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ScienceDirect
Russian Geology and Geophysics 56 (2015) 737–744
RUSSIAN GEOLOGY AND GEOPHYSICS
www.elsevier.com/locate/rgg

Calcareous nannoplankton in the Jurassic deposits of the Dobrudja foredeep (*Ukraine and Moldova*)

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Received 8 November 2013; received in revised form 1 April 2014; accepted 21 April 2014

Abstract

The paper is concerned with Jurassic calcareous nannoplankton from the Dobrudja foredeep. The regional Jurassic stratigraphy based on nannoplankton is considered. The NJ10/Stephanolithion speciosum, NJ11/Pseudoconus enigma, NJ14/Stephanolithion bigotii maximum, and NJ15/Cyclagelosphaera margerelii Zones, consistent with the International Nannoplankton Zonation Scheme, have been recognized in the deposits of the Dobrudja foredeep.

Keywords: calcareous nannoplankton; Jurassic deposits; Dobrudja foredeep

Introduction

The Jurassic sediments in the Dniester–Prut interfluve fill the Dobrudja foredeep, which is a graben-like structure with a gently sloping northeastern limb and a steep southwestern limb. The northern boundary of the study area passes north of Leova and Cãinari Village and then turns southward, parallel to the stream of the Dniester, east of Tarutyne, Sarata, Kolesnoe, and Bol'shaya Balabanovka Villages. It is bounded in the east by a fault in the direction Cahul–Vulcãnesti–Izmail (Fig. 1) (Romanov, 1973).

The history of study of this region is presented in (Leshchukh et al., 1999; Romanov, 1973, 1976; Romanov and Danich, 1971).

The many-year studies of malacofauna by L.F. Romanov, supplemented by the works of R.I. Leshchukh, serve as a basis for a modified chart (Uvanik et al., 2013). The regional stratigraphic chart was correlated with the International Stratigraphic Chart of D.G. Ogg (Gozhyk, 2012). The formations contain foraminifers (M.M. Danich, V.G. Dulub, and D.M. P'yatkova), ostracodes (M.I. Mandel'shtam, N.Yu. Andreeva, and L.P. Rachenskaya), Charophyceae (I.M. Shaikin), and spore–pollen assemblages (G.G. Yanovskaya) (P'yatkova, 2012; Romanov and Danich, 1971; Yanovskaya, 1971, 1973).

The goal of the present paper is to determine the species composition of assemblages of calcareous nannoplankton for the stratigraphic division of the Jurassic sediments of the Dobrudja foredeep. The results of early studies were described in (Matlai, 2010). The presence of calcareous nannoplankton in the Jurassic sediments of the Dobrudja foredeep has been proven. New rock samples permitted supplementing nannoplankton assemblages and proving their correspondence to international standard nannoplankton zones.

In the Dniester–Prut interfluve, three structure–facies regions were distinguished: Western, Central, and Eastern, which correspond to the inner, central, and outer zones of the Dobrudja foredeep (Fig. 1). The Jurassic sediments here differ in the degree of completeness of the section, thickness, and abundance and species composition of organic remnants.

The Dobrudja foredeep contains paleontologic evidence for the presence of Upper Bajocian, Upper Bajocian–Lower Bathonian, Middle and Upper Callovian, Oxfordian, and Upper Oxfordian–Lower Kimmeridgian sediments. The Jurassic section ends with a thick series of Kimmeridgian–Tithonian variegated sediments (Romanov, 1973).

Materials and methods

The Jurassic rocks of the Dobrudja foredeep are localized beneath thick sedimentary strata, and all the evidence was obtained from studies of core samples from the wells drilled during prospecting and exploration works of different years.

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http://dx.doi.org/10.1016/j.rgg.2015.04.005

