The Evolution Stages of the Romania's Landforms and the Resulted Erosion Surfaces

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Les étapes d'évolution du relief de la Roumanie et les surfaces d'érosion résultéés. Les unités morphostructurales de la Roumanie se sont réalisées par étapes, suite aux différents rapports, au cours du temps, des microplaques situées au bord de la plaque eurasiatique (des collisions et des submersions, des rifts locaux et des éloignements), en résultant dans différentes étapes, des systèmes montagneux, des soulèvements saccadés, des bassins tectoniques profon dément sédimentés, l'exondation de certaines plaines en submersion, etc. L'ancienneté et la complexité de l'évolution sépare deux grands groupes d'unités : les unités de plate-forme et d'orogène hercinique de l'est et du sud (avec une tectonique et des conditions de modelage différentes à partir de l'ère paléozoïque) et le domaine carpatique (orogène alpin et bassins de sédimentation propres) généré et évolué en spécial dans l'ère néozoïque.
Suite à la longue évolution sous aérienne des unités de terre ferme créées par la tectonique ont résulté des formes de relief qui reflètent un certain état d'équilibre, parmi lesquelles les surfaces d'aplanissement réalisées pendant des millions d'années, présentent des caractéristiques morphologiques particulières en fonction du système génétique qui les a créées, de la durée de sa manifestation et de l'évolution ultérieure.
En fonction du spécifique évolutif concrétisé dans différents types de surfaces d'aplanissement, on peut distinguer plusieurs situations dans les unités morphostructurales qui forment le relief de la Roumanie : les unités de plate-forme de l'est et du sud avec des fragments de pédiplaines précambriennes et des plaines d'accumulation de l'ère paléozoïque – néozoïque en état de fossile, à côté des niveaux de vallée et des glacis pliocène quaternaires ; la Dobrodgea avec des étapes d'aplanissement (à partir de l'ère précambrienne jusqu'à celle quaternaire) et différentes formes résultées (des pédiplaines en état de fossile ou d'exhumation, des pédiments, des plaines d'érosion, des gradins d'abrasion) d'une unité à l'autre ; les Carpates qui possèdent des preuves provenant d'une pédiplaine du crétacique supérieur – paléogène et plusieurs surfaces d'aplanissement du néozoïque qui appartiennent à des complexes morphogénétiques étagés ; les régions de plateaux et de coteaux limitrophes aux Carpates qui ont une surface d'aplanissement, 1-3 niveaux d'érosion étroits et fragmentés dans des vallées, des glacis, des contacts structuraux, réalisés en spécial pendant le pliocène supérieur et quaternaire.

1. General data

Romania's morphostructural units developed gradually at the margin of the Euro-Asian plate that broke into many micro-plates. Their relation changed in time (collisions and subductions, local rifts and lateral movements, etc.), a fact that generated (during different stages) mountain systems, intermittent uplifts, intensely deposited tectonic basins, the emergence of some undersea plains, etc. This old and complex evolution separates two large groups of units – those from east and south (the platform and orogenic units) with different tectonics and denudation conditions starting with the Paleozoic, and the Carpathian domain (the Alpine orogenic unit and its own sedimentary basins) that formed and developed especially during the Neozoic.

The long sub-aerial evolution of the land units created by tectonics generated landforms that reflect a certain equilibrium state. The most important developed in millions of years: the erosion (planation) surfaces. They have certain morphologic characteristics depending on the genetic system that created them, its duration and the subsequent evolution.

One may separate several situations for the morphostructural units of the Romania's landforms, generated by the evolution and its materialization in different erosion surfaces:

- the south and east platform units have fragments of underground fossilized Precambrian pediplains, planation surfaces of some fossilized accumulation plains from Paleozoic-Neozoic, and some late Pliocene – Quaternary valley levels and glacises.

- in Dobruja the planation stages as well as the resulted forms differ from one unit to another. In the south there are: fragments of a Precambrian pediplain at the level of some fossilized blocks at different depth; fossilized erosion plains from Paleozoic-Neozoic; a post-Sarmatian surface presently exhuming under the Quaternary loess; a local abrasion step (late Pliocene). In Central Dobruja, there is a Paleozoic pediplain mostly exhumed in Neozoic under the Jurassic deposits, and local Quaternary pediments. In Northern Dobruja there is a post-Hercynian polycyclic pediplain and late Pliocene-Quaternary pediments.
- the Carpathian Mountains show proofs starting with a late Cretaceous – Paleogene pediplain on the main valleys and several Neozoic erosion surfaces that form tiered morphogenetic complexes.
- the plateau and hill regions adjacent to the Carpathians have one erosion surface, 1-3 narrow and fragmented erosion levels on the valleys, glacises on the structural contacts – all of them generated during the late Pliocene and Quaternary evolution.
- in Transylvania and Western Hills, an erosion surface presently fossilized is supposed to exist on the basal blocks made up of Mesozoic crystalline rocks of Carpathian origin; it was exhumed only in some ridges of the Apuseni Mountains and the borders of Lăpuş Depression at the end of the Pliocene.

