COMMENTS ON THE SUPRAGETIC NAPPE IN THE CENTRAL-EASTERN SOUTH CARPATHIANS

STELEA Ion

Abstract. Within the double-arcuate orogen of the Romanian Carpathians, the central-eastern South Carpathians connect the two bends formed as a result of the Cretaceous and Miocene compressions exerted by the eastward drifting of the pre-Apulian block inside the orogenic arc and the synchronous westward drifting of the outside Moesian block. The parallel sliding of the two crustal blocks involves a transcurrent tectonic regime in the central-eastern South Carpathians, routinely seen as a stack of thrust nappes. The existence of a large Supragetic Nappe on this orogenic segment is questioned in geodynamic context.

Keywords: South Carpathians, geodynamic context, Supragetic Nappe.

Rezumat. Observaţii asupra Pânzei Supragetice din Carpaţii Meridionali central-estici. În orogenul dublu arcuit al Carpaţilor româneşti, Carpaţii Meridionali central-estici racordează cele două curburi formate sub acţiunea compresiilor exercitate în timpul Cretacicului şi Miocenului de migrarea spre est a blocului preapulian de la interiorul arcului carpatic, simultan cu migrarea spre vest a blocului moesic de la exterior. Alunecarea paralelă a celor două blocuri crustale implică un regim tectonic transcurent în Carpaţii Meridionali central-estici, văzuţi de regulă ca o stivă de pânze de şariaj. Existenţa unei Pânzei Supragetice de amploare este pusă în discuţie în context geodinamic.

Cuvinte cheie: Carpaţii Meridionali, context geodinamic, Pânza Supragetică.

INTRODUCTION

The Supragetic Nappe is the most controversial tectonic unit in the South Carpathians. In contrast to the Mid Cretaceous Getic Nappe (MURGOCI, 1910a), practically unchanged until today, the Supragetic Nappe has been from the start an inconsistent tectonic concept, difficult to define despite many attempts.

A nappe over the Getic Nappe was defined for the first time by POPESCU-VOITEŞTI (1911) in the Iezer-Leaota Mountains area, later being extended over the internal margin of the South Carpathians (POPESCU-VOITEŞTI, 1929). This nappe was redefined on the Olt Valley by SCHMIDT (1930), and STRECKEISEN (1934) gave it another cartographic contour by including the entire eastern South Carpathians in a large Upper Nappe. Contested by GHIKA-BUDEŞTI (1940) and ignored for a while, the Upper Nappe has been once again redefined by CODARCEA et al. (1967) under the name of Supragetic Nappe, with a reduced cartographic contour by excluding the Iezer-Leaota Mountains from the nappe body. Finally, the north Sebeş-Cibin Massif was also excluded from the nappe by SĂNDULESCU (1980, 1984). In its current contour (Fig. 1), the Supragetic Nappe in the central-eastern South Carpathians includes the eastern border of the Lotru Mountains (the western slope of the Olt Valley), the Făgăraş and the Cozia Mountains.