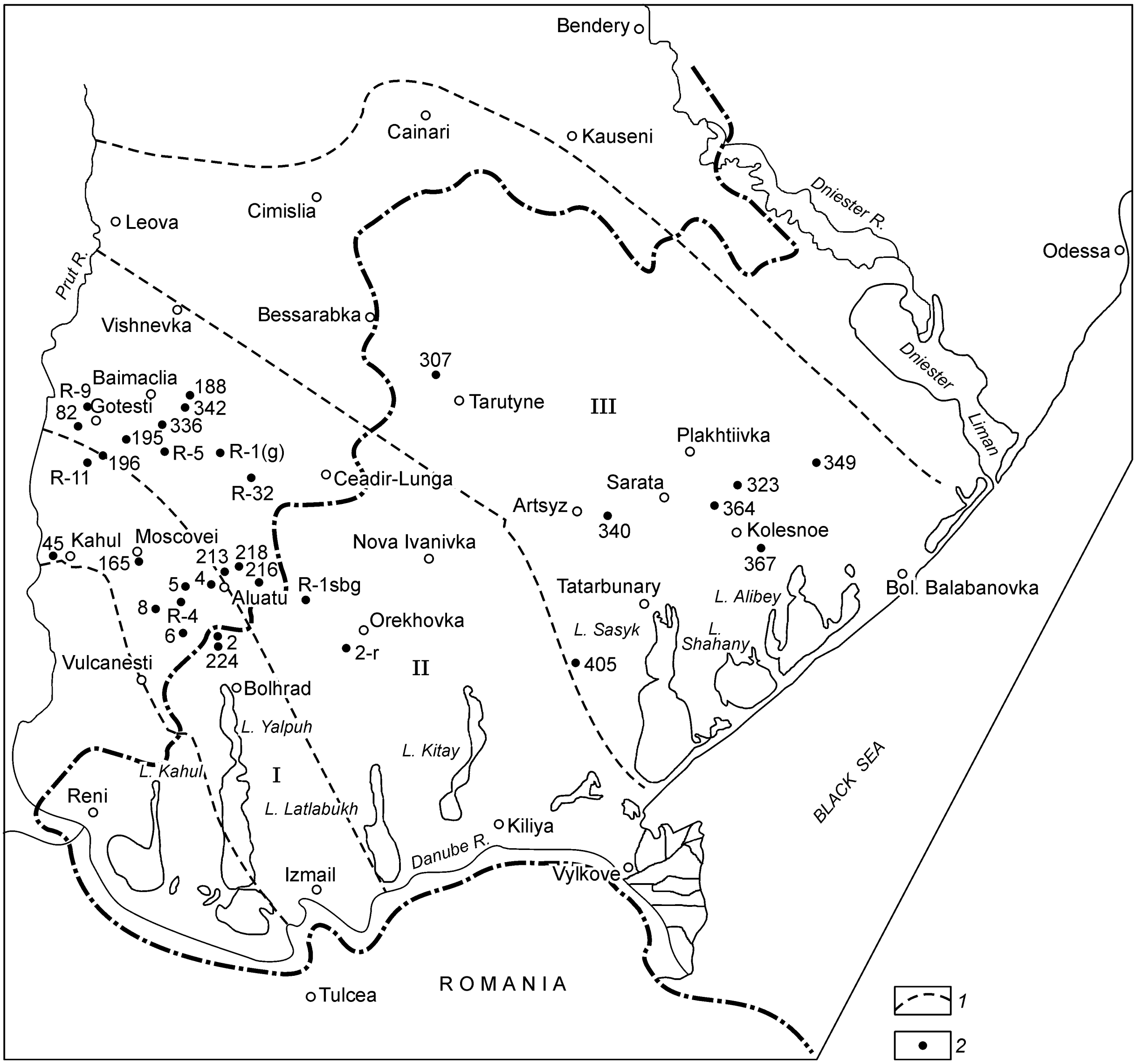

Fig. 1. Sketch map of occurrence of Jurassic sediments in the Dniester–Prut interfluve, after (Romanov, 1973), supplemented by the author. *1*, boundaries of the area occupied by Jurassic sediments; *2*, wells. Facies regions of the Dniester–Prut interfluve: I, Western; II, Central; III, Eastern.

Forty-two samples from 25 wells were provided to the author by L.F. Romanov, and 156 samples from nine wells were provided by D.M. P'yatkova. In total, 197 samples were studied.

The samples were prepared for microscopic study of microfossils by the standard technique of Deflandre and Fert (Shumenko, 1987). Nannoplankton was studied in time slices using an immersion lens with 90× magnification under an MBI-6 optical polarization microscope in ordinary and polarized light at a magnification of 1500×. Photographs were taken using a digital camera under an optical microscope in polarized light at a magnification of 2000×.

The systematic classification by J.R. Young and P.R. Bown (Bown, 1998) was used in the present paper.

Results

The rocks filling the Dobrudja foredeep are dominated by Late Bajocian sediments, which overlie Silurian, Devonian, Permian, and Triassic rocks with sharp angular and stratigraphic unconformity (Romanov, 1973). These sediments are compact dark gray clays and siltstones; most often, with a member of quartz–feldspar sandstones and siltstones at the base. On the slope of the East European Platform, the Upper Bajocian sediments are dark gray plastic clays up to 250 m in thickness. The upper Upper Bajocian sediments are preserved only in the Dobrudja foredeep, in which they are overlain by an undivided Upper Bajocian–Lower Bathonian series and Paleogene and Neogene rocks, and on the buried slope of the East European Platform, where they are overlain by Middle Callovian, Upper Jurassic, or Upper Cretaceous rocks (Romanov, 1973). These sediments contain ammonites, bivalves, and foraminifers (Romanov, 1973; Romanov and Danich, 1971).

