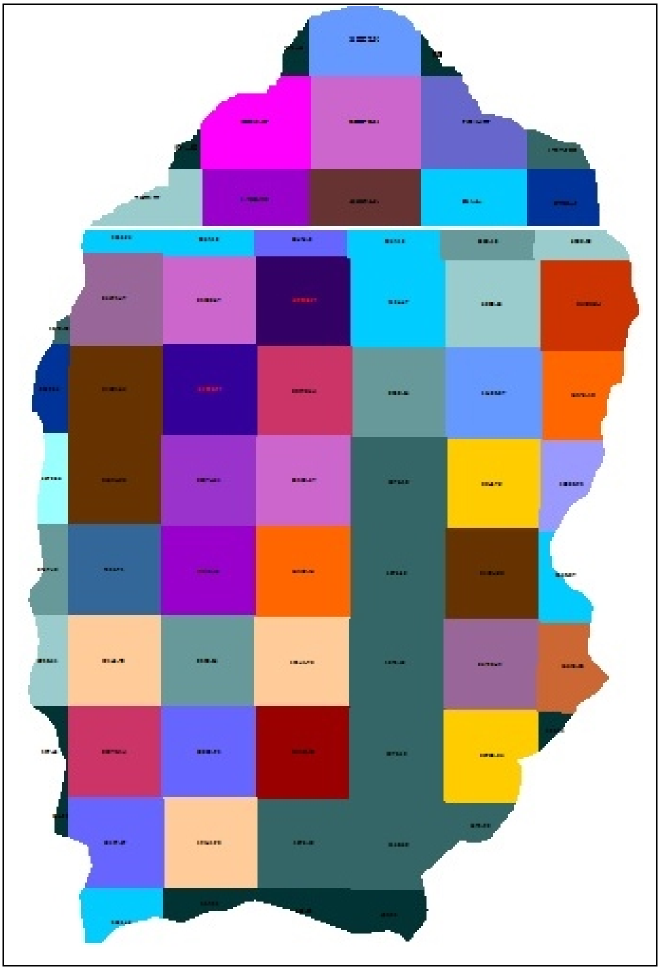

***Fig. 4. Map the thickness of the eroded material in the catchment Reghiu***

## 4. CONCLUSIONS

The indirect assessment of the volume of the eroded material by the above-mentioned methods offers quantitative estimations of the erosion processes, during older geological periods. This approach, through indirect quantitative evaluation, may be the result of calculating the rate of a specific eroded volume (Rvser, cubic meters/square km.year) in fact, a report between specific eroded volume Vser and the time of erosion T (in years). For example, for the 180,000-year old Reghiu Stream, its deepening commenced in the beginning of the Pleistocene, and, logically, we admit that the slopes of the valley started being shaped by torrents only after the formation of the first fluvial terraces. In such case as this, the torrential basins took shape on the slopes of the main valleys ever since the Mid Pleistocene, which was about 150,000 years ago.

The denudation rate (Rd, mm/year) uses the formula of calculating the rate of the specific eroded volume, when the terms of volume (cubic mm) and surface (square mm) have the same unit of measurement. Both the specific erosion and the denudation depend of time, so to find out more accurately the relative absolute age of the base surfaces where the erosion had started will need a more accurate method of calculation.

The study was built on the fifth-order basins (inferior to the sixth-order, the main), two of which being located in the sprig area, and the third on the left-side slope of the basin. The data prove that the most in-depth erosion (the largest volume of discharged material) occurred in the third basin, where the slopes were affected by powerful erosional processes (landslides and torrents), particulalry in the east of  Farcas Village. Also, the first basin records significant values, from the north-east side, as its asymetry caused the rivers to flow from the east to the west, to the detriment of those flowing from west to the east.

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