STRUCTURAL AND PALEOGEOGRAPHIC CORRELATIONS OF THE MOLDAVIDES WITHIN THE EAST CARPATHIANS

MIRCEA SĂNDULESCU

Faculty of Geology and Geophysics, Bd. N. Bălcescu no. 1, Bucharest, Romania

Abstract. Following the structural correlation of the main units (nappes) of the East Carpathians Moldavides it was possible the analyse of the palinspastic-paleogeographical correlation. Since the Lower Cretaceous until the Lower Miocene the different palinspastic-paleogeographicaly domains were analysed. Two main subsiding turbiditic troughs may be stressed out: the Cretaceous Convolute Flysch Trough and the Palegene Tarcău-"Central Depression" Trough. They develops, in different areas, with an asymmetrical shape and, both, with a complex outern marginal slope. The arenitic suplayng areas are analysed. Constantly the Foreland was one of this arenitic source areas. Toward the inner sides of the Moldavides different cordilleras have delivered arenitic material. There are: the Peri-Moldavian, the Cumanian and the Peri-Danubian, cordilleras. The palinspastic-paleogeographycal correlations between the different main troughs was discussed, maily the north-western prolongation of the Convolute Flysch Trough towards the Dukla Trough.

Key words: Moldavides, Convolute Flysch and Tarcău troughs, Cumanian and Peri-Danubian cordilleras.

Résumé. Suivant la corrélation structurale des plus importantes unitées (nappes) des Moldavides des Carpathes Orientales on arrive à la corrélation palinspastique-paléogéographyque. Depuis le Crétacé inférieur jusqu'au Miocène inférieur sont analysés les différentes domains palinspastique-paléo-géographiques. On peut distinguer deux principaux sillons turbiditiques, d'ages différents: le Sillon du Flysch Courbicortical, pour le Crétacé et le Sillon de Tarcău et «Dépression Centrale» pour le Paléogène. Ces deux sillons ce développent, dans des aréals différentes avec une complèxe marge externe qui a été constamment tributaire à la source des arénites provenant de l'Avant-pays. Du côté interne des Moldavides, plusieurs différentes cordillères ont délivré des arénites. Ce sont les cordillères: Péri-Moldavienne, situé sur le bord interne du Sillon du Flysch Courbicortical, celle Coumanne, dans le domaine interne du Lithofaciès Silésien et celle Péri-Danubienne, entre le Sillon du Flysch Courbicortical et le Domaine Silésien. Ces cordillères ont été actives pendant des périodes différentes. Le problème de la corrélation des différentes sillons subsidents ont été discuté, surtout le problème de la corrélation du Sillon du Flysch Courbicortical avec celui de la Nappe de Dukla.

Mots-clés: Moldavides, Sillons des Flysch Courbicortical et Tarcău, cordillères Cumane et Péri-danubienne.

The Carpathians Flysch Zone is one of the largest turbiditic sedimentary area within the whole Alpine chains of Europe. There are recognized different lithofacies of flysch formations of Upper Jurassic, Cretaceous, Paleogene and Lower Miocene ages. Some of them arrived to several thousand metres in thicknesses, generating important subsiding troughs of different ages.

STRUCTURAL CORRELATION

It was clearly demonstrated (Săndulescu, 1980a; 1980b; 1984) that the Magura Group toghether with the Pieniny Klippen Belt, prolongate inward in respect with the Central East Carpathians Nappes System, in the Maramureş Area (**Fig. 1**). They represent the Pienidian segment of the Main Tethyan Suture Zones of the Carpathians realm. They are limitated south-westward by the North Transylvanian Fault which separated them in respect with the Transylvanides, another segment of the Main Tethyan Suture Zone within the Carpathians. The Pienides was structurated during the Senonian and Burdigalian tectogeneses. Consequently it is demonstrated that the Outern Dacidian nappes (Black

Flysch and Ceahlău) of the East Carpathians Flysch Zone have not an outcroping corespondent in the Western Carpathians Flysch Zone or that the prolongation of this group of nappes is tectonically overlaped by the Magura Nappe (Săndulescu, 1980b, 2008, 2009).

The Moldavidian Nappes of the Carpathian Flysch Zone, group together all the cover nappes situated outward in respect with the Outern Dacides and/or the Magura Nappe. They show a dominant Lower and Middle Miocene tectogeneses.

