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Bivalvia and Stratigraphy of the Lower and Middle Berriasian of the Crimea

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Abstract—The work contains systematic descriptions of 72 species of bivalves from the Lower and Middle Berriasian deposits of Crimea, including 12 new species. The history of their study is briefly outlined, the known species from this region are revised, facies associations of mollusks are analyzed, and data on the stratigraphic and geographical distribution of the studied species are summarized. Eleven type sections, including five new ones, are described. In one section, the Upper Tithonian–Lower Berriasian boundary beds are recognized.

Keywords: bivalves, systematic description, stratigraphic and geographical distribution, stratigraphy, Lower Cretaceous, Lower Berriasian, Middle Berriasian, Crimea

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CONTENTS

† Deceased.

INTRODUCTION

Bivalves are a taxonomically diverse and widespread group of marine organisms in the Lower and Middle Berriasian of the Crimea. They are found in all studied sections, represented by various types of facies. To date, 80 species have been identified from the deposits of the Lower and Middle Berriasian of this region. Of these, 72 are described in this work, including 12 new species. The assemblage includes representatives of almost all families known in coeval deposits of the Alpine subregion of the Mediterranean paleozoogeographic region. Moreover, an earlier occurrence in the Crimea of many species described in Western Europe from younger deposits was established, which suggests westward migration of many species in the Berriasian from their Crimean center of origin.

At present, Crimean Berriasian bivalves are stratigraphically studied relatively better than their coeval assemblages in Western Europe described in classical works (d'Orbigny, 1843–1847; Pictet and Campiche, 1864–1871, etc.). In all Crimean sections, for each species, its zonal stratigraphic position is indicated; in most sections, bivalve assemblages are associated with zones marked by index ammonite species. For the vast majority of bivalve species of the Berriasian of Western Europe, there is no zonal association in their classical localities. Only for some species is a more detailed reference known than Neocomian or Valanginian in their previous interpretations (Treatise, 1969–1971; Dhondt, 1973).

In the paleontological part of the work, the history of the study of the Early and Middle Berriasian bivalves known from the Crimean Mountains is briefly considered. All identifications of species described by previous authors are revised; facies association of the species are analyzed; the data on the stratigraphic and geographical distribution of the studied species are summarized.

Only the family Trigoniidae is not included in this work, since its species were described by the author previously in a monograph on the Early Cretaceous trigoniids of Crimea (Yanin, 2004).

The paleontological characterization of the studied sections includes both the author's identifications (bivalves) and published data on the systematic composition of different groups are given: corals (Kuzmicheva, Bugrova), gastropods (Golovinova, Lysenko), bivalves (Muromtseva, Bogdanova), ammonites (Drushchits, Kvantaliani, Arkadiev and Bogdanova, Glushkov and Baraboshkin and others), aptychi (Drushchits and Myshkina), belemnites (Kabanov), brachiopods (Smirnova and Lobacheva), sea urchins (Poslavskaya, Solovyov, and Tur), crinoids (Klikushin). Lists of species for many groups are given in the description of specific sections; the most characteristic of them are placed in the corresponding logs.

Geological institutions, the abbreviated names of which, are used in the text:

VNIIGAZ—Scientific Research Institute of Gas (Gazprom VNIIGAZ) (Moscow)

VSEGEI—Russian Geological Research Institute (St. Petersburg)

GMSPGGI—Mining Museum of Saint Petersburg Mining University

DPMSU—Department of Paleontology of Moscow State University

CFU—Vernadsky Crimean Federal University (Simferopol)

MSU—Moscow State University

MZMSU—Earth Science Museum at Moscow State University

PIN RAS—Paleontological Institute of the Russian Academy of Sciences (Moscow)

SPBU—St. Petersburg State University

TsNIGRM—F.N. Chernyshev Central Geological Research Museum (St. Petersburg).

CHAPTER I. STRATIGRAPHIC REVIEW

The deposits of the lower and middle Berriasian in the Crimean Mountains are very widespread in the area of both the Second and First ridges. They extend from the vicinity of the city of Balaklava in the west to the city of Feodosia in the east. These outcrops are interrupted only in the middle part of the Second Ridge, on the Kacha Uplift, between the right bank of the Kacha River and the valley of the Bolshoi Salgir River. On this vast area, which most likely represented land that adjoined the Simferopol Uplift in the north, there was no deposition in the Berriasian.

In the extreme south-west of the region, the Berriasian outcrops have complex outlines due to a pronounced, strongly dissected pre-Cretaceous relief and the development of numerous tectonic faults.

In the basin of the Bel'bek River, the line of outcrops bifurcates into northern and southern branches. The northern branch is composed of terrigenous rocks of the lower and middle substages and carbonate rocks of the upper substage. The rocks form a gently sloping monocline and form the base of the Lower Cretaceous sections in the area of the villages of Bogatoe Ushchelie, Kuibyshevo, Solnechnosel'e, Vysokoe, and the Kaya-Tepe Mountains. The southern branch of outcrops contains carbonate deposits of the Lower Berriasian, common on the northern slope, and possibly on the Aipetrian Yayla Plateau. They are strongly tectonically reworked, which makes it difficult to separate them and correlate them with deposits of the northern branch.

A continuous strip of Berriasian outcrops extends to the east of the Bolshoi Salgir River, up to the watershed between the Sarysu and Tonas rivers. Here, the width of the strip increases sharply: in the west of the

area, from north to south, it occupies the area from Mount Kolbair on Dolgorukovskaya Yaila in the south to the village of Ivanovka in the Maly Salgir River basin in the north. To the east, in the basins of the Beshterek, Zuya and Burulcha rivers, it narrows somewhat. Further, the southern margin of the strip overlies the northern side of the plateau of the Karabi-Yaila Massif (the area of the Kazanly well), and the northern margin can be traced to the latitude between the villages of Novoklyonovo-Kozlovka. The Lower Berriasian deposits are especially widespread here. The general monoclinal bedding in the Maly Salgir-Sarysu interfluve is complicated by numerous latitudinal, meridional and diagonal normal faults and thrust faults have been established, which have a particularly complex structure on the Dolgorukovskaya and Karabi Yaila plateaus.

The bedding the Lower and Middle Berriasian deposits in the basins of the Tonas and Indola rivers differs sharply from that in the aforementioned areas. Here they fill a deep and extensive pre-Cretaceous depression with steep sides, with Lower Berriasian flyschoid facies and Middle Berriasian argillaceous facies. In the Feodosia region, the studied deposits are also represented by flyschoid series occurring in areas with considerable tectonic reworking.

Thus, the Lower and Middle Berriasian line of outcrops contains several clearly distinguishable areas with different tectonics, paleogeographic and depositional settings, and numerous unconformities. Additionally, the successions show profound changes in the thickness of units and beds, strong facies variability and the uneven distribution of fossils in time and space, while some sections have depositional gaps. Difficulties in understanding the stratigraphy of the Berriasian deposits require thorough examination of the reference sections. Characteristic reference or type sections of the Berriasian in the Crimea have long been identified. For example, Drushchits (1975) described the Feodosia, Belogorsk, and Bel'bek type sections; Bogdanova et al. (1981) designated as type sections: East Crimean Section (Feodosia and Nanikovo regions), Tonas Section (Krasnoselovka), Central Crimean Section (Sarysu, Beshterek), Bel'bek Section (Kuibyshevo, Solnechnosel'e) and Southwestern Crimean (Peredovoe). At the Eighth All-Russian meeting of the Cretaceous Commission in Crimea in October 2016, the Belbek, Tonas and Feodosia sections were given the status of "reference" (Baraboshkin et al., 2016). In this work, the following sections are proposed to be considered as "type" sections: Balaklava, Kuchki, Urkusta, Aipetri, Bel'bek, Dolgorukovsky, Beshterek, Karabi, Saigin-Balki, Tonas and Feodosia (Fig. 1).

In the Lower–Middle Berriasian deposits of the region, about 500 species of fossil marine organisms have been identified to date, belonging to all systematic groups known in the Early Cretaceous. Their distribution along the sections is uneven, facies-dependent. In the Lower–Middle Berriasian deposits of the region, about 500 species of fossil marine organisms have been identified to date, representing all systematic groups known in the Early Cretaceous. Their distribution along the sections is uneven, which is primarily facies-dependent. The vast majority of fossil finds associated with shallow sandy-siltstone deposits are represented by shells of bivalves, gastropods, and brachiopods. Limestones of biogenic origin are also shallow-water. Their lithological types differ in the composition of the remains of dominant organisms: oncolithic, coral, coral-algae (mainly in bioherms), gastropods, and rudists. Flyschoid facies, represented by alternation of clays, marls or clastic limestones, are developed in the Eastern Crimea. They are relatively deep-water, therefore, the faunal assemblages in them, usually are not as systematically diverse as shallow-water ones confined to sandy-siltstone and bioclastic-detrital rocks. Clays and marls in some intervals of the sections contain numerous finds of ammonites, but very few benthic fossils.

The deposits of most sections contain distinctive assemblages of fossil organisms, which in most cases makes it possible to dismember and correlate them at the zonal level. But due to the high variability of facies, the correlation of some sections is still conditional. At the end of the stratigraphic part of the work, a general table of the distribution of bivalve species in the Berriasian deposits of the region is given, indicating their position in the corresponding zone of the stratigraphic scale adopted for the Crimea.

In recent years, due to the refinement of the stratigraphic scheme of the Tithonian, Berriasian, and Valanginian, the age determination of many species previously described in atlases, monographs, and many articles has changed.

When characterizing the type sections and substantiating the age of the deposits, we present new data on the taxonomy and stratigraphic position of species from different groups of organisms.

I.1. A Brief Review of the Study of the Stratigraphy of the Lower and Middle Berriasian of the Crimea

At the earliest stages of studying the Lower Cretaceous stratigraphy of the region, the Berriasian deposits were described as Neocomian. So Huot (1842) described sandstones in the area of the village Terenair (Deep; Broili (1902) described limestones along the Bakhchisarai-Yalta highway on the northern slope of the Aipetri Yaila; Karakash (1907) described sandstones near the villages of Ayrigul (Solnechnosel'e) and Fotisala (Golubinka). Other researchers described them as Valanginian: Borissiak (1901) described *Aucella* sandstones near Balaklava (Mount Psilerakhi) and ammonites in the vicinity of the village of Urkusta (Peredovoe), Biyuk-Uzen Ravine.

In the Crimea, the Berriasian was established by Kilian (1895, 1910) based on a revision of the ammonite assemblage identified by Sokolov (1886) and Retowski (1893) from the "Feodosia marls" strata, which are exposed in the area of Cape St. Elijah and along the southern coast of the Feodosia Bay. V.D. Sokolov, who was the first to study ammonites from these marls, dated them as Tithonian. O. Retowski, who described 65 ammonite taxa from these deposits, also concluded that they are of late Tithonian age. Kilian drew attention to the mixed nature of the species assemblage identified by Sokolov and Retowski, and based on the presence of species typical of the Berriasian deposits of southeastern France, he attributed the "Feodosian marls" to the lowest horizons of the Lower Cretaceous, to the *Hoplites (Thurmannia) boissieri* zone, i.e., to the lower Valanginian or Berriasian.

Berriasian as an independent stratigraphic unit was recognized by G. Coquand (1871) to designate the sequence of marls and clays in the area of the village of Berrias in southeastern France. Kilian (1907–1913) assigned the Berriasian to the Cretaceous and believed that the Berriasian deposits correspond to the lower Valanginian in the stratotype of the latter stage, i.e., the Berriasian was considered by him as the lower substage of the Valanginian Stage. This point of view was accepted by most authors in the 19th and the first half of the 20th centuries.

In the Crimea, the Berriasian deposits (in their modern understanding) in different sections were assigned to the Valanginian (Weber, 1937), Lower Valanginian or Berriasian (Moiseev, 1937a, 1937b; Pchelincev, 1962; Uspenskaya, 1969), Lower Valanginian or Berriasian Horizon (Muratov, 1947; Lychagin, 1969), Lower Valanginian (Drushchits in *Atlas* ..., 1960), Berriasian (Moiseev, 1930; Muratov, 1937; Lysenko and Popov, 1962), Infravalanginian or Berriasian Horizon (Muratov, 1960). Only after it was decided at the Lyon colloquium to consider the Berriasian as an independent stage of the Cretaceous system, separated from the Valanginian Stage (*Colloque* ..., 1975), researchers in geological, stratigraphic and paleontological works on the Crimea began to use the terms "Berriasian", "Berriasian Stage", or "Berriasian deposits".

In the middle of the 20th century, a Crimean-Caucasian expedition was organized at the Geological Faculty of Moscow State University to participate in the compilation of the Geological Map of the USSR. The study of the Lower Cretaceous deposits in both regions was a task assigned to the Lower Cretaceous team led by V.V. Drushchits. The tasks of the team were the development of a detailed stratigraphic scale of the Lower Cretaceous of the Crimea and the North Caucasus and the preparation of an "Atlas" of the main groups of fossil organisms as a guide for geological survey.

In the course of many years of expeditionary and scientific work, the Lower Cretaceous team examined for the first time dozens of Lower Cretaceous sections of the Crimea and the Northern Caucasus, collected representative collections of the main groups of the Early Cretaceous fauna, which was the basis for the creation of the *Atlas nizhnemelovoy fauny Severnogo Kavkaza i Kryma* (Atlas of the Lower Cretaceous Fauna of the North Caucasus and Crimea) (1960). Berriasian deposits were not recognized in the *Atlas* or in other publications of the members of the Lower Cretaceous team. They were considered as Lower Valanginian, based on the view of V. Kilian (see above).

At the "Colloquium on the Jurassic-Cretaceous Boundary" (Colloque...., 1975) held in Lyon in September 1973, schemes for the zonal division of the Berriasian of France and other territories based on ammonites were first proposed (Le Hégarat—France; Sakharov—the Northern Caucasus; Drushchits—Crimea, etc.).

In 1975 Drushchits (1975) indicated the position of the main ammonite zones in the type sections of the Berriasian (Feodosia, Sarysu, Bel'bek), and in 1979 (Drushchits and Gorbachik, 1979) the first general zonal scale for the entire Lower Cretaceous of the south of the USSR was proposed, in which the Berriasian zones were based on the Crimean sections. This scale was used in writing papers and summarizing monographs on the stratigraphy of the Lower Cretaceous of the region (Aliev et al., 1985; Drushchits et al., 1986).

A new stage in the study of stratigraphy and fauna of the Berriasian of the Crimea was the work of the St. Petersburg teams (VSEGEI: T.N. Bogdanova, S.V. Lobacheva and others; St. Petersburg State University: V.A. Prozorovsky, A.Yu. Glushkov, V.V. Arkadiev and others), Crimean (Crimean University: N.I. Lysenko), Georgian (GIN GSSR: I.V. Kvantaliani) geologists. Between 1978 and 2012 the main sections of the Berriasian were re-examined, new collections were collected for all the most important groups of fossils, and the definitions of previously described ammonites were revised. As a result, new sections were compiled with a refined distribution of ammonites, based on the data of V.V. Arkadiev, T.N. Bogdanova, A.Yu. Glushkov, and I.V. Kvantaliani. A new stratigraphic scheme for the Berriasian of the Crimean Mountains was created, accurately correlated with the standard scale adopted for France. Since the 1980s, when describing Crimean sections and characterizing fossil complexes, researchers began to indicate the corresponding ammonite zone, subzone, Beds with "fauna" or their analogues. The generalizing monograph "Berriasian of the Crimean Mountains" (Arkadiev et al., 2012) outlined the main results of the work of a team of authors led by V.V. Arkadiev both on stra-

tigraphy and paleontology of the Berriasian deposits of the region.

E.Yu. Baraboshkin and V.V. Arkadiev published on the development of zonal stratigraphy of the Berriasian of Crimea, and of the zonal correlation schemes for various areas of the Mediterranean belt. Particularly important results of their work are the lithological and paleontological re-examination of the section in the vicinity of Feodosia using a new paleomagnetic research technique (Guzhikov et al., 2012).

To date, the Berriasian successions in the Crimea are well-studied. Atlases, (*Atlas,* 1960, 1997), monographs and major articles describing and illustrating the marker fossil species. Particular attention was paid to ammonites, which are used as the basis for zonal schemes in Western Europe and the regional stratigraphic scheme in the Crimea (Arkadiev et al., 2012).

I.2. Zonal Scheme of the Berriasian Stage

In the first half of the 20th century, most geologists dated the Lower Valanginian (Berriasian) deposits of the Crimea using assemblages of ammonites, aptychi, belemnites, brachiopods, bivalves, etc., found in these sections (K.K. Foght, V.D. Sokolov, A. A. Borissiak, G.F. Weber, A.S. Moiseev and others). However, only a few researchers indicated a specific ammonite zone. For example, Muratov (1937), following Kilian (1895, 1910), attributed the marls in the area of Feodosia to the *Hoplites (Thurmannia) boissieri* zone. The same zone was recognized by some researchers in the Southwestern Crimea (Lysenko and Popov, 1962). Eristavi (1957) recognized the *Spiticeras negreli* Zone in the Lower Valanginian in the region of the Baidar Basin, the valley of the Bel'bek River, and in the vicinity of Feodosia.

Only in the second half of the last century, geologists began to develop a Berriasian zonal scheme for the entire territory of the Crimea. The scheme of zoning of the Berriasian deposits according to ammonites in the Berriasian Stage stratotype in the vicinity of the village of Berrias in Southeastern France, compiled by several experts on this group (Le Hégarat, 1973; Hoedemaeker and Rawson, 2000; Reboulet et al., 2011) was adopted as a reference, Table 1). At present, this scheme is the "standard" for the Berriasian of the Mediterranean paleobiogeographic region.

Based on the finds in the Berriasian deposits of the Crimean Mountains of an ammonite species assemblage similar to that in the Berriasian stratotype, it became possible to recognize three "standard" zones in the sections: *Berriasella jacobi* and *Tirnovella occitanica* in the lower Berriasian and *Fauriella boissieri* in the upper Berriasian and several subzones characteristic of the stratotype (Table 1). The problem of dividing the Berriasian stage into zones and subzones, as well as establishing the Tithonian-Berriasian and Berriasian-Valanginian boundaries, was considered in great detail by V.V. Arkadiev and T.N. Bogdanova in the monograph *Berrias Gornogo Kryma* (Berriasian of the Crimean Mountains) (Arkadiev et al., 2012). Findings in the Crimea of zonal ammonite species, which are index species for the Berriasian stratotype section in southeastern France and a number of sections in southern Spain, allowed the authors to correlate the regional stratigraphic scale for Crimea with standard zones. In this work, I use the zonal scale proposed by V.V. Arkadiev and T.N. Bogdanova (Arkadiev et al., 2012, Table 5).

The Berriasian Stage is usually subdivided into two substages. However, in this work, for the convenience of considering the stratigraphic position of bivalves in larger units than zones, the author accepted the proposal of I.V. Kvantaliani (see Kvantaliani and Lysenko, 1979b; Kvantaliani, 1989) on the tripartite subdivision of the Berriasian Stage with the recognition of the lower, middle, and upper substages, with a corresponding standard ammonite zone for each, while in several sections, subordinate biostratigraphic units were recognized. A proposal to subdivide the Berriasian Stage into three substages in the Crimea can also be found in some later publications. Thus Baraboshkin (1997) recognized three substages in the general biostratigraphic scheme of Lower Cretaceous deposits in the interfluve of Kacha and Bodrak (Southwestern Crimea): (southwestern Crimea) recognized three substages: lower (*Berriasella jacobi* Zone); middle (*Tirnovella occitanica* Zone with three subzones: *Tirnovella subalpina*, *Berriasella privasensis*, *Dalmasiceras dalmasi*) and upper (*Fauriella boissieri* Zone with three subzones: *Malbosiceras paramimounum*, *Berriasella picteti*, *Tirnovella alpillensis*). This scheme contains three zones and five subzones in the same as in the "standard" Mediterranean scale. The tripartite subdivision of the Berriasian was also accepted by us previously when describing bivalves in the monograph *Berrias Gornogo Kryma* (Arkadiev et al., 2012, Table 14).

When subdividing the Lower–Middle Berriasian deposits based on index ammonite taxa, I distinguish three categories of biostratigraphic units: zone, subzone, "Beds with fauna". They are indicated in the sections "Locality" and in the explanations of the figures and plates.

Zone is a biostratigraphic unit of the standard scheme based on the index species. It is recognized in the Crimea when in a particular section there is an index species known in the standard scheme, or it is certain that the given interval of the section corresponds to this zone in terms of the stratigraphic position and fossil assemblage. The zone in its composition has from one to three subordinate biostratigraphic units. For example, the *Berriasella jacobi* Zone (=*jacobi* Zone) is subdivided (from bottom to top) into the *B. jacobi* (*jacobi* Subzone) and *Pseudosubplanites*

Table 1. Schemes of stratigraphy of the Lower and Middle Berriasian of the Crimea

Zonal Mediterranean marine standard (Hoedemaeker, Rawson, 2000; Reboulet et. al., 2011)		Kvantaliani and Lysenko, 1979			Bogdanova et al., 1981	Arkadiev, Bogdanova, et al., 2006, 2012		This study		
Fauriella boissieri Zone	*Fauriella boissieri* Zone	Upper	*Fauriella boissieri* Zone	*Tauricoceras crassicostatum* Subzone	Beds with *Tauricoceras crassicostatum*	*Fauriella boissieri* Zone	Subzone *Riasanites crassicostatum*	Upper	*boissieri* Zone	*Crassicostatum* Subzone
	Malbosiceras paramimounum			*Euthumiceras euthumi* Subzone	Beds with *Euthumiceras* and *Neocosmoceras*		Beds with *Euthumiceras* and *Neocosmoceras*			*Euthumi* Subzone
Tirnovella occitanica	*Dalmasiceras dalmasi*	Middle	*Tirnovella occitanica* Zone	*Dalmasiceras dalmasi* Subzone	Beds with *Dalmasiceras crassicostatum*	*Tirnovella occitanica* Zone	Subzone *Dalmasiceras tauricum*	Middle	*Occitanica* Zone	*Tauricum* Subzone
	Berriasella privasensis			*Spiticeras spitiense* Subzone			Beds with *Tirnovella occitanica*—Retowskyceras retowskyi			
	Tirnovella subalpina									
Berriasella jacobi		Lower	*Pseudosubplanites grandis*—*Berriasella jacobi* Zone	*Malbosiceras malbosi* Subzone	Beds with *Malbosiceras* sp.	*Berriasella jacobi*	Beds with *Malbosiceras chaperi*	Lower	*Jacobi* Zone	Beds with *chaperi*
				Pseudosubplanites euxinus Subzone	*Pseudosubplanites ponticus*—*P. grandis* Subzone		Subzone *Pseudosubplanites grandis*			*Qrandis* Subzone
				Pseudosubplanites grandis Subzone			*Berriasella jacobi* Subzone			*Jacobi* Subzone

grandis Subzone (*grandis* Subzone) and the Beds with *Malbosiceras chaperi* (*chaperi* Beds).

Subzone is a regional unit; is recognized by a local species-index known in several sections. For example, the *Dalmasiceras tauricum (tauricum Subzone)* Subzone is typical of several regions of eastern, central and southwestern Crimea; as a subordinate unit, it is included in the standard *occitanica* Zone. If there is no zone or subzone in the section, they are established according to the species assemblage characteristic of this interval in other sections, but with the caveat: "equivalents of the zone ... / subzone ...".

Beds with fauna is a local subdivision based on an index species that occurs in a few sections of one area. For example, Beds with *Malbosiceras chaperi* (*chaperi* Beds); is a subordinate unit of the standard *jacobi* Zone, located stratigraphically above the *grandis* Subzone in sections of the Central Crimea.

The biostratigraphic adopted in this study are briefly described below.

Lower Berriasian

The *Berriasella jacobi* Zone is a zone of the standard zonal scheme (Hoedemaeker et al., 2003). It was established in the east of the peninsula in the vicinity of Feodosia at Cape St. Elijah (Arkad'ev and Rogov, 2009; Arkad'ev et al., 2008, 2012; Baraboshkin et al., 2016). Because of the presence of the index species, it was also established in the western part of the Eastern Crimea, on the Tonas River (Arkadiev et al., 2005, 2012; Baraboshkin et al., 2016). As the Berriasian deposits were studied, various index species became included in the name of this zone. For instance, V.V. Drushchits (*Atlas* ..., 1960) indicated as a marker species *Berriasella pontica* found in the marls of the Lower Valanginian (Berriasian) in the area of Feodosia and clays with interbeds of sandstones and marls on the Tonas River. This species dominates in the ammonite assemblages of the Eastern Crimea. Later, the *B. pontica* Zone was identified in the Berriasian, which V.V. Drushchits later replaced with the *Pseudosub-*

planites euxinus Zone (Drushchits, 1975; Drushchits and Gorbachik, 1979). It was correlated with the *B. jacobi* Zone (Upper Tithonian) and *P. grandis* Zone (Lower Berriasian) of southeastern France (Le Hégarat, 1973). In 1985, Drushchits accepted the *grandis* zone as the lower zone of the Lower Berriasian.

Subsequently, the following names were proposed for the zone under consideration within the same geochronological range: *P. grandis* zone (Sasonova and Sasonov, 1974; Lower Berriasian); *P. grandis* Subzone, lower subzone of the Lower Berriasian *P. grandis*–*B. jacobi* Zone (Kvantaliani and Lysenko, 1979b; Glushkov, 1997); *P. ponticus*–*P. grandis* Zone (Bogdanova et al., 1981, 1984, lower zone of Lower Berriasian); *Pseudosubplanites grandis*–*Berriasella jacobi* Zone (Kvantaliani and Lysenko, 1979b; Kvantaliani, 1989; Arkadiev, 2003: Lower Berriasian); *B. jacobi* Zone with two subzones: lower, *B. chomeracensis* Subzone and upper, *P. grandis* Subzone (Arkadiev and Bogdanova, 2004; Lower Berriasian); *B. jacobi* Zone with two subzones: the lower one, *B. jacobi* Subzone, and the upper one, *P. grandis* Subzone (Arkadiev et al., 2012).

The deposits of the *jacobi* zone are distinguished in the sections of the Eastern Crimea (Feodosia, Tonas). In the more western regions, a similar sequence of limestones and marls is recognized almost everywhere, occurring below the *tauricum* Subzone (Middle Berriasian), but no ammonite index species have yet been found in it. Therefore, in the sections of the Lower Berriasian in the basins of the Sarysu, Zuya, Beshterek, Maly Salgir rivers, on the northern slope of the Aipetri Yajla and in the northern side of the Baidar Basin, these limestones can only be considered as "equivalents of the *jacobi* zone".

The *grandis* Subzone was identified in the Lower Berriasian of Southeast France based on the index species *Pseudosubplanites grandis* (see above). In the Crimea, this species was first found in the flyschoid sequence at Cape St. Elijah in 1996 (Glushkov, 1997). Arkadiev and Bogdanova (see Arkadiev et al., 2012) indicate the finding of this species in the Tonas River Basin (Krasnoselovka, Kuchuk-Uzen' Creek) and on the northern margin of the Karabi-Yaila Plateau (Kazanly well area). It has not yet been found in coeval deposits in the more western regions of the region (in some sections, we recognized this subzone tentatively, based on the stratigraphic position).

Beds with *Malbosiceras chaperi* are a local subdivision in sections of the Central Crimea, corresponding to the upper part of the Lower Berriasian. In the stratigraphic scheme, it occupies a place between the *grandis* Subzone (middle part of the Lower Berriasian) and the *tauricum* Subzone (Middle Berriasian). Initially, I.V. Kvantaliani (Kvantaliani and Lysenko, 1979b) identified the *M. malbosi* Subzone in the Lower Berriasian section in the Enisarai Ravine (Sarysu River basin) above the *grandis* Subzone, in siltstones with marl nodules occurring at the top of the sandstone and siltstone Sequence, 10–15 m thick, containing bivalves, brachiopods and solitary corals (*Montlivaultia* Horizon. Bogdanova et al. (1981), in a section along the Enisarai Ravine based on the find of *Malbosiceras* sp. indet. in the sandstone and siltstone sequence, 28 m thick according to their measurements, instead of the *M. malbosi* Subzone (see above), Beds with *M.* sp. indet. and place them in the upper part of the lower Berriasian. However, Kvantaliani (1989) insisted on the identification of the *Acanthodiscus malbosi* Zone (=*M. malbosi* in Kvantaliani and Lysenko, 1979) and transferred it from the Lower to the Middle Berriasian. Arkadiev and Bogdanova (Arkadiev et al., 2012) re-examined *M.* sp. indet. from the collection of Bogdanova, identified it as *M. chaperi* and based on that recognized the Beds with *M. chaperi*.

Middle Berriasian

The *tauricum* Subzone is a local division predominantly in sections of the southwestern and Central Crimea. Identified on the basis of a new species *Dalmasiceras tauricum* (Bogdanova and Arkadiev, 1999). The history of the recognition of this subzone is very complicated. Drushchits (in *Atlas*, 1960, pl. 6) for the first time cited species *Dalmasiceras dalmasi* (Pict.) on the Bel'bek River and *D. punctatum* (Pict.) and *Euthymiceras euthymi* (Pict.) on the Beshterek River. He later noted that they are characteristic of the Upper Berriasian.

In 1975, Drushchits identified the *E. euthymi*–*D. dalmasi* Zone (Gorbachik et al., 1975; Drushchits, 1975). It corresponded to the upper part of the Middle and lower part of the Upper Berriasian of the standard scheme as understood by Le Hégarat (1973). This zone was accepted by many researchers for a long time, but its stratigraphic position was indicated ambiguously in their works: Middle Berriasian (Drushchits and Gorbachik, 1979); the lower zone of the Upper Berriasian (Drushchits et al., 1985, 1986; Yanin and Smirnova, 1981; Yanin and Vishnevsky in Geologicheskoe stroenie, 1989); Middle–Upper Berriasian (Baraboshkin, 1997). Other names have also been proposed for the subdivision under consideration: the *Dalmasiceras dalmasi* Zone (Kvantaliani and Lysenko, 1979; Kvantaliani, 1989: Middle Berriasian); Bogdanova et al., 1981; Middle Berriasian: Sei and Kalacheva, 1993; Lower Berriasian, *D. crassicostatum* Zone (Yanin and Baraboshkin, 2000; upper zone of the Middle Berriasian zone). As a result of the revision of the genus *Dalmasiceras* by Bogdanova and Arkadiev, the species *D. crassicostatum* described by Drushchits (*Atlas* ..., 1960) and previously accepted by Bogdanova et al. (1981, p. 6), was re-identified as *D. tauricum* Bogd. et Ark., which began to be considered as a zonal index species of Beds with *D. tauricum* in the same volume (Bogdanova and Arkadiev, 1999).

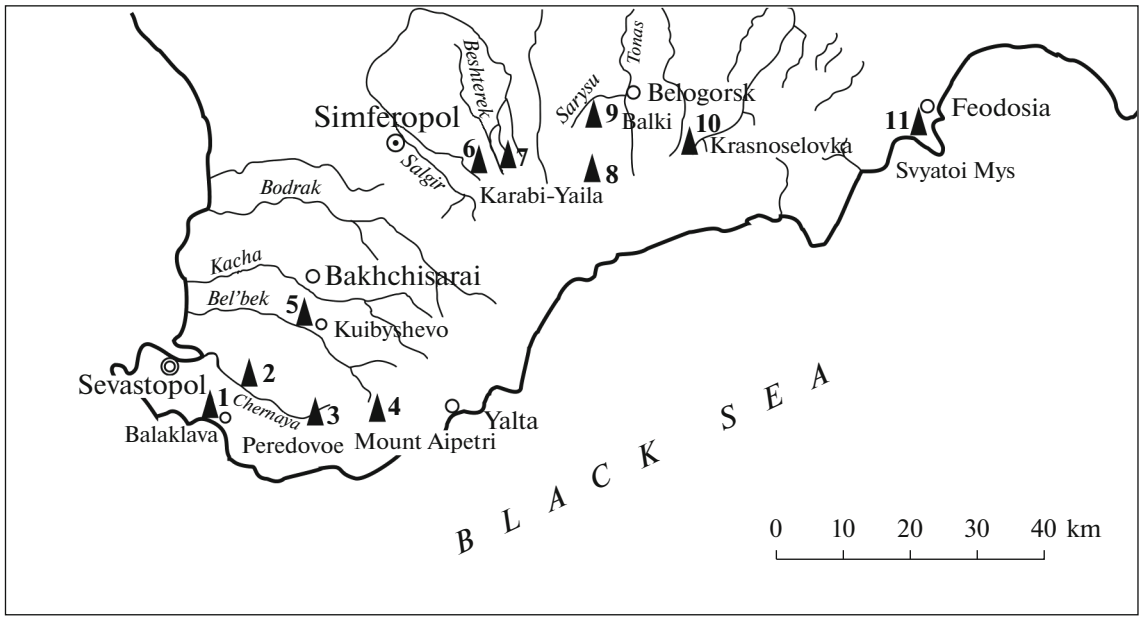


Fig. 1. Location of the Lower and Middle Berriasian type sections in the Crimea: (1) Balaklava (flux quarry on the northwestern vicinity of Balaklava), (2) Kuchki (creek of the same name in the vicinity of the village of Kuchki), (3) Urkusa (near the village of Peredovoe, northern side of the Baidar Depression), (4) Aipetri (northern slope of Aipetri Yaila, Bakhchisarai–Yalta highway), (5) Bel'bek (south of the village of Kuibyshevo, Kabaniy Log), (6) Dolgorukovsky (northern slope of Dolgorukovskaya Yaila, Mount Kolbair, vicinity of the villages of Glubokoe, Ivanovka), (7) Beshterek (Beshterek River, southern vicinity of the village of Solovjevka), (8) Karabi (northern slope of the Karabi-Yaila plateau, Kazanlak Basin), (9) Saigin-Balki (Sarysu River basin: Saigin Ravine, vicinity of the villages of Blagodatnoe, Kozlovka, Balki), (10) Tonas (valley of the Tonas River, vicinity of the village of Krasnoselovka, Belogorsk–Povorotnoe highway, Kuchuk-Uzen' Creek), (11) Feodosia (vicinity of Feodosia, Cape St. Elijah, south coast of Feodosia Bay, Zavodskaya Balka).

Evidently, the names and stratigraphic position of the same unit have changed many times, but it has always been based on species of the genus *Dalmasiceras*. Kvantaliani (1989) suggested that for this subdivision, the name *D. dalmasi* introduced by Drushchits (see above) should not be changed "as it is rooted in the literature" (p. 148). This proposal cannot be accepted, since the Crimean specimens of this species are not illustrated, and its earlier identifications have not been confirmed (Bogdanova and Arkadiev, 1999). Since this unit is local, but can be traced in many sections, according to our criteria, it should be called the *tauricum* Subzone, which corresponds to the upper subzone of the *Tirnovella occitanica* Zone of the standard stratigraphic scheme.

Upper Berriasian

The *euthymi* subzone is distinguished based on the findings of the index species *Neocosmoceras (=Euthymiceras) euthymi* (Pict.) and is traced in the sections of the eastern (Tonas), central (Sarysu, Kozlovka) and southwestern (Bel'bek, Kuibyshevo, Kabani Log; Solnechnosel'e) Crimea. In other sections, this subzone is not recognized due to the absence of finds of the index species.

I.3. Descriptions of Type Sections

The sections are described from west to east in the following order: Balaklava, Kuchki, Urkusta, Aipetri, Bel'bek, Dolgorukovsky, Beshterek. Karabi, Saigin-Balki, Tonas, Feodosia (Fig. 1).

When describing the sections, the following provisions are accepted:

(1) abbreviation of names of groups of organisms: Am—ammonites, Ap—aptychi, Br—brachiopods, Al—algae, Gs—gastropods, Bv—bivalves, Co—corals, Ech—echinoids, Cr—crinoids, Nt—nautiloids, Rd—rudists, Fr—foraminifers, Tn—tintinnids.

(2) the authors of species taxa of bivalves are not given in the description of the sections;

(3) for the majority of other groups they are indicated only at the first mention of the species;

(4) stratigraphic units are indicated by indexes: J_3tt_3—Upper Jurassic, Upper Tithonian; K_1ber—Berriasian: K_1ber_1—Lower, $K_1ber_1^1$—*jacobi* Subzone, $K_1ber_1^2$—*grandis* Subzone, $K_1ber_1^3$—*chaperi* Beds; K_1ber_2—Middle, *tauricum* Subzone; K_1ber_3—Upper, *euthymi* Subzone.

Balaklava Section

Composite section, described by V.V. Drushchits in 1955. It includes man-made outcrops in the walls of a limestone quarry in the vicinity of Balaklava, natural outcrops along the western side of the Balaklava valley, and also at the foot of the northern slope of Mount Psilerakhi on the outskirts of the village of Flotskoe. The section clearly shows three facies rock types in its different parts: limestones in the lower part (member I), siltstones, clays and sandstones in the middle part (member II), clays with nodules in the upper part (members III and IV). The rocks form a monocline generally dipping north. In some places, their occurrence is complicated by tectonic disturbances. Thus, in a quarry near the boundary of siltstones with underlying limestones of Unit I, a fault zone 2 m wide was found with breccia consisting of limestone fragments, coarse-grained and gravel sandstones with pebbles (5 mm) and clays. In the fault zone, the clay is sheared and strongly limonitized. The northern flank of the fault is subsided and composed of Berriasian (probably middle) shales, dipping steeply NE 30° <50°. This fault distorted the true thickness of members I and II.

The first brief description of the Berriasian deposits in the studied area is given in the works of A.A. Borissiak (1901, 1904) and M.S. Eristavi (1957). The section log is published by Zeisler (1959) as the "Balaklava region") and Drushchits (in *Atlas* ..., 1960), as the "Chernaya River". Fossils were identified by V.V. Drushchits (Am); B.T. Yanin, T.L. Muromtseva, and V.F. Pchelincev (Bv); N.I. Lysenko and V.F. Pchelincev (Gs).

Section Description (Fig. 2)

The Berriasian deposits in this area lie at the base of a thick series of Lower Cretaceous clays filling an ancient erosive depression formed as a result of uplift of the area to the day surface in the Pre-Cretaceous. The relief, formed during the subaerial exposition on the surface of the Upper Jurassic limestones, was ingressively flooded by sea waters in the Berriasian and Valanginian (Muratov, 1960, 1973).

K_1ber_1. Member I (apparent thickness 20 m, underlying sediments not studied)—limestone sequence, organogenic-detrital, gray, thick-platy, in places with an abundance of gastropod shells; Gs—*Phaneroptyxis rugifera* (Zitt.); Bv—*Heterodiceras commune* Pchel., *H. haliotideum* Pchel., *Valletia antiqua* Favre.

K_1ber_2. Member II (5 m)—siltstones, yellowish-gray, strongly clayey; at the contact with limestones, in places, with a thin interbed of loosely cemented sandstone with small quartz pebbles. The sandstone fills irregularities on the eroded limestone surface; the siltstones contain: Am—*Haploceras* sp., *Ptychophylloceras semisulcatum* (D'Orb.); Bv—*Gervillella anceps, Integricardium deshayesianum, Limatula tombeckiana, Pinna rodinaldina, Protocardia carinata, Spondylopecten subspinosus.*

To the west, on the northern slope of Mount Psilerakhi, siltstones contain interbeds of calcareous serpulid sandstones, in which A.A. Borissiak observed lenticular concretions of dense sandstones with carbonized plant remains; fossils include: Am—*Desmoceras* aff. *latidorsatum* Mich., *Hoplites* aff. *splendens* D'Orb. and Bv—*Buchia crassicolis* Keys. (Borissiak, 1901, 1904), *Integricardium deshayesianum* (Zeisler, 1959).

K_1ber_3. Member III (15.5 m—clays, black, dark gray and greenish gray, with thin interbeds of very dense, gray, coarse-grained, quartz sandstones and horizons of brownish-red spherosiderite concretions (5 × 20 cm).

Member IV (>50 m), clays with concretions similar to the underlying clay member; at the base are two slabs of fine-grained sandstones; here accepted as a "marker horizon". In clays, N.I. Lysenko (pers. Comm.) found *Neocosmoceras euthymi*, an index species for the Upper Berriasian.

Geological Age

K_1ber_1. Lower Berriasian (*jacobi* Zone; Member I). Limestones series: formerly assigned to the Upper Jurassic (Borissiak, 1901; Eristavi, 1957; Zeisler, 1959; Drushchits in *Atlas* ..., 1960); Kimmeridgian-Tithonian (Moiseev, 1930, 1937; Muratov, 1947); Tithonian (Muratov, 1973; Lychagin, 1969; Lichagin and Permyakov, 1971); Upper Tithonian (Uspenskaya, 1969). Based on the gastropods *Phaneroptyxis rugifera* (identified by N.I. Lysenko), as well as correlations with more easterly sections (see Kuchki and Urkusta sections, the limestones of Member I are here attributed to the Lower Berriasian, equivalents of the *jacobi* Zone. In the Urkusta Section, similar limestones occur below sandstones with Middle Berriasian ammonites (*tauricum* Subzone).

K_1ber_2. Siltstones, clays and sandstones of Member II were previously considered Lower Valanginian (Drushchits in *Atlas* ..., 1960) or belonged to the "Berriasian Horizon" of the Lower Valanginian (Zeisler, 1959; Lychagin, 1969; Muratov, 1947, 1973). Based on the finding of ammonites *Ptychophylloceras semisulcatum* and bivalve association in the siltstones, as well as on the stratigraphic position, deposits of Member II are here included in the *tauricum* Subzone.

K_1ber_3. Members III (15.5) and IV (> 50 m). Upper Berriasian, equivalents of the *euthymi* Subzone—clays with spherosiderite concretions and rare fossils. Drushchits (see *Atlas* ..., 1960) indicate for them a thickness of 140 m, notes that they are almost barren, and classifies them as undivided Valanginian-Hauterivian. The boundary is here between the clay member III and clay member IV on based on that N.I. Lysenko (personal communication) found ammonites in the middle part of the stratum of these clays (about 50 m

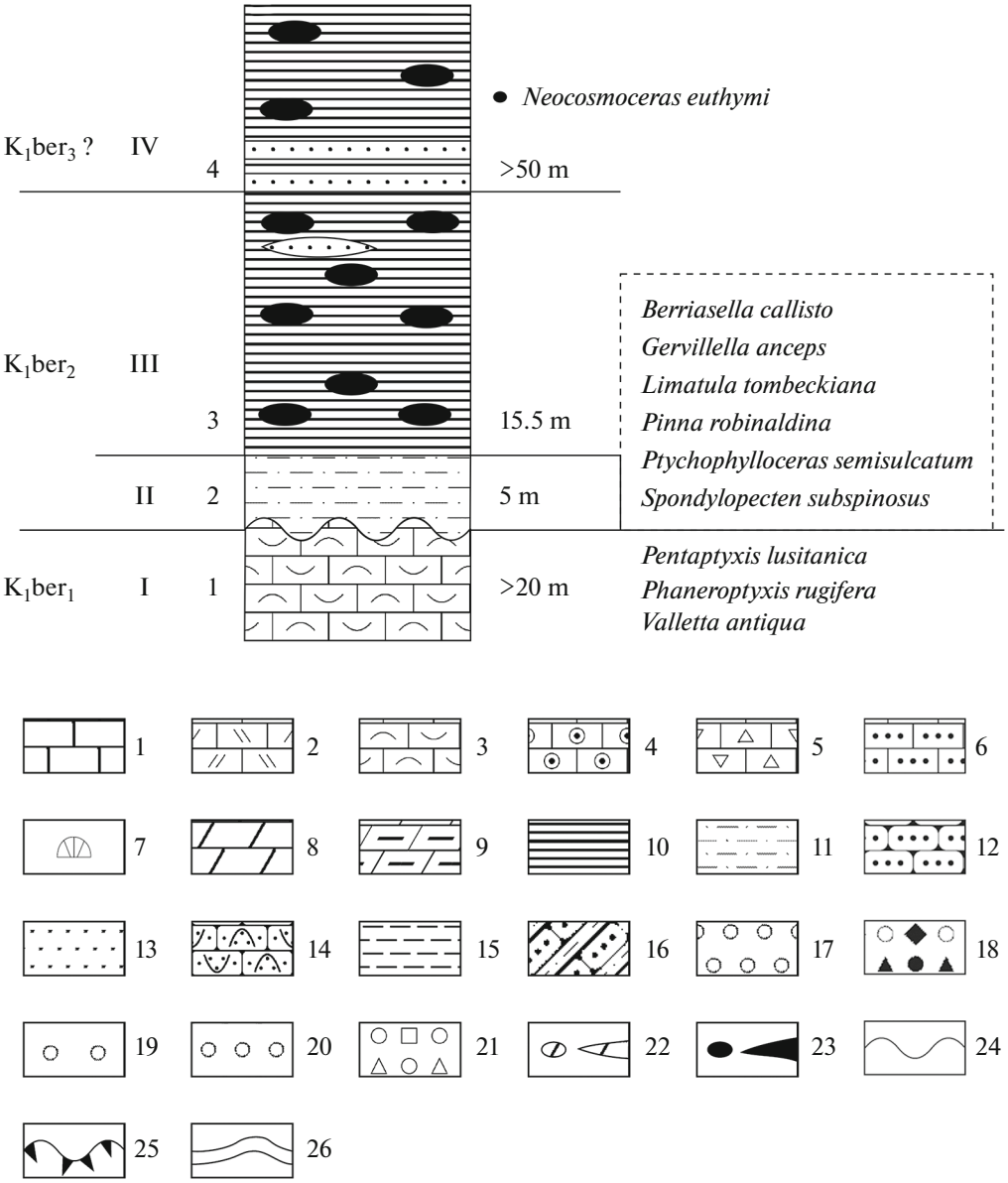


Fig. 2. Balaklava type section, no. 1, in the quarry in the vicinity of Balaklava. Explanations: (1–7) limestone: (1) pelitic, (2) detrital, (3) bioclastic, (4) oncolitic, (5) breccioid, (6) sandy, (7) bioherms; (8) marl, (9) clayey marl; (10) clay, (11) siltstone; (12–15) sandstone: (12) compactly, slightly cemented, (13) strongly calcareous, (14) shelly sandstone and shelly pavement, (15) clayey sandstone; (16) rocks of the Tavria Formation; alternation of sandstones, siltstones and clays; (17–21) conglomerate and pebble gravel: (17) conglomerate mainly quartz and (18) polymictic, (19) isolated pebbles, (20) horizon of pebbles and (21) boulders; (22–23) concretions and lenses: (22) marl, (23) siderite; (24) unconformity plane, (25) hardground surface, (26) reduced thickness; stratigraphic units: (J_1tv) Lower Jurassic, Tavria Formation; (J_3tt$_3$) Upper Jurassic, Upper Tithonian; (K_1) Lower Cretaceous: (K_1ber) Berriasian: (K_1ber$_1$) Lower Berriasian, *jacobi* zone: (K_1ber$_1^1$) *jacobi* Subzone, (K_1ber$_1^2$) *grandis* Subzone, (K_1ber$_1^3$) Beds with *chaperi*; (K_1ber$_2$) Middle Berriasian, *occitanica* Zone, *tauricum* Subzone; (K_1ber$_3$) Upper Berriasian, *boissieri* Zone, *euthymi* Subzone; stratigraphy of geologic columns: (I, II ...) members, (1, 2...) beds, (23 m...) thickness.

above the limestones of unit I): Upper Berriasian index species *Neocosmoceras* (=*Euthymiceras) euthymi* (Pict.), and also *Protocanthodiscus* sp. and *Ptychophylloceras semisulcatum*. Unfortunately, their exact position in the section remains unknown.

Kuchki

The section is continuous, described in the area of Kuchki Creek near the former village of Kuchki and in its deep creek channel on the steep slope of the right side of the Chernorechensky Canyon. The lower Ber-

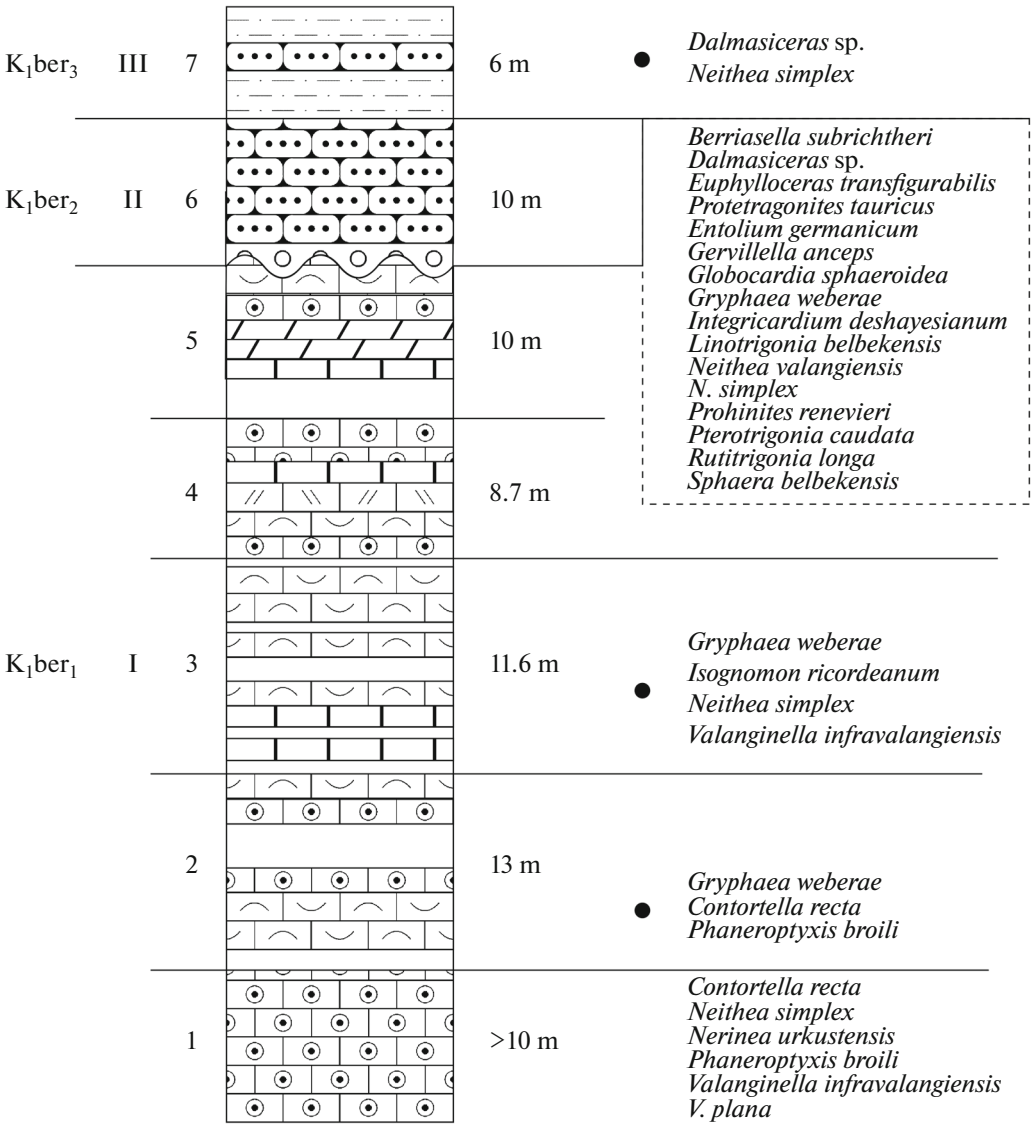


Fig. 3. Kuchki type section, no. 2, in the vicinity of the village of Kuchki (see explanations for Fig. 2).

riasian deposits of the are represented by a thick stratum of carbonate rocks, while those of the middle one are predominantly sandstones that form gentle slopes and clearings on both sides of the valley in the horizontal part of the creek. The rocks have a general monoclinal northern dip at 10°–15°.

The section was compiled based on the materials of the author's field studies conducted in 1959, 1965 and 1978 (in 1978, together with T.N. Bogdanova, S.V. Lobacheva and N.I. Lysenko). A brief description of the deposits of individual units is given in the works (Eristavi, 1957; Pchelintsev, 1931, 1962; Moiseev, 1934; Muratov, 1947; Lychagin, 1969; Uspenskaya, 1969; Solov'ov, 1971; Yanin and Smirnova, 1981; Bogdanova et al., 1981). A bed-to-bed description of the section with its illustration is given in (Fedorova, 2000; Yanin, 2004). To date, from the deposits of the lower and middle Berriasian, the following have been identified and partially described: Fr (Fedorova, 2000), Gs (Lysenko, 1964; see also Bogdanova et al., 1981), Bv (Yanin et al., 1981; Yanin, 2004), Br (Smirnova, see Yanin and Smirnova, 1981; Lobacheva, 1983), Ech (Soloviev, 1971).

Section Description (Fig. 3)

K_1ber_1. Member I, Beds 1–5 visible thickness >52 m, underlying sediments were inaccessible due to sheer cliffs in the sides of Kuchki Creek flowing into the Chernorechensky Canyon), alternation of gray and cream slabs, bioclastic detrital, detrital, oncolitic, less commonly micritic and arenaceous limestones, slabs and bluish interbeds-gray marls, in places with an abundance of gastropods. At the top of the member

(5 m), the limestones are enriched with gravel material and pebbles (4 cm) of quartz. In places, the rock is a conglomerate of well-rounded pebbles of various sizes. Marls and limestones contain: Bv—*Gryphaea weberae, Isognomon ricordeanus, Neithea simplex*; Gs (from the top of the pack, according to N.I. Lysenko)—*Ampullina pidanceti* Pict. et Camp., *Archimedea longa* Pchel., *Contortella recta* Pchel., *Nerinea urkustensis* Pchel., *Phaneroptyxis broili* Pchel., *Pseudoglauconia kuckensis* Fogdt, *Valanginella borissjaki* Pchel., *V. grandis* Pchel., *V. infravalangiensis* Choff., *V. plana* Pchel.

K_1ber_2. Member II, Bed 6 (10 m, exposed in glades in gardens on the left side of Kuchki Creek), rhythmic alternation of loosely-cemented interbeds and dense slabs (15 cm) of sandstones and arenaceous limestones; in the lower half of the bed there is a slab (1 m) of bioclastic, yellowish-brown, nodular limestone. The occurrence of loosely-cemented sandstones on the uneven eroded surface of the underlying limestones is well exposed to the south on the road towards the village of Morozovka; the beds contain sponges, solitary and colonial corals, bivalves, gastropods, ammonites, belemnites, brachiopods, bryozoans, crinoids, and echinoids.

Member II contains: Am—*Pseudosubplanites subrichteri* (Ret.), *Dalmasiceras* sp., *Protetragonites tauricus* Kulj.-Vor.; Bv—*Ceratostreon tuberculiferum, Entolium germanicum, Gervillella anceps, Globocardium sphaeroideum, Gryphaea weberae, Integricardium deshayesianum, Isognomon* sp., *Linotrigonia belbekensis* Yanin, *Neithea valangiensis, N. simplex, Prohinnites renevieri, Pterotrigonia caudata* (Ag.), *Rutitrigonia longa* (Ag.), *Sphaera belbekensis*.

K_1ber_3. Member III, Bed 7 (visible thickness >6 m), overlying deposits: overburden: poorly exposed sequence of clays, siltstones and dense, platy sandstones with quartz pebbles and algae nodules; their lower boundary is provisional; contact with the rocks of Member II was not observed; fossils are very rare: Am—*Dalmasiceras* sp.; Bv—*Neithea simplex*.

Geological Age

K_1ber_1. Member I, Lower Berriasian, upper subformation of the Eli Formation, *jacobi* Zone: a thick series of gray limestones with sandstone and marl interbeds. Previously, these limestones were classified as: Upper Jurassic (Zeisler, 1959); Upper Tithonian (Pchelintsev, 1931, 1962; Moiseev, 1934; Uspenskaya, 1969; Solovyov, 1971); Berriasian (Lysenko, 1964; Yanin and Smirnova, 1981: *Euthymiceras euthymi-Dalmasiceras dalmasi* Zone; Fedorova, 2000); lower Berriasian (Yanin, 2004).