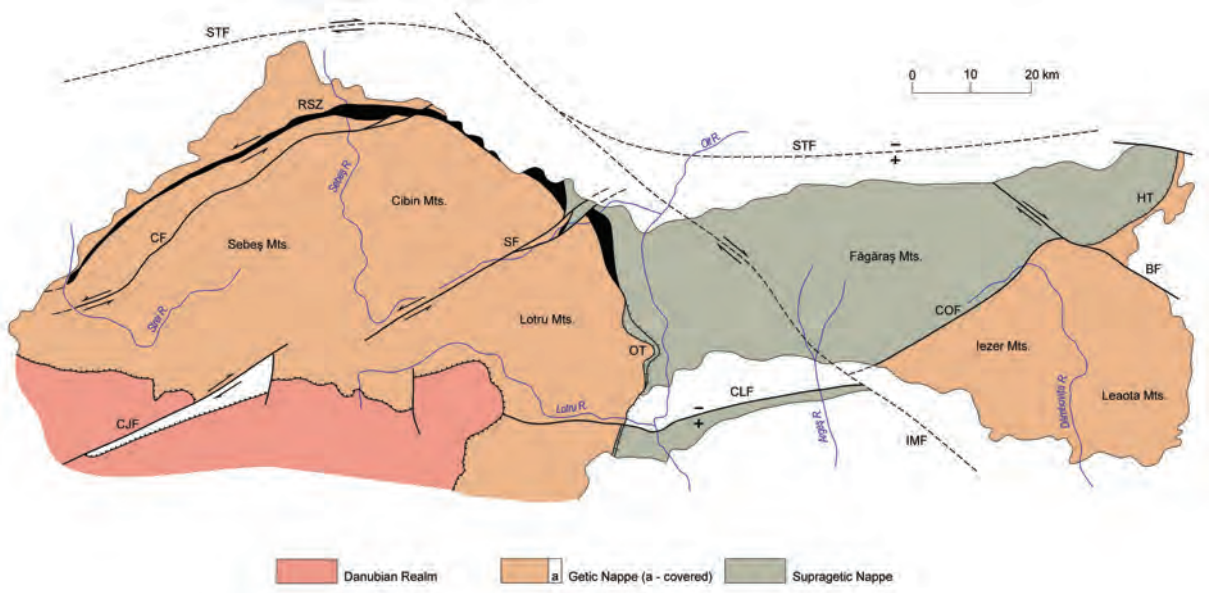

Figure 1. Main Alpine tectonic lineaments in the central-eastern South Carpathians: STF-South Transylvanian Fault; RSZ-Răşinari Shear Zone; CF-Cioclovina Fault; OT- Olt Valley thrust faults; CJF-Cerna-Jiu Fault; SF-Sadu Fault; IMF-Intramoesian Fault; BF-Bârsa Fault; HT-Holbav thrust; COF- Curmătura Oticului Fault CLF-Cozia-Lotru Fault.

The Alpine nappe-structure of the central-eastern South Carpathians is however difficult to explain given their position within the double-arcuate Carpathian belt. According to SĂNDULESCU (1980, 1984), the two bends of the Romanian Carpathians are the result of the Cretaceous and Miocene compressions on E-W direction exercised by the westward drifting of the Moesian block outside of the orogenic arc, at the same time with the eastward drifting of the pre-Apulian block inside the orogenic arc and the subsequent clockwise rotation of its transport direction. Moving parallel to the central-eastern South Carpathians, the two continental blocks have exerted compressions only on the orogenic segments in front of them, i.e. the Eastern Carpathians and the western South Carpathians.

Now widely accepted, this geodynamic scenario requires a transcurrent tectonic regime along the orogenic segment connecting the bends and a subsequent transpressive one in the north-eastern Făgăraş Mountains, closer to Vrancea bend. Consequently, a revaluation of the compressional tectonics role in the Alpine structuring of the central-eastern South Carpathians is necessary, the more so as no structural studies have been done on the assumed thrust planes in this region, the nappes being defined on the basis of the stratigraphic and lithofacial characters of their sedimentary cover. This paper is a short history of the Supragetic Nappe as a tectonic concept, commented from the perspective of the Alpine structures in the crystalline basement of the central-eastern South Carpathians.

THE TRANSCURRENT TECTONICS IN THE SOUTH CARPATHIANS

STILLE (1953) was the first author with an overall mobilistic vision on the Romanian Carpathians geotectonics. Like MURGOCI (1910a), Stille considered that the Getic Nappe emplacement started in the Palaeozoic as a result of the Moesian Platform underthrust beneath the western South Carpathians. A predicted deep fault on its northern margin allowed the platform translation towards WNW. This hypothesis was based on the observation that the pre-Alpine basement of the western South Carpathians was regenerated during the Alpine orogenesis, while the basement of the central-eastern South Carpathians preserved its Hercynian structure. That is true, except the northern slope of the Făgăraş Mountains, restructured by tight-folding in low-grade metamorphic conditions. Subsequent geophysical researches confirmed the Moesian Platform displacement towards WNW (e.g. AIRINEI, 1983) and the existence of some fault systems that accommodated this movement (e.g. VISARION et al., 1988).

