FORAMINIFERA FROM THE LATE JURASSIC AND EARLY CRETACEOUS CARBONATE PLATFORM FACIES OF THE SOUTHERN PART OF THE CRIMEA MOUNTAINS, SOUTHERN UKRAINE

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Abstract: Upper Jurassic and Lower Cretaceous deposits of the Crimea Peninsula are rich in microfossils frequently used for stratigraphic interpretations. In case of foraminifera, the research has been carried predominantly on assemblages obtained by washing the rock samples. The present paper is based on investigations of thin sections from the more indurated sediments that seldom were objects of study. Its goal was to obtain additional information on age and environment of sediments studied. Over 250 thin sections from 16 surface outcrops yielded abundant foraminifera from which over fourty are described herein. Many foraminiferal species (e.g., Labirynthis mirabilis, Parurgonina caelinitis, Neokilianina rakhonensis, Amijella amiji, Anchispirocyllina lusitanica) are stratigraphically significant and known from the Kimmeridgian–Tithonian of the Mediterranean Tethys. The Early Cretaceous fauna is represented by Protopeneroplis ultragranulata, Everticyclammina kellerti, Nautiloculina bronnimanni, Monsalevia salevensis, and Mayncina bulgarica. Generally, the investigated fauna is typical for paleoenvironment of the carbonate platform. Older (Kimmeridgian–Tithonian) assemblages represent the inner, and younger (Berriasian) outer parts of the platform. Palaeogeographic distribution of many species described from the studied area indicates their affiliation with cosmopolitan biota known from the north Tethyan shelf. Additionally, few calcareous cysts of Dinoflagellata have been identified and described.

Key words: foraminifers, dinoflagellata, Upper Jurassic, Lower Cretaceous, Crimea.

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INTRODUCTION

The Crimean microfossil stratigraphy of the Upper Jurassic–Lower Cretaceous deposits has been based mainly on foraminifera described by Russian and Ukrainian palaeontologists (vide Kuznetsova & Gorbatchik, 1985; Gorbatchik & Kuznetsova, 1994). In majority of cases, microfossils were extracted from soft or moderately compact rocks by washing samples with water. Micropaleontological studies of thin sections were rare (Volozhina et al., 1965; Gorbatchik & Mohamad, 1997). Indurated rocks, however, supply very important palaeontological information useful in stratigraphical or palaeoenvironmental interpretations (Sliter, 1989, 1999). This encouraged present authors to complete microbiostratigraphy of the Upper Jurassic sediments of the SW segment of the Crimea Mountains based on the data from thin sections (Fig. 1A). The examined samples yielded rich foraminiferal fauna, which can be used for stratigraphical and environmental investigations. Based on microfaunal data, the paper presents the results of new studies from bedded and massive facies of the Upper Jurassic sediments which represent central part of the Crimea Mountains.

GEOLOGICAL SETTING

The Crimea Mountains occupy the southern, maritime part of the Crimea Mountains and form a narrow belt extending nearly W–E at a distance of more than 150 km (Fig. 1A). The basement of the Upper Jurassic rocks shows a
complicated structure, including a number of intrusive bodies, thrusts of chaotic complexes, faults and tectonic melanges (Nikishin et al. 1998; Yudin, 1999, 2001; Mileev et al., 2006).

The main ridge of the Crimea Mountains includes an allochthonous complex that is composed of thrusts of Upper Jurassic and Lower Cretaceous rocks. This complex unconformably overlies folded flysch strata of the Tauride series (Upper Triassic–Lower Jurassic; Fig. 2). Five main series were distinguished within the Crimea Mountains: Eskiorda, Taurida, Karadag, Sudak, and Yaila (Fig. 2; Mileev et al., 2006; cf. Leshukh et al., 1999).
Rocks building the main part of the Crimea Mountains span a time interval between Callovian and Berriasian (Sudak and Yaila series), although stratigraphic sequence is sometimes disturbed due to complicated tectonic deformations (cf. Mileev & Baraboshkin, 1999), and additionally in certain regions strata of some stages do not occur at all. Deposition in the Crimea Mountains area proceeded in a back-arc basin, which was filled with shallow- to relatively deep-water marine sediments, close to land areas within marginal parts of an epicontinental basin that surrounded the Tethys from the north (Zonnenshain & Le Pichon, 1986; Golonka, 2004).

The Crimea Mountains are subdivided into several smaller massifs (called Yaila), up to 1.500 m a.s.l. Individual massifs, although situated side by side, frequently represent tectonically isolated fragments that are characterized by different morphology, lithology and stratigraphic position of Upper Jurassic and Lower Cretaceous strata. The subject of interest: the Aj-Petri and Yalta Yaila massifs (Fig. 1B), are mainly composed of Tithonian and Berriasian rocks belonging to the Yaila Series (Krajewski & Olszewska, 2006; Mileev et al., 2006).

The gross part of Aj-Petri and Yalta Yailas is mainly composed of thick complexes of bedded limestones, showing variable bed thicknesses: from finely laminated to thick-bedded ones. Thin-bedded marly limestones are ubiquitous. Massive limestones facies of carbonate buildups occur rarely within carbonates of the area. The studies of bedded and massive facies in the western Crimea Mountains indicate that the Aj-Petri and Yalta massifs are mainly built up of limestones representing mostly shallow water facies (peloidal, oncoclastic, detrital, coral, stromatoporoid, microbial and marly) as well as sandy limestones and sandstones (e.g., Leshukh et al., 1999; Krajewski & Olszewska, 2006; Mileev et al., 2006).

**METHODS**

The presented material was collected from massive and bedded limestones and from marly limestones. A few hundred samples were collected, from which thin and polished sections were made. The material was collected from seventeen sections between Lograf Ridge and At-Baş Mountain (Fig. 1B). Over 250 thin sections with microfossils were examined under Nikon Eclipse LV100 Pol microscope. Photos of microfossils were taken with the aid of Nikon photomicrographic attachments Microflex HFX–DX and NIS-Elements Documentation, alternatively.

