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The Valley System Evolution in Romania

Mihai IELENICZ, Smaranda SIMONI (TOMA)

The Valley System Evolution in Romania. The valley system in Romania developed gradually from the Miocene until the Holocene, starting from the Carpathians outward (plains and Dobruja) as the morphologic units completed.

Its configuration depended on the time and spatial joint of many factors: the gradual emergence and uplift of landforms from the Carpathians to the plains; the regional influence of the extra-Carpathian base levels of erosion and the subsidence areas; the local influence of structural contacts, tectonic faults, etc. Therefore the valley system has several characteristics: convergence toward the Transylvania Depression, divergence outward Carpathians, many valley generations (the most numerous in the Carpathians and less in the plains), and a hierarchy with many distinct groups. This is the case of the *main valleys* formed by sector joint when the land gradually extended, with at least three distinct situations (from the Carpathians to the plains - the eldest Pliocene-Quaternary valleys, from the Subcarpathians to the plains – from mid-Pliocene until Holocene) and autochthon valleys with 1-2 generations (for each main landform unit) from upper Pleistocene and Holocene.

There are three stages of the system evolution considering the period when the main valley generation developed on the great landform units (the Carpathians, the hills and plateaus, the plains). The paper also points out some important evolutional aspects of the main valleys.

Key words: valley system, evolution stages, Romania

1. General Aspects

The present valley system is complex and consists of several generations, aged Pliocene second half and especially Quaternary.

The system configuration (figure 1) was conditioned by several factors of general or local role in the valley genesis and evolution, namely:

- The major orographic system dominated by the Carpathian "ring", surrounded by plateaus, hills and finally plains (southward and westward). This led to the development of a major valley system, convergent to Transylvania and divergent outward.
- The large tectonic basins (Pannonic, Transylvanian and Geto-Pontic) functioned as base levels of erosion toward which the adjacent rivers directed, and dictated indirectly the valley directions of different generations.
- The landforms developed gradually, starting with the Carpathian system completion (the end of Mesozoic-Paleogene – for the crystalline units and up to Pliocene for the volcanic mountains), then the plateaus (gradual emergence and slow uplift from the upper Miocene until the early Quaternary), and finally the filling of the last aquatic areas (Pannonic, and Geto-Pontic) and the plain units completion (upper Pleistocene-Holocene). This general evolution dictated two major tendencies for the valley system development. The first one refers to the main valleys that cross those units that became land in different phases and stages. They are made up of different age sectors. The second tendency refers to the fact that an elder geomorphologic unit has more valley generations that form a hierarchic system with different morphographic and morphometric characteristics.
- The mountain or even hill massifs of well defined structure (volcanic, crystalline, conglomeratic) and sufficient height have a second level of divergent valleys with main outer collectors (the Călimani Mountains surrounded by the river Mureş and the Bistriţa's affluents; the Ceahlău Mountains with the outer valleys Bistriţa, Bistricioara and Bicaz; the Şureanu Mountains with the valleys Sebeş, East Jiu and Strei, etc.).
- The large (tectonic and volcanic barrier, erosion) depressions dictated hydrographic convergences (toward one or two centers – Braşov, Comăneşti), parallel valley systems, or tributary systems to a central collector (Ciuc, Gheorgheni).