The erosion surfaces are deeply studied in the geomorphologic PhD theses. There are also regional syntheses mainly for the Carpathian chains, but also for the entire Romania (Posea et al., 1976; Posea, 2003; Ielenicz, 2005; Geografia României vol. I, 1983).

2. The evolution stages and the resulted landforms

2.1. The stage of platform structures and pre-Hercynian denudation

This is the oldest stage and the planation influenced some eastern and southern land regions of our country. The denudation results may be observed in Central Dobruja, and the rest of them may be identified at different depth as fragments of erosion surfaces fossilized by younger sedimentary layers (the Romanian Plain, Southern Dobruja, the Moldavia Plateau, etc.).

The mountain (hill) landforms that existed here were the result of many phases of orogenetic movements during late Precambrian and early Paleozoic. After the Cambrian age, the regions became rigid gradually, a fact that encouraged planation. This process was facilitated by the lack of superior vegetation and by the warm (there were coral reefs in the adjacent sees) and dry climate (the accumulated sediments in the adjacent sees are reach in sand). Therefore, the weathering processes (especially the physical weathering), the sheet erosion and the gully erosion were very important in landforms planation, and a landform of pediplain type developed (called "peneplain" in earlier studies). The correlated deposits are late Precambrian-Silurian (a period of about 100 million years). The abrasion process in early Paleozoic also contributed to its completion, when the sea covered most of the previously eroded landforms.

The denudation results of this period were the *erosion surfaces of pediplain type*. In the Moldavia Plateau, they cut the Precambrian basal ground, decrease gradually to the south due to the subsequent tectonic fragmentation and slope westward as they sink under the flysch Carpathians; deposits of many sedimentation cycles cover them. In the Romanian Plain this surface cuts the crystalline, block-fragmented basal ground of the Moesia Platform and it sinks northward (also in the pre-Carpathian Depression), covered by thick sediments (of many cycles). The same surface also cut the crystalline schist basal ground of Northern Dobruja that at the beginning of Paleozoic was tectonically fragmented into many blocks and then covered by sea as it subsided.

The Caledonian orogenesis movements (maximum Paleozoic first half) produced some notable changes: the emergence of most part of the Moldavian Platform (late Silurian) and Southern Dobruja, along with a new erosion phase that influenced the local sedimentary

plains; the green schists folded and the mountain (hill) landforms spread from Central Dobruja to the north-west (the green schists belt); this region was eroded to the pediplain stage by the end of Paleozoic, under a warm but wet (Devonian-Carboniferous) and dry (Permian) climate.

Conclusions

a) the pre-Hercynian denudation involved the eastern and southern landforms;
b) it took place in two distinct sub-phases: a pediplain formed during the first one (pre-Devonian), cut the crystalline basal ground of the Moldavia Plateau, Southern Dobruja and Romanian Plain and was covered by sedimentary rocks since the Silurian. Therefore it is now a fossilized pediplain, situated at different depth, due to the subsequent tectonic subsidence of the blocks it was fragmented into. During the second sub-phase (after the Silurian), erosion plains developed on the gradually emerged surfaces in the Moldavia Plateau (Permian-Cretaceous) and Southern Dobruja (Devonian-Jurassic). At the same time (Ordovician-Jurassic), the green schist's cordillera was intensely eroded to a pediplain, out of which only the unit in Dobruja (the Casimcea Plateau) was preserved at surface.

2.2. The completion stage of the platform structures, of the Hercynian orogen units, and of the erosion surfaces during the first half of the Mesozoic

It spread between late Paleozoic and late Cretaceous and had consequences for both south and east, but also central and west regions of our country. The macro-plate tectonics (Euro-Asian and African) determined several new situations by colliding or splitting (rifting) the existing fragments (micro-plates). The important results were: the Hercynian orogenetic system formed, spreading from Crimea, via Northern Dobruja to Lissa Gora (Poland) and western Europe; the Tethys rift occured in Triassic (from Northern Dobruja westward); the Kimmeric and Austrian orogeneses generated metamorphism, folding, and even partial emergences within the Carpathian basin, and different duration emergences of some platform units (Moldavia, Southern Dobruja, Romanian Plain).