As a result of the re-examination of the stratigraphic position of the limestones of the section, the determination of new fossil collections and the correlation with neighboring sections, Bogdanova et al. (1981) concluded that they were of early Berriasian age. They compared this limestone unit with marls cropping out in the area of the Kazanly Well on the Karabi-Yaila, in which the Lower Berriasian ammonites *Pseudosubplanites ponticum* (Ret.) were found. Bogdanova's opinion was supported by Arkadiev et al. (2012) and the author. The above assemblages of gastropods and bivalves from Member I are widespread in the Berriasian of the Crimea.

K_1ber_2. Member II, Middle Berriasian, *tauricum* Subzone: sandstones and siltstones with ammonites. Previously, they were assigned to: Valanginian (Muratov, 1947; Solovjev, 1971); lower Valanginian (Eristavi, 1957; Zeisler, 1959); Berriasian (Lychagin, 1969; Bogdanova et al., 1981); lower Berriasian (Fedorova, 2000; Yanin, 2004). Unfortunately, no index species of ammonites was found in the sediments of the Member; only *Pseudosubplanites subrichteri*, characteristic of the Berriasian of the Eastern Crimea, was found. In addition, we determined the age of the rocks by their stratigraphic position, by analogy with the neighboring Urkusta Section, where Member (5 m) sandstones with ammonites also occur above the limestone series, in which Bogdanova et al. (1981) found the Middle Berriasian index species *Dalmasiceras crassicostatum* Djan. (=*D. tauricum* Bogd. et Ark.; see Ammonite Revision). Bogdanova et al. (1981) view was supported by V.V. Arkadiev. It is adopted and in the present work. The assemblages of ammonites, bivalves, and gastropods listed above in the description of the section are widespread in the Middle Berriasian deposits of the Crimea. Unfortunately, the index species *Neocosmoceras euthymi* was not found in the overlying deposits of Member III (Bed 7); therefore, there are assigned to the Upper Berriasian provisionally.

Urkusta

The section is composite: its lower part is described on the southern slope of the Urkusta Hill near the eastern vicinity of the village of Peredovoe (=Urkusta), and the upper part is described from several isolated outcrops (Korlu and Biyuk-Uzen' ravines, Peredovoe-Bechku highway). Two lithologically distinct members are clearly distinguished in the section (Fig. 4): the lower one, represented mainly by limestones, and the upper one, composed of sandstones and clays. In the region under consideration, the Berriasian deposits are broken up by numerous faults; the presence of blocks with reverse-dip beds and the absence of some units from the section were recorded. Thus, in the section, rocks of Members I and II dip north monoclinally, and the upper part of Member II in the area of the highway south of a young pioneer camp has a reverse dip. We studied the section during several field seasons from 1962 to 1990 (in 1978, together with Bogdanova, Lobacheva, and Lysenko).

The history of the study of the stratigraphy of the Lower Cretaceous deposits, present on the northern side of the Baidar Valley, has more than 100 years and

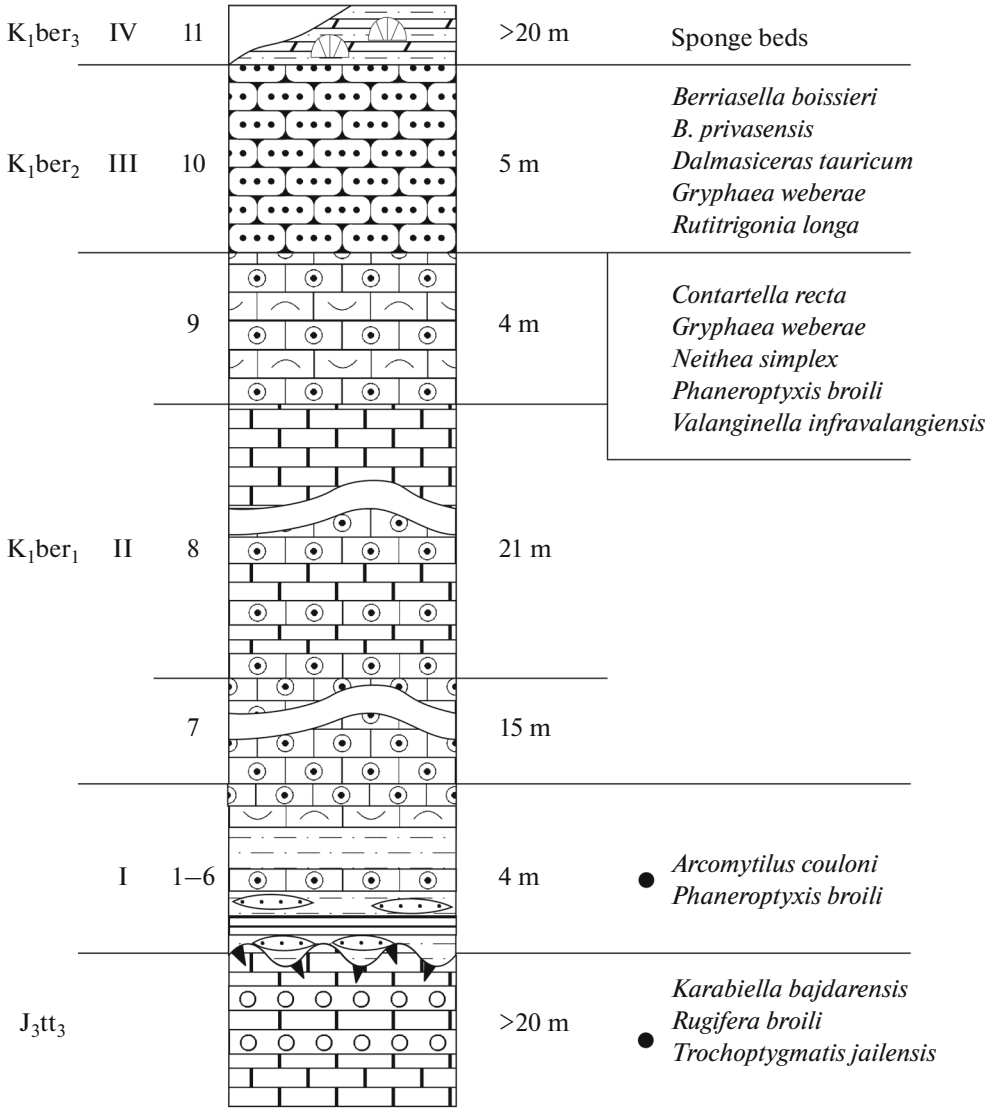


Fig. 4. Urkusta type section, no. 3, in the vicinity of the village of Peredovoe (see explanations for Fig. 2).

is associated with the names of Fogdt, Borissiak, Moiseev, Weber, Muratov, Pchelintsev, Lysenko, Bogdanova, et al. A brief description and image of the Urkusta Section are given in (Yanin and Smirnova, 1981; Bogdanova et al., 1981; Fedorova, 2000). A detailed description of the section with an indication of the association of fossils with the beds is given here for the first time.

To date, the following fossils have been described from the Lower-Middle Berriasian deposits of the area: Fr (Mamontova, 1972; Fedorova, 2000), Bv (Pchelintsev, 1959; Yanin, 1989; Yanin, 2020a), Br (Smirnova, 1972; Lobacheva, 1983; Lobacheva and Smirnova, 2006), Ech (Solovjev, 1971). The section below was compiled by the author, taking into account the data of Bogdanova et al. (1981).

Section Description (Fig. 4)

J_3tt_3. Underlying deposits (visible thickness >20 m)—series of alternations of gray and red massive limestone slabs, interbeds and lenses of dense polymictic sandstones and interbeds of loosely-cemented siltstones; the rocks are locally overfilled with shells of large gastropods and rudists. They are exposed in the lower part of the Urkusta Hill, above the Peredovoe-Novobobrovskoe road; Gs (mainly nerineids, sometimes forming coquinae, according to Lysenko)—*Elegantella skeliensis* Pchel., *Pentaptyxis kuchkensis* (Pchel.), *Rugifera broili* (Pchel.), *Tryptyxis acutecochleata* (Broili), *Upellaornata carinata* Pchel.; Rd—*Heterodiceras bajdarense*, *H. subovale* Pchel., *Paradiceras* sp., *Valletia urkustensis* (Pchelintsev, 1959).

K_1ber_1. Member I, beds 1–6 (4 m)—interbeds (0.2–1.2 m) of strongly arenaceous siltstones and clays

with lenses of fine-grained sandstones and slabs of light gray and yellowish limestones; at the top of the member, a slab of bioclastic-oncolite limestone; at the base, clayey interbed (0.5 m) with sandstone lenses, resting on a heavily eroded surface of underlying limestones; the hardground surface is uneven, with hillocks and deep (0.2 m) ditches; with borings of *Trypanites* sp.; as a result of faster weathering of the covering loose rocks, a wide (2–4 m) strip was formed on the limestone surface (a path passes along it on the southern slope of the Urkusta Hill). This surface is conventionally accepted as the Upper Tithonian-Lower Berriasian boundary; Fr—large *Anchispirocyclina lusitanica* (Egg.); Gs (identified by Lysenko)—*Contortella* sp., *Fibula borissjaki (Pchel.)*, *Phaneroptyxis broili*; Rd—*Heterodiceras bajdarense*, *Valletia urkustense, V. gigantea;* Bv—*Arcomytilus couloni*.

Member II, Beds 7–9 (40 m)—limestones, grey, platy, bioclastic and oncolithic, with corals and gastropods; rare interbeds of clays and siltstones; in the upper part of the member—limestones with quartz pebbles, passing into horizons and lenses (3–4 m) of quartz conglomerates; fossils from the top of the limestones: Fr—*Anchispirocyclina lusitanica*; Cr—*Montlivaltia* sp.; Gs (identified by Lysenko)—*Ampullina pidanceti*, *Archimedea longa*, *Contortella recta*, *Nerinea urkustensis*, *Phaneroptyxis broili*, *Pseudoglauconia kuchkensis, P. infravalanginensis*, *V. plana, V. scalata* Pchel. et al.; Bv—*Ceratostreon tuberculiferum, Gryphaea weberae,* and *Neithea simplex*.

K_1ber_2. Member III, Bed 10 (5 m; there are no members of the member at the top of the Urkusta Hill, as they were squeezed out as a result of tectonic dislocation; they are recognized in scattered outcrops east of the village of Peredovoe): sandstones, dark gray, loosely-cemented, with dense slabs and nodules of marly sandstones; contact with underlying limestones was not observed; there is an abundance of fossils in the sandstones. In the Biyuk-Uzen' Ravine, Borissiak (1901) discovered: Am—*Haploceras carachtheis* Zeusch., *H. subchaperi* Ret., *Lyticoceras liebigi* (Opp.), *Phylloceras semisulcatum*. Eristavi (1957) determined from here (1957): Am—*Berriasella boissieri* Pict., *B. privasensis* Pict., B. *subrichteri*, *Lytoceras liebigi*, *Phylloceras serum* Opp., *Ptychophylloceras semisulcatum*, *Salfeldiella calypso* D'Orb., *Negreliceras negreli* Math., and *N. theodosiae* Ret. Subsequent collecting in similar sandstones in the Korlu Ravine showed: Am—*Dalmasiceras tauricum* Bogd. et Ark. *Spiticeras nicolovi,* large lytoceratids (to 0.5 m in diameter); Bv—*Entolium germanicum, Gryphaea weberae, Integricardium deshayesianum*, *Rutitrigonia longa*, *Spondylopecten subspinosus*; Br—*Belbekella airgulensis* (Mois.), *Monticlarella korlukensis* Lob., *Praecyclothyris gracilis* Lob. A ditch of the Peredovoe-Bechku highway, 1 km west of the mountain pass: Bv—*Gryphaea weberae, Isognomon ricordeanum, Rutitrigonia longa*: Am—*Dalmasiceras crassicostatum* (=*D. tauricum*); Br—*Praecyclothyris gracilis*. In one outcrop near road sign no. 11, below sandstones with ammonites, there are interbeds of brownish-red silty clays with interbeds (0.5 m) of coarse-grained sandstones containing abundant quartz pebbles; they contain numerous Bv—*Isognomon ricordeanum*; this clay bed was not found in the area of Urkusta Hill due to the dislocation of deposits.

K_1ber_3 (Member IV, Bed 11: overlying deposits—"sponge beds"); the boundary between deposits of units III and IV is established in the Korlu Ravine, where sandstones with ammonites are overlain by clays (0.2 m) with sponges. Sponge beds are excellently exposed along the highway opposite the "Atlantic" pioneer camp.

Geological Age

The summary section contains: *jacobi* Zone (Lower Berriasian) and *tauricum* Subzone (Middle Berriasian).

K_1ber_1. Lower Berriasian, *jacobi* Zone; Members I, II; limestones series; at the base there is an interbedding of siltstones and sandstones resting on the uneven hardground surface of the underlying limestones. Previously, the deposits of these members in the considered section were dated as Upper Tithonian (Borissiak, 1903; Pchelintsev, 1959, 1962; Uspenskaya, 1969; Yanin, 1989); later dated as the upper Tithonian-Lower Berriasian (Fedorova, 2000; Arkad'ev, 2007); Berriasian (Lysenko, 1964; Bogdanova et al., 1981); Lower Berriasian (Yanin, 2020a).

Unfortunately, ammonites were not found in the deposits of Members I, II, but the species assemblage of other fossil groups allows dating the host beds: such species as *Arcomytilus couloni*, *Gryphaea weberae* and *Neithea simplex* (Bv) and *Phaneroptyxis broili*, *Fibula borissjaki* (Gs), widespread in the Lower Berriasian deposits of the Southwestern and Central Crimea. In addition, the rocks in the Members data here occur stratigraphically below the Middle Berriasian (Member III) ammonite horizon and correlate with the limestones of the upper Eli Formation (see above).

K_1ber_2. Middle Berriasian, *occitanica* Zone, *tauricum* Subzone; Member III, sandstones with ammonites; they were discovered by Borissiak (1901) in the Biyuk-Uzen' Ravine; Borissiak, based on a representative ammonite assemblage (see the description of Member III), determined their Berriasian age. Later, some geologists considered them Lower Valanginian (Moiseev, 1927, 1930; Weber, 1937; Muratov, 1947, 1949; Lysenko and Popov, 1962; Lysenko, 1964; Lychagin, 1969; Solovjev, 1971), others as Berriasian (Yanin, Smirnova, 1981 *Euthymiceras euthymi-Dalmasiceras dalmasi* Zone; Bogdanova et al., 1981: *Dalmasiceras crassicostatum* local zone). The above ammonites represent an assemblage characteristic of the Berriasian Stage; the find of *D. crassicostatum* accurately determines the age of the sandstones. At present, *D. crassicostatum*, according to the revision of

ammonites, has been transferred to the synonymy of *D. tauricum*, which, with a tripartite subdivision of the stage, is an index species of *tauricum Subzone* of the Middle Berriasian.

Aipetri

The section is located on the northern slope of the Aipetri Yaila south of the Bolshoi Canyon, 5 km from the mountain pass. The section was described by the author along the Sokolinoe-Yalta highway (the southeastern slope of the Salamlar Rise). The characterization of the section includes definitions of fossils found in neighboring outcrops: in highway ditches, on the slope of Mount Kizil-Kaya, and also in the upper reaches of the Kizil-Dere ravine. The Lower Cretaceous here is represented only by Lower Berriasian deposits, which are shallow-water carbonate facies distinct from the terrigenous facies common in the more northerly Bel'bek type section.

The Aipetrinsky section is dominated by zoogenic (oncolitic, bioclastic and bioherm) limestones and fine detrital clayey marls, to a lesser extent calcareous clays. Macrofaunal remains are unevenly distributed over the section; most of the fossils are associated with zoogenic limestones. In tectonic terms, the deposits of the lower Berriasian form a monocline with a general northern dip. They compose the upper part of a single monoclinal carbonate series, the so-called Bedenekyr Formation, dated late Tithonian–early Berriasian. The studied area is disrupted by numerous tectonic faults oriented across the dip of the beds. In the first half of the 20th century, the geological survey by the Geological Committee of Russia showed a wide distribution of Upper Jurassic deposits on the plateau and northern slopes of the Main Range of the Crimean Mountains (Karakash, 1907; Borissiak, 1912; Weber, 1937, et al.), which was reflected in geological maps compiled under the editorship of Vogt et al. (1926), Moiseeva (1937), Muratov (1967) et al., as well as on the geological schemes given in a number of papers and monographs.

But there was a different view. In 1897, during the VII International Geological Congress (*Guide* ..., 1897), on one of the excursions on the descent of the highway under construction at that time from the Aipetri pass to the village of Kokkozy (=Sokolinoe), in the region of 32 versts from Bakhchisaray a small collection of fossil invertebrates was assembled by several geologists (Broilly, Rothpletz, Steinmann and Zittel) from marls and limestones, exposed in rocky cliffs and on steep slopes. As a result of its study, Broili (1902) described several species of corals, gastropods, bivalves, brachiopods and echinoids and came to the conclusion about the early Neocomian age of the host deposits. Broili's conclusions about the age of carbonate rocks in these outcrops along the Bakhchisarai highway were criticized by Russian geologists, who traditionally considered all carbonate deposits in the area of the Crimean Yaila as Late Jurassic. Some considered the presence of Neocomian deposits in this area to be insufficiently substantiated (Karakash, 1907), others erroneous (Moiseev, 1927, 1937; Weber, 1934; Muratov, 1947), others simply ignored a different point of view. It should be noted that the Crimean geologist G.A. Lichagin, bearing in mind Broili's data, in 1969 wrote about the possibility of the presence of Lower Valanginian deposits among the carbonate-arenaceous strata in the upper reaches of the Kokkozka River in the Bolshoi Canyon basin and expressed his regrets that "the stratigraphy of this area has not been studied enough" (Lychagin, 1969, p. 160). The data presented in this paper somewhat compensate for this insufficiency. In 1962 V.F. Pchelintsev recognized a carbonate series on the northern slope of the Aipetri Yaila into the Bedenekyr Formation with a stratotype on the Bedenekyr Mountain and, based on the species assemblage of gastropods, brachiopods and ammonites, attributed it to the middle Tithonian. Later, Uspenskaya (1969) substantiated its Late Tithonian age based on the ammonites *Ptychophylloceras ptychoicum* (Qu.) and *Thysanolytoceras liebigi*. Permyakov et al. (1984), based on the above ammonites, as well as *Berriasella richteri* (Opp.) et al. confirmed the late Tithonian–Berriasian age of the formation. Studies by Drushchits (*Atlas* ..., 1960), Arkadiev (*Atlas* ..., 1997), Yanin and Baraboshkin (2000), showed that these ammonite species are widespread in the Berriasian deposits of the region. In the southwestern Crimea, they are found in the Bel'bek River basin in the Middle Berriasian. Unfortunately, Permyakov et al. did not indicate find sites and horizons in sections for these ammonite species in the area. There is only one report in the literature (Ovechkin, 1956) that specimens of the ammonite *Ptychophylloceras ptychoicum* were found at the ninth kilometer of the Bakhchisarai highway. It can be assumed that the author measured the distance to the north of the margin of the Yaila escarpment. In this case, the locality for this species was right on the highway, but its exact position remained unknown. One of the possible points is shown on the Geological Map of the Crimean Mountains (1984) 2.5 km north of Mount Bedenekyr near the Bakhchisarai Highway. Here on the map there is a small area of the undifferentiated (Upper Tithonian–Lower Berriasian) Bedenekyr Formation, surrounded by faults. The carbonate deposits of the Bedenekyr Formation on the northern slope of the Aipetri Yaila remained undivided for a long time, due to their great thickness (500 m according to Uspenskaya, 1969; 200–500 m according to Permyakov et al., 1984), poor exposure, development of tectonic faults of various types and sizes and the lack of a detailed description of specific sections with a poor distribution of faunal remains.

In 1986–1987, the present author explored carbonate outcrops in the upper part of the Bedenekyr Formation on the northern slope of the Aipetrinsky Yayla,

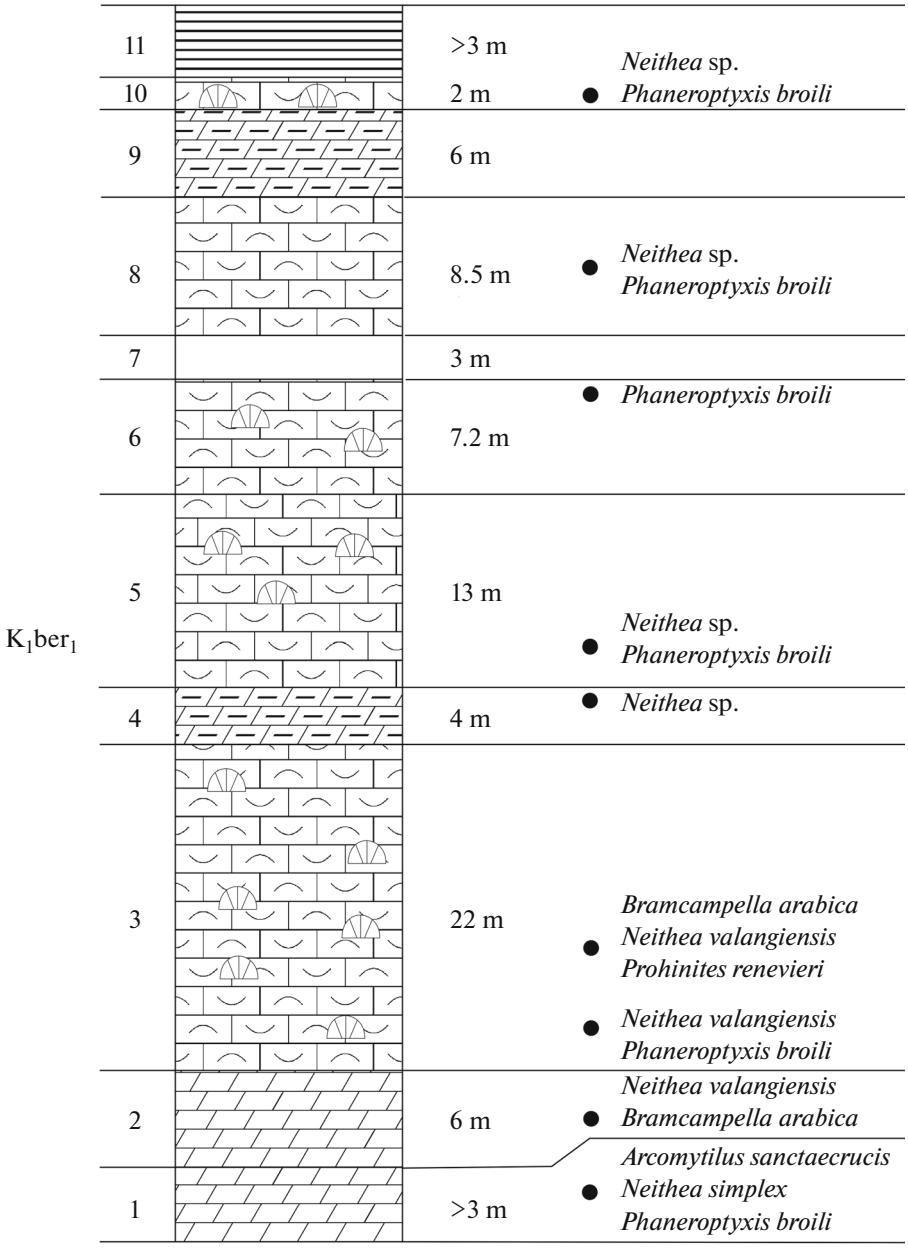


Fig. 5. Aipetri type section, no. 4, on the northern slope of the Aipetri Yaila (see explanations for Fig. 2).

in the area south of the Bolshoi Canyon. As a result of the subsequent comprehensive study of the fossil material carefully sampled from four outcrops, new data were obtained on the assignment of these deposits to the Lower Berriasian, which significantly clarifies the conclusions of F. Broili. Brief reports about this conclusion have been published (Gorbachik and Mohamad, 1997; Kuzmicheva, 2002). The Lower Berriasian section in this area was first described with paleontological material by the author (Yanin, 2020a). The species from the section were identified by: Fr and Tn—T.N. Gorbachik; Co—E.I. Kuzmicheva; Gs—N.I. Lysenko; Bv and Ech—B.T. Yanin; Al—I.Yu. Kalyuzhnaya.

Section Description (Fig. 5; first publication)

The section was compiled based on outcrops on steep slopes along the Bakhchisarai-Yalta highway, between road signs 36/34 and 37/33, above the spring near the tourist site. The underlying deposits are covered by the highway surface.

K_1ber_1. Bed 1 (visible thickness >3 m, exposed near the sign 37/33) interbedding (0.15–0.8 m) limestones, strongly marly, bioclastic in places, and interbeds

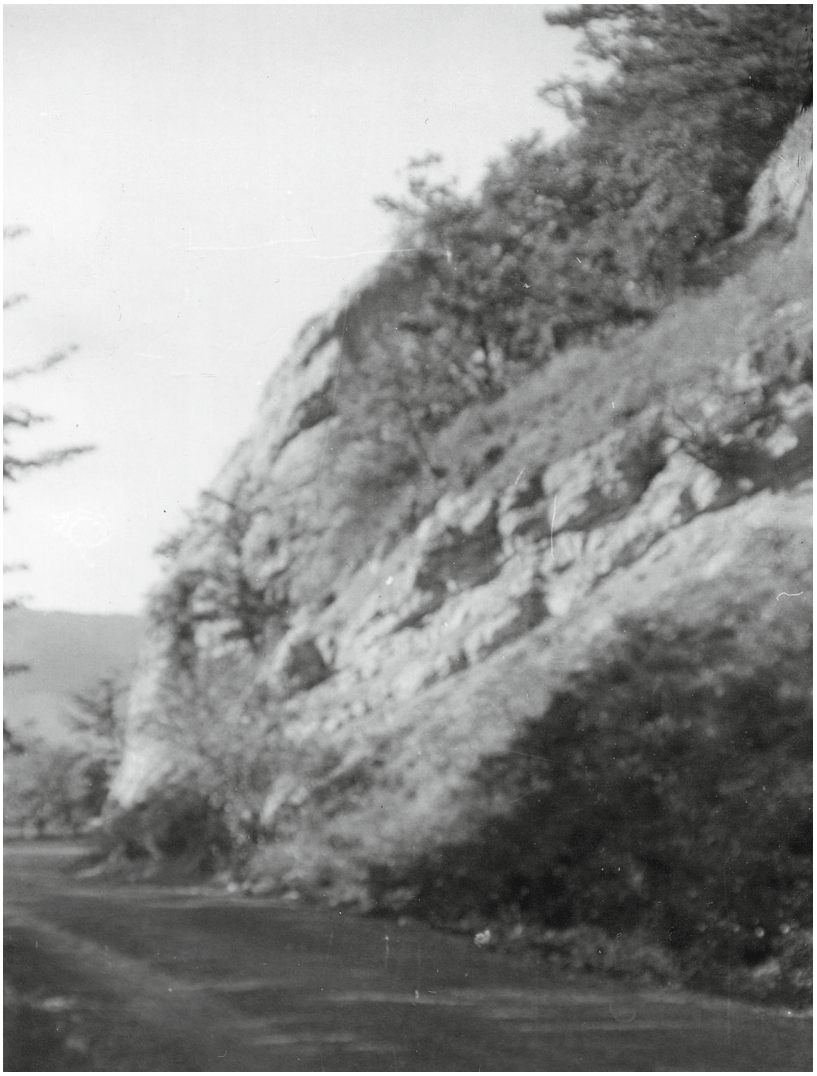


Fig. 6. Rock outcrop of bioclastic limestones at the sharp turn of the Bakhchisarai-Yalta highway, south of the Grand Canyon on the northern slope of Aipetri Yaila; Section no. 4, upper part of Bed no. 3; Lower Berriasian, *jacobi* Zone (photo by the author, 1986).

(0.2–0.4 m) marls and marly clay; Bv—*Arcomytilus sanctaecrucis, Neithea simplex, Protocardia broili;* Gs—*Phaneroptyxis broili*.

Bed 2 (6 m)—limestones and highly marly clays; Fr—*Bramkampella arabica* (Redm.); Bv—*Neithea valangiensis*.

Bed 3 (22 m)—limestones, gray, reddish in places, massive, nodular, bioclastic, with many colonies (15 × 42–25 × 32 cm) of corals and hydroids, shells of gastropods, oysters, brachiopods, echinoid spines, algal lumps; form a vertical wall rising above the highway at its sharp turn (Fig. 6); the beds dip 295 WNW at 34°; Gs—*Phaneroptyxis broili*; Bv—*Neithea valangiensis, Prohinnites renevieri*; Ech—spines of *Cidaris punctatissimus* (Ag.). This this limestone bed is here accepted as a marker horizon for correlation with the more northerly section on Mount Kizil-Kaya, where it is 23 thick. Bv—*Prohinnites renevieri* and *Protocardia broili* were found directly below the level of the marker horizon.

Bed 4 (4 m)—limestones, gray, marl, nodular in places; at the base of an interbed (0.6 m) of plastic clay; dip 340 NW, at 30°; Bv—*Neithea* sp.

Bed 5 (13 m)—limestones, massive, in places with biogenic bedding; oncolitic at the top of the bed; Bv—*Neithea* sp.; Gs—*Phaneroptyxis broili*.

Bed 6 (7.2 m)—limestones, bioclastic and detrital, with colonies of corals and chaetetids as lens-shaped banks (0.2 × 1 m); Fr—*A. lusitanica*; Gs—*Phaneroptyxis broili*.

Bed 7 (3 m)—gas in observation.

Bed 8 (8.5 m)—limestones, finely detrital; in the middle part massive, nodular; dip 290WNW at 32°; Bv—*Neithea* sp.; at layer level in a nearby highway outcrop: *Tortarctica weberi*; Gs—*Phaneroptyxis broili*.

Bed 9 (6 m)—limestones, gray, detrital; Bv—*Neithea* sp.

Bed 10 (2 m)—limestones, bioclastic and detrital, becoming along the strike massive, nodular, composed of colonies of corals and hydroids, forming bioherms up to 2 m high; Fr—abundant *A. lusitanica*; Bv—*Neithea* sp.; Gs—*Contortella* sp., *Phaneroptyxis broili*, *Umbonella macroumbilicata* Lys. et Al.

Bed 11 (visible thickness over 3 m)—clays, dark gray, silty, thin-bedded. Overlying deposits are not exposed.

Geological Age

The age of the described carbonate sequence is substantiated by the assemblage of species from different groups of organisms. Unfortunately, zonal ammonite species have not yet been found here. A report by Kuzmicheva (2002, p. 87) that on the "northern slope of the Aipetri Yaila...crops out a series of limestones and marls about 100 m thick, dated early Berriasian based on the presence of *Pseudosubplanites ponticus* Ret.", is shown to be erroneous.

I attribute the deposits described here to the Lower Berriasian based on the following criteria:

(1) Based on the stratigraphic position: the limestone series is clearly traceable in a number of typical sections in the Crimea based on its lithology. In this sections equivalent limestones are overlain by sandstones (Kuchki, Urkusta, Dolgorukovsky, and Beshterek sections) and clays (Saigin-Balki Section), containing the Middle Berriasian fossil assemblage of the *occitanica* Zone, *tauricum* Subzone.

(2) The limestones of the described section contain foraminifers characteristic of the Lower Berriasian, including the index species *Bramkampella arabica* (Kuznetsova and Gorbachik, 1985). The presence of this species in the Aipetri Section makes it possible to compare limestones with the upper part of the carbonate deposits of the Eli Formation in the Chernaya River basin, where, according to Fedorova (2000) this species is present. Based on foraminifers, I recognize the Beds with *Bramkampella arabica* in the Aipetri Section.

(3) This is in agreement with the macrofossil assemblage: the bivalve species *Arcomytilus sanctaecrucis, Neithea simplex, N. valangiensis*, and *Prohinnites renevieri* known from the lowermost part of the Lower Cretaceous in Western Europe; *A. sanctaecrucis* described in the Eastern Crimea, on the Tonas River, in the same clay unit together with the Lower Berriasian ammonite, index species *Pseudosubplanites grandis* (Maz.) (Arkadiev et al., 2005); *P. renevieri* also found in the Karabi Section together with the same species. According to *Treatise* (Cox and Newell, 1969), representatives of the genus *Neithea* first appeared only in Berriasian; they are widespread in the deposits of the Lower (*chaperi* beds) and Middle (*tauricum* Subzone) Berriasian of the Crimea; the gastropod species *Phaneroptyxis broili* is characteristic of the Upper Tithonian and Berriasian of the Crimea and Caucasus; according to N.I. Lysenko, in the Crimea, it was found in the Lower Berriasian of the Baidar valley (village of Vedovoe) and in the upper Berriasian in the basin of the Burulcha River. According to the above data, we attribute the described carbonate sequence on the northern slope of the Aipetri Yaila to the Lower Berriasian, to the equivalents of the *jacobi* Zone. The log of the Aipetri Section shows only its upper part (73 m), whereas the lower part recognized on the eastern slope of mountain Kizil-Kaya Mount. The presence in the sections of the marker horizon and the transitional Tithonian–Berriasian Zone allows determination of the apparent thickness of the Lower Beriassian deposits, equal to 155 m (including 15 m from the transitional zone). Below the transitional zone, the beds contain the Upper Tithonian foraminiferal species *Pseudospirocyclina mayanci* Hott. The apparent thickness of the Upper Tithonian deposits is here 51 m. The lower horizons of the Bedenekyr Formation are exposed in the middle and lower parts of the eastern slope of Mount Kizil-Kaya and in the vicinity of Mount Bedenekyr.

Based on the occurrences of the foraminiferal species *Pseudospirocyclina mayanci* and *Bramkampella arabica*, the carbonate series of the Kizil-Kaya Section can be subdivided into two parts: lower, Beds with *P. mayanci* (Upper Tithonian) and upper, Beds with *B. arabica* (Lower Berriasian). I consider them as subformations. Thus, the previously undivided Bedenekyr Formation was subdivided into two subformations: the Lower and Upper Bedenekyr Formations (Yanin, 2020a, b).

Bel'bek Section

The section was compiled from outcrops on the right side of the Kabani Log Ravine, which flows into the Bel'bek River on the right in the area of road sign 15/57 on the Bakhchisarai-Sokolinoe highway, 1.7 km southeast of the village of Kuibyshevo (=Albat). The units identified in it are easily traced to the east, in the Bezymianny and Orekhovy ravines on the southern slopes of the Konglomeratovaya and Karatlykh mountains, 2 km northeast of the village of Golubinka (=Fotisala).

Lower Berriasian deposits are represented by a conglomerate series. The Middle Berriasian is composed of siltstones, sandstones and coquina, in places with abundant fossils. Among them, a representative ammonite assemblage, including an index species, was identified, which enables correlation with the standard scale. Tectonically, the Berriasian deposits form a monocline with a total dip 300NW at 18°. They are confined to the southeastern slope of the Kacha Uplift (Geologicheskoe stroenie, 1989). The area with the

described section is complicated by longitudinal and sublatitudinal faults.

The Bel'bek section has a long history of study, with over 60 studies on its stratigraphy and paleontology in monographs and atlases. It was studied by authors various geological institutions in Russia, Ukraine and Georgia. The section has long been considered a classic section for the Berriasian of the southwestern Crimea and was proposed as a type section. (Drushchits, 1975: "Belbeck-type section"; Bogdanova et al., 1981: "Belbek-type section") or "reference section" (Arkadiev in Baraboshkin et al., 2016). I examined this section on many occasions 1956 to 1990.

Karakasha (1907) was the first to publish on the stratigraphy of the deposits of the region. The Lower Cretaceous deposits of the Bel'bek region have been studied particularly intensely since the middle of the 20th century. Stratigraphy and paleontology of the Berriasian deposits of the area under consideration with a graphic representation of the section (log) has been published in many works (Drushchits, 1956; Drushchits and Yanin, 1958; Zeisler, 1959; *Atlas* ..., 1960; Drushchits, 1975; Gorbachik et al., 1975; Kravtsov, Shalimov, 1978; Bogdanova et al., 1981, 1999; Yanin and Smirnova, 1981; Yanin in *Geologicheskoe stroenie* ..., 1989; Arkadiev in *Atlas* ..., 1997; Yanin and Baraboshkin, 2000; Yanin, 2004; Arkadiev et al. , 2012; Baraboshkin et al., 2016).

The Lower and Middle Berriasian deposits in the studied region contain abundant and diverse fossil assemblages. The description of species of the main groups of fossils is given in many works: Foraminifera (hereinafter Fr) (Gorbachik and Shokhina in *Atlas* ..., 1960; Kuznetsova and Gorbachik, 1985); corals (Kr) (Kuzmicheva in *Atlas* ..., 1960; Kuzmicheva, 2002; I. Bugrova in *Atlas* ..., 1997); gastropods (Gs) (Golovinova and Kostyuchenko in *Atlas* ..., 1960; Golovinova and Korobkov in *Atlas* ..., 1997); bivalves (Bv) (Muromtseva in *Atlas* ..., 1960; Yanin, publications 1958–1989; Yanin, 2004; Bogdanova and Yanin, 1995; Bogdanova et al. in *Atlas* ..., 1997); ammonites (Am) (Drushchits in *Atlas* ..., 1960; Atabekyan et al. in *Atlas* ..., 1997; Arkad'ev, 2007; Baraboshkin et al., 2016; Arkadiev et al., 2012); belemnites (Bl) (Kabanov in *Atlas*..., 1960; Kabanov, 1967); brachiopods (Br) (Smirnova in *Atlas* ..., 1960; Lobacheva et al. in *Atlas* ..., 1997; Lobacheva and Smirnova, 2006); sea lilies (Ml) (Klikushin in *Atlas* ..., 1997); marine echinoids (Me) (Soloviev, 1971; Tour to *Atlas* ..., 1997).

Section description (Fig. 7)

The underlying deposits are shales of the Tauride formation.

K_1ber_1. Member I, Bed 1 (in the Kabaniy Log, only the upper 3 m of the member is exposed; in the more easterly ravines it reaches 40 m)—conglomerates, dark and brownish-gray, brownish-red, mostly medium pebble (35–50 mm); often there are boulders and poorly rounded fragments up to 20 cm in diameter (Fig. 8); conglomerates polymictic: quartz, quartzite, siltstone, sandstone predominate, to a lesser extent mudstone, igneous and metamorphic rocks; at different levels in the member there are lenses of brown shales and cross-bedded sandstones; deeply eroded conglomerates rest on Taurian shales; their thickness in the northeast direction decreases from 40 m in the Bel'bek River basin (Fig. 9) to several meters on Mount Kaya-Tepe on the left side of the Kacha River (they are absent in the river valley).

K_1ber_2. At the base of Member II (Bed 2), there is a basal horizon of quartz conglomerates that fill irregularities on the eroded surface of the underlying rocks of Member I, from which they differ in the absence of boulders and a more uniform composition of pebbles and gravel grains. In the Kabaniy Log, the conglomerate forms a slab (0.3 m), and to the east, in the Bezymyanny Ravine, instead of one dense slab, there is an alternation of loose quartz pebbles and slabs of strongly cemented conglomerates with a total thickness of 1.7 m. The conglomerates of the Kabaniy Long contain: Fr—*Epistomina caracolla* (Roem.), *Lenticulina* ex gr. *macra* Gorb., *Trocholina alpina* Leup. In the Bezymyanny Ravine, the conglomerates yielded: Bv—*Entolium germanicum*, *Gervillella anceps, Globocardium sphaeroideum, Linotrigonia belbekensis, Neithea valangiensis, Pterotrigonia caudata*, *Sphaera belbekensis*; Br—*Sellithyris uniplicata* Sm.; Ech—*Toxaster* sp.

The overlying beds 3–11 (10.5 m) of Members II and III are composed of alternating beds (1–2 m) of loose and loosely cemented sandstones and arenaceous siltstones and slabs (0.5–1.5 m) of highly calcareous, dense sandstones (Figs. 10a, 10b). Microscopic examination of sandstones has shown that they are composed of angular, unrounded grains of quartz, plagioclase, bioclastic detritus, and debris of thick-walled bivalve shells and serpulid tubes. There is a gradual increase in the carbonate content of rocks in the upper part of Member III due to the cementing material and the appearance of small oncolites. As a result of uneven weathering of rocks, the slope of the ravine has a stepped character. Separate interbeds and slabs contain abundant remains of invertebrates, mainly bivalve shells, forming coquinas and, in places, "shell pavements", indicating an active wave sedimentation environment (Figs. 10, 11). Siltstones and sandstones at different levels of Members II and III contain numerous remains of various groups of organisms. Species definitions are given here only for ammonites and bivalves (for a more complete list, see Yanin and Baraboshkin, 2000).

Am (as identified by Drushchits in Atlas, 1960, Drushchits, 1975)—*Dalmasiceras crassicostatum*, *D. dalmasi* Pict., *Euphylloceras serum* Opp., *Haploceras carachtheis*, *Holcophylloceras calypso* (d'Orb.),

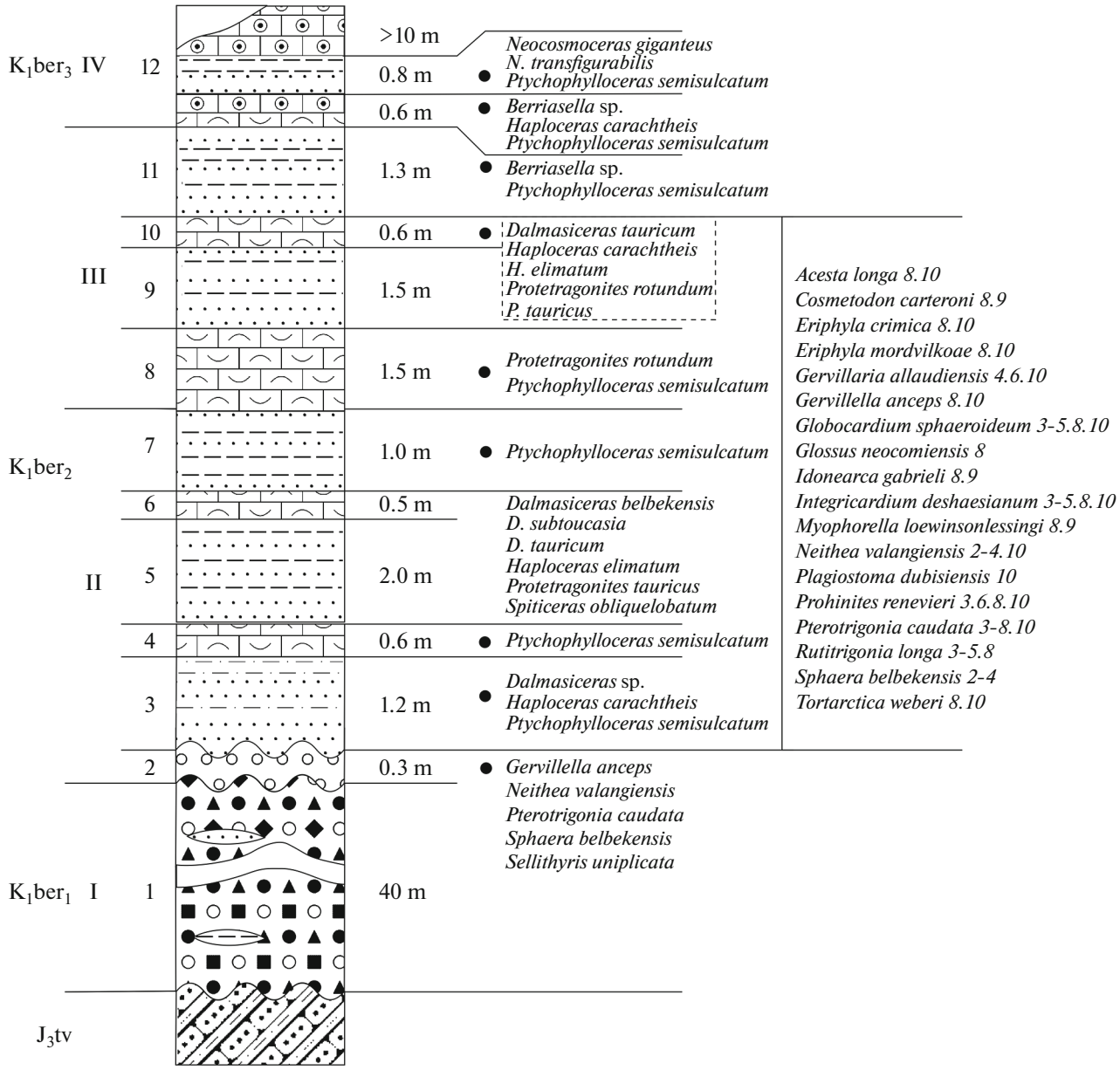


Fig. 7. Bel'bek type section, no. 5, in the Kabanii Log, vicinity of the village of Kuibyshevo (see explanations for Fig. 2).

Protetragonites rotundum (Drusch.), *P. tauricus*, *Ptychophylloceras semisulcatum*; according to Arkadiev (2012) (see Baraboshkin et al., 2016)—*Dalmasiceras* belbekensis Bogd. et Ark., *D. subtoucasi* Bogd. et Ark., *D. tauricum* Bogd. et Ark., *Haploceras elimatum* (Opp.), *Protetragonites tauricus*, *Ptychophylloceras inordatum* (Touc.), *P. semisulcatum*, *Spiticeras obliquelobatum* (Uhl.); Bv—*Acesta longa, Arcomytilus couloni, Ceratosteon tuberculiferum, Cosmetodon carteroni, Entollium germanicum, Eriphylla crimica, E. mordvilkoae, Fimbria berriassica, Garum valangiensis, Gervillaria allaudiensis, Gervillella anceps, Globocardium sphaeroideum, Glossus neocomiensis, Goniomya villersensis, Gryphaea weberae, Idonearca forbesi, I. gabrielis, Inoceramus belbekensis, Inoperna taurica, Integricardium deshayesianum, Limatula tombeckiana, Linotrigonia belbekensis, Myophorella loewinsonlessingi* (Renng.), *Neithea simplex, N. valangiensis, Oxytoma cottaldina, Panopea neocomiensis, Pholadomya gigantea, Plagiostoma aubersonensis, P. dubisiensis, Platymyoidea marullensis, Prohinnites renevieri, Protocardia peregrina, Pterotrigonia caudata*, *Ptychomya robinaldina, Rutitrigonia longa, Sphaera belbekensis, Spondylopecten subspinosus, Tortarctica weberi.*

K_1ber_3. Overlying Upper Berriasian, Member IV, Bed 12 (1.4 m): in the lower part (0.6 m)—a slab (fifth of the basal quartz conglomerates) of calcareous, dense, greenish-gray sandstone-shell rock, with

Fig. 8. Series of polymictic conglomerates (40 m) in the left bank of the Bel'bek River, near the western vicinity of the village of Putilovka; corresponds to the base of Section no. 5, Member I; Lower Berriasian, *jacobi* Zone (photo by the author, 1956).

numerous small algal oncoids; above (0.8 m) sandy siltstones with ammonites (according to V.V. Arkadiev in Baraboshkin et al., 2016, excursion 5A)—*Fauriella rarefurcata* (Pict.), *Lytoceras honnorati* (d'Orb.), *Malbosiceras malbosi* (Pict.), *Neocosmoceras* cf. *transfigurabilis* (Bog.), *N. giganteus* Ark. et Bogd., *Ptychophylloceras semisulcatum*.

Geological Age

The section contains: the Lower Berriasian (*jacobi* Zone), Middle Berriasian (*occitanica* Zone, *tauricum* Subzone) and Upper Berriasian (*boissieri* Zone, *euthymi* Subzone).

K_1ber_1. Member I, Lower Berriasian, *jacobi* Zone: polymictic conglomerates (40 m). Their age determination was changed many times as the stratigraphy of the Lower Cretaceous of the Southwestern Crimea was emended. They belonged to: the Neocomian (Karakash, 1907); Tithonian (Moiseev, 1927); Upper Jurassic (Weber, 1937; Drushchits in *Atlas* ..., 1960; Drushchits, 1975); Valanginian (Odessky, 1969); lower Valanginian (Eristavi, 1957; Muratov, 1947, 1960, 1973; Drushchits et al., 1958; Lychagin, 1969); Berriasianu (Zeisler, 1959; Lichagin and Permyakov, 1971; Kravtsov and Shalimov, 1978; Arkadiev in *Atlas* ..., 1997; Arkadiev et al., 2012); lower Berriasian (Gorbachik et al., 1975; Yanin et al., 1981; Yanin in *Geol. structure* ..., 1989; Kuznetsova and Gorbachik, 1985; Aliev et al., 1985; Drushchits et al., 1986; Yanin and Baraboshkin, 2000: provisionally; Yanin, 2004). In this work, I assigned polymictic conglomerates to

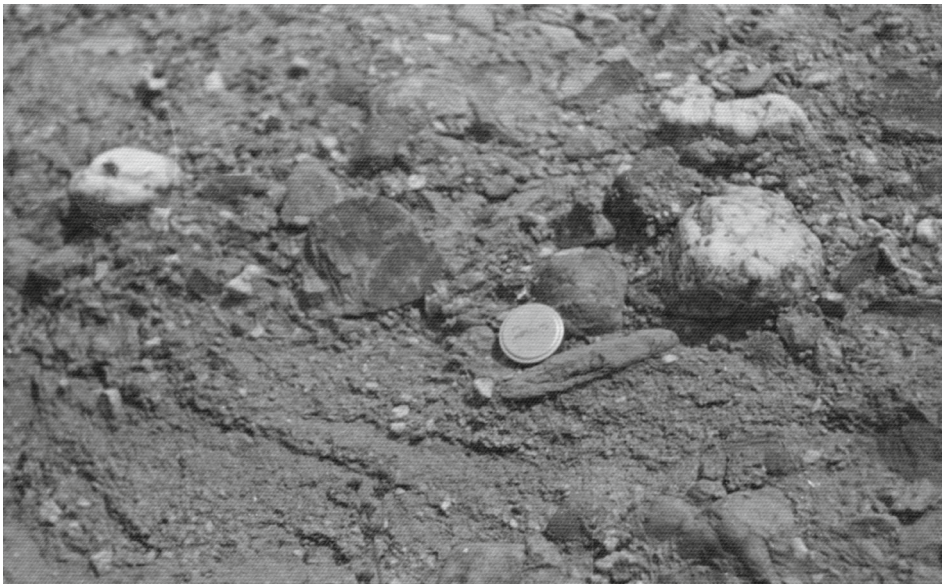


Fig. 9. Polymictic conglomerates, consisting of poorly rounded fragments of dark-colored sandstones and siltstones of the Tavria Formation and rare quartz boulders (up to 0.2 m in diameter); basin of the Bel'bek River, southern slope of Mount Konglomeratovaya, nameless ravine northwest of the village of Golubinka; corresponds to Member I, Bed 1 in section no. 5 (Kabaniy Log); Lower Berriasian, *jacobi* Zone (photo by the author, 1956).

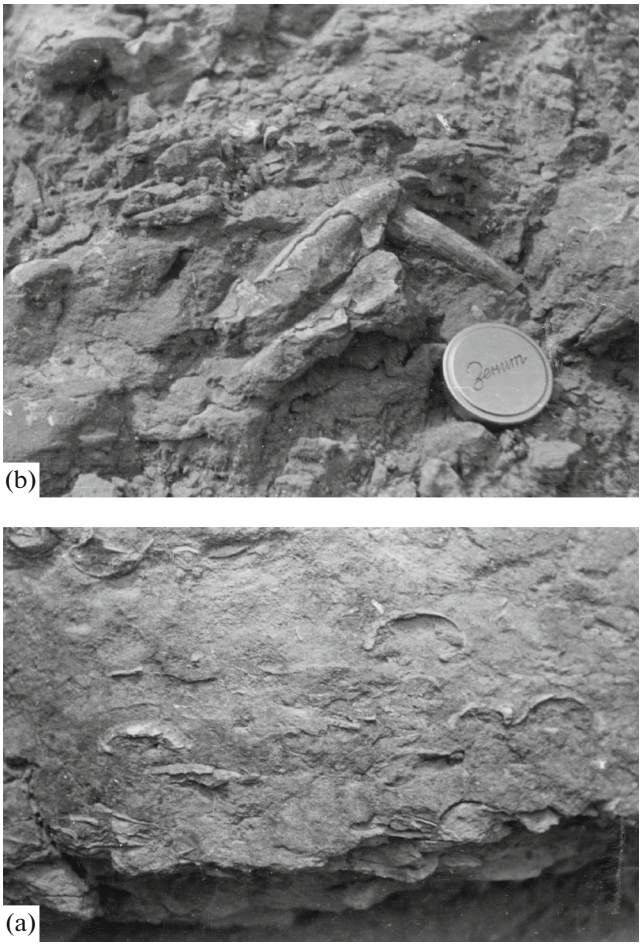


Fig. 10. Orientation of isolated valves of bivalves in dense calcareous sandstone-shell rock: (a) "shell pavement" of large valves of *Integricardium deshayesianum*, convexly oriented upwards; their long axes are parallel to the bed bedding plane (×1/3); (b) accumulation of *Gervillella anceps* valves on the top of the sandstone slab; valves are convexly directed upwards (× 1/2); (a) and (b) Bel'bek River basin, vicinity of the village of Kuibyshevo, Kabaniy Log; section no. 5, Member III, Bed 10; Middle Berriasian, *tauricum* Subzone (author's photo, 1963).

the *jacobi* Zone tentatively, since they did not contain ammonites index species or other characteristic taxa.

There are published data on fossils in the series of polymictic conglomerates of the Bel'bek Section. For instance, Weber (1937) was the first to report the discovery of an imprint of a Jurassic ammonite shell, which was similar to *Perisphinctes transitorius* Opp., but this is not confirmed by new finds of this species. In addition, Drushchits et al. (1958) reported on the discovery of the Valanginian foraminifers *Epistomina (=Hoeglundina) caracolla caracolla* Bart. et Brand and bivalves *Sphaera* ex gr. *corrugata* at the top of the conglomerate series in the Kabaniy Log. Kravtsov and Shalimov (1978) found bivalves *Myophorella loewinsonlessingi* in the cement of the conglomerate in the Orekhovyi Gully, which are typical of the overlying cyclic series. Upon further study of this outcrop, it turned out that the shells of this species are confined not to the top of polymictic conglomerates, but to the overlying horizon of alternating quartz conglomerates, sandstones and siltstones (here Member II, Bed 2).

A detailed examination of the contact zone between the polymictic and quartz conglomerates in the Bezymyannyi Ravine (1.2 km east of the Kabany Log) showed that their interface is uneven; overlying quartz conglomerates form a horizon (1.5 m) of loose, sandy pebbles with a slab (0.2 m) of strongly cemented calcareous conglomerate. Loosely cemented beds in this section contain: Bv—*Gervillella anceps, Entolium germanicum, Neithea valangiensis, Pterotrigonia caudata*, *Linotrigonia belbekensis*, *Sphaera belbekensis, Globocardium sphaeroideum*; Br—*Sellithyris uniplicata*, indicating that the quartz conglomerate and sandstone belong to the Middle Berriasian cyclic series (Yanin and Baraboshkin, 2000). Thus, my new data refute the above reports of Valanginian or Berriasian fossils found in polymictic conglomerates and therefore cannot be accepted as facts to prove their age. It can be stated that there are still no reliable data on the age of polymictic conglomerates. Here, as before (Yanin and Baraboshkin, 2000), I provisionally attribute them to the Lower Berriasian based on their position directly below the Middle Berriasian intercalation unit. This view is also shared by Arkadiev (in Baraboshkin et al., 2016, excursion 5A), who described the Bel'bek Section as a reference section. It should be noted that these conglomerates underlie the Middle Berriasian sandstones at a considerable distance within the Bel'bek structural-facies zone (from the village of Bogatoye Gorge in the west to Mount Kaya-Tepe in the northeast), being, most likely, basal conglomerates of the Early Berriasian transgression.