The outernmost nappe of the Romanian East Carpathians is the Subcarpathian Nappe. The Sambor-Rojniatov Unit (Burov *et al*., 1974) should be the corresponding unit within the Ukrainian East Carpathians. They are cover nappes, built up by, mostly, Lower and Middle Miocene molasses and Salt formations and very few preserved Oligocene bituminous formations. The final overthrust of these nappes is of Lowermost Upper Miocene (Lower Sarmatian) age.

The Subcarpathian Nappe is overthrusted by the Marginal Folds Nappe and in some segments, also, by the outern subunits of the Tarcau Nappe (Fig. 1). The Marginal Folds Nappe prolongate in the Pokutzia-Boryslav-Truskavetzk Unit of the Ukrainian East Carpathians. The equivalent, within the Ukrainian Carpathians of the Tarcău Nappe are the "Skiba Unit" and the "Central Depression". Farther westward the Tarcău Nappe correspond to the: Skole, Subsilesian and Silesian nappes.

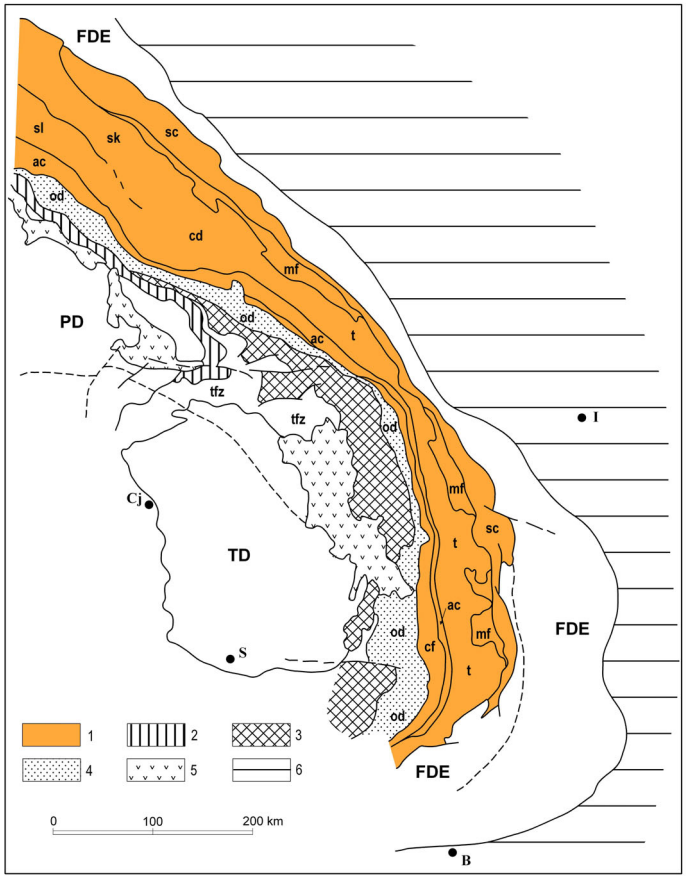

Fig. 1 – General tectonic sketch of the Flysch Zone and surrounding units.

1 – Moldavidian Units, 2 – Pienides, 3 – Median Dacides, 4 – Outern Dacides, 5 – Neogene Volcanic Chain, 6 – Foreland, TD – Transylvanian Depression, PD – Pannonian Depression, tfz – Transcarpathian Flysch Zone, od – Outern Dacides, cf – Convolute Flysch Nappe, ac – Audia-Czernahora Np., t – Tarcău Np., mf – Marginal Folds Np., cd – Central Depression, sk – Skole Np., sl – Silesian and Sub-Silesian Nps., Sc – Subcarpathian Np., FDE – Foredeep; B – Bucharest, I – Iaşi, S – Sibiu, Cj – Cluj.

The both Marginal Folds and Tarcău Nappe as well as their equivalents show a large lithostratigraphic sequence: from the Barremian up to the Lower Miocene. In the Western Moldavides, within the Silesian and Subsilesian nappes also Tithonian-Neocomian formations crops out.

The Audia-Czarnahora Nappe, developed along the Romanian and the Ukrainian East Carpathians, is overthrusted above the Tarcău Nappe and, consequently, above the "Central Depression". The sedimentary formations are of Barremian-Paleogene age. Specific massive arenitic turbidites (Siriu, Prisaca and Skupova sandstones), Senonian-Paleocene or Eocene in age, are developed within several outern scales of this nappe.