The land regions experienced different denudation processes depending on their height or the climate that changed during several phases (warm, wet, with luxuriant vegetation in Carboniferous, warm and dry in Permian and Triassic, warm and wet with rich vegetation in Jurassic – mid-Cretaceous that favored the laterite mantle-rocks formation on the limestone in Southern Dobruja and Pădurea Craiului Mountains, etc).

The sequence of these events had different results that may be classified into landform evolution sub-stages.

The pre-Austrian sub-stage had distinct consequences for the platform regions. Thus, in Northern Dobruja, the intense denudation influenced Măcin and Babadag units, generating an erosion surface, fossilized in Babadag unit (Cretaceous) but still developing sub-aerially in Măcin unit. A local rift in the Niculiţel unit generated ophiolite accumulation (Niculiţel Plateau) for a short period of time. The Kimmeric orogeneses folded the sediments east to Măcin and emerged them. This new land adjoined the other units, being continuously modelled until present. Central Dobruja and part of Southern Dobruja were covered by sea since the Jurassic, and became a low deep submersed platform on which corals grew, forming atoll-type structures. The sea fell southward in late Dogger and remained there until late Cretaceous.

The Kimmeric movements also uplifted some sectors of the Carpathian basin that subsided after planation, being covered by the sea. In consequence, the abrasion surfaces previously formed were fossilized by sedimentary strata, having the characteristic of stratigraphic discontinuity surfaces for different periods in Triassic or Jurassic (for example, pre-Lias or pre-Dogger in Hăşmaş, Piatra Craiului and Bucegi massifs).

The Austrian sub-stage was mid-Cretaceous and had consequences for both platform regions

and Carpathian basin. In the first case the emergences in the Romanian Plain (Aptian-Albian) and the local emergences in Dobruja were important, the latter being for the first time (after Cenomanian) entirely exposed to denudation. In case of the Carpathian area, the tectonic movements had a prime importance, so they may be considered a preamble of the Alpine stage. They strengthened the rock metamorphosis, caused the drifting in the crystalline unit (for example the Getic unit moved from northwest to cover the Moesian Autochton in the south) and determined emergences, accompanied by sub-aerial erosion (later on they were covered by sedimentary deposits in Vranconian-Senonian).

Conclusions: this was an important stage out of which the followings have been preserved:

a) fragments of planation surfaces in the Hercynian system;
b) a pediplain gradually extended over the entire Northern Dobruja;
c) local erosion surfaces fossilized by later sediments in the platform units and the Carpathian basin;
d) the beginning of drifting in the crystalline unit of the Carpathian area.

2.3. The Alpine stage

Its main characteristics are the formation of Carpathian domain and the emergence of all sedimentary basins. Secondly, as the planation land was gradually completing, erosion surfaces of different height, spatial extent and aspect resulted. They developed during three sub-stages. The fourth one may be added, for the Quaternary period.

This stage has spread from the Cretaceous and up to present, a period during which the old structural platforms and the Carpathian orogenic unit connected, on one hand; on the other, polygenetic and polycycle planation steps have been cut in the Carpathians.

The Alpine tectonic movements depending on the micro-plate collision (pushed from east, south-east, south and north-west) generated during the more intense phases folding, drifting, orogenic belt building, volcanic eruptions, and the uplift of the adjacent regions. To summarize, they:

- generated one by one the Carpathian structural units, uplifting them to the present altitudes;
- involved in this uplift the regions adjacent to the Carpathians, that functioned for a long time as sedimentary basins (they were filled with sediments of mainly Carpathian origin); generated their structural features (Subcarpathians, Transylvania Plateau, Western Hills, etc.);
- influenced in late Pliocene and Quaternary the unit completion with the east and south platform regions, determining their emergence and uplift. The phases with active tectonics alternated with relative steady ones, as the orogenic energy wasted and the sub-aerial denudation prevailed; at the same time the sedimentary basins were filled.

The morphogenesis was strongly influenced by the climate evolution that changed gradually (from tropical in Cretaceous, to subtropical in Neozoic and the Quaternary alternative sequences of temperate and polar-subpolar climates). Compared to this general trend, there were certain changes within the different geological periods, meaning different variations (warmer and wetter, warm and dry, cold and wet, cold and dry, according to T. Gridan and N. Ţicleanu, 2006).

These conditions dictated certain morphogenetic systems that created during long periods of time different types of major landforms, among which the most important are the erosion surfaces. They have distinct morphogenetic features (pediplains, erosion levels, etc.), their number is different from one landform unit to another (the most numerous are in the Carpathians) and each of them defines a certain evolution phase. They were studied in all landform units, so that in many studies (especially the PhD theses) there are important data regarding their extent, genesis and age. There are also syntheses for large landform units, including Romania. Important contributions were made by Emm. de Martonne, V. Mihăilescu, G. Vâlsan, M. David, N. Popp, T. Morariu, Gr. Posea, P. Coteţ, Valeria Velcea, I. Sârcu, Gh. Niculescu, L. Badea, Gh. Pop, I.

