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# PRESENT TENDENCIES IN THE DYNAMICS OF ROMANIA'S RELIEF

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RESUMEN

*TENDENCIAS ACTUALES EN LA DINAMICA DEL RELIEVE RUMANO.–En el presente trabajo tratamos de identificar, de acuerdo con experimentos de campo, algunas tendencias actuales en la dinámica del relieve de Rumania. Con este fin señalamos brevemente las condiciones presentes de la morfogénesis, las vías de análisis y las principales conclusiones relacionadas con la erosión mecánica y química y el balance morfodinámico en grandes regiones morfológicas.*

SUMMARY

*In this paper we try to identify, on account of the field experiments, some present tendencies in the dynamics relief from Romania. In this respect we shall briefly show the present conditions of morphogenesis, the way of analysis and the main conclusions regarding mechanical erosion, chemical erosion and the morphodynamic balance on great morphological regions.*

## Introduction

Romania's territory (237.500 km$^2$) belongs the continental -temperate area, sometimes to excessively continental one. The Carpathians determine an altitudinal belt of the morphogenese conditions up to the alpin belt inclusively. The relief with a large erosion potential (the mountains and hills) occupy about 63% of Romania's territory. In the mountain region the lithological

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structure is given by crystalline schists, sedimentary rocks and volcanic rocks; in the Sub-Carpathians region it is given by rocks characterising the molasse and in the hill region, by stightly consolidated sedimentary rocks. The recent crustal movements have a maximum amplitude of about 10.000 mm/$10^3$ years (+6.000 mm/$10^3$ years in the centralnorthern part of the Eastern Carpathians and –4.000 m/$10^3$– years in the Tara Bârsei Depression, in the southern part of the Eastern Carpathians) (Cornea and coworkers, 1979). The climatic elements with direct effect in the dynamics of the processes characterising this territory show the following yearly average values: temperature between –2°C and 11° C; the precipitations between 300 mm. and 1.400 mm.; about 15-30% of one year's rainfalls have an hydrological effect (for rivers); showers have a high frequences, several of them may even reach the intensity of up to 10 mm./min. (on the 7th of July 1889 at Curtea de Arges there were showers of 205 mm. in 20 minute). About 70% of river dischrage are produced in Spring and Summer. The main usages of the lands are: agricultural land, 41%; woods, 27%, and pasture and hay fields, 19%.

**Specific mechanical erosion** ($E_{ms}$)

1. We determined the $E_{ms}$ rate by computations of sediments in about 200 river cross-sections on the whole territory, for period of 18 years (data according "The Romania's Rivers" Bucharest, ed. by DIACONU, 1971) and by measurements of the sediment yields from the small drainage basins (GASPAR und UNTARU 1979; ICHIM, N. RADOANE, M. BADOANE, 1979; MOTOC and TALOESCU, NEGUT, 1979; RADOANE, 1979). In the transformation of the sediments weights into volume unities and than into eroded deposits column, we took into account the volumetric weight (and no standard density) of the soils from the analysed drainage basins (according by *Manual for Agronom engineers,* Bucharest, 1959). To make it possible that our data be compared to those of other regions we give the yield sediments in ton/km$^2$/year. The $E_{ms}$ rate is correlated, mainly, with specific discharge (runoff). In our opinion this elements would reflected the convergency of all complex conditions with influence on the erosion processes.

