23 ABOUT THE PALYNOLOGICAL CORRELATION OF DEVONIAN FORMATIONS OF NORTHERN DOBROGEA

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Abstract: Palynological studies of the Devonian Formations in Northern Dobrogea, represent a good criterion of palynostratigraphical correlation. The Devonian assemblages obtained from the Bujoarele Hills, Igliţa Promontory, Mahmudia Hills and Orlovca (Cartal) Hillock were correlated with Devonian assemblages that come from the same geological formations of the Moesian Platform and the East European Platform. Using the palynological results, the common palynozones were established in all analysed geological formations.

Key words: Devonian, Correlation, Palynology, Northern Dobrogea, Moesian Platform, East European Platform

Introduction

The spreading of the Devonian Formations in Northern Dobrogea is represented by isolated points, wholly covering a small outcropping area. This outcrop of Devonian Formations is the result of the tectonic and erosion factors (Săndulescu, 1984). The classical outcrop points of Devonian Formations in Northern Dobrogea are the Bujoare Hills, in the Măcin Unit and the Mahmudia (Bestepe) Hills, in the Tulcea Unit. Beside these well known points, the Devonian Formations outcrop in others of small importance, such as Piatra lui Boboc, Beilia Hills, or in such new points cropped out by the erosion phenomenon such as Igliţa Promontory, Isaccea, Orlovca (old Cartal, Ukraine). The old geological studies (Murgoci, 1914; Simionescu, 1924; Atanasiu, 1940; Mirăuţă and Mirăuţă, 1964-1967; Iordan, 1974) and the recent palynological ones (Olaru, 1992-1993 a, b; Olaru, Sliusari, 1996), opened the possibility of correlating these Devonian Formations, in Northern Dobrogea, with other adjacent regions, such such as the Moesian Platform and the East European Platform (Beju, 1971, 1972, 1973; Avkhimovich et al., 1993).

The difficulties in correlation consist in the pointed spreading of Devonian Formations of Northern Dobrogea, in the incomplete composition of lithological columns of these ankimetamorphic formations and the absence of characteristic faunal remains in these geological formations. But, by the corroboration of all old faunal and new palynological results, we can work out a model of palynological correlation between Devonian Formations of Northern Dobrogea and other adjacent regions.

1. Peculiarities of the palynological correlation of the Devonian Formations of Northern Dobrogea

1.1. The Lower Devonian of the Măcin Unit

The Gedinian stage of Northern Dobrogea is present only in the Bujoarele Formation of the Măcin Unit. Here, the Gedinian begins with white and grey limestones, followed by the succession of schists and quartzite sandstones (Tab. 1). This rhythmical succession of schists and grey silicic sandstones, white and greenish quartzite sandstones, is characteristic of the whole lithological column of the Lower Devonian of the Bujoarele Formation, the Bujoarele Hills and the Igliţa Promontory. The full thickness of this column is 300-400 m. In the Moesian Platform, the Gedinian Formation continues the Silurian one, represented by the same lithological members of black clays. Here, the separation between the Silurian Formation and the Gedinian one was made by the typical quantitative palynological assemblages and by macrofaunal remains. In the Moesian Platform, the Gedinian lithological column is monotonous, represented by a succession of grey and black clays, with a calm sedimentation, proper to the wide sea domain (Beju, 1971).

On the contrary, in Northern Dobrogea a rhythmical sedimentation took place in the wide open shelf zones with a rich and variable terrigenous contribution in the pre-flysch facies.

The faunal content in the Moesian Platform is rich (Beju, 1971; Iordan, 1974), but in Northern Dobrogea it is poor. In the Bujoarele Formation of Northern Dobrogea in the white and grey limestones at the basis of the lithological column of the Bujoarele Hills, the fragments of crinoides (Iordan, 1974) and *Icriodus woschmidti Zigler*, of conodonts (Mirăuţă, 1966) were determined, very important arguments for the establishment of the Gedinian age for these rocks. Only one species of trilobites is common to these two sedimentation regions, for the Lower Devonian, such as Asteropige (Rhenops) hammerschmidti (Iordan, 1974). The other stages of the Lower Devonian such as the Siegenian and the Emsian were also determined in the Moesian Platform, in the same argillaceous lithological member as the Gedinian one, but this separation was made by palynological and faunal criteria, too. The same two stratigraphical stages of the Lower Devonian, the Siegenian and the Emsian, were separated from the Bujoarele Formation of the Măcin Unit in Northern Dobrogea, but only on the palynological criterion (Olaru, 1992-1993).