Donisă, N. Popescu, M. Grigore, I. Ilie, M. Ielenicz, I. Mac, D. Bălteanu, N. Josan, etc.

Within this epoch one may separate four sub-stages, according to the morphogenetic features.

2.3.1. The sub-stage of pre-Neogene denudation and the Carpathian pediplain development

The late Cretaceous movements (the Laramic orogenesis) finalized the tectonic style of the Carpathian crystalline rock region (with magmatic intrusions), generated drifting, emerged it and exposed it to the sub-aerial erosion. Secondly, they influenced differently the platform regions, generated the subsidence of the adjacent units resulting sedimentary basins and also their emergence outward. Thus the costal plains and the sedimentary basins resulted. In the third place, they generated the formation (in different phases) of some immense tectonic basins (Pannonic, Transylvanian and Getic) with a Neozoic evolution dominated by sedimentary conditions interrupted by partial or total emergences.

The deposits correlated to the Carpathian denudation are not made up of coarse sedimentary series for Creataceous - Paleocene. Only for Eocene and regionally Oligocene there are conglomerate strata (the contact of the Meridional Carpathians and the Getic Depression, the Petrosani Depression), but in most cases there are alternate strata of grit stones, marls, clays. The deposit characteristics prove the existence of a hill landscape of low altitude within the Carpathian area that was eroded under a warm and wet climate. This favored the formation of laterite mantle-rocks that were washed out and accumulated as red clay layers nearby (for example the northern Apuseni Mountains). According to Gh. Pop (1962-1972), there was a tropical climate that changed into a subtropical one with two distinct seasons. There were low and smooth landforms on the plains that resulted from the emergence of the platform units (Moldavia, South Dobruja and Babadag unit, south Romanian Plain) or on those created during the pre-Alpine stage that evolved in sub-aerial conditions most part of Mesozoic (the post-Hercynian pediplain of Northern Dobruja and the pre-Jurassic pediplain of Central Dobruja, which would be exhumed in most part).

The denudation by pedimentation that lasted 40-65 million years (Posea et al., 1974) generated a surface with different characteristics – a pediplain in the Carpathian crystalline units, an old weakly fragmented pediplain that continued its planation in Northern and Central Dobruja (as it exhumed under the Jurassic limestone) and an erosion plain on the emerged sedimentary platforms.

Those that studied it in different regions, named it differently. Thus, Emm.de Martonne called it "the platform of the Carpathian heights" or "Borăscu platform"; M. Ilie in 1958 – "Carpathian-Transylvanian peneplain"; Gr. Posea in 1962 – "Carpathian peneplain" and then "Carpathian pediplain"; D. Paraschiv for the Romanian Plain – "Moesic peneplain presently fossilized". The geographic literature also offers names for extended areas: "Moldavia Paleogene fossil peneplain", "Dobruja post-Cretaceous peneplain" and many others attributed by the authors of some PhD theses only for their studied areas. On the other hand, these many studies present the aspect, altitude range and connection for extended areas, as well as evolution and duration estimates. Hence two situations may be distinguished.

The first refers to the Carpathian domain where this surface has several characteristics, namely:

- the highest altitude preserved by now in the crystalline massifs (it reflects their first planation phase, in case of Făgăraş, Iezer, Căpăţânii, Parâng, Şureanu, Cindrel, Retezat, Godeanu, Ţarcu, Semenic, Bihor-Vlădeasa-Muntele Mare, Rodnei massifs);
- peaks and residual ridges that rise above it (Făgăraş, Retezat, Godeanu, Rodnei Mountains, etc.);
- its position at different altitudes as a consequence of uplift or subsidence with different intensity during the next evolution stages of the same region: for example it spreads at ±1600m in the central Apuseni Mountains and decreases at 1100m and even 1000m northward; it decreases from 1400m in

the Banatului Mountain (the Semenic Mountains) to 1100-1200m outward; in the Meridional Carpathians it reaches the largest extent and raises from 1800m in the west to above 2000m in the east; it spreads at 1800-2000m in the Rodnei Mountains and below 1000m in the exhumed Meseş and Preluca ridges;

- the surface was doubled or tripled as steps, as a result of the positive epirogenic movements in Eocene (the Pirenean phase): for example, in case of the northern Apuseni Mountains, Gh. Pop describes three steps at 1750-1800m; at 1600m and 1450-1500m altitude; there are usually two steps in the Meridional Carpathians, situated at 1800-1900m and 2000-2200m altitude, dominated with 100-150m by peaks and ridges;

- a different duration of planation (from late Cretaceous – Eocene to late Cretaceous – Oligocene and sometimes until Aquitanian), depending on the time a strong uplift or an important marine transgression occurred (Posea et al., 1974);

- fragments of this surface were tectonically sank at different depth in the Transylvanian marine basin (during different sequences starting in late Eocene until Badenian) and Pannonian basin (after Oligocene, but mainly in early Miocene), where they were covered by sediments. Those situated at low depth partially emerged (for example Meseş and Codrului ridges, etc.).