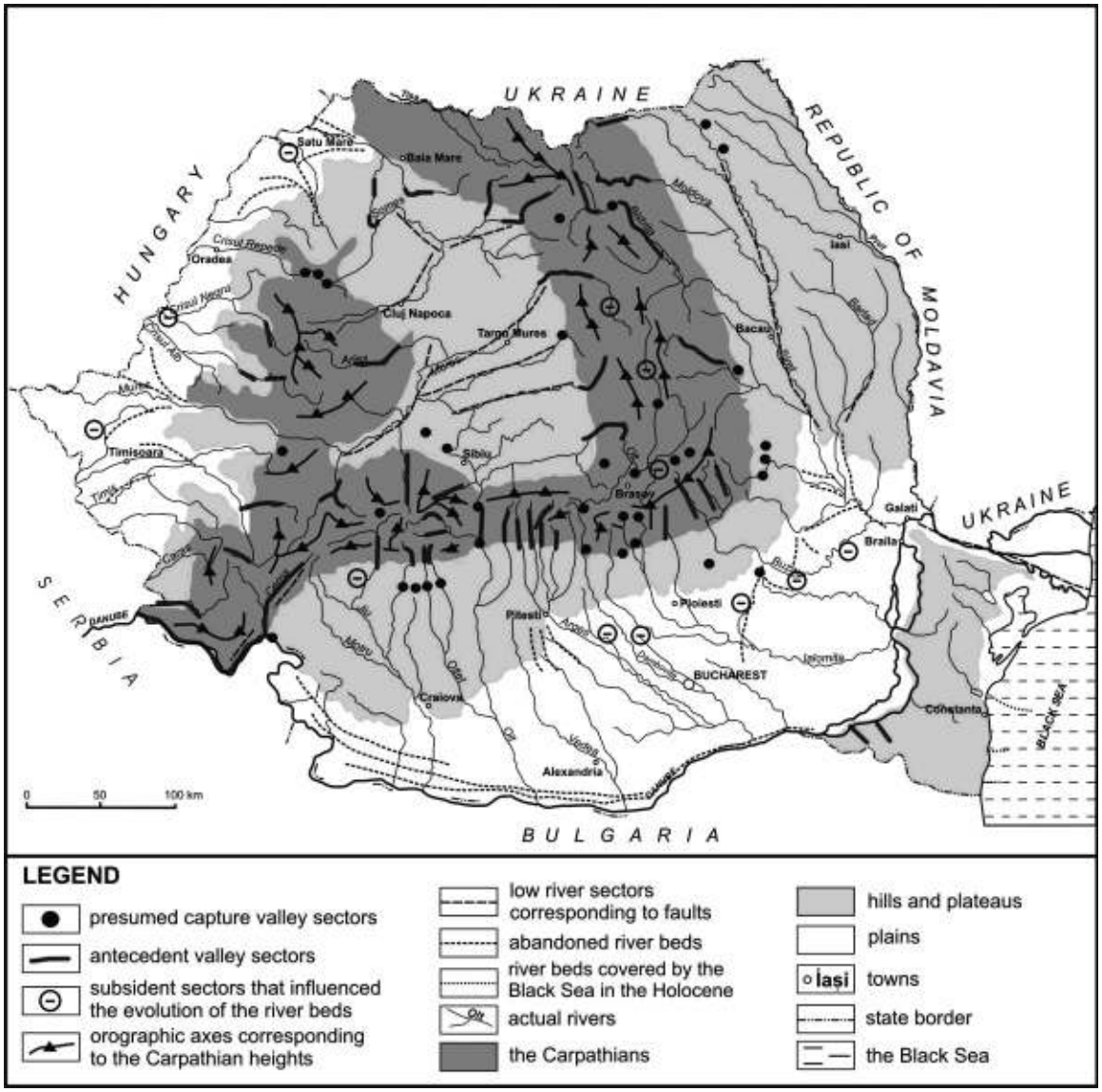

Figure 1. **Elements defining the river system evolution in Romania**

- The position of the structural units (especially within the Oriental Carpathians flysch), the main faults and tectonic flexures (along the rivers Siretului, Oltului, Târnave, Someş), and the grabens (the Occidental Carpathians) generated the primordial directions of the main valley system, many of them preserved by now, others left as hanged proofs (the canals at the Getic Sheet level in the Meridional Carpathians indicated by D. Burileanu are sheet waves according to Gh. Munteanu-Murgoci).
- The upper Pliocene-Quaternary subsidence areas represented and still represent hydrographic convergences, a fact that influenced the convergent valley development in some cases (toward the subsidence centers in the depressions Braşov, Ciuc, etc.), the asymmetrical valleys (with one-side valley terraces – for example the river Bârlad) or obvious deviations (changes) of the river beds (where the active subsidence centers migrated – for example the rivers Argeş, Ialomiţa, Buzău where they enter the plain units).
- The piedmont and mountain glacises development was accompanied by the divergence of the rivers that made them and also by their own valley generation (Cotmeana, Cândeşti, Olteţului, etc.).
- Many valleys of the latest generations in the mountains, Subcarpathians and some plateaus were cut by river deepening on petrographic or structural contacts (especially along the trust-sheets or faults in the Oriental Carpathian flysch).
- The river deepened first in the Pliocene accumulations of some depressions (in the Oriental Carpathians, the Western Hills or even when they entered the Western Plain) and then in harder strata (volcanic, crystalline) beneath them, generated epigenetic gorges (the rivers Someşul Mare, Crişul

Alb, etc.). There are also antecedent valley sectors, where the rivers deepened at the same time as the units uplifted tectonically.

- The Black Sea shoreline fell eastward in the Pleistocene as its level decreased and the Dobruja land extended along with its valley system. The Holocene transgressions covered part of this land and wipe out the flooded valleys, turning them into fluvio-maritime limans (Techirghiol, Taşaul, Tatlageac, etc.).
- During the late Pleistocene and early Holocene, the Danube set its course gradually downstream Drobeta-Turnu Severin and its main tributaries set their courses through the plain (until the mid-Pleistocene west to Argeş river, during the upper Pleistocene to Brăila, and during the Holocene downstream Galaţi).