A palynozonation of the Lower Devonian was made for the first time in the Moesian Platform (Beju, 1971). One palynozone, D1, and three subzones, D1a, D1b and D1c, were established for the Lower Devonian Formation, the typical palynological elements of the biozone and subzone, in comparison with the faunal biozonation (Beju, 1971, 1972, 1973).

For the palynozonation of the Lower Devonian of the Bujoarele Formation, typical taxa and common cenozone taxa of these two sedimentation areas were used. Thus, one palynozone was established, e.g. D1, with their subzones, e.g. D1a, D1b and D1c. (Tab. 1)

The presence must be remarked, in the Gedinian stage of the Măcin Unit, of a species of Emphanisporites minutus and Emphanisporites mcgregorii, typical of subzone D1, of the Moesian Platform, and of the other Gedinian palynozones of Europe. Beside these typical species, others complete the

Table 1

STRATIGRAPHICAL DISTRIBUTION AND PALYNOSTRATIGRAPHYCAL CORRELATION OF PALYNOMORPHS ASSEMBLAGES IN THE LOWER DEVONIAN FORMATIONS FROM THE IGLIŢA PROMONTORY AND BUJOARELE HILLS, NORTH DOBROGEA

LITHOLOGY	TAXONOMIC UNITS	SILURIAN	DEVONIAN				PALYNOZONES
			GEDINIAN	SIEGENIAN	EMSIAN	DEV. 2	
- Shales and slates	*Cyclogranisporites zumbosus* Cramer						
	Dictyotriletes minor (Naum.) *negritellus* Nadler						
	Lophotriletes rugosus Naum. major Nadler						
	Archaeozonotriletes chlus (Cramer) Rich. & Lister						
	Leiotriletes microrugosus (Ibr.) Naum.						
	Camarozonotriletes avatus Naum.						
	Dyctiotriletes nigratus Naum.						
	Retusotriletes semizonalis Mc Gregor						
	Cyclogranisporites sp.						
	Leiotriletes confertus Mc Gregor						D_{1c}
	Calamospora panucea Rich.						
	Verrucosisporites sp.						
	Verrucosisporites absurdus Tchibr.						
	Hymenozonotriletes sp.						
	Reticulatisporites emsiensis Allen						
	Veryhachium trispinosum Eis.						
	Polyedrixium sp.						
	Dictyotriletes emsiensis Allen						
- Grey, silicic sandstones	*Anapiculatisporites burtonensis* Streel						
	Acanthotriletes perpusillus Naum.						
	Dictyotriletes devonicus Naum.						
	Leiotriletes pagius Allen						
	Veryhachium europaeum Stock & Will.						
	Calamospora nigrata (Naum.) Allen						D_{1b}
	Calamospora microrugosa Ibr.						
	Linochitina erratica Eis.						
	Acanthotriletes acerosus Naum.						
	Dictyotidium dictyotum Eis.						
	Perforosporites sp.						
	Tasmanites balticus Eis.						
	Leiosphaeridia fastigatirugosa Stapl.						
	Leiosphaeridia fragile Downie						
	Emphanisporites mcgregorii Cramer						
	Emphanisporites minutus Allen						
	Baltisphaeridium ramusculosum Defl.						
	Retusotriletes cf. *warringtonii* Rich. & Lister						
	Veryhachium cf. *thyrae* Cramer						
	Ancyrochitina tumida Taug. & Jeck.						
	Angochitina devonica Eis.						
	Angochitina echinata Eis.						
	Leiotriletes simplex Naum.						D_{1a}
	Retusotriletes communis major Schultz						
	Leiotriletes levis Naum.						
- Greenish quartzite sandstones	*Tasmanites huronensis* (Dowson) Allen						
	Trachysphaeridium uspenskyi Tim.						
	Conochitina decipiens Taug. & Jeck.						
	Desmochitina densa Eis.						
	Leiofusa sp.						
White quartzites	*Gothlandochitina* cf. *martinsoni* Lauf.						
	Gothlandochitina spinipes Eis.						
	Cyathochitina campanulaeformis (Eis.) Eis.						
	Leiosphaeridia wenlockia Downie						
Grey limestones	*Sphaerochitina sphaerocephala* Eis.						
	Sisphaerocephala macrostoma Beju & Dăneţ						

palynological assemblage of Edinian subzone D1, of the Bujoarele Formation, such as *Retusotriletes cf. warringtonii, R. communis major, Leiotriletes simplex, L. laevis* (Tab. 1). In this assemblage, characteristic species of acritarchs and chitinozoans were also determined such as *Leiosphaeridia fragile, Baltisphaeridium ramusculosum, Veryhachium tyrae, Ancyrochitina tumida, Angochitina devonica, A. echinata* (Tab. 1).

