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 forty are described herein. Many foraminiferal species (e.g., Labrinthina mirabilis, Parurgonina caelimensis, Neokilianina rahonensis, Amijella amiji, Anchispirocyclina lusitanica) are stratigraphically significant and known from the Kimmeridgian-Tithonian of the Mediterranean Tethys. The Early Cretaceous fauna is represented by Protopeneroplis ultragranulata, Everticyclammina kelleri, 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. Micropalaeontological studies of thin sections were rare (Voloshina 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 Peninsula 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, oncoidal, 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-Baś 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 Yaila 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 orthostratigraphic scheme based on ammonites, foraminifers are ubiquitous in the studied sediments, unlike ammonites.

**Fig. 2.** General stratigraphy of the Crimea Mountains after Mileev et al., 2006; modified

Furthermore, due to complicated tectonics in some areas, the strata are disturbed (Mileev & Baraboshkin, 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 (Pseudocyclus, Everticyclus, Rectocyclus, Rectocyclus,
Fig. 3. The southern escarpment of the Yalta and Aj-Petri Yaila with location of the samples presented in Figs 4–9
Amijella, Labirynthina). The Tithonian–Berriassian 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 dinoflagellates. Three characteristic species of these groups have been also described.

FORAMINIFERA


Class Foraminifera d'Orbigny, 1849
Order Lituolida Lanneker, 1885
Suborder Lituolina Lanneker, 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 coprolithiformis Schwager: Winter, p. 8, pl. 1, figs 1-21, text-fig. 6.

Remarks. Longitudinal sections show a tightly coiled, planispiral early part and a short rectilinear, uncoiled adult part.

Range. Oxfordian–Kimmeridgian.

Occurrence. Section KC.

Genus Troglotella Wernli & Fookes, 1992

Troglotella incruxtans Wernli & Fookes, 1992

1996. Troglotella incruxtans Wernli & Fookes: Bucur, Senowbari-Daryan & Abate, p. 69, pl. 2, fig. 3; pl. 5, figs 6, 9, 10.
1999. Troglotella incruxtans 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, KN, 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

Fig. 4 D

1890. Bigenerina arcuata n.sp.: Haeusler, p. 73. (fide Ellis & Messina, 1941-2007).

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.

Pseudogaudryina magharaensis Said & Bakarat, 1958

Pseudogaudryina magharaensis Said & Bakarat (1958)

Fig. 4 E

1958. Pseudogaudryina magharaensis 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 Pseudogaudryina varsovis (Bielecka & Pozaryski, 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 bukowiensi Cushman & Glazewski (1949) from the Nizhniov suite of Ukraine differs in being much larger.

Range. Late Kimmeridgian–Middle Berriasian.

Occurrence. Sections: KA, KB, KG, KK, KN, KR.

Paleogaudryina varsovis (Bielecka & Pozaryski, 1954)

Fig. 4 F

1954. Neobulimina varsovis n.sp.: Bielecka & Pozaryski, p. 65, pl. 10, fig. 50.

Remarks. Mode of occurrence of the species resembles that of Paleogaudryina magharaensis 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 challenger Holbourn & Kaminski, (KE 9a); D – Haghimashella arcuata (Haeusler), (KC 4a); E – Paleogaudryina magharaensis Said & Bakarat, (KL 5); F – Paleogaudryina varsoviensis (Bielecka & Pożaryski), (KA 2a); G – Uvigerinammina uvigeriniformis (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. 8 B]

1949. *Verneulina polonica* n.sp.: Cushman & Glazewski, p. 7, pl. 1, figs 14, 15.
1997. *Verneuilinoides* polonicus (Cushman & Glazewski): Neagu, 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–Barremian.

**Occurrence.** Sections: KA, KB, KD, KG, KK, KO, KR.

1964. *Nautiloculina oolithica* Mohler: Brönnimann, p. 54-61, 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–Berriasian.

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

Family *Reophacellidae* Mikhailievich & Kaminski, 2004

Genus *Nautiloculina* Mohler, 1938

*Nautiloculina broonnimanni* Arnaud Vanneau & Peybernès, 1978  
[Fig. 4H]

1978. *Nautiloculina bronnimanni* n.sp.: Arnaud Vanneau & B. Peybernès, p. 70, pl. 1, figs 6-8; pl. 2, figs 4-11.
2003. *Nautiloculina broonnimanni* Arnaud-Vanneau & Peybernès: Dragastan & 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 whorls of semicircular chambers and characteristic projections (septa) over apertural part of the preceding chamber.

**Range.** Berriasian–Hauterivian.

**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: Brönnimann, 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 shows two whorls composed of slowly enlarging, rectangular chambers, finely agglutinated walls. Sections of the macroscopic specimens show more numerous and narrow chambers and tendency to uncoiling. The subaxial sections show successive openings between chambers and acute periphery.