- Part of the latest valley generation was generated in the plains and in some low plateaus covered with loess by the processes of sag, suffusion and rill-erosion.

2. Acknowledgement

Many Romanian and foreign geographers and geologists analyzed the valley system evolution, especially for the mountains and the Subcarpathians (the 19th century, the beginning of the 20th century), because some morphological elements along the main valleys and the reports between the large hydrographic basins had to be explained. Many analyses and genetic explanations regarded the long and deep gorges downstream some depressions (most of them tectonic depressions), the sudden change of some valley directions, the report between the different positions of the heights and the actual watershed with some low, large and gravel covered saddles, the continuity of valley levels and terraces in the hydrographic basin, etc.

These studies started first with the main rivers that crossed the Carpathians (Olt, Jiu, Danube), extended then in the Subcarpathians, plateaus and even plains. The opinions were based on two ides – the actual valleys were formed by capture, or their gorges are antecedent or epigenetic. The arguments of these ideas referred to: the extent of terraces and erosion levels, the regional paleogeographic evolution, the correlative analysis of the deposists accumulated in the adjacent sedimentary basins that represented at the time local base levels of erosion and so on, all of them based on mappings, profiles, geological map interpretation, etc.

Important regional contributions were brought by: Emm. de Martonne, I. Popescu-Voiteşti, Gh. Munteanu-Murgoci, G. Vâlsan, I. Cvijic, N. Popp, R. Fischeaux, A. Nordon, N. Al. Rădulescu, N. Orghidan, V. Mihăilescu, M. David, N. Lupu, Gr. Posea, I. Donisă, H. Grumăzescu, L. Badea, Al. Roşu, Gh. Pop, A. Posea, I. Mac, N. Popescu, M. Ielenicz, V. Gârbacea, N. Josan, I. Berindei, C. Brânduş, etc.

Many of the local and regional studies are part of some PhD theses, added to the syntheses of the large geographical units (N. Orghidan for the Carpathians, I. Donisă for the Oriental Carpathians, M. Ielenicz for the Curvature Carpathians and the plateaus, Emm. de Martonne for the Meridional Carpathians, Gr. Posea for the Carpathians, Transylvania and the plains, Florina Grecu for the Transylvania plateau, etc.) or the entire Romania (Gr. Posea).