For the Siegenian stage, subzone D1b was established with the typical palynological assemblage, (Tab. 1), with several species of spores, such as *Acanthotriletes acerosus, A. perpusillus, Dictyotriletes devonicus, Calamospora nigrata, C. microrugosa, Leiotriletes pagius, Perforosporites* sp.

From among acritarchs, the following species were determined: Veryhachium europaeum, Dictyotidium dictyotum and from Tasmanaceae, Tasmanites balticus. From chitinozoans, only Linochitina erratica is present, much better represented by characteristic taxa as in Northern Dobrogea.

For the Emsian stage, subzone D1c was established, with characteristic spore taxa, such as *Archaeozonotriletes chlus, Cyclogranisporites zumbosus, Verrucosisporites absurdus, Dyctyotriletes emsiensis, D. minor, Leiotriletes microrugosus, L. confertus, Lophotriletes rugosus, Retusotriletes semizonalis, Reticulatispasites emsiensis, Camarozonotriletes atavus*. In the acritarch group, only some species of Polyedrixium are characteristic and the chitinozoan species are missing. Centric and Pennatae species of Diatomes are present. (?)

The Devonian of the Tulcea Unit

In the Tulcea Unit, the Devonian is wholly represented by the Bestepe Formation, with all the stratigraphic members, the Lower, Middle and Upper Devonian, especially in the Mahmudia (Bestepe) Hills.

The Lower Devonian Member (the flyschoid member)

Lithologically, the Lower Devonian is represented, as in the Măcin Unit, by the rhythmical succession of grey-blackish schists, silts and grey quartzite sandstones, sedimented in the flyshoid facies. This lithological complex, little metamorphosed composes the schist member of the Lower Devonian stage. The thickness of the lithological column is 100-150 m (Tab. 2). From the limestones interbedded in this lithological succession a conodont fauna was determined (Mirăuță & Mirăuță 1968, Mirăuță, 1971). This attested the Lower Devonian age for the flyschoid member. Taking into consideration the lithological composition of the sedimentological environment and the content of the conodont fauna, the Lower Member of the Bestepe Formation is the same as in the Bujoarele Formation of the Măcin Unit. There are also some similarities between these two Lower Devonian Formations, according to palynological studies.

Considering the palynological assemblages (Olaru, 1992-1993 b), some common taxa were determined, such as *Retusotriletes cf. warringtonii, R. communis, Leiotriletes simplex, L. pagius, Calamospora microrugosa, Acanthotriletes acerosus, A. perpusillus, Anapiculatisporites burtonensis, Archaeozonotriletes chlus, Ambitisporites dilutus, Perforosporites sp.* (Tab. 2). In analysing this assemblage, one can observe that it represents a more extended stratigraphical interval than in the Bujoarele Formation. Here, in the Lower Devonian Member of the Bestepe Formation, of the Mahmudia Hills, the Gedinian stage was not palynologically established, because the typical species of the genus *Emphanisporites*, are missing. The palynological correlation between the Lower Member of the Bestepe Formation and the Bujoarele Formation, of the Măcin Unit, can be made at the level of the Siegenian-Emsian stratigraphic interval. The richest palynological assemblage is the Siegenian one, with some characteristic species for the Emsian (Tab. 2). Here, the chitinozoan taxa are missing, and from among acritarchs some species are present, such as *Leiosphaeridia fragile, L. wenlockia, Leiofusa* sp. Finally, the age of this Lower Bestepe Member, by palynological data is Siegenian-Emsian.

Considering the palynozonation of the Lower Devonian of the Mahmudia Hills we can correlate it with the biozones established for the Moesian Platform and the Bujoarele Formation. The established palynological assemblage can be included in palynozone D1, proper to the Lower Devonian. The palynological assemblage can be appreciated to reflect subzones D1b-D1c, characteristic of the Siegenian-Emsian stratigraphic interval (Tab. 2). The last Eifelian palynological assemblage is missing in the two Lower Devonian Formations, studied in Northern Dobrogea, Bujoarele and Bestepe.