PAVELESCU & NITU (1977) distinguished two stages of different tectonic regimes in the evolution of the Carpatho-Balkan chain, first of Cretaceous compressions, when the thrust nappes were emplaced, and second of post-Cretaceous strike-slips, when the pre-existing structures were aligned parallel to the chain axis, arcuate around the Moesian Promontory. The strike-slips in the South Carpathians are explained by the westward translation of the Moesian Platform simultaneously with the eastward translation of the crustal blocks inside the Romanian Carpathians. One of the most important transcurrent faults in the western South Carpathians is the Cerna-Jiu Fault, with dextral strike-slip of 30-40 km during the Eocene (BERZA & DRĂGĂNESCU, 1988).

In his geodynamic model, SĂNDULESCU (1980, 1984) does not make explicit references to the transcurrent tectonics of the South Carpathians, but admits that the transport of the continental blocks in this area was accommodated by the South Transylvanian, Intramoesian, and Peceneaga-Camena transcurrent faults. The dextral strike-slip on the South Transylvanian Fault also involves a transcurrent tectonic regime on the northern margin of the central-eastern South Carpathians. A transcurrent tectonic lineament on the northern Sebeş-Cibin Massif is Răşinari Shear Zone (Fig. 1). This is a pre-Alpine vertical fault intermittently reactivated as sinistral strike-slip fault from the Early Jurassic to the Mid Cretaceous (STELEA, 2000). The net horizontal displacement on the central segment of the shear zone is of 12 km.

However, the folded structure of the crystalline basement in the Făgăraş Mountains east of the Intramoesian Fault shows a transpressive tectonic regime decreasing from NE (tight-folded area) to SW (gently-folded area). Following the Late Cretaceous rotational motions of some tectonic blocks inside the pre-Apulian area (SURMONT et al., 1990), the eastern segment of the South Transylvanian Fault was probably locked, the dextral strike-slip on its western segment being transferred on the Intramoesian Fault, oblique to the orogen axis. Because the Intramoesian Fault is a long-lived fault, and still active, the Cretaceous horizontal displacement is difficult to quantify.

THE SUPRAGETIC NAPPE IN THE CENTRAL-EASTERN SOUTH CARPATHIANS

The first Supragetic Nappe was the Bucegi Conglomerates Nappe, of Miocene age, presumed by POPESCU-VOITEŞTI (1911) in the eastern South Carpathians. Based on stratigraphic and structural correlations between the Tertiary deposits in the Getic Depression and the East Carpathians, the author included in this nappe the Iezer-Leaota Mountains and the north-eastern part of the Făgăraş Mountains.

Later, POPESCU-VOITEŞTI (1929) separated three nappes within the Getic Nappe, the upper one including, beside the Iezer-Leaota Mountains, the north Sebeş-Cibin Massif and the entire northern part of the Făgăraş Mountains. All the vertical faults in the South Carpathians were considered as overthrust except for those in the north Sebeş-Cibin Massif and north Iezer Mountains, correctly seen as uncertain thrusts. The nappe was argued by an inaccurate observation regarding the lower metamorphic grade of its crystalline basement as compared to the Getic Nappe basement, which is only partly true. This second Supragetic Nappe was initially correlated with the Bucegi Conglomerates Nappe and the Bucovinic Nappe in the East Carpathians, then only with the Bucovinic Nappe (POPESCU-VOITEŞTI, 1942).

On similar criteria, SCHMIDT (1930) theorized the existence of a Supragetic Nappe in the eastern South Carpathians in order to explain the differences between the crystalline basement of the Lotru Mountains, then considered monometamorphic, and the polymetamorphic basement of the Făgăraş Mountains. The thrust fault outcrops on the Valley of Stan, where the augen gneisses of the Cumpăna Series are overlaying on the Getic Nappe. The thrust fault was continued northward on the north-eastern margin of the Sebeş-Cibin Massif up to Căpâlna Village on the Sebeş Valley.

At that time, the author was referring to the polymetamorphism of the Făgăraş Series in the northern Făgăraş Mountains, where a low-grade dynamic metamorphism is superimposed on the pre-Alpine medium-grade regional metamorphism. The tectonic relationship on the Valley of Stan involves the gently-folded augen gneisses in the southern Făgăraş Mountains. Representing the deepest structural level of the nappe basement, just the augen gneisses should be the most affected by the thrust related deformations.