4. The valley system evolution stages

The valley system developed gradually as the land extended definitively, during many stages dictated by the tectonic movements in the Carpathians and adjacent platforms. They also determined their structural completion and altitude. The intermittent rhythm of land uplift separated evolution stages and phases of external agent action that left many proofs: the erosion levels and surfaces, the piedmonts and the valleys with erosion benches and terraces, etc. The terraces belong to a different number of generations (from one unit to another) and form systems of different extent (for large units and hydrographic basins). The characteristics of the valley generations reflect the general evolution of the major landforms. *The existing proofs allow us to reconstruct the valley system generations from the Pliocene until the Holocene*. One cannot identify accurately the valley systems for the elder landform evolution stages (though the interfluves preserve proofs of their morphodynamics). There are some saddles presumed to be former valley, and also gentle slope surfaces on the cross profiles of the main valleys that might indicate elder drainage directions, probably Miocene. They were indicated by some authors to prove the antecedence and the age of some valleys. *But it is obvious that the elder and the most numerous valley generations are in the Carpathians and they decrease in number toward the plains.*

All these differentiate three evolution stages of the valley system (figure 2), according to the final emergence of the major landforms; these stages may be divided in some phases that explain the number of valley generations.

The name of the stages was given according to the period the main valley generation settled on the major landforms.