K_1ber_2. Members II and III, Middle Berriasian, *tauricum* Subzone: alternation of siltstones and sandstones (10.5 m). The deposits have a long history of stratigraphic and paleontological study. They were assigned to: the Neocomian (Karakash, 1907); Hauterivian (Muratov, 1947; Drushchits, 1956); Valanginian (Weber, 1937); the Lower Valanginian (Eristavi, 1957: *Spiticeras negreli* Zone; Drushchits et al., 1958; Lychagin, 1969; Muratov, 1960, 1973; Zeisler, 1959); Berriasian (Plotnikova et al., 1976; Kravtsov et al., 1978; Arkadiev in *Atlas* ..., 1997; Gorbachik et al., 1975: *Euthymiceras euthymi-Dalmasiceras dalmasi* Zone; Yanin et al., 1981: the same Zone); Lower Berriasian: *Dalmasiceras dalmasi* Zone (Drushchits, 1975), *D. crassicostatum* local Zone (Bogdanova et al., 1981, 1999; Yanin and Baraboshkin, 2000); *occitanica* Zone, *tauricum* Subzone (Arkadiev, 2012; Baraboshkin et al., 2016); Upper Berriasian: *Euthymiceras euthymi-Dalmasiceras dalmasi* Zone (Aliev et al., 1985; Drushchits et al., 1986; Yanin et al., 1989).

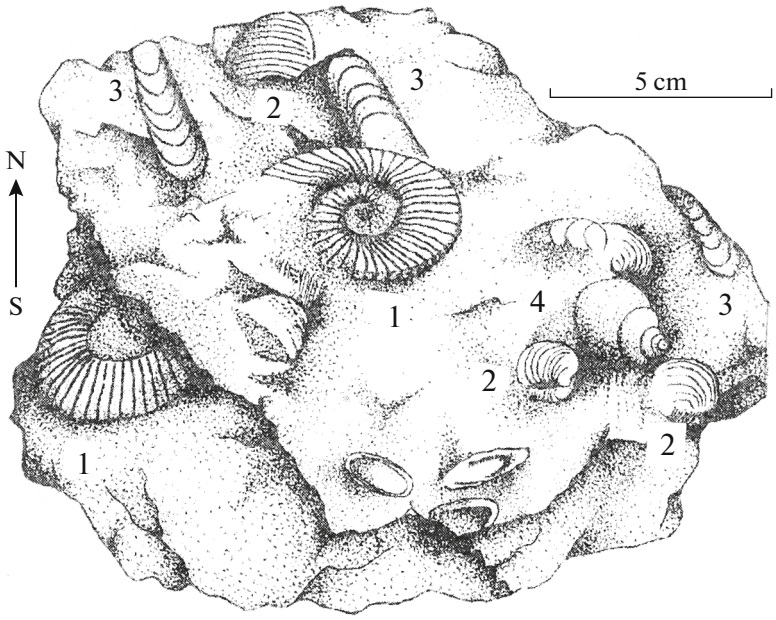


Fig. 11. Sandstones-coquinae with remains of ammonite shells (1), bivalves (2) *Eriphyla crimica*, (3) *Gervillella anceps*), gastropods (4) and others; Bel'bek River, Kabaniy Log; Middle Berriasian, *tauricum* Subzone; correspond to Member III in Section no. 5 (field drawing by V.V. Arkadiev, 2012, text-fig. 32).

Arkadiev et al. (2012), based on the revision of Drushchits's ammonite collection (*Atlas* ..., 1960), proposed for the index species *D. crassicostatum* to be considered as a synonym for the new species *D. tauricum*. Therefore, we, according to the point of view of Arkadiev et al. (2012) and Arkadiev (in Baraboshkin et al., 2016), the Members II and III deposits are assigned to the Standard *occitanica* Zone and the Regional *tauricum* Subzone. According to the tripartite subdivision of the Berriasian adopted in this work, I consider these deposits to be Middle Berriasian.

Dolgorukovsky

The section is composite, compiled along the meridional line: Mount Kolbair in the south, areas of the villages of Glubokoe and Ivanovka in the north. The Berriasian deposits of the Dolgorukovsko-Ivanovskaya Zone are the westernmost outcrops in the territory of the Central Crimea. They are represented by shallow-water facies with numerous lenses and rapidly wedging out interbeds of sandstones, pebbles and conglomerates, indicating intensive erosion of the western shores of the basin, composed of Bairakli conglomerates. These Lower Berriasian facies differ considerably from the coeval formations of the more eastern regions of the Central Crimea.

Tectonically, the deposits of the Lower Berriasian described here are monoclinal with a general northwestern dip (310°–350° NW at 8°–10°). Along the western slope of the Dolgorukovskaya Yaila, they are cut off by a meridional regional fault. On the northern slope of the yaila, low-amplitude sublatitudinal faults are established, which cause an undulating terrain, which makes it difficult to correlate the distinguished layers and Members, as well as distorting their true thickness. Lower- and middle-Berriasian deposits, exposed to the north, in the area of the village of Ivanovka, on the contrary, have almost the opposite dip 120° SE at 8°. This occurrence indicates a large sublatitudinal tectonic fault in the northern part of the monocline, associated with the Dolgorukovsky fault or representing a thrust structure. As reported in a number of works on the regional tectonics (e.g., Mileev et al., 1995), Dolgorukovskaya Yaila has a very complex scale-folded structure.

I studied this section in many occasions in 1975, 1976, 1986, 1990 and together with N.I. Lysenko in 1987. Separate parts of the section have been published (Lysenko and Yanin, 1979; Yanin et al., 1981; Yanin, 2004). In the area under consideration, the lower I–IV members of the section are well exposed on the northern slope of Dolgorukovka between Mount Kolbair and the Terenair Ravine; Members IV (upper part)—X on the right side of this ravine, in the vicinity of the village of Glubokoe (=Terenair), and members XI–XII—near the village of Ivanovka. The fossil lists in the description and the log are cited according to: Fr (Mamontov), Gs (Lysenko), Am (Drushchits), Bv (Yanin), Br (Lobachev), and ichnofossils (Yanin).

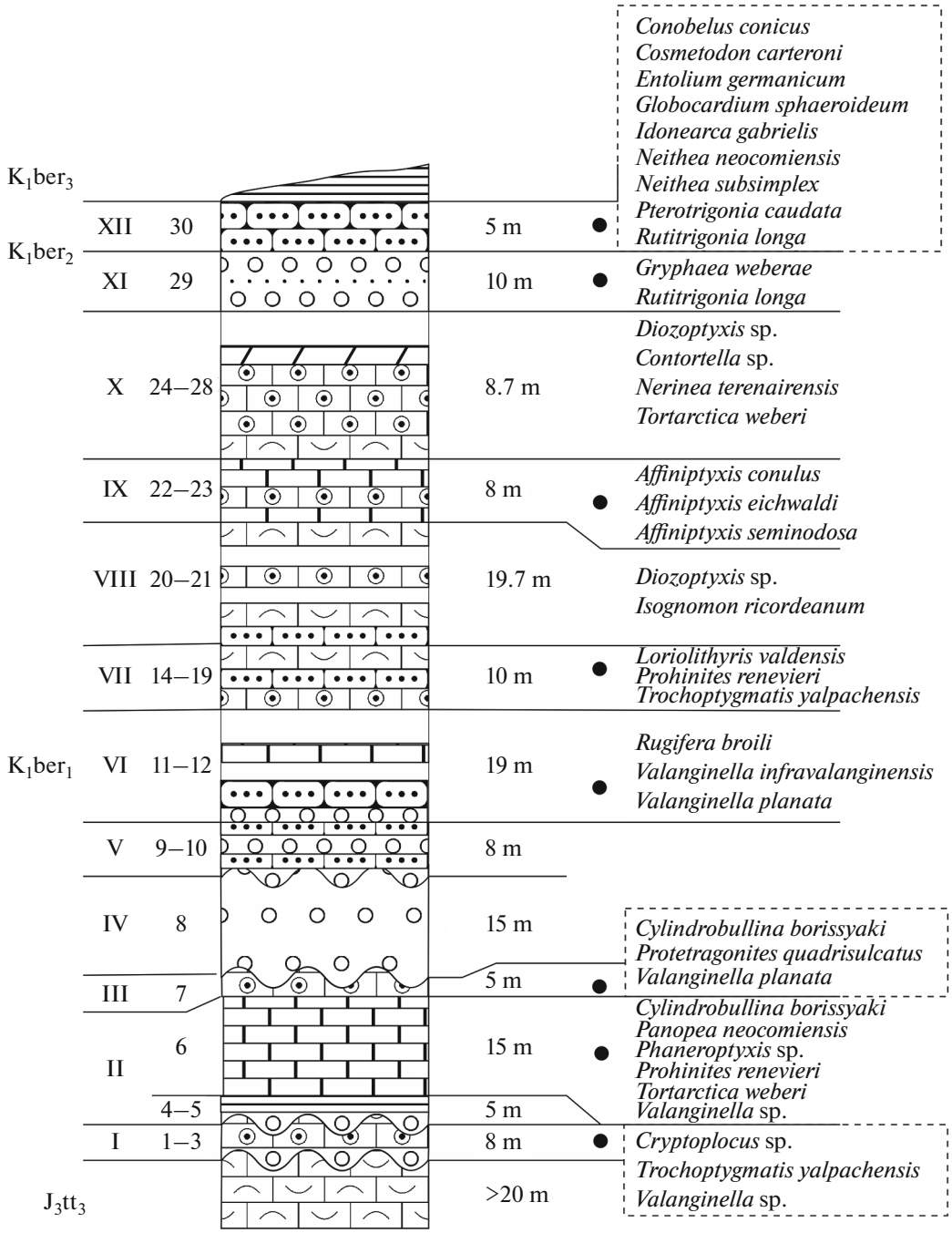


Fig. 12. Dolgorukovsky type section, no. 6, in the region of the Kol'bair Mountain, villages Glubokoe and Ivanovka (see explanations for Fig. 2).

Section Description (Fig. 12)
(never published previously)

J_3tt_3. The underlying deposits are a series (>20 m) of, gray, bioclastic and oncolitic limestone, with quartz pebbles and dark-colored rocks; the top of the limestone is uneven, covered with a limonite crust; I provisionally accept it as the Tithonian-Lower Berriasian boundary, which is well exposed on the northwestern side of Mount Kolbair; the limestones here dip 310° NW at 10°–12°.

K_1ber_1. Member I (8 m; rocks compose the northern gentle slope of Mount Kolbair), an alternation of dense limestone slabs and loose sandy-clayey beds.

Bed 1 (2 m)—clayey-sandy interbed with an abundance of algae nodules, gastropod and rudist shell fragments; at the base with pebbles of quartz and dark-

colored limestones; Gs—*Cryptoplocus* sp., *Trochoptygmatis yalpachensis* (Fogdt); Rd—*Heterodiceras* sp.; at the top of the bed, a slab (0.35 m) of limestone, cream-colored, small-oncolitic, with an abundance of the gastropods *Valanginella* sp.

Bed 2 (3 m)—slabs (0.5 m) of limestone, light gray, oncolitic, with an abundance of solitary corals and rare dark-colored limestone pebbles.

Bed 3 (3 m)—slabs (1 m) of limestone, gray, oncolitic, marly in places.

Member II (20 m)—limestones of different composition; pebbly horizon at the base; rocks traced for a considerable distance along a field road; due to the development of transverse sublatitudinal faults, the duplication of individual parts of the member is possible, which, most likely, can explain the overall greater thickness (275 m) of the carbonate stratum indicated earlier in the article by Lysenko et al. (1979).

Bed 4 (0.5 m)—pebblestone and weakly cemented polymictic conglomerate, consisting of quartz pebbles, quartzite, dark-colored Bairakli conglomerates and underlying oncolitic limestones, with rare well-rounded boulders (up to 20 cm) of limestones, pebbles from algae and skeletons of solitary corals; the top of the underlying limestones in Bed 3 is heavily eroded.

Bed 5 (2 m)—gap in observation.

Bed 6 (15 m)—limestones, gray and bluish-gray, dense, splintered, marly, in places finely detrital, oncolitic, with rare (poorly preserved) ammonite molds, bivalves, gastropods, echinoids and crayfish burrows; upward marl content in the rocks increases; Gs—*Contortella* sp., *Cylindrobulina borissjaki* Pchel., *Valanginella* sp.; Bv—*Heterodiceras* sp., *Panopea neocomiensis*, *Pinna* sp., *Prohinnites renevieri*, *Tortarctica weberi*, large oysters; Ech—spines of regular echinoids; ichnofossils *Thalassinoides suevicus* (Rieth.). Especially abundant fossils were found in calcareous marls in the dumps of ditches 500 m north of Mount Kolbair. In the abundance of fossils, their systematic composition and state of fossil preservation, this locality is close to that in the area of the Kazanly well (see the Karabian type section, "bulldozer clearing"), from where Bogdanova et al. (1981) reported *Pseudosubplanites ponticus*, a Lower Berriasian zonal ammonite.

Member III. Bed 7 (5 m)—alternation of oncolitic and bioclastic, predominantly gastropod, locally marl limestones and thin beds of calcareous clay with ammonite and gastropod molds; Am—*Protetragonites quadrisulcatum* (d'Orb.); Gs—*Cylindrobulina borissjaki, Valanginella plana* et al.

Member IV. Bed 8 (15 m)—conglomerates, predominantly quartz, with an abundance of dark-colored limestone pebbles, redeposited during erosion of the Bairaklin-type conglomerates; are exposed in small quarries in the vicinity of the village of Glubokoe; conglomerates lie on the uneven, heavily abraded surface of the underlying limestones

Member V (8 m)—predominantly terrigenous rocks.

Bed 9 (5 m)—alternation of quartz conglomerates (with rare pebbles of mafic limestones) and sandstones with interbeds (0.6 m) arenaceous and oncolitic limestones and clays; upward, the conglomerates include smaller pebbles and are gradually replaced by sandstones and limestones; Fr—*Anchispirocyclina lusitanica*; Gs—*Rugifera broili*, *Valanginella infravalanginensis*, *V. plana*.

Bed 10 (3 m)—quartz conglomerates.

Member VI (19 m)—alternation of sandstones, limestones and clays.

Bed 11 (4 m)—alternation of sandstones and oncolitic limestones; sandstones and cross-bedded sands, coarse-grained, polymictic, with lenses (8–10 cm) of pebbles of dark-colored limestones and quartz pebbles; Bv—*Prohinnites renevieri*; Gs—*Rugifera broili, Valanginella infravalanginensis, V. plana*.

Bed 12 (1.5 m)—limestones, gray, marly, bedded, with numerous oysters.

Bed 13 (14 m)—in the lower part there is a scree on limestones; in the middle, a slab (0.4 m) of gray, dense, fine-oncolitic limestone; in the upper part of the bed, a scree on clays; at the top, a bed (2 m) of grey, coarse-grained, highly calcareous sandstone.

Member VII (10 m)—predominantly carbonate rocks.

Bed 14 (1.5 m)—limestones, gray, marl, bedded, with oysters.

Bed 15 (2 m)—limestones, light gray, strong, massive, bioclastic and oncolitic, with large oysters; on the slope form a clearly defined plate.

Bed 16 (1.5 m)—sandstones and conglomerates with rare boulders (up to 15 cm); in the talus: Cor—*Montlivaltia* sp.; Bv—*Ceratostreon* sp., *Prohinnites renevieri*; Br—*Loriolithyris valdensis* (Lor.).

Bed 17 (2.5 m)—limestones, light-gray, marly; Gs—*Affiniptyxis* sp.

Bed 18 (1 m)—limestones, finely oncolitic, indistinctly bedded, with oysters.

Bed 19 (1.5 m)—sandstones, coarse-grained, with small quartz pebbles and oysters; Gs—*Trochoptygmatis yalpachensis*.

Member VIII (19.7 m)—limestones.

Bed 20 (5 m)—limestones, light gray, finely oncolitic, marly in places, with an abundance of bivalves (*Isognomon* coquinas); Bv—*Isognomon ricordeanum*.

Bed 21 (14.7 m), poorly exposed interval covered by scree over limestones; at the base is a slab (0.7 m) of bioclastic limestone; in the middle is a slab (0.6 m) of oncolitic limestone; four meters above it is a slab (0.3 m) of gastropod limestone; Gs—*Diozoptyxis* sp., *Leviathania* sp.; Bv—*Prohinnites renevieri*.

Member IX (8 m)—limestones.

Bed 22 (3 m)—limestones, light-gray, with abundant gastropods; Gs—*Affiniptyxis seminodosa* (Eichw.) et al.

Bed 23 (5 m)—limestones, finely oncolitic; Gs—*Diozoptyxis* sp.

Member X (8.7 m)—alternation of bioclastic and oncolitic limestones.

Bed 24 (2.5 m)—limestones, oncolitic clastic, light-gray and yellowish-gray; form a lower ledge on the slope; Gs—*Contortella* sp., *Nerinea* sp., *Ptygmatis* sp.; Bv—small rudists *Valletia* sp., large oysters.

Bed 25 (0.25 m)—a slab of yellowish gray limestone with quartz pebbles and skeletal fragments of sponges, gastropod shells, colonial branched corals and algae nodules; Bv—*Tortarctica* sp.

Bed 26 (2 m)—limestones, nodular, biogenic bedding, with massive colonies (0.3 × 0.4 × 0.5 m) of corals; Gs—*Contortella* sp., *Nerinea terenairensis* Pchel.

Bed 27 (2 m)—limestones, yellowish-gray, oncolitic; form the upper ledge of the plateau; Gs—*Nerinea terenairensis*.

Bed 28 (~2 m)—limestones, marl, form a gentle slope of the top, rising above the right side of the Terenair Ravine, overlain by concretion-bearing sandstone exposed in sand pits.

The continuation of the section could be observed to the north, in the vicinity of the village of Ivanovka, and along a gully to the west of the line of poplars on the right side of the Maly Salgir River. A partial description and image of this section interval was first given by us earlier (Yanin, 2004). For the Ivanovo part of the section, a number of papers and atlases describe some fossils: Fr (Mamontova, 1972), Gs (Pchelintsev, publications 1924–1965; Golovinova, Kostyuchenko in *Atlas* ..., 1960), Bv (Yanin, 2004).

K_1ber_2. Member XI, Bed 29 (10 m)—clays and siltstoneseds, with lenses and interbeds of loosely cemented and unconsolidated cross-bedded sandstones and conglomerates; at the base with a horizon (10 cm) of basal conglomerates with pebbles (1–4 cm) of oncolitic limestones and dark-colored Bairakli conglomerates; the horizon lies on the uneven abraded surface of the top of limestones, which are compared with similar lower "Solovjev" limestones (see Beshterek type section); clay beds abundantly contain Gs—*Valanginella infravalanginensis*, sandstones contain Bv—*Gryphaea weberae, Rutitrigonia longa, Tortarctica weberi*.

Member XII, Bed 30 (5 m)—alternation of interbeds of dense, highly calcareous sandstones, with pebbles (4 cm) of quartz, loose, bedded sands and slabs of bioclastic and nodular oncolitic limestones; dense sandstones contain a huge number of remains of various organisms, as a rule, fragmented and randomly oriented; only in places a "shell pavement" is slightly developed containing valves of *Trigonia*; serpulids—*Filograna* sp.; Cor—solitary *Montlivaltia intumescens* (Trd.); Bv—*Ceratostreon tuberculifera, Cosmetodon carteroni, Entolium germanicum, Fimbria berriassica, Gervillia gottschei, Globocardium sphaeroidea, Gryphaea weberae, Idonearca gabrielis, Isognomon* sp., *Monopleura* sp., *Neithea neocomiensis, N. subsimplex, Plagiostoma dubisiensis, Prohinnites renevieri, Pterotrigonia caudata*, *Sphaera belbekensis, Tortarctica weberi;* Bl—*Conobelus conicus* (Bl.).

K_1ber_3. Overlying sediments: in the lower part (7 m)—Member of alternating clays and sandstones, up the section (36 m) there is a series of limestones with upper Berriasian gastropods and rudists.

Geological Age

The section contains the Lower Berriasian—*jacobi* Zone and Middle Berriasian—*tauricum* Subzone.

K_1ber_1. Lower Berriasian, *jacobi* Zone, Members I–X. Carbonate deposits on the northern slope of the Dolgorukovskaya Yaila were previously traditionally dated by many geologists as Tithonian (Sokolov, 1889; Muratov, 1947; Lichagin, 1958; Drushchits et al., 1959; Pchelintsev et al., 1965); Upper Tithonian (Weber, 1934; Moiseev, 1937; Lychagin, 1969; Uspenskaya, 1969). Muratov (1949, p. 119) noted that "the entire plateau of the Dolgorukovskaya Yayla is covered by Upper Tithonian limestones." On all geological maps and various schemes of that time, Dolgorukovka was located in the zone of development of the Tithonian deposits. The late Tithonian age of limestones in this area was also accepted by the author in a joint work with N.I. Lysenko. At that time, four units were recognized in the section with the corresponding "Beds with fauna", substantiated by gastropod assemblages, which were considered Upper Tithonian. New data on the stratigraphic position of the identified units and the distribution of individual groups of organisms made it possible to revise the structure of the section described here, partially published earlier (Lysenko and Yanin, 1979).

Unfortunately, ammonite index species of have not yet been found in these deposits, but according to the bivalve assemblages containing *Prohinnites renevieri, Tortarctica weberi* and others (see above) and the gastropods *Cylindrobulina borissjaki, Valanginella plana* and others al., one can conclude that they are of Berriasian age. Moreover, a comparison of the Dolgorukovka carbonate series with similar deposits at Karabi-Yail facilitated its unambiguous dating. The index species *Pseudosubplanites ponticus* was found in the Karabian Section (Bogdanova et al., 1981). Thus, according to the stratigraphic position and complex of species, we assign the lower (carbonate) part of the Dolgorukovsky section to the Lower Berriasian, the *jacobi* Zone.

The overlying deposits, exposed in the vicinity of the village of Glubokoe, on the right side of the Terenair Ravine, form the upper, carbonate, part of the

combined Dolgorukovsky section. They are clearly separated from the deposits in neighboring areas of the region, so we propose to separate them into an independent, so-called Terenair section (after the name of the ravine of the same name). It has a 180-year history of study. The section was first studied by the French geologist Huot in 1837. Its brief description was published later (Huot, 1842). In the series of alternating limestones, marls, sandstones and conglomerates, he identified 13 beds with oysters and brachiopods. Based on the oysters *Exogyra couloni*, he attributed the entire series to the Neocomian. Huot compared the Lower Cretaceous deposits of this region with the Neocomian sandstones of southeastern France, containing abundant oysters.

Later, Russian geologists assigned these deposits to: the Tithonian (Sokolov, 1886; Pchelintsev, 1924, 1931); Upper Tithonian (Uspenskaya, 1969); Valanginian–Hauterivian (Salman & Shalya, 1959); Berriasian (Weber, 1934; Moiseev, 1937; Mamontova, 1972; Plotnikova et al., 1976); Upper Berriasian (Gorbachik et al., 1970). Pchelintsev (1924, 1926, 1931, 1965) published inconsistent data on the age of the deposits in the Terenair section. At different times, based on different gastropods, he attributed the deposits to the Tithonian, then to Tithonian-Valanginian, then to Valanginian.

The present author, after a detailed study together with Lysenko (1979), the entire series (30 m, our V–X members), which is exposed above the village of Glubokoe, was assigned to the Lower Berriasian: according to the stratigraphic position (below *tauricum* Subzone, see Members XI–XII, area of the village of Ivanovka) and according to the assemblages of bivalves, gastropods and brachiopods (see above), widespread in the Berriasian of the Crimea.

Unfortunately, the ammonite index species of in the Terenair section has not yet been found. In our opinion, the Terenair part of the general Dolgorukovskyi section can be compared with the upper part of the carbonate sequence of the Karabi section, which lies between the deposits of the *grandis* Subzone and equivalent *chaperi* beds (see Karabi type section).

K_1ber_2. Middle Berriasian, *tauricum* Subzone; members XI–XII: series of interbedding (15 m), exposed on the right side of the Maly Salgir River, in the vicinity of the village of Ivanovka. For the first time, the Ivanovo part of the composite section was described by me in a study of *Trigonia* of the Lower Cretaceous of the Crimea (Yanin, 2004). According to the stratigraphic scheme adopted by us at that time, these deposits with the trigoniids *Pterotrigonia caudata* and *Rutitrigonia longa* were assigned to the Lower Berriasian. In the present work, with a tripartite subdivision of the stage, they refer to the middle Berriasian.

Unfortunately, the ammonite index species was not found in the rocks of these units, but based on the general structure of the units, their lithology, stratigraphic position and association of bivalve species (see above), I consider these deposits to be Middle Berriasian. In a similar alteration series in the Bel'bek and Beshterek type sections, *Dalmasiceras tauricum*, an index species of the Middle Berriasian Subzone was found along with a similar species assemblage of ammonites, bivalves, gastropods, and other fossils.

According to drilling data in 3 and 4.5 km to the east, on the meridian of the central part of Dolgorukovskaya Yaila, in a series of interbedding of shallow, gray, oncolitic-detrital limestones, gray clays and sandstones, 148 m thick (well No. 81) and 240 m (No. 82), remains of foraminifers, ammonites, bivalves, and gastropods characteristic of Berriasian have been found (Plotnikova et al., 1976). The presence of the ammonites *Dalmasiceras* and *Neocosmoceras* ammonites in the series indicates that it is Middle or Upper Berriasian. It was found that on the southeastern slope of the Simferopol Uplift, 7 km northeast of the village of Mazanka, the Berriasian deposits are wedged out.

Beshterek

The section is continuous, measured in the vicinity of the village of Solovyovka at a distance of two kilometers on the right side of the Beshterek River valley. It describes the deposits of the Lower and Middle Berriasian, represented by carbonate and siliciclastic facies, respectively. The rocks lie monoclinally with a general northern dip. Several sublatitudinal normal faults have been identified in the monocline, making it difficult to correlate outcrops and measure the true thickness of units.

The description of the section was based on personal field materials obtained by the author during many years of work in 1959–1986, as well as data from other researchers. The Lower Cretaceous deposits of the area have been studied by many geologists since the end of the 19th century. For the first time Tsebrikov (1893) in the vicinity of the village of Atalyk-eli (=Solovjovka) established the presence of the lower Valanginian with the ammonites *Acanthodiscus malbosi* Pict. et al. Later, sandstones with ammonites were attributed to the Berriasian. The description of the section with the image of the column is given in (*Atlas* ..., 1960; Lysenko and Yanin, 1979; Yanin et al., 1981; Yanin, 2004).

The Beshterek section of the Lower Cretaceous deposits has long been considered typical for the Central Crimea. The Berriasian part of the section was included by different authors in the type section under other names: Belogorsky (Drushchits, 1975), type section of the Central Crimea (Lysenko and Yanin, 1979), Central Crimean type section (Bogdanova et al., 1981). Many authors described the Berriasian species: Fr (Gorbachik and Shokhina in *Atlas* ..., 1960); Kr (Kuzmicheva in *Atlas* ..., 1960; Kuzmicheva,

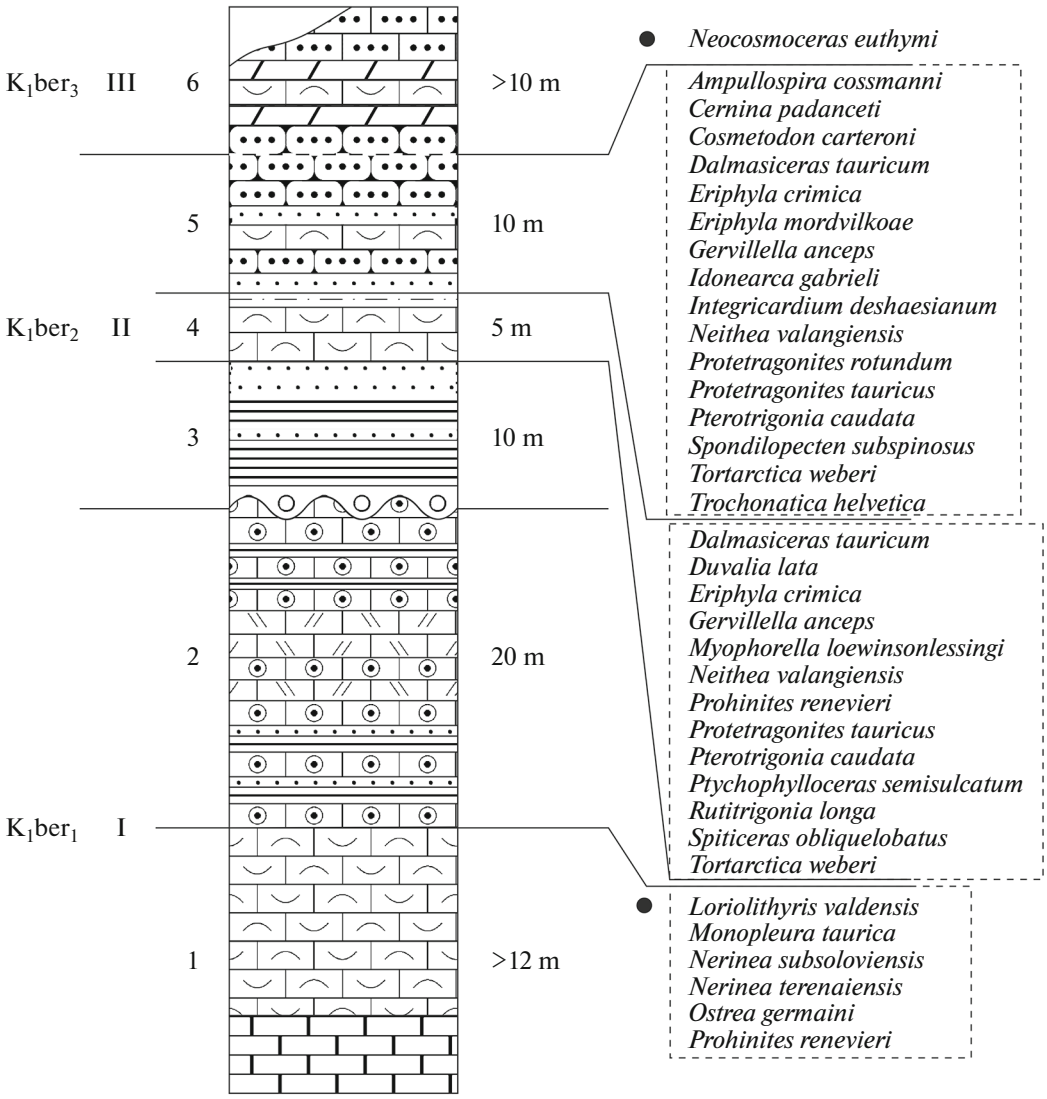


Fig. 13. Beshterek-type section, no. 7, in the vicinity of the village of Solovjevka (see explanations for Fig. 2).

2002); Gs (Pchelintsev, 1931; Golovinova and Kostyuchenko in *Atlas* ..., 1960); Bv (Pchelintsev, 1959; Muromtseva in *Atlas* ..., 1960; Yanin in *Atlas* ..., 1960; Yanin, 1989, 2004; Bogdanova and Yanin, 1995); Nt (Shimansky in *Atlas* ..., 1960); Am (Drushchits in *Atlas*..., 1960; Arkadiev, Bogdanova in the book Berriasian of the Crimean Mountains, 2012).

Description of the section (Fig. 13) (the underlying deposits are not exposed due to the heavy forest that covers of the upper reaches of the valley).

K_1ber_1. Member I (visible thickness 32 m, exposed in gullies on the right side of the river, 1.5 km south of the village of Solovjovka) is represented by carbonate deposits.

Bed 1 (>12 m)—limestones, light-gray, bioclastic and oncolitic, with an abundance of colonial corals, gastropods and rudists; Cr—*Calamophylliopsis* sp., *Comoseris* sp., *Thamnasteria* sp., *Thecosmilia* sp.; Gs (identification by N.I. Lysensko)—*Rugifera rugiferi* (Zitt.), *Salinea corpulensis* (Pchel.), *Valanginella scalaris* Pchel.; Bv—*Monopleura taurica* (locally form rudist banks), *Ostrea germaini*, *Prohinnites renevieri*; Br—*Loriolithyris valdensis*, *Terebrataliopsis* sp.; echinoid spines.

Bed 2 (20 m)—limestones, gray, bluish-gray, oncolitic, finely detrital or pelitic; massive, thickly platy (1–2 m) alternating with thin, loose interbeds of dark gray, argillaceous sandstones and yellowish gray, highly calcareous clays (Fig. 14a). It its lithology and fossils, the rock is similar to marly limestones with small oysters that make up the sections of the lower Berriasian on the northern slopes of the Karabi-Yaila and in the sides of the Saigin Ravine; Bv—*Ceratostreon* sp.; Br—*Loriolithyris valdensis*, *Septaliphoria* sp.; in some places the rocks contain numerous with burrows

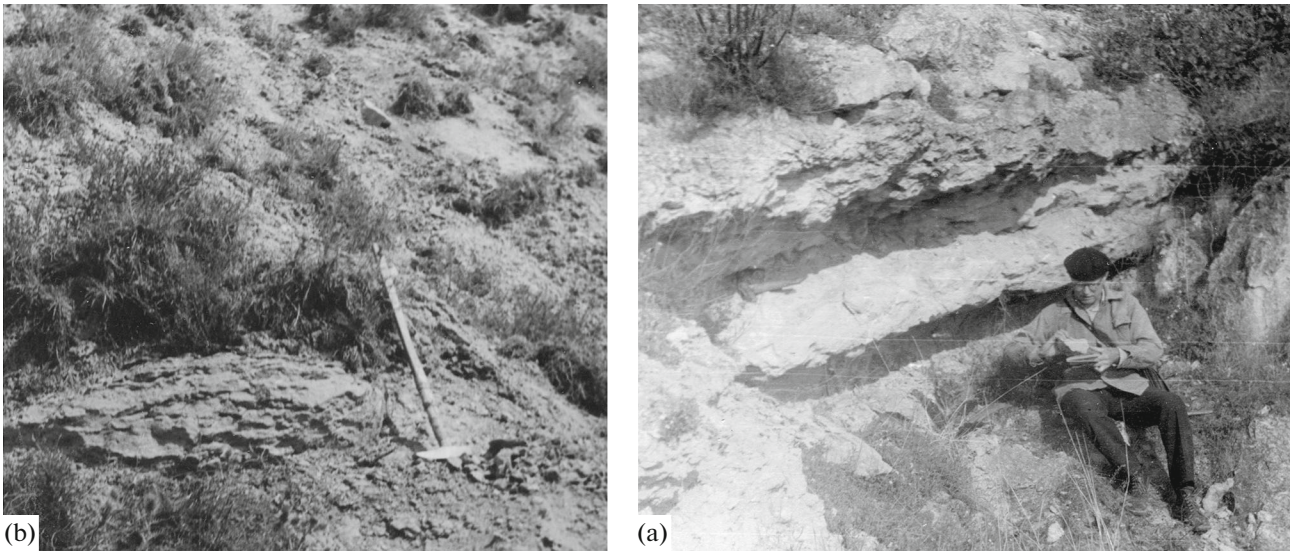


Fig. 14. Berriasian rock outcrops near the southern margin of the village of Solovjevka (right bank of the Beshterek River): (a) platy gray limestones of the lower Berriasian, in stratigraphic position corresponding to the grandis subzone (15 m above the rudist-gastropod "Lower Solovjevka" limestones (see section no. 7, Member I, Bed 2); (b) nodules of calcareous sandstone with shells of ammonites, bivalves et al.; Middle Berriasian, *tauricum* Subzone (section no. 7, Member II, Bed 4); (a) and (b) photo by the author, 1962.

Thalassinoides suevicus. A structural terrace was formed along the top of the limestones in the relief.

The deposits of Member I are also exposed downstream of the river, in its left side, on the southern vicinity of the village of Lesnosel'e. Here they occur in the northern uplifted limb of the latitudinal reverse fault and are represented by alternation beds (0.6–2 m) of oncolitic and bioclastic (gastropod) limestones and interbeds of gray shales and cross-bedded, yellowish-brown sandstones with horizons of pebbles; pack thickness 22 m; in its top there are platy limestones (6 m) with abundant gastropods (*Diozoptyxis* sp., *Trochoptygmatis neisatzensis* (Pchel.), *Valanginella infravalangiensis, V. planata*).

K_1ber_2. Member II (25 m, rocks of the member are exposed near the southern and eastern vicinity of the village of Solovjovka, as well as in the vicinity of the village of Lesnosel'e), an alternation of clays, sandstones and limestones.

Bed 3 (10 m)—clays, greenish-gray, calcareous, in places silty, at the top of the bed the silt content and arenacous content of the clays increases and argillaceous sandstones appear; the boundary with the underlying limestones is uneven, eroded; at the base of the bed, poorly rounded pebbles (2–3, rarely 8 cm) of gray limestones; in clays, an abundance of foraminifera and the small oysters *Ceratostreon* sp.

Bed 4 (5 m)—weakly cemented glauconite sandstones and siltstones, dark gray, with large (8 cm) charred plant remains and rare, scattered quartz pebbles; in the middle part, lenticular interbeds and concretions (0.3 m) of sandstone, brownish gray, strongly calcareous, fine-grained, hard, with numerous pebbles of various rocks and thin slabs of oncolitic limestone (Figs. 14a, 14b); in some places—coquina; Cor—*Montlivaltia minima* Kusm., *Trochosmilia* sp.; Gs—*Natica submexilhoeirensis* Pchel., *N. pidanceti* Coq.; Bv—*Acesta longa, A. orbignyana, Ceratostreon minos, C. tuberculiferum, Cosmetodon carteroni, Gervillella anceps, Gervillia gottschei*, *Globocardium sphaeroideum, Glossus neocomiensis, Gryphaea weberae, Fimbria berriassica, Entolium germanicum, Eriphyla crimica, Integricardium deshayesianum*, *Neithea valangiensis, Oxytoma cottaldina, Myophorella loewinsonlessingi*, *Pinna robinaldina, Plagiostoma dubisiensis, Prohinnites renevieri, Pterotrigonia caudata*, *Rutitrigonia longa*, *Sphaera belbekensis*, *Tortarctica weberi*; Am—*Dalmasiceras tauricum*, *Protetragonites tauricus*, *Ptychophylloceras semisulcatum*, *Spiticeras obliquelobatum*); Nt—*Aulaconautilus druzczici* Shim.; Bl—*Duvalia lata* Bl.; Br—*Sellithyris uniplicata*; fish scales are occasionally found.

Bed 5 (10 m)—alternation of clays, siltstones, sandstones, marls and limestones; clays and siltstones similar to those in Bed 4; brownish-gray sandstones, coarse and fine-grained, quartz-feldspar, weakly calcareous; limestones of the same color, bioclastic, sandy, hard, forming ledges on the slope; marl greenish-gray, soft, slightly sandy; siliceous sponges, colonial and solitary corals appear in marls at the top of the bed Cor—*Dimorphocoenia alpina* Koby, *Montlivaltia crimica* Kusm., *M. kaufmani* Koby, *M. minima*; Gs—*Ampullospira cossmani* Pchel., *Cernina pidanceti* Coq., *Trochonatica helvetica* (Pict. et Camp.); Bv—*Acesta longa*, *A. orbignyana*, *Cosmetodon carteroni, Fimbria*

berriassica, *Gervillella anceps, Entolium germanicum*, *Eriphylla crimica, E. mordvilkoae, Glossus neocomiensis*, *Goniomya* villersensis, *Gryphaea weberae*, *Idonearca gabrielis*, *Inoperna taurica*, *Integricardium deshayesianum*, *Lithophagana avellana*, *Neithea valangiensis*, *Oxytoma cottaldina, Pinna robinaldina, Platymyoidea marullensis, Protocardia carinata, P. peregrina, Pterotrigonia caudata* (Ag.), *Ptychomya robinaldina*, *Sphaera belbekensis*, *Spondylopecten subspinosus*, *Tortarctica weberi*; Am—*Dalmasiceras tauricum*, *Haploceras carachtheis*, *Protetragonites rotundum*, *P. tauricum*, *Ptychophylloceras semisulcatum*, *Spiticeras obliquelobatum*; Bl—*Conobelus conicus* Bl., *Duvalia lata*; Cr—*Apiocrinites* sp. In some beds of sandstone there are so many bivalve shells that it represents a coquina. Member II deposits are also traced to the north, in the area of the southern outskirts of the village of Lesnoselye, where they occur in the northern limb of the sublatitudinal reverse fault (see above). Here they are represented by alternations of slabs (0.2–0.5 m) oncolitic, detrital and bioclastic limestones and interlayers (2–5 m) of yellowish-gray, strongly clay loose sands; their total thickness is 19–20 m. The deposits lie on the uneven, eroded surface of the underlying limestones of Member I. At the contact between them there is a boulder-pebble horizon (0.8 m) with poorly rounded boulders (0.3 × 0.5 m), becoming upward into platy oncolitic limestones with coral colonies and gastropod shells.

K_1ber_3. Member III, Bed 6 (> 10 m): overlying deposits, heavily turfed and covered with dense shrubs, are represented by an alternation of siltstones, clays and marls; in the lower part of the alternation series, marly sandstones contain nodular nodules of silicon sponges ("sponge horizon"); ammonite index species *Neocosmoceras* (=*Euthymites) euthymi* was found in the Upper Berriasian talus.

Geological Age

In this section I recognize the Lower—*jacobi* Zone and Middle Berriasian—*tauricum* Subzone.

K_1ber_1. Lower Berriasian, *jacobi* Zone: limestones (Member I, beds 1, 2, Lower Solovjevka limestone); make up the upper part of the thick carbonate strata that make up the northern slope of the Dolgorukovskaya Yaila. Previously, they were assigned to the Tithonian (Veber, 1934; Moiseev, 1937; Muratov, 1947; *Atlas* ..., 1960). In the monograph by Pchelintsev (1931) for the same limestone strata exposed near the southern margin of Solovjovka, based on the identification of gastropod species, different ages were indicated: Tithonian, Tithonian–Valanginian, or Valanginian. Later, in a monograph on rudists (1959), he attributed them to Valanginian.

In the paper by Lysenko and Yanin (1979) assigned limestone data containing the rudists *Monopleura taurica* and numerous gastropod species (see above, Member I, Bed 1) to Lower Berriasian Beds with *Nerinea terenairensis-Monopleura taurica*. Later, this point of view acquired the status of a generally accepted one (Bogdanova et al., 1981; Drushchits et al., 1986; Yanin, 1989; Yanin, 2004). Bogdanova et al. (1981) considered the "Solovjevka limestones" as equivalents of the Lower Berriasian *Pseudosubplanites ponticus* Zone, which they first established in the Karabi-Yaila carbonate series (see the Karabi type section). At present, the limestones described here are attributed by us to the Lower Berriasian, the *grandis* Subzone.

The discovery of the brachiopods *Loriolithyris valdensis*, found together with *Pseudosubplanites ponticus* at Karabi-Yaila (Bogdanova et al., 1981), confirms this conclusion. Kvantaliani (1989) unreasonably attributed the "Lower Solovjevka limestones" to the lower zone of the Middle Berriasian, the *Protocanthodiscus malbosi* Zone. It should be noted that ammonites of this species have not yet been found in these limestones.

K_1ber_2. Middle Berriasian, *tauricum* Subzone; Middle Berriasian, Tauricum Subzone; terrigenous deposits (member II, Beds 3–5), exposed in the right side of the Beshterek Ravine.

Tsebrikov (1893) was the first to report on the presence of Valanginian deposits near the village of Atalikeli; he identified several ammonite species from sandstones, including *Hoplites neocomiensis* Pict., *Olcostephanus* ex gr. *astieri*. Moiseev (1937), with reference to Veber noted that near the village of Solovjovka, glauconite sandstones with ammonites were assigned to the Lower Valanginian (=Berriasian). Muratov (1947) cited Berriasian ammonites from these sandstones and clays in the upper Beshterek: *Thurmannia boissieri* Pict., *Phylloceras calypso* D'Orb., et al. This ammonite horizon was also assigned to the Lower Valanginian by Drushchits (*Atlas* ..., 1960) based on the findings of *Dalmasiceras punctatum* Djan., *Euthymiceras transfigurabilis, Spiticeras obliquelobatum, Duvalia lata,* and others. Later, the alternation of glauconite sandstones, siltstones, clays and marl limestones was considered Berriasian based on the species association of ammonites, bivalves, gastropods, and other fossils (Lysenko and Yanin, 1979; Yanin et al., 1981) and Lower Berriasian (Yanin, 2004). In the present work, these deposits, according to the accepted scheme of tripartite subdivision of the stage, are attributed to the middle Berriasian, the *tauricum* Subzone. The boundary between the deposits of the Middle and Upper Berriasian remains conditional so far, since its index species *Neocosmoceras euthymi* has not yet been found in situ in the clays of the upper substage.

Karabi

The section is continuous, measured on the northwestern side of the plateau of the Karabi-Yaila Massif in the area of the Kazanlyk Basin and along the highway from Karabi to the village of Blagodatnoe. While the lower part of the section is a conformable series of beds dipping 10° at 10° and 20°–40° NW at 10° to 350° NW at 10°, its upper part is composed of outcrops exposed in the first, second and the third notch of the highway at the very beginning of its descent. Here, at a distance of several hundred meters, two sublatitudinal low-amplitude discharges were installed, due to which the Members power could double. The correlation of Members in different outcrops is difficult due to the similarity of the lithological composition of the rocks.

Despite this circumstance, we were able to identify a general pattern in the structure of the carbonate section of the lower Berriasian: alternation of limestones and marls in its lower part and alternation of marls and clays in its upper part. The significance of this section lies in four aspects: (1) *grandis* Subzone was established; (2) the southernmost outcrop is described for the sandstone *chaperi* Bed, correspondingly overlying the *grandis* Subzone carbonate sequence; (3) new outcrops of Lower Berriasian sediments were discovered below the known horizon with Pseudosubplanites *grandis* (Maz.), a zonal index species which increased the thickness of these sediments by 30 m in the upper part of the undivided Bedenekyr Formation; (4) it was found that in terms of general structure, facies and thickness of individual Members, the series corresponds to similar sections in more northern areas (Saigin Ravine, Belaya Mountain and Enisarai Ravine in the vicinity of the villages of Novoklyonovo and Chernokamenka).

The first brief description of the outcrop corresponding to the middle part of this section was published by Bogdanova et al. (1981) without a lithological log. We have studied the section on many occasions: in 1978, 1979, 1986, 1987 and 1990, In 1987, the author took part in joint field trips with T.N. Bogdanova, S.V. Lobacheva, and N.I. Lysenko. The first, schematic, image of the entire section was published by Yanin et al. (1981). In the present work, its detailed description is given along with a list of fossils. The underlying deposits exposed in the southern margin of the Kazanlak Basin were not studied.

Section Description (Fig. 15)

$K_1ber_1^1$. Member I (visible thickness 12 m, exposed in the right side of the western part of the Kazanlak basin, 1 km west of the well)—limestones and marls.

Bed 1 (4 m)—limestones, gray, oncolitic; form a clear lens (1 m) at the base of the slope.

Bed 2 (5 m)—marls, gray, clayey, platy, with an abundance of small oysters; exposed on a gentle slope between a ledge and a pine forest; the section contains nodules of hydroids, and gastropods; Bv—*Neithea* sp., *Prohinnites renevieri,* small oysters.

Bed 3 (3 m)—limestones, gray, platy, oncolitic-detrital; nodules (10 × 13 × 15 cm) of chaetetids; Bv—*Neithea* sp., *Prohinnites renevieri*; brachiopods.

Member II, Bed 4 (6 m, exposed at the eastern edge of the forest, along the highway)—alternation of slabs of gray detrital and bioclastic limestones and interlayers of clay marls; nodules of chaetetids in marls; Gs—*Nerinea* sp., Bv—*Neithea* sp., in limestones

Member III, Bed 5 (10 m, exposed along the edge of the forest)—marls, gray, platy, finely detrital, in places strongly argillaceous; nodules of chatetids, overgrown with small oysters; Gs—large *Cernina* sp.; Bv—*Prohinnites renevieri, Tortarctica weberi*; burrows by *Thalassinoides* sp.

Member IV, Bed 6 (3 m, are exposed in the roadcut, near a water well), marls, gray, bedded; nodules of the chaetetids; Bv—*Neithea* sp., *Prohinnites renevieri*, *Tortarctica weberi*; brachiopods.

$K_1ber_1^2$. Member V, Bed 7 (10 m, rocks of the member were well exposed in the "bulldozer clearing" immediately at the beginning of the descent of the highway towards the village of Blagodatnoe, in the area of the steep loop of the highway)—limestones and marls, gray, with a bluish tinge, micritic, platy, in places finely detrital (their alternation is shown on the log provisionally); with an abundance of faunal remains: nodules of chaetetids; Gs—*Ampullina* sp., *Cernina* sp.; Bv—*Ceratostreon tubercuiferum*, *Integricardium deshayesianum*, *Neithea subsimplex, Panopea* sp., *Pinna carabiensis*, *Prohinnites renevieri*, *Ptychomya* sp., *Tortarctica* weberi; Am—*Berriasella callisto* (D'Orb.), *Pseudosubplanites ponticus* (=*P. grandis*).

The beds along the strike to the east, near the farm above the well, in marls and limestones contain: Gs—*Contortella* sp., *Pleurotomaria* sp.; Bv—*Ceratostreon tuberculiferum*, *Lithophaga* in a nodule of chaetetids, *Neithea* sp., *Prohinnites renevieri*, *Protocardia* sp., *Tortarctica weberi*; Am—impressions of *Berriasella* sp.; Br—*Loriolithyris valdensis*; crab carapax and a claw.

The continuation of the section could be traced along the cuts along the highway descending over a gentle slope to the village of Blagodatnoe. The marl-limestone beds are uniform, have varying attitudes, and are complicated by a series of several sublatitudinal faults, hence the thickness of the units is given provisionally.

Member VI (20 m)—gray limestones and marls.

Bed 8 (~10 m)—nodular marly limestones.

Bed 9 (5 m)—alternation of slabs of marly limestones and nodular marls; the nodular texture of the rock is due to the abundance of burrows of *Thalassinoides* sp.

Bed 10 (0.6 m)—marl slab with an abundance of burrows.

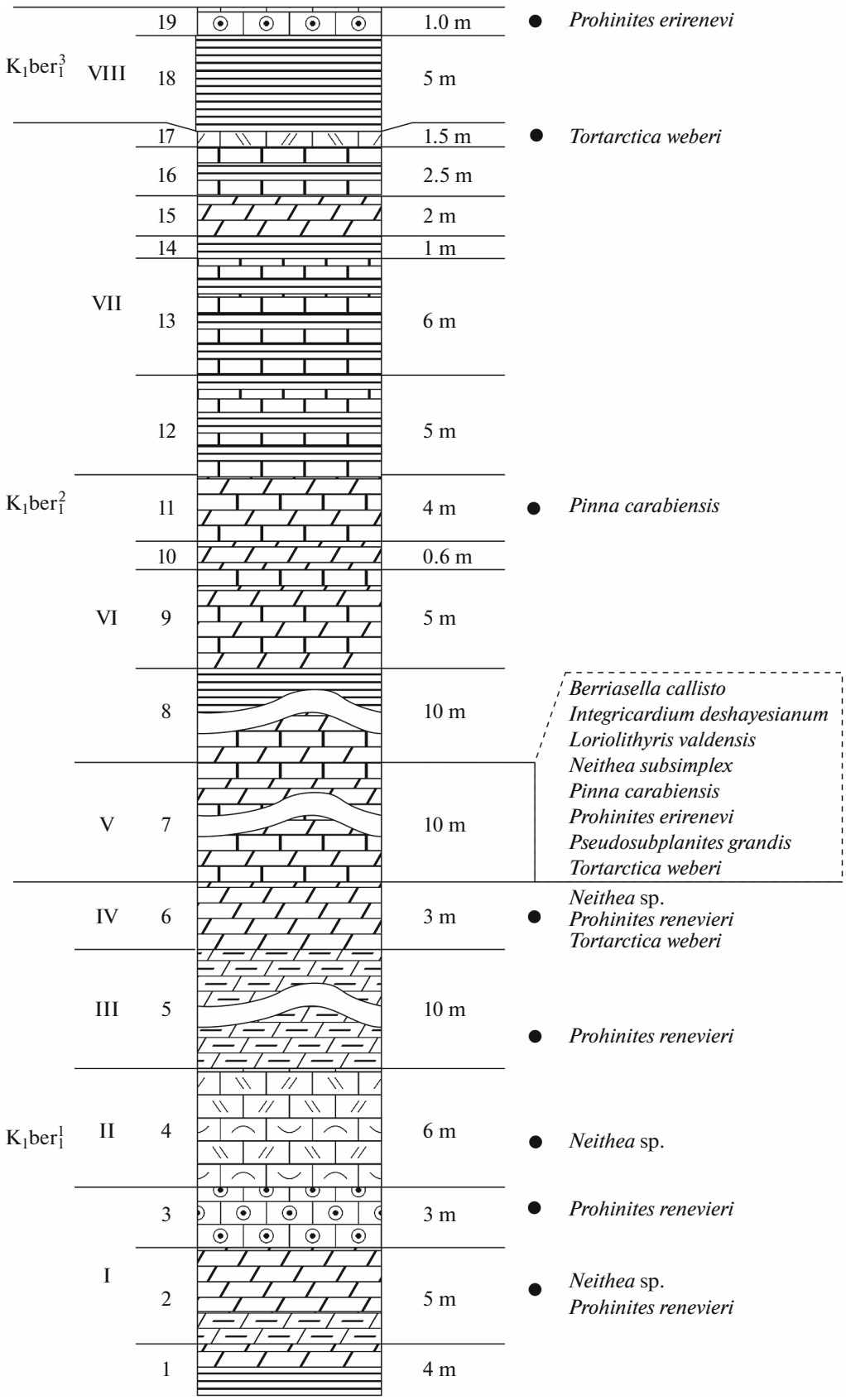


Fig. 15. Karabiiskii-type section, no. 8, in northern side of the Karabi-Yaila Plateau, region of the well Kazanli (see explanations for Fig. 2).

Bed 11 (4 m)—alternation of marls and limestones; the upper part of the member is well exposed to the right of the highway, opposite the third roadcut (counting from the "bulldozer clearing", in a ravine near the northwestern corner of the pine forest plantation); Bv—*Pinna karabiensis, Tortarctica weberi*; crustacean burrows.

Member VII (18 m, here in the ravine)—alternation of limestones, marls and clays; differs from Member VI in the abundance of clay interbeds; these beds are also traced on the highway, where they are exposed in 4–6 roadcuts.

Bed 12 (5 m)—alternation of slabs (0.8 m) of gray marl limestones and interbeds of strongly calcareous whitish clays.

Bed 13 (6 m)—alternation of thin-platy, grey, knotty limestones and interbeds (5 cm) calcareous clays.

Bed 14 (1 m)—whitish clays.

Bed 15 (2 m)—limestones, platy, bedded, marly, in places nodular.

Bed 16 (2.5 m)—clays with thin slabs of nodular limestones.

Bed 17 (1.5 m)—limestones, marly, detrital, with an abundance of small oysters and burrows; Bv—*Ceratostreon tuberculiferum*, *Tortarctica weberi*.

$K_1ber_1^3$. Member VIII (6 m, exposed in the northwestern corner of the coniferous forest)—clay, sandstones, limestones.

Bed 18 (5 m)—clays, dark gray, with thin interbeds (3–8 cm) and lenses (0.3 m) of brownish-gray, coarse-grained sandstones and gravelstones, predominantly composed of quartz; small rostra of belemnites in the scree.

Bed 19 (1 m)—limestones, brownish-gray, oncolitic, with fine lenses of sandstones; Bv—*Prohinnites renevieri*.

Overlying deposits are eroded. Judging by the clayey soil around the small pond, the sandy-clayey beds of the Lower Berriasian continue above Bed 19.

Geological Age

The section contains the Lower Berriasian (*jacobi* Zone), subdivided into three units: the *jacobi* subzone, the *grandis* Subzone and *chaperi* Beds. The carbonate series, which forms the northern and northwestern parts of the Karabi-Yayla plateau, earlier, until the 1970s, was assigned to the Upper Jurassic: Tithonian (Tsebrikov, 1902; Weber, 1937; Uspenskaya, 1969; Lichagin et al., 1971; Drushchits, 1975); Kimmeridgian-Tithonian (Moiseev, 1937; Muratov, 1947, 1949); middle-upper Tithonian (Pchelintsev and Lysenko, 1965). The latter assignment was used in all the Geological maps of the Crimea (1926, 1937, 1984), on which the Upper Jurassic deposits occupy the entire space of the Karabi Plateau and its northern slopes.