The innermost nappe of the Romanian East Carpathians Moldavides is the Convolute Flysch Nappe. Between the Convolute Flysch and the Audia-Czarnahora Nappe, discontinuously, crops out the Macla Nappe. This last one shows a condensed lithostratigraphic sequence, of Albian-Upper Cretaceous age, of a transitional lithofaces between the Audia-Czarnahora Nappe and the Convolute Flysch Nappe, respectively.

The Convolute Flysch Nappe is built up by a more than 5 km thickness lithostratigraphic sequence of Barremian-Lower Senonian turbidites and some, more thinned, marly, Upper Senonian-Paleogene formations.

In the Western Carpathians the innermost nappe of the Moldavides is the Dukla Nappe. It shows a Cretaceous-Paleogene turbiditic sequence of several km in thicknes. A specific feature of the Lower Cretaceous formations of the Dukla Nappe is the Silesian development. The Duckla Nappe have a, structurally, inward tectonic position in respect with the Audia-Czarnahora Nappe

Tacking into account the "Silesian type" of its Lower Cretaceous the problem of the correlation have several solutions:

– the Dukla Nappe have an inward obliquelink ("en-échélon") position in respect with the Audia-Czarnahora Nappe;

– the Dukla Nappe have an outward obliquelink position in respect to the Convolute Flysch Nappe;

– the Pre-Dukla Nappe is a western development of the Macla Nappe or the Czarnahora Nappe and the Duckla Nappe is a lithostratigraphic changed equivalent of the Convolute Flysch Nappe!

PALEOGEOGRAPHIC DEVELOPMENTS AND CORRELATIONS

The oldest, large developed, lithofacies recorded within the Moldavidian Domain is the Silezian Lithofacies of Barremian-Albian age.

The Tithonian-Neocomian ***Techen Formation*****,** older as the Silesian Lithofacies crops out within a restricted area in the Polish Western Carpathians in the Silesian and Subsilesian nappes. It is very difficult to conclude if this formation was developed in large areas of the Moldavidian troughs. It is also possible to conclude that this Formation was generated in a, more or less, restricted elongated within-plate rift (with the Teschen Formation are associated Upper Jurassic alkali-basalts) located within the thinned European Continental Margin. It is very probably that this rift generated and developed synchronous, but outside in respect with the Ceahlău Rift of the Outern Dacides.

The ***Silesian Lithofacies*** is a marine euxinic-type development of the Lower Cretaceous. The arenitic, turbiditic, clastics were generated from the Foreland. This is evidently demonstrated by the arenites inlayered in this Lithofacies in the Romanian and Ukrainian Carpathians, rich in "Green Schists" clastics. The Vendian ankimetamorphic "Green Schsits" Formation (chloritic shales and arenites) crops out in Central Dobrogea (Moesian Platform). They was the clastics source area along the eastern border of the palinspastic-paleogeographical Outern Flysch basins, since the Lower Cretaceous time until the Lower Miocene.

The Silesian Lithofacies have generally reduced thicknesses, compared with the some other Lower Cretaceous sequences, as the Convolute Flysch. This marine-euxinic lithofacies is located on a large, marginal area of the Lower Cretaceous Moldavidian Domain (**Fig. 2**). Predominantly shaly, the Silesian Lithofacies shows turbiditic sequences, mostly in the Barremian and Albian. In the southern East Carpathians (Vrancea mts.) the whole Lower Cretaceaous development of the Silesian Lithofacies is a turbiditic (flysch) development (Streiu Formation). There was, probably, a more deepest area of the Silesian Domain whithin the East Carpathians. This conclusion is supported also by the silicolithic radiolarian development, within this area, of the Vraconian-Turonian deposits (Tisaru Formation).

The sedimentary area of the Silesian Lithofacies covered, within the East Carpathians, the most important part of the Moldavidian Domain, excepting the large subsiding turbiditic through of the Convolute Flysch.