A well-preserved abundant assemblage of calcareous nannoplankton is found in a core sample from well R-1 sbg near Starye Troyany Village (interval of 1245–1252 m), Central region. In nonbedded mudstone-like gray clays with a low silt content, which contain spangles of mica and fine detritus as well as bivalve remnants, the following species were defined: *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *W. manivitiae* Bukry, *Cyclagelosphaera margerelii* Noël, *Lotharingius contractus* Bown and Cooper, *L. crucicentralis* (Medd) Grün and Zweili, *L. sigillatus* (Stradner) Prins, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, *Schizosphaerella punctulata* Deflandre and Dangeard, *Biscutum dubium* (Noël) Grün, *Polypodorhabdus escaigii* Noël, *Anfractus harrisonii* Medd, *Stephanolithion speciosum* Deflandre *speciosum*, and *Staurolithites quadriarculla* (Noël) Wilcoxon. The zonal species *Stephanolithion speciosum* Deflandre *speciosum* testifies to the Late Bajocian age of these sediments, which corresponds to the age of macrofauna estimated by L.F. Romanov (1973). The species *Lotharingius contractus* Bown and Cooper is an additional taxon in the Upper Bajocian–Lower Bathonian interval, because there is paleontologic evidence for a Late Bathonian–Early Callovian gap in the sediments of the Dobrudja foredeep (Romanov, 1973). The taxonomic composition of the nannoplankton assemblage corresponds to the NJ10/Stephanolithion speciosum Zone (International Nannoplankton Zonation Scheme of P. Bown) (Bown, 1998; Gozhyk, 2012).

An assemblage of calcareous nannoplankton in the lower part of the Upper Bajocian series is defined in a core sample from well 307 (interval of 1130.5–1140.5 m), Eastern region: *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *Biscutum dubium* (Noël) Grün, *Lotharingius contractus* Bown and Cooper, *L. crucicentralis* (Medd) Grün and Zweili, *L. sigillatus* (Stradner) Prins, *Stephanolithion speciosum* Deflandre *speciosum*, *Carinolithus superbus* (Deflandre) Prins, *Discorhabdus striatus* Moshkovitz and Ehrlich, *Axopodorhabdus cylindratus* (Noël) Wind and Wise, and *Triscutum sullivanii* de Kaenel and Bergen. The nannoplankton assemblage in a core sample from well R-4 (interval of 1018–1023 m), Western region, is somewhat less abundant: *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *Cyclagelosphaera margerelii* Noël, *Schizosphaerella punctulata* Deflandre and Dangeard, *Lotharingius crucicentralis* (Medd) Grün and Zweili, *Stephanolithion speciosum* Deflandre *speciosum*, and *Triscutum sullivanii* de Kaenel and Bergen. The taxonomic composition of these nannoplankton assemblages corresponds to the NJ10/Stephanolithion speciosum Zone (Bown, 1998).

The upper part of the Late Bajocian series is stripped by well R-11 in the interval 770–776 m, Western region. Bedded strong compact dark gray (in some places black) mudstones with slickensides contain *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *Cyclagelosphaera margerelii* Noël, *Biscutum dubium* (Noël) Grün, *Lotharingius contractus* Bown and Cooper, *L. crucicentralis* (Medd) Grün and Zweili, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, *Schizosphaerella punctulata* Deflandre and Dangeard, *Tubirhabdus patulus* Rood, *Discorhabdus striatus* Moshkovitz and Ehrlich, *Stephanolithion speciosum* Deflandre *speciosum*, *Carinolithus magharensis* (Moshkovitz and Ehrlich) Bown, and *Pseudoconus enigma* Bown and Cooper. The presence of the species *Carinolithus magharensis* (Moshkovitz and Ehrlich) Bown and *Pseudoconus enigma* Bown and Cooper is possible only in the Upper Bajocian sediments corresponding to the parkinsoni Ammonite Zone (Bown, 1998). The taxonomic composition of the nannoplankton assemblage corresponds to the NJ11/Pseudoconus enigma Zone (Bown, 1998; Gozhyk, 2012).

The dark gray mudstone-like clays with a siltstone admixture in well 196 (interval of 779–782 m), Central region, which show a distinct horizontal–wavy bedding, contain the following nannoplankton assemblage: *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *W. manivitiae* Bukry, *Biscutum dubium* (Noël) Grün, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, *Stephanolithion speciosum* Deflandre *speciosum*, *Anfractus harrisonii* Medd, *Octopodorhabdus decussatus* (Manivit) Rood, *Tubirhabdus patulus* Rood, *Axopodorhabdus cylindratus* (Noël) Wind and Wise, and *Hexapodorhabdus cuvillieri* Noël. The presence of Early Bathonian rocks in these sediments is evidenced by the species *Octopodorhabdus decussatus* (Manivit) Rood, whose first appearance was recorded by Manivit (1961) and Rood (1971) in the Early Bathonian sediments of England (zigzag Ammonite Zone) (Bown, 1998; Gozhyk, 2012). The taxonomic composition of the calcareous nannoplankton assemblage corresponds to the NJ11/Pseudoconus enigma Zone in the stratigraphic extent of the zigzag Ammonite Zone (Bown, 1998).