As a result of complex fault tectonics of this region, the stratigraphic position of the Aj-Petri and Yalta Yailas sediments is uncertain. Since only a few ammonites were found in the Yalta Yaila limestones (Oviechkin, 1956; M. A. Rogov, pers. comm.), this paper deals with data provided by foraminiferal studies. Although stratigraphy based on microfossils is not as precise as the orthostatigraphic scheme based on ammonites, foraminifers are ubiquitous in the studied sediments, unlike ammonites.

Furthermore, due to complicated tectonics in some areas, the strata are disturbed (Mileev & Baraboskhin, 1999) and it is difficult to estimate thickness of the deposits and their stratigraphy. According to some older papers, the total thickness reaches a few thousand meters, but it is probably a tectonic effect (cf. Leshukh et al., 1999). Therefore, more probable thickness would be estimated from hundreds to one thousand meters for each sedimentary unit. It is difficult to create realistic general lithostratigraphical section for the area.

**PALAEONTOLOGICAL CHART**

Foraminifera prevail in all microfossil assemblages from the investigated sediments. Benthic forms are the main components. More than forty benthic species have been identified and described, many for the first time from the region (Figs 4–9). In one sample only, representative of planktic *Globuligerina* was spotted. Kimmeridgian assemblages are more diversified and contain large, imperforate forms with complex interior typical for carbonate platforms (*Pseudocyclammina, Everticyclammina, Rectocyclammina,*...
Fig. 3. The southern escarpment of the Yalta and Aj-Petri Yaila with location of the samples presented in Figs 4–9
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Amijella, Labirynthina). The Tithonian–Berriasian assemblages are rich in small forms, especially miliolids and “trocholinas” associated with carbonate build-ups. In both groups, there are numerous species useful for stratigraphical interpretation of investigated sediments (Fig. 9). Noteworthy is the presence of calcareous cysts of dinoflagellata. Three characteristic species of these groups have been also described.

FORAMINIFERA


Class Foraminiferae d’Orbigny, 1926
Order Lituolida Lankester, 1885
Suborder Lituolina Lankester, 1885
Family Lituolidae de Blainville, 1827
Genus Ammobaculites Cushman, 1910
Ammobaculites coprolithiformis Schwager, 1867

1867.
Haplophragmium coprolithiformis n.sp.: Schwager, p. 654, pl. 34, fig. 3 (fide Ellis & Messina, 1941-2007).
1970.
Haplophragmium coprolithiforme Schwager: Winter, p. 8, pl. 1, figs 1-21, text-fig. 6.
1981.
Ammobaculites coprolithiformis (Schwager): Barnard, Cordey & Shipp, p. 389-391, pl. 1, fig. 9, text-fig. 4.
Remarks. Longitudinal section shows a tightly coiled, planispiral early part and a short rectilinear, uncoiled adult part.
Range. Oxfordian–Kimmeridgian.
Occurrence. Section KC.

Genus Troglorella Wernli & Fookes, 1992
Troglorella incrustans Wernli & Fookes, 1992

Troglorella incrustans Wernli & Fookes n.sp.: Wernli & Fookes, p. 97-102, pl. 1 fig. 15; pl. 2, figs 1-12.
1996.
Troglorella incrustans Wernli & Fookes: Bucur, Senowbari-Daryan & Abate, p. 69, pl. 2, fig. 3; pl. 5, figs 6, 9, 10.
1999.
Troglorella incrustans Wernli & Fookes: Schlagintweit & Ebli, p. 404, pl. 3, fig. 4; pl. 6, figs 7, 9, 10.
Remarks. Longitudinal sections show typical set of slightly inflated chambers of variable shape. The early stage, uniserial, boring, is followed by an adult stage horizontally attached to the substrate.
Range. Kimmeridgian–Berriasian.
Occurrence. Sections KA, KB, KC, KG, KJ, KK, KR.

Suborder Spiroplectamminina Mikhalevich, 1992
Family Textulariopsidae Loeblich & Tappan, 1982
Genus Aaptotoichus Loeblich & Tappan, 1982
Aaptotoichus challengeri Holbourn & Kaminski, 1997

1997. Aaptotoichus challengeri Holbourn & Kaminski n. sp.: Holbourn & Kaminski, p. 46-47, pl. 16, figs 6-8; pl. 17, figs 1-4.
Remarks. Longitudinal sections show an early, short biserial stage with bulbous chambers and a following uniserial stage with low chambers subdivided by horizontal sutures.
Range. Tithonian–Barremian.
Occurrence. Sections: KE, KL, KO.

Genus Haghimashella Neagu & Neagu, 1995
Haghimashella arcuata Haeusler, 1890

1890.
Bigenerina arcuata n.sp.: Haeusler, p. 73. (fide Ellis & Messina, 1941-2007).
1968.
Bigenerina arcuata Haeusler: Oesterle, p. 742, text-fig. 37-39.
1995.
Haghimashella arcuata (Haeusler): Neagu & Neagu, p. 216, pl. 2 figs 1-11.
Remarks. Longitudinal sections show the early biserial stage followed by variously inclined adult, uniserial part. Commonly occur isolated biserial parts caused by breaking of fragile specimens.
Range. Middle Oxfordian–Berriasian.
Occurrence. Sections: KB, KC, KJ, KN.

Suborder Verneuilina Mikhalevich & Kaminski, 2004
Family Verneuilinidae Cushman, 1911
Genus Paleogaudryina Said & Bakarat, 1958
Paleogaudryina magnaraensis Said & Bakarat (1958)

1958. Paleogaudryina magnaraensis n.sp.: Said & Bakarat, p. 243, pl. 3, fig. 42; pl. 4, figs 33-36.
Remarks. Common species, usually occurs in separate parts of the triserial and biserial stages. Differs from the Paleogaudryina varsoviensis (Bielecka & Pożaryski, 1954) in larger triserial stage and flattened chambers of the biserial stage giving almost rectangular outline in the transversal sections. Similar in shape and stratigraphic distribution Gaudryina bukoviensis Cushman & Glazewski (1949) from the Nizhniov suite of Ukraine differs in being much larger.
Range. Late Kimmeridgian–Middle Berriasian.
Occurrence. Sections: KA, KB, KF, KG, KK, KL, KN, KR.