We took into consideration a series of drainage basins developed

| N | Drainage bazin | Morphological region | Drainage area (km²) | Average inclination slope | Percentage of afforestation % | Specific mechanical erosion (Ems): Ems rate mm/10³ years | Specific mechanical erosion (Ems): Period of measurement / The authors | Chemical erosion rate (Ec) mm/10³ years | Recent crustal movements rate (Tm) mm/10³ years | Morphodynamic balance rate (Mb) mm/10³ years |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Vasilache Valley | Tutova Hills | 3.86 | 8-35 % | agricultural fields | 790 | 1960-1978 Moțoc, Taloescu & Neguț (1979) | 28 | +750 | -68 |
| 2 | Ghețag Valley | | 5.10 | | | 4280 | | 28 | +750 | -3588 |
| 3 | Tarinei Valley | | 10.33 | | | 1170 | | 28 | +750 | -448 |
| 4 | Secu | Flysch region | 9.80 | 16° | 77 | 190 | 1960-1978 Ichim, N. Rădoane & M. Rădoane (1979) | 75 | +5500 | +5235 |
| 5 | Izvoru Alb | | 23.60 | 20° | 80 | 270 | | | | +5155 |
| 6 | Potoci | | 12.00 | 18° | 61 | 460 | | | | +4565 |
| 7 | Vîrlan | | 1.64 | 15° | 60 | 330 | | | | +5095 |
| 8 | Ruginești | | 2.04 | 13° | 30 | 380 | | | | +5045 |
| 9 | Roșeni | | 3.20 | 20° | 67 | 220 | | | | +5205 |
| 10 | Boștanu | | 0.33 | 14° | 40 | 620 | | | | +4805 |
| 11 | Pîrîul Popei | | 0.51 | 12° | 94 | 70 | | | | +5355 |
| 12 | Boghea | | 0.54 | 21° | 87 | 50 | | | | +5375 |
| 13 | Fîrțigi | | 3.52 | 16° | 100 | 40 | | | | +5385 |
| 14 | Huiduman | | 1.60 | 14° | 0 | 640 | | | | +4785 |
| 15 | Buhalnița | | 16.60 | 19° | 55 | 440 | | | | +4985 |
| 16 | Pîngărați | | 18.00 | | 62 | 424 | 1976-1979 Rădoane (1980) | | | +5079 |
| 17 | Hanganu | | 2.50 | 20-25 % | 20 | 870 | 1966-1975 Gașpar and Untaru (1979) | | +2000 | +1195 |
| 18 | Hurjui | | 1.97 | | | | | | | |
| 19 | Monteoru | | 7.60 | 25-30 % | 80 | 460 | | | +2000 | +1145 |
| 20 | Cremenea | | 2.70 | | | | | | | |

TABLE 1
Erosion rate, recent crustal movement rate and morphodynamic balance in small drainage basins from Romania (mm/$10^3$ years).

into relatively homogeneous rocks (crystalline rocks, andesites, flysch rocks and monconsolidated rocks) or into distinct morphological regions (mountains, Sub-Carpathians, hills) (fig. 1). We have not neglected to the relationships between the $E_{ms}$ rate and other factors. To exemplify, we give in Fig. 2 the relationships between the erosion rate (yield sediments) the surface of drainage basins and the afforestation.

2. The average rate of the $E_{ms}$ for the whole Romania's territory is about 150 mm/$10^3$ years. The smaller values are between 10-20 mm/$10^3$ years, registered both in mountaineous regions (the drainage basins of the rivers: Olt, Mures, Rîul Negru) and hill region (the Colentina drainage basin and other); in the Sub-Carpathians erosion reaches exceptional values of 2,694 mm/$10^3$ years.