**Range.** Middle Oxfordian–Early Valanginian.

**Occurrence.** Sections: KL, KN.

Family *Mayncinidae* Loeblich & Tappan, 1985

Genus *Mayncina* Neumann, 1965

*Mayncina bulgarica* Laugh, Peybernès & Rey, 1968  
[Fig. 4 J, K]

1968. *Mayncina bulgarica* n.sp.: Laugh, Peybernès & Rey, p. 68-76; fig. 3, 1-16.
1991. *Mayncina* sp.: Altiner, pl. 12, figs 1, 2.

**Remarks.** Subequatorial sections of the macroscopic specimens show two whorls composed of slowly enlarging, rectangular chambers, finely agglutinated walls. Sections of the macroscopic 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, KF, KG, KK, KO, KR.

Order *Loftusiida* Kaminski & Mikhailievich, 2004

Suborder *Loftusiina* Kaminski & Mikhailievich, 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 – Mesoendothyrā izjumiana Dain, (KD 5); B – Labirynthina mirabilis Weynschenk, (KA 8a); C, D – Everticyclammina praekelleri Redmond (KP 4a); E – Everticyclammina kelleri Henson (KL 10); F – Rectocyelammina 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)
microgranular walls are also visible.

Recriiinear late stage. Internal pillars within chambers and their non alveolar walls of chambers in the coiled stage.

Remarks. Longitudinal sections show an early involute stage (with characteristic large initial chamber) followed by an evolute, rectilinear late stage. Internal pillars within chambers and their microgranular walls are also visible.

Range. Latest Oxfordian–Early Tithonian.

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

2006. Rectocyclammina chouberti Hottinger: Ivanova & Koleva-Rekalova, pl. 1, fig. 1.

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.
2005. Charentia evoluta (Gorbatchik): Olszewska, pl. 35, pl. IV, figs 7, 8.

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, KE, 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.
1985. Melathrokerion spiralis Gorbatchik: Kuznetsova & Gorbatchik, p. 81, pl. 3, fig. 4.

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 Montsalevidae 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.

Family Everticyclamminidae Septfontaine, 1988
Genus Everticyclammina Redmond, 1964

Everticyclammina kelleri (Henson, 1948).

Fig. 5E

1948. Pseudocyyclammina kelleri 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 & Highton, 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: KA, KB, KC, KG.

Everticyclammina praekelleri Banner & Highton, 1990

Fig. 5C, D

1990. Everticyclammina praekelleri n.sp.: Banner & Highton, p. 8-10, pl. 1, fig. 1; pl. 3, fig. 5; pl. 4, figs 1-11.

Remarks. The species is characterized by thick chamber walls of irregular thickness, irregular shape of chambers and distinct alveoles even in the early part. It differs from Everticyclammina virgiliana (Koechlin) in having thicker walls, irregular shape of chambers and a smaller number of chambers per whorl.


Occurrence. Sections: KA, KB, KC, KD, KE, KF, KG, KJ, KL, KN, KO, KP, KR.

Genus Rectocyclammina, Hottinger, 1967

Rectocyclammina chouberti Hottinger, 1967

Fig. 5F

1967. Rectocyclammina chouberti n.sp.: Hottinger, p. 55, 56, pl. 9, figs 19-21; text-figs 26, 27.
1984. Rectocyclammina chouberti Hottinger: Bernier, p. 513-514, pl. 20, fig. 3.
Fig. 6. A – Siphovalvulina variabilis Septfontaine (KE 11a); B – Dobrogelina ovidi Neagu (KC 44a); C – Amijella amiji (Henson) (KG 5a); D, E – Anchispirocyclina lusitanica (Egger) (KL 11); F – Pseudocyclammina litus (Yokoyama) (KJ 30a); G – Parargonina caelinensis Cuvillier, 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 (Gorbatchik) (KB 3a)


Remarks. Oblique section shows succession of low chambers and traces of vertical partitions in the biserial part.

Range. Late Berriasian–Hauterivian.

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

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

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


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. Schlaginweitz (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.

1984. *Pseudocyclammina* Yabe & Hanzawa, 1926

**Pseudocyclammina lituus** (Yokoyama, 1890)

Fig. 6F

1989. *Cyclammina lituus* n. sp.: Yokoyama, p. 26, pl. 5, fig. 7.

1984. *Pseudocyclammina* Yabe & Hanzawa, 1926

**Pseudocyclammina lituus** (Yokoyama): Bernier, p. 513, pl. 19, figs 5, 6.


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

**Remarks.** According to Septfontaine (1988), genera *Neokilianina* and *Parurgonina* 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, KN, KR.

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**Suborder Involutinina Hohenegger & Piller, 1977**

**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, KJ, 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, 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, KN, KK.

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.

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**Order Textulariidae Delage & Herouard, 1896**

**Suborder Textulariina Delage & Herouard, 1896**

**Family Textulariidae Ehrenberg, 1838**

**Genus** *Kilianina* Cuvillier, Foury & Pignatti, 1968

*Kilianina rahonensis* (Foury & Vincent, 1967)

**Fig. 6H**


**Remarks.** Sections: KA, KC, KK, KL, KR.

**Range.** Oxfordian–Berriasian.

**Occurrence.** Sections: KA, KC, KF, KJ, KK, KL, KR.
Range. Tithonian–Valanginian.

Occurrence. Sections: KB, KO.