Paleogaudryina varsoviensis (Bielecka & Pożaryski, 1954)

1954. Neobulimina varsoviensis n.sp.: Bielecka & Pożaryski, p. 65, pl. 10, fig. 50.
Remarks. Mode of occurrence of the species resembles that of Paleogaudryina magnaraensis Said & Bakarat. It differs in being longer, much slender, having a shorter triserial stage and in more inflated chambers of the biserial part.
Range. Late Oxfordian–Tithonian.
Occurrence. Sections: KA, KC, KD, KE, KG, KL, KO.
Fig. 4.  A – Ammobaculites coprolithiformis (Schwager), (KC 30a); B – Troglotella incrustans Wernli & Fookes, (KA-6a); C – Aaptotoichus challengeri Holbourn & Kaminski, (KE 9a); D – Haghimashella arcuata (Hauesler), (KC 4a); E – Paleogaudyrina magharaensis Said & Bakarat, (KL 5); F – Paleogaudyrina varsoviensis (Bielecka & Pożaryski), (KA 2a); G – Uvigerinammina uvigeriformis (Seibold & Seibold), (KL 6); H – Nautiloculina bronnimanni Arnaud-Vanneau & Peybernès, (KJ 40a); I – Nautiloculina oolithica Mohler, (KF 4a); J, K – Mayncina bulgarica Laugh, Peybernès & Rey, (KJ 12a)
Genus *Verneuilinoides* Loeblich & Tappan, 1949

*Verneuilinoides polonicus* (Cushman & Glazewski, 1949)

Fig. 8B

1949. *Verneulina polonica* n.sp.: Cushman & Glazewski, p. 7, pl. 1, figs 14, 15.


1997. *Verneuilinoides polonicus* (Cushman & Glazewski):

Ecru, p. 313, Fig. 4 (13-19); Fig. 5 (39-49).

Remarks. The subaxial sections show distinct triserial arrangement of the slowly enlarging weakly inflated chambers with characteristic thick walls.

Range. Tithonian–Early Valanginian.

Occurrence. Sections: KD, KF.

Family Reophacellidae Mikhailevich & Kaminski, 2004

Genus *Uvigerinammina* Majzon, 1943

*Uvigerinammina uvigeriniformis* (Seibold & Seibold, 1960)

Fig. 4G

1960. *Gaudryina uvigeriniformis* n.sp.: Seibold & Seibold, p. 334, 335; text-fig. 8b, pl. 7, fig. 4.


Neau & Neau, p. 218, pl. 12, figs 28-43; pl. 6, figs 11-14.


Olszewska, p 34, p. 5, fig. 1.

Remarks. Axial sections show typical for the species sphaerical initial chamber, alternating attachment of chambers and their sack-like shape.

Range. Middle Oxfordian–Early Valanginian.

Occurrence. Sections: KL, KN.

Family Nautiloculinidae Loeblich & Tappan, 1985

Genus *Nautiloculina* Mohler, 1938

*Nautiloculina bronnimanni* Arnaud Vanneau & Peybernés, 1978

Fig. 4H

1978. *Nautiloculina bronnimanni* n.sp.: Arnaud Vanneau & B. Peybernés, p. 70, pl.1, figs 6-8; pl. 2, figs 4-11.


2003. *Nautiloculina bronnimanni* Arnaud-Vanneau & Peybernés: Dragasta & Richter, p. 93, pl. 1, fig. 2: pl. 9, figs 10, 11, 16 n.


Remarks. Axial sections show, typical for the species, slightly acute periphery, 6 whors of semicircular chambers and characteristic projections (septa) over apertural part of the preceding chamber.


Occurrence. Sections: KA, KB, KC, KD, KF, KJ.

*Nautiloculina oolithica* Mohler, 1938

Fig. 4I

1938. *Nautiloculina oolithica* n.sp.: Mohler, p. 19, pl. 4, figs 1-3 (fide Ellis & Messina 1941-2007).

1967. *Nautiloculina oolithica* Mohler: Brönimann, p. 54-61, p. 1, figs 1-6; pl. 2, figs 1-9; pl. 3, figs 1-9; text-figs 1-4.


Remarks. The species differs from *Nautiloculina bronnimanni* in smaller size, larger number of chambers and in much broader periphery. It has also longer stratigraphical distribution.

Range. Late Oxfordian–Barremian.

Occurrence. Sections: KA, KC, KD, KF, KG, KK, KO, KR.

Family Mayncinidae Loeblich & Tappan, 1985

Genus *Mayncina* Neumann, 1965

*Mayncina bulgarica* Laugh, Peybernés & Rey, 1968

Fig. 4J, K


Remarks. Subequatorial sections of the macroospheric specimens show two whors composed of slowly enlarging, rectangular chambers, finely agglutinated walls. Sections of the microspherical specimens show more numerous and narrow chambers and tendency to uncoiling. The subaxial sections show successive openings between chambers and acute periphery.

Range. Tithonian–Barremian.

Occurrence. Sections: KA, KC, KL, KN, KO, KR.

Order Loftusiida Kaminski & Mikhailevich, 2004

Suborder Loftusiina Kaminski & Mikhailevich, 2004

Family Mesoendothyridae Voloshinova, 1958

Genus *Mesoendothyra* Dain, 1958

*Mesoendothyra izjumiana* Dain, 1958

Fig. 5A


Remarks. Axial and subaxial sections show typical, early streptospiral part followed by planispiral late whorl, small number of chambers and a broad external margins.

Range. Late Oxfordian–Tithonian.

Occurrence. Sections: KB, KD, KG.