Upper Bajocian–Lower Bathonian sediments were studied in all the structure–facies zones of the Dobrudja foredeep. The most abundant and taxonomically diverse nannoplankton assemblages were defined in the series for which assignment to the upper part of the Upper Bajocian NJ10 Zone and the Lower Bathonian NJ11 Zone was carried out. Along with transition species with a wide stratigraphic range, the zonal species *Stephanolithion speciosum* Deflandre *speciosum* and *Lotharingius contractus* Bown and Cooper were defined in all the assemblages. The species *Triscutum sullivanii* de Kaenel and Bergen are observed in the assemblages of the lower part of the Upper Bajocian series. The presence of the species *Pseudoconus enigma* Bown and Cooper, *Carinolithus magharensis* (Moshkovitz and Ehrlich) Bown, and *Hexapodorhabdus cuvillieri* Noël indicates that the rocks belong to the upper Upper Bajocian. The presence of an Early Bathonian nannoplankton assemblage was proven only in well 196 (interval of 779–782 m), Central region, by the appearance of the species *Octopodorhabdus decussatus* (Manivit) Rood.

The Callovian sediments, which occur in most of the Dobrudja foredeep, overlie different Upper Bajocian–Lower Bathonian horizons with dramatic unconformity as well as Silurian, Devonian, and Triassic rocks. They are overlain by Oxfordian sediments, the variegated rocks of the Visniovca Group, or Paleogene and Neogene rocks. According to paleontological data, Middle and Upper Callovian sediments are observed (Romanov, 1973).

The slightly bedded gray mudstone-like clays with an admixture of fine silt, bivalve imprints, and numerous mica spangles in a core sample from the interval 951–957 m, well R-1 sbg near Starye Troyany Village, Central region, contain the following assemblage of calcareous nannoplankton: *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *W. manivitiae* Bukry, *Cyclagelosphaera margerelii* Noël, *Lotharingius crucicentralis* (Medd) Grün and Zweili, *L. sigillatus* (Stradner) Prins, *Schizosphaerella punctulata* Deflandre and Dangeard, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, *Biscutum dubium* (Noël) Grün, *Stephanolithion hexum* Rood and Barnard, *S. bigotii* Deflandre *bigotii*, *Podorhabdus grassei* Noël, *Anfractus harrisonii* Medd, *Tubirhabdus patulus* Rood, and *Staurolithites* sp. The assemblage does not include the species *Lotharingius contractus* Bown and Cooper,whose last appearance is recorded in the Lower Callovian. Based on the presence of the species *Stephanolithion bigotii* Deflandre *bigotii* and *St. hexum* Rood and Barnard, the assemblage corresponds to the NJ13/Stephanolithion bigotii bigotii Zone (Bown, 1998; Gozhyk, 2012). The lack of the species *Stephanolithion bigotii* Deflandre *maximum* Medd limits the age of the series to the Middle Callovian.

The results of study of samples from the Chumaiskaya-5 well, drilled near the eastern fringe of Budei Village, Western region, show the abundance of calcareous nannoplankton in Callovian sediments. The mudstone series with limestone interbeds (interval of 499.6–688.9 m) contains *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *W. manivitiae* Bukry, *Cyclagelosphaera margerelii* Noël, *Lotharingius crucicentralis* (Medd) Grün and Zweili, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, *Stephanolithion bigotii* Deflandre *bigotii*, *S. bigotii* Deflandre *maximum* Medd, *Biscutum dorsetensis* Varol and Girgis, *B. dubium* (Noël) Grün, *Schizosphaerella punctulata* Deflandre and Dangeard, *Tubirhabdus patulus* Rood, *Triscutum expansus* (Medd) Dockerill, *Ansulasphaera helvetica* Grün and Zweili, *Staurolithites quadriarculla* (Noël) Wilcoxon, *Stradnerlithus fragilis* (Rood and Barnard) Perch-Nielsen, *Retecapsa octofenestrata* (Bralower) Bown, *Polypodorhabdus escaigii* Noël, *Podorhabdus grassei* Noël, *Crepidolithus crassus* (Deflandre) Noël, *Octopodorhabdus decussatus* (Manivit) Rood, *Retecapsa incompta* Bown, *Anfractus harrisonii* Medd, *Sollasites* sp., and coccospheres of *Watznaueria* sp. The Callovian age of the series is evidenced by the species *Ansulasphaera helvetica* Grün and Zweili and *Stephanolithion bigotii* Deflandre *bigotii*, and assignment to the Upper Callovian (upper part of the lamberti Ammonite Zone) (Bown, 1998) is supported by the presence of the species *Stephanolithion bigotii* Deflandre *maximum* Medd and the appearance of *Stradnerlithus fragilis* (Rood and Barnard) Perch-Nielsen (Perch-Nielsen, 1985).The taxonomic composition of the nannoplankton assemblage corresponds to the NJ13/Stephanolithion bigotii bigotii Zone. The NJ14/Stephanolithion bigotii maximum Zone is not defined in these sediments, because the nannoplankton assemblage includes the Callovian species *Ansulasphaera helvetica* Grün and Zweili.