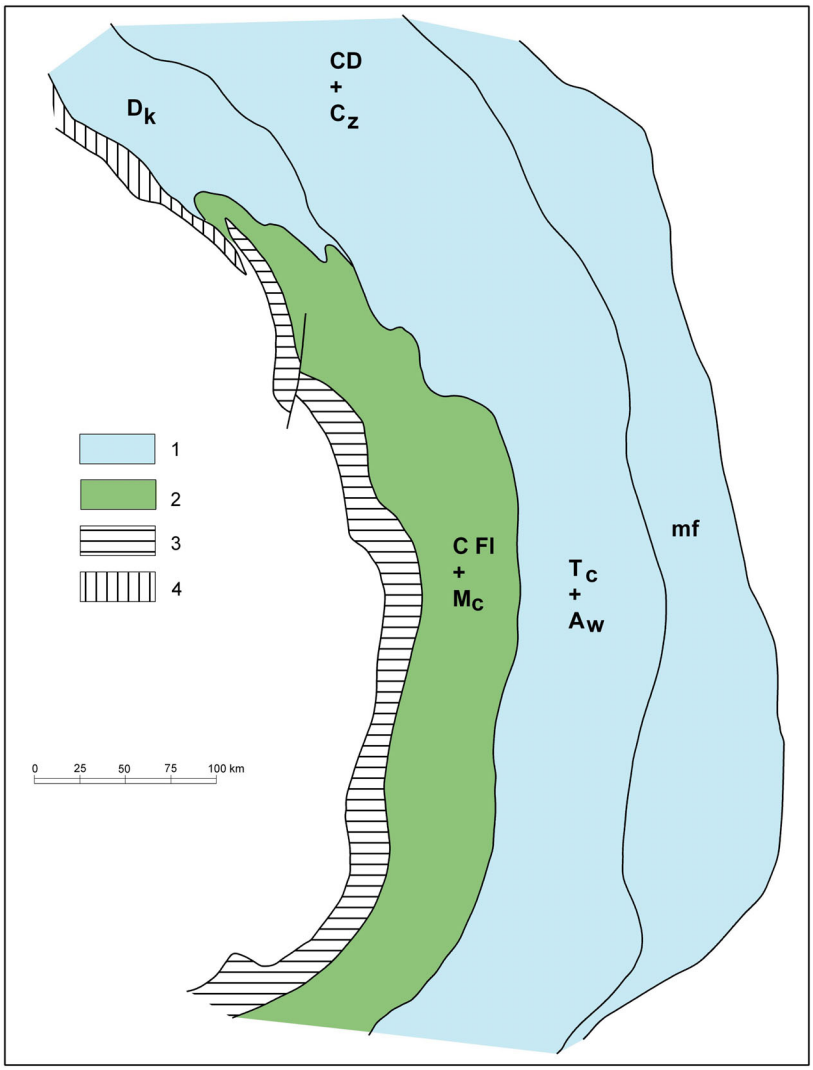

Fig. 2 – Paleogeographic-palinspastic sketch of the Silesian Lithofacies.

1 – Silesian Lithofacies Domain, 2 – Convolute Flysch Lithofacies Domain, 3 – Peri-Moldavian Cordillera, 4 – Silesian Cordillera, Cf+Mc – Convolute Flysch and Macla, Tc+Aw – Tarcău and Audia, mf – Marginal Folds, Dk – Dukla, CD+Cz – Central Depression and Czernahora.

The ***Convolute Flysch Trough*** is the most important Cretaceous subsiding trough within the Moldavidian Domain (Fig. 2). It was separated with respect to the Ceahlău-Severin Trough by the Peri-Moldavian Cordillera (Săndulescu, 1984). The Peri-Moldavian Cordillera supplied the turbiditic arenites of the Convolute Flysch both during the Aptian-Albian time as during the Cenomanian-Lower Senonian one (Antonescu, Săndulescu, 1985; Săndulescu *et al*., 1993).

The subsidence of the Convolute Flysch Trough start during the Lower Barremian time. The lithofacies is similar with the lowermost sequences of the Silesian Lithofacies (Lower Audia Formation). With the Upper Barremian and the Aptian start a more important subsidence (the Toroclej Formation) with a mixed (alternative) lithofacial developments of Silesian type and of Convolute Flysch type. Follows during the Albian and Cenomanian-Lower Senonian the sedimentation of the typical Convolute Flysch Group (with the Lower Convolute Flysch Formation, the Cotumba Sandstone and the Upper Convolute Flysch Formation).

Tacking into account that the, Cretaceous, subsiding amount of the Convolute Flysch Trough is of a large value (more than 5 km) it is expected that the continental-type crust of this trough have been strongly thinned in respect to allowed such an important subsidence. This fact is important for the, later, Upper Tertiary subductions of the thinned, continentaland or oceanized, crusts of the whole Carpathians Flysch Zone.