Genus *Labirynthina* Weynschenk, 1951

*Labirynthina mirabilis* Weynschenk, 1951

Fig. 5B


Fig. 5.  
A – Mesoendothyrza izjumiana Dain, (KD 5); B – Labirynthina mirabilis Weynschenk, (KA 8a); C, D – Everticyclammina praekelleri Redmond (KP 4a); E – Everticyclammina kelleri Henson (KL 10); F – Rectocyclammina chouberti Hottinger (KN 1a); G, H – Charentia evoluta Gorbatchik, (KA 1a); I – Melathrokerion spirialis Gorbatchik (KC 16a); J – Scythiolina camposaurii (Sartoni & Crescenti) (KF 3a); K – Montsalevia salevensis (Charollais, Brönnimann & Zaninetti) (KC 36a)
Family Everticyclamminidae Septfontaine, 1988
Genus *Everticyclammina* Redmond, 1964

*Everticyclammina kelleri* (Henson, 1948).
Fig. 5E

1948. *Everticyclammina praekelleri* n.sp. Henson, p. 16, 17; pl. 9, figs 4, 5, 7 (fide Ellis & Messina, 1941-2007).

1964. *Everticyclammina eccentrica* n.sp.: Redmond, p. 408, pl. 1, figs 16-18; pl. 2, figs 12, 13.

1964. *Everticyclammina elegans* n.sp.: Redmond, p. 408-409, pl. 1, figs 19-21; pl. 2, figs 14-16.

1990. *Everticyclammina kelleri* (Henson): Banner & Hotton, p. 6, pl. 1, figs 2-6; pl. 2, figs 1-4; pl. 3, figs 1, 2.

**Remarks.** In the material studied usually occur, planispirally coiled, early stages of the species followed by one chamber of the uncoiled part. To characteristic features belong two whorls and the non alveolar walls of chambers in the coiled stage.

**Range.** Berriasian–Valanginian.

**Occurrence.** Sections: KD, KE, KK.

Genus *Everticyclammina* Hottinger, 1967

*Rectocyclammina chouberti* Hottinger, 1967

Fig. 5F

1967. *Rectocyclammina praekelleri* n.sp.: Hottinger, p. 55, 56, pl. 9, figs 19-21; text-figs 26, 27.


**Remarks.** Axial sections show the early short planispiral whorl followed by uniserial, rectilinear later part composed of the slowly increasing, overlapping chambers with thick septa. In some sections, characteristic alveoles in chamber walls may be observed.

**Range.** Late Kimmeridgian–Tithonian (?Valanginian).

**Occurrence.** Sections: KB, KE, KF, KL, KN.

Suborder Biokovinina Kaminski, 2004
Family Charentiidae Loeblich & Tappan, 1985
Genus *Charentia* Neumann, 1965

*Charentia evoluta* (Gorbatchik, 1968)
Fig. 5G, H

1968. *Tonasia evoluta* n.sp.: Gorbatchik, p. 8, 9; pl. 2, figs 1-5.

1975. *Charentia evoluta* (Gorbatchik): Kuznetsova & Gorbatchik, p. 82, 83; pl. 3, figs 5, 6.


**Remarks.** Horizontal sections of the early, planispiral part show rectangular chambers subdivided by thin septa. In axial sections (unlike in the genus *Nautiloculina*) the base of chambers lack internal projections. Sections of specimens with uncoiled late part occur rarely.

**Range.** Late Kimmeridgian–Valanginian.

**Occurrence.** Sections: KA, KC, KD, KF, KJ, KK, KN, KR.

Genus *Melathrokerion* Brönnimann & Conrad, 1967

*Melathrokerion spiralis* Gorbatchik, 1968

Fig. 5I

1968. *Melathrokerion spiralis* n.sp.: Gorbatchik, p. 6, 7; pl. 1 figs 1-6.


**Remarks.** Axial sections show typical subacute periphery, streptospiral early whorl, thick septa between chambers (unlike in the genus *Charentia*) and coarse alveolar canaliculi.

**Range.** Tithonian–Valanginian (predominantly on the Carpathian–Crimea area).

**Occurrence.** Sections: KB, KC, KE, KF, KL, KR.

Family Montsaleviidae Zaninetti, Salvini-Bonnard,
Charollais & Decrouez, 1987
Genus *Montsalevia* Zaninetti, Salvini Bonnard, Charollais & Decrouez, 1987

*Montsalevia salevensis* (Charollais, Brönnimann & Zaninetti, 1966)

Fig. 5K

1966. *Pseudotextulariella salevensis* n.sp.: Charollais, Brönnimann & Zaninetti, p. 28-34, pl. 1, figs 1-5; pl. 2, figs 2, 6; text-fig. 1.

Fig. 6. A – *Siphovalvulina variabilis* Septfontaine (KE 11a); B – *Dobrogelina ovidi* Neagu (KC 44a); C – *Amijella antiji* (Henson) (KG 5a); D, E – *Anchispirocyclina lusitanica* (Egger) (KL 11); F – *Pseudocyclammina lituus* (Yokoyama) (KJ 30a); G – *Parargonina caelensis* Cuéllar, Foury & Pignatti Morano (KD 9); H – *Neokilianina rahonensis* (Foury & Vincent) (KD 10); I – *Bigenerina erecta* Dain (KA 14a); J – *Andersenolina alpina* (Leupold) (KA 1a); K – *Andersenolina elongata* (Leupold) (KF 2a); L – *Ichnusella burlini* (Gorbatik) (KB 3a)

Remarks. Oblique section shows successions of low chambers and traces of vertical partitions in the biordinal part. **Range.** Late Berriasian–Hauterivian.

**Occurrence.** Section KC.

Family Cuneolinidae Saidova, 1981

*Scythiolina camposaurii* (Sartoni & Crescenti, 1964) Fig. 5J

1964. *Cuneolina camposaurii* n.sp.: Sartoni & Crescenti, p. 275-277, pl. 24, fig. 1; pl. 48, figs 1-6.


2000. *Scythiolina camposaurii* (Sartoni & Crescenti): Neagu, p. 369, pl. 1, figs 41-44; pl. 2, figs 18-29, pl. 4, figs 50, 54; pl. 7, figs 7-10.