Starting from these assertions, STRECKEISEN (1934) included the entire crystalline basement east of the Olt River in his Upper Nappe, the thrust fault being represented by the tectonic lineament Valley of Stan-Răşinari-Căpâlna. The author brought two arguments in support of the Upper Nappe in the central-eastern South Carpathians, both erroneous: (a) the low-grade schists along the thrust fault represent the deformed sedimentary cover of the Getic Nappe and (b) the supragetic basement contains augen gneisses, in contrast to the getic basement, which does not contain such rocks.

GHIKA-BUDEŞTI (1940) demonstrated that the supposed sedimentary cover represents the low-grade facies (actually mylonitic facies) of the Getic Crystalline and the augen gneisses are also present in the Getic Nappe basement. Concerning the Mesozoic sedimentary formations outcropping on the Valley of Stan, the author mentions the interesting hypothesis of MURGOCI (1910b), according to which these deposits would be autochthonous (i.e. Danubian) sedimentary cover outcropping in a tectonic window beneath the Getic Nappe. Following the paper of Ghika-Budeşti, the Upper Nappe was forgotten for a while.

CODARCEA et al. (1967) brought into discussion the existence of the Upper Nappe, renamed Supragetic Nappe, starting from some lithofacial considerations on the few Triassic sedimentary sequences in the South Carpathians, compared with the Triassic deposits in the East Carpathians. By correlating the Lower Triassic limestones on the Valley of Stan with the Lower-Middle Triassic bituminous limestones near Braşov, the authors outlined a large getic sedimentation basin from which the Făgăraş Mountains were excluded. With Lower-Middle Triassic dolomites in their north-eastern extremity, the Făgăraş Mountains would represent a supragetic sedimentation domain correlated with the bucovinic domain in the East Carpathians. Like POPESCU-VOITEŞTI (1929), the authors consider as uncertain the thrust faults in the north Sebeş-Cibin Massif and north Iezer Mountains. The nappe emplacement is Mid-Cretaceous, the thrust in the western South Carpathians being reactivated during Miocene.

SĂNDULESCU (1984) defines the Supragetic Nappe as crustal shearing nappe, which means that the getic and supragetic domains have formed a single crustal block before the shearing. Based on the sedimentary cover analysis, the author deduces that the nappe emplacement took place during the Mid and Late Cretaceous tectogenetic phases. The Late Cretaceous movements were recognized on the thrust along the Olt Valley and the Holbav thrust in the eastern Făgăraş Mountains. Săndulescu correlates the Supragetic Nappe with the Subbucovinic Nappe in the East Carpathians.

These are the main attempts in defining the Supragetic Nappe in the central-eastern South Carpathians. Despite the uncertainties regarding the thrust faults, the idea of a large Supragetic Nappe in this region is still accepted as proposed by CODARCEA et al. (1967) and adjusted by SĂNDULESCU (1980; 1984). Although many geologists agree with the geodynamic pattern developed by Săndulescu, the required transcurrent tectonic context in the central-eastern half of the South Carpathians was never discussed.

DISCUSSIONS

The structural correlations made by CODARCEA et al. (1967) at the level of the Triassic sedimentary cover are structurally irrelevant, first because this cover is not significant in the South Carpathians, and second because many facies variations without any structural relevance can arise within a large sedimentation domain. Moreover, the few Triassic sequences in the north-eastern Făgăraş Mountains (SĂNDULESCU et al. 1972a, b) show both dolomitic (supragetic) and bituminous (getic) facies. Bituminous limestones 'of getic type' also appear removed in the Paleogene breccias (Fig. 2a) laying on the southern border of the 'supragetic' Cozia Mountains, on the Argeş Valley (DIMITRESCU et al., 1985). Most likely, it was a single sedimentation basin during the Triassic, with the same crystalline basement.

At regional scale, the tectonic lineament Valley of Stan-Răşinari is a branch of Răşinari Shear Zone in the north Sebeş-Cibin Massif. As against the Alpine sinistral displacement on the shear zone, the Olt Valley branch is a restraining bend so that the transcurrent tectonic regime in the north Sebeş-Cibin Massif gradually became transpressive on the eastern border of the Lotru Mountains. The pre-Alpine mylonitic foliation and the Alpine faults within the shear zone are still subvertical on the Sadu Valley (Fig. 2b) and remain subvertical up to the Vadului River, the transpressive regime becoming dominant south of this river.