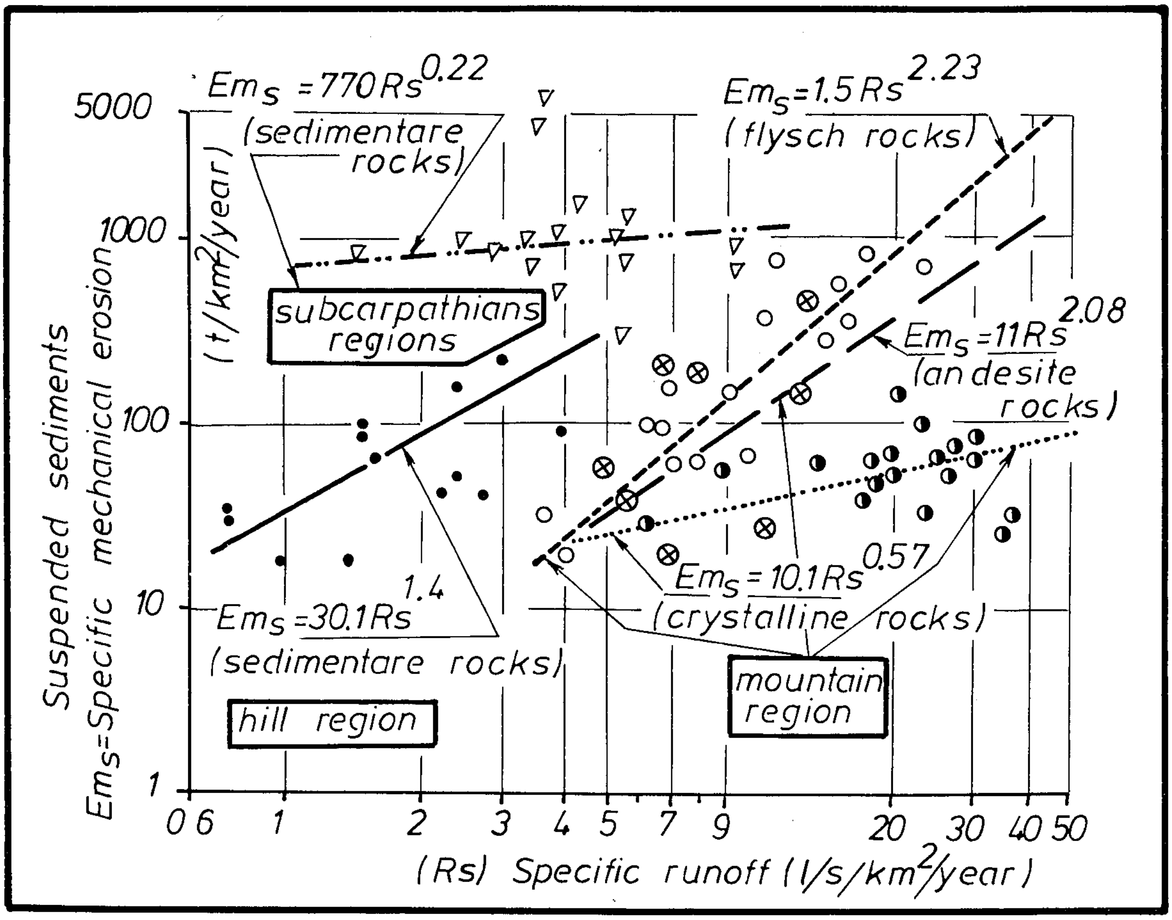


FIG. 1
Specific mechanical erosion ($E_{ms}$) / specific runoff relationships, for darinage basins from Romania

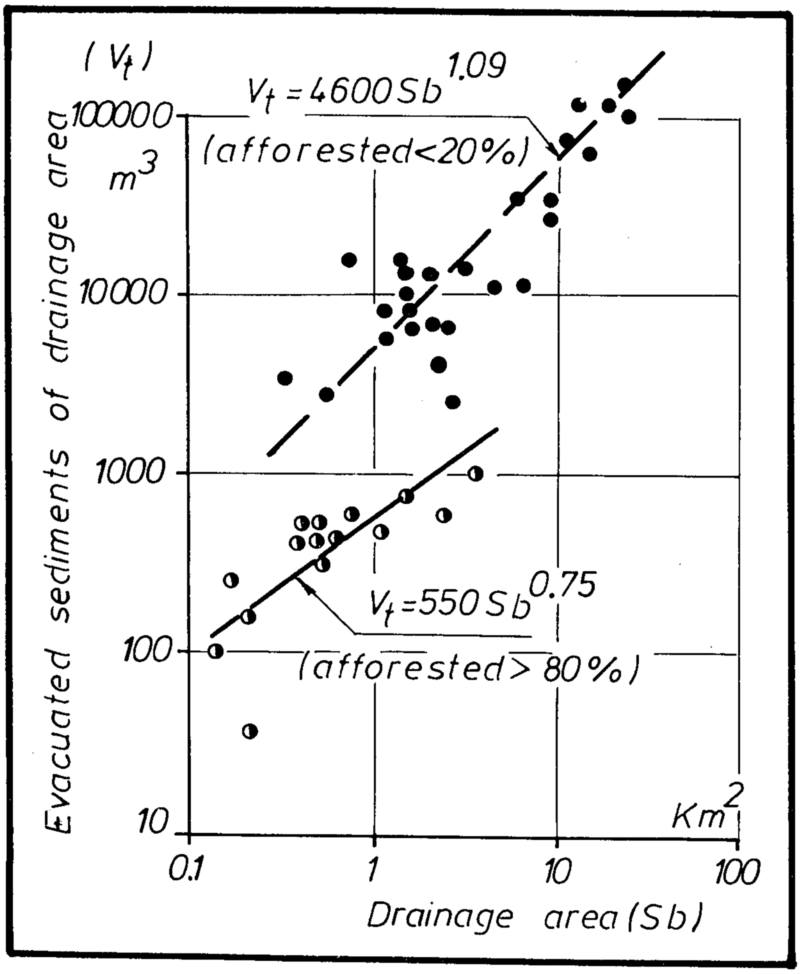


FIG. 2
Yield sediments/drainage area and afforested percentage relationships in flysch mountains (Ichim and co., 1979)