Remarks. Sections parallel to the plane of biseriality show typical for the species flabelliform shape of the test, short early planispiral stage and vertical radial partitions within late chambers. **Range.** Latest Berriasian–Barremian.

**Occurrence.** Section KF.

Suborder Orbitolinina Kaminski 2004

Family Pfenderinidae Smout & Sugden, 1962

*Genus Siphovalvulina* Septfontaine, 1988

*Siphovalvulina variabilis* Septfontaine, 1988 Fig. 6A


Remarks. Longitudinal sections show internal canal parallel to the axis of coiling and the sack-like shape of chambers. **Range.** Middle Jurassic–Tithonian.

**Occurrence.** Sections: KA, KE, KL, KR.

**Genus Dobrogelina** Neagu, 1979

*Dobrogelina ovidi* Neagu, 1979 Fig. 6B

1979. *Dobrogelina ovidi* n.sp.: Neagu, p. 494, pl. 1, figs 1-7; pl. 4, figs 17, 18.


**Occurrence.** Sections: KC, KJ, KL, KN, KR.

**Genus Amijella** Loeblich & Tappan, 1985

*Amijella amiji* (Henson, 1948) Fig. 6C

1948. *Haarmania amiji* n.sp.: Henson, p. 12; pl. 15, figs 5-10.

1967. *Haarmania amiji* Henson: Hottinger, p. 52, pl. 8, figs 1-6, 20-21, text-fig. 2.


1997. *Bramkampella arabica* Redmond: Gorbatchik & Mohamad, pl. 1, figs 8, 9, 11.

Remarks. The subaxial section of typical club-like specimen show a globular initial chamber and slowly enlarging successive chambers with intense subepidermal network of beams and horizontal rafters. Schlaginweit (1991) after the thorough investigation of genera *Amijella* Loeblich & Tappan (1985) and *Bramkampella* Redmond (1964) came to conclusion that they have identical structure thus are synonymous. **Range.** Tithonian–Barremian.

**Occurrence.** Sections: KB, KC, KD, KG, KJ, KK, KL, KN, KP, KR.

**Genus Anchispirocyclina** Jordan & Applin, 1952

*Anchispirocyclina lusitanica* (Egger, 1902) Fig. 6D, E

1902. *Dicyclina lusitanica* n.sp.: Egger, p. 585-586, pl. 6, fig. 3-5 (vide Ellis & Messina 1941-2007).

1971. *Anchispirocyclina lusitanica* (Egger): Ramalho, p. 148-149, pl. 8, fig. 2; pl. 10, fig. 1; pl. 15, figs 4-9; pl. 16, figs 1-2.

1997. *Anchispirocyclina lusitanica* (Egger): Darga & Schlaginweit, p. 213, pl. 2, fig. 2; pl. 4, figs 2, 3.


Remarks. The axial section (D) shows a slightly asymmetrical coiled early part followed by planispiral later part with many chambers (E) irregularly subdivided by beams and rafters. **Range.** Tithonian–earliest Berriasian.

**Occurrence.** Sections: KB, KJ, KK, KL, KN, KO.

**Genus Pseudocyathammina** Yabe & Hanzawa, 1926

*Pseudocyathammina litus* (Yokoyama, 1890) Fig. 6F

1890. *Cyclammina litus* n.sp.: Yokoyama, p. 26, pl. 5, fig. 7.


Remarks. Axial sections show a planispiral early stage, coarsely
agglutinated walls and typical coarse subepidermal network. Uncoiled specimens rarely occur.

**Range.** Oxfordian–Berriasian.

**Occurrence.** Sections: KA, KC, KF, KK, KL, KR.

Family Paragurinidae Septfontaine, 1988

Genus *Paragurina* Cuvillier, Fourny & Pignatti Morano, 1968

Fig. 6G


1975. *Paragurina* *caelensis* Cuvillier, Fourny & Pignatti Morano: Schroeder, Guellal & Villa, p. 319-326, pl. 1, figs 1-4; p. 2, figs 3-5.


**Remarks.** Subaxial sections show a large globular initial chamber with successive chambers added in trochospiral coil what results in a cone-like shape of the test. In transversal section vertical pilars in the central part of the test are also visible.

**Range.** Latest Oxfordian–Early Tithonian, mostly Kimmeridgian.

**Occurrence.** Sections: KA, KC, KR.

Order Textulariidae Delage & Herouard, 1896

Suborder Textulariina Delage & Herouard, 1896

Family Textulariidae Ehrenberg, 1838

Genus *Bigenerina* d’Orbigny, 1826

*Bigenerina erecta* Dain, 1976

Fig. 6I

1976. *Bigenerina erecta* n.sp.: Dain in Dain & Kuznetsova, p. 54-55, pl. 7, fig. 4.

**Remarks.** Longitudinal sections show the early, wedge-shaped biserial part and the directly adjacent uniserial, rectilinear late stage.

**Range.** Tithonian.

**Occurrence.** Section KA.

Family Paravalvulinidae Banner, Simmons & Whittaker, 1991

Genus *Neokilianina* Septfontaine, 1988

*Neokilianina rahonensis* (Fourny & Vincent, 1967)

Fig. 6H


1988. *Neokilianina rahonensis* (Fourny & Vincent); Septfontaine, p. 249.


**Remarks.** According to Septfontaine (1988), genera *Neokilianina* and *Paragurina* are morphologically related, the former being an older homeomorph. Longitudinal-oblique section of the poorly preserved specimens shows conical shape of the test with visible chambers of the rectilinear part alternating in position and subdivided into chamberlets.

**Range.** Kimmeridgian–earliest Tithonian.

**Occurrence.** Sections: KA, KD.

Suborder Involutinina Hohenegger & Piller, 1977

Family Involutinidae Bütschli, 1880

Genus *Andersenolina* Neagu, 1994

*Andersenolina alpina* (Leupold, 1936)

Fig. 6J

1936. *Coscinodiscus alpinus* n.sp.: Leupold, p. 610, pl. 18, figs 1-8 (fide Ellis & Messina, 1941-2007).