The second situation refers to the regions situated east and south to the Carpathian domain. The erosion surface here either was fossilized and it is now at different depth (for example the one in the Romanian Plain lean from south toward north, to the Getic Depression, where the subsidence was more active) or remained emerged and experienced the subsequent denudation, hence its polygenetic character (Northern and Central Dobruja).

Conclusions

a) This sub-stage began with the Laramic orogenetic movements, when the Carpathian crystalline units (it also included Transylvania) were not so high and there were plains in the east, south-east and south platform units. There were sedimentary basins between them;
b) The tropical climate with two distinct seasons favored the pedimentation processes and a pediplain-like surface developed, a surface with a single step in the tectonically steady regions and two or three steps in the uplifted regions (Eocene Pirenean movements);
c) The morphogenetic phase ended earlier in the sectors where tectonic fragmenting and subsidence occurred and generated gradually the Transylvanian basin (from Eocen until Oligocene); the pediplain fragments were fossilized here and are now at different depth;
d) In the Neogene, the pediplain in the Carpathian massifs was tectonically and morphologically fragmented on one hand, on the other it was uplifted several times (and differently in size from one region to another), a fact that produced re-denudation (for example it was modified by the Quaternary glacial and periglacial processes);
e) For the extra-Carpathian platform, the emersed sedimentary plains or the erosion surface from the previous stage (Dobruja) were denudated in late Cretaceous – Badenian.

2.3.2. The sub-stage of pre-Dacian denudation and the "medium Carpathian and border surfaces" development

It corresponds to the Miocene and the first part of Pliocene. The main events were: the Carpathian system united by including the flysch units and most volcanic massifs; it lifted during several orogenetic phases; an intense sedimentation period began in the Transylvanian and Pannoniann basins, the intramontane depressions, the eastern and southern platforms and Southern Dobruja.

Therefore this was a rough morphotectonic sub-stage and the areas exposed to denudation gradually narrowed (but remained dominant in the Carpathians) due to the extent of the tectonic depressions and the large transgressions. There were active sedimentary

basins inside or outside Carpathians, with a maximum extent in Badenian and Pontian.

The analysis of the accumulated deposits in these basins shows sequences of some regional evolutions, as well as the big picture – an archipelago with different limits from one period to another, due to the tectonic movements. Oligocene grit facies regionally continued until Aquitanian marked the beginning of fluvial fragmentation stage for the emerged Carpathian areas that extended during the Savic tectonic movements. A new tectonic impulse occured in Burdigalian, thus resulting the conglomerate and coarse grit series in the depressions situated inside or outside Carpathians; also the lands regionally extended (in Helvetian). The second half of Miocene was very important because the Carpathians became a unit as the flysch units, the volcanic massifs uplift (in the Oriental Carpathians and south the Apuseni Mountains), and the previously outlined tectonic basins subsided. Almost everywhere around the Carpathians the Badenian is conglomeritic, a along a sizable transgression indicates an important land uplift. In Sarmatian and Meotian the continuous uplift is proved by sizable sand layers (or gravel in the Getic Depression) and other emergences began in the platform units (North Moldavia, South Dobruja) and on the margins of the Transylvanian basin. The Pontian transgression was as important as the Badenian one, because it indicated the end of the denudation stage.

The entire evolution developed in a warm climatic system that gradually changed from a wet tropical to a subtropical climate with alternate temperatures and humidity (from dry to wet). Studying the average annual temperature evolution, based on the analysis of the macro-flora and spore-pollen dating in different representative places of this country, T.Gridan and N.Ţicleanu (2006) stated that in Neozoic the temperature gradually decreased from 20-21^{0}C (Aquitanian) to 16^{0}C (Pontian). High temperature values of 18-20^{0}C (Aquitanian; Badenian with a dry climate that favored intense accumulation of evaporates; late Sarmatian) or lower oscillations of 14-16^{0}C occurred (mid and late Burdigalian, early Sarmatian with a dry Mediterranean climate, Meotian).