There is an important difference of the $E_{ms}$ rate in relation with lithological structure (fig. 1) namely: 45 mm/$10^3$ years on crystalline rocks; 90 mm/$10^3$ years on andesites and 160 mm/$10^3$ years on the flysch rocks. On morphological regions, the heaviest Ems. rate is in the Sub-Carpathians (average rate of 600-650 mm/$10^3$ years). In mountaineous regions higher than 1200 m, the $E_{ms}$ rate is at about 40 mm/$10^3$ years and 85 mm/$10^3$ years at altitude between 800-1200 m. Finally, in the hill regions the $E_{ms}$ rate is 32 mm/$10^3$ years. The small values of the $E_{ms}$ in mountaineous and hill regions have different causes: *first,* the presence of rocks more resistent to erosion and high degree of covering the slopes with woods, pastures and hay fields; *second,* a decrease of specific runoff and the competence of the rivers.

The $E_{ms}$ rate determined for small drainage basins (between 24-0,33 $km^2$) expresses values which may reach in the hill region, more than 4000 $mm/10^3$ years, and in the flysch mountains up to 600-650 $mm/10^3$ years (table 2). There are a $E_{ms}$ rate including partially at least, also the effect of some mass-movements in transfering slope deposits over to channels (Ichim and co., 1979).

Showers have a special effect on the growing of $E_{ms}$ rate. The following two exemples are edifiyng: in the Vinderel river basin (8,33 $km^2$ and 45% with woods, in mountain region) with a single shower there was resulted an specific erosion of 20 mm (according data of Munteanu and Costin, 1979); in the Sub-Carpathians, in a drainage basin of 1,3 $km^2$, with a single shower there was an specific erosion of 11 mm. (according data of Balteanu and co., 1976).

## Slope mechanical erosion ($E_{vs}$)

We analyse here the surface erosion ($E_s$) and mass-movement processes.

1. *Surface erosion* ($E_s$) is half-present on the whole of Romania's territory heaving erosion potential. Many experiments have been made of this processes (on plot and small river basins) both in mountaineous regions and in hill regions (STANESCU, 1957; ARGHIRIADE and co., 1960; MOTOC, 1963; MOTOC and co., 1979; UNTARU, 1975; POPA, 1977; ICHIM and co., 1979; ABAGIU and co., 1979; GASPAR, UNTARU, 1979; TRACI, 1979; BALTEANU, 1979; STEFAN, MEASNICOV, 1979, etc.). We tried to establish some correlations between the rate of surface erosion ($E_s$), the discharge coeficient ($\tau = Rs/Rf$, in which $\tau$ is the discharge coefficient, *Rs* is quantity of flow water on the slope and *Rf* is quantity of precipitations) the type of using the lands and the slope in the some regions in Romania's conditions (fig. 3, 4).

The average $E_s$ rate varies between 6-680 $mm/10^3$ years on the wood and hayfields lands. In the mountaineous region higher 800 m, where these conditions dominate, $E_s$ rate is generally below 100 $mm/10^3$ years. On account of Romania's conditions, the relation between the surface erosion ($E_s$), slope and land usage, express a dynamic thereshold between the mountaineous region and hill region (fig. 4). On smaller areas there is a surface erosion at over 10.000 mm/$10^3$ years, for exemples in the Vrancea Depression on the slope of 28° –40° and without vegetation– according data of BOGDAN and col., 1972, cf. UNTARU, 1975).