1994. *Andersenolina alpina* (Leupold): Neagu, p. 133, text-fig. 4, figs 3, 4; pl. 7, figs 8, 9; pl. 8, figs 1-10; pl. 12, figs 1-5.


**Remarks.** Longitudinal sections show a small cone with the apical angle of 80–95° and 4 to 5 whorls of low, crescentic chambers typical for the species.

**Range.** Tithonian–Early Valanginian.

**Occurrence.** Sections: KA, KB, KC, KD, KE,KF, KK, KL, KN, KR.

*Andersenolina elongata* (Leupold, 1936)

Fig. 6K

1936. *Coscinodiscus elongatus* n.sp.: Leupold, p. 617, pl. 8, figs 12-14 (fide Ellis & Messina, 1941-2007).


1994. *Andersenolina elongata* (Leupold): Neagu, p. 130, text-fig. 3, fig. 7; pl. 4, figs 1-22; pl. 6, figs 12-14; pl. 12, figs 13-17.


**Remarks.** Longitudinal sections show a long, slender shape of the species composed of over 7 whorls of low chambers and a sharp apical cone of 22°–30°.

**Range.** Tithonian–Early Valanginian.

**Occurrence.** Sections: KB,KF, KK, KN.

Genus *Ichnusella* Dieni & Massari, 1966

*Ichnusella burlini* (Gorbatchik, 1959)

Fig. 6L

1959. *Trocholina burlini* n.sp.: Gorbatchik, p. 81, pl. 4, figs 3-5.


**Remarks.** Characteristic for the species is a low cone of 100–115° and 4–5 whorls of the low chambers. In the longitudinal or transverse sections of the well preserved specimens close to the umbilical side the calcite crystals are visible.
FORAMINIFERA FROM THE LATE JURASSIC AND EARLY CRETACEOUS, UKRAINE

Protopeneroplis striata (Gorbatchik, 1950)
Fig. 7A

1959. *Trocholina molesta* n.sp.: Gorbatchik, pl 4 figs 1, 2.
1995. *Neotrocholina burgeri molesta* (Grobachot): Neagu, p.16-19; pl. 1, figs 13-16, 21, 22, 25, 26; pl. 7, fig. 62-67, 70, 71; pl. 9, figs 1-9; pl. 13, fig. 13, 25, 26.

Remarks. Test moderately conical with an apical angle of 90–120° and 4 to 6 whorls of the low, crescentic chambers.

Range. Tithonian–Barremian.

Occurrence. Sections: KC, KE, KN, KO.

Fam. Ventrolaminidae Weynschenk, 1950
Genus *Protopeneroplis* Weynschenk, 1950

*Protopeneroplis striata* Weynschenk, 1950
Fig. 8D, E


Remarks. The axial sections show fully planispiral mode of coiling of the species. Axial, subaxial or transversal sections show characteristic two layered chamber walls ("striae"). The internal layer is built of calcite crystals (light in transmitted light) while the external layer is built of microgranular calcite (dark in transmitted light).

Range. Middle-Late Jurassic (up to Tithonian).

Occurrence. Sections: KA, KB, KC, KF.

*Protopeneroplis ultragranulata* (Gorbatchik, 1971)
Fig. 7C

1971. *Hoeoglinda (?) ultragranulata* n.sp.: Gorbatchik, p. 135, pl. 26, fig. 2.
2004. *Protopeneroplis ultragranulata* (Gorbatchik): Ivanova & Kolodziej, pl. 1, fig. C.

Remarks. Characteristic for the species is trochospiral mode of coiling, lack of the microgranular "striae" and the thickened (often recrystallised) hyaline walls of the test.

Range. Middle Late Tithonian–Valanginian.

Occurrence. Sections: KA, KC, KD, KE, KJ, KK, KL, KN, KR.

Suborder Miliolina Delage & Herouard, 1875
Family Cornuspiridae Schulze, 1854
Genus *Meandrospira* Loeblich & Tappan, 1946
*Meandrospira favrei* Charollais, Brönnimann & Zaninetti, 1966
Fig. 7B

1966. *Citaella? favrei* n.sp.: Charollais, Brönnimann & Zaninetti, p. 37-47, pl. 2, figs 3, 4; pl. 3, figs 1-5; pl. 5, figs 1, 2; text-figs 4-6.
2004. *Meandrospira favrei* (Charollais, Brönnimann & Zaninetti): Ivanova & Kolodziej, pl.1, figs L, M.

Remarks. Loeblich & Tappan (1988) included genus *Citaella* into the genus *Meandrospira*. Examined specimens in various sections reveal subsphaerical small initial chamber and typically streptospiral undivided tubular, microgranular, second chamber.

Range. Latest Berriasian–Hauterivian.

Occurrence. Sections: KD, KE,KF, KG, KO.

Family Hauerinidae Schwager, 1876
Genus *Decussoloculina* Neagu, 1984

*Decussoloculina barbui* Neagu, 1984
Fig. 7D

1984. *Decussoloculina barbui* n.sp.: Neagu, p. 81, 82; pl. 2, figs 8-12.
2003. *Decussoloculina barbui* Neagu: Dragastan & Richter, p. 93, pl. 9, fig. 15.

Remarks. Transversal sections show “X” shaped arrangement of four chambers in one whorl what results in somewhat irregular outline of the test.

Range. Middle Tithonian–Valanginian.

Occurrence. Sections: KA, KC, KD, KL, KO.

Genus *Quinqueloculina* d’Orbigny, 1826

*Quinqueloculina semisphaeroidalis* Danitch, 1971
Fig. 7H


Remarks. Transversal sections show almost circular outline of the test and a “Y” mode arrangement of chambers and relatively thick walls.

Range. Late Oxfordian–Tithonian.

Occurrence. Sections: KA, KE, KG, KK, KL, KO.
Quinqueloculina stellata Matsieva & Temirbekova, 1989

Fig. 7F

1989. *Quinqueloculina stellata* n.sp.: Matsieva & Temirbekova, p. 115, pl. 1, figs d, z, e.