The Middle Devonian Member (the limestone-schist member)

Lithologically it was attributed to the Middle Devonian, the middle part of the lithological column, representing prevailing limestone-sandstone rocks, a continuation of the lower flyschoid member (in the upper part) with the modification of lithology by the thickening of the interbedded limestones. From these limestones, conodonts of Middle Devonian age were determined (Mirăuță, Mirăuță, 1964, 1995; Mirăuță, 1971). The thickness of this lithological member is 50 m. By the palynological study (Olaru, 1992-1993 b) of this lithological member a Givetian-Lower Frasnian assemblage was determined (Tab. 2). The important Givetian species, of the palynological assemblage, can be noticed: *Leiotriletes devonicus, L. microrugosus, Verrucosisporites absurdus, Cyclogranisporites plicatus, Dictyotriletes minor, Ancyrospora longispinosa, Punctatisporites scabratus, Retusotriletes greggsii.*

Some species of the palynological assemblage extend to the Lower Frasnian, such as *Dictyotriletes devonicus, Leiotriletes minutissimus, L. microrugosus, Lophotriletes salebrosus famennensis, Acanthotriletes pullus*. This mixed composition of palynological assemblage, confers the limestone-schist member a Givetian-Lower Frasnian age (Middle Devonian).

Considering the palynozonation of this stratigraphic interval, we must also refer to the Moesian Platform (Beju, 1972, 1973). A part of the palynological assemblage being characteristic of the D2 palynozone (Givetian) and another part of the assemblage belonging to palynozone D3 (Frasnian). This mixed palynological assemblage resulted

Table 2

STRATIGRAPHICAL DISTRIBUTION OF THE PALYNOMORPHS' ASSEMBLAGES IN THE GEOLOGICAL DEVONIAN'S FORMATIONS FROM THE MAHMUDIA HILLS

THICKNESS	LITHOLOGY	LITHOLOGICAL MEMBERS	CRONOSTRATIGRAPHY	PALYNOLOGICAL ASSEMBLAGES	PALYNOZONES
	Limestones and conglomerates		TRIASSIC		
100 m	Grey limestones; Black silicolites (hyolites); Red silicolites (jasps); Green silicolites (phtanites); Grey silicolites; Greenish silicon schists	SILICOLITIC MEMBER	UPPER DEVONIAN	Famennian: Dictyotriletes famennensis Naum, Archaeozonotriletes famennensis Naum, Retusotriletes parvimamotus Naum, R. famennensis Naum., Hymenozonotriletes multangularis Naum, H. hyalinus Naum, Lophotriletes megalothelis Naum., L. salebrosus famennensis Naum, L. grumosus famennensis Naum, Stenozonotriletes famennensis Naum., Acanthotriletes pullus Naum. Frasnian: Samarisporites triangulatus Allen, Geminospora svalbardie (Vigran) Allen, Azonomonoletes rarus Naum. Acanthotriletes rugatus Naum, A. cuspidatus Nadler, Leiotriletes microrugosus (Ibr.) Naum. Knoxisporites sp., Veryhachium trispinosum Daunf, Dibolisporites (R.) devonicus Naum, Lophotriletes trivialis Naum., L. communis Naum., L. minor Naum, Archaeozonotriletes micromanifestus Naum., Stenozonotriletes infirmus Naum, St. extensus minor Naum.	D3b D3a
50 m	Limestone schistous; Diabasic or rocks; quartzitic lens; Grey marly limestones; Limestone sandstones; Grey-red-quartzitic sandstones	LIMESTONE-SCHISTOUS MEMBER	MIDDLE DEVONIAN	Leiotriletes devonicus Naum, L. rotundus Naum., Punctatosporites sp., Verrucosisporites (Retusotriletes) absurdus Tchibr., Ancyrospora longispinosa Rich., Hystricosporites sp., Cyclogranisporites plicatus Allen, Punctatosporites scabratus McGregor, Retusotriletes cf. greggsii McGregor, Dictyotriletes minor Naum., D. nigratus Naum., Archaeotriletes cf. filosus Tchibr.	D2 - D3
100 m	Grey limestones; Gritty limestones; Grey-black schists; Quartzitic sandstones; Greenish schists	FLYSCHOID MEMBER	LOWER DEVONIAN	Anapiculatisporites burtonensis Street, Leiotriletes confertus McGregor, L. simplex Naum., L. pagius Allen, Stenozonotriletes furtivus Allen, Acanthotriletes acerosus Naum., A. perpusilus Naum., Retusotriletes cf. warringtonii Rich. & Lister, Calamospora cf. microrugosa (Ibr.), Perforosporites sp., Retusotriletes communis Naum., Ambitisporites dilutus (Hoff.) Rich. & Lister, Cyclogranisporites sp., Verrucosisporites cf. absurdus Tchibr., Leiosphaeridia fragile Dow., L. wenlockia Dow., Leiofusa sp., Archaeozonotriletes (Retusotriletes) chlus Cramer, Rich. & Lister.	D1c D1b D1a ?