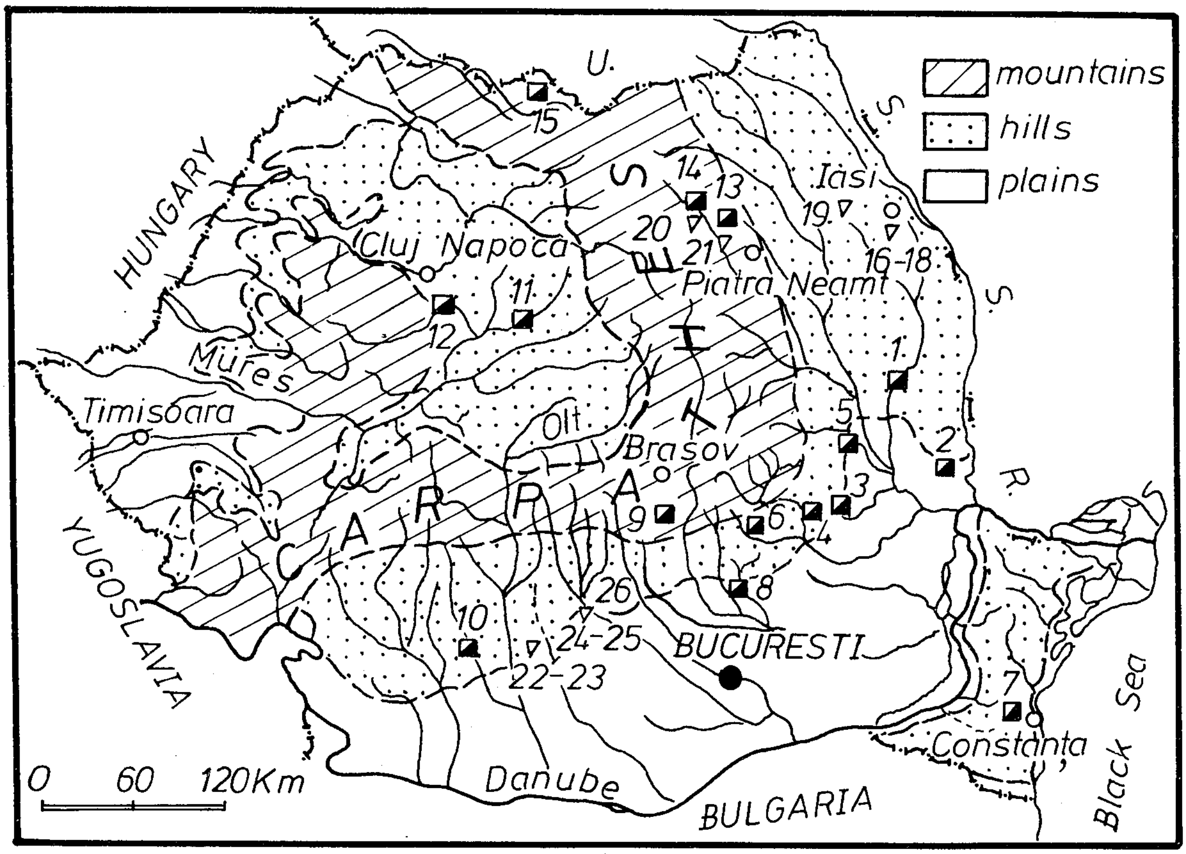


FIG. 3

Experimental fields used for this paper: A. Plots for diagram of fig. 4: 1. Perieni (1950-1972); 2. Moscu (1952-1957); 3. Putreda (1952-1957); 4. Aldeni (1975-1977); 5. Andriesesti (1950-1971); 7. Murfatlar (1952-1955); 8. Valea Calugareasca (1952-1955); 9. Valea lui Bogdan (1952-1957); 11. Sabed (1952-1957); 10. Dragasani (1952-1955); 12. Cîmpia Turzii (1947-1959); 13. Pîngarati (1974-1979). B. Other field experiments (for: gully-erosion, creep, land-slides, sediments balance from the reservoirs) 6. Patîrlagele (1968-1979); 16. Iezareni (1964-1976); 17. Ciurbesti (1963-1976); 18. Cucuteni (1972-1976); 19. Podu Iloaei (1964-1976); 20. Izvoru Muntelui (1960-1978); 21. Pîngarati (1964-1979); 22-23. Scornicesti (1961-1965) and Mazacu (1962-1969); 24-25. Bascov (1973-1976) and Pitesti (1973-1976).