The Callovian age of the series of nonbedded dark gray clays with a low silt content, which contain remnants of smooth-walled pectinids and fine detritus, in well R-5 sbg (interval of 1182–1186 m) near Tataresti Village, Central region, is evidenced by the zonal species *Ansulasphaera helvetica* Grün and Zweili in the assemblage of calcareous nannoplankton.

In most of the studied samples, assigned to the Callovian based on other faunal groups (Romanov and Danich, 1971), nannoplankton is not defined or consists of transition species. This can be explained by the facts that these sediments formed under shallow-water shelf conditions or that the area occupied by the Callovian sediments is smaller than it was presumed before (Romanov, 1973).

The Lower Oxfordian sediments, which are observed only in the foredeep, are clayey marls, limestones, and gray siltstones. Their thickness varies from a few meters in Pripruttia to 130 m in the central part of the foredeep (Romanov, 1973). The Lower Oxfordian sediments are here overlain by a thick clay series with interbeds of Late Oxfordian–Early Kimmeridgian limestones and siltstones (its age in the Ciumai area is Middle Oxfordian–Early Kimmeridgian, according to an oral report by L.F. Romanov). In the southwestern and northeastern parts of the foredeep, the Upper Oxfordian–Lower Kimmeridgian sediments are mainly reef and organogenic–clastic limestones (Romanov and Danich, 1971).

A series of fractured strong compact marls with limestone and mudstone interbeds is stripped in the Chumaiskaya-5 well, interval of 368.60–441.25 m. The assemblage of calcareous nannoplankton includes *Watznaueria barnesae* (Black) Perch-Nielsen, *W. britannica* (Stradner) Reinhardt, *W. manivitiae* Bukry, *Cyclagelosphaera margerelii* Noël, *Lotharingius crucicentralis* (Medd) Grün and Zweili, *L. sigillatus* (Stradner) Prins, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, *Staurolithites quadriarculla* (Noël) Wilcoxon, *Schizosphaerella punctulata* Deflandre and Dangeard, *Retecapsa* cf. *R. schizobrachiata* (Gartner) Grün, *R. octofenestrata* (Bralower) Bown, *R. incompta* Bown, *Biscutum dorsetensis* Varol and Girgis, *B. dubium* (Noël) Grün, *Stephanolithion bigotii* Deflandre *bigotii*, *S. bigotii* Deflandre *maximum* Medd, *Octopodorhabdus decussatus* (Manivit) Rood, *Anfractus harrisonii* Medd, *Axopodorhabdus cylindratus* (Noël) Wind and Wise, and *Podorhabdus grassei* Noël. The taxonomic composition of the assemblage corresponds to the Lower Oxfordian NJ14/Stephanolithion bigotii maximum Zone (Bown, 1998; Gozhyk, 2012).

In the section of the Chumaiskaya-4 well, drilled 2 km from Aluatu Village, Ceadîr-Lunga district, the Oxfordian

Calcareous nannoplankton species	Structural facies region																	
	Western						Central						Eastern					
	J_2bj_2	$J_2bj_2-J_2bt_1$	J_2kl_{2-3}	J_3o_1	$J_3o_2-J_3km_1$	$J_3km_2-J_3tt$	J_2bj_2	$J_2bj_2-J_2bt_1$	J_2kl_{2-3}	J_3o_1	$J_3o_2-J_3km_1$	$J_3km_2-J_3tt$	J_2bj_2	$J_2bj_2-J_2bt_1$	J_2kl_{2-3}	J_3o_1	$J_3o_3-J_3km_1$	$J_3km_2-J_3tt$
Anfractus harrisonii	•		•	•	•			•			•		•		•		•	
Ansulasphaera helvetica			•						•									
Axopodorhabdus atavus				•							•							
A. cylindratus			•	•	•			•			•		•		•		•	
A. rahla											•							
Biscutum dorsetensis			•	•	•						•							
B. dubium	•	•	•	•	•		•	•	•		•		•		•		•	
Carinolithus magharensis		•																
C. superbus													•					
Crepidolithus crassus			•															
Cyclagelosphaera margerelii	•	•	•	•	•			•	•		•		•		•			
C. tubulata											•							
C. wiedmannii								•			•							
Discorhabdus criotus				•							•		•					
D. striatus		•			•						•		•					
Ethmorhabdus gallicus			•	•							•							
Faviconus multicolumnatus					•						•						•	
Hexapodorhabdus cuvillieri			•	•	•			•			•							
Lotharingius contractus	•	•					•						•					
L. crucicentralis	•	•	•	•	•		•	•			•		•		•		•	
L. sigillatus	•		•	•	•		•	•			•		•		•		•	
Miravetesina favula											•							
Octopodorhabdus decussatus			•	•				•										
Podorhabdus grassei			•	•			•				•		•		•			
Polypodorhabdus escaigii			•	•	•						•		•				•	
Pseudoconus enigma		•											•					
Retecapsa incompta			•	•	•						•				•			
R. octofenestrata			•	•							•							
R. cf. *R. schizobrachiata*				•	•													
Schizosphaerella punctulata	•	•	•	•	•		•				•		•		•		•	
Sollasites sp.			•															
Staurolithites lumina					•						•							
St. quadriarculla			•	•	•						•		•		•			
Stephanolithion bigotii bigotii			•	•	•				•		•				•		•	
S. bigotii maximum				•							•							
S. hexum			•												•			
S. speciosum speciosum	•	•					•	•					•					
Stradnerlithus fragilis			•	•	•						•							
Triscutum beaminsterensis			•	•							•				•			
T. expansus			•	•							•						•	
T. sullivanii													•					
Triscutum sp.	•												•					
Tubirhabdus patulus		•	•	•			•	•			•		•		•			
Watznaueria barnesae	•	•	•	•	•		•	•	•		•		•		•		•	•
W. britannica	•	•	•	•	•		•	•	•		•		•		•		•	•
W. fossacincta	•	•	•	•	•		•	•	•		•		•		•		•	
W. manivitiae	•		•	•	•		•	•	•		•		•		•		•	
Zeugrhabdotus erectus	•	•	•	•	•		•	•			•		•		•			
Z. fissus					•						•							