The ***Macla Transitional Stripe*** between the Silesian Domain and the Convolute Flysch Trough may be followed until the northern East Carpathians. It is presumable that the most important part of the Lower Cretaceous of the Macla Zone is of Silesian lithofacies. Starting with the Upper Albian and during the Upper Cretaceous the formations show the specific Macla development (which is a mixed development between the "Convolute Flysch" and the "Silesian" ones).

The prolongation of the Convolute Flysch Trough and the Macla Stripe within the Ukrainian and eastern Polish Carpathians may be a controversional problem. The solution is connected to the prolongation northward of the ***Peri-Moldavian Cordillera***. If this is no more developed north of the northern Romanian East Carpathians the development of the Convolute Flysch – which is supplyed by this cordillera – is source-less. Following this hypothesis the ***Dukla Trough*** should be the correspondent of the Convolute Flysch Trough, with a Lower Cretaceous showing a Silesian development.

In the same palinspastic-paleogeographic framework it is possible to discuss the position of the ***Silesian Cordillera.*** Within the Polish Carpathians this cordillera should limit, inward, the Silesian Cretaceous development in respect with the Magura development. South-eastward it is logical, consequently, to suppose that the Silesian Cordillera border, inward, the Dukla Trough. Concluding, the Peri-Moldavian Cordillera and the Silesian Cordillera are in a obliquelink ("en-échélon") position (Fig. 2).

In the southern part of the Moldavides, within the Silesian Domain was active, during the Uppermost Albian (Vraconian) and the Cenomanian-Turonian, the ***Cumanian Cordillera***. It delivered mostly granodiorites and ankimetamorphic chloritic schists ("Green Schists"?!). It is important to stress out that the Peri-Danubian Cordillera was active in a more "internal" position in respect to the Cumanian Cordillera and in different timespans. Following this arguments a possible hypothesis is that the Cumanian Cordillera belong to the basement of the northwestward prolongation of the Central Dobrogea Domain, within which granodiorites of Cambrian age was intruded.

During the ***Upper Cretaceous*** palinspastic-paleogeography the most important changes are recorded in the Silesian Domain. The euxinic lithofacies was changed – by an important deepening of the Silesian Domain – into a pelagic marine condensed lithofacies ("Variegated shales", Lupchianu Formation) or silicolithic developments (Tisaru Formation). This developments are synchronous with the Upper Convolute Flysch Formation. It is to stress out that the pelagic marine condensed lithofacies

is turbiditeless of foreland debries. This is probably determinated by the overfluding of the Foreland by the Cenomanian large transgression, which "covered" the arenitic sources. In exchange to this level are frequent the debries generated by the Cumanian Cordillera.

The ***Upper Senonian-Lower Paleocene*** palinspastic-paleogeography of the Moldavides shows a more diversificated image. Within the Convolute Flysch Trough the turbiditic sedimentation is absent, probably because the Peri-Moldavian Cordillera was sunked and consequently was no more active. A pelagic "couches rouges-variegated shales" sequence was sedimented in a basin which have included also the Outern and Median Dacides deformed during the Cretaceous tectogeneses. They are more internal units in respect with the Moldavides. Within the Median Dacides this "couches rouges-variegated shales" overlap a molassic Cenomanian-Turonian development generated by the Mid-Cretaceous tectogeneses of the Transylvanian and Central East-Carpathians nappes.

Within the Silesian Domain a turbiditic subsiding trough was developed during the Upper Sennonian-Lower Paleocene time. The most specific sequence of proximal to distal lithofacies are (inward-outward): the Siriu Sandstone and the Horgazu formations, the Poiana Uzului Formation and the Hangu and Lepşa formations. The arenitic suplay is bilateral. For the Hangu and Lepsa formations the source is situated within the Foreland ("Green Schists" debries). The Poiana Uzului Formation is the transitional lithofacies. The problem of the source area of the Siriu and, consequently, the Horgazu formations is more complicated. This is due to the fact that the Convolute Flysch Trough, inward in respect with the Siriu-Horgazu zone, is a pelgic marine basin which may be assimilated with a "barrière-en-creux" (a "trough-barrier"). Consequently it is necessary to accept the emergence of a cordillera situated on the outern border of the Convolute Flysch Trough, with a specific petrological structure (epi- and mesometamorphic rocks, similar with that of the Median or the Marginal Dacides). This cordillera may be supposed to be a prolongation of the outern part of the Danubian Domain (?!). This cordillera-which may be named the ***Peri-Danubian Cordillera*** (Fig. 2) – have suplyed the Siriu-Horgazu sedimentary area and, perhaps, was also active during the Eocene time. This cordillera is not similar with the Cumanian cordillera from different point of view:

– the different petrological feathures of the delivered clastics,

– the different ages of their active period and

– the different "geometrical" position in respect to the palinspastic-paleo-geographical domains.