Transpression in restraining bend can generate folds, reverse faults, and thrusts. In this case one can speak about high-angle reverse faults and strike-slip related upthrusts. Even CODARCEA et al. (1967) considered that the displacement on the Olt Valley thrusts do not exceed 2 Km. Anyway, the crystalline basement on both sides of this tectonic lineament has the same pre-Alpine metamorphic history and the metamorphic formations west of the Olt River are found in the same lithostructural position on the southern slope of the Făgăraş Mountains, (STELEA, 2006). The

getic lithologies east of the Olt River observed by STRECKEISEN (1934) are not simple convergence phenomena, as were considered the author, but represent just the Getic Crystalline.

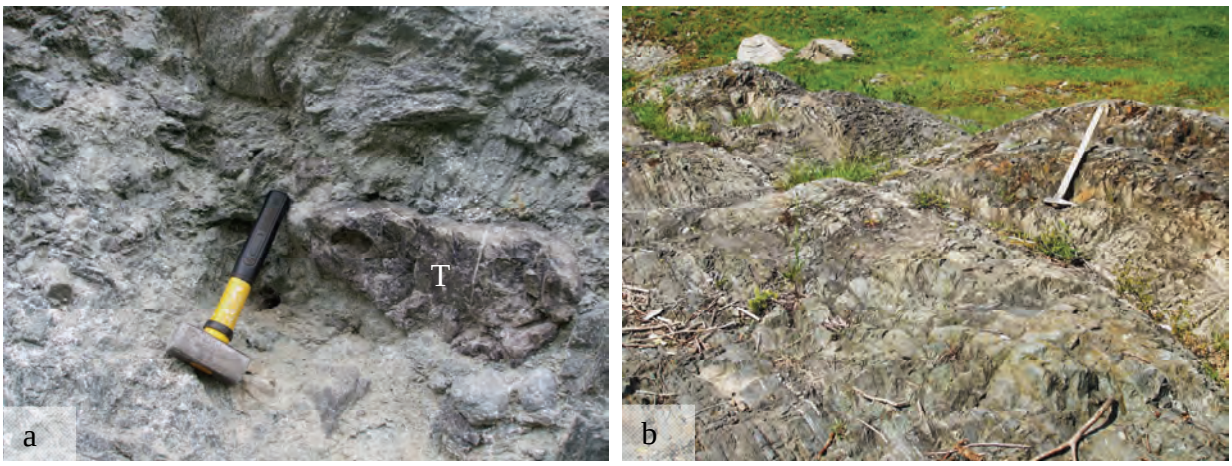

Figure 2. Outcrop photographs: a) block of Triassic bituminous limestones (T) in the Paleocene-Ypresian breccias laying on the crystalline basement of the Cozia Mountains (the Argeş Valley); b) subvertical mylonitic foliation within Răşinari Shear Zone on the Sadu Valley (original).

The tectonic lineament on the south-eastern border of the Făgăraş Mountains was the first time defined as thrust (i.e. Holbav Thrust) in the eastern extremity of the Făgăraş Mountains (SĂNDULESCU et al., 1972b). A post-Cretaceous transpressive tectonic regime in the eastern Făgăraş Mountains (NW-SE compression) occurred from the Burdigalian to the Early Badenian (e.g. HIPPOLYTE et al., 1999). Westward of Bârsa Fault, this lineament was mapped as vertical fault with unclear kinematics (DIMITRESCU et al., 1974, 1978), then interpreted as Mid-Cretaceous thrust by SĂNDULESCU (1984) and Mediterranean retrothrust by BALINTONI et al., (1986).

The same metamorphic formations, in the same structural position, outcrop in the Iezer and Făgăraş Mountains on both sides of this fault, named herein Curmătura Oticului Fault. Moreover, the same dikes of lamprophyres cut across the crystalline basement on both sides of Holbav-Curmătura Oticului lineament, including the Liassic getic cover in the Holbav sedimentary basin, whence their Liassic age (MANILICI & VÂLCEANU, 1962). If there were two sedimentation domains during the Triassic, with different getic and supragetic basements, then how to explain their joint magmatic activity during the Liassic?