**Remarks.** Transversal sections show “Y” mode of chamber arrangement and double projections at outer walls of chambers of the last whorl that mark ribs running along the test.

**Range.** Tithonian–Early Berriasian.

**Occurrence.** Sections: KB, KC, KE, KF, KR.

Genus *Rumanoloculina* Neagu, 1986

Fig. 7E


1989. *Quinqueloculina mitchurini* Dain: Matsieva & Temirbekova, p. 115, pl. 1, figs a–g.

**Remarks.** Transversal section shows “Y” mode of chamber ar-

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**Fig. 7.** A – *Neotrocholina molesta* (Gorbatchik) (KC 25a); B – *Meandrospra favrei* (Charollais, Brönnimann & Zaninetti) (KO 3a); C – *Protopenepropolis utragranulata* (Gorbatchik) (KC 4a); D – *Decussoloculina barbui* Neagu (KC 41a); E – *Rumanoloculina mitchurini* (Dain) (KA 5a); F – *Quinqueloculina stellata* Matsieva & Temirbekova (KR 13a); G – *Scythloculina confusa* Neagu (KB 17a); H – *Quinqueloculina semisphaeroidalis* Danitsch (KB 28a); I, J – *Rumanoloculina verbizhenum* (Dulub) (KB 30a)
rangement and triangular but rounded outline of the test. Similar features of the transversal section display *Quinqueloculina jurassica* Bielecka & Styk from the Late Oxfordian–Early Kimmeridgian of Poland and *Quinqueloculina podubienensis* Tereshuk from the Kimmeridgian–Tithonian sediments of the Western Ukraine. The authors of both above mentioned species relate them to the *Quinqueloculina* sp. A and *Quinqueloculina* sp. B reported by Cushman & Glazewski (1949) from the Tithonian Nizhniy limestone of the Western Ukraine. More detailed investigations are necessary to solve the problem.

**Range.** Tithonian–Berriasian.

**Occurrence.** Sections: KA, KB, KC, KD, KE, KJ, KK, KN, KO, KR.

*Rumanoloculina verbizhiensis* (Dulub, 1964)

Fig. 7I, J


1989. *Quinqueloculina verbizhiensis* Dulub: Matsieva & Temirbekova, p. 115, 117, pl. 1, figs z, c, k.

**Remarks.** Transversal section shows a quinqueloculine chamber arrangement and oval outline of the test. Axial sections show three sets of chambers making the whole test.

**Range.** Kimmeridgian–Tithonian.

**Occurrence.** Sections: KA, KB, KE, KF, KG.

Genus *Scythiloculina* Neagu, 1984

*Scythiloculina confusa* Neagu, 1984.

Fig. 7G

1984a. *Scythiloculina confusa* n.sp.: Neagu, pl. 1, figs 1-8, 16.


**Remarks.** Transversal section show “Y” type of chamber arrangement in numerous whorls which makes outline of the test almost circular.

**Range.** Late Berriasian–Valanginian.

**Occurrence.** Sections: KB, KN, KR.

Suborder Rotaliina Delage & Herouard, 1896

Family Discorbidae Ehrenberg, 1838

Genus *Mohlerina* Bucur, Senowbari-Daryan & Abate, 1996

*Mohlerina basiliensis* (Mohler, 1938)

Fig. 8A

1938. *Conicospirillina basiliensis* n.sp.: Mohler, p. 27, pl. 27, 28; pl. 4, fig. 5.

1984. “*Conicospirillina*” *basiliensis* Mohler: Bernier, p. 525-526, pl. 21, fig. 3.


**Remarks.** Diversely oriented sections show typical for the species trochospiral mode of coiling and a two layered walls: inner-dark and microgranular, outer-clear, hyaline.

**Range.** Oxfordian–Valanginian.

**Occurrence.** Sections: KA, KB, KC, KD, KE, KJ, KK, KL, KN, KR.

Suborder Globigerinina Delage & Herouard, 1896

Family Globuligerinidae Loeblich & Tappan, 1884

Genus *Globuligerina* Bignot & Guyader, 1971

*Globuligerina terquemi* (Iovcheva & Trifonova 1961)

Fig. 8C


**Remarks.** Horizontal sections of this small species show characteristic loose arrangement of chambers of the last whorl, while the axial sections reveal two whorls of chambers arranged in a low spire. Forms mentioned by Kuznetsova (In: Kuznetsova & Uspenskaya, 1980) as *Globuligerina exgraterquemi* (Iovcheva & Trifonova) and later described as *Globuligerina parva* n.sp. (In: Kuznetsova & Gorbatchik, 1985) from the Early Kimmeridgian of Crimea probably belong to the species.

**Range.** Kimmeridgian–Tithonian.

**Occurrence.** Section KP.

**CALCAREOUS DINOCYSTS**

(systematics after Rehánek & Cecca, 1993)

Order Peridiniales Haeckel, 1894

Family Calcidinellaceae Deflandre, 1947 emend. Bujak & Davies, 1983

Genus *Comittosphaera* Rehánek, 1985

*Comittosphaera sublapidosa* (Vogler, 1941)

Fig. 8F

1941. *Cadosina sublapidosa* n.sp.: Vogler, p. 280, pl. 2, fig. 5.


**Remarks.** Spherical cyst with a two layered wall. The inner layer of variable thickness is composed of the microcrystalline calcite. The outer layer, vitreous in transmitted light is composed of the irregular, fine calcite crystals.

**Range.** Tithonian–Hauterivian.

**Occurrence.** Section KP.

Genus *Cadosina* Wanner, 1940

*Cadosina parvula* Nagy, 1966

Fig. 8G

1966. *Cadosina parvula* n.sp.: Nagy, p. 93, pl. 5, fig. 17.

1993. *Cadosina parvula* Nagy: Rehánek & Cecca, p. 155, pl. 1, fig. 12, text-fig. 6A.

**Remarks.** Spherical cyst with a one layered wall composed of microcrystalline calcite. Differs from *Cadosina fusca* Wanner in smaller size and optimal distribution in the Late Oxfordian–Kimmeridgian.

