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NEOGENE GEODYNAMIC HISTORY OF THE EASTERN CARPATHIANS

(1 Fig.)

Abstract: During Neogene Rumanian Eastern Carpathians were subject to three main compressional events: Early Miocene (Old Styrian, 18–20 Ma), Middle Miocene (Young Styrian, 15 Ma) and Late Miocene (Moldavian, 10–12 Ma). Early Miocene events are responsible for the deformations occurring in both Pienide and Moldavidian zones while Middle- and Late-Miocene events are restricted to the Moldavidian zone. Minor deformations during Late Pliocene – Pleistocene occur only locally in the bend area of the Eastern Carpathians, involving Subcarpathian Nappe, its post-tectonic cover and the inner part of the foredeep. Crustal shortening and subduction are responsible both for the generation of cover nappes, detached from their initial basement and for the Neogene andesitic volcanism occurring behind the thrust belt.

Резюме: В течении неогена румынские Восточные Карпаты претерпели три главные события сжатия: в раннеи миоцене (древний штирсий, 18–20 м. л.), в среднем миоцене (молодой штирский, 15 м. л.) и в позднем миоцене (молдавский, 10–12 м. л.). События раннего миоцена вызвали деформации встречающиеся в пиенидской и молдавидской зонах, а стредне- и позднемиоценовые события ограничены молдавидской зоной. Малые деформации встречающся только локально в области сгиба Восточных Карпатов воздействуя на подкарпатский покров, его послетектоническую оболочку и внутренную часть передовой впадлины. Сокращение коры и субдукция являются причиной возникновления покровов оболочки отделившихся от фундамента и неогенного андеситового вулканизма за полосом надвигов.

The Rumanian Eastern Carpathians develop on a length of over 600 km, between the Tisa Valley springs and Dîmboviţa Valley. Inwards the Eastern Carpathians are delimited by Transylvanian Basin and the easternmost part of the Pannonian Basin. Outwards that sector of the Carpathian Orogen borders on East European Platform, the Scythian Platform, the North-Dobrogean Orogen and the Moesian Platform.

As a segment of the Alpine Orogenic Belt, the Eastern Carpathians can be divided into some major structural units which group together nappes of similar type and of synchronous age of tectogenesis. From west to east these are: Transylvanides, Pienides, Median Dacides, External Dacides and Moldavides (Fig. 1).

During their Alpine history, subsequent to the distensional period (Triassic–Neocomian), the Eastern Carpathians underwent two main successive stages of compressional deformations Dacidian and Moldavidian Stages (Dumitrescu et al., 1962; Dumitrescu – Săndulescu, 1970, 1976; Săndulescu, 1980, 1984). These stages are Cretaceous and respectively Miocene in age and led finally to the very intricate structure of the Eastern Carpathians recognizable nowadays. The present paper deals with the evolution of the sedimentary mobile areas of this segment of the Carpathian orogen during Neogene. Older