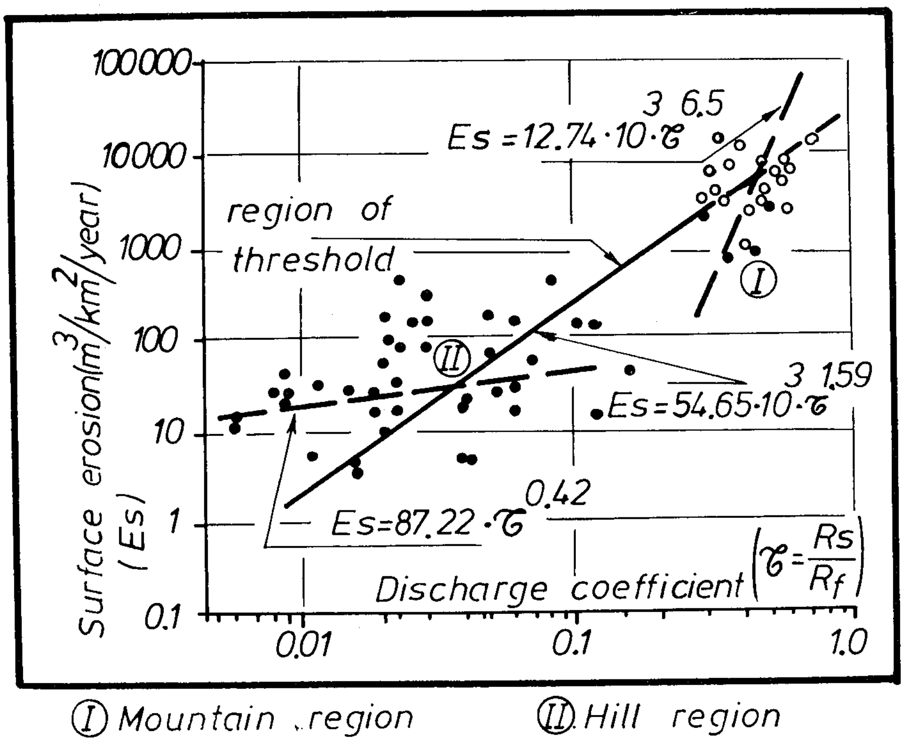


FIG. 4
Surface erosion/discharge coefficient relationships for Romania's conditions (cf. data published for field experiments mentioned in fig. 3)

2. *Mass-movement processes.* Through field measurements there have been established slope denudation rates, average speed of soil-creep and land-slides. UNTARU (1975) has determined a denudation rate by landslides between 512-728 mm / year (in the Vrancea Depression); GASPAR and UNTARU (1979) determined in the Sub-Carpathians Vrancea, 150 mm/years; BALTEANU (1979) determined in the Sub-Carpathians of Buzau 23.2-73.8 mm (for mud-flow), 40 mm (for landslides) and he shows that such phenomena on repeat to 2-50 years. ICHIM (1979) de termined an average speed of 20-30 mm/years for soil-creep in Maramures Mts. on the slopes with 15-20° and 50-70 mm/year in Stînisoara Mts. SURDEANU (1980) determined in the flysch mountains (the Bistrita Valley) average speed of 1685 mm/year for superficial landslides, and for the profund landslides, 3000-3500 mm/year at surface and up to 60 mm/year at 10 m depth in the deluvia deposits of the landslide.

## Chemical erosion ($E_c$)

Up to now, the computation chemical erosion was made only in some karstic regions from Romania. The following $E_c$ rate in karstic regions was established: 19-30 mm/$10^3$ years in the Hasmas Mts. (BOJOI, 1970), 45 mm/$10^3$ years in the Padurea Craiului Mts. and 28 mm/$10^3$ years in the basin of the Motru Sec Valley (Bleahu, 1974). Alike this, BLEAHU (1974) using TROMBE (1952) diagrams showed that the waters from Romania's karstic region are agresive.

We, exclusively, took into account the establishing of the chemical erosion rate on drainage basins. The analysis has as a basis the series of data regarding the chemism of Romania's rivers over period of 18 years (fig. 5).