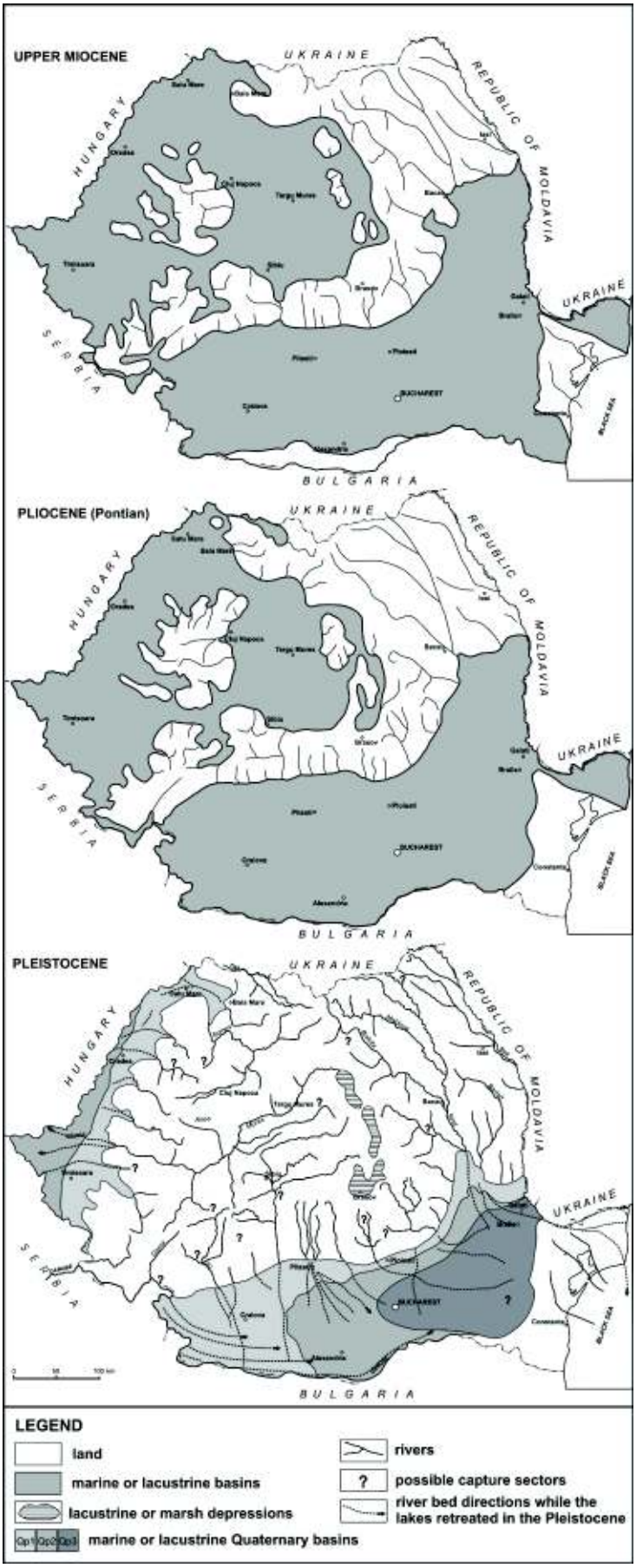

Figure 2. **The valley system evolution stages in Romania**

3.1. The upper Miocene-Pliocene stage of the Carpathian main valley generation. This is the eldest stage, includes almost all the Carpathian Mountains as the large valleys fragmented them into units of I-III degree. From the paleogeographic point of view, during the mid-Miocene, the Carpathians (the crystalline and flysch sectors) were a land crossed by tectonic couloirs (Badenian) that connected the surrounding sea basins (Pannonic, Transylvanian and Geto-Pontic). It was an archipelago with islands limited by marine couloirs and basins (the depressions in the Occidental Carpathians, the Haţeg-Petroşani depression, the Olt couloir, the Curvature Carpathians, etc.); on the first ones a valley system came into being, and sediments accumulated on the second. During the late Miocene and the early Pliocene, the external flysch completed its structure and emerges, then the valley system settled and continued the one from the previous land units (Bistriţa Moldavă, Trotuş, etc.). In other words, the old main valleys extended by new sectors. On the other hand, part of the connecting couloirs between Transylvania and exterior filled with sediments and became lands. Some major valleys settled here and collected the Carpathian rivers. The proofs of a Miocene evolution are few. Some authors (Emm. de Martonne, M. David, I. Donisă, etc.) point out a few valley sectors as Râu Şes, the Olt gorges, Bistriţa, etc., or thought they were some drainages that were destroyed later by the neo-tectonic uplifts or falls (the couloirs that might be primary waves of the Getic Sheet, according to the opinions of Gh. Munteanu-Murgoci, D. Burileanu). But the *Pliocene erosion levels* on these valleys are obvious (better preserved on the upper part of the couloirs cut into the crystalline rocks in the Meridional Carpathians and less preserved in the flysch units). *By joining, they indicate the primordial drainage directions that formed a valley system with springs in the Carpathian units.* On the other hand, *it represented the beginning of erosion for some transversal, long or oblique couloirs* compared to the geological structures. On one hand, the drainage directions show the lower alignments of that time, probably determined by tectonics or lithologic and structural contacts, and on the other hand, the attraction of the low base levels of erosion situated near the mountains – lacustrine or marine basins (Transylvanian, Pannonic and Geto-Pontic).

Concluding, *by late Pontian, the main Carpathian valleys (some of them were transversal couloirs) were formed, and the Carpathian uplift only gave them the antecedent character*. In some cases, *their direction was dictated by the graben alignments in Miocene-Pontian*. They were filled with sediments, emerged gradually and became main collector directions of the Carpathian rivers. Probably when the land altitude was low, they experienced some changes by captures (other authors consider that these situations are presumed in the basins of the rivers Jiu and Olt).

3.2. The upper Pliocene-Pleistocene stage of the main valley generation in the plateaus and hills. The intense tectonic movements (with many phases) of this period generated important structural changes and a gradual land extent. Among them, important for the Subcarpathians are the sediments fold in some sectors (the morphologic landscape with hills on the anticlines and depressions on the synclines) and the monocline structure formation in others. At the same time, the Carpathian landscape completed with the volcanic system that formed mountains of volcanic rocks, or mountains of sedimentary rocks penetrated by magmatic rocks (in the Oriental Carpathians and the south-east Apuseni Mountains). The tectonic uplift in Transylvania urged the uplift of the Badeanian salt blocks (resulting two major structures – diapirs and domes) and also generated the monocline sedimentary structures in the north, northwest and south of it. The other regions of Romania that are now plateaus and hills experienced slight uplifts that determined monocline (the Moldavian Plateau, the Western Hill) and tabular structures (the South Dobruja). The Villafranchian added to these some piedmont plains outside the Meridional and Curvature Carpathians; these plains uplifted with different intensity later. In consequence, a new hydrographic system settled on these new lands, made up of the Carpathian rivers that extended their flows as the emergences extended, and other rivers that sprang from the plateaus or hills. They followed three directions:

- the general slope of the new land (especially in the sectors of monocline structure);
- the lower sectors generated by the tectonics as new synclines (the Subcarpathians, the eastern Transylvania), some lower alignments as surface correspondents of the active deep faults or flexures (for the rivers Mureş, Târnave in N.Josan's opinion, Someş in M. Paucă's opinion, Siret, Dâmboviţa, etc.), the former grabens filled with sediments by late Pannonian in the Oriental Carpathians, etc.;
- the general base levels of erosion of the lakes in the Pannonic and Geto-Pontic basins.

The river system deepening generated many types of valleys.

In the Carpathians there are two types – the pre-Pliocene *old valleys* and the *new valleys* (of their tributaries, with erosion benches on the cross profile, situated above the terraces) that belong to 2-3 generations.

In the hills and plateaus, the difference between the valley generations correlates with the emergence and uplift phases. Thus, in the regions that became land in the first half of the Pliocene (the northern Moldavian Plateau), the main valleys preserve two erosion levels (two evolution phases). Most hills and plateaus in Romania became land after the Dacian and the main autochthon valley system has a single, well preserved erosion level on its upper part.

In both mountains and hills, the existence of large saddles on the interfluves, the alternation of depressions and narrow valleys (sometimes gorges), the existence of valleys with opposite directions led to *interpretations regarding the valley system evolution as frontal or lateral captures*. Some ideas were issued regarding the formation of the river Bistriţa at Zugreni (the upper valley that directed to Transylvania was captured to the east), the river Bistricioara (the capture of the dam lakes in the depressions Borsec and Bilbor, and a similar case for the river Neagra Broştenilor and the lakes Glod and Drăgoiasa), the river Trotuş at Comăneşti (this river or the river Tazlăul Sărat probably crossed the saddle Moineşti), the river Prahova (a capture from the south, through the gorges Posada; losing part its basin in favor of the river Timiş; two Prahova's tributaries, Jepi and Doru, captured the river Izvorul Dorului, the initial tributary of the river Ialomiţa), the river Crişul Repede (came from Oradea and captured the rivers Drăgan, Călata and upper Criş that directed initially northward, toward the Şimleu Depression), etc. In other cases, the researchers presumed that there were overflows of some lakes beyond the volcanic dams (the rivers Mureş in the gorges Topliţa-Deda, Olt in the gorges Racu, Jigodin and Tuşnad), or some basin sectors were beheaded by the occurrence of some tectonic depressions in the upper Pliocene (the upper Buzău, Bâsca Mare lost the rivers that flowed from the north toward the Întorsura Buzăului, and Comandău when the Braşov Depression occurred). There are similar interpretations for the later valley generations in the hills (the saddles on the left side of the river Siret in the Botoşani Hills are former valleys of the river Suceava, and inversely, some rivulets flowed westward on these saddles and were captured by the Prut's tributaries; the saddle between the Meseş Mountains and the Sălaj Hills is considered a former valley of the river Someş westward, etc.). But notice that *for many of the above mentioned situations there are arguments for antecedence in the gorges and other geneses for the saddles considered fragments of old valleys.*

3.3. The upper Pleistocene-Holocene stage of the main valley generation in the low plateaus and plains. The Pannonic (from east to west) and the Getic (from west to northeast) lakes were gradually filled with alluvial deposits. At the same time *the Danube set its course* in the south Romanian Plain and also in the Pannonic Plain; *the Carpathian and hill rivers set their beds toward it* (the newest valley sectors). In the plains, *the first autochthon valley generation with permanent flow and a short one with torrential flow* set. Some Carpathian depressions turned from a lacustrine or marshy regime into a subsidence or piedmont one (Gheorgheni, Ciuc, Braşov), as the collector valley sectors set. The Danube Delta and the fluvio-lacustrine Razim Plain were formed during the last 2000 years.