from all analysed rocks of this lithological member and it cannot be separated into two distinct sub-assemblages. In conclusion, we can confer to this stratigraphic interval palynozones D2-D3 and in the same manner we can make a correlation with similar palynozones of the Moesian Platform (Olaru, 1992-1993 b).

The Upper Devonian Member (the silicolitic member)

Lithologically, the silicolitic member, or the Upper Devonian one, is a continuation of the Middle Devonian limestone-schist member (Tab. 2). In this member, 100 m thick, the silicolites (white, red, green, black) prevail in the upper part, and the silicolite schists (grey-green) in the lower part. All these rocks are slightly metamorphosed. The age of this member was considered to be Upper Devonian, only by the palynological data (Olaru, 1992-1993 b) because the other organic remains are missing. By the palynological investigations (Olaru, 1992-1993 b) two palynologically distinct assemblages were established. The first assemblage comes from the lower part of the silicolitic member, namely the silicolite schists which lie continuing the sedimentation with the imestone-schist member of the Middle Devonian (Tab. 2). This assemblage is rich in characteristic spores, such as *Azonomonoletes rarus, Acanthotriletes rugatus, A. cuspidatus, Leiotriletes microrugosus, Knoxisporites sp., Dibolisporites (Retusotriletes) devonicus, Lophotriletes trivialis, L. communis, Archaeozonotriletes micromanifestus, Stenozo-notriletes infirmus, Archaeotriletes devonicus.*

Samarisporites triangulatus, Gemispora svalbardie. From among acritarchs, the Veryhachium trispinosum is present in this assemblage. This palynological assemblage is characteristic of the Middle and Upper Frasnian stratigraphic interval.

The second assemblage (Tab. 2) comes from the upper part of the silicolite member, exactly from the black silicolites. This assemblage, too, is rich in spore species, such as *Dictyotriletes famennensis, Archaeotriletes famennensis, Lophotriletes salebrosus famennensis, L. grumosus famennensis, L. megalothelis, Stenozonotriletes famennensis, Hymenozonotriletes hyalinus, H. multiangularis, Retusotriletes famennensis, R. parvimamatus. This assemblage is characteristic of the Famennian age and one can establish this age for the upper silicolitic part of the Upper Devonian Member of the Bestepe Formation of the Mahmudia Hills (Olaru, 1992-1993 b).*

By these two palynological assemblages, a correlation with palynozone D3 of the Moesian Platform, can be made (Tab. 2). Having in view the difference in composition of these two assemblages, two subzones were separated from palynozone D3, as follows: subzone D3a for the Middle and Upper Frasnian assemblage, and subzone D3b, for the Famennian assemblage. (Olaru, 1992-1993 b). Thus, for the Devonian stage of the Mahmudia Hills, three palynozones were separated: palynozone D1, with subzones D1b and D1c, for the Siegenian and Emsian, palynozone D2-D3, for the Givetian-Lower Frasnian stratigraphic interval, and palynozone D3, with subzone D3a, for the Middle and Upper Frasnian, and subzone D3b, for the Famennian.

The Devonian of Orlovca (Cartal Ukraine)

At the village of Orlovca (the old Cartal of Southern Bessarabia , now the Ukraine), there are out-cropped rocks, represented by grey-greenish quartzite schists with grey limestones and white quartzites interbedded, having a boudinage aspect. The outcrop point is small, and the thickness of the litological column is 150 m (Fig. 1).