Pchelintsev (1962) assigned the sequence of "yellowish-cream algal limestones" of Karabi-Yaila to the Bedenekyr Formation, identified by him on the Aipetri Yaila (stratotype on Mount Bedenekyr) and dated them as Middle Tithonian. Later (Pchelintsev and Lysenko, 1965, p. 135) it was noted that "Upper Tithonian occupies an insignificant part of the plateau in its northwesternmost part and is developed mainly within the slopes." Uspenskaya (1969, p. 149) indicates that "the Tithonian section of Karabi-Yaila terminates with light-gray with a yellowish tinge, pelitomorphic and fine-grained, highly fractured limestone beds... 500–600 m thick." Uspenskaya listed the ammonites *Haploceras carachtheis* and *Thysanolytoceras liebigi*, which were in her opinion characteristic of the Upper Tithonian *Virgatosphinctes transitorius* Zone from the marly limestones on the northern slope of Karabi-Yaila.

Paryshev et al. (1979) consider that the sequence of interbedded limestones, marls and clays that make up a significant part of the Karabi-Yaila Plateau and its northern slopes can be assigned to the Bedenekyr Formation. They cited the Berriasian ammonites *Berriasella (Malbosiceras) callisto f*rom the upper part of the formation. Based on that, the formation deposits was dated as late Tithonian–Berriasian. This opinion was later adopted by Permyakov et al. (1984). Unfortunately, none of the above authors indicated the exact locality of the Tithonian and Berriasian ammonites. In 1977, Bogdanova and her colleagues (see Bogdanova et al.; 1981 Bogdanova and Kvantaliani, 1983) found the ammonite *Pseudosubplanites ponticus*, an index species in the limestones formerly dated "Tithonian" in the area of bulldozer clearing (our Member V). This discovery was the beginning of identification of the lower Berriasian at Karabi-Yaila and in its zonal subdivision at the Zone level. In 1981, we published a section log (without a description) of the lower part of the carbonate sequence in the area of the Kazanlyk Depression. We propose to consider it typical for the carbonate deposits of the Lower Berriasian in the Central Crimea. Previously (Bogdanova et al., 1981), the interval of the carbonate series in the area of "bulldozer clearing" with the ammonite *Pseudosubplanites ponticus* was included in the Central Crimean type section.

$K_1ber_1^1$. *jacobi* Subzone (Members I–IV, Beds 1–6); recognized based on: (1) stratigraphic position: below deposits with the zonal ammonite *Pseudosubplanites grandis*; (2) paleontological data: the presence of bivalves *Neithea* sp., *Prohinnites renevieri, Tortarctica weberi*, known in other regions of the Crimea only starting from the lower Berriasian; (3) correlations with the eastern Tonas and Feodosia sections, in which the zonal species *Berriasela jacobi* Maz. found below the *grandis* Subzone. In the Karabi section, the lower 30 m (Members I–IV, beds 1–6) are assigned to the *jacobi* subzone. The boundary with the Upper

Tithonian has not been established. It is assumed that the transition to the Tithonian limestones in the western part of the Kazanlak Basin is gradual, original attitudes preserved.

$K_1ber_1^2$. *Grandis* Subzone; was recognized based on the find in the marl limestones in the area of "bulldozer clearing" of the zonal ammonite *Pseudosubplanites ponticus (=P. grandis),* as well as the species of bivalves and brachiopods characteristic of the Berriasian assemblage (see above). Although the species of brachiopods and bivalves cited in the text are also found in the higher horizons of Berriasian, we include them in the Lower Berriasian assemblage based on their first appearance. I refer to this subzone the upper 80 m of the section (members V–VII, beds 7–17). Thus, the thickness of the upper (Lower Berriasian) part of the Bedenekyr Formation here is 110 m. Yanin et al. (1981) attributed the entire carbonate series exposed within the Kazanlak Basin and along the highway to the undivided *Pseudosubplanites ponticus-Berriasella jacobi* zone.

$K_1ber_1^3$. *chaperi* Beds (Member VIII, beds 18, 19). The deposits of this unit lithologically differ profoundly from the underlying carbonate formations. Unfortunately, the zonal species *Malbosiceras chaperi* (Pict.) was not found here. The position in the section and the age of the deposits is determined by lithological and stratigraphic criteria. They are well correlated with terrigenous rocks overlying *grandis* Subzone in adjacent sections along the Saigin and Enisarai ravines and containing the index species *M. chaperi* (Bogdanova and Kvantaliani, 1983). These beds are described in detail by us in the more northern type section of the Saigin-Balki, where they are thicker and occur at the base of the terrigenous part of the Berriasian section.

Saigin-Balki

The section is continuous, made along the left side of the Saigin Ravine, near its mouth (lower part; Members I, II, beds 1–5) and along the meridional ridge, which is located 1.5 km south of the village of Balki (=Argin) and extends from south to north from the mouth of this ravine to the Novoklyonovo-Mezhgorie highway (middle and upper parts of the section, Member III, Beds 7–10). The ridge is the western slope of the high and wide terrace of the Sarysu River, located between its edge and the foot of the hills in the area of the village of Blagodatnoe. A wide valley up to the village of Kozlovka extends to the west of the ridge. The rocks of the middle part of the section are exposed on the slopes of the terrace, in the area of the farm opposite this village.

This section has long been considered a classic for Lower Cretaceous deposits in the Central Crimea. It was partly included in the characterization of type sections: Belogorsk (Drushchits, 1975: Belogorsk-type section) and Central Crimean (Bogdanova et al., 1981). The second one is considered as a reference section to several districts located in the Sarysu and Beshterek basins. In this paper, I limit the characterization of the type section to only one region, the Sarysu River basin.

The study of the section with the comprehensive fossil collecting was conducted by us over many years, from 1956 to 1987, both individually and in joint fieldwork sessions with colleagues (V.V. Drushchits, T.N. Gorbachik, T.L. Muromtseva, T. N. Smirnova, T.N. Bogdanova, N.I. Lysenko, and others). A brief description of the section indicating the presence of Lower Valanginian or Berriasian deposits in it is given in the works of many researchers (Drushchits et al., 1959, 1985, 1986; *Atlas* ..., 1960; Lychagin, 1969; Lichagin et al., 1971; Drushchits, 1975; Kvantaliani et al., 1979; Bogdanova et al., 1981; Yanin et al., 1981; Kvantaliani, 1983, 1989; Yanin, 2004; Arkadiev et al., 2012).

Atlases, monographs and articles contain monographic descriptions of species from different taxonomic groups: Fr (Gorbachik and Shokhina in *Atlas* ..., 1960); Cor (Kuzmicheva in *Atlas* ..., 1960; Kuzmicheva, 2002); Gs (Golovinova, Kostyuchenko in *Atlas* ..., 1960); Bv (Muromtseva, 1960; Cheltsova, 1969; Yanin, 1960, 1980a, b; Bogdanova and Yanin, 1995; Yanin, 2004); Am (Drushchits in *Atlas* ..., 1960; Bogdanova and Kvantaliani 1983; Bogdanova et al., 1999; Kvantaliani, 1989; Arkadiev et al., 2012); Bl (Kabanov, 1960, 1967); Br (Smirnova, 1960–1972; Lobacheva and Smirnova, 2006). Since this section of the Lower-Middle Berriasian deposits is the most typical for the Central Crimea, we give here not only its detailed description, but, if possible, the most complete paleontological characterization for all the beds we have identified.

The underlying deposits, represented by carbonate rocks and related to the *grandis* Subzone, are more fully described above in the Karabian Section. In the Saigin Ravine, they form sides along its entire length. The ravine is crossed by several sublatitudinal faults. Faults and similar lithological composition of the carbonate series complicate the possibility of compiling a section with true thickness of the units along the ravine channel.

Section Description (Fig. 16)

$K_1ber_1^2$. Member I, Bed 1 (visible thickness >10 m, exposed near the mouth of the Saigin Ravine, 1 km southwest of the village of Blagodatnoe, on both sides of the ravine. On the left side, only the uppermost part of the member is well exposed; it is composed of limestones, bluish-gray, micritic, in places fine-detrital, dense, platy (0.1–0.6 m); on the opposite side of the Member ravine, it is more marl-like deposits with occasional limestone slabs (Fig. 17). These outcrops are separated by a normal fault along the thalweg of

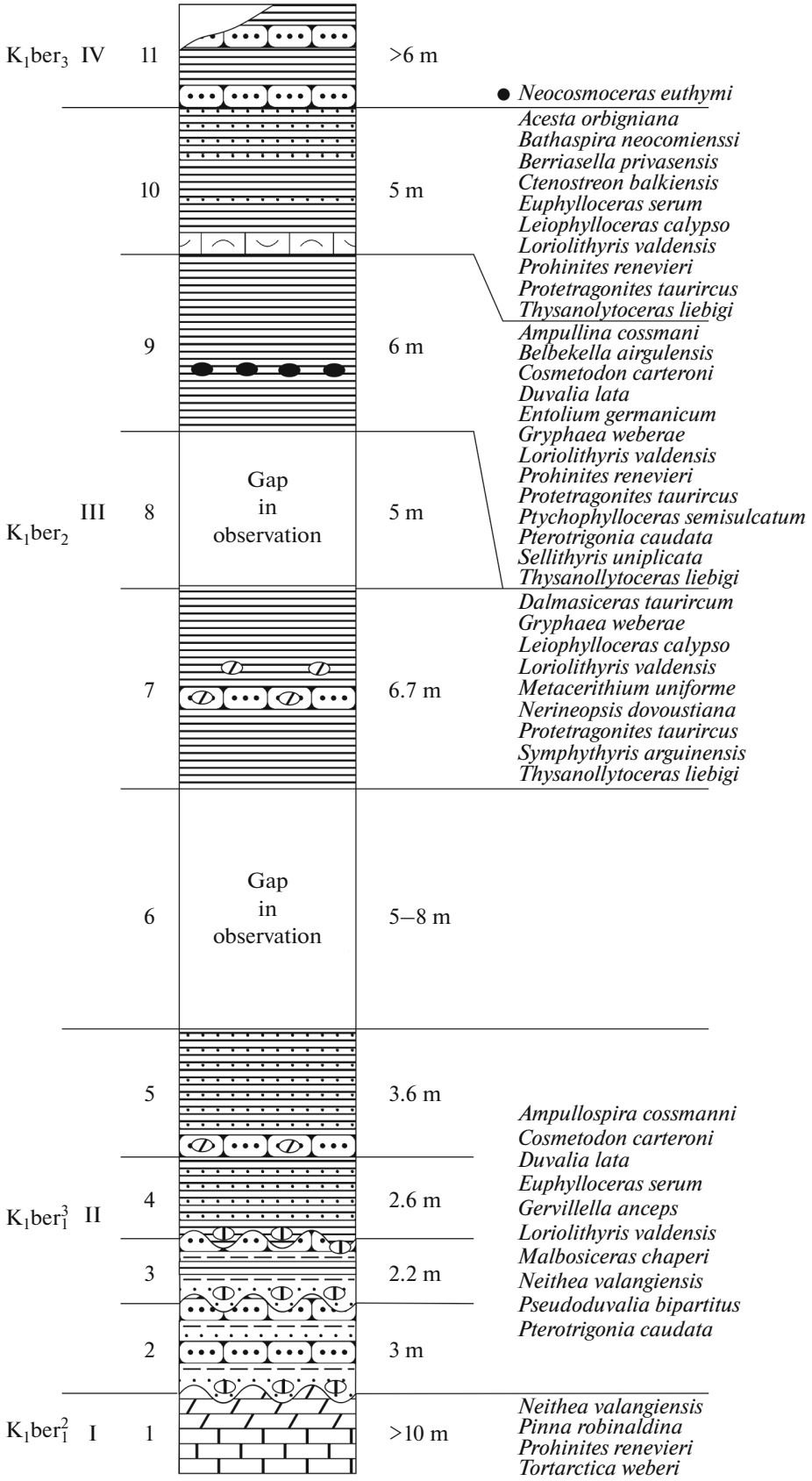


Fig. 16. Saigin-Balkinskii-type section, no. 9, in the vicinity of villages Blagodatnoe, Kozlovka and Balki, basin of the Sarysu River (see explanations for Fig. 2).

Fig. 17. Outcrop of a flyschoid series of hard limestones and carbonate clays on the right side of the Saigin Ravine near its mouth; Sarysu River basin, near the western vicinity of Blagodatnoe village; Lower Berriasian, *grandis* Subzone; in Section no. 9 corresponds to Member I, Bed 1 (photo by the author 1986).

the gully. The bluish-gray limestones in the neighboring Enisarai Ravine form a thicker series and form steep slopes and cliffs (Fig. 18). Member I on the left side of the Saigin Ravine contained: Gs—*Ampullina athleta* (d'Orb.), *A. gigas* (Stromb.), *Cernina hemisphaerica* (d'Orb.), *Cyphosolenus dyonisus* Buv.; Bv—*Ceratostreon tuberculiferum*, *Neithea valangiensis, Pinna robinaldina*, *Prohinnites renevieri*, *Tortarctica weberi*; brachiopods, crustacean claws and numerous burrows of *Thalassinoides* sp.

$K_1ber_1^3$. Member II (11.4 m)—sandy rocks predominate in the lower half of the member, clayey rocks predominate in the upper half. The contact between Members I and II shows a sublatitudinal tectonic fault, which continues to the east along the base of Mount Belaya and in the upper reaches of the Enisarai Ravine.

Bed 2 (3 m)—alternation of sandstones (0.2–0.6 m), limestones (0.1–0.5 m) and clays (0.2–0.9 m); sandstone yellow and rusty-brown, fine-grained, bedded, forms interbeds of varying density; limestone from yellowish to dark gray, dense, detrital (oyster shell and serpulid fragments), arenacous; clay from dark gray to brownish gray, sandy, lumpy when weathered; at the base of the bed is a basal horizon (0.1 m) of rounded limestone pebbles (2–12 cm) lying on an uneven abraded limestone surface of Bed 1; Am—*Thysanolytoceras liebigi*; Bv—*Ceratostreon tuberculiferum, Entolium germanicum*, *Pterotrigonia caudata*; Br—*Loriolythyris valdensis*.

Bed 3 (2.2 m)—clay gray, whitish when weathered, sandy, non-plastic; with thin interbeds of unconsolidated sandstones; upwards it is replaced by marls, weakly cemented sandstones; in the roof of the bed, there is a bed with sandstone concretions (0.5 m) and numerous nodules of the algae *Girvanella* sp.; at the base of the bed there is a slab (0.7 m) of sandstone, yellowish-gray, dense, strongly calcareous, in places detrital, with small (3 cm) sand pebbles; Cor—solitary *Montlivaltia crimica*, *M. kaufmani* and colonial *Monocyclastrae alpina* (Koby); Am—*Berriasella* sp., *Euphylloceras serum*, *Haploceras elimatum*, *H. subcarachtheis* Drusch., *Malbosiceras chaperi* (previously *Malbosiceras* sp. indet. Cited by Bogdanova and Kvantaliani (1983)), *Ptychophylloceras semisulcatum*, *Thysanolytoceras liebigi*); Bv—*Cosmetodon carteroni*, *Entolium germanicum*, *Eriphylla crimica*, *Gervillella anceps*, *Gryphaea weberae*, *Integricardium deshayesianum, Neithea valangiensis, Panopea neocomiensis , Plagiostoma dubisiensis, Prohinnites renevieri, Pseudolimea royeriana, Pterotrigonia caudata*, *Ptychomya robinaldina*, *Sphaera belbekensis*, *Tortarctica weberi*; Gs—*Ampullina koinautensis* Pchel., *A. subautharis* Pchel., *Ampullospira cossmani*, *Cyphosolenus sanctaecrucis* (Pict. et Camp.), *Metacerithium uniforme* Pchel.; Bl—*Conobelus conicus*, *Duvalia lata*, *Pseudoduvalia bipartitus* Bl.; Br—*Dictyothyris spinulosus* Sm., *Loriolithyris valdensis*, *Symphythyris arguinensis* (Mois.), *Terebratulilina arguinensis* Mois.

Sandstone slabs of Bed 3 were also exposed by a ditch 100 m south of the mouth of the Saigin Ravine, on its port side. Numerous bivalves *Eriphylla mordvilkoae* were found on the top of the slab, forming "shell pavements" (Fig. 19a). A similar "pavement" of *E. crimica* shells was observed further south in a tectonic block in the channel of a ravine (Fig. 19b).

Bed 4 (2.6 m)—clays, gray, greenish, calcareous, slightly sandy, with plant remains and fine detritus; loose sandstone (0.3 m) with sandy pebbles (1–2 cm) at the base, making irregularities on the surface of the underlying Bed 3; Am—*Protetragonites rotundum*, *P. tauricus*; Br—*Loriolithyris valdensis*. Kvantaliani et al. (1979) listed from the lower 4–6 m (Beds 3 and 4): Am—*Berriasella privasensis*, *Euphylloceras serum*,

Phyllopachyceras ptychoicum, *Spiticeras obliquelobatus*, *S. spitiense*. The alternating series of Bed 4 is also exposed to the east, near the southern vicinity of Blagodatnoe, near a spring on the highway; sandstones here contained: Bv—*Ceratostreon tuberculiferum, Limatula tombeckiana, Plagiostoma dubisiensis, Rhynchostreon tombeckianum*; burrows of *Thalassinoides suevicus*.

Bed 5 (3.6 m)—clays, dark gray, bedded, strongly sandy, with charred plant remains; at the base of the bed, there is a layer of sandstone (0.6 m), yellowish-gray, bedded, calcareous, weakly cemented, with thin interbeds of dark gray clays and nodules of dense, strongly marl sandstones; by the abundance of single corrals in sandstones, I consider it possible to recognize it as the marker "*Montlivaltia* horizon". Cor—*Monocyclastraea alpina*, *Montlivaltia conica*, *M. kaufmani*; Gs—*Ampullospira cossmanni*, *Metaceritium uniforme*, *Turritella infracretacea* Pchel; Bv—*Cosmetodon carteroni, Entolium germanicum, Gervillella anceps, Idonearca gabrielis, Integricardium deshayesianum, Neithea valangiensis*, *Plagiostoma dubisiensis*, *Prohinnites renevieri, Protocardia* sp., *Sphaera belbekensis, Tortarctica weberi;* Am—*Berriasella berthei* (Touc.), *B. gallica* (Maz.), *Haploceras carachtheis*, *Leiophylloceras calypso*, *Malbosiceras malbosi*, *Ptychophylloceras semisulcatum*; Br—*Dictyothyris spinulosus*, *Loriolythyris valdensis*, *Praecyclothyris berriasensis* Lob., *Symphythyris arguinensis*.

K_1ber_2. Member III, Beds 6–10 (hap at the base of the member, Bed 6: ~5–8 m, a field road crosses the ridge, descending along the clay slope to the west into a wide valley). Continuation of the section along the outcrops along the western slope of the meridional ridge, from the farm opposite the village of Kozlovka to the north, towards the village of Balki.

Bed 7 (6.7 m)—clays, dark gray, with a greenish tinge, micaceous, nonplastic, with plant debris and small marcasite concretions; in the middle part of the bed, two slabs (0.2 m) of fine-grained, calcareous, ferruginous sandstone with spherosiderite concretions; above them, in clays there is a distinct horizon of siderite nodules (15 × 20 cm); Cor—*Aplocyathus laticonica* Damp. et Kot., *Monocyclastraea alpina*, *Montlivaltia conica*; Gs—*Bathraspira neocomiensis* (d'Orb.), *Gymnocerithium icaunensis* (Cossm.), *Metacerithium uniforme*, *Nerineopsis devoustiana* Cott., *Perisoptera acuta* (d'Orb.), *Turritella infracretacea*; Bv—*Gryphaea weberae, Protocardia carinata;* Am (identified by Drushchits)—*Berriasella* sp., *Bochianites goubechensis* Mand., *Dalmasiceras* sp., *Haploceras subcarachtheis*, *Malbosiceras malbosi*, *Protetragonites rotundum*, *P. tauricus, Ptychophylloceras calypso*, *P. semisulcatum*, *Thysanolytoceras liebigi*; Br—*Belbekella airgulensis*, *Loriolythyris valdensis*, *Symphythyris arguinensis*.

In clays with marl-like concretions, Arkadiev et al. (2012) discovered the zonal ammonite species *Dalmasiceras tauricum* in association with *Euphylloceras serum*, *Leiophylloceras calypso*, and *Protetragonites tauricus*.

Fig. 18. Outcrop of the upper part of a unit of bluish-gray marly limestones in the left side of the Enisarai ravine (Sarysu River basin, 2 km south of the Novoklenovo village); Lower Berriasian, grandis Subzone; corresponds to member I, layer 1 of section no. 9 (photo by T.N. Bogdanova, 1977).

Bed 8 (5 m, not exposed, scree on clay).

Bed 9 (6 m, exposed near the farm)—clays, dark gray, in places strongly arenaceous, with plant debris and rusty iron-gypsum nodules (5 cm); in the lower third of bed, a horizon of marl siderite nodules, Cor—*Aplocyathus laticonica*; Gs—*Ampullospira cossmanni*, *Rhynchocerithium subnassoides*, *Spinigera zitteli* Ret; Bv—*Cosmetodon carteroni, Entolium germanicum*, *Gryphaea weberae*, *Prohinnites renevieri*, *Protocardia carinata*; Am (as identified by V.V. Drushchits)—*Berriasella* sp., *Dalmasiceras* sp., *Haploceras carachtheis*, *Protetragonites tauricus*, *Ptychophylloceras semisulcatus*, *Thysanolytoceras liebigi*; Bl—*Duvalia lata constricta*; Br—*Belbekella airgulensis*, *Dictyothyris spinulosus*, *Loriolythuris valdensis*, *Praecyclothyris berriasensis*, *Sellithyris uniplicata*. This bed is characterized by the presence of large (up to 0.5 m) lytoceratitid ammonites.

Bed 10 (5 m)—clays, dark gray, in places variegated with whitish inclusions, silty, with plant detritus; the top of the bed is sandy; at the base with two slabs of

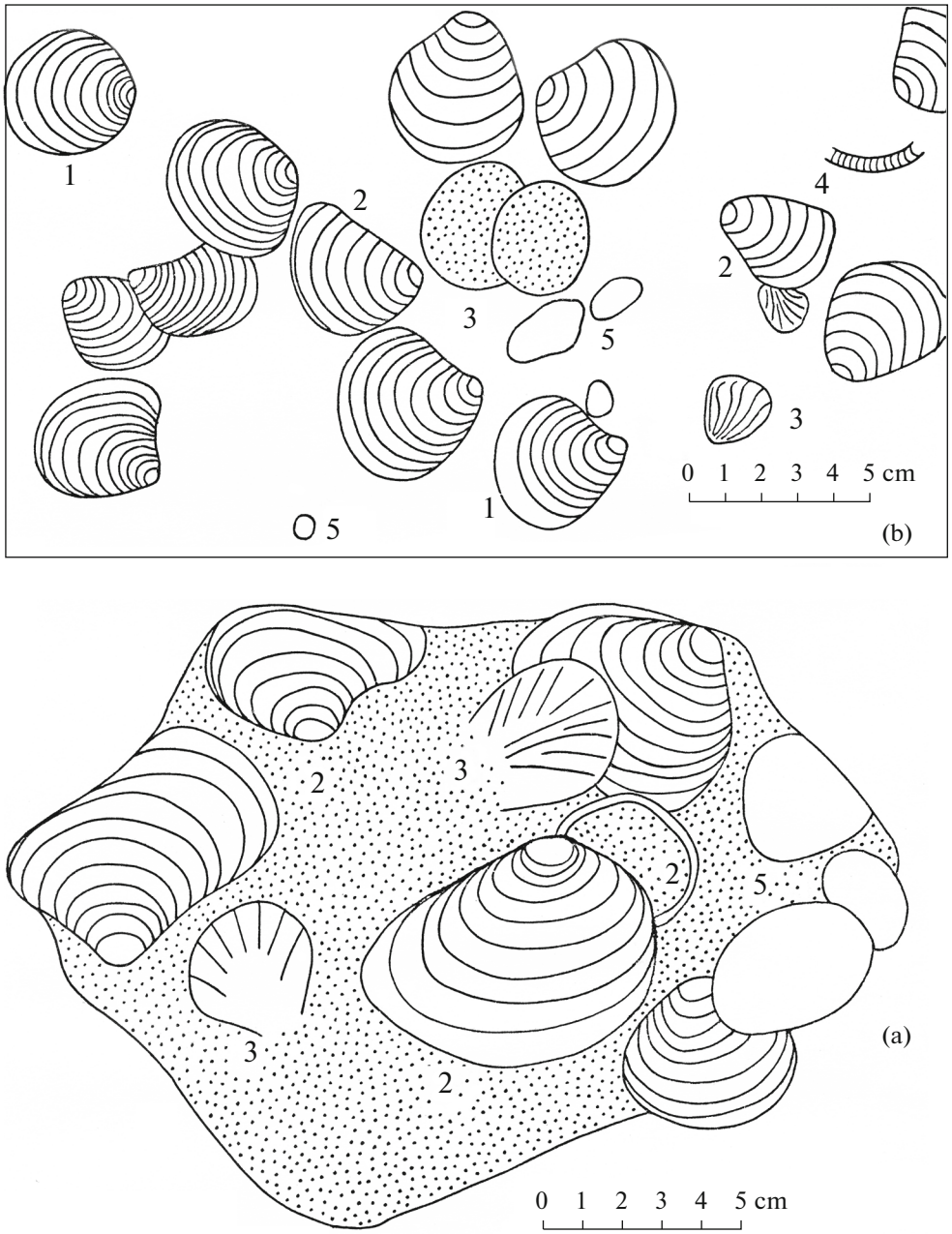


Fig. 19. Weathered surfaces of slabs of calcareous sandstone-shell rocks with scattered valves of bivalve oriented with their convex side up ("shell pavement") in two outcrops in the valley of the Saigin ravine: (a) outcrop 1320 m upstream from its mouth (tectonic wedge in the channel of the ravine) ; (b) outcrop in a diversion ditch 100 m from the mouth of the ravine, on its port side, near the base of section no. nine; explanations: bivalves (1) *Eriphyla crimica*, (2) *E. mordvilkoae*, (3) *Prohinnites renevieri*, (4) one fragment of *E. crimica* valve is oriented vertically to the bedding plane, (5) well-rounded limestone pebbles; (a, b) Sarysu River basin, vicinity of the village of Blagodatnoe; correspond to Member II, Beds 3 and 4 sections no. 9; Lower Berriasian, *chaperi* Beds (field sketches by the author, 1986).

yellowish-gray, compact, calcareous sandstone, separated by a bed of siltstone (total thickness 0.7 m) and filled with oyster shells (*Gryphaea weberae*); shells and scattered valves form a coquina bed (oyster bank), which is a marker horizon traced in several outcrops in the Sarysu basin. The oyster shells are variously oriented: on the top of the lower sandstone slab, scattered valves form a "shell pavement" (Fig. 20b), and below it, whole shells retained their lifetime position in low energy depositional environment (Fig. 20a). Fossils from the oyster beds include: Cor—*Aplocyathus laticonica*); Gs—*Bathraspira neocomiensis*, *Claviscula condardi* Cossm., *Nerineopsis davoustiana*, *Pseudomelania gresslyi* (Pict. et Camp.), *Rhynchocerithium sub-*

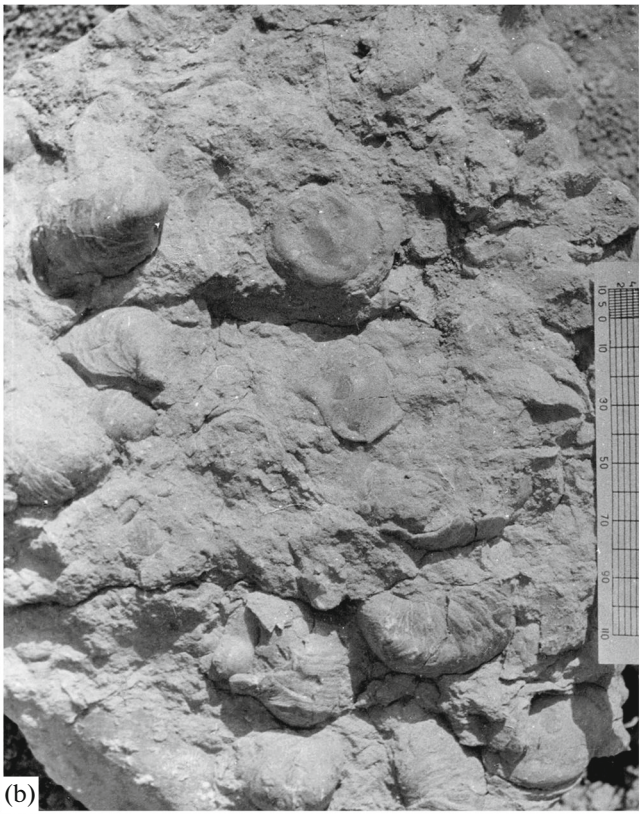


Fig. 20. Different shell orientations of *Gryphaea weberae* oysters in the Middle Berriasian deposits in the Sarysu River valley: (a) burial of whole (bivalve) shells in their vital position in silty clays under the oyster marking horizon: in seven specimens, the lower valves are oriented with their convex side to the bottom of the bed; the upper valves are oriented mainly horizontally (they served as lids; such a position of the valves indicates a sudden falling asleep of live mollusks with sediment); (b) weathered surface of a dense sandstone slab with posthumously oriented scattered valves; the lower and upper flaps with a convexity upwards are the "shell pavement" formed in the wave zone; the Sarysu River basin, the vicinity of the village of Kozlovka; section no. 9, Member III, Beds with respectively 9 and 10; Middle Berriasian, *tauricum* Subzone (author's photo, 1962).

nassoides (d'Orb.), *Spinigera zitteli*, *Turbinopsis multicostulata* Pchel., *Turritella infracretacea*; Bv—*Acesta orbignyana*, *Ceratostreon tuberculiferum*, *Ctenostreon balkiensis, Entolium germanicum, Fimbria berriassica, Goniomya villersensis, Gryphaea weberae, Integricardium deshayesianum, Prohinnites renevieri, Protocardia carinata, Pseudolimea royeriana, Sphaera belbekensis, Spondylopecten subspinosus Tortarctica w*eberi; Am (as identified by V.V. Drushchits)—*Berriasella privasensis*, *Dalmasiceras* sp., *Euphylloceras serum*, *Haploceras carachtheis*, *H. elimatum*, *Leiophylloceras calypso, Malbosiceras malbosi*, *Protetragonites rotundum*, *P. tauricus*, *Ptychophylloceras semisulcatum*, *Spiticeras obliquelobatum*, *Thysanolytoceras liebigi*. Kvantaliani et al. (1979) listed *Dalmasiceras punctatum* (Qu.), *Ptychophyloceras ptychoicum* et al. from the oyster bed; Br—*Loriolithyris valdensis*, *Praecyclothyris berriasensis*, *Sellithyris uniplicata*; Ech—*Diplocidaris bicarinatus* Weber.

Abundant bivalves, gastropods and brachiopods have been collected from the arenaceous clays occurring in the upper part of the bed; the species composition of the assemblage is identical to that of the oyster bank. The ammonites include *Berriasella privasensis*, *Dalmasiceras* sp., *Haploceras carachtheis*, *Leiophylloceras calypso*, *Ptychophylloceras semisulcatum*, *Protetragonites tauricus*, *Spiticeras groteanum* Opp. (Bogdanova and Kvantaliani, 1983).

K_1ber_3. Member IV (Bed 11): overlying sandstones, siltstones and clays, which are well exposed on the western slope of the meridional ridge south of the village of Balki, I attributed to the Upper Berriasian (see the geological age substantiation).

Geological Age

The section contains deposits of: the Lower Berriasian—*grandis* Subzone and *chaperi* Beds, Middle Berriasian—*tauricum* Subzone and Upper Berriasian—*euthymi* Subzone.

$K_1ber_1^2$. Lower Berriasian, *grandis* Subzone—limestones exposed in the sides of the Saigin Ravine (Member I, Bed 1, >10 m). Previously, they were assigned to the Upper Jurassic (Drushchits in *Atlas* ..., 1960; Drushchits, 1975); Lower Berriasian (Kvantaliani et al., 1979; Kvantaliani, 1989; Yanin et al., 1981; Yanin, 2004a, 2004b). At present, the limestones underlying the *chaperi* Beds are correlated by with the upper part of the carbonate series of the Karabi Section containing the zonal species *Pseudosubplanites grandis* (previously identified as *P. ponticus*, see Bogdanova et al., 1981). The presence of the above species of gastropods and bivalves in the limestones of Member I of the considered section indicates their Berriasian age.

$K_1ber_1^3$. Lower Berriasian, *chaperi* Beds—alternation of sandstones, clays and limestones on the left side of the ravine, near its mouth (Member II, Beds 2–5). An interbedded member with numerous solitary corals, bivalves, gastropods, and ammonites was previously classified as Valanginian (Weber, 1937; Moiseev, 1937); lower Valanginian (Drushchits in *Atlas* ..., 1960); Lower Berriasian (Yanin and Smirnova, 1981). The Early Berriasian age of the alternation series is established based on the ammonite index species *Malbosiceras chaperi* in the clay-sand deposits of Bed 3, which makes it possible to attribute the entire member II to *chaperi* Beds.

K_1ber_2. Middle Berriasian, *tauricum* Subzone—clays with arenaceous marl interbeds and siderite nodules in the lower and middle, sandstone and shell (oyster) interbeds in the upper part (Member III, Beds 6–10, 30 m); traced along the western slope of the ridge. The history of zone subdivision of Unit III in this section is quite complex. V.V. Drushchits, accepting the bipartite subdivision of the Berriasian, for a long time attributed the clay sequence with interbeds of sandstones and horizons of siderite nodules exposed south of the village of Balki to the *Euthymiceras euthymi-Dalmasiceras dalmasi* Zone (Drushchits, 1975; Drushchits et al., 1979, 1985, 1986). Kvantaliani and Lysenko (1979) and Kvantaliani (1989) subdivided this zone into two: the *D. dalmasi* (Middle Berriasian) Zone and the *E. euthymi* (Upper Berriasian) Zone. Bogdanova et al. (1981) recognized an 18-m-thick Member in the argillaceous-silty series as the *Dalmasiceras crassicostatum* local Zone. It was later upgraded to the rank of regular Zone with the name of the index species changed to *D. dalmasi* (Bogdanova and Kvantaliani, 1983) on the grounds that *D. dalmasi* Zone is standard and has long been used in subdivision and correlation (Kvantaliani, 1989).

Bogdanova and Arkadiev (1999), revised the *Dalmasiceras* and described a new species *D. tauricum*, that included the specimens from the Crimea previously identified as *D. crassicostatum*. Accordingly, *D. tauricum* became the index species. Arkadiev et al. (2012) consider it to be a local subzone of the *Tirnovella occitanica* standard Zone. In the section described here, according to the tripartite subdivision of the stage adopted in this paper, this subzone is attributed to the middle Berriasian.

Unfortunately the contact with the underlying *chaperi* Beds could not be made due to a gap in the observation (Bed 6). We draw the boundary with the Upper Berriasian *Neocosmoceras euthymi* Subzone at the base of the sandstone slab, which lies 5 m above the marker oyster horizon (Member IV, Bed 11). It is noteworthy that a significant number of species of ammonites, bivalves, gastropods, and brachiopods found in the deposits of this subzone continued at the very beginning of the Late Berriasian (Arkadiev et al., 2012).

Tonas Section

The section is composite, compiled in the area around the village of Krasnoselovka on the right side of the Tonas river valley: the lower part of the section is 1.5 km south of the village, along the Belogorsk-Povorotnoe highway (A), the middle part is along Kuchuk-Uzen' Creek, southeast of the village (B), the upper one is north of the village, between it and the forestry (C). When characterizing the deposits of the upper part of the section, I used the data from the corresponding interval described in the area of the village of Alekseevka on the right tributary of the Tonas River. In the lower part, the section is represented by flyschoid series of clays and brecciated limestones, in the middle part it is composed by interbedding of clays, marls and limestones, in the upper part the section contains clays with interbeds of limestones and horizons of siderite nodules. The section is traced over a distance of 4 km.

The Berriasian deposits everywhere lie monoclinally with a slight change of the dip from 0° N at 28° in the south, in the area of the "Devil's Gate", to 345° NW at 20° in the north. The deposits fill the western sections of the Indole Trough, where they directly adjoin the limestone massifs of the Karabi-Yaila and Chombai Mountains, which in the Berriasian represented the margin of the Indole Depression. Eroded demolition products (Upper Jurassic, most likely Oxfordian limestones) were occasionally supplied to this depression from a steep side. Numerous slabs of limestone in the section, consisting of large limestone breccia and containing unrounded limestone blocks, represent the first architectural elements of turbidites. Rocks at the base of these slabs contain traces of erosion of the underlying deposits.

The Berriasian section was studied by members of the Lower Cretaceous field team of the Department of Paleontology of Moscow State University in 1954, 1963, 1987 and 1989. In their works, at an early stage of studying the Lower Cretaceous deposits of the area, they recognized the Lower and Middle Upper Valanginian (Drushchits in *Atlas* ..., 1960). In later publications, the Lower Valanginian was referred to as the Berriasian (Gorbachik, 1969; Drushchits et al., 1985, 1986). The section description and log presented here were compiled by our team in 1987–1989. Data on its composition and fossils from previous publications are also used.

A brief description of the Berriasian deposits with the image of the complete section or its individual intervals is given in the works (Drushchits in *Atlas* ..., 1960; Gorbachik, 1969; Lychagin, 1969; Gorbachik et al., 1970; Drushchits et al., 1977, 1985; Bogdanova et al., 1981, 1984; Baraboshkin et al., 2016: guide, excursion 3A).

The section lithology and fossils (some Berriasian ammonites, bivalves and brachiopods) were published by Arkad'ev et al. (2003, 2005, 2008, 2012). Based on new collections of ammonites, the section of the flyschoid series of the Lower Berriasian has been subdivided at the zonal level.

The lithological and paleontological features of the Berriasian deposits, as well as their considerable thickness, make it possible for the Tonas section to be considered as type or reference sections for the western part of the Eastern Crimea. For the first time this section was called typical by Gorbachik et al. (1975). Later, in 1977, the same authors (Drushchits et al., 1977) proposed to consider it as a reference section. This was confirmed in 2016 at the VIII All-Russian Conference in the Crimea (Baraboshkin et al., 2016, excursion 3A). Previously Bogdanova et al. (1981) it was partially included in the East Crimean type section. We propose here to call it typical and separate from the East Crimean type section.

Fossils are identified and described in the following works: Fr (Gorbachik, 1969; Kuznetsova and Gorbachik, 1985); Am (Arkad'ev et al., 2005, 2008, 2012); Bv (Yanin, 2004; Bogdanova in Arkad'ev et al., 2005, 2008; Yanin in Arkadiev et al., 2012); Br (Lobacheva, 1983, 2005; Lobacheva et al., 1994, 2006); Cr (Klikushin, 1987); ichnofossils (Baraboshkin et al., 2016; the paper presents a structural diagram of the complete Berriasian section along the Tonas River with a poor distribution of ammonites).

Description of the Tonas A Section (Fig. 21)

J_3tt_3. The underlying deposits are well exposed 1.5 km south of the village of Krasnoselovka in the area of "Devil's Gate" (="Shaitan-Kapu") and are represented by limestone, gray, light-brown, massive, biogenic (coral-hydroid-algae), forming rock outcrops; their visible thickness is about 50 m; the top of the limestones is traditionally taken by many geologists as the boundary between the upper Tithonian and the lower Berriasian.

$K_1ber_I^1$. Members I–III (287 m)—flyschoid series of cyclic interbedding of clays and limestones; the column shows several main cycles of sedimentation, consisting of two rhythms: the first—slabs (0.3–2.5 m) of brecciated limestone with fragments and blocks of gray Upper Jurassic limestones and the second—interbeds (0.2–2.5 m) of dark gray clays and siltstones; limestone slabs rest on underlying rocks over a considerable unconformity. Several of the largest cycles are identified in the pack.

Member I (144 m). Bed 1 (26 m)—at the base there are thick-platy brecciated limestones (9 m), in the middle part there is a slab (0.9–1.0 m) of the same limestones; between them interbeds (3–10 m) of clay; in the upper silty clay, a horizon (0.7 m) of small lime-

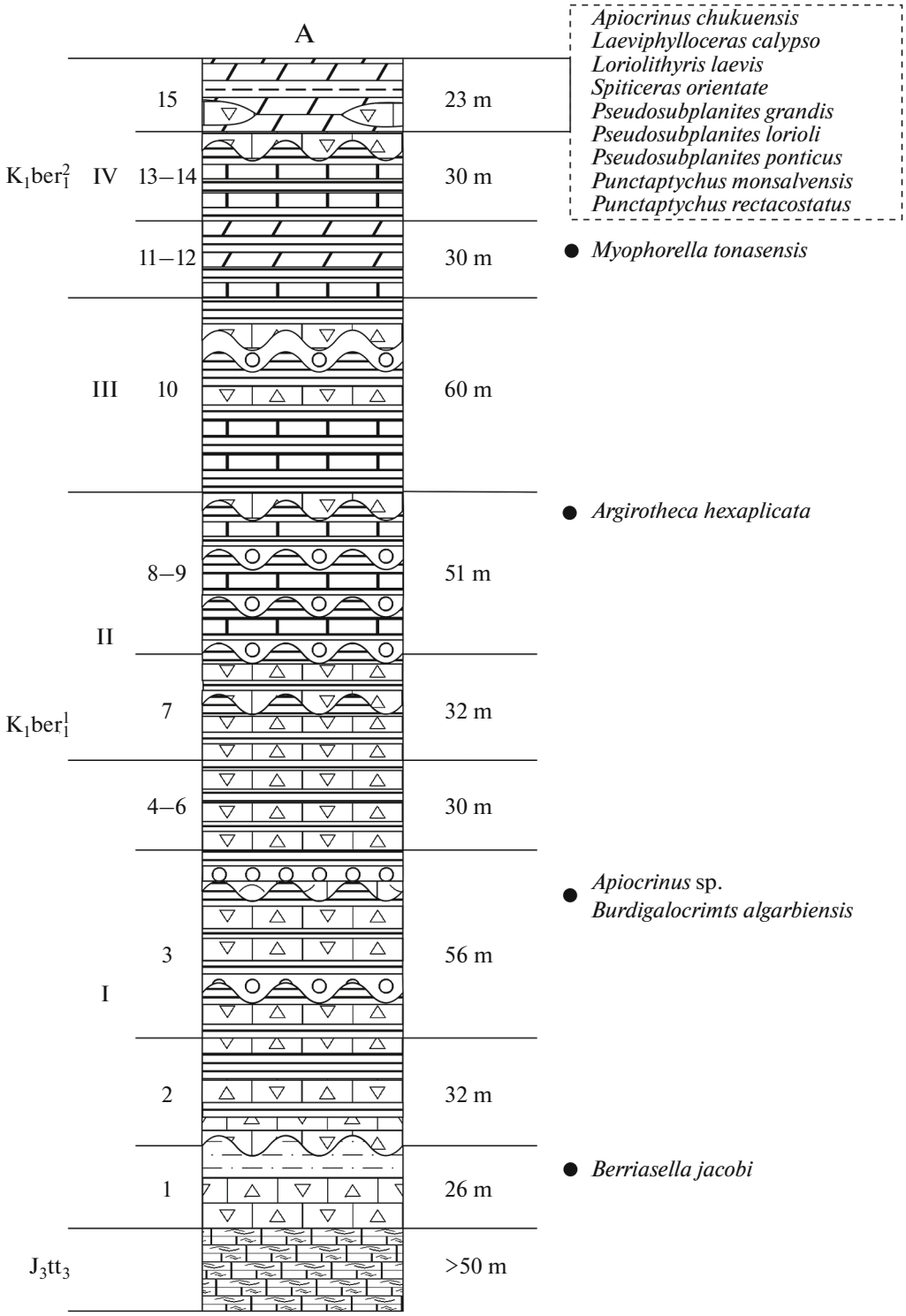


Fig. 21. Tonas type section, no. 10A—lower part of summary section: in the vicinity of the village of Krasnoselovka, described along highway Belogorsk–Povorotnoe; basin of the Tonas River; by data of author; Lower Berriasian, *jacobi* Subzone (see explanations for Fig. 2).

stone pebbles; Am (26 m above the contact with the Tithonian limestones)—*Berriasella jacobi* Maz. (Arkadiev et al., 2005).

Bed 2 (32 m)—at the base, a slab (2.5 m) of boulder conglomerate, turning into brecciated limestone; above, thin-platy alternation of clays and brecciated

limestones; in the upper clay beds there are burrows of *Rhizocorallium jenense* Zenker.

Bed 3 (56 m)—alternation of large-platy limestones; at the base is a slab (2.5 m) with pebbles and blocks (0.5 × 0.8 m) of limestone, lying on the eroded surface of the underlying clay with irregularities up to 1 meter deep; in the interbedding of silty clays and limestones—sponges, corals, hydroids, gastropods, oysters, echinoid spines, crinoid columnals: Cr—*Apiocrinus* sp., *Burdigalocrinus algarbiensis* Lor., *Cyrtocrinus* sp.

Bed 4 (8 m)—at the base is a limestone horizon (2 m) with boulders; above is a fine-rhythmic alternation of clays and limestones.

Bed 5 (8 m)—at the base is a slab (1.55 m) of limestone, in the lower part it is conglomerate, in the upper part it is brecciated; in the overlying clays there are slabs (0.2–0.5 m) of similar limestone.

Bed 6 (14 m)—at the base is a slab (1.6 m) of conglomerate and brecciated limestone; above—clay beds with several limestone slabs (0.2–2.8 m).

Member II (83 m). Bed 7 (32 m)—at the base there is a slab (2.5 m) of limestone with boulder-pebble limestone material; boulders (0.3 × 0.4 m); above clay with limestone slabs, the thickest of which (0.85 m) in the middle part of the member; ammonites are found in clays.

Bed 8 (46 m)—at the base there is a slab (1.0–1.3 m) of brecciated limestone (without blocks and boulders) lying on a strongly abraded surface of underlying clays; the roof of the slab is also uneven, with thin lenses of coarse-grained sandstone with small (2–3 cm) limestone pebbles; higher fine alternation of clays and brecciated limestones; burrows *Rhizocorallium jenense*, *Haentzschelinia* sp.

Bed 9 (5.2 m)—at the base is a slab (0.7 m) of a conglomerate of limestone pebbles and clays; above a fine alternation of clays and brecciated limestones; Br—*Argirotheca hexaplicata*; burrows of *Petaloglyphus crimicus*.

Member III (60 m). Bed 10—at the base is a slab (0.35 m) of conglomerate limestone; above—clayey series with rare interbeds of marls and sandstones and lenticular slabs (15–30 cm) of fine brecciated and detrital limestones; clays contain ammonites and gastropods.

$K_1ber_1^2$. Member IV (83 m, exposed in the "Three Pipes" Ravine, the right wide tributary of the Tonas River near the southern vicinity of Krasnoselovka), an alternation of clays, marls, less often limestones.

Bed 11 (20 m)—at the base is a slab (0.3 m) of fine brecciated limestone; above clay with thin slabs of marls and sandstones and limestone lenses; in sandstone: Bv—*Myophorella tonasensis* in in clay burrowings of *Taenidium* isp.

Bed 12—gap in observation 10–15 m.

Bed 13 (18 m)—clay interbeds and slabs (0.25–0.6 m) of marls and brecciated limestone; the clays contain burrows of *Petaloglyphus crimicus* Viyal.; the limestone contains a burrow of *Taenidium* isp.

Bed 14 (12 m)—marly clays with interbeds and slabs (0.1–0.25 m) of marls and fine brecciated limestones; in places, clear three-element rhythms are observed (bottom-up: limestone, clay, marl).

Bed 15 (visible thickness 23 m)—marly clay with interbeds (0.1–0.5 m) of marls and rare slabs (15 cm) of fine limestones; ammonites, aptychi, ichnofossils are numerous: Am (as determined by T.N. Bogdanova, 1981)—*Leiophylloceras calypso*, *Pseudosubplanites lorioli* (Zitt.), *P. ponticus*; (according to V.V. Arkadiev et al., 2003, 2005, 2012)—*Pseudosubplaniteos lorioli*, *P.* cf. *grandis, P.* cf. *ponticus* , *Spiticeras orientale* (Kil.); Ap—*Punctaptychus imbricatus* Pict. (=*P. monsalvensis* Trauth.), *P. rectecostatus* Cuzzi; Cr—*Apiocrinus chukuensis* Klik., *Loriolicrinus laevis* Klik.; ichnofossils: *Paleodictyon*, *Planolites*, *Taenidium* et al.

Section Description "Tonas B" (Fig. 22B)

The continuation of the section was traced southeast of the village of Krasnoselovka along the sides of Kuchuk-Uzen' Creek. Due to dense vegetation, we were unable to accurately compare the specific beds described in the Three Pipes Ravine (Member IV) with the beds exposed in the banks of Kuchuk-Uzen' Creek (Members V–IX). We assume that the former rest in the lower, and the latter in the middle and upper parts of the entire series of marls with ammonites. Deposits along Kuchuk-Uzen Creek can be referred to as the "ammonite beds".

In general appearance, structure of units and a large number of ammonite molds in marls, they are similar to "Feodosia marls" (see Feodosia type section).

The section along Kuchuk-Uzen' Creek was studied in detail by Bogdanova (in 1977 with the participation of the author). Its description was partially published in 1981, and the section log compiled by Bogdanova with a bed-by-bed distribution of ammonites and other groups was published later (Arkadiev et al., 2005, 2012; Lobacheva et al., 2006). The original drawing of this log is included in this paper, but with additional paleontological information.

$K_1ber_1^2$. Member V, Bed 16 (>10 m, gap in observation).

Member VI, Bed 17 (27.8 m, exposed in the middle reaches of Kuchuk-Uzen' Creek)—alternation interbeds of greenish-gray clays, siltstones and slabs (0.3–0.4 m) of brown-gray detrital limestones; fossils include: Am—*Pseudosubplanites lorioli*; Bv—*Acesta orbignyana, Spondylopecten subspinosus*; Br—*Lacunosella* cf. *monsalvensiformis* (Jac. et Fall.).

Member VII, Bed 18 (42 m)—frequent alternation of clays and marls with slabs of bioclastic limestones

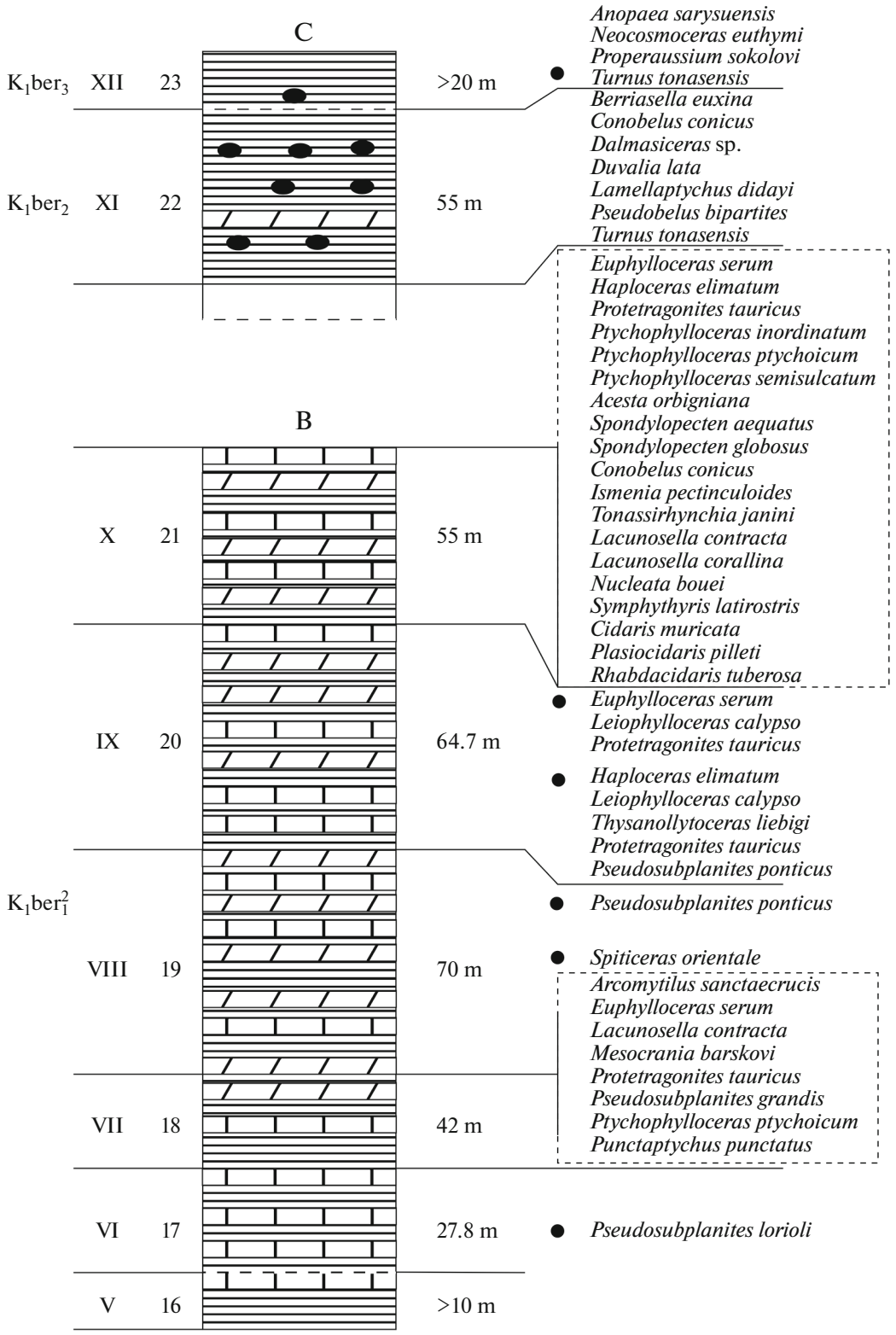


Fig. 22. Tonas type section, no. 10 B and C—middle and upper parts of summary section: (B) in the vicinity of village of Krasnoselovka; Kuchuk-Uzen' Creek; compiled material by Bogdanova et al., 1981 (see also Arkadiev et al., 2012); Lower Berriasian, subzona *grandis*; (C) in the valley of Tonas River; by data of author; Middle Berriasian, *tauricum* Subzone (see explanations for Fig. 2).

Fig. 23. Flyschoid alternation of clays and marls in the right bank of the Kuchuk-Uzen' Creek (basin of the Tonas River, near the village of Krasnoselovka); section 10B, Members IX-X, Beds 20–21; Lower Berriasian, *grandis* Subzone (photo by T.N. Bogdanova, 1977).

and horizons of limestone pebblestones (Fig. 23); there are seven slabs in a pack; Am (identified by T.N. Bogdanova)—*Berriasella* sp., *Biasaloceras liebigi*, *Pseudosubplanites grandis*, *P. lorioli*, *P. ponticus*, *Ptychophylloceras semisulcatum*, *P. tenuicostatum* Ark. et Bogd.; Ap—*Punctaptychus punctatus* Volz.; Bv—*Arcomytilus sanctaecrucis*, *Spondylopecten subspinosus*; Br—*Lacunosella* sp.; Cor—*Cyatophora mirtschinka* Kusm., *Dimorphastraea bellula* (d'Orb.); Cr—*Apiocrinus* sp.

Member VIII, Bed 19 (70 m)—siltstones and clays with slabs (0.1–0.2 m) of marls and detrital limestones; in a pack of seven plates; abundant fossils from different groups: Am—*Berriasella* sp., *Bochianites* sp., *Macrophylloceras* ex gr. *beneckei* (Opp.), *Pseudosubplanites ponticus*, *Ptychophylloceras semisulcatum*, *P. tenuicostatum* (Ark. et Bogd.), *Spiticeras orientale*; Bv—*Rhynchostreon tombeckianum*, *Spondylopecten subspinosus*; Br—*Mesocrania barskovi* Sm., "*Rhynchonella" subvariabilis*.

Member IX, Bed 20 (64.7 m)—siltstones with slabs (0.2–0.5 m) of marls and detrital limestones; throughout the member, cyclicity in rhythms is observed, limestone, marl, siltstone from bottom to top; the member contain seven slabs; Am—*Euphylloceras serum*, *Haploceras elimatum*, *Leiophylloceras calypso*, *Thysanolytoceras liebigi, Protetragonites tauricus*, *Pseudosubplanites ponticus*; Br—*Lacunosella* sp.