Therefore the Oligocene-Pontian was a morphogenetic sub-stage characterized by frequent intervals of uplift (that completed the Carpathian mountain chain) and active subsidence (that created sedimentary basins), but also a stage when the systems of denudation agents were imposed by a warm climate with distinct seasons especially from the point of view of the dryness. All these altered the previously developed Carpathian crystalline units and for the first time the flysch units and the volcanic massifs. Pedimentation, the specific planation system, created several steps in about 30 million years, depending on the number of the important uplift phases that occurred in different Carpathian units (more in case of the crystalline rock mountains and Cretaceous flysch, fewer in the Paleogene flysch and where the uplift effect was small). Add abrasion at the contact area of the Carpathians and the adjoining marine basins (Pannonic, Getic, Transylvanian). They were classified by those that mapped them in two morphosculptural complexes that indicate as many evolution phases.

2.3.2.1. The phase of the „medium Carpathian surface" morphogenetic complex development

This Miocene phase was different (as step number and morphological features) in the Carpathian units. Thus, in the crystalline rock massifs it looks like smooth secondary interfluve plateaus below the pediplain level, and then like benches and small valley-head basins of the earliest valley generation that can be reconstituted (for example Râu Şes in the Godeanu Mountains; Ialomiţa valley in the Bucegi Mountains). The Cretaceous flysch has two steps. The upper one extends on the main interfluves (and structural or petrographic erosion outliers rise above it) and the second forms the secondary ridges that slope toward the axle of the main valleys. In the Paleogene flysch, the pediments have mainly one level, are less wide and form the main ridges dominated by lithologic or structural peaks.

This surface was named differently for the Carpathian massifs, or larger areas and country. Among these names, some have a greater use. Thus, Emm.de Martonne gave the names: „Râu

Şes platform" for the massifs in the Meridional Carpathians (where the surface spreads at 1400-1600m and sometimes 1800m altitude in their central area, and decrease outward at 1200-1300m), „Măguri-Mărişel platform" or „Ţara Moţilor platform" in the Apuseni Mountains (situated at 1000-1200m altitude in the high regions and decreases outward and on the valleys at 800m and even below this altitude in the Huedin Plateau), „Cârja-Tomnacica platform" in the Banat Mountains (1000m altitude in the Semenic Mountains and 600-800m on their margins, even fossilized by Pontian layers at 350m). Later studies pointed out two altitude steps and even though local names were used, they were finally related to the classic terms (Râu Şes I, Râu Şes II or Mărişel I, Mărişel II). Important contributions for different massifs were made by Aurora Posea, T. Rusu, I. Berindei, I. Popescu Argeşel, P. Cocean, M. Grigore, E. Vespremeanu, M. Ielenicz, etc. There are many regional names in the Oriental Carpathians, although there are two synthesis studies for the entire unit that belong to A. Nordon (1932) and Gr. Posea et al. (1974). The first one separates "the pre-Burdigalian peneplain" at 1500-1600m altitude in the northern crystalline massifs, at 1300-1700m altitude in the central massifs due to the following neotectonic deformations; it is not described south of Trotuş valley, though later research has found it at 1600-1800m altitude from the Ciucaş to the Bucegi Mountains. The second step named "Sarmation erosion step" is described in both crystalline (as benches) and flysch massifs (at 1200-1400m altitude north to Bistriţa valley and 1400-1650m altitude in the Curvature Carpathians). Gr. Posea et al. (1974) use the terms Plaiuri I and Plaiuri II for the two steps, based on the similitude between the names and the steps' features (also used by N. Al. Rădulescu, 1940) in the Vrancei Mountains. Secondly, they generalize the two steps for the entire stage as "the medium Carpathian surface", a name that fits better for the entire Carpathian chain from the points of view of position and extent. The general contributions made by T. Morariu, I. Sârcu, N, Barbu, M. David, Gr. Posea, R. Mayer, N. Al. Rădulescu, M. Ielenicz, I. Ichim, etc. consist of explanations and additions regarding the extent, correlation, genesis and evolution of this surface in different massifs. Steps' different features in the Oriental Carpathian massifs were determined by their structural complexity (crystalline, Creataceous flysch, Paleogene flysch, volcanism) achieved in different phases or by uplift and subsidence of various intensity in time, or between different structural units or groups of massifs.

2.3.2.2. The phase of the "Carpathian border surface" morphogenetic complex development

It was named by Gr.Posea et al. (1974) starting from the main step extent outward Carpathian massifs, where it looks like an abrasion shelf, usually fragmented by the valleys that spring from its higher sectors. For the Meridional Carpathians, the term „Gornoviţa platform" is widely used, a name first given by Emm.de Martonne (1907) and then accepted by those that studied different units. It spreads at about ±1000m altitude at their margins; it increases inward up to 1200m; it represents the main step in the intramontane depressions at 1100-1200m. Emm.de Martonne named this surface „Feneş-Deva" in the Apuseni Mountains at 450-600m outward and 700-900m inward (on valleys and in depressions) and "Teregova platform" in the Banat Mountains at 400-450m in the Almăj Mountains and 600-750m in the Semenic Mountains.