Add to this evolution and the previous valley system a *new generation of short valleys in the mountains and hills, directed mainly on structural, petrographic and hypsometric contacts*. These valleys extended regressively and made local captures.

4. Valley sectors with controversial genesis

There are many geographic and geologic studies that analyze the evolution of some valley sectors, the most controversial are the large rivers, as the authors support either the antecedence, or the captures. Most studies refer to valleys in the Carpathians, the Subcarpathians, the Transylvanian Hills, the Romanian Plain and the Western Plain. Some of them are presented below:

The Danube formation from Baziaş to Vârciorova. Along Danube there are many basins and narrow sectors, and also sudden changes of direction. The Danube completion by capture or antecedence was differently interpreted. In only two studies the arguments for antecedence (J. Cvijič) or capture (Gr. Posea et al.) were based on the erosion levels and the terraces of the gorge. The others submitted for one of the two variants with geologic (especially the faults and the character of tectonic couloir in Miocene) and geographic arguments from the region or from the units situated downstream or upstream. For those that support the theory of capture, the moment the Danube completed in the gorge and the position of watershed between the

west and the east river are different (G. Vâlsan, R. Fischeaux, P. Coteţ, Gr. Posea et al.).

The Mureş formation is proven by capture in the gorge Dobra at Zam (a river that came from Arad captured the river that passed the saddle Holdea to the river Timiş – Gh. Pop), and also the sector Orăştie-Alba Iulia-Aiud (Gr. Posea stated that a river that came from southwest beheaded more valleys that came from the Apuseni Mountains and headed to the Olt basin). Also the river crossed the gorge Topliţa-Deda directed to the river Someşul Mare, but it was capture at Reghin by the river Mureş that existed in the middle of the Transylvania. Other authors supposed other captures between the rivers Mureş and Târnave at Ighiu-Şard (N. Popp) and between Târnava Mare and Olt over the saddle at the springs of Vişa (I. Rodeanu, Gr. Posea), etc.

Al. Savu considered that *the Someş basin* extended in Romanian over most Transylvania. He considered that there was a series of captures in the Quaternary that came from the rivers Mureş, Crişul Repede or the formation of the valleys Almaş and Agrij (that advanced on faults).

For the *Subcarpathians*, the researchers imagined longitudinal valley systems that were beheaded by the Quaternary captures into the actual structures. The ideas of Emm. de Martonne regarding the existence of some rivers that flowed parallel to the mountains and created one or two chains of depressions, and then they were captured by the rivers that advanced from the south or southeast were taken, amplified and proved for different sectors (N. Popp, N. Al. Rădulescu, Al. Roşu, L. Badea, Gh. Niculescu, H. Grumăzescu, etc.). There are also supporters of valley antecedence. They considered that the depressions near the mountains are the natural results of the more active uplift of the Subcarpathians. Thus, the lower depression couloirs are near the mountain, as they have a synclinal character, and they were closed outward by anticline hills. The rivers that spring from the Carpathians had an initial flow direction in accordance to the general slope, from the mountain outward. A the hills uplifted, the rivers cut in them epigenetic gorges and two-three terraces in the synclinal depressions (M. Ielenicz, N. Popescu, C. Brânduş, etc.).