Member X, Bed 21 (55 m)—siltstones with slabs of marls and detrital limestones; Am—*Euphylloceras serum*, *Haploceras elimatum*, *Protetragonites tauricus*, *Ptychophylloceras inordinatum* (Touc.), *P. ptychoicum*, *P. semisulcatum*; Bv—*Acesta orbignyana, Spondylopecten aequatus*, *S. globosus*; Br—*Ismenia pectunculoides* (Schloth.), *Lacunosella contracta*, *L. corallina neocomiensis*, *Nucleata bouei* (Zeusch.), *Symphythyris latirostris* Suess, *S. substriata* (Schloth.).

Section Description "Tonas C" (Fig. 22C)

We traced the continuation of the section in the Tonas valley at a distance of 2 km north of the village of Krasnoselovka to the forestry. The lower part of the section near the mouth of Kuchuk-Uzen Creek, near the pond in the vicinity of the village, is very poorly exposed, hence there was a gap of about 30 m in observation.

K_1ber_2. Member XI, Bed 22 (55 m, is exposed in the right side of Tonas, below the mouth of Kuchuk-Uzen' Creek), alternation series of (4–6 m) of greenish-gray dense clays, slabs (0.5–5.0 cm) of light-gray, clayey marls and rare slabs (10–20 cm) brownish-gray, brecciated limestones; clays contain interbeds (5–10 cm) of sandstones and an abundance of interbeds (5–50 cm) and horizons of nodules (10 × 50 cm) of marly siderite; Am (identified by V.V. Drushchits)—*Berriasella* sp., *Dalmasiceras* sp., *Haploceras* sp., *Protetragonites* sp., *Ptychophylloceras semisulcatum*, *Thysanolytoceras liebigi*; Ap—*Lamellaptychus didayi* Coq.; Bl—*Conobelus conicus*, *Duvalia lata constricta*, *Pseudobelus bipartitus*; Bv—*Inoceramus* sp., *Turnus tonasensis*.

Member XII, Bed 23 (over 20 m)—clay gray, greenish-gray and black, carbonate, with numerous marly concretions (5 × 12–20 × 50 cm) and their sheet-lenticular interbeds (15 cm) and rare slabs (0.4 m) of brec-

ciated and detrital limestones and fine-grained, highly ferruginous sandstones with abundant coalified plant debris; horizons of siderite nodules are revealed on the slopes in the form of red-brown stripes on a gray background; up the section, the clay is heavily arenaceous; Am (identified by V.V. Drushchits)—*Euthymiceras euthymi*., *E. transfigurabilis* Bogosl.; Bl—*Conobelus conicus*; Bv—*Anopaea sarysuensis* Yanin, *Propeamussium sokolowi*, *Turnus tonasensis;* ichnofossils—*Chondrites intricatus* (Stern.), *Helmintopsis* isp., *Planolites beverleyensis* (Bill.).

Geological Age

The Tonas type section, contains the *jacobi* Zone with two subzones: *jacobi* and *grandis* (Lower Berriasian), the *occitanica* Zone with the *tauricum* Subzone (Middle Berriasian), and the *boissieri* Zone with the *euthymi* Subzone (Upper Berriasian).

$K_1ber_1^1$. Lower Berriasian, *jacobi* Subzone (section A, Members I–III). Flyschoid deposits in the Tonas Basin have long been considered Upper Jurassic. For instance, Moiseev (1937, p. 123) noted that "a thick limestone cornice with rudists (=Chertovye Vorota") is followed by a flysch band consisting of shale clays with interbeds of brecciated limestones prevailing in the lower horizons of the series. The upper horizons are dominated by clays with rarer and thinner interbeds of sandstone and limestone." He attributed both horizons to the Upper Jurassic. This point of view was reflected on the Geological maps of the Crimea of 1926 and 1937, on which the Tithonian-Valanginian boundary was drawn north of the village of Krasnoselovka. Uspenskaya (1969, p. 146) in the list of the so-called "Upper Tithonian ammonites" included the species *Berriasella pontica* Ret., which already at that time was considered characteristic of the Lower Berriasian from the flyschoid series occurring directly "above the thick horizon of brecciated limestones".

Drushchits (*Atlas* ..., 1960) first attributed the deposits of the first and second horizons to the lower Valanginian, and also drew the boundary between it and the Tithonian along the top of a thick limestone unit that forms the "Devil's Gate" in the relief. Other authors attributed the flyschoid deposits occurring in the lower part of the section to the Lower Valanginian (=Berriasian Horizon) (Lychagin, 1969); partly Berriasian and partly Tithonian (Bogdanova et al., 1981); Berriasian (Muratov, 1969, 1973) or Lower Berriasian (Klikushin, 1987).

Gorbachik (1969) and Gorbachik et al. (1970) believed that the lowest part of the flyschoid interbedding (30 m) is Tithonian, and the middle part of the similar series (96 m) overlying it is Lower Berriasian. Such a subdivision of the lithologically homogeneous series was based on the species complex of foraminifers. Bogdanova et al. (1981, 1984) the lower part of the flyschoid series (147 m), which is exposed on the Krasnoselovka–Povorotnoye highway directly above the massive limestones near the "Devil's Gate", was attributed to Tithonian, and its middle part (284 m, along the highway and along Kuchuk-Uzen' Creek) to the Lower Berriasian (*Pseudosubplanites ponticus*–*P. grandis* Zone). The dating by Gorbachik and Bogdanova et al. were provisional, since zonal ammonite species in the lower part of the flyschoid series, which is exposed along the highway, were not found at that time.

Later, after the index species *Berriasella jacobi* was found at the very base of the interbedding (26 m above the Tithonian limestones in the Chertovye Vorota area), a clear justification was obtained for the identification of Zone and *jacobi* Subzone (Arkadiev et al., 2003, 2012). The authors attributed to it the lower part of the interbedding (160 m) from Bed with *B. jacobi* to the appearance of the ammonite assemblage of the *grandis* Subzone. According to our data, the thickness of *jacobi* Subzone reaches 287 m.

$K_1ber_1^2$. Lower Berriasian, *grandis* Subzone (section A: Member IV, Beds 11–15 and Section B: Members V–X, Beds 16–21). The deposits of this subzone also have a flyschoid character, but differ from the underlying series in a more clay-marl alternation with an abundance of faunal remains, a decrease in the number and thickness of brecciated limestone slabs. The deposits contain a rich assemblage of ammonite, aptychi, belemnite and bivalve species due to the finely-grained facies. In general appearance, the architecture of the units and the abundance of ammonites, they are similar to the "Feodosia marls" (see Feodosia type section).

The deposits described here were previously assigned to: the Lower Valanginian (Drushchits in *Atlas* ..., 1960: by the presence of ammonites *Berriasella pontica*, *Euthymiceras* sp. and aptychi *Punctaptychus imbricatus*; Gorbachik, 1969: based on foraminiferal assemblage); Berriasian Horizon (Lychagin, 1969: based on the ammonites *Berriasella delphinensis* Kil., *B. incomposita* Ret., *B. subrichteri* and aptychi *Punctaptychus punctatus*); Lower Berriasian (Bogdanova et al., 1981: Zone *Pseudosubplanites ponticus*–*P. grandis*; Lobacheva et al., 2006: *Berriasella jacobi*-*Pseudosubplanites grandis* Zone; Arkadiev et al., 2003, 2012; Baraboshkin et al., 2016: *B. jacobi* Zone, *P. grandis* Subzone). The last variant of assigning Members IV–IX to the *grandis* Subzone is also accepted in this paper.

K_1ber_2. Middle Berriasian, *tauricum* Subzone (section "C": Member XI, Bed 22, 55 m). The deposits of this subzone, represented by clays and siltstones with interbeds of limestones and horizons of siderite nodules, were previously assigned to: Lower Valanginian (Uspenskaya, 1969: based on the presence of the ammonites *Berriasella obtusenodosa* Ret., *Neocomites occitanicus* (Pict.); Middle–Upper Valanginian (Drushchits in *Atlas* ..., 1960: based on the assemblage

of the belemnites *Duvalia lata constricta*, *Pseudobelus bipartitus* and the aptychi *Lamellaptychus didayi*, *L. seranonis* Coq., Upper Valanginian (Gorbachik, 1969: based on foraminifers), Lower Berriasian (Drushchits et al., 1985: *Berriasella boissieri* Zone) Unfortunately, no zonal ammonite species was found in the deposits of Member XI.

Based on the complex of ammonites, belemnites and aptychi (see the description of Member XI), one can be sure that the deposits belong to the Middle-Upper Berriasian. Their exact age is determined by comparison with similar formations exposed in a more eastern section, along the valley of the right tributary of the Tonas, in the vicinity of the village of Alekseevka, where T.N. Bogdanova et al., 1981, p. 10) recorded the ammonites *Dalmasiceras* ex gr. *crassicostatum* and *D.* ex gr. *subspiticeroides* Djan. in the middle part of the "series of gray clay with interbeds of crimson and brown clays".

Based on that, some of the clays (42 m) were attributed by the authors to the *D. crassicostatum (=D. tauricum)* local Zone. This point of view was accepted by Baraboshkin et al. (2016: Excursion 3A) when describing the Tonas reference section. Arkadiev et al. (2003, 2012, p. 43) "a series of gray with interbeds crimson and brown clays" in the Alekseevsky section, containing *Dalmasiceras tauricum* and *D. belbekense* Bogd. et Ark., were also assigned to the *tauricum* Subzone. The lower and upper boundaries of this subzone have not yet been precisely established. In the Tonas section, we include clays with siderite nodules (section C, Member XI, 55 m) occurring between the underlying deposits of Unit X (clays and marls in the banks of Kuchuk-Uzen' Creek, section B) and overlying similar clays (section C, Member XII, >20 m) based on the first appearance of the Upper Berriasian zonal ammonite species *Neocosmoceras euthymi*.

K_1ber_3. Upper Berriasian, *euthymi* Subzone (section C, Member XII, clays with siderite nodules, >20 m). Gorbachik (1969, p. 64, table 3) remarked that in the area from the pond on the northern vicinity of the village of Krasnoselovka to the ravine near the forester's house and further along the Tonas valley in the area of the reservoir, "in a series of greenish-gray carbonate clays with siderites" ammonites were found, identified by Drushchits as *Euthymiceras euthymi*. Later Drushchits et al. (1985, p. 15) noted that in "the base of the Upper Berriasian... in clays with interbeds of detrital limestones and marls (51 m)" containing the same Upper Berriasian ammonite index species, currently referred to as *Neocosmoceras euthymi*. The boundary between the upper Berriasian and the lower Valanginian in the Tonas section remains unsubstantiated, since no index species of Valanginian ammonites have yet been found in the overlying clay series with horizons of blocky conglomerates. Conventionally, it is drawn at the base of the lowest member of alternating sandstones and conglomerates with limestone boulders.

Feodosia

The section is composite: the lower part along the southern slope of Cape St. Elijah (section A) and along the outcrops along the southern coast of the Feodosia Bay (B), the upper part, along the left side of the Zavodskaya Gully near the western vicinity of the city of Feodosia (C). These parts of the general section are separated by large sublatitudinal and submeridional tectonic faults disrupting the bedding and complicating correlation. The deposits are represented in the lower part by flyschoid alternations of clays, limestones and marls of the Lower Berriasian, and in the upper part by clayey alternations of the Middle and Upper Berriasian.

The Feodosian section is considered a classic in the study of Upper Tithonian and Berriasian deposits, gradually replacing each other and represented by similar facies. Easily accessible outcrops in the coastal cliffs of Cape St. Elijah, Dvuyakornaya Bay and Feodosia Bay have long attracted the attention of foreign and domestic geologists. Almost all researchers involved in the study of the geology of the Crimea, starting from 1838, visited the Feodosia section in order to study the Berriasian and Tithonian stratigraphy, lithology and paleontology.

The Feodosia section is traditionally considered as a type section: Feodosia-type section (Drushchits, 1975); Eastern Crimean type (Bogdanova et al., 1981); reference section for the Crimea (Drushchits in Aliev et al., 1985; Kvantaliani, 1989). In 2016, at the VIII All-Russian meeting in the Crimea (September 26–October 3, 2016), the section under consideration was approved as a reference section (Baraboshkin et al., 2016; guidebook, excursions 1.1–1.2).

To date, a high level of exploration of the Tithonian and Berriasian deposits of the area has been achieved. A classic example in this regard is a generalizing collective work (Guzhikov et al., 2012), compiled on the basis of an integrated method for studying a geological section: lithological, bio- and magnetostratigraphic. A detailed description of the section of Berriasian formations in this area, with the image of its log and indication of fossil assemblages for specific horizons, is given in (Drushchits, 1975; Bogdanova et al., 1981, 1984; Glushkov, 1997; Arkadiev, 2003, 2004) Arkad'ev, 2007; Arkad'v et al., 2005, 2006, 2008, 2012; Guzhikov et al., 2012; Baraboshkin et al., 2016).

Paleontologists from different institutions monographically studied the main groups of fossil organisms: Fr (Gorbachik and Shokhina in *Atlas* ..., 1960; Gorbachik et al., 1984; Kuznetsova and Gorbachik, 1985; Arkadiev and Fedorova et al., 2006), ostracods (Tesakova and Savelyeva, 2005), Am (Drushchits in *Atlas* ..., 1960; Glushkov, 1997; Kvantaliani, 1989,

1999; Arkad'ev and Rogov, 2009; Arkadiev et al., 2012; Baraboshkin et al., 2016), Br (Lobacheva and Smirnova, 2006), and ichnofossils (Baraboshkin in Guzhikov et al., 2012).

At the end of the 19th century, all flyschoid deposits exposed in the coastal cliffs of the Black Sea in the area of the city of Feodosia were referred by geologists to the Upper Jurassic. Sokolov (1886, 1889), based on ammonites collected in the so-called "Feodosia marls", determined their age as Tithonian. This conclusion was supported by Retowski (1893), who described a large collection of ammonites, belemnites, bivalves, gastropods and brachiopods from the "Feodosia marls". Kilian (1895, 1910), who revised the list of ammonite species described by Retowski, came to the conclusion about their mixed Tithonian-Berriasian age. By the presence of obviously Berriasian taxa, Kilian argued that the series of interbedding is of Berriasian age, since the Retowski ammonite assemblage is similar to the cephalopod fauna from the typical Berriasian deposits of the Ardèche department in southern France.

After Kilian's conclusion, domestic geologists began to attribute the "Feodosia marls" to the Berriasian (Moiseev, 1937 et al.). Muratov (1937) wrote that they "should be attributed to the lowest horizons of the Lower Cretaceous, specifically to the *Hoplites (Thurmannia) boissieri* Pict. Zone, i.e. to the lower Valanginian or Berriasian" (p. 60). For the Tithonian and Berriasian boundary, he conditionally accepted the base of "a bed of a thicker limestone conglomerate (about 1 m), which is very well traced along the southern cliffs of the Cape St. Elijah and in coastal outcrops near the city of Feodosia" (p. 57). When describing the section, Muratov recognized the "Berriasian" as an independent heading in the text, and when characterizing the deposits, he used the name "horizon of Berriasian marls". Subsequently, Lychagin (1969) considered Muratov's "Berriasian horizon" as a synonym for "Lower Valanginian".

Drushchits (in *Atlas* ..., 1960), on the contrary, instead of "Berriasian" used its synonym—"lower Valanginian". The Tithonian–Berriasian boundary he also, like M.V. Muratov, drew at the base of a thick marker limestone bed. He assumed that the flyschoid alternation continued below it, but how far below, remained unclear, since the corresponding outcrops were located at that time near the stage border. And only in the 1980s, geologists were given the opportunity to study sections along the coast of the more southern Dvuyakornaya Bay and at Cape St. Elijah. New teams of researchers from various geological institutions over the past 40 years have done a tremendous amount of work on the study of the Lower Cretaceous and Tithonian deposits of the area.

As the general biostratigraphic scale of the Lower Cretaceous of Crimea was being developed on the basis of finds of ammonite index species, various proposals were made to attribute the flyschoid series of the Feodosia section to one or another stratigraphic units at the zonal level: "white marl with *Berriasella pontica*" (Drushchits in *Atlas* ..., 1960); *Berriasella jacobi–Pseudosubplanites grandis* Zone (Sasonova and Sasonov, 1974); *Pseudosubplanites ponticus–P. euxinus* and *Berriasella privasensis–Spiticeras spitiense* Zone (Drushchits, 1975; Drushchits et al., 1976); *Pseudosubplanites ponticus–P. grandis* Zone (Bogdanova et al., 1981). After the discovery of the index species *Pseudosubplanites grandis* in 1995 in the "Feodosia marls" on the southern coast of the Feodosia Bay (near the boat station), it became possible to compare a part of the "marl" section with the corresponding standard zone of the Berriasian Stage stratotype (Glushkov, 1997). A more recent subdivision of the lower Berriasian of the Feodosia section has recently been proposed by several authors: *Berriasella jacobi* Zone, B. *jacobi* Subzone and *Pseudosubplanites grandis* Subzone (Arkadiev, 2004, 2006; Arkadiev et al., 2005, 2010, 2012; Guzhikov et al., 2012 ; Baraboshkin et al., 2016). A description of sections A, B, C, located in different parts of the Feodosia region, but forming a composite summary typical section is below.

Section description "A"
(southern coast of Cape St. Elijah). Fig. 24A

The section description is based on published data (Arkadiev et al., 2006, 2012; Baraboshkin et al., 2016). The section column was compiled by Arkadiev et al. (2006; see also Baraboshkin et al., 2016, text-fig. 1.3).

$K_1ber_1^1$. Member 18 (16.6 m, deposits of the member occur at the base of the section, at the level of the waterline)—alternation series of (1.5–2.0 m) greenish-gray, dense, splintered clays, with limonitized pyrite concretions and slabs and lenses (10–15 cm) light-gray, light-brown, detrital limestones; Am—*Berriasella chomeracensis* (Touc.). *Fauriella* cf. *floquinensis* Hég., *Ptychophylloceras* cf. *semisulcatum*; Bv—*Propeamussium sokolowi*; Br—*Tonasirhychia janini* Lob. et Sm.; abundant ichnofossils.

Member 19 (8 m)—greenish-gray clay; in the middle of a member with thin interbeds of detrital limestones; abundance of ichnofossils

Member 20 (17 m)—interbeds (2–3 m) greenish gray, splintered clays with slabs (0.3–0.5) of limestones and interbeds (10–20 cm) of dark gray marls with the ammonites *Haploceras carachtheis*.

Member 21 (10 m)—greenish-gray clay with interbeds (0.1–0.75 m) of creamy detrital limestones; in the middle part, a limestone slab (0.8 m) with rounded limestone pebbles on the bedding plane.

Member 22 (13 m)—alternation of bluish-gray lamellar clays and slabs (0.5—0.6 m) of dark brown, massive, detrital limestones.

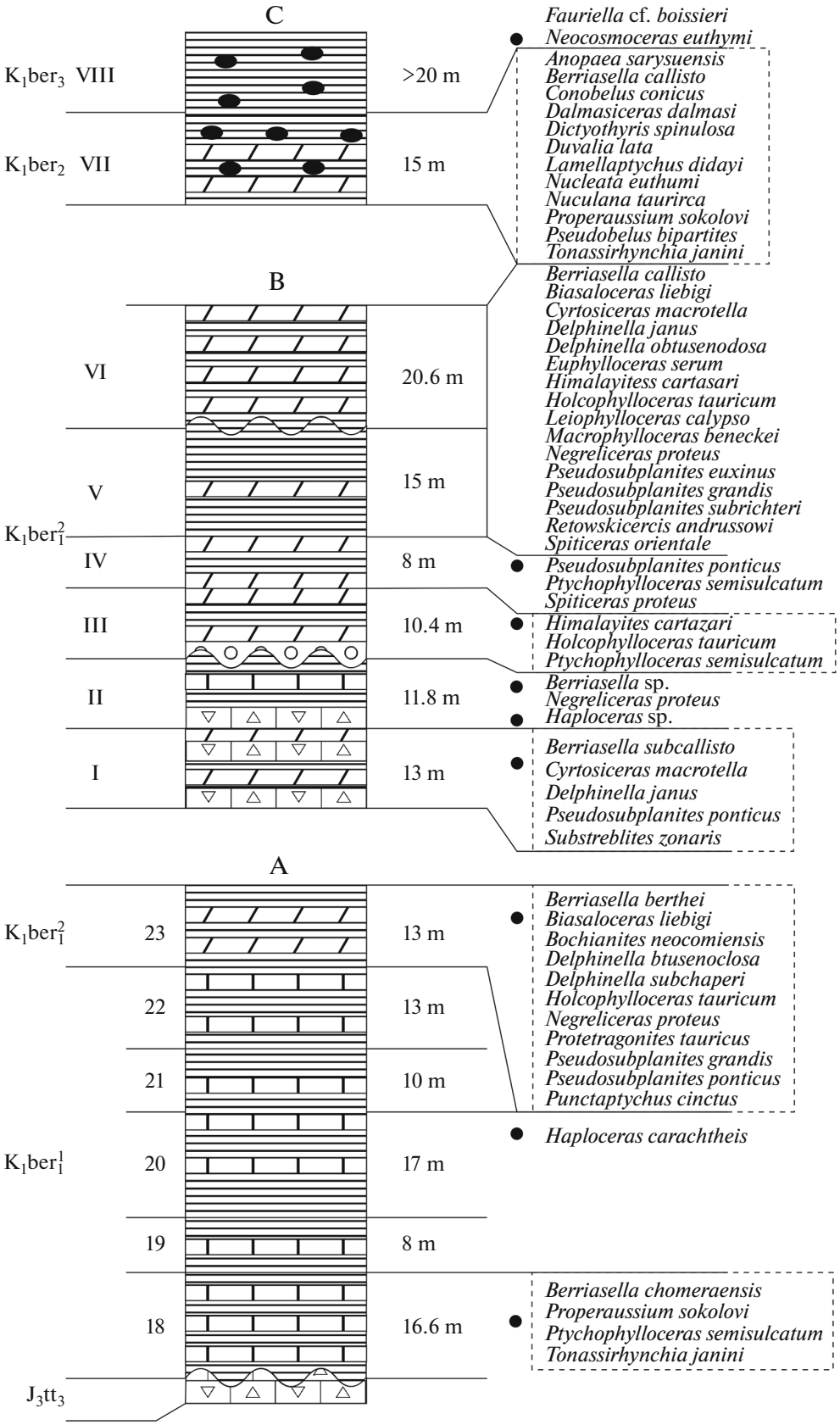


Fig. 24. Feodosia type section, no 11, put from three outcrops in the vicinity of the town Theodosia: (A) lower part of summary section—on Cape Holy-Il'ya (by data of Arkadiev et al., 2012 and Baraboshkin, 2016); Lower Berriasian, subzones *jacobi* and *grandis;* (B) middle part—along of the shore of Feodosia Bay; Lower Berriasian, subzone *grandis*; (C) upper part—in the Zavodskaya Balka; Middle Berriasian, subzone *tauricum* (B and C—by data of author); (see explanations for Fig. 2).

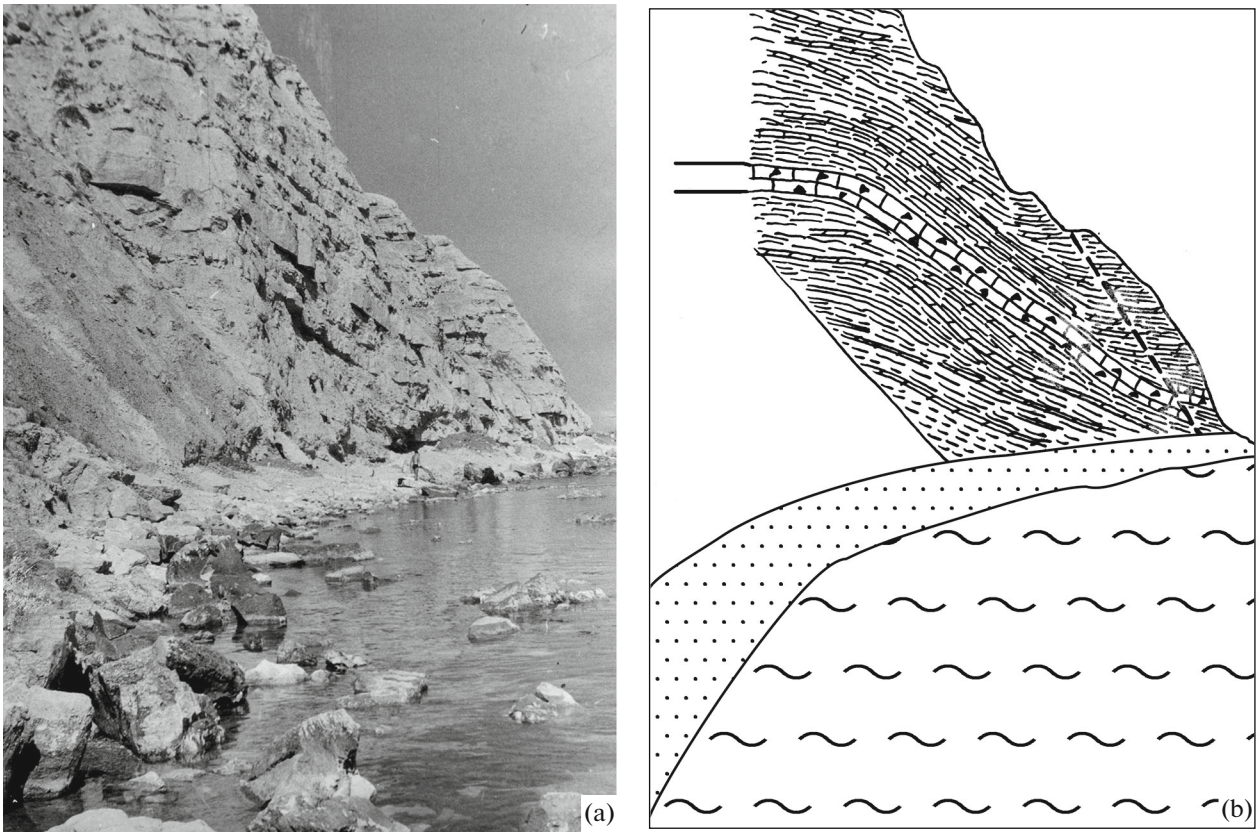


Fig. 25. Outcrop of the lower part of the series "Feodosia marls" on the southern coast of the Feodosia Bay (a); the "marker horizon" is highlighted in the figure, a Bed (1.25 m) of bioclastic limestone (b); section no. 11B, Members II and III; Lower Berriasian, *grandis* Subzone (author's photo, 1962).

$K_1ber_1^2$. Member 23 (13 m)—"Feodosia marls", alternation of yellowish-gray splintered clays (1.0–1.5 m) and yellowish-gray platy marls (0.5–0.8 m); six plates in a pack; with ammonites, aptychi, and brachiopods: Am—*Berriasella berthei*, *Biasaloceras liebigi*, *Bochianites neocomiens*is (d'Orb.), *Delphinella crimensis* (Burck.), *D. janus* (Ret.), *D. obtusenodosa* (Ret.), *D. pectinata* Ark. et Bogd., D. *subchaperi* (Ret.), *D. tresanensis* (Hég.), *Haploceras carachtheis*, *Holcophylloceras tauricum*, *Negreliceras proteum* (Ret.), *N. mirum* (Ret.), *Protetragonites tauricus*, *Pseudosubplanites grandis*, *P. combesi* Hég., *P. lorioli*, *P. ponticus*, *Ptychophylloceras semisulcatum*; Ap—*Punctaptychus cinctus* Trauth. (Arkadiev et al., 2006, 2012; Guzhikov et al., 2012; Baraboshkin et al., 2016). There are no overlying deposits on the cape.

Section description B (Fig. 24B) compiled from outcrops in coastal cliffs on the southern side of the Feodosia Bay; deposits are described by V.V. Drushchits with the participation of T.N. Gorbachik and the author in 1968.

$K_1ber_1^2$. Member I (visible thickness 13 m; exposed on the easternmost side of the coast in the area of the ravine in anterior of Cape St. Elijah), fine flyschoid alternation of interbeds (0.4–1.0 m) of dark gray and greenish-gray clays and slabs (0.15–0.8 m) of gray marls; the member contains seven slabs; Am (according to Drushchits, 1975)—*Cyrtosiceras macrotella* (Opp.), *Substreblites zonaris*; according to E.Yu. Baraboshkin et al. (2016)—the member also contains *Delphinella* cf. *tresannensis* (0.45 m below its top); *Pseudosubplanites ponticus* and *Berriasella subcallisto* (Touc.) (1 m below its top) and *Delphinella janus* (in the middle of the member).

Member II (11.8 m)—at the base of the member, a bed (1.2 m) of bioclastic, in places brecciated limestone with graded bedding; the bottom of the formation is uneven, bumpy, with furrows 5–9 wide and up to 5 cm deep; on an uneven roof of limestone, there is a thin (1 cm) bed of coarse-grained sandstone with burrows; in places the limestone contains poorly rounded fragments of brachiopods, coral skeletons, hydroids, bryozoans, and echinoderms; Am—*Haploceras* sp.; this limestone bed is a clear marker horizon for a significant length of the coastline of the Feodosia Bay (Fig. 25). It is overlain by clays interbedding with limestone slabs similar to those below; Am—*Berriasella* sp., *Negreliceras proteum*.

Deposits of Members III–VI are represented by the so-called "Feodosia marls" (Fig. 26):

Member III (10.4 m)—alternation of interbeds (0.6–0.8 m) gray clay and slabs (0.2–0.8 m) light gray marls; Am—*Himalayites cartazari*, *Holcophylloceras tauricum*, *Ptychophylloceras semisulcatum*.

Member IV (8 m)—alternation interbeds (1.2–2.9 m) of gray clays, slabs (0.15–0.7 m) of brecciated limestones and gray marls; there are seven plates in a pack; Am—*Pseudosubplanites ponticus, Ptychophylloceras semisulcatum, Spiticeras proteus* (Ret.).

Member V (15 m)—in the lower half of the member of alternation of gray clays and light-gray and white marls, in the upper half, clays; abundance of ammonite molds (see below).

Member VI (20.6 m)—in the lower part of the member—gray clay, in the upper part—alternation series (0.6–2.8 m) of gray clays and slabs (0.35–0.7 m) of light-gray and white marls; at the base of the member, an erosion horizon with small limestone pebbles; Members V and VI contain the same ammonite assemblage (after Drushchits, 1975): *Pseudosubplanites euxinus* (Ret.), *P. ponticus*; in addition he identified: *Berriasella callisto*, *Biasaloceras liebigi*, *Cyrtosiceras macrotella*, *Delphinella obtusenodosa*, *D. janus*, *Euphylloceras serum*, *Haploceras elimatum*, *Himalayites cartazari*, *Holcophylloceras tauricum*, *Leiophylloceras calypso*, *Macrophylloceras beneckei*, *Negreliceras proteus*, *Pseudosubplanites grandis*, *Ptychophylloceras semisulcatum*, *Retowskiceras andrussowi* (Ret.), *Spiticeras orientale*.

The overlying deposits on the southern coast of the Feodosia Bay are not exposed, as they are located in the urban development zone. A gentle slope of the terrain in the area of the Genoese fortress and the absence of any outcrops of platy rocks on it suggest that up the section, the deposits are represented by clayey sequence. The continuation of the composite section was observed near the western vicinity of Feodosia, in the sides of the Zavodskaya Gully leading to the brick factory (section C). Here, in the upper reaches of the gully, the upper part of the alteration series of the Lower Berriasian clays and marls is exposed. These are overlain by a series of Middle Berriasian clays. The top of the uppermost slab of light-gray "Feodosia marls", corresponding to the top of member VI in section "B", is taken as the Lower–Middle Berriasian boundary.

Fig. 26. Outcrop of the middle part of the "Feodosia marls" Series on the southern coast of Feodosia Bay; Section no. 11B, Members IV–VI; Lower Berriasian, *grandis* Subzone (author's photo, 1962).

Section Description C (Fig. 24 C) (Zavodskaya Gully)

K_1ber_2. Member VII (15 m)—clays dark gray, with a greenish tinge, spotty, calcareous, in places silty, non-plastic, strongly fissile, with numerous lenses and nodules of clayey marl and small nodules of siderite; a horizon with jarosite aggregates is traced at the base of the member; the beds contain coalified plant remains, thin shells of small gastropods, bivalves, belemnite rostra, ammonite shells and molds; fossils include (after Eristavi, 1957; see also Lychagin, 1969)—*Phylloceras serum*, *Thurmannia thurmanni* Pict.; Ap—*Aptychus didayi*, *A. seranosis*; Bl—*Conobelus conicus*, *Duvalia lata* , *D. dilatata* Bl., *Pseudobelus bipartitus*; after Drushchits (*Atlas* ..., 1960)—*Ptychophylloceras semisulcatum*, *Thurmanniceras* cf. *thurmanni*; Ap—*Lamellaptychus didayi*; Bl—*Conobelus conicus*, *Pseudobelus bipartitus*; Am (after Drushchits, 1975; Drushchits et al., 1985)—*Berriasella callisto*, *B. jauberti* Maz., *Dalmasiceras dalmasi*; Am (after Bogdanova et al., 1999; Arkadiev et al., 2006, 2012; Arkadiev in Baraboshkin et al., 2016: field guide, excursion 1.3—*Retowskiceras retowskyi* Kvant., *Tirnovella occitanica* (Pict.); Bv (as identified by Yanin)—*Anopaea sarysuensis* (Yanin), *Buchia* sp., *Nuculana taurica, Propeamussium sokolowi;* Gs (as identified by M.A. Golovinova)—*Sulcoactaeon albensis* (d'Orb.); Br (as identified by Lobacheva)—*Tonassirhynchia janini*.

K_1ber_3. Member VIII (>20 m); overlying deposits are represented by gray and dark gray marl clays, with nodules of siderite and barite; contain nests of brown limonite and interbeds of ferruginous clay marl. Arkadiev (in Baraboshkin et al., 2016) indicated that these beds contain ammonites (above our Member VII):

Neocosmoceras euthymi and *Fauriella* cf. *boissieri*, characteristic of the Upper Berriasian *euthymi* Subzone. Until the exact position of the horizon with *N. euthymi* is established, the Middle–Upper Berriasian boundary in this section is drawn tentatively.

Geological Age

In the deposits of the Feodosia type section, we identified: *jacobi* Zone with the *jacobi* and *grandis* subzones (Lower Berriasian), *occitanica* Zone with the *tauricum* Subzone (Middle Berriasian) and *boissieri* Zone with the *euthymi* Subzone (Upper Berriasian).

$K_1ber_1^1$. Lower Berriasian, *jacobi* Subzone (section A, Members 18–22). The description of the deposits of this subzone was given by us based on new data from other researchers who had the opportunity to study the lowermost part of the section at Cape St. Elijah and in Dvuyakornaya Bay. The bed description and units their numbering (members) are published here for the first time. Arkadiev et al. (2006, 2012), Guzhikov et al. (2012), Baraboshkin et al. (2016) proposed the zonal stratigraphy for the Lower Berriasian and positioned the Tithonian–Berriasian boundary in the sections. The *jacobi* Subzone was established at Cape Elijah based on the record of the index species *Berriasella jacobi* (according to Arkadiev et al., 2006, previously identified as *B. chomeracensis*). In Dvuyakornaya Bay, the deposits are assigned to this subzone according to their stratigraphic position, which is a correlation with a similar alternation (54 m) described in this section. In addition, the Upper Tithonian–Lower Berriasian transitional beds have been identified here, although no Upper Tithonian index ammonite species have not yet been found. Transitional beds are present in this section in the interval of 53–60 m and are located between Members 7 and 8 (according to Guzhikov et al., 2012, text-fig. 4).

$K_1ber_1^2$. Lower Berriasian, *grandis* Subzone (sections: A, Member 23 and B, Members I–VI). Deposits, represented mainly by "Feodosia marls" and exposed at Cape St. Elijah, in the northern part of Dvuyakornaya Bay and on the southern coast of Feodosia Bay, form the basis of the Feodosia type section. The history of the study of the "Feodosia marls", including variants of their zonal division, is given by us above. At present, the "Feodosia marls" by all geologists belong to the *jacobi* Zone and the *grandis* Subzone. According to the characteristic structure of the members and the abundance of ammonites, they are easily distinguished from the underlying and overlying formations.

K_1ber_2. Middle Berriasian, *tauricum* Subzone (section C, Member VII). The member is composed of a series of clays with occasional marl slabs and horizons of siderite nodules. The stratigraphic position of the argillaceous series changed over time. Previously, they referred to: undivided upper Valanginian-Hauterivian (Moiseev, 1937); the Middle Valanginian (Muratov, 1937); Upper Valanginian (Eristavi, 1957); undivided Middle Valanginian–Hauterivian (Drushchits in *Atlas* ..., 1960); Middle–Upper Valanginian (Lychagin, 1969). Later, the authors began to use the name "Berriasian" instead of "Lower Valanginian". In this section, the Berriasian was divided into: the *Dalmasiceras dalmasi* Zone (Drushchits et al., 1985, 1986); *Tirnovella occitanica–Retowskiceras retowskyi* Zone (Bogdanova et al., 1999); Beds with *T. o.–R. r.* (Arkadiev et al., 2012; Arkadiev in Baraboshkin et al., 2016).

Drushchits (1975) in the list of ammonites from the middle part of the "Zavodskaya Gully" section (in the original Bed 11, 26 m) cited *Dalmasiceras dalmasi*). This record is nominal, since it was not described or illustrated from this section. The *D. dalmasi* specimens from the Drushchits' collection were re-examined by Arkadiev and Bogdanova (1999, see also Arkadiev et al., 2012) and formed the basis for the identification of a new species *Dalmasiceras tauricum*, which was considered by the authors as an index species of the subzone. According to the tripartite subdivision of the Berriasian Stage adopted in this work, the deposits containing this index species are here assigned to the Middle Berriasian, *tauricum* Subzone.

I.4. Stratigraphic Distribution of Bivalves in the Lower and Middle Berriasian Deposits of the Crimean Mountains

The vertical and horizontal distribution of bivalves in the Berriasian deposits is directly dependent on the development of certain facies types. Identification of species assemblages of bivalves in specific sections and their comparison, is usually possible in cases where the beds are represented by identical or similar rocks. Only a few species are found in coeval beds of different origin. Such species are of exceptional importance for correlation of different facies. Most of the bivalve species in this paper, which, with rare exceptions, are benthic organisms, are characterized by a wide range of vertical distribution in those sections in which similar facies are preserved from bed to bed. The horizontal distribution of bivalves is also facies-controlled.

The most favorable conditions for the habitat of benthic animals were coarse- and medium-grained sandy sediments of the sublittoral and littoral zones of the sea. A significant number of organisms were also associated with fine-grained silty sediments. Clay and marly sediments were less favorable for bivalves. Different assemblages were associated with reef facies. This dependence was reflected in the distribution of bivalves in the sections. In accordance with the change in facies in the section, the bivalves also changed, both in shell size and in their shape and ornamentation. The quantitative and qualitative ratio of individuals, species and genera also fluctuated significantly (Table 2).

Table 2. Facies dependence of the number of genera and species of bivalves in the sediments of the Lower and Middle Berriasian of the Crimea

Lower Berriasian, *jacobi* Zone				
Rock types	Alternation of sandstones and siltstones (Sarysu: Blagodatnoe, Novoklyonovo, Enisarai)—*chaperi* Beds	Limestones with interbeds of sandstones, siltstones, conglomerates (Peredovoe, Beshterek, Ai-Petri, Dolgorukovka)—*jacobi* Zone	Marly limestones (Karabi-Yaila, highway)—*grandis* Subzone	Flyschoid series: alternation of clays and marls (Tonas: Kuchuk-Uzen'; vicinity of Feodosia)—*grandis* Subzone
Genera/species	25/35	29/24	6/7	6/7
Middle Berriasian, *occitanica* Zone, *tauricum* Subzone				
Rock types	Sandstones and siltstones (Bel'bek: Labaniy Log, Golubinka, Solnechnosel'e)	Sandstones and siltstones (Beshterek: Solovjevka)	Clays with siderite concretions and sandstone interbeds (Sarysu: Kozlovka, Novoklyonovo)	
Genera/species	40/48	36/41	13/13	

The restricted facies association of bivalves does not allow identification of a general trend in the development of the group in the Crimean Basin in the Berriasian. For instance, most sections with the Early-Middle Berriasian boundary show a sharp change in the depositional settings: the carbonate formations of the *jacobi* Zone were almost everywhere overlain by sandy, silty, or clayey sediments of the *tauricum* Subzone (Balaklava, Kuchki, Urkusta, Dolgorukovsky, Beshterek, and Saigin-Balki sections). As a result, there was no continuation in the evolution of the assemblages. There was not only a change in the number of species, but also a change in the associations of organisms in a taxonomic and ecological sense. In the same areas of the basin, where there was a continuous deposition clay facies, the diversity of bivalves was very low, since the habitats were extremely unfavorable for benthic organisms (Tonas and Feodosia sections).

An analysis of the stratigraphic distribution of bivalves in the deposits of the lower and middle Berriasian region revealed the following trends: (1) a low number of transitional species continuing from the Upper Jurassic to the Berriasian (four in total: *Spondylopecten aequatus, S. subspinosus*—Kimmeridgian-Berriasian; *Heterodiceras bajdarense, Valletia urkustensis*—Tithonian–Berriasian; (2) only 24 species are limited to the lower Berriasian; of these, most are confined to limestones and marls with interbeds of sandstones and siltstones, only seven come from flyschoid facies; (3) the vast majority of species (32) make up a single Lower–Middle Berriasian assemblage restricted to sandy-silty facies (*chaperi* Beds and *tauricum* Subzone; (4) a well-represented Middle Berriasian bivalve assemblage of 26 species (Table 3); at the same time, there was no marked difference between this assemblage and the previous one either morphologically or ecologically, since there was no change in the depositional settings, but taxonomically in the Middle Berriasian (*tauricum* Subzone), the generic composition of the assemblage is changed: in includes 18 new genera unknown in the Lower Berriasian (*shaperi* Beds); (5) a small number (six) species continues from the Middle Berriasian to the Upper Berriasian, which was clearly established in the Bel'bek and Saigin-Balki sections.

Based on the frequency of occurrence in the sections of bivalves given in Plate III, we distinguish three assemblage species: I—Lower Berriasian (*jacobi* Subzone and *grandis* Subzone), II—Lower-Middle Berriasian (*chaperi* Beds and *tauricum* Subzone) and III—Middle Berriasian (*tauricum* Subzone).

CHAPTER II. PALEONTOLOGY

This chapter provides a monographic description of 72 species of bivalves from the deposits of the lower and middle Berriasian region. The work includes almost all species studied by the author and other authors who published materials on the species considered here at different times in various publications (see "Material"). The taxonomy of the described species follows Nevesskaja et al. (2013).

II.1. A Brief Overview of the History of the Study of Berriasian Bivalves of the Crimea

The first researchers of the Crimean geology back in the first half of the 19th century, when studying sections of the Lower Cretaceous deposits of the region, established the presence in them of beds with numerous and varied oysters—*Exogyra couloni*, *Ostrea* "with serrated and folded margins" et al. These Beds with came from the Neocomian sandstones of southeastern France, also containing oysters. Subsequently, in

Table 3. Stratigraphic distribution of bivalves in the Berriasian deposits of the Crimea

Species	L.B.1	L.B.2	L.B.3	M.B.
Protocardia broili sp. nov.	–			
Monopleura taurica Pchel.	–			
Valletia auris Favre	–			
Valletia antique Favre	–			
Valletia gigantea Yanin*	–			
Valletia urkustensis Pchel.	–			
Heterodiceras bajdarense Pchel.	–			
Heterodiceras luci (Defr.)	–			
Arcomytilus sanctaecrucis (P-C)	–	–		
Nuculana taurica sp. nov.	–	–		
Gryphaea weberae (Yanin)	–	–	–	–
Prohinnites renevieri (Coq.)	–	–	–	–
Plagiostoma dubisiensis (P-C)	–	–	–	–
Panopea neocomiensis Leym.	–	–	–	–
Ostrea germaini Coq.	–	–	–	–
Eriphylla crimica Yanin	–	–	–	–
Neithea simplex Mordv.	–	–	–	–
Neithea valangiensis (P-C)	–	–	–	–
Tortarctica weberi Mordv.	–	–	–	–
Cuspidaria theodosiana (Ret.)		–		
Pinna karabiensis sp. nov.		–		
Propeamussium pawlowi (Ret.)		–		
Propeamussium sokolowi (Ret.)		–		
Myophorella tonasensis Yanin*		–		
Turnus tonasensis sp. nov.		–		
Plagiostoma aubersonensis (P-C)		–		
Globocardium sphaeroideum (Forb.)		–	–	–
Integricardium deshayesianum (Lor.)		–	–	–
Spondylopecten aequatus (Quenst.)		–	–	–
Spondylopecten subspinosus (Schl.)		–	–	–
Neithea subsimplex (Bogd.-Yanin)		–	–	–
Orthotrigonia mordvilkoae Yanin*			–	–
Pinna robinaldina (Orb.)			–	–
Rhynchostreon tombeckiana (Orb.)			–	–
Ceratostreon tuberculiferum (K-D)			–	–
Cosmetodon carteroni (Orb.)			–	–
Barbatia marullensis (Orb.)			–	–
Limatula tombeckiana (Orb.)			–	–
Eriphylla mordvilkoae Yanin			–	–
Protocardia carinata sp. nov.			–	–
Ptychomya robinaldina (Orb.)			–	–
Garum valangiensis (P-C)			–	–
*Pseudolimea ro*yeriana (Orb.)			–	–
Glossus neocomiensis (Ag.)			–	–
Pterotrigonia caudata (Ag.)*			–	–

Table 3. (Contd.)

Species	L.B.1	L.B.2	L.B.3	M.B.
Acesta orbignyana (Math.)			–	–
Acesta longa (Roem.)				–
Fimbria berriassica sp. nov.			–	–
Sphaera belbekensis Yanin			–	–
Myophorella loewinsonlessingi (Renng.)*			–	–
Entolium germanicum Woll.			–	–
Gervillella anceps (Desh.)			–	–
Oxytoma cottaldina (Orb.)				–
Neithea neocomiensis (Orb.)				–
Ctenostreon balkiensis Yanin				–
Veniella carinata sp. nov.				–
Buchia striata sp. nov.				–
Buchia uncitoides (Pawl.)				–
Trigonia carinata Ag.*				–
Modiolus simplex (Desh.)				–
Pachymya crimica Yanin				–
Platymyoidea marullensis (Orb.)				–
Lithophaga avellana (Orb.)				–
Nuculana balaklavensis sp. nov.				–
Rutitrigonia longa (Ag.)*				–
Linotrigonia belbekensis Yanin*				–
Arcomytilus couloni (Marc.)				–
Gervillia gottschei Boehm				–
Gervillaria allaudiensis (Math.)				–
Idonearca forbesi (P-C)				–
Inoceramus belbekensis Yanin				–
Inoceramus bogdanovae sp. nov.				–
Inoperna taurica Yanin				–
Pholadomya gigantea (Sow.)				–
Protocardia peregrina (Orb.)				–
Goniomya villersensis (P-C)				–
Modiolus montmollini (P-C)				–
Idonearca gabrieli (Leym.)				–
Isognomon ricordeanus (Orb.)				–

* Species are described in earlier works of the present author (Yanin, 1979, 2020a, 2020b).

some sections, the age of Neocomian deposits was confirmed by finds of fossils from other groups, for example, Neocomian on the Bodrak River.

In separate sections, the age of the "Neocomian" deposits was changed to Berriasian–Valanginian (village areas of Terenair: Huot, 1842 and Ayrigul: Karakash, 1907). Karakash (1907) listed *Ostrea* (*Alectryonia*) *rectangularis*, *O. couloni, Gervillia anceps, Panopaea neocomiensis, Lima royeri, Cyprina* sp., *Trigonia* sp., and others from the "Neocomian" (now Berriasian) deposits, represented by a series of interbedding sandstones and siltstones and occurring at the base of the Lower Cretaceous sections in the Bel'bek River basin.

Retowski (1893) was the first to publish a monographic description and illustrations of Berriasian bivalve species. In a monograph on fossils from the so-called "Feodosia marls" he listed a large assemblage of bivalve species: *Pholas tithonia, Neaera theodosiana, N. boehmi, N. glabra, N. elongate, Astarte* sp., *Arca*

alata, A. gracilima, Modiola zebrikowi, Pecten (Entolium) theodosianus, P. (Amusium) sokolowi, P. (A.) pawlowi, Hinnites sp., *Lima* sp., and *Ostrea* sp. In total, he described 11 species, all new. Unfortunately, none of the geologists who subsequently studied the Feodosia section succeeded in repeating the Retowski's bivalve collections, which represented benthic molluskan fauna of a relatively deep-water flysch basin. Over many years of collecting fossils in marls and clays in the area of Feodosia, we managed to find only a few specimens of bivalves assigned to three species, while the same beds yielded hundreds of ammonite imprints and molds.

In 1901 A.A. Borissiak recorded *Aucella crassicollis* Keys. from the Lower Cretaceous (=Berriasian) sandstones in the vicinity of Balaklava. In 1902, F. Broili described several species of bivalves from limestones exposed along the Bakhchisarai-Yalta highway, on the northern slope of Aipetri Yaila: *Mytilus sanctaecrucis, Protocardia* sp. nov., and also (judging by the valve ornamentation) *Neithea* sp. Based on the finds of spines of regular echinoids, Broili attributed these limestones to the "Lower Neocomian". Russian geologists for a long time considered this assignment erroneous and attributed these deposits to Tithonian (see section I: "Aipetri type section").

After A.A. Borissiak and N.I. Karakash none of the Russian paleontologists studied the Lower Cretaceous bivalves of the region until the middle of the 20th century. Later Mordvilko (1949) described a new species of *Veniella weberi* from Valanginian in the vicinity of the village of Fotisala (=Golubinka). Most likely, specimens of this species originate from the "alternation series" of the Middle Berriasian, which is well exposed in the Kabaniy Log.

M.S. Eristavi in 1957 from the same part of this section briefly described and illustrated the following species: *Astarte buchi*, *Cyprina deshayesiana*, *Gervilleia anceps*, *Panopaea gurgitis*, *Lima dubisiensis*. Pchelintsev (1959) described two new rudist species (*Heterodiceras bajdarense, Valletia urkustensis)* from the Upper Tithonian limestones in the vicinity of the village of Urkusta (=Peredovoe; at present, some of the series of these limestones are attributed by us to the Lower Berriasian, see Chapter I: "Urkusta type section"), as well as *Monopleura taurica* from the Valanginian limestones in the section near the village of Solovjevka (now these limestones are considered Lower Berriasian, see Chapter I: "Beshterek type section").

The author of this work began to study the Lower Cretaceous bivalves of the south of the USSR as a 5th year student. Since the summer of 1954, the author has been a member of the Lower Cretaceous fieldwork team (see Chapter I.1) together with T.L. Muromtseva (graduate of the Biology Faculty of Moscow State University) began collecting and studying bivalves in the Crimea and Northern Caucasus. According to the program of collective work on the Atlas of the Lower Cretaceous fauna of the North Caucasus and Crimea, the author described bivalves from the orders Schizodonta, Heterodonta and Rudistae, while T.L. Muromtseva, of the orders Taxodonta, Anisomyaria and Desmodonta (*Atlas* ..., 1960). For the first time in the Crimea, in the Lower and Middle Berriasian deposits, 22 genera and 26 species of bivalves were found. They have been found in many sections of the region, predominantly in the "Lower Valanginian (now Middle Berriasian) alternation series". Subsequently, different authors described separate species from the "Valanginian" (Cheltsova, 1969; Yanin, 1972; Klikushin, 1971) and Berriasian (Yanin, 1980a, 1980b, 1982) or groups of species of some families (Yanin, 1989; Bogdanova and Yanin, 1995; Yanin, 2004). In 1997, the Atlas of the Cretaceous Fauna of the Southwestern Crimea was published. In it T.N. Bogdanova published a description of 34 bivalve species, mainly from the deposits of the "Lower" (now Middle) Berriasian in the Bel'bek basin. This work is of exceptional importance, since the description of genera and species by the author takes into account all the new data on the taxonomy of the group that appeared in print after 1960 (Cox and Newell, 1969, 1971; Dimitrova, 1974 et al.). In a later work, T.N. Bogdanova, published a brief description of ten species from the lower Berriasian (*jacobi* Zone) section near the village of Krasnoselovka on the Tonas River is given (Arkadiev and Bogdanova et al., 2005). This work is essentially the second after the publication of Retowski (1893) with a description of the assemblage of bivalve species from relatively deep-water flyschoid deposits of the Eastern Crimea. Separate species from this assemblage, previously identified in shallow water deposits in more western sections, make it possible to correlate coeval formations of different genesis, common in the Eastern, Central and Southwestern Crimea. In 2004, the author of this work published a description of eight species of Berriasian bivalves from the family Trigoniidae (Yanin, 2004). In the monograph "Berriasian of the Crimean Mountains" (Arkadiev et al., 2012), we briefly described 65 bivalve species, of which 32 come from the Lower Berriasian and 35 from the Middle Berriasian; 24 occur in deposits of both substages. Finally, the author recently described six species of bivalves belonging to different families from the Berriasian deposits of the Southwestern Crimea (Yanin, 2020a, 2020b). This work was conducted within the program of the Department of Paleontology of Moscow State University "Biodiversity". It is a generalization of all known and original materials on the systematic composition and stratigraphic distribution of Early and Middle Berriasian bivalves in the Crimea, as part of the Alpine Zone of Northern Eurasia. In the 177 years since the first mention of Berriasian bivalves, a huge taxonomic diversity of the group has been established in the region: about 100 species, 70 genera and 35 families). In this work, 72 species belonging to 51 genera

and 34 families are monographically described. In addition, we previously described trigoniids: nine species from the family Trigoniidae (of which some of the most common species are also indicated here in the text, columns, species lists in the chapter "Stratigraphy" and in Table 3).

II.2. Revision of Previous Identifications of Bivalves from the Lower and Middle Berriasian Deposits of the Crimea

The present section includes papers containing records of Bivalves occurrences, described and figured species in papers, monographs, and atlases. The revised status of the names of species is given in square brackets.

Acesta longa (Roemer) (Yanin in Arkadiev et al., 2012, p. 258, pl. 43, fig. 12; *Lima l.*(see*)* [*A.* l.].

Acesta orbignyana (Matheron) (Bogdanova in Arkadiev et al., 2008, p. 125, pl. 3, fig. 5, sine descript.; Yanin in Arkadiev et al., 2012, p. 259, pl. 43, fig. 13); *Lima o.* (see) [*A. o.*].

Antiquilima dubisiensis (Pictet et Campiche) (Bogdanova, 1997, p. 76, pl. 18, figs. 4 and 5; Bogdanova in Arkadiev et al., 2008, p. 73, pl. 5, figs. 6 and 7, sine descript. [*Plagiostoma* d. (see)].

Arca carteroniana (d'Orbigny) (Muromtseva, 1960, p. 174, pl. 1, figs. 13 and 14); *Parallelodon c.* (Klikushin, 1971, p. 117, text-fig. 1) [*Cosmetodon c.* (see)].

Arca gracillima Retowski (1893, p. 76, pl. 6, fig. 21); *Catella g. (*Bogdanova in Arkadiev et al., 2008) [see *Catella g.*].

Arcomytilus couloni (Marcou) (Muromtseva, 1960, p. 201, pl. 18, fig. 6; Kravzov et al., 1983, p. 22, pl. 11, fig. 5; Bogdanova, 1997, p. 61, pl. 16, fig. 9; Bogdanova in Arkadiev et al., 2008, p. 73, pl. 5, fig. 5, sine descript.; Yanin in Arkadiev et al., 2012, p. 239, pl. 41, fig. 10) [*A. c.*].

Arcomytilus sanctaecrucis (Pictet et Campiche) (Bogdanova in Arkadiev et al., 2008, p. 125, pl. 3, fig. 1, sine descript.; Yanin in Arkadiev et al., 2012, p. 445, pl. 46, fig. 11, sine descript.) [*A. s.*].