There are many differences in the Oriental Carpathians due to different lithology and evolution of these mountain units. Those that studied it here gave it various names. The main characteristics are: it develops in all mountain units as plateaus in the Paleogene flysch mountains and depressions' borders (at 900-1000m altitude), secondary ridges in the main valley couloirs of the Cretaceous (1100-1200m) and Paleogene flysch massifs (1100-750m), erosion benches in the crystalline rock mountains (at 1100-1300m) etc. On greater uplift alignments it reaches 1350-1400m altitude (for example the maximum uplift alignment in the Curvature Carpathians).

Analyses of this step for different massifs or groups of massifs were made by the

geographers: T. Morariu, I. Sârcu, N. Barbu, M. David, Gr. Posea, N. Al. Rădulescu, St. Mateescu, M. Ielenicz, G. Vâlsan, Valeria Velcea, Gh. Niculescu, M. Grigore, Aurora Posea, Gh. Pop, etc.

Conclusions

a) The sub-stage when the two morphologic complexes developed took place in late Oligocene – Pontian and involved mainly the Carpathians.
b) This stage had several phases of tectonic movements that generated slow or active uplift and subsidence, with different fragmentation and denudation rhythms and certain effects on the regional characteristics of correlated deposits and resulted planation steps.
c) The climatic background with an evolution from a wet tropical to a dry or wet subtropical climate favored a denudation by pedimentation processes that generated lee erosion surfaces of pediment type, of different sizes and sometimes abrasion features at the contact with the adjacent sea basins.
d) Two step complexes resulted in the Carpathians due to the tectonic fragmentation determined by the Stiric movements and accompanied by sizable uplift. These movements generated important morphologic unbalances that determined the end of a sub-stage and the beginning of another.
e) Carpathian uplift caused the emergence of some adjacent units (after mid-Sarmatian in northern Moldavia, most part of Southern Dobruja, margins of the Transylvanian basin) where plain landforms resulted. They were denudated mainly in the Meotian, a process that has gone on by now in some cases or was interrupted by the Pontian transgression (and generated the fossilization of the erosion landforms).
f) The evolution went on in late Pliocene – Quaternary, but depending on the uplift rate and especially the rock resistance, the previously formed steps reduced to ridges, erosion benches and small plateaus, etc., out of which low slopes to the valley axle or some surfaces situated on mountains' or depressions' margins have lasted by now.

2.3.3. The late-Pliocene sub-stage, of erosion levels and glacises development in most part of our country

It spread over circa 3.5 million years from the end of the Pliocene and in some places until the early Pleistocene. During this period the Alpine tectonic movements went on (in Dacian). Therefore the previously denudated landforms are lifted to a medium altitude. As the sedimentary basins gradually emerged, plains formed around them (as those in Transylvania, north Moldavia, intramontane depressions that were gulfs in Pontian, western margin of the Occidental Carpathians). The sedimentary deposits of Subcarpathians folded and the last important volcanic eruptions occurred in the western Oriental Carpathians. The tectonic movements became intense in early Pleistocene and generated the last folding in the Subcarpathians, uplifted the salt massifs that gave the diapiric structure and the dome structure in Transylvania, caused important uplift in all regions (with locally differences of intensity) as well as some subsidence in some depressions, West Plain or Romanian Plain. The deposits in the sedimentary basins reflect these moments, as they consist of alternating sand and clay in Dacian and coarse gravel and sand alternating with clay lens in Romanian-Pleistocene (Cândeşti strata). There are thick clay accumulations between them, a fact that reveals the end of uplift and not so high landforms, at least near the sedimentary basins.

The climate was also subtropical, but the annual temperatures decreased from 13-14^{0}C in Dacian and first half of the Romanian to 9-11^{0}C at the beginning of the Pleistocene (Gridan, Ţicleanu, 2006).

On these terms (intermittent movements at shorter periods of time and a transition climate from subtropical to temperate) the erosion processes acted differently (during the two distinct seasons) and the results were different from one landform unit to another, as they were influenced by the uplift rhythm and intensity and the lithologic and structural differences. They acted in two specific ways that generated

two types of landforms. The first acted in the Carpathians that uplifted more, the altitudes were higher and the valley system was more developed. Combined pedimentation and fluvial erosion generated here two types of erosion steps. The valley benches are the first ones (short planation ridges, sometimes reduced by the Quaternary erosion to small erosion outliers). They are situated along the long valley profile, on the main valleys as they go out of the mountains. In the Meridional and Oriental Carpathians they are situated at 1100-1200m altitude in the centre of the mountain area and decrease at 700-800m at the contact with the adjacent units, but there are many regional exceptions due to some regional tectonic and structural features. They can be found at lower altitudes (350-400m) in the Occidental Carpathians. The second type is represented by the uplifted and cut surfaces of erosion glacis that have a great extent on the contact with the units adjacent to the mountains and on the margins of the intramontane depressions (at 550-800m). In both cases, this altitude range includes two steps (rarely one or three) separated by a 100-150m difference of altitude.