Consequently the Peri-Danubian Cordillera must be situated more inward in respect with the Cumanian one. In the same time the Peri-Danubian Cordillera is of more large development both in time and space.

Tacking into account the above outlined palinspastic-paleogeographical picture it is possible to suppose that an equivalent of the Convolute Flysch Trough is, in the Southern Carpathians, during the Barremian-Upper Cretaceous time, the pelagic Inner Danubian Domain (with Iuta and Nadanova formations), but without turbiditic developments.

Consequently it is necessary to accept that the "Danubian" – type continental crust, thinned and "oceanized", situated below the Convolute Flysch Trough, was consumpted during the Miocene tectogeneses of the Moldavides.

During the ***Eocene*** time, within the Moldavidian Domain of the Romanian East Carpathians was developed two turbiditic basins:

– the ***Şotrile Basin*** developed above the Convolute Flysch Trough and the Outern Dacides (Ceahlău and Bobu nappes), and

– the ***Tarcău Trough*** and his ***Marginal Slope***, developed above the main part of the Cretaceous Silesian Domain.

A marginal, internal, slope of the Tarcău Trough (Siriu, Prisaca and Skupova sandstones) was developed above internal stripe of the Silesian Domain (Audia Nappe).

The Şotrile Basin hosted turbidites of "hieroglyphic beds" type flysch, not very thick, with marly pelagic lutitic components and calcareous polymictic arenites. The source area for the arenites seems to be the Median Dacides (Central East Carpathians). But also some "contributions" from the Peri-Danubian Cordillera may not be excluded.

The Tarcău Trough is the most subsiding basin during the Eocene, starting since the Upper Paleocene. The source area of the massive arenites should be the same Peri-Danubian Cordillera as for the Siriu and Prisaca sandstones. The Marginal Slope lithofacies (Leşunţ, Sucevița, Greşu etc.) are depended to the platform ("Green Schists") source area. An intermediate lithofacies (Tazlău Fm.) is normaly developed.

The Tarcău Trough is, for the Paleogene palispastic-paleogeography, a similar domain as the Convolute Flysch Trough for the Cretaceous palispastic-paleogeography. These two large subsiding troughs have had an important contribution to the "thinning" and the "oceanizing" processes of the crust below the Moldavidian Domain.

During the Upper Priabonian a general deepening of the Moldavidian Domain determinated the development of a marly pelagic lithofacies – the ***Globigerina Marls*** lithofacies – which is large developed also in many areas of the Alpine Tethys (fide Dercourt *et al*., 1993).

Northward, within the Ukrainian East Carpathians, may be, also, recognized the Tarcău Trough and its Marginal Slope. The Tarcău Trough correspond to the "***Central Depression"***. It is to stress out that the inner slope of the Tarcău Trough, characterized by the development of the Oligocene-Lower Miocene "Slon Lithofacies" may be reccognised also within the innermost zone of the Central Depression. The ***Marginal Slope***, of the Tarcău Trough, correspond, within the Ukrainian East Carpathians, to the ***Skiba Units.*** The developments of the lithofacies are similar with the Romanian East Carpathians, both as position and lithological features.

Farther toward the Polish Flysch Zone the Central Depression branch out into the ***Silesian*** and ***Subsilesian nappes***, which generated in the north-western part of the Central Depression (Fig. 1). The Skiba Unit extend within the Polish Carpathians Flysch Zone within the ***Skole Nappe***, outward in respect with the Subsilesian Nappe.

During the ***Oligocene-Early Miocene*** time the Moldavidian Domain of the East Carpathians and easternmost Polish Carpathians shows similar developments. There are two main lithofacies:

– the ***Dyssodilic-Kliwa Lithofacies****,* and

– the ***Krosno-Fusaru Lithofacies.***

The Dyssodilic-Kliwa Lithofacies is an euxinic development within the outern area of the East Carpathian Moldavides. It is known within the Romanian and the Ukrainian Moldavides. The Krosno-Fusaru Lithofacies is developed within the inner areas of the Romanian and Ukrainian Moldavides and covers all the Western Moldavides.