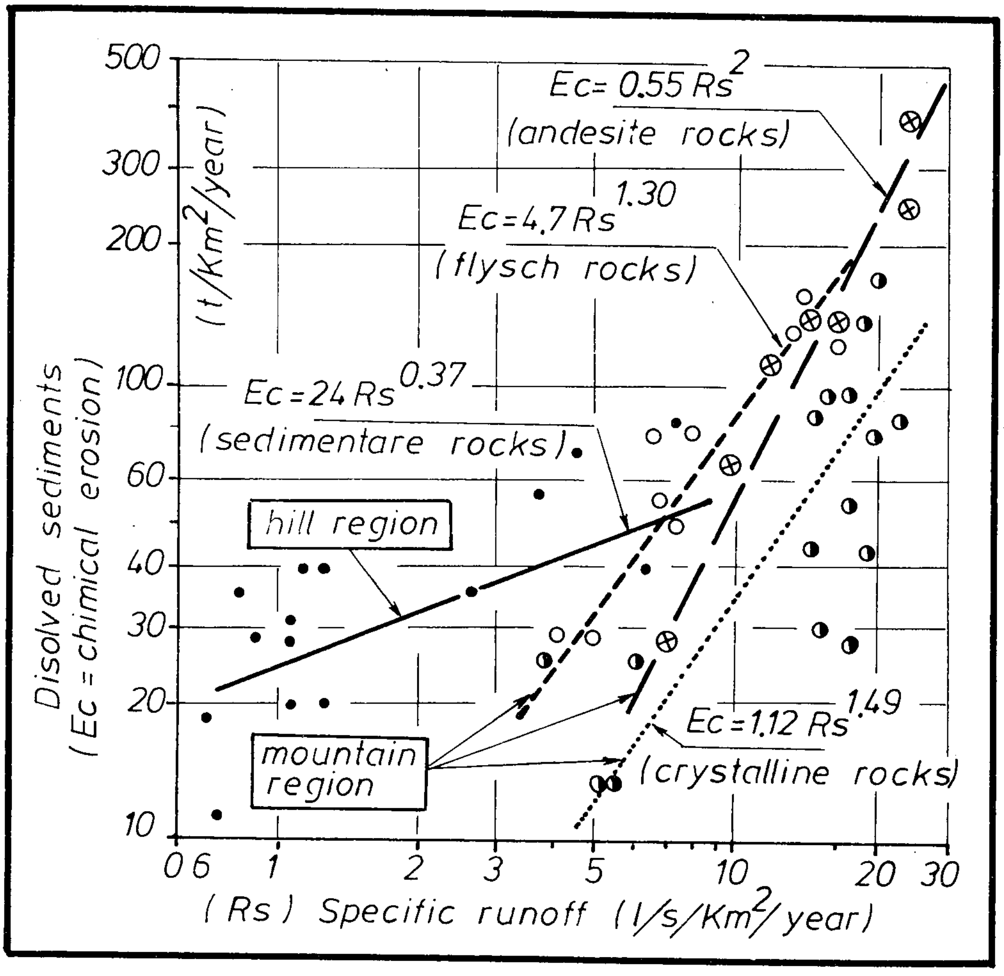


FIG. 5
Chemical erosion/specific runoff relationships for some drainage basins from Romania

The average rate of $E_c$ for the whole territory includes this area into domain of heavy chemical erosion (70 mm/$10^3$ years)[1] (in the acceptance of BIROT, CORBEL & MAUXART, 1968). Except the basin of the Slanic river (421 km$^2$) where the heavy presence of soluble salts, up to date, cause a high erosion rate (421 mm/$10^3$ years), the chemical erosion overpasses in a few cases, 100 mm/$10^3$ years. In the mountaineous area the average chemical erosion rate is 55-60 mm/$10^3$ years, on the crystalline rocks, 100-130 mm/$10^3$ years on andesite rocks and 70-80 mm/$10^3$ years on the flysch rocks. In the Sub-Carpathians area, under the conditions of deposits rich in salts, it comes to an average chemical erosion rate of 160-180 mm/$10^3$ years. The dependence of chemical erosion on specific runoff expreses a greater sensitivity in the mountaineous regions (fig. 5).

## Total specific erosion ($E_{ts}$)

This category comprises the specific mechanical erosion ($E_{ms}$) and chemical erosion ($E_c$) determined on drainage basins. The conclusions of the analysis can be as follows:

the ration between the specific mechanical erosion and chemical erosion is on average about 1,5 for the whole territory of Romania, but present variations between 0.17-27.18 (table 1). The interrelationships is given by equation:

$$E_{ms} = 0.17\ E_c^{15}$$

In the mountaineous region higher than 1200 m, the chemical erosion is dominant over mechanical erosion. There is a certain differentiation of erosion as to the main altitudinal belt in the mountaineous regions: over 1200 m. altitude $E_{ts3}$ rate = 100-120 mm/$10^3$ years; between 1200-800 m altitude, $E_{ts}$ = 140-160 mm/$10^3$ years; it also results that on the crystalline rocks the average rate is about 100-120 mm/$10^3$ years; an andezites it is 200-210 mm/$10^3$ years and on the flysch rocks 220-230 mm/$10^3$ years. In the Sub-Carpathians area there is the highest total specific erosion rate is about 750-800 mm/$10^3$ years.

b - Taking into account that $E_{ts}$ expresse at the same time the

1 Only applying the standard density (2.5), $E_c = 40$ mm/$10^3$ years.

evacuation rate of eroded deposits from drainage basins given, we can, indirectly, state the erosion and accumulation balance in some valleys making the difference between the slope yield sediments (slope erosion) and sediments evacuated from drainage river basins (total specific erosion).

**Problem of the morphodynamic balance and present tendencies of the relief dynamic**

Through morphodynamic balance we mean relation between the exogenic processes rate (generally, the erosion and accumulation) and the neotectonic movement rate, both expressed in mm/$10^3$ years. This offers an image of the general evolution of a region, at least from the point of view of increasing and decreasing of the relief altitude. Through the morphodynamic balance estimated separately for the main morphological elements of river morphology (valleys, slopes), we can also estimate the tendency in the relief morphology.