Another problem regarding the existence of a large Supragetic Nappe in the eastern South Carpathians is the post-thrust erosion. It is assumed that the Supragetic Nappe was largely eroded in the central South Carpathians (SĂNDULESCU, 1984). Then why the nappe was not eroded in the Făgăraş Mountains? The Făgăraş Mountains area underwent erosion more than the central South Carpathians due to the up-lift subsequent to the Tertiary tectogenetic phases, especially to the Wallachian one. The supposed erosion contour of the Supragetic Nappe west of the Olt River outcrops at altitudes of 500-800 m while the nappe east of the Olt River is not eroded neither at altitudes of 2500 m. A tectonic window in the Getic Crystalline should be occurred along the main crest of the Făgăraş Mountains if there would be a Supragetic Nappe.

CONCLUSIONS

The geodynamic model of the Carpathians belt evolution during the Cretaceous-Miocene time span (SĂNDULESCU, 1984) involves a prevalent transcurrent tectonic regime in the central-eastern South Carpathians. The Alpine structures in this region show a transcurrent regime in the north Sebeş-Cibin Massif and a transpressive one in the Făgăraş Mountains, decreasing from NE to SW. The Late Cretaceous crust-shortening in the Făgăraş Mountains east of the Intramoesian Fault was accommodated by folding. East of Bârsa Fault, where an additional transpressive regime occurred in the Early Miocene (e.g. HIPPOLYTE et al., 1999), the crust-shortening was accommodated by folds and thrust faults.

The thrust faults on the Olt Valley are related to the Alpine sinistral strike-slip on Răşinari Shear Zone in the north Sebeş-Cibin Massif. Perpendicular to the orogen axis, the Olt Valley tectonic lineament has the significance of an intra-getic structural discordance that separates the crystalline basement of the central South Carpathians, with Hercynian tabular structure, from the crystalline basement of the eastern South Carpathians, partly reworked during the Alpine orogeny.

REFERENCES

AIRINEI ŞT. 1983. Rapports géodynamiques entre la microplaque moesienne et l'arc carpato-balkanique sur le territoire de la Roumanie. *Anuarul Institutului Geologic al României.* Bucureşti. **40**: 7-14.

BALINTONI I., HANN H. P., GHEUCA I., NEDELCU L., CONOVICI M., DUMITRAŞCU G., GRIDAN T., 1986. Consideration on a Preliminary Structural Model of the South Capathians Crystalline East of the Olt River. *Dări de seamă ale şedinţelor Institutului Geologic*. Bucureşti. **62**(2): 27-39.

BERZA T & DRĂGĂNESCU A. 1988. The Cerna-Jiu fault system (South Carpathians, Romania), a major Tertiary lineament. *Dări de seamă ale şedinţelor Institutului Geologic*. Bucureşti. **72-73**(5): 43-57.

CODARCEA A., LUPU M., CODARCEA-DESSILA MARCELA, LUPU DENISA. 1967. Unitatea supragetică în Carpaţii Meridionali. *Studii şi Cercetări de Geologie, Geofizică şi Geografie, seria Geologie.* Academia Română. Bucureşti. **12**(2): 387-392.

DIMITRESCU R., POPESCU I., SCHUSTER A. C. 1974. *Harta geologică a României, scara 1:50.000, foaia Bârsa Fierului*. Institutul Geologic al României. Bucureşti.

DUMITRESCU R., ŞTEFANESCU M., RUSU A., POPESCU B. 1978. *Harta geologică a României, scara 1:50.000, foaia Nucşoara-Iezer*. Institutul Geologic al României. Bucureşti.

DIMITRESCU R., HANN H. P., GHEUCA I., ŞTEFĂNESCU M., SZASZ L., MĂRUNŢEANU MARIANA, ŞERBAN ELIZA, DUMITRAŞCU G., 1985. *Harta geologică a României, scara 1:50.000, foaia Cumpăna*. Institutul Geologic al României. Bucureşti.

GHIKA-BUDEŞTI Ş., 1940. Les Carpates Méridionales Centrales. *Anuarul Institutului Geologic al României*. Bucureşti. **20**: 175-220.

HIPPOLYTE J.-C., BĂDESCU D., CONSTANTIN P. 1999. Evolution of the transport direction of the Carpathian belt during its collision with the east European Platform. *Tectonics*. **18**(6): 1120-1138.