Astarte buchi Roemer (Eristavi, 1957, p. 28, pl. 1, fig.1) [=*Eriphyla crimica* (see)].

Astarte gigantea Deshayes in Leymerie **(**Bogdanova, 1997, p. 85, pl. 19, fig. 11) [*Eriphyla mordvilkoae* (see)].

Astarte obovata Sowerby (Drushchits,1956, p. 56) [*Eriphyla mordvilkoae* (see)].

Aucella crassicolis Keyserling (Borissiak, 1901, p. 24, pl. 2, fig. 2 [*Buchia c.*].

Catella gracillima (Retowski) (Bogdanova in Arkadiev et al., 2008, p. 125, pl. 3, fig. 6, sine descript.; Yanin in Arkadiev et al., 2012, p. 279, pl. 46, fig. 12, sine descript.) [according to Bogdanova; this species is not present in our collection].

Ceratostreon minos (Coquand) (Tchelcova, 1969, p. 68, pl. 12, fig. 5; Bogdanova, 1997, p. 80, pl. 19, figs. 2 and 3; Yanin in Arkadiev et al., 2012, p. 248, pl. 43, fig. 6) [*C. m.*].

Ceratostreon tuberculiferum (Koch et Dunker) (Yanin in Arkadiev et al., 2012, p. 248, pl. 43, fig. 5) [*C. t*].

Cosmetodon carteroni (d'Orbigny) (Bogdanova, 1997, p. 60, pl. 16, figs. 3 and 4; Yanin in Arkadiev et al., 2012, p. 252, pl. 41, figs. 11 and 12) [*C. c.*].

Ctenostreon balkiensis Yanin (1980a, p. 23, pl. 7, fig. 18; pl. 8, fig. 2; Yanin in Arkadiev et al., 2012, p. 263, pl. 44, fig. 11) [*C. b.*].

Cucullaea forbesi (Pictet et Campiche) (Bogdanova, 1997, p. 61, pl. 16, figs. 6 and 7) [*Idonearca f.* (see)].

Cucullaea gabrielis Leymerie (Muromtseva, 1960, p. 175, pl. 2, fig. 1; Bogdanova, 1997, p. 60, pl. 16, fig. 5) [*Idonearca g.* (see)].

Cuspidaria theodosiana (Retowski, 1893, *Naera th.*: p. 73, pl. 14, figs. 13 and 14) [*C. th.*].

Entolium germanicum (Wollemann) (Yanin in Arkadiev et al., 2012, p. 255, pl. 43, fig. 9); *Syncyclonema g.* (see) [*E. g.*].

Eriphyla crimica Yanin (1980b, p. 29, pl. 9, figs. 11–13; 2012, p. 272, pl. 45, figs. 2 and 3); *E. mordvilkoae* (Bogdanova, 1997, p. 86, pl. 19, fig. 9 [*E. c.*].

Eriphyla mordvilkoae Yanin (1980b, p. 28, pl. 9, fig. 14; pl. 10, figs. 1–3; (Bogdanova, 1997, p. 86, pl. 19, fig. 10; *Astarte gigantea* (see), *Astarte moreausa* (see) [*E. m.*].

Exogyra minos Coquand (Karakash, 1907, p. 181, pl. 18, figs. 1, 3, 4,5, 7,8; pl. 129, fig. 28; Mordvilko, 1950, p. 199, pl. 15, figs. 2–5; Kravzov et al., 1983, p. 21, pl. 10, fig. 7) [*Ceratostreon m.* (see)].

Exogyra tuberculifera Koch et Dunker (Muromtseva, 1960, p. 199, pl. 15, figs. 6–8); *Ostrea (Exogyra) t.* (Karakash, 1907, p. 181, pl. 18, figs. 11, 12, 14, 16–19; pl. 21, fig. 28) [*Ceratostreon t.* (see)].

Gari valangiensis (Pictet et Campiche) (Muromtseva, 1960, p. 218, pl. 27, figs. 6, 8; Kravzov, 1983, p. 25, pl. 12, fig. 7; Bogdanova, 1997, p. 88, pl. 20, figs. 3 and 4) [*Garum v.*].

Gervillaria allaudiensis (Matheron) (Bogdanova, 1997, p. 62, pl. 17, figs. 1 and 2; Bogdanova in Arkadiev et al., 2008, p. 73, pl. 4, fig. 3; Yanin in Arkadiev et al., 2012, p. 242, pl. 42, fig. 5); *Gervillia a.* (Muromtseva, 1960, p. 182, pl. 5, figs. 1 and 2; Kravzov et al., 1983, p. 17, pl. 6, fig. 9) [*Gervillaria a.*].

Gervillella anceps (Deshayes in Leymerie) (Bogdanova, 1997, p. 63, pl. 17, figs. 3 and 4; Bogdanova in Arkadiev et al., 2008, p. 73, pl. 4, fig. 7; Yanin in Arkadiev et al., 2012, p. 243, pl. 42, figs. 6 and 7); *Gervillea a.* (Eristavi, 1957, p. 39, pl. 1, fig. 2); *Gervillia a.* (Drushchits, 1956, p. 56; Muromtseva, 1960, p. 182, pl. 4, figs. 1–

3; Kravzov et al., 1983, p. 17, pl. 6, figs. 8a, 8b) [*Gervillella a.*].

Gervillia gottschei Boehm (1883, p. 596, pl. 66, fig. 23) [*G. g.*].

Globocardium sphaeroideum (Forbes, 1845: *Protocardia* s. (see)) [*G.s.*].

Glossus neocomiensis (d'Orbigny) (Bogdanova, 1997, p. 90, pl. 20, fig. 8; Yanin in Arkadiev et al., 2012, p. 278, pl. 46, figs. 5 and 6); *Isocardia n.* (see) [*G. n.*].

Goniomya archiaci (Pictet et Renevier) (Muromtseva, 1960, p. 222, pl. 29, figs. 1–3; Kravzov, 1983, p. 26, pl. 12, fig. 11; Bogdanova, 1997, p. 91, pl. 21, figs. 2 and 3) [*G. villersensis*].

Goniomya villersensis (Pictet et Campiche) (Yanin in Arkadiev et al., 2012, p. 268, pl. 44, figs. 8 and 9; *G. archiaci* (see) [*G. v.*].

Gryphaea weberae Yanin (in Cheltsova, 1969, p. 56, pl. 4, figs. 6–8;); *Pycnodonte w.* (see) [*G. w.*].

Heterodiceras bajdarense Pchelincev (Pchelintsev, 1959, p. 135, pl. 34, fig. 3;

pl. 35, figs. 1 and 2; pl. 36, figs. 1 and 2; Yanin, 1989, p. 159, pl. 4, figs. 1a, 1b [*H. b.*].

Heterodiceras luci (Defrance) (Yanin, 1960, p. 223, pl., fig. 6; Kravzov et al., 1983, p. 26, pl. 13, figs. 2a, b; *H. crimicus* (Yanin, 1989, p. 160, pl. 5, figs. 1 and 2; [*H. l.*].

Idonearca forbesi (Pictet et Campiche) (Yanin in Arkadiev et al., 2012, p. 254, pl. 42, fig. 3; *Cucullaea f.* (see) [*I. f.*].

Idonearca gabrielis (Leymerie) (Yanin in Arkadiev et al., 2012, p. 253, pl. 42, figs. 1 and 2; *Cucullaea g.* (see) [*I. g.*].

Inoceramus bogdanovae Yanin (holotype in Bogdanova, 1997, p. 63, pl. 17, fig. 5 as *I. belbekensis* (see) [*I. bogd.*].

Inoceramus belbekensis Yanin (1972, p. 71, pl. 2, figs. 1 and 2: in the explanation of pl. 2 (holotype), locality erroneously listed as "Chernaja, village Kuchki"; in actual fact from Bel'bek, Kabanii Log); Bogdanova, 1997, p. 63, pl. 17, fig. 5: holotype of *I. bogdanovae* (see); (Yanin in Arkadiev et al., 2012, p. 245, pl. 43, fig. 1 [*I. bogd.*].

Inoperna gillieroni (Pictet et Campiche) (Bogdanova, 1997, p. 62, pl. 16, fig. 8; Bogdanova in Arkadiev et al., 2008, p. 73, pl. 4, fig. 4; sine descript.); *Modiola g.* (see) [*I. g.*].

Inoperna taurica Yanin, sp. nov. [holotype—*Inoperna gillieroni*, represented in Muromtseva, 1960, pl. 18, fig. 10].

Integricardium deshayesianum (Loriol) (Yanin, 1960, p. 216, pl. 26, fig. 8;

Bogdanova, 1997, p. 87, pl. 20, fig. 7; Yanin in Arkadiev et al., 2012, p. 276, pl. 46, figs. 1 and 2) [*I. d.*].

*Isocardia neocomiensis (*d'Orbigny) (Yanin, 1960, p. 212, pl. 23, figs. 5 and 6; Kravzov et al., 1983, p. 23, pl. 12, fig. 1) [*Glossus n.* (see)].

*Isognomon ricordeanum (*d'Orbigny) (Muromtseva, 1960, p. 183, pl. 7, figs. 1 and 2; Yanin in Arkadiev et al., 2012, p. 241, pl. 42, fig. 4) [*I. r.*].

*Laternula agassizi (*d'Orbigny) (Muromtseva, 1960, p. 221, pl. 29, figs. 4 and 5; Kravzov et al., 1983, p. 25, pl. 12, fig. 12) [*Platymyoidea marullensis* (see)].

Lima aubersonensis Pictet et Campiche (Muromtseva, 1960, p. 193, pl. 12, fig. 8) [*Plagiostoma a.* (see)].

Lima dubisiensis Pictet et Campiche (Muromtseva, 1960, p. 192, pl. 12, fig. 1; *Antiquilima d.* (see) [*Plagiostoma d.* (see)].

Lima longa Roemer (Drushchits, 1956, p. 56; Muromtseva, 1960, p. 193, pl. 12, fig. 5) [*Acesta l.* (see)].

Lima orbignyana Matheron (Muromtseva, 1960, p. 193, pl. 12, fig. 6) [*Acesta o.* (see.)].

*Limatula tombec*kiana (d'Orbigny) (Yanin in Arkadiev et al., 2012, p. 260, pl. 43, fig. 14) [*L. t.*].

Lithophaga avellana (d'Orbigny) (Muromtseva, 1960, p. 204, pl. 18, figs. 17a, 17b) [*L .a.*].

Modiola gillieroni (Pictet et Campiche) (Muromtseva, 1960, p. 202, pl. 18, fig. 10) [fig. 10—holotype of *Inoperna taurica* (see)].

Monopleura taurica Pchelincev (Pchelintsev, 1959, p. 169, pl. 42, figs. 1–9; pl. 43, figs. 3–8; Yanin, 1960, p. 224, pl. 29, fig. 7; 1975, p. 73, pl. 1, figs. 1–6; 1989, p. 165, pl. 7, figs. 4–6) [*M. t.*].

Neithea neocomiensis (d'Orbigny) (Yanin in Arkadiev et al., 2012, p. 267, pl. 44, fig. 7); *N.* (*Neitheops) n.* (Bogdanova and Yanin, 1995, p. 51, pl. 5, figs. 19–23; pl. 6, figs. 1 and 2) [*N. n.*].

Neithea simplex Mordvilko in Bogdanova et Lobacheva (Yanin in Arkadiev et al., 2012, p. 266, pl. 44, figs. 3 and 4); *N. (Neitheops) s.* (Bogdanova and Yanin, 2004, p. 68, pl. 25, fig. 12; Bogdanova in Arkad'ev et al., 2008, p. 73, pl. 5, fig. 4, sine descript.) [*N. s.*].

Neithea subsimplex Bogdanova et Yanin (in Arkad'ev et al., 2012, p. 267, pl. 44, figs. 5 and 6) [*N. s.*].

Neithea valangiensis (Pictet et Campiche) (Muromtseva, 1960, p. 190, pl. figs. 1 and 2); *N. (Neiheops) v.* (Bogdanova and Yanin, 1995, p. 50, pl. 5, figs. 5–12); *Neithea v.* (Yanin in Arkadiev et al., 2012, p. 265, pl. 44, figs. 1 and 2) [*N. v.*].

Ostrea (Exogyra) minos (Coquand) (Karakash, 1907, p. 181, pl. 18, figs. 1, 3–5); *Exogyra m.* (Muromtseva, 1960, p. 199, pl. 15, figs. 2–6) [*Ceratostreon m.* (see)].

Ostrea (Alectryonia) rectangularis (Roemer) (Karakash, 1907, p. 182, pl. 18, fig. 6); *Lopha r.* (Muromtseva, 1960, p. 198, pl. 14, figs. 15 and 16); *Arctostrea r.* (Tschel'cova, 1969, p. 50, pl. 2, figs. 8 and 9); *Rastellum r.* (Bogdanova, 1997, p. 82, pl. 19, fig. 1; Yanin in Arkadiev et al., 2012, p. 246, pl. 43, fig. 3) [*R. r.* (see)].

Oxytoma cottaldina (d'Orbigny) [*O. c.*].

Pachymya (Pachymya) crimica Yanin (1982, p. 123, text-fig. 2, fig. 1, holotype) [*P. (P.) c.*].

Panope neocomiensis (Leymerie) (Yanin, 1960, p. 219, pl. 27, fig. 9; Kravzov et al., 1983, p. 25, pl. 12, fig. 8; Bogdanova, 1997, p. 90, pl. 21, figs. 4 and 5) [*Panopea n.*].

*Pecten (Amusium) pawlow*i Retowski (1893, p. 287, pl. 6, fig. 27) [*Propeamussium p.* (see)].

Pecten (Amusium) sokolowi Retowski (1893, p. 279, pl. 6, figs. 24–26) [*Propeamussium s.* (see)].

Pholadomya gigantea (Sowerby in Fitton) (Muromtseva, 1960, p. 221, pl. 28, figs. 5–7; Kravzov et al., 1983, p. 25, pl. 12, fig. 9; Bogdanova, 1997, p. 91, pl. 21, fig. 6) [*P. g.*].

Pinna robinaldina d'Orbigny (Muromtseva, 1960, p. 181, pl. 3, figs. 18 and 19; Yanin in Arkadiev et al., 2012, p. 240, pl. 43, fig. 8) [*P. r.*].

Plagiostoma aubersonensis (Pictet et Campiche) (Bogdanova, 1997, p. 77, pl. 18, fig. 7; Yanin in Arkadiev et al., 2012, p. 262, pl. 43, fig. 7; *Lima a.* (see) [*P. a.*].

Plagiostoma dubisiensis (Pictet et Campiche) (Yanin in Arkadiev et al., 2012, p. 261, pl. 43, fig. 15); *Lima a.* (see), *Antiquilima* (see) [*P. a.*].

Platymyoidea marullensis (d'Orbigny) (Yanin in Arkadiev et al., 2012, p. 270, pl. 44, fig. 10); *Laternula agassizi* (see) [*P. m.*].

Plesiopecten subspinosus (Schlotheim) (Bogdanova in Arkad'ev et al., 2008, p. 73, pl. 4, figs. 9 and 10; sine descript.; Yanin in Arkadiev et al., 2012, p. 281, pl. 46, fig. 7 and 8; sine descript.); [*Spondylopecten s.* (see)].

Prohinnites renevieri (Coquand) (Muromtseva, 1960, p. 189, pl. 10, figs. 1 and 2; Bogdanova, 1997, p. 73, pl. 21, fig. 1; Yanin in Arkadiev et al., 2012, p. 264, pl. 44, fig. 12) [*P. r.*].

Propeamussium pawlowi (Retowski) (Yanin in Arkadiev et al., 2012, p. 257, pl. 43, fig. 11); *Pecten (Amussium) p.* (see) [*P. p.*].

Propeamussium sokolowi (Retowski) (Yanin in Arkadiev et al., 2012, p. 256, pl. 43, fig. 10); *Pecten (Amussium) s.* (see) [*P. s.*].

Protocardia peregrina (d'Orbigny) (Yanin in Arkadiev et al., 2012, p. 274, pl. 45, figs. 6 and 7) [*P. p.*].

Protocardia sphaeroidea (Forbes) (Yanin, 1960, p. 215, pl. 26, figs. 3 and 4; Kravzov et al., 1983, p. 24, pl. 12, fig. 4; Bogdanova, 1997, p. 87, pl. 20, figs. 5 and 6; Yanin in Arkadiev et al., 2012, p. 275, pl. 45, figs. 8 and 9) [*Globocardium s.* (see)].

Pseudolimea royeriana (d'Orbigny) (Bogdanova, 1997, p. 77, pl. 18, fig. 6) [*P. r.*].

Ptychomya rodinaldina (d'Orbigny) (Yanin, 1960, p. 217, pl. 27, fig. 4; Bogdanova, 1997, p. 89, pl. 20, figs. 10 and 11) [*P. r.*].

Pycnodonte weberae (Yanin in Cheltsova) (Bogdanova, 1997, p. 78, pl. 18, fig. 8; Bogdanova in Arkad'ev et al., 2008, p. 73, pl. 4, figs. 9 and 10) [*Gryphaea w.* (see)].

Sphaera belbekensis Yanin in Bogdanova, sp. nov. (1997, p. 84, pl. 20, figs. 1 and 2; Yanin in Arkadiev et al., 2012, p. 273, pl. 45, figs. 4 and 5) [*S. b.*].

Sphaera corrugata Sowerby (Drushchits, 1956, p. 56; Yanin, 1960, p. 214, pl. 25, fig. 8; Kravzov et al., 1983, p. 24, pl. 12, fig. 3) [*S. belbekensis.* (see)].

Spondylopecten aequatus (Quenstedt) (Yanin in Arkadiev et al., 2012, pl. 46, fig. 9; sine descript.) [*S. a.*].

Spondylopecten aff. *globosus* (Quenstedt) (Yanin in Arkadiev et al., 2012, pl. 46, fig. 10; sine descript.) [for information of Bogdanova; in aur collection is absent].

Spondylopecten subspinosus (Schlotheim) (Bogdanova, 1997, p. 73, pl. 18, fig.1); (*Plesiopecten s.* (see) [*S. s.*].

Syncyclonema germanica (Wollemann) (Muromtseva, 1960, p. 186, pl. 8, figs. 4 and 5; Bogdanova in Arkad'ev et al., 2008, p. 73, pl. 5, fig. 3, sine descript.) [*Entolium germanicum* (see)].

Thetironia aff. *minor* Deshayes (Drushchits, 1956, p. 56) [*Protocardia* sp. indet.].

Tortarctica weberi (Mordvilko) (Yanin in Arkadiev et al., 2012, p. 277, pl. 46, figs. 3 and 4); *Veniella w.* (see) [*T. w.*].

Valletia antiqua Favre in Joukowsky et Favre (Pchelintsev, 1959, p. 165, pl. 39, fig. 6; pl. 41, fig. 4; pl. 43, fig. 2; determination is conventional); Yanin, 1989, p. 166, pl. 8, figs. 2 and 3) [*V. ant.*].

Valletia auris Favre et Richard, 1927 [*V. aur.*].

Valletia urkustensis Pchelintsev (1959, p. 166, pl. 43, fig. 1, holotype; Yanin, 1989, p. 167, pl. 8, fig. 4) [*V. u.*].

Veniella weberi Mordvilko (1949, p. 138, pl. 28, fig. 3, holotype; in Bodylevskii et al., 1960, p. 109, pl. 24, figs. 9 and 10; Yanin, 1960, p. 213, pl. 25, figs. 1–4; Kravzov et al., 1983, p. 23, pl. 12, fig. 2; Bogdanova, 1997, p. 89, pl. 20, fig. 9) [*Tortarctica w.* (see)].

II.2. Material, Methods, Terminology

M a t e r i a l. The work is based on the bivalves from the Lower and Middle Berriasian, collected from sections throughout the Crimean Mountains personally by the present author, members of the Lower Cretaceous team of the Department of Paleontology of Moscow State University and colleagues from other geological institutions over a long time (from 1954 to 1990). The collections of bivalves studied by the author are kept in various museums: MZMSU (Yanin: nos. 10, 36, 39, 42, 44, 46, 47, 53, 57); TsNIGRM (Yanin: 12658, 12701, 2012; Bogdanova and Yanin: 13220); GMSPGGI (Bogdanova: 332). The collection of the author's previously published monograph on Crimean Early Cretaceous trigonids is housed at PIN

RAS (Yanin: 4925). The collection of described in this work has also been deposited with PIN (5596). The studied collection, which was at the disposal of the author at the Department of Paleontology of Moscow State University, has about 500 specimens. The vast majority of specimens are well preserved and are represented by complete shells and individual valves with a calcite shell layer and external ornamentation. This form of preservation is especially typical for specimens from sandstones and siltstones of the "alternation series" of the upper part of the Lower Berriasian (*chaperi* Beds: Zuya, Sarysu rivers) and Middle Berriasian (*tauricum* Subzone: Bel'bek, Beshterek). In marl limestones of the lower Berriasian (*jacobi* Zone: Karabi- and Dolgorukovskaya Yaila), bivalves are mainly represented by molds with a shell layer preserved only in places. Bioclastic limestones usually contain whole shells or scattered valves of excellent preservation (*jacobi* Zone: Beshterek; Karabi-Yayla, Lanchin Ravine; Aipetri Yaila). In the flyschoid deposits of the Eastern Crimea, the samples are of different preservation. The main collections of bivalves were carried out in the basins of Belbek (settlement of Kuibyshevo, villages of Golubinka, Solnechnose'e), Malyi Salgir (village of Ivanovka), Beshterek (village of Solovjevka), Zuya (Balanovsky Reservoir), Sarysu (villages of Balki, Blagodatnoe, Kozlovka, Novoklyonovo). In some sections, bivalve shells make up a significant part of coquina. This type of burial is especially pronounced in beds "alternation series" of sandstones and siltstones both in the South-Western (Bel'bek: Kuibyshevo, Kabani Log; Solnechnosel'e) and in the Central Crimea (Beshterek: Solovjevka; Zuya: Balanovskoe Reservoir; Sarysu: Novoklyonovo, Kozlovka). A characteristic type of burial is observed among cementing rudists, shells of which form lifetime intergrowths and banks in Lower Berriasian bioclastic limestones of the (Beshterek: Solovjevka; Lanchin Ravine on the northern slope of Karabi-Yaila). The total number of specimens of complete shells or individual valves can be found in the species description in the "Material" sections.

Methods. When processing the bivalves collection, we used the generally accepted method of visual study of specimens (Korobkov, 1954; Nevesskaja, 1960; Saveliev, 1962; Nevesskaja, 2003; Nevesskaja et al., 2013). The process of species identification was preceded by a general preparation of the outer and inner surface of the shell, in particular, ornamentation and dentition. The specimens were photographed in different years using various photography equipment. In recent years, macro-photography was digital. Photographers I.L. Sadovenko (Laboratory of Scientific and Applied Photography, Cinematography and Television of the Institute of the History of Science and Technology, Moscow), I.I. Zardiashvili and G.P. Petukhova (Moscow State University), A.V. Mazin and S. Bagirov (PIN). Some of the photographs were taken by the author. Some images of shells placed on paleontological plates were obtained by reproduction from the printed works of other authors, to which there are references in the explanation of the plates. All drawings explaining the methods of measuring shells and the structure of dental apparatus are made by the author.

Terminology. When describing species, we used the terminology for designating elements of shell structure adopted in general guidelines and reference books (Korobkov, 1954; Fundamentals of Paleontology, 1960; Cox and Newell, 1969–1971; Nevesskaja, 2003; Nevesskaja et al., 2013).

The following designations have been adopted for the main types of shells and individual valves (Fig. 27):

L—length: distance between anterior and posterior margins on shells with central, prosogyr and opisthogyrate umbos (1a, b, 2), or distance between the terminal umbo and posterior shell margin (3);

H—height: distance between upper and lower margins on shells with central, prosogyrate and opisthogyrate umbos (1a, 2); on shells with auricles and wings, the horizontal line of the auricles (2) is taken as the upper margin;

UV—upper valve, LV—left, LV—lower valve, RV—right valve; Sh—complete shell with two valves.

When describing species, the relative size of the shell or valve is indicated according to the following scale (calculated according to the largest length or height of an adult individual): small—up to 25, medium—25–60, large >60 mm.

II.4. Systematic Paleontology

CLASS BIVALVIA

Superorder Protobranchia Pelseneer, 1889

Order Nuculida Dall, 1889

Superfamily Nuculanoidea H. et A. Adams, 1858

Family Nuculanidae H. et A. Adams, 1858

Genus *Nuculana* Link, 1807

***Nuculana taurica* Yanin, sp. nov.**

Plate 1, figs. 1–4

Etymology. From the Greek *taurikos* (Tauris, an old name for the Crimea).

Holotype. PIN, no. 5596/1; shell with open valves (Pl. 1, fig. 1); Eastern Crimea, Borehole no. 16, near the village of Planerskoe, interval 240–244 m; Lower Cretaceous, Lower Berriasian, *jacobi* Zone.

Description. The shell is small (D ≤ 10 mm), oval, strongly elongated (D > H), moderately and evenly convex, thin-walled, strongly inequilateral. The dorsal margin is long, almost straight; smoothly into strongly and evenly convex, short, broadly rounded anterior and posterior margins; the ventral margin is slightly convex. The umbo is very small, sharply rounded, very close to the anterior margin.

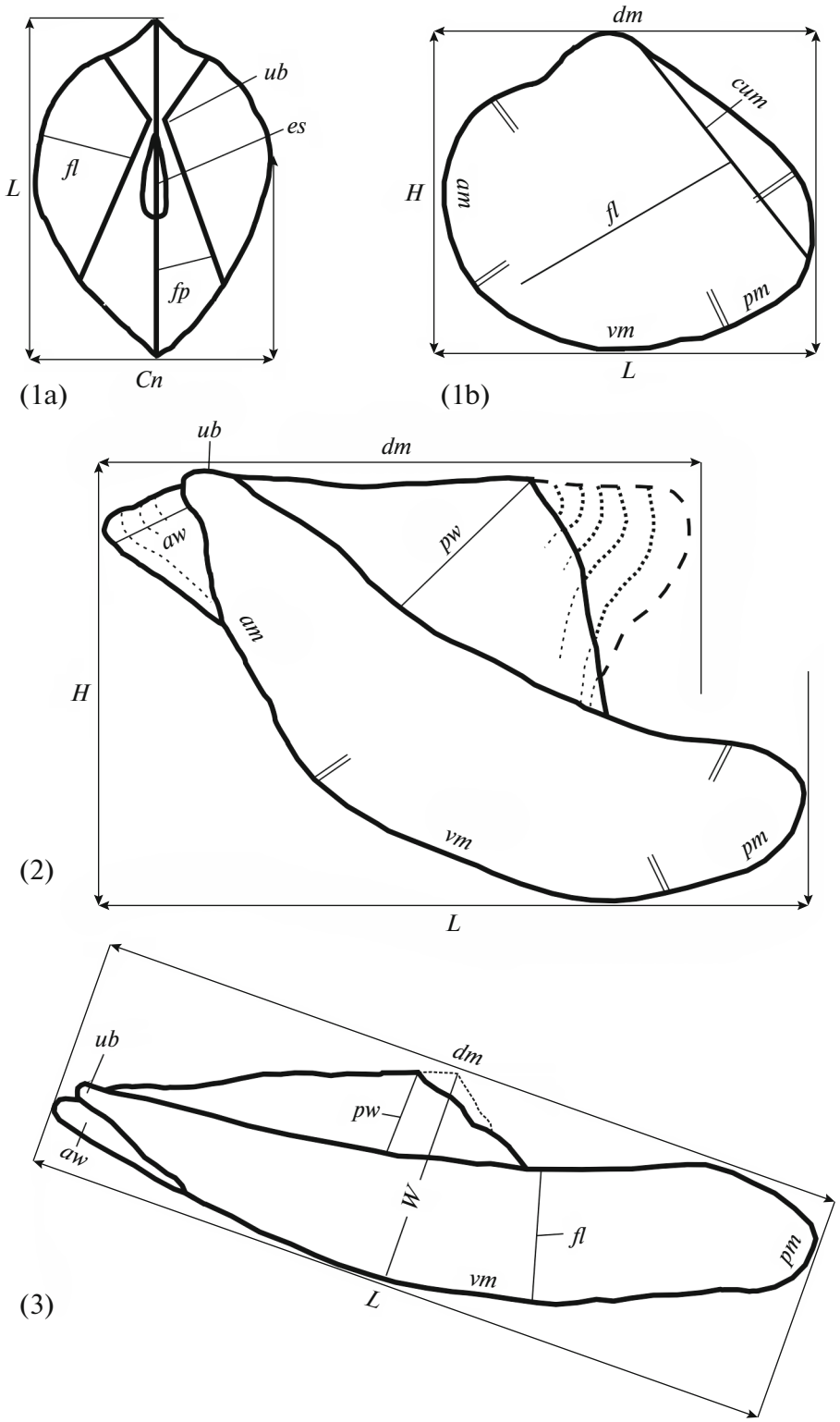
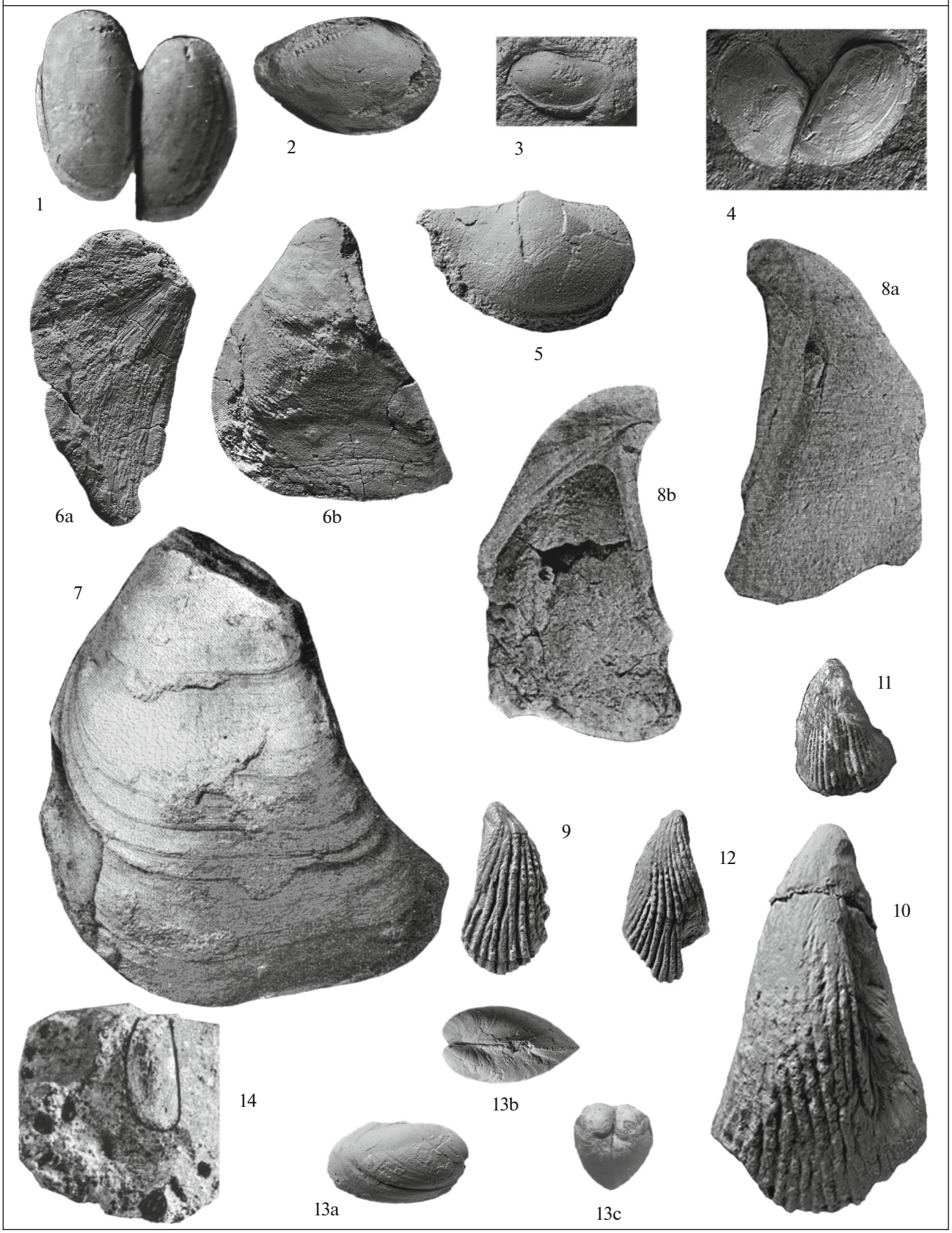


Fig. 27. Measurements and terminology of the shells of bivalves: (1.2) with ortogyrate, opisthogyrate, prosogyrate and (3) terminal umbo; species, external view: (1) *Integricardium deshayesianum* (Pl. 18, figs. 1a, 1b), ×1: (1a) left valve view, (1b) umbonal view; (2) *Gervillaria allaudiensis* (Pl. 3, fig. 7a), ×1, left valve view; (3) *Gervillella anceps* (Pl. 3, fig. 1a), ×1, left valve view. Explanations: (am) anterior margin, (aw) anterior wing, (Cn) convexity, (cum) umbonal carina, (dm) dorsal margin, (es) escutcheon, (fl) flank, (fp) posterior field, (H) height, (L) length, (pm) posterior margin, (pw) posterior wing, (ub) umbo, (vm) ventral margin, (W) valve width.

Plate 1



The surface is usually smooth, rarely very thin concentric streaks are preserved, visible only at high magnification. The cardinal platform is long and narrow; its anterior branch is short, arcuate; the posterior is twice as long as the anterior. The hinge consists of two branches: the anterior branch has more than seven very small teeth; there are more than 12 of them in the posterior branch (they are visible through the wall of the shell of the holotype).

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
PIN 5596/2 (LV)	5	3	0.6
PIN 5596/3 (RV)	8	4	0.5
PIN 5596/4 (LV)	9	5	0.5
PIN 5596/1 (LV) (holotype)	10	5	0.5

Comparison. This species differs from the most similar species *N. speetonensis* (Woods, 1899) and *N. seeleyi* (Gardner) (see Woods, 1899; Lower Cretaceous, Speeton Clay, Southern England) in the strongly elongated shell (L/H—1.8 vs. 1.6 in *N. speetonensis* and 1.42 in *N. seeleyi*) and a small prosogyrate umbo (in the compared species it is central in *N. speetonensis* and orthogyrate in *N. seeleyi*).

Material. 4 specimens; Crimea, Berriasian: lower Berriasian, *jacobi* Zone—village of. Planerskoe (Borehole 16, depth 240–244 m); Middle Berriasian, *tauricum* Subzone—Tonas River (village of Alekseevka) and Kuchuk-Karasu (village of Povorotnoe), Feodosia (Zavodskaya Gully).

***Nuculana balaklavensis* Yanin, sp. nov.**

Plate 1, fig. 5

Etymology. From the town of Balaklava (Southwestern Crimea).

Holotype. PIN, no. 5596/5, right valve mold; vicinity of Balaklava ("flux quarry"); Lower Cretaceous, Middle Berriasian, *tauricum* Zone.

Description. The shell is small (L = 8 mm), oval (L > H), almost equilateral (the anterior margin is only slightly shorter than the posterior). The umbo is almost central, slightly protruding, with the tip pointing backwards. The anterior branch of the dorsal margin is slightly convex, smoothly fused with a steeply rounded anterior margin; the ventral margin is widely convex; replaced by slightly convex posterior margin; the posterior branch of the dorsal margin is straight, forming an acute angle with the posterior one. The valve mold is smooth, with only thin growth lines.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
PIN 5596/5 (RV) holotype	8	5	0.6

Comparison. This species differs from the rostral shells of *N. scapha* (d'Orbigny, 1843–1847; Neocomian of France) in the straight posterior branch of the dorsal margin (in the *N. Scapha,* it is concave); greater valve height (H/L–0.6 versus 0.4); the presence of concavity of the lateral median part and flattening of the posterior side of the valve (in *N. scapha*, the convexity is more uniform); and in the more pointed rostrum.

Material. One specimen from the type locality.

Explanation of Plate 1

Figs. 1–4. *Nuculana taurica* Yanin, sp. nov.: (1) specimen PIN, no. 5596/1, holotype, appearance of a shell with open valves on the surface of a dense siltstone slab, ×3; Eastern Crimea, vicinity of the village Planerskoe, Borehole 16, interval 240–244 m; Lower Berriasian, *jacobi* Zone (collection of V. G. Aleksandrov, collections of 1955); (2) specimen PIN, no. 5596/3, right valve mold, appearance, lateral view, on the surface of the marl slab, ×3; environs of Feodosia, southern coast of the bay; Lower Berriasian, *grandis* Subzone (collecteor by Drushchits, 1954); (3) specimen PIN, no. 5596/2, appearance of the core of the left valve on the surface of the clay plate, ×1.5; Tonas River, village of Krasnoselovka; Middle Berriasian, *tauricum* Subzone (collected by T.N. Gorbachik, 1963); (4) specimen PIN, no. 5596/4, external view of the shell mold with open valves on the surface of compacted clay, ×3; Tonas River, village of Krasnoselovka; Lower Berriasian, *jacobi* Subzone (collected by T.N. Gorbachik, 1963).

Fig. 5. *Nuculana balaklavensis* Yanin, sp. nov.: specimen PIN, no. 5596/5, holotype, right valve, external view, lateral view, ×4; vicinity of Balaklava, flux quarry; Middle Berriasian, *tauricum* Subzone (collected by B.T. Yanin, 1955).

Figs. 6–8. *Arcomytilus couloni* (Marcou): (6) specimen MZMSU, no. 156/57, right valve with a truncated umbonal region, external view, ×1: (6a) lateral view, (6b) anterior view; Bel'bek River, village of Bogatoe Ushchel'e; Middle Berriasian, *tauricum* Subzone (collected by B.T. Yanin, 1956); (7) specimen TsNIGRM, no. 12/332, shell with a truncated umbonal region, external view, lateral view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Arkadiev, 2008); (8) specimen TsNIGRM, no. 97/13220, left valve, ×1: (8a) external view, lateral view, (8b) from inside; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (the same collector).

Figs. 9–12. *Arcomytilus sanctaecrucis* (Pictet et Campiche): (9) specimen PIN, no. 5596/6, left valve, external view, lateral view, ×2; northern slope of Aipetri Yaila, Bakhchisarai-Yalta highway; Lower Berriasian, equivalent of the *jacobi* Zone (coll. B.T. Yanin, 1987); (10) specimen PIN, no. 5596/7, right valve, external view, lateral view, ×3.5; the same locality, age and collector; (11) specimen PIN, no. 5596/8, right valve, external view, lateral view, ×1; the same locality, age and collector; (12) specimen PIN, no. 5596/9, right valve, external view, lateral view, ×1.5; the same locality, age and collector.

Figs. 13–14. *Lithophaga avellana* (d'Orbigny): (13) specimen PIN, no. 5596/10, shell, external view: (13a) lateral view, right valve view, (13b) top view, ×2, (13c) anterior view, ×1; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962); (14) specimen PIN, no. 5596/11, shell *in situ* in a hole etched with a mollusk in limestone pebbles (the mouths of other holes are visible on its surface) ×1; Malyi Salgir River, village of Ivanovka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1975).

Superorder Autobranchia Grobben, 1894

Order Mytilida Férussac, 1822
(=Cyrtodontida Ulrich, 1894)

Superfamily Mytiloidea Rafinesque, 1815

Family Mytilidae Rafinesque, 1815

Subfamily Mytilinae Rafinesque, 1815

Genus *Arcomytilus* Agassiz in J. Sowerby, 1842

***Arcomytilus couloni* (Marcou, 1846)**

Plate 1, figs. 6–8

Mytilus couloni: Marcou, 1846, p. 139 (nom. nud.); Pictet and Campiche, 1864–1867, p. 487, pl. 132, figs. 1 and 2.

Arcomytilus couloni: Muromtseva, 1960, p. 201, pl. 18, fig. 6–8; Bogdanova, 1961, p. 140, pl. 2, figs. 1–3; 1988, p. 137, pl. 29, fig. 5 and 6; 1997, p. 61, pl. 16, fig. 9; 2008, p. 73, pl. 5, fig. 5; Bogdanova et al., 1966, p. 109, pl. 11, fig. 1 and 2; Yanin in Arkadiev et al., 2012, p. 239, pl. 41, fig. 10.

Topotype. Specimen of *Mytilus couloni* (see Pictet and Campiche, 1864–1867, pl. 132, fig. 1); Switzerland (town of Hauterive); Lower Cretaceous, Valanginian (designated herein).

Description. The shell is large (Sh ≤ 90 mm), wedge-shaped, strongly convex, carinate, thick-walled. The dorsal margin is long, almost straight in its anterior part, arcuately smoothly curved in posterior part; the ventral margin is long and widely concave; the posterior margin is strongly convex, forming an acute angle with ventral. The umbo is terminal, sharp, detached, with a forward curved tip. Two carinae are present: the ventral is sharp, crested, sharp at the umbo (<50°) and straight in the middle of the valve; the dorsal is distinct, obtusely rounded (near the umbo about 100° to the posterodorsal corner it flattens out to 140°). The ventral field is wide, uniformly flattened-concave; the lateral field is wide, flattened (especially at the posterior margin). The ligament furrow is wide; the nymph is short, depressed.

The surface with numerous, very fine, often dichotomizing, in places sinuous radial striae; on the ventral field, the striae are very short, running obliquely or perpendicularly to the valve margin from the ventral carina. The shell margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	W	H/W	T	T/L
MZ 156/57 (RV)	51	44	0.8	29	0.56
TsNIGRM 97/13220 (LV)	71	38	0.5	32	0.45

Comparison. It differs from *A. pectinatus* (Sowerby, 1837–1842; Kimmeridgian of Western Europe), which is close in shell shape, in a more pointed umbo, a more concave ventral margin, and a strongly developed sharp, crested ventral carina; pointed posteroventral angle.

Remarks. As noted by Pictet and Campiche (1864–1867, p. 487), the author of the species (Marcou, 1846) did not provide a description and image of the shell, so the holotype or lectotype cannot be established. But in their work they indicate (in the synonymy of the species, p. 488) that the specimen described and illustrated by them in pl. 132, fig. 1 as *Mytilus couloni*, comes from the same locality as the forms studied by Marcou (from the Valanginian district of the village of Hauterive—"couche inférieur de la étage des marnes d'Hauterive a Censeau"). On the basis of this indication, we accept here the shell depicted in fig. 1, pl. 132 (Pictet and Campiche, 1864–1867) as a topotype.

Occurrence. Berriasian–Valanginian: Berriasian of the Crimea, Northern Caucasus, Mangyshlak, Kopetdag; Upper Valanginian of Switzerland and France.

Material. Two specimens; Crimea, Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; villages of Solnechnosel'e and Bogatoe Ushchel'e).

***Arcomytilus sanctaecrucis* (Pictet et Campiche, 1866)**

Plate 1, figs. 9–12

Mytilus sanctae-crucis: Pictet and Campiche, 1864–1867, p. 490, pl. 132, figs. 5–7; Loriol, 1868, p. 32; Broili, 1902, p. 606, pl. 1, fig. 3.

Arcomytilus sanctaecrucis: Bogdanova in Arkadiev et al., 2005, p. 125, pl. 3, fig. 1 (sine descript.); Yanin in Arkadiev et al., 2012, p. 279, pl. 46, fig. 11 (sine descript.); Yanin, 2020a, p. 9, pl. 1, figs. 1–4.

Lectotype. A specimen of *Mytilus sanctaecrucis* (see Pictet and Campiche, 1864-1867, pl. 132, figs. 7a, 7b; shell); the Campiche collection at the Museum of Natural History in Geneva; Switzerland (Sainte-Croix); Lower Cretaceous, Upper Valanginian (chosen here based on the indication by the authors of the species that the specimen illustrated by them in fig. 7 is a "type of short and wide shells" ("du type court et large", p. 490).

Description. The shell is small (Sh ≤ 27 mm), elongated (L > W), wedge-shaped, slightly curved, strongly narrowed anteriorly, with pointed terminal umbo, and pterygoid posteriorly; the dorsal margin is smoothly rounded; the posterior margin is steeply rounded, gradually passing into the dorsal and ventral margins; the ventral margin is slightly concave, separated on the lateral field of the valve by a distinct, often sharp carina. The ventral field is flattened or slightly concave; with lateral, numerous, sharp, rounded, radial ribs, usually, dichotomously diverging at the posterior and dorsal margins, less often in the middle part of the valves; the ribs of the ventral field are more densely spaced and much thinner than those of the lateral field. Thin scales and spines are distinguishable along the entire length of the ribs on well-preserved

specimens; these are especially pronounced on the specimen described by Broili (1902, pl. 1, fig. 3; area of the Bakhchisarai highway). The intercostal spaces are rounded, equal in width to ribs or several narrower, posterior margin weakly serrated at rib ends.

Dimensions in mm and ratios:

Specimen no.	L	W	W/L
PIN 5596/6 (LV)	13	6	0.46
PIN 5596/9 (LV)	14	6	0.40
PIN 5596/8 (RV)	24	15	0.62
PIN 5596/7 (RV)	27	14	0.51

Comparison. This species is distinguished from *A. couloni* (Marcou, 1846; Valanginian of Switzerland) and *A. pectinatus* (Sowerby, 1812–1823; Kimmeridgian of England)—in the smaller and strongly constricted shell; pointed terminal umbo; greater curvature of the ventral margin of the valves; coarser and less numerous scaly ribs (in the compared species, the striae are smooth); from *A. morrisi* (Sharpe) (Loriol and Cotteau, 1868; Portlandian of France) with a more wedge-shaped shell; terminal umbo (in the compared species, the ventral margin protrudes slightly beyond the tip of the umbo); a sharper carina (*A. morrisi* has a rounded carina); more concave ventral field and coarser ribbing

Remarks. By the nature of the ribbing (coarse radial dichotomous scaly ribs) and the mytiloid shape of the shell, it is close to two Jurassic species, but differs: from "*Mytilus*" *furcatus* Münster in Goldfuss (1834–1840; Upper Oxford of Germany; Pchelintsev, 1931; Tithonian of the Caucasus)—narrower and elongated sink; sharp terminal tops; pronounced carina; concave ventral field; from *"Mytilus" pretiosus* Pzhelintsev (Tithonian of Transcaucasia, Kakheti)—in the more elongated and narrowed shell; sharper carina; less dichotomous and less curved ribs (in the compared species, the ribs are steeply scalloped, herringbone-shaped, curving towards the shell margins throughout the carinate median inflection).

Occurrence. Berriasian–Valanginian: Berriasian of the Crimea; Upper Valanginian of Switzerland (Sent-Crua, "marls with bryozoans") and southeastern France (Villers-le-Lac, "limonite limestones").

Material. Six specimens; Crimea, Lower Berriasian: *jacobi* Zone—northern slope of the Aipetri Yaila (Bakhchisarai highway), the same Zone, *grandis* Subzone—Tonas (Krasnoselovka, Kuchuk-Uzen' Creek).

Subfamily Modiolinae Keen, 1958

Genus *Modiolus* Lamarck, 1799

Modiolus simplex (Deshayes in Leymerie, 1842)

Plate 2, fig. 1

Modiola simplex: Deshayes in Leymerie, 1842, p. 8, pl. 7, fig. 8.

Mytilus simplex: d'Orbigny, 1843–1847, p. 269, pl. 338, figs. 1–4.

Holotype. Specimen of *Modiola simplex* Deshayes in Leymerie (1842, p. 8, pl. 7, fig. 8; right valve); Lower Cretaceous, Neocomian of France (Aube, Vill-sur-Terre) (by monotypy, designated herein).

Description. The shell is medium in size (L = 40 mm), elongated (L > twice W), moderately convex; sharply inequilateral. The anterior margin is very short, sharply rounded, protruding slightly in anterior of the umbo; the dorsal margin is long, weakly and uniformly convex (without median inflection); the ventral margin is long, subparallel to the dorsal margin, very slightly and widely concave; the posterior margin is rounded. The umbo is subterminal. The external carinate flexure on the valves is not pronounced; it corresponds to the line of greatest convexity. The shell margins are smooth inside.

Dimensions in mm and ratios:

Specimen no.	L	W	W/L	T	T/L
PIN, no. 5596/16, shell	40	14	0.3	10	0.2

Comparison. In its narrow, elongated shell and the absence of a ventral depression, it is easily distinguished from other Early Cretaceous species: *M. reversus* (d'Orbigny), *M. montmollini* (see below), *M. carteroni* (d'Orb.) and *M. aequalis* (d'Orb., 1843–1847) first described in France.

Occurrence. Berriasian–Valanginian: Berriasian of the Crimea; Berriasian–Valanginian of France and Switzerland.

Material. One specimen; Crimea, Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log).

Modiolus montmollini Pictet et Campiche, 1866

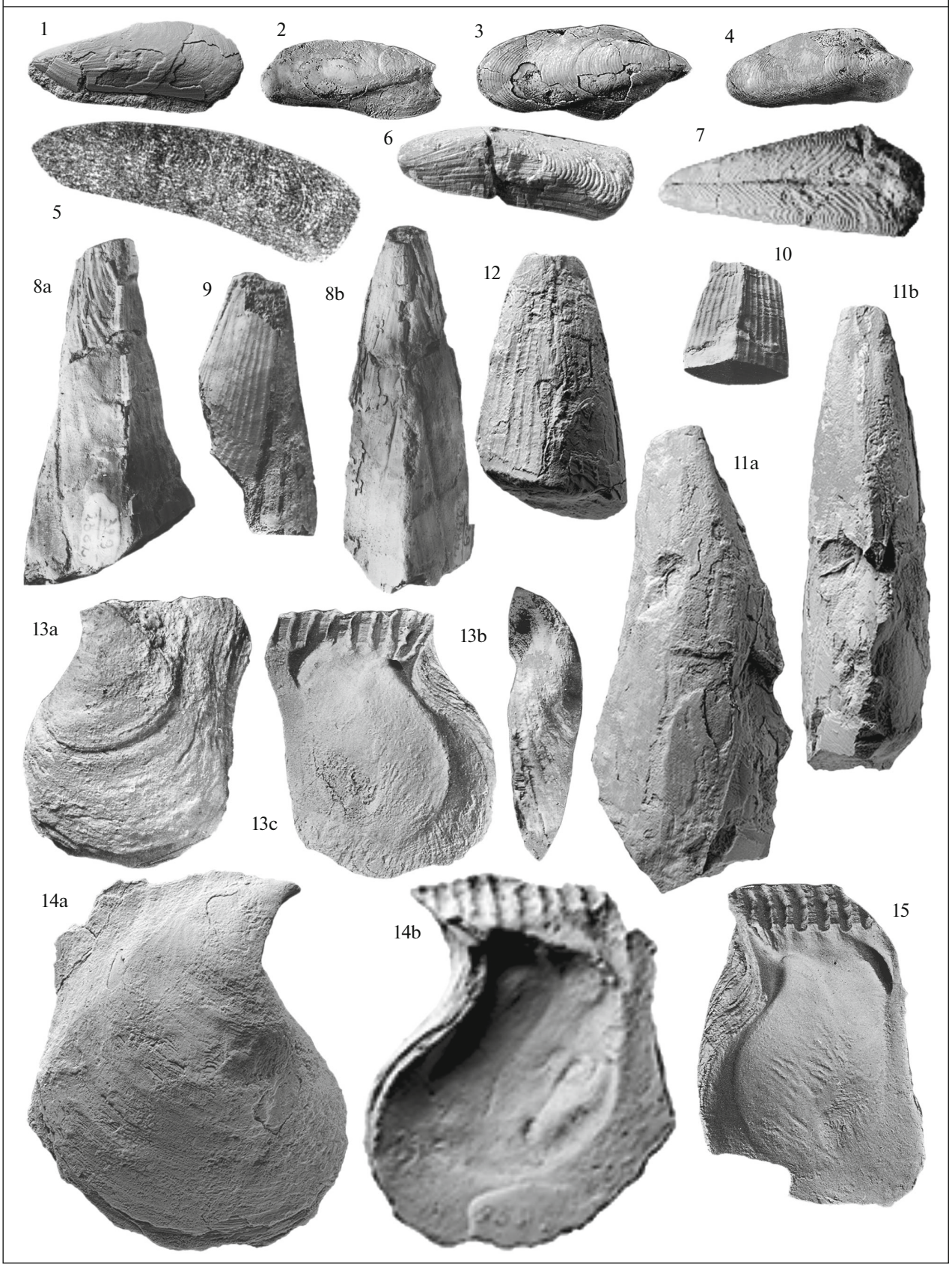
Plate 2, figs. 2–4

Mytilus montmollini: Pictet and Campiche, 1864–1867, p. 498, pl. 133, figs. 1, 2.

Lectotype. Specimen *Mytilus montmollini* (Pictet and Campiche, 1864–1867, pl. 133, figs. 2a, 2b; shell); Switzerland (Metabief); Lower Cretaceous, Valanginian (designated herein).

Description. The shell is small to medium-sized (D ≤ 40 mm), elongated-rhomboidal, strongly uneven-sided (the anterior part of the shell is much shorter than the posterior one). The anterior margin is short, sharply rounded; the dorsal margin is long, slightly convex, forms a noticeable bend in the anterior part; the ventral margin is long, slightly concave in the middle part; the posterior margin is sharply rounded. The umbo is subterminal, strongly pushed forward to the anterior margin. The carinate inflection is distinct, dividing the valves into two unequal fields: the dorsal one is uniformly convex in the middle and posterior

Plate 2



parts, while along the valve margin it is widely concave; the ventral one is narrower than the dorsal one, along it a distinct wide depression extends along the inflection, separating the anterior wing and causing the concavity of the ventral margin. The entire surface is covered with numerous filiform, smooth, concentric ribs; some of them bifurcate. The margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	W	W/L
PIN 5596/15 (RV)	33	13	0.3
PIN 5596/13 (Sh)	37	15	0.4
PIN 5596/14 (RV)	40	20	0.5

Comparison. This species differs from *M. aequalis* (Sowerby, 1818; d'Orbigny, 1843–1847; Neocomian of France), which is the closest in the shell morphology: in the more elongated and narrower posterior side of the shell; the presence of a clear inflection of the dorsal margin (in *M. aequalis*, this margin is uniformly convex); and in the much more pronounced ventral depression.

Occurrence. Berriasian–Valanginian: Berriasian of the Crimea; Neocomian of France.

Material. Three specimens; Crimea, Middle Berriasian: *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e).

Subfamily Lithophaginae H. et A. Adams, 1857

Genus *Lithophaga* Roding, 1798

***Lithophaga avellana* (d'Orbigny, 1844)**

Plate 1, figs. 13, 14

Lithodomus avellana: d'Orbigny, 1843–1847, p. 291, pl. 344, figs. 13 and 14; Pictet and Campiche, 1864–1867, p. 520, pl. 137, figs. 2–4.

Lithophaga avellana: Muromtseva, 1960, p. 204, pl. 18, figs. 17a, 17b.

Holotype. Specimen of *Lithodomus avellana* (d'Orbigny, 1843–1847, pl. 344, fig. 13 and 14; shell); southern France (Haute Marna); Lower Cretaceous, Neocomian (designated by monotypy herein).

Description. The shell is small (L = 20 mm), oval-elongated, date-shaped, moderately and evenly convex, strongly inequilateral. The anterior margin is short, rounded, not protruding beyond the tip of the umbo; the dorsal margin is long, slightly convex, slightly longer than ventral; the ventral margin is also slightly convex, smoothly turning into a widely rounded posterior margin. The umbo is very small, terminal, projecting slightly beyond the tip of the umbo.

Dimensions in mm and ratios:

Specimen no.	L	W	W/L
PIN 5596/10 Sh	20	8	0.4

Explanation of Plate 2

Fig. 1. *Modiolus simplex* (Deshayes): specimen PIN, no. 5596/12, shell weth slightly shifted valves, external view, left valve view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955).