Fig. 2. Stratigraphic range of calcareous nannoplankton in the Jurassic sediments of the Dobrudja foredeep.

sediments are mudstones and clayey limestones (interval of 950.60–1070.35 m). They contain *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *W. manivitiae* Bukry, *Cyclagelosphaera margerelii* Noël, *Lotharingius crucicentralis* (Medd) Grün and Zweili, *L. sigillatus* (Stradner) Prins, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, *Retecapsa octofenestrata* (Bralower) Bown, *Faviconus multicolumnatus* Bralower, *Stephanolithion bigotii* Deflandre *bigotii*, *Biscutum dorsetensis* Varol and Girgis, *B. dubium* (Noël) Grün, *Staurolithites quadriarculla* (Noël) Wilcoxon, *Hexapodorhabdus cuvillieri* Noël, *Axopodorhabdus cylindratus* (Noël) Wind and Wise, *A. atavus* (Grün) Bown, *Triscutum expansus* (Medd) Dockerill, *Schizosphaerella punctulata* Deflandre and Dangeard, *Tubirhabdus patulus* Rood, *Polypodorhabdus escaigii* Noël, *Ethmorhabdus gallicus* Noël, *Staurolithites lumina* Bown, *Miravetesina favula* Grün, etc. The taxonomic composition of the assemblage corresponds to the NJ15/Cyclagelosphaera margerelii Zone (Bown, 1998) in the stratigraphic extent of the Middle Oxfordian–Lower Kimmeridgian. Interestingly, the appearance of the species *Staurolithites lumina* Bown was recorded by P. Bown in the Upper Kimmeridgian sediments of the Gorodishche section (Russia).

A similar assemblage is defined in the mudstones and clayey limestones (interval of 556–802 m) of a core sample from the Chumaiskaya-6 well, drilled 0.5 km north of Greceni station.

Monolithic dark gray sandstone with a bedded base, found in a core sample from the Chumaiskaya-8 well (Vladimirovca Village, Vulcănesti district), interval of 690–750 m, contains