The source area for arenites of the Dyssodilic-Kliwa Lithofacies is situated within the Foreland; as well for the Kliwa Sandstone as for the "Green Schists" bearing other arenites (Săndulescu, Micu, 1989).

The source areas for the Krosno-Fusaru Lithofacies seems to be more diversified. Within the East Carpathians Moldavides it is possible to accept that the arenitic sources are the Median and Outern Dacides. The Slon Formation, exolistostromic development with Şotrile exolistolites, support, this conclusion.

The upper sequences of the Dyssodilic-Kliwa Lithofacies shows, in the outern segments of this domain, molassic developments with a Foreland source area ("Green Schist"). This molassic developments are supplied by erosional submarine chanels (Săndulescu, Micu, 1989).

It is of interest to stress out, within the outern areas of the Moldavides, that in two different periods (Lower Cretaceous and Oligocene-Early Miocene), euxinic lithofacies developed:

– the Silesian Lithofacies, and

– the Dyssodilic-Kliwa Lithofacies.

At the same time, in the both periods, quartzitic arenites are associated with the euxinic successions. For the both quartzitic arenites the source areas were situated in the Foreland. Consquently it is possible to conclude that, in the both periods, eolian formations was generated within the proximal Foreland area of the Moldavides. The absence of the Dyssodilic-Kliwa Lithofacies, for instance in the Western Moldavides, is probably due to the different environmental features of the proximal Foreland.

The Tarcău and "Central Depression" troughs, for the Eocene time as well as the Krosno-Fusaru trough for the Oligocene-Early Miocene time, were the last important subsiding turbiditic troughs within the East Carpathians Flysch Zone. For the both a Marginal Slope, well developed, was a specific feature.

During the ***Lower Miocene*** the molassic and "schlier" developments have had the outernmost positions within the Moldavides. There are recognized in the Subcarpathian Nappe and in the post-tectonic covers of the Inner Moldavides.

The Miocene molassic lithofacies have a bilateral source areas. For the post-tectonic covers (Brebu Conglomerates) the source area is situated within the inner East Carpathians. For the Subcarpathian Nappe (Pietricica or Plesu conglomerates) the source area is situated within the Foreland: "Green Schists" suplay but also some Mesozoic rocks of the Foreland sedimentary cover.

The Upper Miocene and the Pliocene subsiding areas were situated outside in respect with the folded Moldavides, mainly within the Focşani Depression.

CONCLUSIONS

The analyse of the sedimentary areas of the Moldavides, between the Lower Cretaceous and the Lower Miocene, stressed out several conclusions:

– The Lower Cretaceous palinspastic-paleogeography is dominated by the Silesian Lithofacies which is the most extended within the East Carpathian Moldavidian Domain. The most important subsiding trough during this time is the Convolute Flysch Trough which is connected with the areal development of the Peri-Moldavian Cordillera. This was the most important arenitic source area for the turbiditic sequences of the Convolute Flysch Trough.

– The Peri-Moldavian Cordillera is in a obliquelink ("en-échélon") position with the Silesian Cordillera in the area of the Dukla Trough development.

– A deepening of the Silesian Basin occur during the Cenomanian-Turonian time, with pelagic, condensed, marly and/or silicolitic sediments.

– Starting with the Upper Senonian and Early Paleocene the important subsiding turbiditic trough of the Moldavides, migrated toward the Foreland. It is the Tarcău – "Central Depression" Trough. His Marginal Slope shows also turbiditic developments suplyed by the Foreland.

– It is necessary to accept the existence during the Upper Senonian-Eocene time of a Peri-Danubian Cordillera separating the Convolute Flysch Trough from the Silesian Domain.

– The Oligocene-Early Miocene palinspastic paleogeography shows two main lithofacies: the Krosno-Fusaru and the Dyssodilic-Kliwa one. The arenites of this two lithofacies are suplyed bilateraly: from the Median and Outern Dacides, for the Krosno-Fusaru Lithofacies and from the Foreland for the Dyssodilic-Kliwa Lithofacies.

– A common feature of the Lower Cretaceous and of the Oligocene-Early Miocene lithofacies is the quartzitic arenites generated, by transport from a proximal Foreland eolian sand development.

– There is evident that the different cordilleras activated in different timespans and in different places. The rising of each cordillera seams to be an effect of a compressional moment within the Moldavidian domain as an echo of the tectonic deformations within the neighbouring areas.

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