In the *plains*, the valley changes were determined by two factors, namely the evolution of the active subsidence centers toward many rivers directed, and the rich alluvial deposits that generated meanders. G. Vâlsan (1915) analyzed the most eloquent situation in the Romanian Plain (the meanders in the basins of Ialomiţa, Prahova, Buzău that left abandoned river beds), then N. Popp (the Buzău-Râmnic Plain), P. Coteţ (the Oltenia Plain), Gh. Niculescu (the Ploieşti Plain), Gr. Posea (for different sectors of the eastern Romanian Plain), Şt. Manciulea, M. Paucă, Gr. Posea for the Western Plain (the rivers Timiş, Criş, Someş), etc.

In Dobruja there are two problems. The first one is the formation of the valley Carasu whose bed is directed from east to west (decreases from Constanţa and flows into the Danube), opposite to the direction the watershed decrease (from west to east). The explanations of C. Brătescu (1928) are eloquent to accept the idea of epigenesis, along with the other rivers in southwestern Dobruja, given the neotectonic uplift of this region. The second problem is the valleys near the shore that in the upper Pleistocene were the springs of some rivers that advanced longer on the beach plain that extended eastward; when the sea-level increased, most of this plain submerged, then the strand-walls of the last millennium turned the rivers into limans.

5. Conclusions

- The actual valley system of Romania developed gradually from the Carpathians outward and mainly from the Pliocene until the Holocene.
- It is made up of valleys that cross the great landforms in different ways. The largest valleys that spring from the Carpathians and flow toward the plains (some of them into the Danube) are made up of joint sectors (the oldest are in the mountains, the youngest are in the plains). Each main hypsometric step (mountains, hills and plateaus, plains) has more valleys generations, according to the number of phases of epeirogenetic uplift they experienced and the evolution of the regional base level of erosion. Therefore the number of generation is higher in the Carpathians and decreases in the plains and in Dobruja.
- Most valleys kept their directions with the general slope dictated by the emergence direction of different stages (mainly from the Carpathians outward) or adapted regionally to the neotectonic movements (with different intensity and direction), with more active local centers or certain directions (faults, flexures, tectonic couloirs, etc.).
- The valleys of eldest generations are transversal in the Carpathians and Subcarpathians, according to their directions toward the geographic and structural units. In the first case, there are valleys that cross the entire mountain chain or the Subcarpathians (the river Olt at Turnu Roşu-Cozia, the Danube, the river Crişul Repede), and other

cross most of them (Bistriţa, Trotuş, Buzău, Prahova, Argeş, Crişul Alb, etc.). In the second hand, the situations are various: the valleys may cross entirely or partially the great structural units (crystalline, flysch, Subcarpathian molasses, eruptive) or their subunits (sheet alignments, anticlines, etc.). The second situation refers to the valleys with alternant transversal and longitudinal sectors (along important faults, the head of trust-sheets, the synclines, the waves of large sheets, etc.)

- The valleys of younger generations in the hills, plateaus and plains have a dominant direction dictated by the general slope of land extent, and by local influences generated by the neotectonics (subsidence sectors especially in the plains, active uplifts in the hills, the surface correspondents of deep faults and flexures on the rivers Siret, Someş, Bârlad), structural characteristics (especially the monoclinal structure), and petrographic contacts.
- Most valleys kept their initial directions so that many gorges are epigenetic and antecedent.
- The changes of some rivers accompanied by amputations or basin extents occurred in different situations:
  - at the beginning of a valley generation evolution when the general landform amplitude and the river deepening were low;
  - when the tectonic depressions occurred (Braşov, Comăneşti, the Transylvania basin and the golf depressions);
  - when the volcanic chain developed and separated the Transylvanian basin from the central and western sectors;
  - a normal evolution by regressive extent of the younger rivers, locally accompanied by captures;
  - by diffluences in the sectors with rich alluvial deposits (on the glacis plains), or by direction changes dictated by a more intense subsidence of some centers (in the plains), etc.

In general, *the morphologic arguments for the capture evolutions may be excluded from the upper Pliocene and up to present. The rest of them are only suppositions.*

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