Regarding the general tendencies of the present evolution of Romania's relief, the data we have got permit the following conclusions:

a – There are important subsidence areas in which aggradation do not compensate the tectonic lowering rate. The most conclusive exemples are the Bodoc Mts. (1193 m) and the Baraolt Mts. (934 m) in which the maximum rate of tectonic lowering comes to attain –4,000 mm/$10^3$ years, and the specific total erosion rate is about 22 mm/$10^3$ years, fact that shows unimportant sediment yields that compensates this tectonic down-lift. Accordingly, the region has the greatest the Western Plain of country (the subsidence rate is up to -2500 mm/$10^3$ years), the Black Sea shore and with a more reduced amplitude, the Romanian Plain (below -500 mm/$10^3$ years).

b – There are areas of subsidence (generally, with a moment below -500 mm/$10^3$ years) in which, at least on the botom of the valleys and at the slope bases, the aggradation rate compensate the subsidence rate. We include into this category the hills between Tîrgoviste town and Mizil town, developed on the boundary of the piemont region with the Romanian Plain.

c – There are areas in which the uplift movement rate is roughly speaking "cancelled" by specific erosion rate. In this category one may include the central area of the Transilvanian Depression, the western-central part of the Tutova Hills and the boundary between the Western Hills and Western Plain.

d – There are also, area in which the specific erosion overpasses the uplift movement rate and is a general processe of down-lift of the relief altitude. A typical exemple in this respect are the Sub-Carpathians of Curbura (between river Putna and river Buzau) with a positive crustal movement rate of over 750 mm/$10^3$ years and an average specific erosion rate of over 1200-1000 mm/$10^3$ years.

e – In the other regions of Romania the dominant characteristic is given by the positiv morphodynamic balance caused by crustal movement (up to over 6000 mm/$10^3$ years).

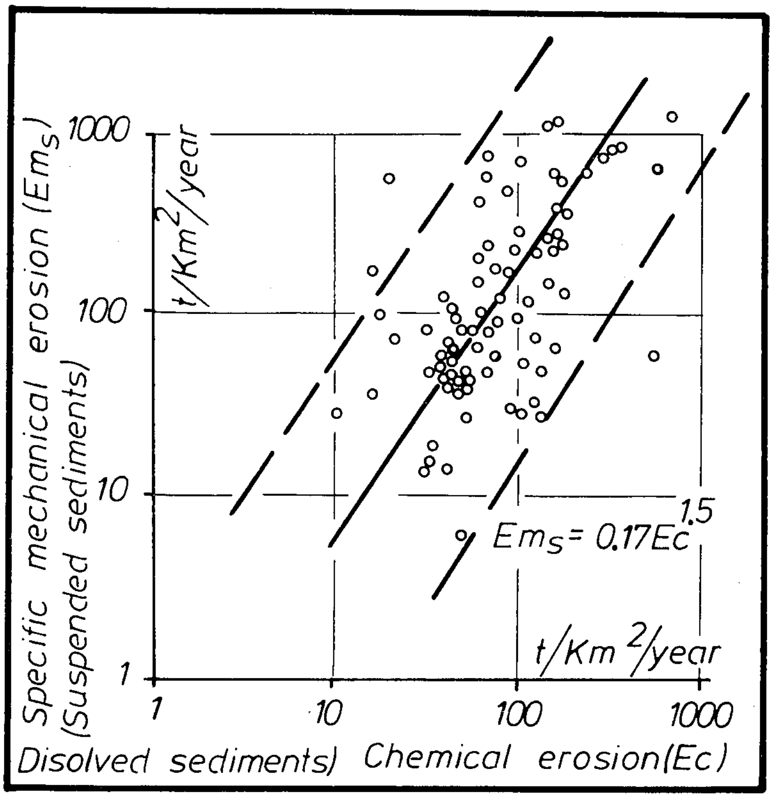


FIG. 6
Specific mechanical erosion/chemical erosion interralationships from Romania's territory

f – A general tectonic uplift of the relief take place the mast powerful being that of the Eastern Carpathians. At same time, the specific erosion rate (below 150 mm/$10^3$ years) shows unimportant deepening of the valleys as to the tectonic uplift which overpasses 6000 mm/$10^3$ years. We underline this conclusion because in many cases the stressed dissection of some regions is explained only by tectonic rejuvenation and alike cutoway of the fluvial terraces.

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