**Range.** Late Oxfordian–Tithonian.

**Occurrence.** Section KB
Fig. 8. A – Mohlerina basiliensis (Mohler) (KC 14a); B – Verneulinoides polonicus (Cushman & Glazewski) (KD 3); C – Globaligerina terquemi (Iovcheva & Trifonova) (KP 5a); D, E – Protopeneroplis striata Weynschenk (KB 2a); F – Comitosphaera sublapidosa (Vogler) (KP 4a); G – Cadosina parvula Nagy (KB 14a); H – Crustocadosina semiradiata (Wanner) (KL 1)
<table>
<thead>
<tr>
<th>Foraminifera (sample)</th>
<th>Callovian</th>
<th>Oxfordian</th>
<th>Kimmeridgian</th>
<th>Tithonian</th>
<th>Berriasian</th>
<th>Valanginian</th>
<th>Hauterivian</th>
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<tr>
<td><strong>Remarks.</strong> Spherical to oval cyst with two layered walls. The inner dark, microgranular layer has thickness equal to larger than the thickness of the outer, white, radial layer.</td>
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<td><strong>Range.</strong> Late Oxfordian–Early Albion.</td>
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<td><strong>Occurrence.</strong> Section KL.</td>
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**REMARKS ON STRATIGRAPHY**

Foraminiferal assemblages from the Aj-Petri and Yalta Yaila contain many species of small and large foraminifera of the recognised stratigraphical value for Jurassic carbonate sediments (Fig. 9). Among the large forms, *Labirynthina mirabilis* Weynschenk, *Paragonina caelensis* Cuvillier, Foury & Pignatti Morano and *Neokilianina rahonensis* (Foury & Vincent) are known predominantly from the Kimmeridgian of the Mediterranean Tethys (Bassoullet, 1997). In the same area species *Anchispirocyclina lusitanica* (Egger) characterises the Tithonian strata (Bassoullet, 1997; Darga & Schlagintweit, 1991). In the Central and NW Crimea *Anchispirocyclina lusitanica* (Egger) is present in both Tithonian and Berriasian strata (Voloshina, 1977; Gorbatich & Mohamad, 1997; Zhabina, 1989). Interesting is the persistent presence in the material studied the long lasting (Liasic–Berriasian) *Amijella amiji* (Henson) common in Tithonian strata of the Alpino-Crimean segment of the Tethys (Voloshina, 1977; Schlagintweit, 1991; authors’ observations). The species also constitutes an index taxon for the lower Berriasian “beds with Bramkampella” reported by Gorbatchik and Mohamad (1997) from the Crimea.

In the upper part of the Tithonian species *Protopeneroplis ultragranulata* (Gorbatchik) makes its first appearance; being frequently used as an index taxon for the Early Berriasian of the northern margin of the Tethys (Azema et al., 1977; Bassoulet & Fourcade, 1979; Kuznetsova & Gorba-
tchik, 1985; Sotak in Vašček et al., 1994; Gorbatchik & Mohamad, 1997). The Early Cretaceous age of the topmost part of the investigated profiles is also suggested by the appearance of such species, as: *Everticyclammina kelleri* (Henson), *Nautiloculina bronnimanni* Arnaud-Vanneau & Peybernés, *Montsalevia salevensis* (Charollais, Brönnimann & Zaninetti) or *Scythiolina camposaurii* (Sartoni & Crescenti), and *Mayncina bulgarica* Laug, Peybernés & Rey.

Palaeoenvironmetal, rather than stratigraphic, significance have the occurrence of abundant “trocholinas” and miliolids in Tithonian part of the Aj-Petri carbonates and Yalta Yaila. Development of both groups (known also from the Alpino-Carpathian realm and Moesian Platform) may be attributed to seasonal variations of sea level during the stage.

To sum up, one may conclude that stratigraphic ranges of characteristic species of foraminifera (cf. Fig. 9) identified in the investigated samples suggest the Kimmridgian to Berriasian age for the Aj-Petri and Yalta Yaila carbonates.

Correlation of the thin-plate assemblages obtained from the indurated carbonates with those from the water-processed soft sediments of the same region (vide Kuznetsova & Gorbatchik, 1985) is somewhat difficult. The latter do not reflect neither spatial nor temporal original distribution of taxons in the rock. They also reflect different sedimentary regime.

**REMARKS ON PALAEOENVIRONMENT AND PALAEOBIOGEOGRAPHY OF FORAMINIFERA**

Flügel in his fundamental work (Flügel, 2004, p. 660) states that “carbonate platforms are dynamic systems that change through time and space”. The rightness of the statement is confirmed also by changes in foraminiferal assemblages of the investigated area. The Kimmridgian–Tithonian assemblages are predominantly made of the internal platform genera such as: *Pseudocyclammina*, *Everticyclammina*, *Rectocyclammina*, *Parurgonina*, *Anchispirocyclina*, *Amijella* or *Neokilianina*, and *Miliolidae* (Septfontaine, 1980; Pélissié, Peybernés & Rey, 1984). The Early Cretaceous assemblages contain more outer platform elements, such as “trocholinas”, and genera: *Mohlerina*, *Protopeneroplis*, *Charentia*, *Montsalevia* (Chiocciini et al., 1988).

Known palaeogeographic occurrences of many of Aj-Petri and Yalta Yaila foraminifera indicate that they belong to cosmopolitan forms connected predominantly with the north Tethyan shelves during the end of Jurassic and the early Cretaceous (Pélissié et al., 1982; Bassoulet et al., 1985; Arnaud-Vanneau, 1986). The authors thank the reviewers J. Smoleń (PIG Warsaw) and J. Tyszka (ING PAN Kraków) for theirs suggestions; B. M. Romanyuk (Liv National University), M.A. Rogov (Geological Institute of RAS, Moscow), V. V. Yudin (Ukr. Min. Resources State Inst. Simféropol) and J. Matyszkiewicz (AGH, Kraków) for help in literature collection and discussions. This research was financed by the AGH grants no. 10.10.140.463 and 11.11.140.560.

**REFERENCES**