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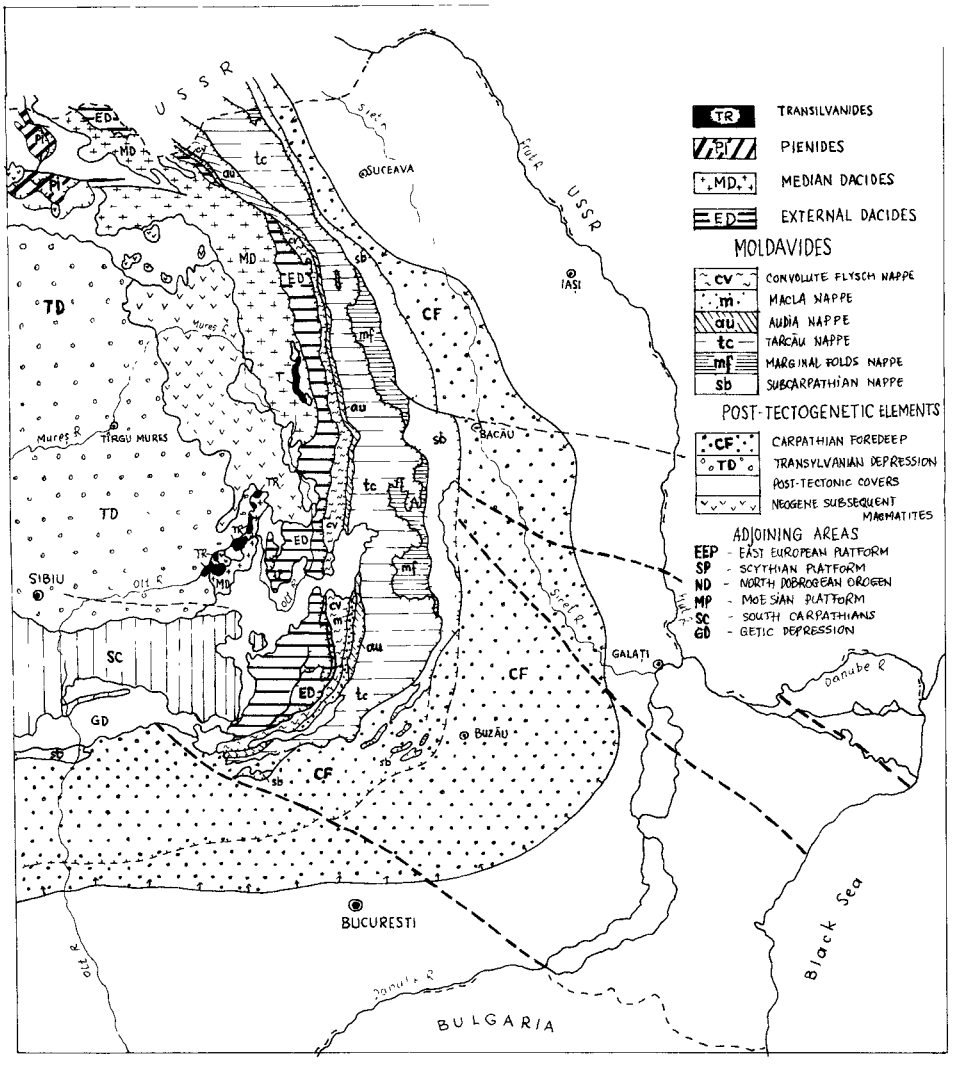

Fig. 1. Tectonic sketch-map of the Eastern Carpathians and adjoining areas (after S ă n d u l e s c u , 1984 – simplified).

events will be only briefly presented in so far as they subsequently influenced the area under discussion.

Pre-Neogene tectogenetic events

The Cretaceous compressional events were responsible for the deformation of the inner part of the Eastern Carpathians. This compressional stage reached several tectonic climaxes

known as the Austro-Alpine phase (Barremian–Aptian), Mesocretaceous phase (Late Albian) and Laramian phase (intra-Maastrichtian). During this Dacidian period were emplaced Transylvanides (Aptian–Albian), Median Dacides (Barremian–Albian), External Dacides (Late Albian and intra-Senonian). Pienides underwent both Cretaceous (Albian and Maastrichtian) compressions, followed later by Early Miocene (intra-Burdigalian) deformations. Thus, except the Pienides, the inner part of the Eastern Carpathians gained approximately its present structure by the end of the Cretaceous. Since then this area behaved as rigid blocks, separated each-other by strike-slip faults, being intermittently overlapped by post-tectonic covers comprising Upper Cretaceous and Paleogene–Lower Miocene rocks. Subsequent movements along above mentioned faults slightly deformed in places these post-tectonic covers.

It is worth mentioning that older rocks situated below the Neogene Pannonian and Transylvanian basins were deformed during Dacidian (Cretaceous) events too. These deposits belong to different nappes of the Inner- and Median Dacides, Pienides and Transylvanides.

During Paleogene and Earliest Miocene large areas of the Eastern Carpathians were the site of intensive sedimentation, mainly of flysch type. The most important zones of subsidence were in the Moldavides and in the Pienides areas where various flysch formations deposited practically uninterrupted from Cretaceous until Early Miocene. During this time span the internal parts of the Eastern Carpathians were subject of strong subaerial erosion, acting as source areas for the flysch deposits. Especially in the case of Outer Moldavides the foreland supply was sometimes important (green schists clasts of Dobrogean type being the main component of this "exotic" supply).

Unlike the North Carpathians where Pyrenean movements (Late Eocene–Oligocene) are considered responsible for some deformations (Oszczypko–Zytko, 1987) in the Eastern Carpathians similar events were not recorded.

Neogene tectogenetic events

The first Neogene deformations within the Eastern Carpathians started in Early Miocene when the inner nappes of the Moldavides (convolute Flysch Nappe, Macla Nappe and Audia Nappe) were overthrust. The compressional deformations here are intra-Burdigalian, the youngest deposits overthrust by these nappes being Aquitanian or Lower Burdigalian in age (Vineţişu-Krosno Flysch, Cornu Beds) and their post-tectonic cover is represented by Upper Burdigalian Dofteana Molasse.