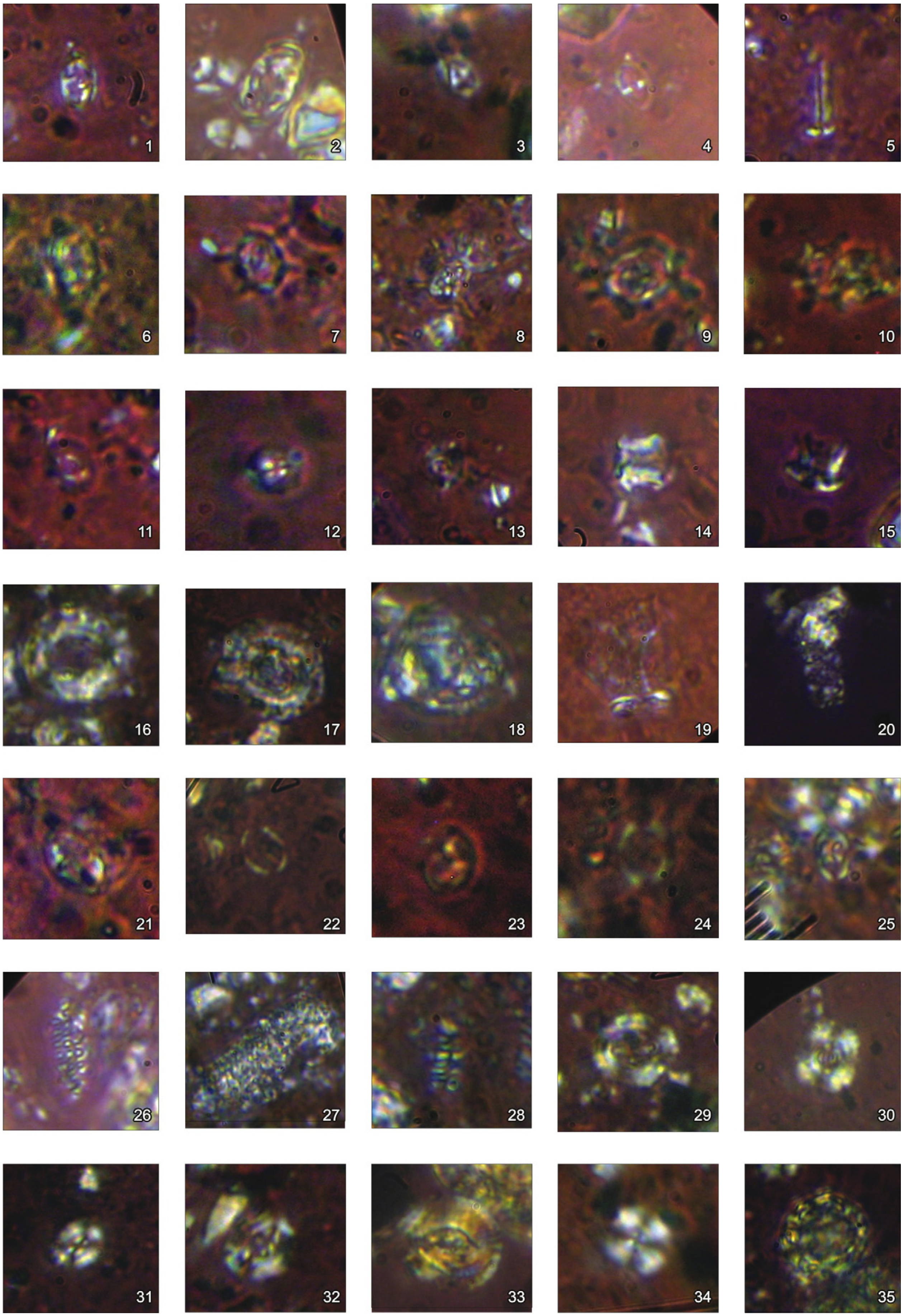
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Fig. 3. Calcareous nannoplankton in the Jurassic sediments of the Dobrudja foredeep.
Nicols × (90°), ×1575. The scale of the photographs was violated during the operation of the Photoshop software. Figs. 1, 2, *Tubirhabdus patulus* Rood, Western region; Figs. 3, 4, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, Western region; Fig. 5, fragment of *Carinolithus* sp., Eastern region; Fig. 6, *Stephanolithion hexum* Rood and Barnard, Eastern region; Figs. 7, 8, *Stephanolithion bigotii* Deflandre *bigotii*, Western region; Fig. 9, *Stephanolithion bigotii* Deflandre *maximum* Medd, Western region; Fig. 10, *Stephanolithion* sp., Central region; Fig. 11, *Biscutum dubium* (Noël) Grün, Western region; Fig. 12, *Biscutum* aff. *dorsetensis* Varol and Girgis, Western region; Fig. 13, *Biscutum dorsetensis* Varol and Girgis, Central region; Figs. 14, 15, *Ansulasphaera helvetica* Grün and Zweili, Western region; Figs. 16, 17, *Triscutum* sp., Western region; Fig. 18, *Axopodorhabdus atavus* (Grün) Bown, Central region; Fig. 19, *Podorhabdus grassei* Noël, Western region; Fig. 20, *Pseudoconus enigma* Bown and Cooper, Eastern region; Fig. 21, *Staurolithites* aff. *lumina* Bown, Western region; Fig. 22, *Staurolithites* sp., Western region; Fig. 23, *Staurolithites quadriarculla* (Noël) Wilcoxon,Central region; Fig. 24, *Anfractus* aff. *harrisonii* Medd, Eastern region; Fig. 25, *Anfractus harrisonii* Medd, Western region; Figs. 26–28, *Faviconus multicolumnatus* Bralower, Western region; Fig. 29, *Lotharingius crucicentralis* (Medd) Grün and Zweili, Western region; Fig. 30, *Lotharingius contractus* Bown and Cooper, Western region; Fig. 31, *Watznaueria barnesae* (Black) Perch-Nielsen, Western region; Fig. 32, *Watznaueria britannica* (Stradner) Reinhardt, Western region; Fig. 33, *Watznaueria manivitiae* Bukry, Western region; Fig. 34, *Cyclagelosphaera margerelii* Noël, Western region; Fig. 35, *Schizosphaerella punctulata* Deflandre and Dangeard, Central region.

the species *Lotharingius crucicentralis* (Medd) Grün and Zweili and *Stephanolithion bigotii* Deflandre *bigotii*, which refutes the conclusion of V.V. Pertsovskii (1964) about the Late Bajocian–Early Bathonian age of these sediments. Also, Callovian zonal species are missing, but mudstones (interval of 615 m) already contain Kimmeridgian species: *Staurolithites leptostaurus* (Cooper) Bown, *Staurolithites lumina* Bown, and *S. stradneri* (Rood) Bown as well as *Octopodorhabdus decussatus* (Manivit) Rood and *Discorhabdus criotus* Bown, which disappear in the Middle Oxfordian. The same species are observed in the Middle Oxfordian–Lower Kimmeridgian assemblage of the Chumaiskaya-4 well.