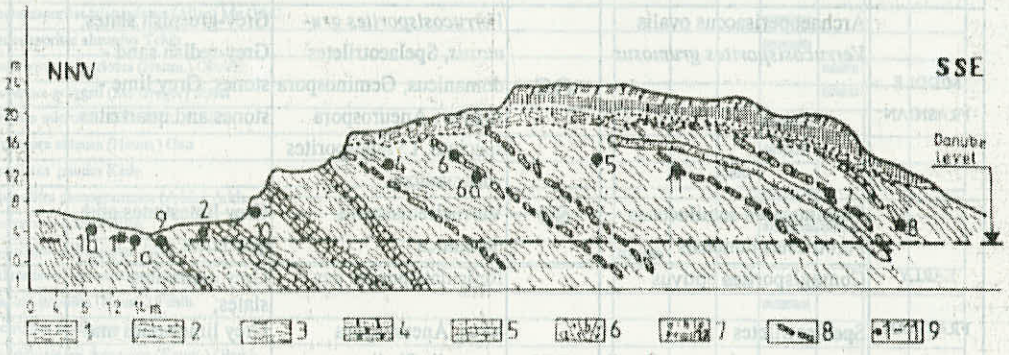

Figure 1 - Geological section through the Orlovça outcrop (after Sliusari, 1978-1983). Caption: 1. Grey-greenish-blue quartzite-phyllite schists. 2. Grey-phyllitic-calcareous schists. 3. Grey-greenish sericite-chlorite quartzite, fine stripet schists. 4. Grey-quartzite sandstones, interbedded. 5. Quartzite limestones and quartz-calcite marble. 6. Veins of magma rocks: a. basic; b. quartzite porphyres. 7. Present deposits: a. soil; b. loess; c. eluvial deposits with fragments of schists and quartzites. 8. Boudins (interbedded lens). 9. Analysed proofs.

All these rocks were sedimented in the flyschoid facies and later on were slightly metamorphosed. This lithological composition represents the Orlovca Formation. This lithological composition is the same as the one of the lithological segment of the limestone-schist member of the Mahmudia Hills, of Northern Dobrogea (Olaru, Sliusari, 1996), or the Middle Devonian Member of the Bestepe Formation, the same as the Middle Devonian Member of the Bestepe Formation. The first palynological assemblage (Velikanov et al., 1979) is represented by the species of following genera: *Leiotriletes, Retusotriletes, Lophotriletes, Acanthotriletes, Archaeozonotriletes, Hymeno-zonotriletes, Stenozonotriletes*, which defined the Middle Devonian age for this Orlovca Formation. These rocks are tectonised, where a mixture content of the Lower and Middle Devonian microflora can be found. Aseeva et al. (1981), by some conodonts and small number of spores, consider that the age of this geological formation is Famennian.

Recently, also by palynological investigation, Olaru, Sliusari (1996) established two distinct palynological assemblages for the Orlovca Formation (Tab. 3).

In the lower part of the lithological column, a Givetian palynological assemblage was determined, such as Geminospora extensa, Chelinospora concina, Aneurospora heterodonta, Perotriletes microbaculatus, Cristatisporites triangulatus, Cirratriradites monogrammos. In this assemblage, there are some common species with the Givetian assemblage of the Mahmudia Hills, such as *Leiotriletes devonicus, L. pagius, Cyclogranisporites plicatus, C. magnificus, C. triangulatus, Verrucosisporites absurdus* (Tab. 3). It is clear that these two assemblages can be correlated and included in palynozone D2 typical for the Middle Devonian of the Moesian Platform (Beju, 1971). But the Givetian assemblage of Orlovca, and also that of the Mahmudia Hills, can be correlated with palynozone EX of the East-European Platform (Tab. 4).

For this palynozone, the typical taxon Geminospora extensa established for the East European Platform (Avkhimovich et al., 1993) is also present in the Givetian assemblage of Orlovca (Olaru, Sliusari, 1996).

In the upper part of the lithological column three palynozone assemblages were established, which can be correlated with the same ones of the East European Platform.

For the Early Frasnian the OK palynozone assemblage (Tab. 4) was established with the following taxa: *Reticulatisporites perlotus, Aneurospora greggsii, Chelinospora concina, Dictyotriletes devonicus, Verruciretusispora domanica, Acanthotriletes eximus* (Tab.3).