MANILICI V. & VÂLCEANU P. 1962. Contribuţii la studiul rocilor eruptive din bazinul Codlea. *Studii şi cercetări de geologie*. Academia Română. Bucureşti. **7**(3-4): 549-568.

MURGOCI G.-M. 1910a. The geological synthesis of the South Carpathians. *Comptes rendus du XI-éme Congrès International de Géologie*. Stockholm: 871-880.

MURGOCI G.-M. 1910b. Discuţiune asupra tectonicei Văii lui Stan. *Dări de seamă ale şedinţelor Institutului Geologic*. Bucureşti. **2**: 17-19.

PAVELESCU L. & NITU G. 1977. Le problème de la formation de l'arc Carpato-Balcanique. *Analele Universităţii din Bucureşti*. **26**: 1-35.

POPESCU-VOITEŞTI I. 1911. Contribuţiuni la studiul stratigrafic al numuliticului Depresiunii Getice. *Anuarul Institutului Geologic al României*. **3**: 275-394.

POPESCU-VOITEŞTI I. 1929. Aperçu synthétique sur la structure des regions carpathiques. *Revista Muzeului de Geologie şi Mineralogie al Universităţii din Cluj*. Cluj-Napoca. **3**: 1-40.

POPESCU-VOITEŞTI I. 1942. Exposé synthétique sommaire sur la structure des régions carpathiques roumaines. *Buletinul Societăţii Române de Geologie*. Bucureşti. **5**: 15-73.

SĂNDULESCU M., SĂNDULESCU JANA, SCHUSTER A., BANDRABUR T. 1972a. *Harta geologică a României, scara 1:50.000, foaia Codlea*. Institutul Geologic al României. Bucureşti.

SĂNDULESCU M. POPESCU I., SĂNDULESCU JANA, MIHAILA N., SCHUSTER A., 1972b. *Harta geologică a României, scara 1:50.000, foaia Zărneşti*. Institutul Geologic al României. Bucureşti.

SĂNDULESCU M. 1980. Analyse géotectonique de la chaînes alpines située autour de la Mer Noire occidentale. *Anuarul Institutului Geologic al României*. Bucureşti. **56**: 5-54.

SĂNDULESCU M. 1984. *Geotectonica României*. Edit.Tehnică. Bucureşti. 334 pp.

SCHMIDT O. 1930. Scurtă expunere a rezultatelor cercetărilor geologice făcute în regiunile cristaline ale Carpaţilor Meridionali. *Dări de Seamă ale Şedinţelor Institutului Geologic*. Bucureşti. **17**: 80-89.

STELEA I. 2000. Formaţiuni blastomilonitice în Munţii Sebeş. Teză de doctorat. Universitatea din Bucureşti. 115 pp.

STELEA I. 2006. Corelări litostructurale în fundamentul cristalin al Carpaţilor Meridionali Centrali şi de Est. *Anuarul Institutului Geologic al României*. Bucureşti. **74**: 208-211.

STILLE H. 1953. Der geotektonische Verdegang der Karpaten. *Beihefte zum Geologische Jahrbuch.* Hannover. **8**: 1-239.

STRECKEISEN A. 1934. Sur la tectonique des Carpates Méridionales. *Anuarul Institutului Geologic al României*. Bucureşti. **16**: 327-419.

SURMONT J., SĂNDULESCU M., BORDEA S. 1990. Mise en évidence d'une réaimantation fini-Crétacée des Séries Mésozoïques de l'unité de Bihor (Monts Apuseni, Roumanie) et de sa rotation horaire ultérieure. Comptes Rendus *de l'Académie des Sciences*. Paris. **310/2**: 213-219.

VISARION M., SĂNDULESCU M., STĂNICĂ D., VELICIU Ş. 1988. Contribution a la connaissance de la structure profonde de la plate-forme moesienne en Roumanie. *Studii Tehnice şi Economice*. Institutul Geologic al României. Bucureşti. **D/15**: 211-222.

Stelea Ion
Geological Institute of Romania
1 st Caransebeş Street, 012271 - Bucharest, Romania
E-mail: ionstelea@yahoo.com

Received: April 15, 2016
Accepted: July 20, 2016