Genus Neotrocholina Reichel, 1956 emended Neagu, 1995

Neotrocholina molesta (Gorbatchik, 1959)

Fig. 7A

1959. Trocholina molesta n.sp.: Gorbatchik, pl 4 figs 1, 2.
1995. Neotrocholina burgeri molesta (Gorbatchik): 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.
1998. Trocholina molesta (Gorbatchik): Ebli & Schlagintweit, p. 15, pl. 2, fig. 3.

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: KE, NK, KO.

Family Ventrolaminidae Weynschenk, 1950

Genus Protopenopleris Weynschenk, 1950

Protopenopleris 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, KE.

Protopenopleris ultra granulata (Gorbatchik, 1971)

Fig. 7C

1971. Hoeoglurina (?) ultra granulata n.sp.: Gorbatchik, p. 135, pl. 26, fig. 2.
1999. Protopenopleris ultra granulata (Gorbatchik): Schlagintweit & Ebli, p. 420-423, pl. 6, figs 5, 6, 9.
2004. Protopenopleris ultra granulata (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 Tithonian–Valanginian.

Occurrence. Sections: KB, KE, KK, KO, KR.

Suborder Mioliolina 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 subphaerical small initial chamber and typically streptospiral undivided tubular, microgranular, second chamber.

Range. Latest Berriasian–Hauterivian.

Occurrence. Sections: KE, KF, KG.

Family Hauserinidae 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.
Fig. 7.  

A – Neotrocholina molesta (Gorbatchik) (KC 25a); B – Meandrospira favrei (Charollais, Brönnimann & Zaninetti) (KO 3a); C – Protopenepolpis utragranulata (Gorbatchik) (KC 4a); D – Decussoculina barbui Neagu (KC 41a); E – Rumanoloculina mitchurini (Dain) (KA 5a); F – Quinqueloculina stellata Matsieva & Temirbekova (KR 13a); G – Scythiloculina confusa Neagu (KB 17a); H – Quinqueloculina semisphaeroidalis Danitsch (KB 28a); I, J – Rumanoloculina verbizhiensis (Dulub) (KB 30a)

**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

**Rumanoloculina mitchurini** (Dain, 1971)  
Fig. 7E


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

**Remarks.** Transversal section shows “Y” mode of chamber ar-
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 podlubienensis* 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 Nizhniov 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, KB, 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 what 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.

1991. **“Conicospirillina” basiliensis** Mohler: Altner, pl. 3, figs 8, 9.


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

**Range.** Oxfordian–Valanginian.

**Occurrence.** Sections: KA, KB, KC, KD, KE, KJ, KK, KN, KO, 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 exerginata* (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 Peridiniiales Haecckl, 1894


Genus *Comittosphaera* Rehánek, 1985

*Comittosphaera sublapidosa* (Vogler, 1941)

Fig. 8F

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


2005. *Comittosphaera sublapidosa* (Vogler): Olszewska, p. 31, pl. 3, fig. 7

**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 – Verneuilinoides polonicus (Cushman & Glazewski) (KD 3);  
C – Globuligerina terquemi (Iovcheva & Trifonova) (KP 5a);  
D, E – Protopeneroplis striata Weynschenk (KB 2a);  
F – Comittosphaera sublapidosa (Vogler) (KP 4a);  
G – Cadosina parvula Nagy (KB 14a);  
H – Crustocadosina semiradiata (Wanner) (KL 1)
### Foraminifera (sample)

<table>
<thead>
<tr>
<th>Genus</th>
<th>Species Name (Reference)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crustocadosina</td>
<td>semiradiata (Wanner, 1940)</td>
</tr>
</tbody>
</table>

#### 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, *Parurgonina caelimensis* Cuvillier, Foury & Pignatti Morano and *Neokilianina rahonensis* (Foury & Vincent) are known predominantly from the Kimmeridgian of the Mediterranean Tethys (Bassoulet, 1997). In the same area species *Anchispirocyclina lusitanica* (Egger) characterises the Tithonian strata (Bassoulet, 1997; Darga & Schlagintweit, 1991). In the Central and NW Crimea *Anchispirocyclina lusitanica* (Egger) is present in both Tithonian and Berriasian strata (Voloshina, 1977; Gorbatchik & Mohamad, 1997; Zhabina, 1989). Interesting is the persistent presence in the material studied the long lasting (Liassic-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 & Gorbatich, 1997).
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 Kimmeridgian–Tithonian assemblages are predominately made of the internal platform genera such as: *Pseudocyclammina, Evertycyclammina, Rectocyclammina, Parargonina, Anchispiracyclina, Amijella or Neokiliamina*, and *Miliolidae* (Septfontaine, 1980; Pélissié, Peybernès & Rey, 1984). The Early Cretaceous assemblages contain more outer platform elements, such as “trocholinas”, and genera: *Mohlerina, Protopeneproplis, Charentia, Montsalevia* (Chioccini 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).

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