This typical assemblage is the cenozone one, and it is accompanied by the palynozone taxa, *Contagisporites*

Table 3

PALYNOZONATION AND CORRELATION OF PALYNOLOGICAL ASSEMBLAGES FROM THE ORLOVCA FORMATION

AGE	TYPICAL PALYNOZONES OF EAST EUROPEAN PLATFORM		ORLOVCA FORMATION		PALYNOZONES OF THE MOESIAN PLATFORM
	PALYNOLOGICAL ASSEMBLAGES	ZONES	PALYNOLOGICAL ASSEMBLAGES	LITHOLOGIE	
LATE FRASNIAN	Cristatisporites deliquescens Verrucosisporites evlanensis	DG	Cymbosporites eximus, Diphanospora rugosa, Chelinospora lepidus	Grey quartzite slites; Grey-redish sand - stones; Quartzite li- mestones.	? D_{3a}
MIDDLE FRASNIAN	Archaeoperisaccus ovalis *Verrucosisporites grumosus*	OG	*Verrucosisporites grumosus*, Spelaeotriletes domanicus, Geminospora rugosa , Aneurospora speciosa, Cymbosporites vetlasjanicus.	Grey-greenish slates; Grey-redish sand - stones; Grey lime - stones and quartzites.	
EARLY FRASNIAN	Geminospora semilucensa Perotriletes donensis	SD	Verruciretusispora domanica	Grey limestones and quartzites.	
	Contagisporites optivus Spelaeotriletes krestovnikovii	OK	Reticulatisporites per - lotus, Aneurospora greggsii, Chelinospora concina, Dictyotriletes devonicus, Acanthotri - letes eximus	Grey quartzites slates; Grey limestones and quartzites.	D_2
MIDDLE DEVONIAN (Givetian)	*Geminospora extensa*	EX	Leiotriletes devonicus, L. paglus, Cyclograni - sporites triangulatus, Verrucosisporites ab - surdus, Perotriletes microbaculatus, *Gemino - spora extensa*, Cirratri - radites monogrammos, Chelinospora concina, Rugospora impolita, Cristatisporites triangu - latus, Archaeozonotri - letes timanicus, Coryti - sporites spinutissimus, Cyclogranisporites pli - catus, Grandispora in - culta, Aneurospora hete - rodonta, Lanatisporites bislimbatus	Grey quartzites sla - tes; Grey-greenish slates, Grey lime - stones and quartzites, Grey-redish sand - stones; Quartzite sandstones.	D_2

optivus and *Spalaeotriletes krestovinikovii*, but they are missing in the Orlovca Formation.

For the Middle Frasnian, palynozone OG, for the East European Platform, was established (Avkhimovich et al., 1993). One typical taxon of this palynozone, *Verrucosisporites grumosus* (Tab. 3, 4) was determined, from the grey limestones and quartzites of the upper part of the lithological column, of the *Orlovca Formation* (Olaru, Sliusari, 1996). The second typical palynozone taxon, Archaeoperisacus ovalis cannot be found in the Orlovca Formation. The cenozone assemblage is characteristic and includes the following species: *Spelaeotriletes domanicus*, *Geminospora rugosa*, *Cymbosporites vetlasjanicus*, *Convolutispora crassitunicata* (Tab. 4).

Table 4

RANGE CHART SHOWING PALYNOMORPHS DISTRIBUTION IN THE DEVONIAN FORMATION OF ORLOVCA (CARTAL)