Figs. 2–4. *Modiolus montmollini* (Pictet et Campiche): (2) specimen PIN, no. 5596/13, shell, external view, lateral view, right valve view, ×1; Bel'bek River, village of Golubinka, southern slope of Mount Karatlykh, Orekhovyi Ravine; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (3) specimen PIN, no. 5596/14, right valve with a broken anterior wing, external view, lateral view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; age and collector are the same; (4) specimen PIN, no. 5596/15, shell with a broken anterior wing, external view, lateral view, right valve view, ×1; Bel'bek River, village of Solnechnosel'e; the same age (coll. V.V. Drushchits, 1955).

Figs. 5–7. *Inoperna taurica* Yanin, sp. nov.: (5) specimen MZMSU, no. 160/57, holotype, shell, external view, lateral view, left valve view, ×1; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (6) specimen PIN, no. 5596/16, shell, external view, lateral view, left valve view, ×1; the same locality, age and collector; (7) specimen PIN, no. 5596/17, shell with a broken posterior margin, external view, dorsal view, ×1; the same locality, age and collector.

Figs. 8–10. *Pinna robinaldina* d'Orbigny: (8) specimen PIN, no. 5596/18, mold with a broken posterior margin, external view, ×1: (8a) lateral view, left valve view, (8b) ventral view; Sarysu River, village of Novoklyonovo; Lower Berriasian, *chaperi* Beds (coll. B.T. Yanin, 1962); (9) specimen TsNIGRM, no. 98/13220, a large shell fragment with broken anterior and posterior margins, external view, right valve view, ×1; Zuja River, area of Tau-Kipchak Cave; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1955); (10) specimen MZMSU, no. 44/57, fragment of the middle part of the shell, external dorsal view, ×1; Sarysu River, village of Novoklyonovo; Lower Berriasian, *chaperi* Beds (coll. B.T. Yanin, 1956).

Figs. 11–12. *Pinna karabiensis* Yanin, sp. nov.: (11) specimen PIN, no. 5596/19, holotype, mold with broken umbo and posterior margin, external view, ×1: (11a) lateral view, right valve view, (11b) ventral view; northern slope of Karabi-Yaila Massif, Kazanlak Basin, "bulldozer clearing on the highway"; Lower Berriasian, *grandis* Subzone (coll. B.T. Yanin, 1986); (12) specimen PIN, no. 5596/20, mold with broken umbo and posterior margin, external view, dorsal view, 1; the same locality, age and collector.

Figs. 13–15. *Isognomon ricordeanum* (d'Orbigny): (13) specimen PIN, no. 5596/22, left valve, ×1: (13a) external view, lateral view, (13b) anterior view, (13c) internal view; northern Baidar Depression, vicinity of the village of Peredovoe, roadcut on highway near Bechku pass; Middle Berriasian, *tauricum* Subzone (coll. G.K. Kabanov, 1961); (14) specimen PIN, no. 5596/23, right valve, ×1.5: (14a) external view, lateral view, (14b) from inside; the same locality, age and collector; (15) specimen PIN, no. 5596/24, right valve, from inside; the same locality, age and collectorthe same locality, age and collector.

Comparison. This species differs from *L. oblonga* (d'Orbigny, 1843–1847; Neocomian of France) in the relatively shorter shell (W/L—0.4, in *L. oblonga*—0.3); the umbo is slightly protruding beyond the anterior margin; in the wider anterior margin.

Remarks. One shell of *L. avellana* in our collection is found *in situ* in a burrow drilled by a mollusk in a limestone pebble (Pl. 1, fig. 14).

Occurrence. Berriasian–Barremian: Middle and Upper Berriasian of the Crimea; Valanginian—Urgonian of Switzerland; Neocomian of France.

Material. Two specimens; Crimea, Middle Berriasian, *tauricum* Subzone—Malyi Salgir River (village of Ivanovka) and Beshterek (village of Solovjevka).

Genus *Inoperna* Conrad in Keer, 1875

Inoperna taurica Yanin, sp. nov.

Plate 2, figs. 5–7

Modiola gillieroni: Muromtseva, 1960, p. 202, pl. 18, fig. 10, non *M. gillieroni* Pictet et Campiche, 1864–1867.

Etymology. From Tauris, the old name for the Crimea.

Holotype. MZMSU, no. 160/57, specimen of *Modiola gillieroni* (Muromtseva, 1960, pl. 18, fig. 10; shell); Central Crimea, river Beshterek (village of Solovjevka); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone (designated by monotypy herein).

Description. The shell is medium-sized to large (L ≤ 67 mm), strongly elongated (L three times larger than W), narrow, shank-shaped, ribbed, inequilateral. The anterior margin is very short, almost does not extend beyond the umbo, sharply rounded, gradually merges into a long, straight or slightly concave ventral margin; the posterior margin is relatively short, rounded, smoothly turning into a slightly convex, long dorsal margin. The umbo is subterminal, not protruding above the dorsal margin. The carinate bend is distinct, smoothly rounded, often crested in the umbonal region, dividing the valve into two approximately equal fields: the ventral margin is slightly and uniformly convex, slightly flattened along the margin; the dorsal margin is slightly and evenly convex throughout.

The ornamentation is of two types: concentric and transverse. The dorsal field is with numerous, sharp, often coarse, symmetrical, smooth, rounded concentric ribs; each rib near the carinate inflection is divided into 2–3 thinner ribs; the latter do not go beyond the inflection. The ventral field is covered with coarse growth lines, against which numerous, very thin striae transverse to the growth lines are visible (under magnification). The intercostal spaces on the dorsal field are smooth, concave, equal in width to the ribs.

Dimensions in mm and ratios:

Specimen no.	L	W	W/L	T	T/L
PIN 5596/16 (Sh)	47	15	0.3	–	–
PIN 5596/17 (Sh)	~50	17	0.3	18	0.3
MZMSU 160/57 (Sh) holotype	67	19	0.3	–	–

Comparison. This species differs from shells similar in shape and ornamentation: from *I. gillieroni* (Pictet et Campiche, 1864–1867; Valanginian of Switzerland) in a more narrowed anterior end of the shell; lesser concavity of the ventral margin; more numerous and thinner ribs on the dorsal field; development of numerous transverse striae on the ventral field; from *I. flagellifera* Forbes (Woods, 1899; Lower Aptian of England)—less sharp carinate bend; more numerous and thinner ribs dichotomizing near it; from *I. carolinensis* (Conrad, see Cox and Newell, 1969; Upper Cretaceous Texas, United States) with a more sharply rounded anterior and less curved ventral margins; a more pronounced carinate flexure near the umbo; the absence of concentric ribbing on the ventral field (in the compared species, concentric ribs pass through the carinate inflection and continue on the posterior and middle parts of the ventral field).

Material. Three specimens; Crimea, Berriasian: Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Solnechnosel'e) and Beshterek (village of Solovjevka); Upper Berriasian, *euthymi* Subzone—Burulcha River (village of Mezhgorie).

Superfamily Pinnoidea Leach, 1819

Family Pinnidae Leach, 1819

Genus *Pinna* Linnaeus, 1758

Pinna robinaldina (d'Orbigny, 1844)

Plate 2, figs. 8–10

Pinna robinaldina: d'Orbigny, 1843–1847, p. 251, pl. 330, fig. 1–3; Pictet and Renevier, 1855–1858, p. 117, pl. 16, figs. 5a–5d; Pictet and Campiche, 1864–1867, p. 532, pl. 139, figs. 3–6; Loriol, 1882, p. 82, pl. 10, figs. 3–5; Choffat and Loriol, 1888, p. 86, pl. 5, figs. 4 and 5; Woods, 1899–1913, p. 96, pl. 12, figs. 11–15; Muromtseva, 1960, p. 181, pl. 3, figs. 17–20; Yanin in Arkadiev et al., 2012, p. 240, pl. 43, fig. 8.

Holotype. Specimen of *P. robinaldina* (d'Orbigny, 1843–1847, pl. 330, figs. 1–3, shell); France (Ionna); Lower Cretaceous, Hauterivian (designated by monotypy herein).

Description. The shell is medium and large in size (L > 70 mm), equivalated, pyramidal in shape, elongated-wedge-shaped, very narrow, pointed in anterior and moderately widening, widely gaping behind, slightly compressed laterally, rhombic in section. Dorsal and ventral margins straight, long, converging at an angle of 20° at the terminal umbo. The median carina is sharp, crested, sharply rounded, straight, coinciding with the line of greatest convexity,

dividing the valve into two unequal fields: the dorsal margin is flat; the ventral margin is wider, slightly convex in the anterior and flattened in the posterior part of the valve.

The surface possesses radial ribs; 6–7 on the dorsal field, very narrow, low, smooth, symmetrical, with wide, smooth, flat intercostal spaces; a reticulate pattern is formed at the intersection of radial ribs with thin concentric growth lines. On the ventral field along the carina there are up to six radial ribs similar to those on the opposite field; the radial ribs gradually flatten towards the middle of the field and the posterior margin of the valve; the lower half of the ventral field bears only oblique growth wrinkles approaching the ribs and carina at an acute angle.

Dimensions. It was not possible to produce accurate measurements, since the material is represented by shells and molds with broken anterior and posterior margins or by fragments of valves and molds.

Comparison. The shells differ from similar ones in size, shape and ornamentation: from *P. decussata* Goldfuss (1834–1840; Aptian of Germany)—smaller; more angular (rhombic) cross-section and relatively narrower shell; from *P. suprajurensis* (Loriol and Cotteau, 1868; Portlandian of France), in the narrower shell; sharper median carina; a more angular rhombic shell cross-section and fewer radial ribs on the dorsal field; from *P. karabiensis* sp. nov. (see below)—in the narrower regular pyramidal shape of the shell, almost straight dorsal and ventral margins (expansion of the shell occurs gradually and evenly, in the compared species its ventral margin is strongly convex, and the dorsal margin is concave; shell expands rapidly and it becomes pterygoid); in the sharper crested median carina; thinner and more numerous ribs on the dorsal field.

Remarks. Previously, Yanin (in Arkadiev et al., 2012, p. 241) erroneously designated the lectotype of the species (d'Orbigny, 1843–1847, pl. 330, fig. 1). It would be more correct to indicate the holotype of the species *P. robinaldina* by monotypy, since his work shows one shell in three positions (see synonymy). In 2012, in the "Material" section, we indicated the discovery of shells of this species in the Berriasian deposits on the northern slope of the Karabi-Yaila Massif. At present, the *Pinna* shells from this locality are classified by us as a new species, *P. karabiensis* (see below).

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Berriasian–Aptian of the Northern Caucasus, Switzerland, France; Aptian of Georgia, Spain; Lower Aptian–Cenomanian of England; Neocomian of Germany.

Material. Four specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu River (village of Novoklyonovo) and Zuya River (Balanovsky Reservoir); Middle Berriasian, *tauricum* Subzone—Chernaya River (vicinity of Balaklava, "flux quarry") and Bel'bek River (village of Solnechnosel'e).

***Pinna karabiensis* Yanin, sp. nov.**

Plate 2, figs. 11, 12

Etymology. After the Karabi-Yaila mountain range in the Central Crimea.

Holotype. PIN, no. 5596/19, mold of a shell with a broken posterior margin (Pl. 2, fig. 11); Central Crimea, northwestern margin of the Karabi-Yaila Plateau (Kazanlyk Basin); Lower Cretaceous, Lower Berriasian, *grandis* Subzone.

Description. The shell is large (L > 90 mm), irregularly wedge-shaped, strongly narrowed anteriorly and sharply widening towards the posterior margin, widely gaping, moderately laterally compressed, highly rhombic in cross section. The dorsal margin is strongly concave; the ventral margin is strongly convex, with a noticeable bend in its anterior third; the margins converge at the terminal umbo at an angle of 20° (the posterior margin was not preserved, but judging by the growth lines in the middle part of the valves, it was widely rounded). The median carina is not sharp, in the form of a rounded shoulder; divides valves into two unequal fields: the dorsal field is flattened, narrower; the ventral field is convex in anterior and along the carinate inflection, often flattened at the margin.

The ornamentation (based on the remains of a shell layer on the molds) is represented by rounded, low, narrow, smooth radial ribs separated by wider flat intercostal spaces. The ribs are traced distinctly on the dorsal field, on and along the carinate bend on the ventral field. The ventral field along the margin on the mold is smooth, with only weak growth lines.

Dimensions in mm and ratios:

Specimen no.	L	W	T	T/W
PIN 5596/19 (mold) (holotype)	~110	42	25	0.5
PIN 5596/21 (mold)	–	43	26	0.6

Comparison. This species is distinguished from other species: from *P. hombresi* Pictet et Campiche (1864–1867; Hauterivian of Switzerland)—in the concave dorsal margin of the shell; a more pronounced median carinate bend and the presence of radial ribbing on the dorsal field, on the carinate bend and in the upper half of the ventral field; from *P. decussata* Goldfuss (1834–1840, see also Ivanova, 1959) from the Lower Cretaceous of Germany and the Lower Aptian of the Saratov Volga region—in the smaller shells; more pronounced inflection of the ventral margin; concave dorsal margin; sharper median carina; possibly less developed radial sculpture on the ventral field; from *P. sulcifera* Leymerie (1842, see also d'Orbigny, 1843–1847; Neocomian of France)—in the less wide shell; the presence of a clearly pro-

nounced carinate inflection (the compared species has no carina); less coarse and more densely spaced radial ribs, possibly absent on the ventral field (in the compared species, this field bears the same ornamentation as the dorsal field).

Remarks. Previously described specimens of *P. karabiensis* were erroneously assigned by the author (Yanin in Arkadiev et al., 2012, p. 241) to *P. robinaldina* d'Orbigny.

Material. Three specimens from the type locality.

Superfamily Isognomonoidea Woodring, 1825

Family Isognomonidae Woodring, 1825

Genus *Isognomon* Lightfoot, 1786

***Isognomon ricordeanus* (d'Orbigny, 1845)**

Plate 2, figs. 13–15

Perna ricordeana: d'Orbigny, 1843–1847, p. 494, pl. 399, fig. 1–3; Pictet and Campiche, 1869–1871, p. 93, pl. 157, fig. 1.

Isognomon ricordeanus: Yanin in Arkadiev et al., 2012, p. 241, pl. 42, fig. 4.

Lectotype. Specimen of *Perna ricordeana* (d'Orbigny, 1843–1847, pl. 399, fig. 1 and 2; shell); France (Ionna); Lower Cretaceous, Neocomian (designated by Yanin in Arkadiev et al., 2012, p. 241).

Description. The shell is medium-sized (P ≤ 60 mm), lenticular, from pterygoid to subrectangular in shape, smooth, high (H > L), thick-walled, strongly flattened; slightly oblique in anteroventral direction. The umbo is acute, terminal, located at the anterior end of the ligament area. The upper part of the shell is slightly narrowed. The dorsal margin is straight, long (ratio of its length to valve length, 0.87). The anterior margin is strongly and widely concave in the upper half; at the base it is strongly convex, widely rounded; the angle between the dorsal margin and the convex part of the anterior margin is 105°–115°. The posterior margin is longer than the anterior margin, sometimes widely concave in the middle part; the angle between the dorsal and posterior margins is 70°–80°. The ventral margin is convex, regularly and broadly rounded, blending smoothly into the anterior and posterior margins. The posterior wing is triangular, wide, flat; separated from the lateral surface of the valve by a wide depression. The line of greatest convexity is curved: from the umbo it is directed at an angle of 60°–65° back and down, approximately to the middle of the ventral margin. The valves near it are uniformly convex. The byssal notch is wide, deep, equally developed on both valves. The byssal fissure is long, widened in the upper part.

The ligament area is straight, wide, flat, with 9–11 narrow, deep, concave transverse pits (Figs. 30.5a, 30.5b). The spaces between them are flat, narrow (usually narrower than the pits in width, but sometimes they have the same width with them). Beneath the ligament area at its posterior end, on a smooth, even series of both valves, tooth-like ridges and dental sockets are developed. On the left valve, the posterior tooth-like ridge is single, thick, elongated, high, crested, weakly departing from the sixth or seventh ligament fossa obliquely downwards; with its upper end it sometimes extends into the lower part of the ligament area; its lower end curves downward parallel to the posterior margin of the valve. A deep, asymmetric dental socket is developed anterior to tooth-like ridge. On the right valve, from the sixth (sometimes from the eighth) pit, a deep, smooth, elongated notch extends obliquely backwards and downwards, bounded anteriorly and posteriorly by sharp, low crested dental ridges, of which the anterior one is the most developed.

The adductor muscle scar is single, close to the posterior margin, oval in shape, with a long axis extended parallel to the margin. The pallial line is distinct, continuous, far from the valve margin.

Dimensions in mm and ratios:

Specimen no.	L	W	H/L	T	T/L
PIN 5596/22 (LV)	43	51	1.1	13	0.3
PIN 5596/23 (RV)	44	53	1.2	10	0.2
PIN 5596/24 (RV)	41	60	1.4	12	0.3

Comparison. The species differs from the closest *I. germani* (Pictet et Campiche, 1869–1871; Hauterivian of Switzerland) by the sharper umbo protruding beyond the anterior margin; more curved line of the greatest convexity, in connection with which the growth lines have asymmetric suboval outlines (in the compared species they are symmetrical and strictly concentric).

Occurrence. Berriasian–Barremian: Berriasian of the Crimea; Berriasian—Lower Valanginian of the Northern Caucasus; Valanginian—Hauterivian of Switzerland; Neocomian of France; Barremian of England.

Material. Three specimens; Crimea, Berriasian: Middle Berriasian, *tauricum* Subzone—northern side of the Baidar Depression (village of Peredovoe, road to Bechka mountain pass); Upper, *euthymi* Subzone—Beshterek River (village of Lesnosel'e).

Family Bakevellidae King, 1850

Genus *Gervillella* Waagen, 1907

***Gervillella anceps* (Deshayes in Leymerie, 1842)**

Plate 3, figs. 1–4; Figs. 27.3, 29.8

Gervillia anceps: Deshayes in Leymerie, 1842, p. 9, pl. 10, fig. 3a–3c; d'Orbigny, 1843–1847, p. 482, pl. 394, fig. 1–4; Pictet and Campiche, 1868–1871, p. 82, pl. 155, fig. 5; Muromtseva, 1960, p. 182, pl. 4, figs. 1–3.

Gervilleia anceps: Eristavi, 1957, p. 39, pl. 1, fig. 2.

Gervillella anceps: Dimitrova, 1974, p. 63, pl. 32, fig. 4; pl. 33, fig. 7; Bogdanova, 1997, p. 63, pl. 17, figs. 3 and 4; Yanin in Arkadiev et al., 2012, p. 243, pl. 42, figs. 6 and 7.

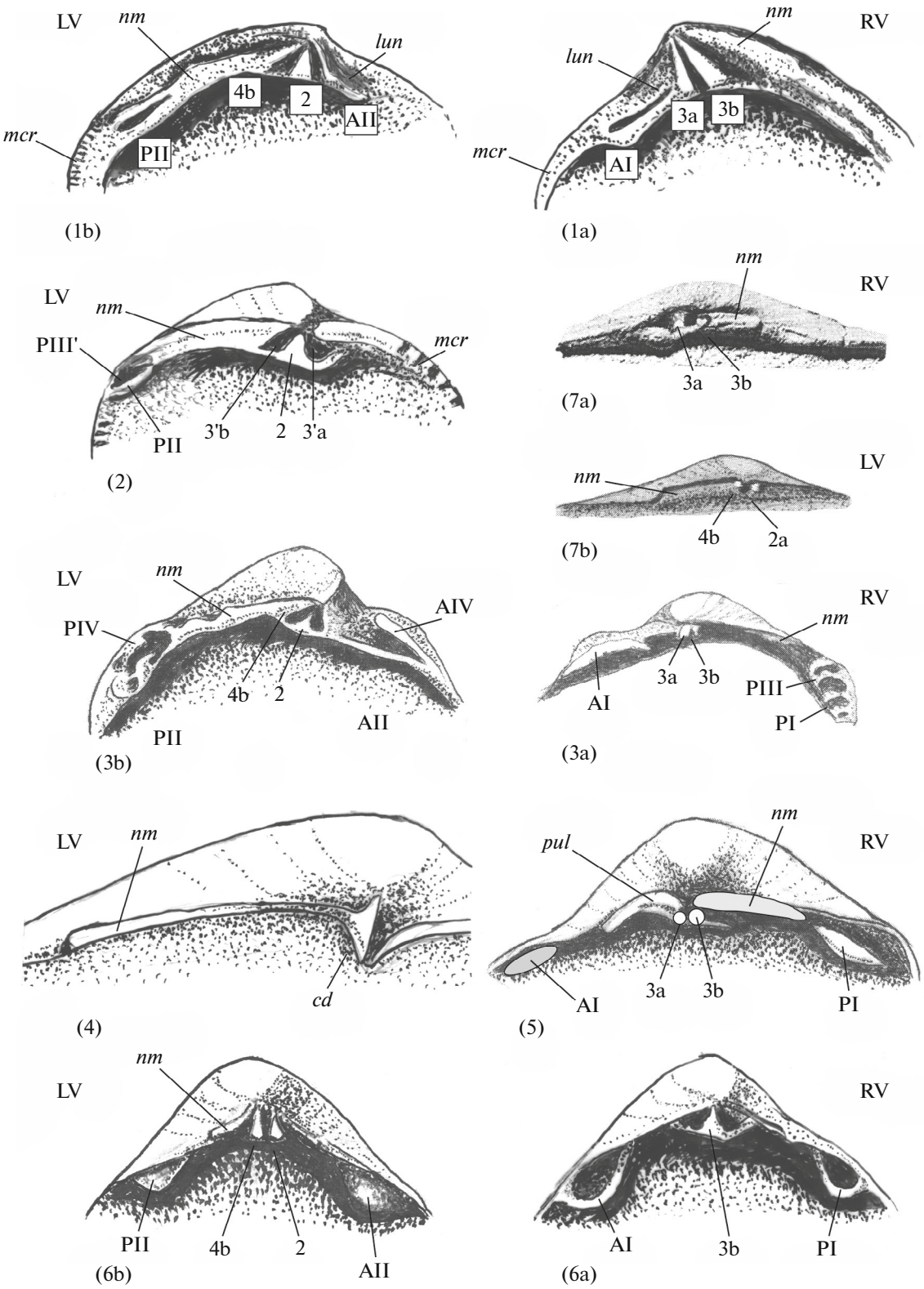
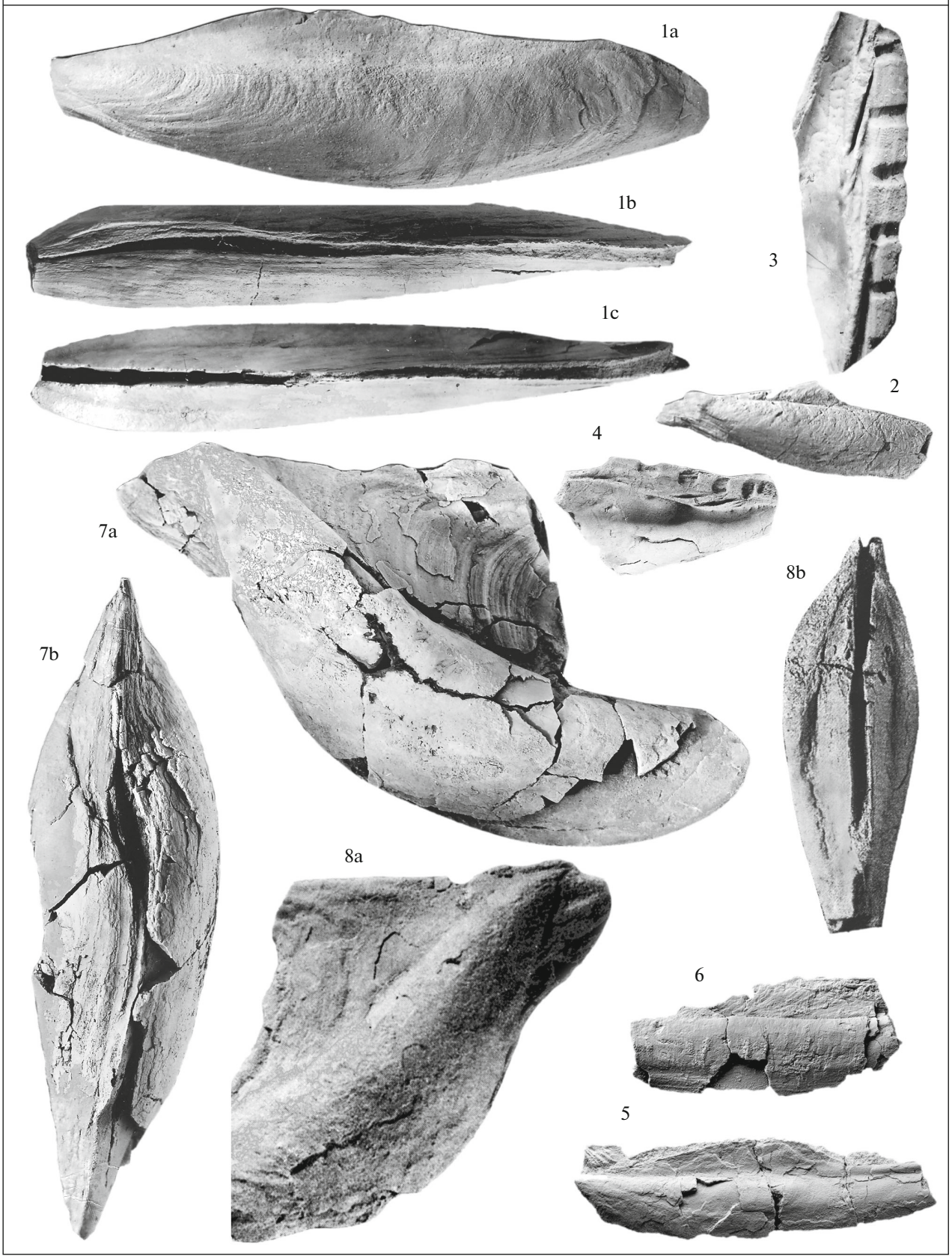


Fig. 28. Hinge of the shells in some species (lower view): (1) *Eriphylla*: (1a) *E. crimica*, right valve (Pl. 15, fig. 2a), ×2; (1b) *E. mordvilkoae*, left valve (Pl. 14, fig. 7b); (2) *Fimbria berriassica*, left valve (Pl. 15, figs. 9, 10b, 11b), ×2; (3) *Sphaera belbekensis*: (3a) right valve (Pl. 16, fig. 2b), ×1; (3b) left valve (Pl. 16, fig. 3b), ×1.2; (4) *Panopea neocomiensis*, left valve (Pl. 16, fig. 5), ×3; (5) *Protocardia broili*, right valve (Pl. 16, fig. 9b), ×4; (6) *Globocardium sphaericum*: (6a) right valve (Pl. 17, fig. 13), ×2; (6b) left valve (Pl. 17, fig. 10b), ×2; (7) *Garum valangiensis*: (7a) right valve (Pl. 17, fig. 18b), ×2; (7b) left valve (Pl. 17, fig. 17), ×1. Explanations: (*cd*) cardinal tooth, (*lun*) lunule, (*mcr*) crenulated margin, (*nm*) nymph, (*pul*) preumbumal label; (LV) left valve, (RV) right valve (for other explanations see Fig. 13).

Plate 3



Holotype. Specimen of *Gervillia anceps* Deshayes (Leymerie, 1842, pl. 10, figs. 3a, 3b; left valve); France (Aube); Lower Cretaceous, Lower Neocomian (designated by monotypy by Yanin in Arkadiev et al., 2012, p. 243).

Description. The shell is medium-sized and large (L > 180 mm), smooth, thick-walled, irregularly lanceolate, strongly elongated and slightly oblique in the posteroventral direction, slightly curved along the longitudinal axis; inequivalvate (Fig. 27.3). The left valve is slightly more convex than the right one. The umbo is subterminal, very close to the anterodorsal end of the valve, very slightly protruding, strongly bent forward and inward; the tip of the umbo of the left valve hangs over the ligament area. The anterior wing is short, wedge-shaped, its anterior end is sharply rounded. The posterior wing is long (four times as long as the anterior), narrow (a third of the valve width). The shell unevenly convex, due to which it is cylindrical in cross-section in the umbonal region, oval-triangular in the middle part, and flattened at the posterior margin. The axial line is slightly curved, running approximately in the middle of the lower half of the valve (axial angle 35°). In the area of the wing, the valve is strongly and sharply flattened, while in the lower part it is strongly swollen. There is no carinate bend between the wing and the lateral surface of the valve.

The dorsal margin is straight, moderate in length (less than half the length of the shell); the posterior margin in its upper part is long, slightly concave; in the lower part, short, convex, sharply rounded; smoothly passes into the wing and forms a blunt bend with the dorsal margin. The ventral margin is very long, slightly convex, smoothly and broadly curved. The lower side of the entire shell is flattened in its anterior third and has a clear gaping. The byssal fissure is long, narrow, in a wavy curve of the ventral margin of the left valve; it also has a long, shallow, narrow byssal groove, which runs from the umbo to the posterior end of the byssal fissure and separates the anterior wing from the main part of the valve.

The ligament area is straight, serialized, wide, with five to seven transverse fossae, irregularly spaced (Fig. 29.8). Under the area, on a wide platform, there are two or three smooth, long obliquely longitudinal ridge-like dentate ridges starting below the umbo and subparallel to the ventral margin. Between them there are deep long tooth sockets of the opposite valve.

Dimensions in mm and ratios:

Specimen no.	L	W	W/L	T	T/L
PIN 5596/26 (LV)	49	16	0.3	7	0.1
PIN 5596/31 (LV)	70	26	0.3	13	0.1
TsNIGRM 101/1322(LV)	80	33	0.3	–	–
PIN 5596/25 (Sh)	120	40	0.3	20	0.1
TsNIGRM 28/332 (LV)	180	35	0.3	–	–

Comparison. This species differs from the closest species in the following: from *G. alpina* (Pictet et Campiche, 1868–1871; Aptian of Switzerland)—in the uneven shell; a considerable narrowing at its posterior margin; the presence of a clearly expressed posterior wing, as well as an uneven arrangement of ligament fossae; from *G. extenuata* (Eichwald, 1846; Hauterivian–Aptian of the Northern Caucasus)—in the smaller shell size; less strongly narrowing subterminal umbo; development of the anterior wing; and a shorter ligament area.

Occurrence. Berriasian–Albian: Berriasian of the Crimea; Valanginian–Albian of Switzerland; Hauterivian-Aptian of Bulgaria; Aptian of Turkmenistan; Neocomian of Spain and France.

Material. Sixty specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu (villages of Blagodatnoe, Novoklyonovo, Chernokamenka); Middle Berriasian, *tauricum* Subzone—Chernaya River (Balaklava, flux quarry), Bel'bek (villages of Bogatoe Ushchel'e; village of Kuibyshevo, Kabaniy Log; Solnechnosel'e), Beshterek (village of Solovjevka).

Explanation of Plate 3

Figs. 1–4. *Gervillella anceps* (Deshayes), ×1: (1) specimen PIN, no. 5596/25, shell, external view: (1a) left valve view, (1b) ventral view, (1c) ligament area view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (2) specimen PIN, no. 5596/26, left valve of a young specimen, external view, lateral view; locality, same age (coll. V.V. Drushchits, 1955); (3) specimen PIN, no. 5596/27, fragment of the right wing, from the inside; Bel'bek River, village of Solnechnosel'e; the same age (coll. B.T. Yanin, 1956); (4) specimen TsNIGRM, no. 102/13220, left valve fragment, from inside; Sarysu River, village of Novoklyonovo; Middle Berriasian, *tauricum* Subzone (coll. V.G. Aleksandrova, 1954).

Figs. 5–6. *Gervillia gottschei* Boehm: (5) specimen PIN, no. 5596/28, shell with displaced valves, external view, lateral view, left valve view, ×1.2; Zuja River, Balanovskoe Reservoir; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1986); (6) specimen PIN, no. 5596/29, shell with broken front and back edges, external view, lateral view, right valve view, ×1; locality, age and collector are the same.

Figs. 7–8. *Gervillaria allaudiensis* (Matheron): (7) specimen PIN, no. 5596/30, shell, external view, ×1: (7a) lateral view, left valve view, (7b) ventral view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. E.I. Kuzmicheva, 1955); (8) specimen TsNIGRM, no. 100/13220, shell, external view, ×1: (8a) right valve view, (8b) ligament area view; locality, same age (coll. V.V. Drushchits, 1955).

Genus *Gervillia* Defrance, 1820

***Gervillia gottschei* Boehm, 1883**

Plate 3, figs. 5, 6

Gervillia gottschei: Boehm, 1883, p. 596, pl. 66, fig. 23.

Holotype. Specimen of *G. gottschei* (Boehm, 1883, pl. 66, fig. 23, right valve); Czech Republic (Štramberk); Upper Tithonian (designated by monotypy here).

Description. The shell is medium-sized and large (L > 75 mm), shank-shaped, slightly oblique, narrow, elongated (L > W), strongly laterally flattened, with a terminal umbo, slightly inequivalve, smooth, inequilateral. The dorsal margin straight in anterior part, slightly concave in posterior part; the ventral margin is uniformly convex; the posterior one is short, steeply rounded, gradually merging into the ventral one. The posterior wing is long (occupies half the length of the shell), passes into the dorsal margin at an obtuse angle. The anterior wing is not preserved.

Dimensions in mm and ratios:

Specimen no.	L	W	W/L
PIN 5596/28 (Sh)	~55	15	~0.3
PIN 5596/29 (Sh)	>50	18	–

Comparison. This species is distinguished: from *G. solenoides* Defrance, 1820 (see Cox and Newell, 1969; Nevessakaya et al., 2013; Upper Cretaceous of Germany)—less strongly oblique shell; a longer posterior wing, which occupies half of the total length of the valves (in *G. solenoides*, this wing is about a quarter of the length); it differs from *G. metaforbesiana* Amano et Matsuda (see Matsuda, 1985; Cenomanian of Japan) in the larger shell size; a sharper angle between the posterior wing and the dorsal margin.

Occurrence. Tithonian–Berriasian: Upper Tithonian of Czech Republic (Štramberk); Middle Berriasian of the Crimea.

Material. Four specimens; Crimea, Middle Berriasian, *tauricum* Subzone—Zuja River (Balanovskoe Reservoir).

Genus *Gervillaria* Cox, 1951

***Gervillaria allaudiensis* (Matheron, 1842)**

Plate 3, figs. 7, 8; Fig. 27.2

Avicula allaudiensis: Matheron, 1842, p. 175, pl. 26, fig. 1; d'Orbigny, 1850, p. 82.

Gervillia allaudiensis: Pictet and Campiche, 1868–1871, p. 81, pl. 155, figs. 1a, 1b; Muromtseva, 1960, p. 182, pl. 5, figs. 1 and 2.

Gervillaria allaudiensis: Dimitrova, 1974, p. 61, pl. 31, fig. 2 and 3; pl. 32, fig. 3; Bogdanova, 1997, p. 62, pl. 17, fig. 1 and 2; Yanin in Arkadiev et al., 2012, p. 242, pl. 42, figs. 5a, 5b.

Holotype. Specimen of *Avicula allaudiensis* (Matheron, 1842, pl. 26, fig. 1; shell); southern France (environs of Marseille); Lower Cretaceous, Neocomian (designated by monotypy: Yanin in Arkadiev et al., 2012, p. 242).

Description. The shell is large (D ≤ 118 mm), pterygoid in outline, thick-walled, smooth, moderately elongated (L > H), strongly oblique in the posteroventral direction, weakly inequivalvate: the left valve is more convex than the right valve. The dorsal margin is straight, long; the posterior part is of complex shape: in the upper part it is strongly and widely concave, in the lower part it is strongly convex, rounded, gradually turning into the ventral margin; converges with the dorsal margin at an acute angle, forming the posterodorsal end of the wing; the ventral margin is long, moderately convex, smoothly and widely curved posteriorly; in the anterior third of the shell, at the base of the forewing, gently concave (Fig. 27.2). The byssal fissure is short, usually wide, in the bend of the ventral margin of both valves, in connection with which the entire margin is smoothly curved and undulating; the byssal groove is on the right valve, long, narrow, shallow, extending from the umbo to the middle of the byssal fissure and separating the anterior wing from the lateral part of the valve. The umbo is very close to the anterodorsal end of the valve, very slightly protruding, strongly bent forward.

The anterior wing is relatively short, well set apart; its anterior end is sharply rounded. The posterior wing is long (three times the length of the anterior wing), very wide. The point of greatest convexity is located almost in the middle part of the valves. The axial line is curved: in the umbonal region, the axial angle is 50°; it becomes sharper towards the posterior end of the shell. The valves in the wing regions are strongly and sharply flattened. A strong rounded carina is developed on both valves between the lateral surface and the posterior wing.

The ligament area is straight, of moderate width, with three to five transverse or oblique transverse pits, unevenly spaced. In addition to the pits on the area under the umbo, there are several thin denticles extending posteriorly from the umbo and obliquely downward.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN, no. 5596/30, shell	118	72	0.6	19 (LV)	0.16
				17 (RV)	0.14

Comparison. This species differs from *G. alaeformis* (Sowerby, 1819; see d'Orbigny, 1843–1847; Neocomian of France) in having a smaller convexity and a relatively longer and very oblique shell; longer and attenuated hind wing with a sharp, sometimes rostral termination; it is distinguished from *G. alaeformis* from the Caucasus (see Muromtseva, 1960; Hauterivian of the Northern Caucasus), the Crimean specimens of *G. allaudiensis*, in addition to the above characters, by the complete absence of ribbing on the lateral side of the valves.

R e m a r k s. The descriptions of *Avicula allaudiensis* known from the old literature o (Matheron, 1842; Pictet and Campiche, 1868–1871) were given based on a few isolated molds. The Crimean material, represented not only by molds, but also by shells, made it possible to give a more complete characterization of the species, including the first description of the byssal groove, as well as to establish the absence of longitudinal crested dental ridges below the ligament area.

O c c u r r e n c e. Berriasian–Hauterivian: Berriasian of the Crimea; Berriasian–Hauterivian of Bulgaria, France, and Switzerland.

M a t e r i a l. 31 specimens; Crimea, Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Bogatoe Ushchel'e).

S u p e r f a m i l y Inoceramoidea Giebel, 1852

Family Inoceramidae Giebel, 1852

Subfamily Inoceraminae Giebel, 1852

Genus *Inoceramus* Sowerby, 1814

***Inoceramus belbekensis* Yanin, 1972**

Plate 4, figs 1, 2

Inoceramus belbekensis: Yanin, 1972, p. 71, pl. 2, fig. 1 and 2; Yanin in Arkadiev et al., 2012, p. 245, pl. 43, fig. 1.

H o l o t y p e. MZMSU, no. 5/36 (Yanin, 1972, pl. 2, fig. 1a, 1b; shell mold); Southwestern Crimea, Belbek River (village of Kuibyshevo, Kabaniy Log); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone (by original designation by Yanin (1972, p. 71).

D e s c r i p t i o n. The shell is medium-sized (Sh ≤ 30 mm), irregularly rounded outlines; with anterior side shorter than the posterior, slightly inequivalvate (left valve has a slightly larger convexity and a more protruding umbo than the right one). The posterior branch of the dorsal margin is straight, at a rounded angle of 135° passes into a convex posterior, which is gradually merged with a convex, widely rounded ventral margin; the anterior branch of the dorsal margin is concave, which is associated with the development of an alveolar depression. The terminations of the umbos of both valves are turned forward and bent inward. The surface (judging by the cores with remains of the shell bed) is covered with weak irregular concentric folds. The ligament area is narrow, straight, with numerous oblique pits.

D i m e n s i o n s i n m m a n d r a t i o s:

Specimen no.	L	H	H/L	T	T/L
MZMSU 4/36 (RV)	23	21	0.8	–	–
MZMSU 5/36 (Sh)	30	30	1.0	18	0.6

C o m p a r i s o n. This species differs from the closest species *I. neocomiensis* d'Orbigny (1843–1847; Neocomian of France) in the more convex, strongly protruding anterior margin of the shell; the development of a preumbonal alveolar depression, causing the anterior branch of the dorsal margin becomes concave; the sharper, forward-curved ends of the umbos; less acute angle of inflection between the posterior branch of the dorsal margin and the posterior margin (118° versus 134°).

R e m a r k s. When describing this species in the monograph "Berriasian of the Crimean Mountains" (2012), the author made two mistakes: incorrectly cited the holotype number as 145/6 (p. 245) and erroneously indicated its locality—"Sarysu River, the village of Balki" in the explanation of pl. 43, fig. 1 instead of the Bel'bek River (see above). Previously T.N. Bogdanova (*Atlas* ..., 1997, p. 63, pl. 17, fig. 5) described one specimen of *Inoceramus* from the Berriasian of the Bel'bek River as *I. belbekensis*. For many reasons, we cannot attribute it to this species (see below).

M a t e r i a l. Four specimens from the type locality.

***Inoceramus bogdanovae* Yanin, sp. nov.**

Plate 4, fig. 3

Inoceramus belbekensis: Bogdanova et al. (*Atlas* ..., 1997, p. 63, pl. 17, fig. 5), non Yanin, 1972.

E t y m o l o g y. In honor of paleontologist Tamara Nikolaevna Bogdanova.

H o l o t y p e. TsNIGRM, no. 66/332, specimen figured by T.N. Bogdanova (*Atlas* ..., 1997, pl. 17, fig. 5, left valve), as *I. belbekensis* Yanin, Southwestern Crimea, Bel'bek River (Kuibyshevo, Kabaniy Log); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone.

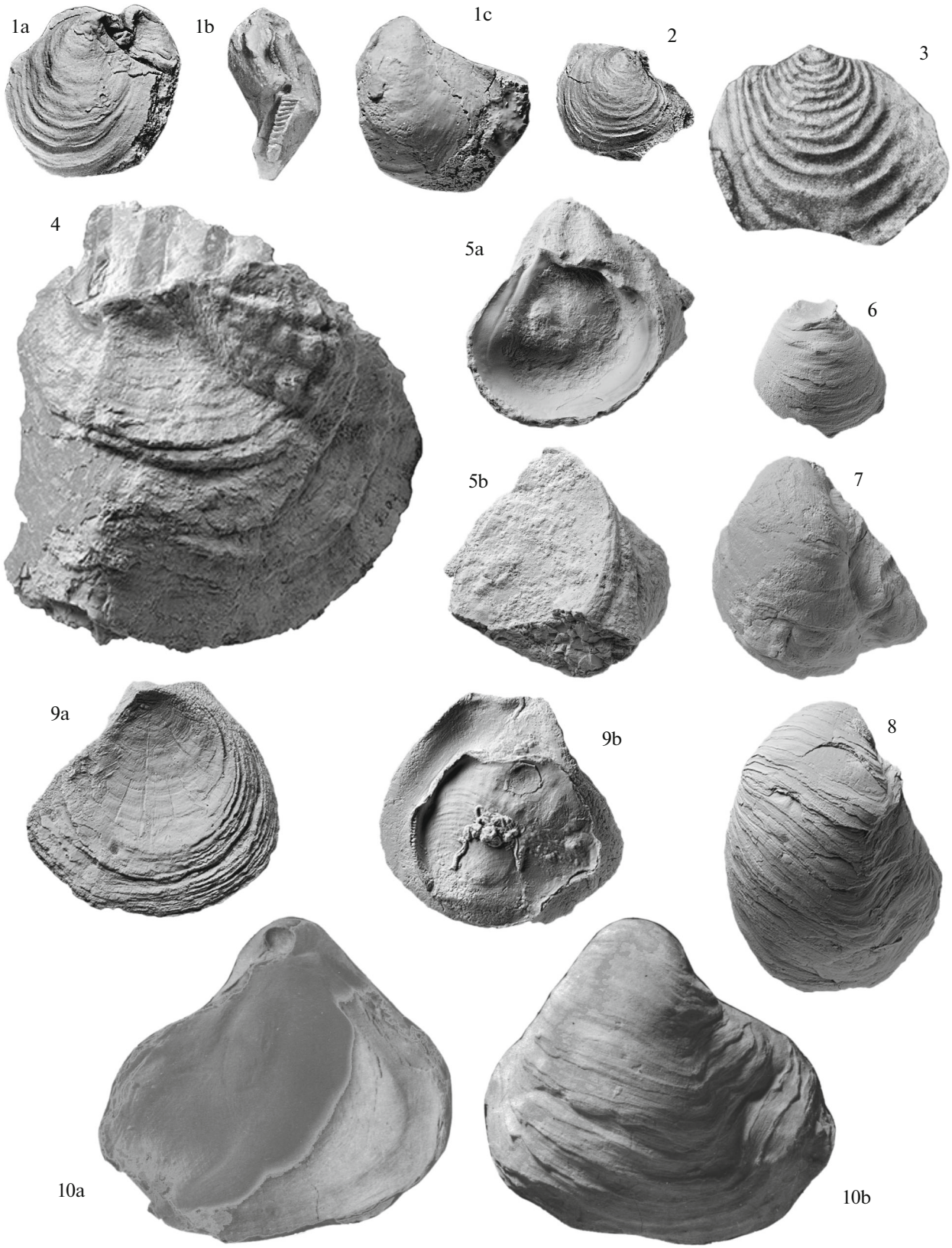
D e s c r i p t i o n. The shell is medium-sized (H = 37 mm), rounded in outline (the shell margins smoothly, almost in one arc, merge one into another); slightly inequilateral (anterior side slightly shorter than the posterior). The umbo is prominent, almost central. The shell surface has 14 regular coarse, smooth concentric ribs, with a rounded ridge; in the middle part of the lateral side, they bifurcate. The intercostal spaces are wide, smooth, evenly deepened.

D i m e n s i o n s i n m m a n d r a t i o s:

Specimen no.	L	H	H/L
TsNIGRM 66/332 (Sh) holotype	45	37	0.8

C o m p a r i s o n. This species differs from *I. neocomiensis* d'Orbigny (1843–1847; Neocomian of France) in the more rounded valve outlines (the length is slightly greater than the height, the H/L ratio is opposite in *I. neocomiensis*); in the more rounded, strongly protruding anterior margin; the presence of a deep pre-umbo hole; completely regular, fewer, large rounded concentric ribs (in *I. neocomiensis*, the valves are covered with irregular, more numerous concentric folds); it is distinguished from *I. belbekensis* (see above) by the rounded shell outline; the absence of an

Plate 4



angular inflection between the dorsal and posterior margins; the absence of the pre-umbonal lunule; symmetrical position of the umbo and more regular wide rounded concentric ribs (in *I. belbekensis*, the ornamentation is represented by irregular, narrow ribs resembling growth wrinkles).

Material. 1 specimen from the type locality.

Superfamily Ostreoidea Rafinesque, 1815

Family Ostreidae Rafinesque, 1815

Genus *Ostrea* Linnaeus, 1758

***Ostrea germaini* Coquand, 1869**

Plate 4, figs. 4, 5

Ostrea germaini: Coquand, 1869, p. 191, pl. 66, fig. 14–16; Pictet and Campiche, 1869–1871, p. 295, pl. 189, figs. 1–6; Pugaczewska, 1975, p. 64, pl. 14, figs. 1–9.

Holotype. The specimen of *Ostrea germaini* (Coquand, 1869, pl. 66, fig. 14–16; shell); Switzerland; Lower Cretaceous, Valanginian (designated by monotypy herein).

Description. The shell is medium-sized to large (P ≤ 90 mm), subtriangular, high (H > L), smooth, slightly inequilateral, with a longer posterior margin slightly sloping back and down; weakly inequivalvate: the lower valve is more convex than the upper one. The umbo is very prominent, central, pointed or sharply rounded. Anterior, posterior and ventral margins merge smoothly into each other. The surface of both valves is evenly covered with wide, coarse growth ridges and near the posterior margin with short, irregular, rounded radial folds.

The ligament area (in a young specimen: pl. 4, fig. 5a) is oblique-triangular, located in the plane of commissure; separated from the posterior margin by a deep groove; the resilifer is straight and deep. No chomata are present. The muscle scar is oval in shape, shifted down from the umbo and close to the posterior margin. The margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
PIN 5596/33 (LWV)	34	40	1.0
PIN 5596/32 (Sh)	90	90	1.0

Comparison. This species differs from the similar species *O. leymerii* Deshayes in Leymerie (1842; Hauterivian–Barrème of France) in the more rounded, sometimes irregular (with drawn posterior margin) outline; lower shell height and better pronounced radial folds.

Remarks. Specimens of *O. germaini* described by Pugaczewska (1975) from Valanginian of Poland differ from the Crimean and typical forms from Switzerland in their very small size.

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Valanginian of Poland, Switzerland.

Material. Two specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—Beshterek River (village of Solovjevka, "Lower Solovjevka limestones"); Middle Berriasian, *tauricum* Subzone—Malyi Salgir River (village of Ivanovka).

Family Gryphaeidae Vialov, 1936

Genus *Gryphaea* Lamarck, 1801

***Gryphaea weberae* Yanin in Cheltsova, 1969**

Plate 4, figs. 6–10; Plate 5, figs. 1–6; Figs. 20a, 20b

Gryphaea weberae: Yanin in Cheltsova, 1969, p. 56, pl. 4, fig. 6; figs. 7 and 8 (thin sections).

Pycnodonte weberae: Bogdanova, 1997, p. 78, pl. 18, fig. 8; Yanin in Arkadiev et al., 2012, p. 251, pl. 43, fig. 16.

Holotype. DPMSU, no. 331/16, specimen *Gryphaea weberae* Yanin (in Cheltsova, 1969, pl. 4,

Explanation of Plate 4

Figs. 1–2. *Inoceramus belbekensis* Yanin, ×1: (1) specimen MZMSU, no. 4/36, holotype, shell with shifted valve, external view: (1a) lateral view, right valve view, (1b) from the side of the umbos, (1c) left valve view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (2) specimen MZMSU, no. 6/36, shell, external view, lateral view, right valve view; the same locality, age and collector.

Fig. 3. *Inoceramus bogdanovae* Yanin, sp. nov.: specimen MCPbGGI, no. 66/332, holotype, left valve, external view, lateral view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. T.N. Bogdanova, 1978).

Figs. 4–5. *Ostrea germaini* Coquand: (4) specimen PIN, no. 5596/32, shell, lateral view, lower valve view (in the umbonal region of the scar, the shell of a large gastropod, to which the individual has attached itself); ×0.75; Beshterek River, village of Solovjevka; Lower Berriasian, *jacobi* Zone, lower "Solovjevka limestones" (coll. B.T. Yanin, 1986); (5) specimen PIN, no. 5596/ 33, lower valve, ×1: (5a) from inside, (5b) external view, lateral view; extensive, slightly concave attachment scar; Malyi Salgir River, village of Ivanovka; Middle Berriasian, *tauricum* Subzone (coll. the same).

Figs. 6–11. *Gryphaea weberae* Yanin, ×1: (6) specimen PIN, no. 5596/34, lower valve, external view, lateral view; fragment of the shell of an oyster-substrate is on the umbo; Sarysu River, vicinity of the village of Novoklyonovo, Enisarai Ravine; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1954); (7) specimen PIN, no. 5596/35, lower valve, external view, lateral view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (8) specimen PIN, no. 5596/36, lower valve, external view, lateral view; Sarysu River, Enisarai Ravine; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1954); (9) specimen PIN, no. 5596/37, upper valve: (9a) external view, lateral view, (9b) from inside; accidental presence on its inner surface of the upper valve of a younger individual, when the large valve was turned over in the turbulence zone; Sarysu River, village of Kozlovka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962); (10) specimen TsNIGRM¸ no. 109/13220, lower valve: (10a) external view, lateral view, (10b) from inside; on the gryphoid umbo attachment scar; Sarysu River, village of Novoklyonovo; Middle Berriasian, *tauricum* Subzone, "oyster beds" (coll. B.T. Yanin, 1962).

Plate 5

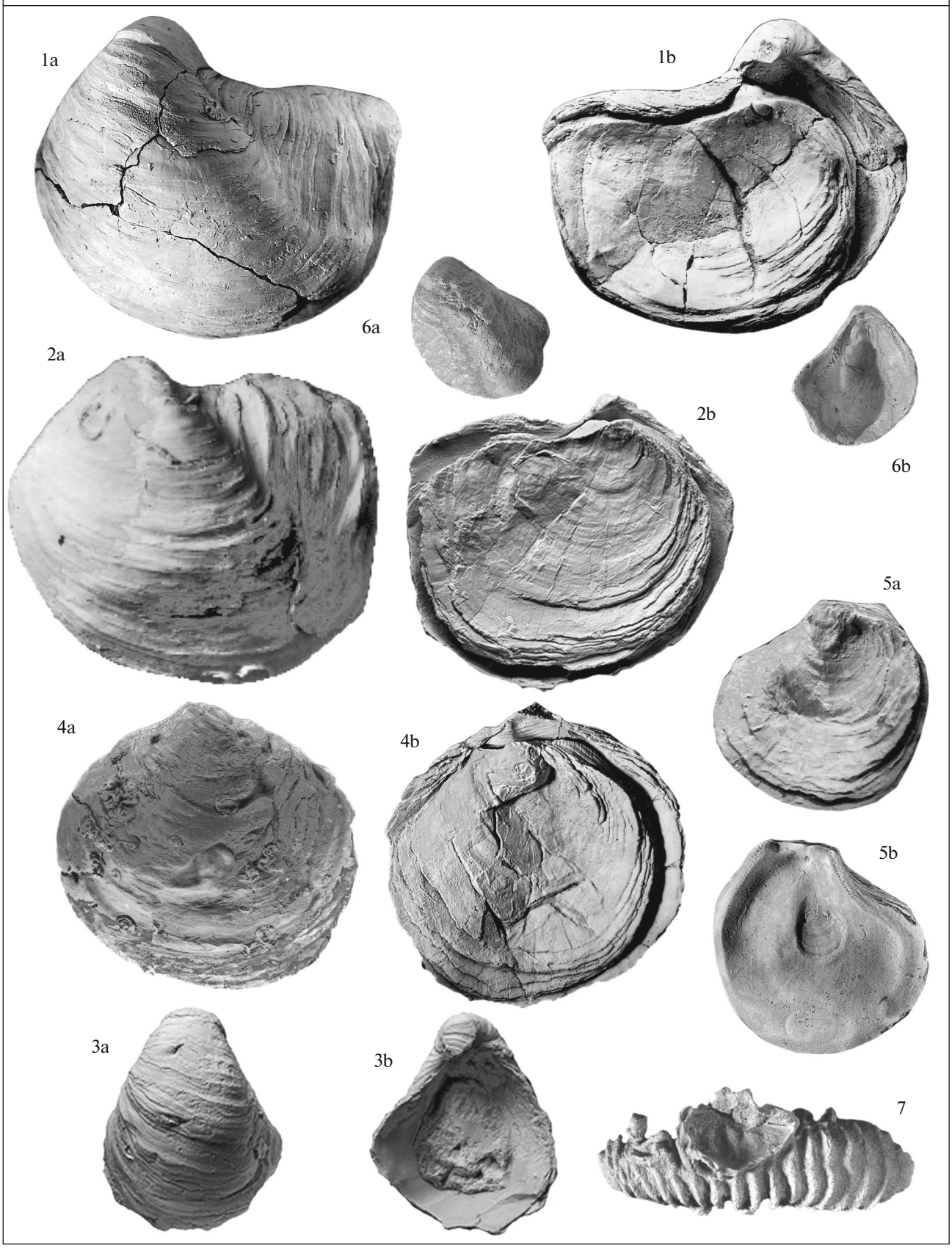


fig. 6; lower valve); Central Crimea, Sarysu River, vicinity of the village of Balki; Lower Valanginian (currently Middle Berriasian) (by original designation: Cheltsova, 1969, p. 56).