Deformed units belonging to the Pienides overthrust Lower Burdigalian deposits and are unconformably overlapped by the Upper Burdigalian Hida Molasse on the northern border of the Transylvanian Basin.

During Lower Miocene the sedimentation of flysch type continued in the outermost zone of the Eastern Carpathians i.e. in the area of the Outer Moldavides (Tarcău-, Marginal Folds- and Subcarpathian nappes). These flysch deposits locally contain olistoliths derived from the Carpathian realm (Slon Facies of the Vineţişu Flysch) or from the foreland (Gura Soimului Formation). The presence of older flysch rocks as olistoliths shows that an important part of the Flysch Carpathians (Inner Moldavides) was yet uplifted and eroded. In the higher part of the Gura Soimului Formation gypsum layers locally occur. The following deposits (Salt Formation) develop only on the area of the Marginal Folds Nappe and Subcarpathian Nappe and constitutes a typical molasse composed of gypsiferous clays with halite and potash salts. Laminated sandstones and coarse conglomerates derived mainly from the foreland also develop.

The Burdigalian evaporites of the Outer Eastern Carpathians appear to be contemporaneous with Lower Miocene tectogenetic events responsible for the overthrusting of the Inner Moldavides. The temporary decrease or even cessation of the subsidence over a large area could be related to the development of a compressional stress field, a similar phenomenon occurring again during the Middle Miocene (Săndulescu, in press).

The Lower Miocene (Burdigalian) Salt Formation sedimentation is followed in the Outer Carpathians mobile area by deposition of thick molasse sediments which contain a great quantity of clastics derived from the foreland. These pre-Badenian deposits are builtup in their lower part mainly by conglomerates and in the upper one by alternating shales and laminated sandstones, characterized by fairly abundant mammalians and birds tracks. These deposits change over into grey sometimes red marls and siltstones, clays and sandstones, sporadically interbedded with tuffites, gypsum layers and thin laminated limestones. In the lower part of these deposits animal and bird imprints are still present. That, associated with some sedimentary structures such as wave-ripple marks, mud cracks, rain prints etc. suggest that the deposits under discussion represent shallow-water or even continental environments. The presence of exotic rocks shows that at least during the Lower Burdigalian the uplifted foreland still constituted an important source of material (Micu, 1982).

It is worth of mention that locally in the inner parts of the Marginal Folds Nappe conglomerates younger that Burdigalian Salt Formation unconformably overlap older flysch deposits (Bistriţa and Gura Putnei half-windows). Thus it is possible that the parosysmal stage of Early Miocene movements led primarily to the folding and uplifting of the flysch deposits and subsequently to the erosion and/or non-deposition of Salt Formation on some areas of the Outer Moldavides (Micu, 1987; Micu – Constantin, in press).

According to Săndulescu (1980, 1984) crustal shortening and subduction during Early Miocene involved old oceanic crust beneath the Pienides and continental or thinned continental crust below the External Dacides. The new formed nappes constituting the Inner Moldavides consist only of sedimentary rocks detached from their basement (cover nappes).

The Early Miocene compressional events occurring in the Eastern Carpathians are equivalent of the Old Styrian tectogenetic phase (18–20 Ma). The older term – Savian phase – is not used here because this was previously related to events occurring at the boundary between Oligocene and Miocene. Recent discoveries showed that the orogenetic processes in the Carpathian realm are in fact younger than previously assumed.

The second period of Neogene tectogenetic events involved only the Moldavides and occurred during Middle Miocene (Badenian). During this period Tarcău and Marginal Folds nappes were owerthrusted. Their youngest deformed rocks are of Earliest Langhian age (Lowermost Badenian) whilst the youngest deformed rocks of the Subcarpathian Nappe overthrust by the Tarcău and/or the Marginal Folds Nappes are Langhian Lower Badenian in age.

Subsequent to the normal marine sedimentation during Early Badenian, the middle part of the Badenian is represented by gypsum, anhydrites and locally by salt-bearing deposits. This salinity "crisis" is, as in the case of the Lower Miocene Salt Formation, contemporaneous with the Middle Miocene tectogenetic events which are responsible for the overthrusting of the Tarcău and Marginal Folds Nappes over the Subcarpathian realm. Normal marine sedimentation is resumed after the evaporite deposition. During this time strong Indo-Pacific influences are felt, the microfaunal assemblages occurring at these levels clearly pointing out the temporary resumption of the wide connections from the east with the Tethys (fide Popescu in Micu, 1982).