TAXONOMIC UNITS	CHRONOSTRATIGRAPHIE						
	EMS	EIFEL.		GI-	FRASNIAN		
	Late	Early	Late	VET.	Earl y	Mid.	Late
Azonomonoletes microtuberculatus Tchib.							
Leiotriletes devonicus Naum.							
Leiotriletes pagius Allen							
Azonomonoletes tuberculatus Tchib.							
Cyclogranisporites triangulatus (Allen) Mc G&C							
Retusotriletes microbaculatus							
Archaeozonotriletes ignoratus (Naum.) Tchib.							
Punctatosporites tortuosus (Tchib.) Arkh.							
Cyclogranisporites triangulatus (Allen) Mc G&C							
Verrucosisporites absurdus Tchib.							
Reticulatisporites perlotus (Naum.) Obukh.							
Aneurospora greggsii (Mc Gregor) Streel							
Perotriletes microbaculatus Rich. & Lister							
Geminospora extensa (Naum.) Gao							
Lophotriletes paucus Kedo							
Cirratriradites monogrammos (Arkh.) Arkh.							
Chelinospora concina Allen							
Retusotriletes ambagiosus Tchib.							
Acanthotriletes variaculeatus Kedo							
Rugospora impolita (Naum.) Tchib.							
Dictyotriletes devonicus Naum.							
Verruciretusispora domanica (Naum.) Obukh.							
Verrucosisporites grumosus (Naum.) Obukh.							
Cristatisporites triangulatus (Allen) Mc G & C							
Archaeozonotriletes timanicus Naum.							
Acanthotriletes eximus Naum.							
Spelaeotriletes domanicus (Naum.) Obukh.							
Periplecotriletes tortus Egorova							
Cymbosporites eximus (Obukh.) Obukh.							
Geminospora rugosa (Naum.) Obukh.							
Corystisporites spinutissimus (Kedo) Obukh.							
Auroraspora speciosa (Naum.) Obukh.							
Cymbosporites vetlasjanicus Medianik &Obuch.							
Diphanospora rugosa (Naum.)Byvscheva							
Azonomonoletes subreticularis Tchib.							
Cyclogranisporites plicatus Allen							
Retusotriletes clandestinus Tchib.							
Grandispora inculta Allen							
Rhabdosporites mirus Arkh.							
Aneurospora heterodonta (Naum.) Streel							
Lanatisporites bislimbatus (Tchib.) Arkh.							
Chelinospora lepidus (Obukh.) Obukh.							
Geminospora decora (Naum.) Arkh.							
Convolutispora crassitunicata (Obukh.) Obukh.							
Synorisporites verrucatus Rich. & Lister							
Sphaerochitina sphaerocephala Eis.							
Lagenochitina ponceti Rauch.							
Angochitina longicola Eis.							
Cyathochitina cf. campanulaeformis Eis.							
Angochitina moldavica Beju & Dăneț							

For the Upper Frasnian (Tab. 4) the cenozone assemblage was established, for the DE palynozone (Olaru, Sliusari, 1996). This assemblage includes the following taxa: *Cymbosporites eximus, Diphanospora rugosa, Chelinospora lepidus*. The typical palynozone taxa such as *Cristatisporites deliquescens* and *Verrucosisporites evlanensis*, are not found.

Thus, one can draw the conclusion that at the village of Orlovca an analysis was made of a segment of the lithological column of the Middle Devonian with the Givetian-Middle Frasnian, possible to Upper Frasnian stratigraphic interval. The Orlovca Formation can be correlated with a similar stratigraphic interval of the Mahmudia Hills (Middle Member of the Bestepe Formation). Also, by the palynological data, palynozones EX, OK, OG, DE of East European Platform can be found again in the Orlovca Formation (Tab. 4).

General conclusions

After palynological investigations in Northern Dobrogea one can draw the following general conclusions:

The Devonian Formations in Northern Dobrogea are spreading in isolated points and in incomplete composition of lithological columns, except for the Mahmudia Hills, where the lithological column is more complete.

All Devonian rocks were sedimented in the flysch facies and later were slightly metamorphosed, tectonised and crossed by the igneous intrusions. Structurally the investigated Devonian Formations belong to two units: the Măcin Unit in the west side, and the Tulcea one, in the east side of Northern Dobrogea.

Palynologically, the Devonian Formations offer typical assemblages of spores and marine microplankton (acritarches and chitinozoans) for the Lower, Middle and Upper Devonian age.

From the palynostratigraphic point of view, the correlation between the Devonian assemblages of the Northern Dobrogea Formations and the Moesian Platform ones can be made. Thus, common palynozones and subzones can be established, such as D1a, D1b, D1c for the Lower Devonian; D2 (without subzones) for the Middle Devonian, and D3a and D3b for the Upper Devonian.

The palynozonation can be made in the Bujoarele Formation (Măcin Unit) for the Lower Devonian; in the Bestepe Formation (Tulcea Unit) for the Lower to Upper Devonian and in the Orlovca Formation (the same unit), only for the Middle Devonian.

Considering the correlation of the East European Platform the typical assemblages for palynozones EX, OK, SD and DE of the Givetian to the Middle (possible to Upper) Frasnian age, can be found again in the Orlovca Formation. Thus, at the Middle Devonian level, the correlation and palynozonation between the East European Platform and the Moesian Platform can be extended, by the assemblages of geological formations of Northern Dobrogea.

The absence of the majority, of micro - and macrofauna remains of analysed rocks, could not permit the comparative establishment of correlations between palynostratigraphical and faunal biozones.

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