The second evolution type was specific to the land regions situated inside (Transylvania) and outside the Carpathian chain. The present plateau units in Moldavia and Transylvania gradually emerged at the end of Pontian and slowly uplifted. A first generation of valleys developed and depressions were cut near the mountain. Therefore, a general planation in Dacian-Romanian formed here some surfaces of erosion glacis type (sometimes pediments and even piedmonts). I. Dionisă and I. Băcăuanu indicate in northern and central Moldavia a generalization of these surfaces to a glacisplain. A similar step situated on the present heights also developed in Transylvania. They are generally situated at 450-600m altitude. It was fragmented after that (especially where it cut less resistant rocks).

Below this late Romanian-early Pleistocene step, the following steps were cut: one bench level on valleys couloirs, erosion or mixed glacises on the margins of depressions or lithologic and structural cliffs and one level of secondary ridges, all at 350-400m altitude.

There were different regional conditions of tectonic, lithologic, structural and orographic nature in the Subcarpathians. Two erosion steps were cut on the valleys that spring from the mountain and one on the autochthon ones. Due to the active tectonic movements, there is one more step in the Curvature Subcarpathians, situated at 650-800m altitude near the mountain and 350-400m outward the hills. The valley long profiles show some deformations in the sectors more lifted in the Quaternary. Secondly, there are mixed glacises surrounding depressions (above the superior terrace) and some valley-head small basins, sometimes hung up behind some valley narrow sectors. All of them were transformed by erosion and gravitational processes in the Quaternary, therefore their identification and correlation are difficult.

Although the superior erosion step is preserved on the secondary interfluves that are situated above the Cândeşti strata as reference, the other correlates with these layers.

Emergence occurred in the Western Hills (the Banat-Someş Hills) and southern Moldavia Plateau at the end of Pliocene and therefore here are two glacis levels, situated at the contact with the plain, along the valleys and within the depressions. Sometimes the rivers fragmented them quite intensely in the Quaternary.

In Pliocene-early Quaternary, most Dobruja was erosion plain, the result of a long polycycle and polygenetic evolution. The last segment that joined the Dobruja land after the Sarmatian was situated on its central and south-east part; the Getic Lake in the south-east gradually stepped back, leaving behind an abrasion step (terrace) in the Romanian (C. Brătescu). This retreat was caused by the slow uplift determined by the micro-plates collision that tectonically influenced the Silistra-Negru Vodă sector and north-western Dobruja. In consequence, the rivers with subtropical hydrological regime deepened. In Northern Dobruja, due to a structural and petrographic variety, denudation created a system of pediments and inselbergs to the prejudice of the pediplain that reduced to erosion outliers.

Conclusions

a) This is short sub-stage whose evolution results may be found in most of the plateaus, hills and Carpathians.
b) The evolution took place under conditions of a sequence of uplift phases and a subtropical climate that gradually became temperate-continental. The short denudation period generated two characteristics. First, the erosion surfaces are not so extent and secondly, they were reduced to 1-3 steps on valley couloirs (there are erosion benches here), depressions' margins and contact landform units (mixed glacises, pediments and even piedmonts).
c) From the altitudinal point of view they have the highest values in the Carpathians, some regional differences and relative uniform extent in the plateau or hill units.
d) They were fragmented by rivers, gullies and slope processes (especially landslides) in the Quaternary.

2.3.4. The stage of Quaternary denudation

It lasted over circa one million years and its main features are:

- the tectonic movements (the Walachian phase) uplifted the Carpathians and their adjacent regions and indirectly favored an intense fluvial erosion and the transport of a huge volume of materials, that filled the Getic and the Pannonian lakes and created the south and west plains;
- the climate changed since the mid-Pleistocene into alternating temperate and cold phases (periglacial-glacial), a fact that periodically changed the morphogenetic systems;
- the result of this evolution is the terrace systems development. Generally, there are 8-9 terraces for the eldest valleys in the hills, plateaus and Carpathians and 1-2 terraces for those in the plains; there are more terraces in the active positive neotectonic regions and they disappear in the subsident regions;
- mixed glacises and piedmonts have developed locally.

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