The maturity of arenites and relative abundance of pelites in the Middle Miocene point out

the absence of an active relief at the margin of the depositional domain. The terminal part of the Middle Miocene indicates shallow-marine sedimentary conditions as a prelude of brackish molassic environment settled during the Sarmatian.

The compressional events of Middle Miocene (intra-Badenian) age can be correlated with the Young Styrian phase (15 Ma). Apart from the generation of some nappe structures crustal shortening and subduction are evidenced on Rumanian territory by andesitic volcanism known in the inner part of the Eastern Carpathians.

The last tectogenetic events during Neogene affected only the Outer Carpathians and are intra-Sarmatian in age. Known as the Moldavian tectogenetic phase this phase corresponds to the stratigraphic boundary between Sarmatian s.str. and Pannonian in the inner parts of the Carpathian realm. According to the chronostratigraphy used for the external zones of the Carpathians and in the foreland area this event took place during Bessarabian.

In the Volhynian (Early Sarmatian s.l.) the domain of sedimentation overlay to a large extent the area which would constitute subsequently the Subcarpathian Nappe. The Volhynian gritty-conglomerate molassic facies unconformably overlies older formations of the Tazlău Subcarpathians proving that in this area the shore line must have been situated not very far to the west. During the Bessarabian the basin configuration underwent several modifications in the sense of a possible migration east- and southwards. Such deposits are unconformably overlapping older Miocene deposits of the Subcarpathian Nappe, thus proving the intra-Bessarabian age of the overthrust of the Subcarpathian Nappe over the external zone of the Carpathian Foredeep. A significant reduction of the domain of sedimentation on the present Subcarpathian Nappe can be observed at the Meotian–Pontian boundary, deposits of this age being known only from the Trotuş Valley to the south.

The Late Miocene tectogenetic events known as Moldavian phase are considered to be synchronous with the peri-Mediteranean Tortonian tectogenetic events (Săndulescu, in press).

Moldavian phase generated both the overthrusting of the Subcarpathian Nappe over the Carpathian Foredeep and the thrusting of the Tarcău and Marginal Folds Nappes (this time acting as a homogeneous block) over the Subcarpathian one.

During Latest Pliocene–Earliest Pleistocene weak compressional events affected locally the Eastern Carpathians realm. The areal extent of these deformations is delimited by two strike-slip faults, the Peceneaga–Camena and Intra–Moesian Faults which are still active and delimit inwards an area of high seismicity in the bend zone of the Eastern Carpathians (Săndulescu, 1984). Known as Wallachian phase above mentioned deformations consist only of tilting, folding and slight thrusting with maximum horizontal displacement not exceeding 1–2 km. Involving young sedimentary rocks of the Subcarpathian Nappe, the tectonic cover of this one and the inner part of the foredeep, the Wallachian movements are responsible also for the generation of diapiric structures occurring in the bend area of the Eastern Carpathians.

Conclusions

– Neogene compressional events within the Eastern Carpathians follow the Cretaceous deformations, the latter affecting only the internal parts of the mountain belt;

– Paleogene and Early Miocene sedimentary mobile areas include two main troughs, Pienide Trough and Moldavidian Trough respectively where continuously mainly flysch deposits sedimented. These troughs were separated by an uplifted area represented by nappes deformed in Cretaceous time and subsequently subjected to intensive subaerial erosion.

While the Pienide Trough is situated on oceanic crust the Moldavidian Trough had initially a continental or thinned continental crust as basement. Flysch sedimentation was replaced by molassic sedimentation since Lower Miocene (Burdigalian), the eastward migration of the depocentre being obvious in the case of the Moldavidian realm;

– The above mentioned troughs were subject of three main compressional events during Early Miocene (Old Styrian Phase), Middle Miocene (Young Styrian Phase) and Late Miocene (Moldavian Phase), all of them generating important overthrusts. The youngest deformations occurring in the Eastern Carpathians (Wallachian Phase – Late Pliocene–Earliest Pleistocene) have a fairly reduced areal development and are by far less important in comparison with the previous ones;

– The nappes generated within Eastern Carpathians during the Neogene tectogeneses are cover nappes, made entirely of sedimentary rocks detached from their initial basement;

– Apart from the generation of nappe structures resumption and continuation of the crustal shortening and subduction during Neogene led also to the eruption of andesitic volcanics behind the thrust belt.

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