The fractured strong light gray limestones with mudstone interbeds and slickensides, stripped by the Chumaiskaya-2 well, interval 418–570 m (Cairaclia Village, Ceadîr-Lunga district), contain the species *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *W. manivitiae* Bukry, *Cyclagelosphaera margerelii* Noël, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, *Faviconus multicolumnatus* Bralower, *Schizosphaerella punctulata* Deflandre and Dangeard, *Retecapsa* cf. *R. schizobrachiata* (Gartner) Grün, *Staurolithites quadriarculla* (Noël) Wilcoxon, *Stephanolithion bigotii* Deflandre *bigotii*, *Lotharingius crucicentralis* (Medd) Grün and Zweili, *Biscutum dorsetensis* Varol and Girgis, and *B. dubium* (Noël) Grün. The taxonomic composition of the nannoplankton assemblage corresponds to the NJ15/Cyclagelosphaera margerelii Zone (Bown, 1998) in the stratigraphic extent of the Late Oxfordian–Early Kimmeridgian. The assemblage of calcareous nannoplankton becomes less abundant in the reef limestones, so that it is limited to species of the family Watznaueriaceae in the upper intervals.

The Upper Oxfordian–Lower Kimmeridgian nannoplankton assemblage is defined in a core sample from wells 45 sbg (interval of 385–390 m), Western region; R-1 g (674–688 m); 218 (568–586 m); Pandakliiskaya 2-r (827–1226 m), Central region; and 323 (887.4–894.2 m), Eastern region.

An abundant Early Kimmeridgian assemblage of calcareous nannoplankton is observed in well 224 (Musaitu Village, Western region), the interval of 378–510 m. The brown sandy carbonate mudstones with mica spangles and interbeds of marls and cavernous limestones contain the species *Watznaueria barnesae* (Black) Perch-Nielsen, *W. fossacincta* (Black) Bown, *W. britannica* (Stradner) Reinhardt, *W. manivitiae* Bukry, *Cyclagelosphaera margerelii* Noël, *Biscutum dubium* (Noël) Grün, *Zeugrhabdotus erectus* (Deflandre) Reinhardt, *Z. fissus* Grün and Zweili, *Stephanolithion bigotii* Deflandre *bigotii*, *Schizosphaerella punctulata* Deflandre and Dangeard, *Anfractus harrisonii* Medd, *Axopodorhabdus cylindratus* (Noël) Wind and Wise, *Faviconus multicolumnatus* Bralower, *Staurolithites lumina* Bown, *S. quadriarculla* (Noël) Wilcoxon, and *S. stradneri* (Rood) Bown.

A similar nannoplankton assemblage is defined in wells 213 (interval of 577–585 m) and 82 sbg (452–459 m), Central region.

The results of study of calcareous nannoplankton in the Jurassic sediments of the Dobrudja foredeep are shown in Figs. 2 and 3.

Conclusions

Thus, the presence of calcareous nannoplankton in the Jurassic marine sediments of the Dobrudja foredeep proves the presence of all the stratigraphic units recognized by L.F. Romanov and other researchers. The taxonomic composition of the nannoplankton assemblage permits a reliable determination of Late Bajocian, Early Bathonian, Callovian, Early and Middle Oxfordian, and Late Oxfordian–Early Kimmeridgian sediments. The characteristic nannoplankton assemblages correspond to international standard zones, permitting a correlation between the sections of the Dobrudja foredeep and the coeval sediments of the adjacent regions. Of particular value are Late Bajocian, Early Bathonian, Early Oxfordian, and Early Kimmeridgian assemblages of calcareous nannoplankton, which are poorly represented on the Crimean Peninsula.

The present study proves that it is worthwhile to study calcareous nannoplankton in the stratification of the Jurassic sediments of the Dobrudja foredeep.

The author thanks L.F. Romanov† for providing samples and for useful discussion. Also, thanks go to D.M. P'yatkova, Candidate of Geology and Mineralogy, for the opportunity to work with her collection of samples and literature. Finally, the author is grateful to V.A. Prisyazhnik, Candidate of Geology

† Deceased.

and Mineralogy, for help and valuable comments all through the period of the studies.

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Editorial responsibility: B.N. Shurygin