Description. The shell is from small to medium-sized (Sh ≤ 67 mm), very variable outlines: from round, rounded oval to subquadrate; as a rule, with a retracted and pterygoidly widened posterior side; inequilateral; strongly inequivalvate: with a convex bucket-shaped lower valve and a cap-shaped concave upper valve. The lower valves are usually moderately convex, sometimes swollen; their swelling is uneven; the anterior side and middle of the valves are convex, widely arcuate; posterior side, separated from the rest of the surface by a wide radial depression, slightly convex or flattened. The line of greatest convexity extends from the umbo approximately to the middle of the ventral margin of the valve. The position of the umbos, the degree of their curvature, their size are very variable; in a typical case, the tops are moved to the anterior margin, moderately protrude above the dorsal margin; gryphoid, slightly curved inward, hanging over the upper valve; their tip is sharp and turned posteriorly; in specimens with a large area of attachment, the umbo is almost central and completely uncurved inwards. The anterodorsal margin is short, slightly convex or nearly straight, with anteroventral convex margin forming a marked flexure; posterodorsal, usually, long, slightly concave, gradually or through a noticeably rounded bend passes into a long, wide-rounded, angular or wavy-curved posterior margin; the ventral margin is long, broadly and evenly convex. The ligament area of the lower valve is triangular, slightly sloping back, concave, with a deep resilifer. It is separated from the shell margins on each side by narrow marginal grooves extending from the umbo along the anterodorsal and posterodorsal margins of the valve and bounded below by ridges. The grooves vary greatly in width, length, and concavity. The upper slope of the ridges always possesses numerous, thin, short, transverse, marginal chomata. The muscle scar is rounded, noticeably depressed, close to the posterodorsal margin. A low, broadly rounded inner ridge extends from the umbo to the posteroventral margin of the valve, corresponding to the midline of the outer radial depression. The muscle scar imprint is located between this ridge and the posterior marginal groove. The upper valve is widely and evenly concave, sloping backwards and downwards, with a small, pointed umbo, somewhat bent to the outer side. Anterior, ventral and posterior margins are convex; the posterior margin is upper concave. The ligament area is triangular, slightly turned posteriorly, flattened, with a distinct concave resilifer; limited by sharp crested and marginal ridges. The plane of the area, as a rule, is located at an acute or right angle to the plane of commissure . On the inside, the anterodorsal and posterodorsal margins of the valve bear numerous, small marginal denticles. The muscle scar is rounded, flattened, markedly depressed above and anteriorly; close to the posterodorsal margin of the valve. The surface of both valves have coarse lamellar growth wrinkles. The upper valve sometimes bears thin radial striae, irregular in number and length.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/34 (LWV)	18	20	1.1	10	0.6
PIN 5596/39 (LWV)	23	27	1.1	15	0.6
PIN 5596/45 (LWV)	27	32	–	13	–
PIN 5596/35 (LWV)	34	34	1.0	16	0.5
PIN5596/47(LWV)	37	35	0.9	13	0.3
PIN 5596/41 (Sh)	48	56	1.1	14	0.2
PIN 5596/44 (LWV)	55	53	0.9	17	0.3
PIN 5596/46 (LWV)	64	60	0.9	23	0.3
TsNIGR 109/13220 (LWV)	65	62	0.9	24	0.3
TsNIGRM109/13220(LWV)	65	62	0.9	24	0.3
PIN 5596/38 (Sh)	67	60	0.9	27	0.4
PIN 5596/40 (Sh)	67	60	0.9	23	0.3

Comparison and remarks. In terms of the shape of the shell, the structure of the umbonal

Explanation of Plate 5

Figs. 1–6. *Gryphaea weberae* Yanin, ×1: (1) specimen PIN, no. 5596/38, shell, external view, lateral view: (1a) lower valve view and (1b) upper valve view; Sarysu River, village of Kozlovka; Middle Berriasian, *tauricum* Subzone, "oyster horizon" (coll. B.T. Yanin, 1962); (2) specimen PIN, no. 5596/40, shell: (2a) external view, lateral view, lower valve view and (2b) upper valve view; the same locality, age and collector; (3) specimen PIN, no. 5596/43, lower valve: (3a) external view, lateral view, (3b) from inside; the same locality, age and collector; (4) specimen PIN, no. 5596/41, shell, external view: (4a) lower valve view; (4b) upper view; Sarysu River, village of Novoklyonovo; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1955); (5) specimen PIN, no. 5596/42, upper valve: (5a) external view, lateral view, (5b) from inside; Sarysu River, Enisarai Ravine; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1954); (6) specimen PIN, no. 5596/39, lower valve of a young individual: (6a) external view, lateral view, (6b) from inside; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956).

Figs. 7. *Ceratostreon tuberculiferum* (Koch et Dunker): specimen PIN, no. 5596/44, lower valve, attached to an ammonite shell, viewed from inside; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1968).

region, the presence of a radial depression and a pterygoid posterior side, it is most similar to *G. dilatata* Sowerby (see Gerasimov, 1955; Callovian–Oxfordian) and *G. lucerna* Trautschold (Gerasimov, 1955; Callovian of the Russian Platform), but differs from them in a number of characters: from the first, usually, by the wider shell (in the compared species, H > D); strong development of the posterior pterygoid protrusion; the umbos being less curved inward; in the less strongly convex shell; more developed radial depression; from the second, the umbos are more protruding and stronger hanging over the ligament area; more developed pterygoid expansion of the posterior margin; the muscle scar more shifted backward and upward (in the compared species it is almost central, only slightly closer to the posterior margin).

Material. 85 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern side of the Baidar Depression (village of Peredovoe, Ukrusta Hill); the same Zone, *chaperi* Beds—Sarysu River (village of Blagodatnoe, Saigin Ravine); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; villages of Bogatoe Ushchel'e, Solnechnosel'e); Beshterek (village of Solovjevka), Sarysu (village of Kozlovka, Novoklyonovo; Enisarai Ravine) and Upper Berriasian, *euthymi* Subzone—Sarysu River (vicinity of the village of Balki).

Genus *Ceratostreon* Bayle, 1878

***Ceratostreon tuberculiferum* (Koch et Dunker, 1837)**

Plate 5, fig. 7; Plate 6, figs. 1–11

Exogyra tuberculifera: Koch, Dunker, 1837, p. 54, pl. 6, fig. 8; Marie and Mongin, 1957, p. 416, text-fig. 4Da–4Dc.

Ostrea tuberculifera: Coquand, 1869, p. 189, pl. 63, fig. 8 and 9; Pictet and Campiche, 1868-1871, p. 280, pl. 186, figs. 1–11; Karakash, 1897, p. 35, pl. 3, fig. 12; pl. 5, fig. 13 (non fig. 12).

Ostrea (Exogyra) tuberculifera: Karakash, 1907, p. 181, pl. 18, fig. 4, 9–12, 14, 16–19; pl. 19, figs. 28a, 28b.

Exogyra tuberculifera: Woods, 1899-1913, p. 404, pl. 61, fig. 7–11; Renngarten, 1926, p. 64; Muromtseva, 1960, p. 199, pl. 15, figs. 6–11.

Ceratostreon tuberculiferum: Renngarten, 1964, p. 38, pl. 5, figs. 2 and 3; Pugaczewska, 1975, p. 56, pl. 12, fig. 2, 4, 5, 7, 8; Yanin in Arkadiev et al., 2012, p. 248, pl. 43, fig. 5.

Holotype. Specimen of *Exogyra tuberculifera* (Koch et Dunker, 1837, pl. 6, fig. 8; shell); Germany; Lower Cretaceous, Hauterivian (designated by monotypy herein).

Description. The shell is small (P ≤ 20 mm), variable in shape: usually from regular oval to oval-elongated; sometimes expanded in the middle, with a strongly narrowed and somewhat retracted margin in the posteroventral direction; inequilateral; with small opisthogyrate umbos pressed against the surface of the valves. The dorsal, anterior, and ventral margins of valves are convex, angular or gradually rounded; the

Explanation of Plate 6

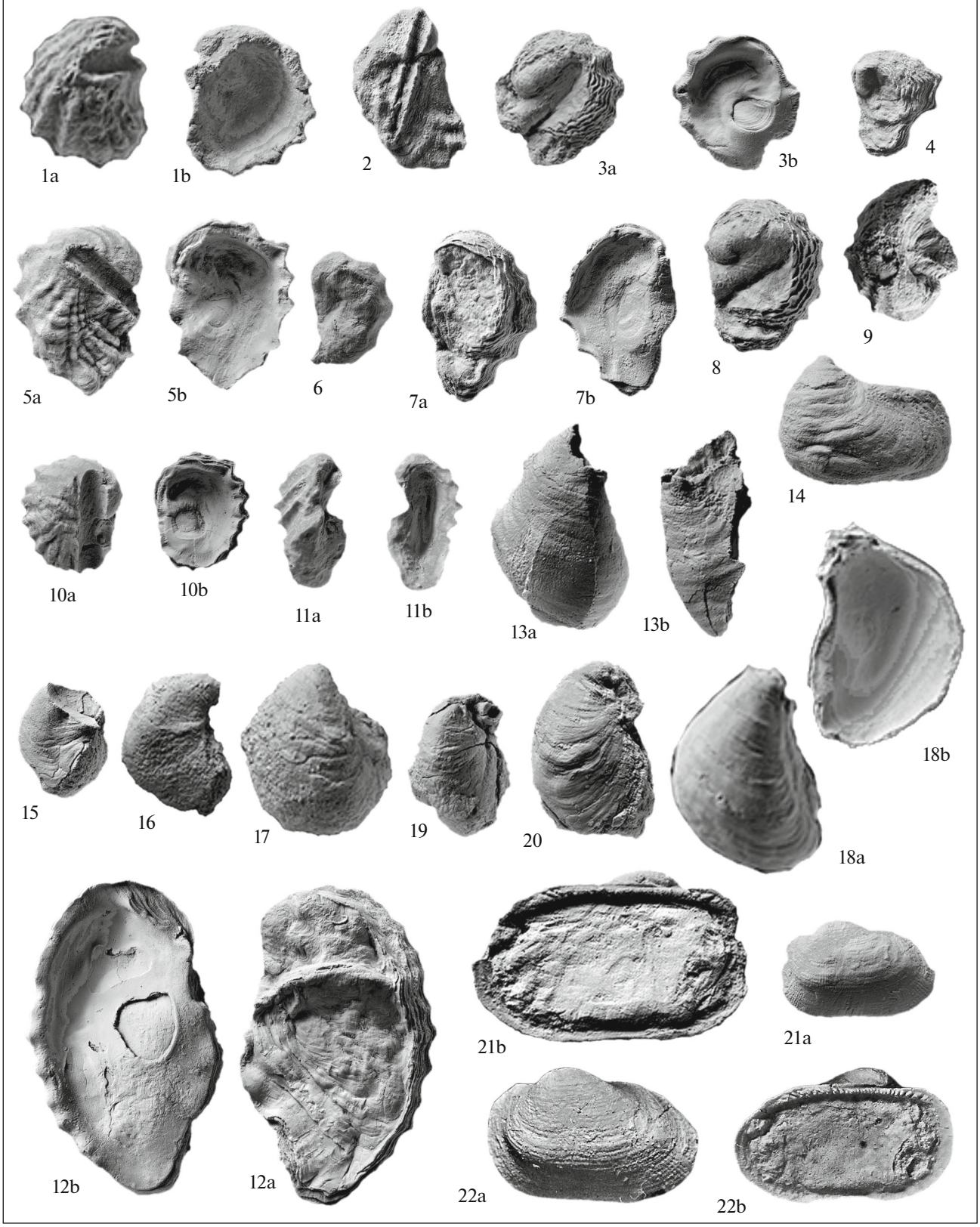
Figs. 1–11. *Ceratostreon tuberculiferum* (Koch et Dunker): (1) specimen PIN, no. 5596/48, lower valve, ×1.5: (1a) external view, lateral view, (1b) view from inside; Sarysu River, village of Blagodatnoe, Saigin Ravine; Lower Berriasian, *chaperi* Beds; tectonic wedge in a ravine (coll. B.T. Yanin, 1986); (2) specimen PIN, no. 5596/49, lower valve, external view, lateral view, ×1.5; the same locality, age and collector; (3) specimen PIN, no. 5596/50, upper valve, ×1: (3a) external view, lateral view, (3b) from inside; the same locality, age and collector; (4) specimen PIN, no. 5596/51, upper valve, external view, lateral view, ×1.5; the same locality, age and collector; (5) specimen PIN, no. 5596/52, lower valve, ×1.5: (5a) external view, lateral view, (5b) from inside; the same locality, age and collector; (6) specimen PIN, no. 5596/53, upper valve, external view, lateral view, ×1.5; the same locality, age and collector; (7) specimen PIN, no. 5596/54, upper valve, ×1.5: (7a) external view, lateral view, (7b) from inside; Sarysu River, village of Blagodatnoe, eastern foothills of Mount Belaya; Lower Berriasian, *chaperi* Beds (coll. B.T. Yanin, 1986); (8) specimen PIN, no. 5596/58, upper valve, external view, lateral view, ×1.5; the same locality, age and collector; (9) specimen PIN, no. 5596/57, shell, external view, lateral view, lower valve view; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin); (10) specimen PIN, no. 5596/55, lower valve, ×1.5: (10a) external view, lateral view, (10b) view from inside; Sarysu River, village of Blagodatnoe, Saigin Ravine; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1986); (11) specimen PIN, no. 5596/56, lower valve, ×2; (11a) external view, lateral view, (11b) view from inside; the same area, a ravine at the eastern foothill of Mount Belaya; *chaperi* Beds; (age and collector are the same).

Fig. 12. *Ceratostreon minos* (Coquand): specimen PIN, no. 5596/64, upper valve, ×1; (12a) external view, lateral view (an individual of the same species attached to the valve), (12b) view from inside; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956).

Figs. 13–20. *Rhynchostreon tombeckianum* (d'Orbigny): (13) specimen PIN, no. 5596/60, lower valve, external view, ×2: (13a) lateral view, (13b) view from the posterior side (at the top of the scar growth); vicinity of Balaklava, flux quarry, clay over limestone; Middle Berriasian (coll. B.T. Yanin, 1956); (14) specimen PIN, no. 5596/66, lower valve, external view, lateral view, ×1.2; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (15) specimen PIN, 5596/67, lower valve, external view, lateral view, ×1.5; the same area, the village of Golubinka, Nameless Ravine; age, same collector; (16) specimen PIN, no. 5596/68, lower valve, external view, lateral view, ×1.5; the same area, village of Solnechnosel'e; the same age and collector; (17) specimen PIN, no. 5596/69, lower valve, external view, lateral view, ×1.5; the same locality, age and collector; (18) specimen PIN, no. 5596/70, lower valve, ×2: (18a) external view, lateral view, (18b) view from inside; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin,1969); (19) specimen PIN, no. 5596/71, lower valve, external view, lateral view, ×1.5; Sarysu River, village of Novoklyonovo; Lower Berriasian, *chaperi* Beds (coll. B.T. Yanin, 1956); (20) specimen PIN, no. 5596/72, lower valve, external view, lateral view, ×2; the same locality, age and collector (coll. 1962).

Figs. 21–22. *Barbatia marullensis* (d'Orbigny): (21) specimen PIN, no. 5596/74, left valve: (21a) external view, lateral view, ×1; (21b) view from inside, ×2,5; Zuja River, vicinity of village of Krasnogorie, area of Tau-Kipchak Cave; Middle Berriasian, *tauricum* Subzone (coll. E.I. Kuzmicheva, 1955); (22) specimen PIN, no. 5596/75, left valve, ×2: (22a) external view, lateral view, (22b) view from inside; the same locality, age and collector.

Plate 6


1a
1b
2
3a
3b
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5a
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10a
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13b
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18a
18b
12b
12a
21b
21a
22a
22b

posterior margin is convex in the upper part, usually concave in the lower part; between the posterior and ventral margins, as a rule, there is a sharp, acute-angled bend. The lower valve is from flat or flattened to strongly convex. The carina or carinate flexure is well expressed on it: it is sharp and marginal on flattened valves, or median, obtusely rounded on convex valves. The anterior field of the flat valve is very narrow, in the form of a smooth or slightly wavy strip, bounded by the marginal carina; on convex valves it has a different width (depending on the degree of their convexity). The lateral field is of varying width: on flat valves it is wide, often slightly concave; on the convex ones it ranges from flat and concave to convex, usually complicated by a growth scar or attachment site, which has a different shape: from short oval to elongated and deep (in case of attachment to tubular objects). The anterior field on the convex valves is covered with sparse, coarse, crested and subradial ribs extending from the carinate inflection straight or obliquely to the shell margins, strongly and saw like serrated. Sometimes small ribs extend from the carina and on the rear field. On the upper valves, the carina is marginal or close to their middle. In the anterior field, sparse, rounded ribs also extend from the carina to the margins of the valves, with wavy or angularly serrated shell margins at their ends; the back field is usually smooth.

The ligamentous area is not expressed. The ligament was located in a narrow deep groove oriented parallel to the dorsal margin of the valves. The muscle scar is rounded or oval-angular in outline, strongly approximated to the posterior margin and umbonal region of valves. No chomata are observed.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/50 (UV)	7	12	1.5	5	0.7
PIN 5596/62 (UV)	9	12	1.3	5	0.5
PIN 5596/56 (LWV)	9	17	1.4	5	0.5
PIN 5596/53 (UW)	10	13	1.3	5	0.5
PIN 5596/44 (LWV)	10	13	1.3	7	0.7
PIN 5596/63 (LWV)	11	15	1.3	10	0.6
PIN 5596/49 (LWV)	10	17	1.7	4	0.4
PIN 5596/58 (UV)	11	15	1.3	10	0.9
PIN 5596/51 (UV)	12	14	1.5	4	0.3
PIN 5596/61 (LWV)	12	15	1.4	8	0.6
PIN 5596/57 (Sh)	13	17	1.3	7	0.5
PIN 5596/54 (UV)	13	18	1.3	4	0.3
PIN 5596/48 (LWV)	14	14	1.0	7	0.5
PIN 5596/52 (LWV)	15	19	1.2	10	0.6
PIN 5596/60 (LWV)	15	20	1.2	8	0.4

Comparison. It has the greatest similarity with *C. minos* in the general shape of the shell and the presence of a carina (see below), but differs from it mainly in smaller sizes; a different structure of the ligament area (there is a narrow ligament groove, in the compared species, instead of it, a clear oblique-triangular ligamental area with a median resilifer is developed); often with a rostral extension of the posteroventral angle of the valves.

Variability. High, in all respects, especially in the lower valves: H/L from 0.3 in rounded ones to 2.0 in narrow ones; T/L varies from 0.4 in flattened specimens to 0.9 in strongly convex specimens; the outlines of the posterior margin of both valves and the shape of the platform or attachment scar on the lower valves are also variable.

Occurrence. Berriasian–Aptian: Berriasian–Hauterivian Crimea; Berriasian of Poland; Berriasian–Barremian Northern Caucasus; Valanginian–Aptian Switzerland, France; Hauterivian of Germany; Barremian–Aptian of southern England.

Material. 60 specimens; Crimea, Berriasian: Lower, *jacobi* Zone, *chaperi* Beds—Sarysu River (village of Blagodatnoe, region near Mount Belaya; Saigin Ravine); Middle Berriasian, *tauricum* Subzone—Beshterek River (village of Solovjevka).

Ceratostreon minos (Coquand, 1869)

Plate 6, fig. 12

Ostrea minos: Coquand, 1869, p. 183, pl. 64, fig. 1–3; pl. 73, fig. 5–9; Pictet and Campiche, 1868–1871, p. 278, pl. 185, fig. 1–4; Karakash, 1907, p. 181, pl. 18, figs. 1a, 1b, 3, 5, 7a, b, 8a, b (non 4); pl. 19, figs. 28a–28d.

Exogyra minos: Renngarten, 1926, p. 59; Muromtseva, 1960, p. 199, pl. 15, figs. 2–5.

Ceratostreon minos: Cheltsova, 1969, p. 68, pl. 12, figs. 5a, 5b, 6–8; Pugaczewska, 1975, p. 54, pl. 10, figs. 1–6; pl. 11, figs. 1–14; Bogdanova, 1997, p. 80, pl. 19, figs. 2 and 3; Yanin in Arkadiev et al., 2012, p. 248, pl. 43, fig. 6.

Ostrea minos (Coquand, 1869, pl. 64, figs. 1–3; shell); France; Lower Cretaceous, Neocomian (subsequent designation by Cheltsova, 1969, p. 68).

Lectotype. Specimen of *Ostrea minos* (Coquand, 1869, pl. 64, figs. 1–3; shell); France; Lower Cretaceous, Neocomian (subsequently designated by Cheltsova, 1969, p. 68).

Description. The shell is small to medium-sized (P ≤ 40 mm), regularly oval to oval-curved in outline, inequilateral and inequivalvate. The umbos of both valves are small, opisthogyrate, pressed to the surface. The dorsal, anterior and ventral margins of valves are convex, broadly and smoothly rounded; the posterior margin is of variable outlines (it can be straight, slightly convex, slightly concave or wavy-curved). Often there is a distinct, broadly rounded shoulder between the posterior and ventral margins. The lower valve is larger, moderately convex, with a sharp, often crested marginal carina extending from the umbo to the posteroventral end of the valve and

very close to the anterior margin. The stripe of the anterior field is narrow (0.67 of the lateral field), uniformly convex, oriented obliquely or almost at right angles to the plane of commissure; the field is covered with large, slightly curved, symmetrical, rounded, short subradial ribs, extending straight or obliquely from the carina and extending with their lower ends to the anterior margin of the valve, as a result, the latter becomes undulatingly serrated. The lateral field is wider, flattened or slightly concave, smooth or often irregularly wavy, with a large (sometimes throughout the entire field) area of attachment. The upper valve is flat, without a carina, or slightly convex, with a low, rather sharp carina running along the anterior and ventral margins of the valve. The anterior field in this case is very narrow (2.5 times narrower than the lateral one) and is covered with coarse, transverse, rounded subradial ribs, their endings extending to the margin and serrating it. An undulating, often sharply serrated margin is characteristic of both carinated and noncarinated valves. The lateral field is wide, flattened or irregularly wavy, smooth (without ribs), its posterior margin is smooth or wavy-denticulated. The ligament area on lower valve relatively wide, with distinct, widely concave resilifer; strongly twisted posteriorly in the plane of closure. On the upper valve, the ligament furrow is very narrow, groove-like, also strongly bent backwards. The muscle scar is large, rounded, almost central, somewhat close to the posterior margin.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
PIN, 5596/64 UV	34	55	1.6

Comparison. This species differs from *C. tuberculifera* (Koch et Dunker) (see above) in the larger shell sizes; a larger (almost along the entire lateral area) attachment scar on the lower valve; the presence of ribs and serrations on the anterior margin of the upper valve (in the compared species, it is smooth); the wider ligament area on the lower valve; from *C. boussingaultii* (d'Orbigny, 1843–1847; Neocomian of France)—in the absence of a sharp extension of the shell in the posterior direction; a wider (almost along the entire lateral area) area of attachment on the lower valve (in shells of the compared species, in most cases, the growth scars are located on the umbo); in the absence of subradial ribbing on the lateral field of the lower valve; in the marginal carinae more strongly shifted to the valve margin and in the absence of subradial bifurcating ribs on them.

Occurrence. Berriasian–Aptian: Berriasian–Hauterivian of the Crimea; Berriasian–Valanginian of the Northern Caucasus, Mangyshlak; Valanginian–Hauterivian of Poland, Switzerland, France; Valanginian–Aptian of Trinidad; Neocomian—Barremian of Argentina.

Material. One specimen; Crimea, Middle Berriasian, *tauricum* Subzone—Bel'bek (village of Kuibyshevo, Kabaniy Log) and Beshterek (village of Solovjevka).

Genus *Rhynchostreon* Bayle, 1878

Rhynchostreon tombeckianum (d'Orbigny, 1846)

Plate 6, figs. 13– 20

Ostrea tombeckiana: d'Orbigny, 1843–1847, p. 701, pl. 467, figs. 4–6; Coquand, 1869, p. 182, pl. 66, figs. 8–11.

Exogyra tombeckiana: Wollemann, 1900, p. 11.

Exogyra tombecki: Renngarten, 1926, p. 65.

Rhynchostreon tombeckianum: Pugaczewska, 1975, p. 58, pl. 13, figs. 1–4; Bogdanova, 1988, p. 149, pl. 25, figs. 2, 3; pl. 26, figs. 1–11; pl. 27, figs. 1–3.

Holotype. A specimen of *Ostrea tombeckiana* (d'Orbigny, 1843–1847, pl. 467, fig. 4–6; shell); France (Haute Marna); Lower Cretaceous, Neocomian (designated by monotypy: Rengarten, 1926, p. 65).

Description. The shell is small (P ≤ 20 mm), smooth, variable in outline (from round to semilunar), inequilateral (with shorter anterior and longer posterior sides), inequivalvate. The lower valve is very convex (the line of greatest convexity can occupy a different position). The valve is concave or flattened. The anterior margin is usually long, evenly rounded, forming a smooth curve with the ventral margin; the posterior margin, shorter, variable outlines (from slightly convex to straight or concave). The umbo is prominent, usually opisthogyrate, with a tip pressed against the valve surface, with a small accretion scar. The carina is usually present, rounded, especially pronounced in the umbonal region, mostly median or close to the anterior margin, rarely absent. Some specimens have a slight narrow longitudinal furrow between the carina or line of greatest convexity and the posterior margin. The ligament area is very small, triangular in shape, with a resilifer, the apex of which is directed backwards. No chomata are present. The muscle imprint is round in shape, but with a truncated upper margin, located approximately in the middle of the height line and close to the posterior margin.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/71 (LWV)	8	13	1.6	–	–
PIN 5596/72 (LWV)	8	14	1.7	–	–
PIN 5596/65 (LWV)	13	20	1.5	8	0.6
PIN 5596/67 (LWV)	16	15	0.9	–	–
PIN 5596/68 (LWV)	17	17	1.0	–	–
PIN 5596/66 (LWV)	20	17	0.8	8	0.4

Comparison and remarks. This species differs from *Gryphaea arduennensis* (d'Orbigny, 1843–1847; Albian of Crimea, France and Switzerland), which has a smooth shell in the less coiled and higher

shell. It differs from *Ceratostreon tuberculiferum* (see above) in the absence of ornamentation on both valves; in the gryphoid umbo of the lower valve; its greater convexity (in the compared species, it is flattened); the median position of a weakly expressed carina on the same valve (in *C. tuberculifera*, the carina may be marginal, sharp, carinate); lack of serrations of the anterior margin.

Occurrence. Berriasian–Barremian: Berriasian of the Crimea and Mangyshlak; Hauterivian–Barremian of the Northern Caucasus; Hauterivian of France; Valanginian–Hauterivian of Poland; Neocomian of Germany.

Material. 15 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds–Sarysu River (village of Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Chernaya River Balaklava, flux quarry), Bel'bek (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e) and Beshterek (village of Solovjevka).

Order Arcida Stoliczka, 1871

Superfamily Arcoidea Lamarck, 1809

Family Arcidae Lamarck, 1809

Subfamily Arcinae Lamarck, 1809

Genus *Barbatia* Gray, 1842

***Barbatia marullensis* (d'Orbigny, 1844)**

Plate 6, figs. 21, 22; Fig. 29.7

Arca marullensis: d'Orbigny, 1843–1847, p. 205, pl. 310, fig. 3 and 4; Pictet, Campiche, 1864-1867, p. 432, pl. 130, fig. 1–4.

Barbatia marullensis: Woods, 1899–1913, p. 38, pl. 7, figs. 4–7.

Holotype. A specimen of *Arca marullensis* (d'Orbigny, 1843–1847, pl. 310, figs. 3 and 4; shell); France (Aube, Marolles); Lower Cretaceous, Neocomian (designated by monotypy herein).

Description. The shell is small (D ≤ 19 mm), elongated, angular, close to parallelogram, outlines, slightly convex, slightly uneven-sided, equal-valve, thick-walled. The dorsal margin is long, straight; the ventral margin is long, straight or slightly concave in the middle part, parallel to the dorsal; the anterior one is rounded-convex, forming an angle of 105°–110° with the dorsal one; posterior margin is slightly longer than anterior, slightly sloping towards the posteroventral corner or regularly rounded; forms an angle of 115°–120° with the dorsal one. The umbos are prosogyrate, small, moderately shifted forward; the apical angle is 100°–105°. The umbilical carina is smoothly rounded, sometimes protruding to the posteroventral angle of the shell. The lateral field is wide, irregularly convex (flattened near middle part of the ventral margin). Sometimes a radial, weakly and widely concave depression extends to it from the umbo. The posterior field is narrow and flattened. The ligament is amphidetic, external, on a long, narrow chevron-shaped area with knee-shaped grooves (up to two in the anterior and up to six on the posterior side of the area). The surface with numerous, very thin, smooth, rounded, equal in size radial striae (noticeable only under magnification), separated by spaces, in which intercalation of additional, even thinner striae is observed. They intersect with thin growth lines forming a reticulate pattern. The cardinal platform is long, narrow, slightly arcuately curved at the margin (straight in the middle part) (Fig. 29.7). The hinge consists of three umbilical, tuberculate, vertical and oblique marginal teeth: seven anterior and 19 posterior teeth. Towards the ends of the hinge margin, both the size of the teeth and the angle of their inclination increase. The umbilical and adjacent oblique teeth with their upper ends extend to the hinge margin; the terminal marginal teeth are separated from it by a smooth narrow strip. Narrow byssal gaping is present in middle part of the ventral margin; it corresponds to the concavity of the margin, which then passes into a wide depression on the lateral side of the valves. The margins of the valves are smooth from the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5506/74 LV	20	12	0.6	5	0.2
PIN 5596/? PV (specimen is lost no.? 317-826)	20	7	0.3	4	0.2

Comparison. This species differs from: *B. baudoniana* (Cotteau) (see Pictet and Campiche, 1864–1867; Neocomian Switzerland) in smaller shells; angular outlines of valves; very small umbo; from *B. aubersonensis* (Pictet et Campiche, 1864–1867; Valanginian of Switzerland), in the smaller shell size; less convex posterior margin; less prominent umbo; from *B. raulini* (d'Orbigny, 1843–1847; Neocomian of France) it is distinguished by a well-defined reticulate ornamentation; from *B. neocomiensis* (d'Orbigny, 1843–1847; Neocomian of France)—by the absence of coarse sparse ribs in the anterior part of the valves and a straight or slightly concave ventral margin; from *B. aptiensis* (Pictet et Campiche) (see Woods, 1899–1913; Aptian of England) it differs in the straight ventral margin; less oblique posterior margin and the presence of a thin uniform reticulate ornamentation; the absence of coarse radial ribs near the shell anterior and posterior margins.

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Neocomian–Aptian France; Urgonian of Switzerland; Barremian–Aptian of England.

Material. Two specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Zuja (village of Krasnogor'e, near Tau-Kipchak Cave), Sarysu (Enisarai Ravine); Middle Berriasian, *tauricum* Subzone—Sarysu River (village of Novoklyonovo).

Subfamily Grammatodontinae Brancon, 1842

Genus *Cosmetodon* Brancon, 1842

Cosmetodon carteroni (d'Orbigny, 1844)

Plate 7, figs. 1–4; Fig. 29.5

Arca carteroni: d'Orbigny, 1843–1847, p. 202, pl. 309, fig. 4–8; Pictet and Campiche, 1864–1867, p. 436, pl. 130, fig. 9; Woods, 1899–1913, p. 33, pl. 6, fig. 4 and 5; Dimitrova, 1974, p. 49, pl. 22, fig. 2.

Arca carteroniana: Muromtseva, 1960, p. 174, pl. 1, figs. 13 and 14.

Parallelodon carteroni: Klikushin, 1971, p. 117, text-figs. 1a–1d.

Cosmetodon carteroni: Bogdanova, 1997, p. 60, pl. 16, fig. 3 and 4; Bogdanova and Yanin, 2004, p. 66, pl. 25, fig. 8; Yanin in Arkadiev et al., 2012, p. 252, pl. 41, fig. 11 and 12.

Lectotype. A specimen of *Arca carteroni* (d'Orbigny, 1843–1847, pl. 309, figs. 4 and 5; shell); France (Aube); Lower Cretaceous, Neocomian (designated by Yanin in Arkadiev et al., 2012, p. 252).

Description. The shell is small to medium-sized (L ≤ 50 mm), angular, close to parallelogram in shape, obliquely attenuated in the posteroventral corner, ribbed, moderately convex, strongly elongated (L > H twice), thick-walled, strongly inequilateral. The dorsal margin is long, straight; its posterior branch is three times as long as the anterior one; the ventral margin is long, usually curvilinearly curved, less often straight or slightly convex; the anterior margin is short, convex, with dorsal forms an angle of 80°–95°; the posterior margin is oblique, curvilinearly is curved: slightly concave in the upper part, strongly convex in the lower part; forms an angle of 100°–120° with the dorsal margin, and a sharply rounded angle with the ventral margin. The posterior side of the shell is usually wider than the anterior. The umbo is prosogyrate, prominent, strongly shifted forward, with sharp beaks hanging over the area. The umbilical carina is sharply rounded, flattening only at the posteroventral angle of the valve. The lateral field is wide, unevenly convex, flattened or slightly concave near the anterior part of the ventral margin, which is associated with the byssal gaping; the posterior margin is broadly concave.

The ligament area is long, broadly triangular, with articulated-curved chevrons. In the anterior branch of the area they are straight and parallel to each other; the grooves of the posterior branch of the area often do not correspond in number and character to the anterior grooves; some straight grooves fall out, and grooves with a herringbone pattern develop instead of them, or an additional triangle of two to three grooves appears; adult forms usually have five to eight grooves.

The surface with numerous, very thin, smooth, rounded, symmetrical, clearly expressed radial striae only on the lateral field; main and additional striae are distinguished; approximately from the middle of the valve, they intercalate; the spaces are smooth, concave, equal in width to striae. Often near the anterior margin, the striae are replaced by thin ribs. The posterior field is smooth.

The cardinal platform is long, narrow, and straight (Fig. 29.5). The hinge consists of three series of teeth. The umbonal teeth (6–7) are tuberculate; they are gradually replaced by anterior and posterior marginal teeth. Of these, the anterior (3–4) are thin, fan-shaped divergent; posterior (9–10)—are thin, longitudinally elongated; the anterior ones approach obliquely to the hinge margin, and the posterior ones (4–5) are almost horizontal. All teeth approach the hinge margin, often in contact with the chevron grooves. The byssal gaping in anterior half of ventral margin, is narrow and short; it corresponds to the byssal notch. The margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
TsNIGRM 111/13220 (LV)	34	15	0.40	9.0	25
PIN 5596/77 (RV)	35	15	0.42	–	–
TsNIGRM 110/13220 (LV)	38	20	0.50	16	0.40
PIN 5596/ 310/10 (RV)	43	16	0.37	8	0.18
MZMSU 11/57 (Sh)	50	18	0.36	20	0.40

Comparison. This species differs from *C. sanctaecrucis* (Pictet et Campiche, 1864–1867; Valanginian of Switzerland) in sharper angularity between the anterior and dorsal margins (the anterior angle is close to 90°, in the compared species it is 110°–120°); more oblique anterior margin; strong curvature of the posterior margin; lack of ornamentation in the back field; from *C. keyserlingi* (d'Orbigny, 1843–1847; Neocomian of France; Russian Platform Oxford: see Gerasimov, 1955)—lack of concentric striae, wider area; a large number of teeth (18–20 vs. 9–12) and shorter posterior marginal teeth (the length of the largest tooth in the described species is 1/4, in the compared species 1/2 of the shell length).

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Valanginian–Middle Aptian of the Northern Caucasus and Dagestan; Neocomian–Urgonian of France; Barremian–Lower Aptian of England; Aptian of Bulgaria.

Material. 31 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu River (villages of Blagodatnoe, Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Golubinka, Mount Karatlykh), Sarysu (village of Kozlovka) and Malyi Salgir (village of Ivanovka).

Family Cucullaeidae Stewart, 1930

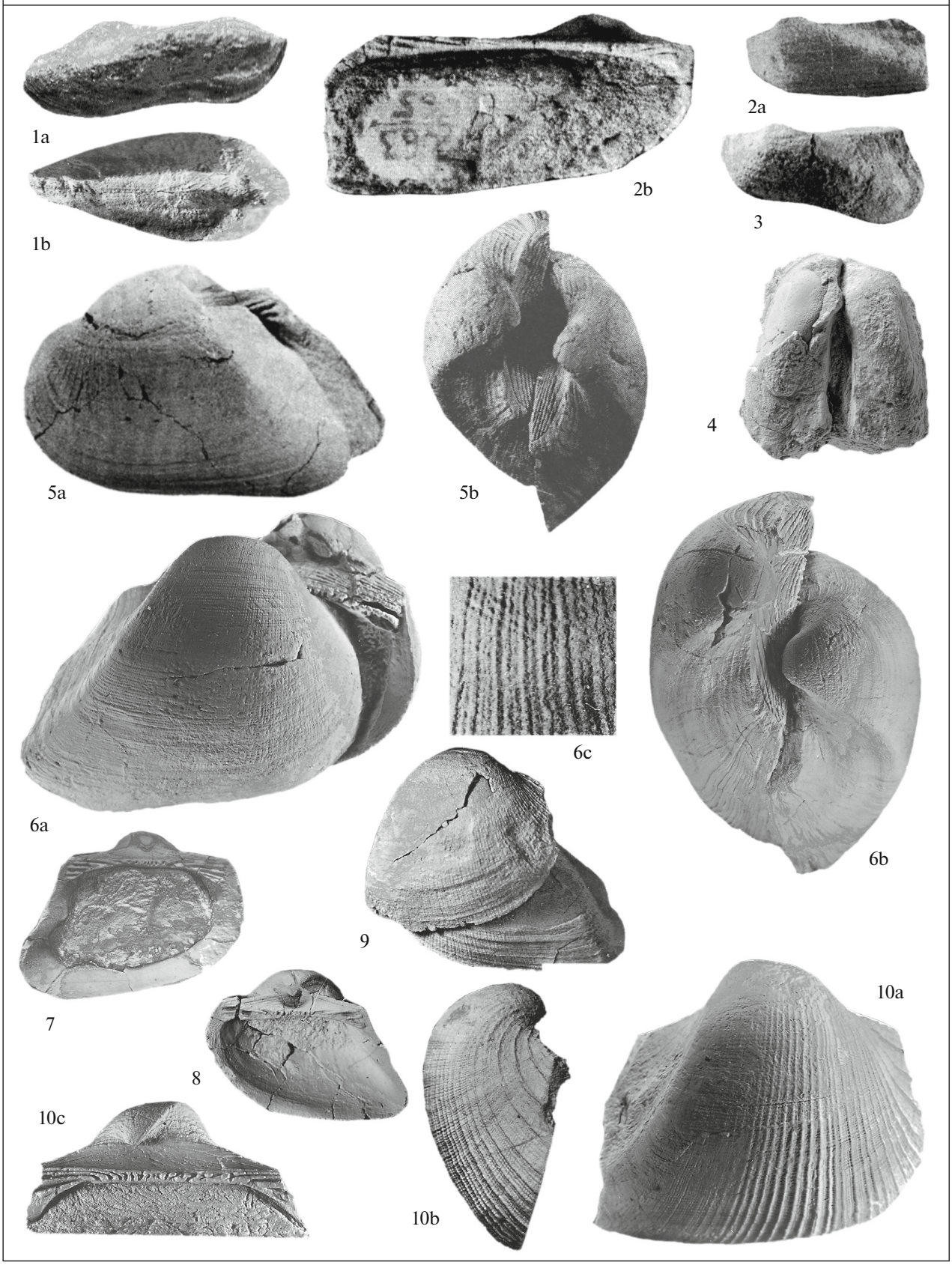
Genus *Idonearca* Conrad, 1862

Idonearca gabrieli (Leymerie, 1842)

Plate 7, figs. 5–9

Cucullaea gabrielis: Leymerie, 1842, p. 6, pl. 7, figs. 5a–5c; Muromtseva, 1960, p. 175, pl. 2, fig. 1; Dimitrova, 1974, p. 51, pl. 22, fig. 15; pl. 23, fig. 1; Bogdanova, 1997, p. 60, pl. 16, fig. 5.

Plate 7



Cucullaea gabrieli: Mordvilko, 1932, p. 36, pl. 4, fig. 11; 1949, p. 126, pl. 20, fig. 1, 10; Saveliev, 1962, p. 201, pl. 6, fig. 1; pl. 7, figs. 1a, 1b.

Arca gabrielis: d'Orbigny, 1843–1847, p. 198, pl. 308, figs. 1–5; Pictet and Campiche, 1864–1867, p. 450.

Idonearca gabrielis: Yanin in Arkadiev et al., 2012, p. 253, pl. 42, fig. 1 and 2.

Holotype. A specimen of *Cucullaea gabrielis* in (Leymerie, 1842, pl. 7, fig. 5a, shell); France (Aube); Lower Cretaceous, Lower Neocomian (designated by monotypy: Saveliev, 1962, p. 201).

Description. The shell is medium-sized and large in size (L ≤ 68 mm), ribbed, angular, trapezoidal, strongly convex, elongated (L > H), strongly inequilateral, drawn in the posteroventral direction, with a widened and oblique posterior side, thick-walled. The dorsal margin is long, straight or slightly concave in the middle; anterior margin is strongly convex, with dorsal forms an angle of 110°; the ventral margin is slightly convex, in adult forms straight in the posterior half; the posterior margin is longer than anterior, strongly oblique, straight or curvilinearly curved; forms an angle of 120°–130° with the dorsal one, and an acute angle with the ventral one. The umbos are prosogyrate, massive, strongly protruding, widely spaced, with sharp beaks hanging like a beak over the area.

The umbilical carina is well developed along its entire length; it is especially sharp in the umbonal region, where the angle of the carina is close to 90°. The lateral field is wide, uniformly convex; sometimes flattened near carina and near ventral margin; the posterior margin is wide, is slightly concave or flattened. The ligamental area is triangular (in young forms) or trapezoid, very wide, slightly concave, separated from the outer surface of the valve by sharp carinate shoulders. The chevron grooves, parallel in each branch, converge at the umbo at different angles (the closer the angle to the umbo, the sharper it is); adults have 10–12 chevron grooves on the area.

The shell surface has numerous radial ribs, radial and concentric striae, especially distinct in the anterior and lateral parts of the valve (in most cases only radial elements are visible due to poor preservation). The radial ribs are thin, frequent, rounded, usually identical, changing into radial striae on the lateral field, on the carina and posterior field, and always inequilateral in the anterior part of the valve. Here, the coarsest and largest crested, symmetrical, granularly serrated at the intersection with concentric striae, the main radial ribs are developed and between them one to three thin additional radial striae. In some forms, radial ribs and striae are developed and in the posterior field. Concentric striae are very thin, uniform, often merging with growth lines; at the points of their intersection with the radial elements, small granules are formed.

The cardinal platform is long, straight, narrow, especially in the middle; the hinge consists of a series of teeth (umbonal—vertical and marginal: anterior and posterior—subhorizontal). The umbonal teeth (9–15) small, short, equal in size, rounded tuberculate, sometimes pointed; oriented vertically or slightly obliquely to the line of the hinge line; anterior and posterior marginal teeth (three–four in each branch) are smooth, elongated, ridge-like, straight and slightly curved, arranged in echelon at the thickened ends of the hinge area; the longest of them are up to 10 mm (in adult individuals), located at the hinge margin. The marginal teeth do not reach the anterior and posterior margins of the valve, being separated from them by a smooth narrow strip. The pallial line is well expressed; the limb is wide. The muscle scars are inequilateral: the anterior is rounded-triangular, slightly concave, closely adjacent to the hinge area; the posterior one is larger than the anterior one, rounded elongated, separated from the inner surface of the valve by a crested ridge. The shell margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/85 (Sh)	38	31	0.8	28	0.8
PIN5596/82 (RV)	40	32	0.8	–	–
PIN5596/83 (LV)	50	39	0.78	21	0.42
PIN 5596/84 (Sh)	52	44	0.84	46	0.88
PIN 5596/79 (Sh)	68	48	0.70	50	0.73

Explanation of Plate 7

Figs. 1–4. *Cosmetodon carteroni* (d'Orbigny): (1) specimen MZMSU, no. 11/57, shell, external view, ×1: (1a) lateral view, right valve view, (1b) umbonal view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955); (2) specimen TsNIGRM, no. 111/13220, left valve: (2a) external view, lateral view, ×1; (2b) from inside, ×2; the same locality, age and collector; (3) specimen TsNIGRM, no. 110/13220, shell, external view, left valve view, ×1; the same age and locality (coll. B.T. Yanin, 1956); (4) specimen PIN, no. 5596/76, shell with open valves, view from the umbonal side, ×1; the same age and locality (coll. V.V. Drushchits, 1955).

Figs. 5–9. *Idonearca gabrielis* (Leymerie): (5) specimen TsNIGRM, no. 112/13220, shell with displayed valve, external view, ×1: (5a) left valve view, (5b) umbonal view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (6) specimen PIN, no. 5596/79, shell with displayed valve: (6a) external view, right valve view, (6b) umbonal view, ×1; (6c) enlarged area of the surface of the lateral field fig. 6a (radial ribs of two orders), ×5; the same locality, age and collector; (7) specimen PIN, no. 5596/80, left valve, view from inside, ×1; the same locality, age and collector; (8) specimen PIN, no. 5596/81, right valve, view from inside, ×1; the same locality, age and collector; (9) specimen PIN, no. 5596/82, nested two separate valves, from the outside (left from below, right top view), ×1; the same locality, age and collector.

Fig. 10. *Idonearca forbesi* (Pictet et Campiche), specimen PIN no. 5596/86, right valve, ×1: (10a) external view, lateral view, (10b) anterior view, (10c) from inside; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955).

Comparison. This species differs from: *I. forbesi* (see below) in the finer and less pronounced ornamentation; coarser umbilical and less thin marginal teeth; from *I. glabra* (Parkinson, 1811; Aptian of England) in the more pronounced umbilical carina; more acute and angular umbonal carinae; in the umbos more strongly overhanging over the area.

Remarks. Previously, the author (Yanin in Arkadiev et al., 2012, p. 253) erroneously designated the lectotype for the described species, since Saveliev (1962, p. 201) indicated a holotype, the shell illustrated in the work of the author of the species (Leymerie, 1842, pl. 7, fig. 5a).

Occurrence. Berriasian–Aptian: Berriasian–Valanginian of the Crimea; Lower Hauterivian of Mangyshlak and Western Kopetdag; Barremian–Lower Aptian of the Northern Caucasus and Dagestan; Valanginian–Hauterivian of Switzerland; Valanginian–Aptian of France; Aptian of Bulgaria and Spain; Neocomian of Argentina.

Material. 150 specimens; Crimea, Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log) and Beshterek (village of Solovjevka).

Idonearca forbesi (Pictet et Campiche, 1866)

Plate 7, fig. 10; Plate 8, fig. 1; Fig. 29.6

Arca forbesi: Pictet, Campiche, 1864–1867, p. 471.

Cucullaea forbesi: Woods, 1899–1913, p. 49, pl. 9, figs. 1–6; Mordvilko, 1932, p. 38, pl. 2, figs. 5, 5a; Muromtseva, 1960, p. 176, pl. 2, fig. 2; Dimitrova, 1974, p. 53, pl. 25, fig. 2; Bogdanova, 1997, p. 61, pl. 16, figs. 6 and 7; Yanin in Arkadiev et al., 2012, p. 254, pl. 42, figs. 3a, 3b.

Holotype. Not designated.

Description. The shell is medium-sized (Sh ≤ 50 mm), ribbed, angular, irregularly trapezoidal, slightly elongated (P ≤ L), strongly convex, slightly uneven, thick-walled. The dorsal margin is long, straight; the anterior margin is strongly convex, widely rounded, forming a clear obtuse angle with the dorsal margin; the posterior margin is strongly oblique, straight, makes an angle of 110° with the dorsal margin; forms a sharply rounded bend close to 90° with the ventral margin. The ventral margin is long, slightly convex, almost straight in the middle in adults. The umbos are prosogyrate, massive, prominent, with sharp carinated beaks hanging over the area; the apical angle is 65°–70°. The umbonal carina is sharply rounded throughout; forms an angle of 90° at the umbo. The lateral field is wide, uniformly convex; the posterior field is wide, slightly concave or flattened. The ligament area is triangular, with slightly curved lateral sides, long, wide, slightly concave, separated from the outer surface of the valve by sharp carinated bends. The chevron lines are articulated, developed throughout the area; they converge under the top of the head at almost equal angles.

The surface bears numerous strong radial ribs, radial and concentric striae on the entire surface of the valves. The radial ribs on lateral field are crested, usually finely serrated; in the anterior half of the field, the ribs (24–26) are large and sparse; the intercostal spaces are wide (2–4 mm) with very thin radial striae (one to five per space); towards the carina, the radial ribs become densely spaced, level off in width and pass into thin, frequent radial striae, also developed on the carina. There are about five to eight radial ribs on the posterior field. Concentric striae over the entire surface are very thin, identical; at the points of their intersection with the radial elements, small wavy scales are formed; especially distinct scales and a fine reticulate pattern are observed between the large radial ribs in the anterior part of the lateral area.

The cardinal platform is long, straight, narrow, especially in the middle (Fig. 29.6). The hinge consists of two series of teeth; umbilical teeth (12) small, short, lamellar (several tuberculate teeth in the center), diverging fan-like towards the sides; the anterior and posterior marginal teeth (three in the anterior and four in the posterior branches) are long (uppermost of them up to 12 mm), lamellar, sharp, fan-shaped at the ends of the hinge platform. The margins are smooth on the inside.

Dimensions in mm and ratios:

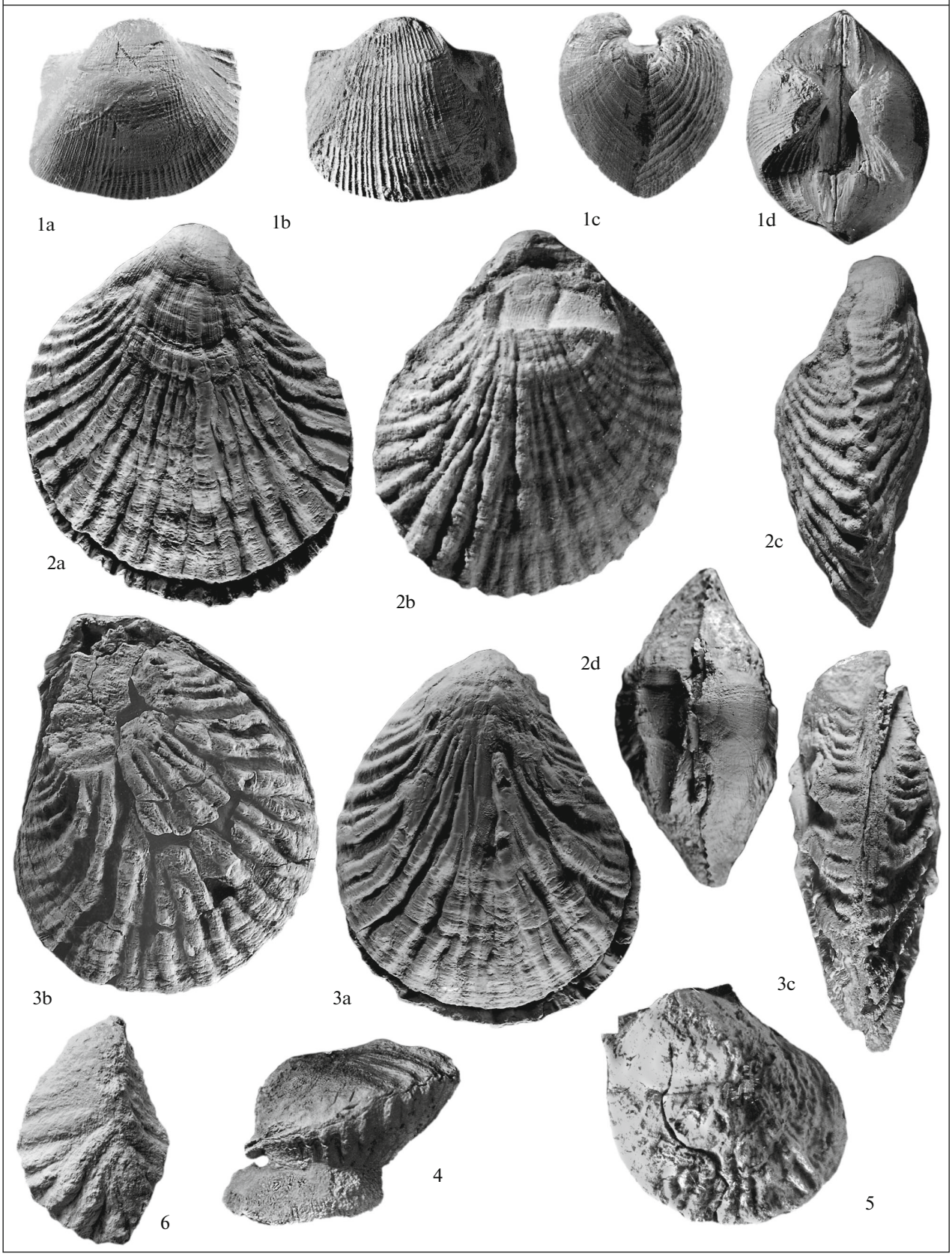
Specimen no.	L	H	H/L	T	T/L
SPGGI 51/332 (RV)	36	29	0.80	–	–
SPGGI 34/332 (Sh)	41	35	0.85	33	0.80
TsNIGRM 114/13220 (Sh)	42	36	0.85	34	0.80
PIN 5596/87 (LV)	46	41	0.80	20	0.40

Explanation of Plate 8

Fig. 1. *Idonearca forbesi* (Pictet et Campiche), specimen TsNIGRM, no. 114/13220, shell, external view, ×1: (1a) from the right and (1b) left valves; (1c) anterior view, (1d) umbonal view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955).

Fig. 2–6. *Prohinnites renevieri* (Coquand), specimen MZMSU no. 84/57, shell, external view, ×1: (2a) upper view, (2b) lower view (in the umbo region there is a trace of attachment to the shell of a gastropod), (2c) anterior view, (2d) umbonal view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (3) specimen TsNIGRM, no. 122/13220, shell with slight offset, external view, ×1: (3a) lateral view, from the upper and (3b) lower valve, (3c) anterior view; the same locality, age and collector; (4) specimen PIN, no. 5596/88, shell attached to a pebble from a coral colony, external view from the posterior side, ×1; the same locality, age and collector; (5) specimen PIN, no. 5596/89, shell, external upper valve view, ×1; northern slope of Aipetri Yaila, Bakhchisaray-Yalta highway; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin); (6) specimen PIN, no. 5596/90, shell, external view, lateral view, upper valve view, ×1; the same locality, age and collector.

Plate 8



Comparison. This species differs from the most closely similar species *I. glabra* (Parkinson, 1811; Aptian of England) by well-developed coarse radial ribs (shells in *I. glabra* are smooth or with fine concentric striations); more sharply rounded carina; more strongly carinated shells, with acute umbos (in *I. glabra*, the umbo is not carinated). See above for differences from *I. gabrieli*.

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Barremian– Lower Aptian of the Northern Caucasus; Lower Aptian of Dagestan, England; Aptian of Turkmenistan and Bulgaria.

Material. Four specimens; Crimea, Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log).

Order Pectinida H. et A. Adams, 1857

Suborder Pectinina H. et A., 1857

Superfamily Pectinoidea Rafinesque, 1815

Family Pectinidae Rafinesque, 1815

Subfamily Chlamysinae Teppner, 1922

Genus *Prohinnites* Gillet, 1922

***Prohinnites renevieri* (Coquand, 1869)**

Plate 8, figs. 2–6; Plate. 9, fig. 1

Ostrea Renevieri: Coquand, 1869, p. 191, pl. 63, figs. 10–12.

Hinnites Renevieri: Pictet, Campiche, 1868–1871, p. 227, pl. 176, figs. 1–4; Renngarten, 1926, p. 57.

Prohinnites renevieri: Muromtseva, 1960, p. 189, pl. 10, fig. 1 and 2; Bogdanova, 1988, p. 138, pl. 22, figs. 1–3; 1997, p. 73, pl. 21, fig. 1; pl. 22, fig. 3; Yanin in Arkadiev et al., 2012, p. 264, pl. 44, fig. 12; Yanin, 2020a, p. 10, pl. 1, figs. 8a, 8b.

?Ctenostreon ponti: Broili, 1902, p. 606, pl. 1, figs. 9 and 9a.

Holotype. A specimen of *Ostrea renevieri* (Coquand, 1869, pl. 63, figs. 10–12, upper valve); Switzerland; Lower Cretaceous, Valanginian (designated by monotypy: Yanin in Arkadiev et al., 2012, p. 264).

Description. The shell is medium-sized and large (Sh ≤ 100 mm), irregularly lenticular, round or oblique-oval outline (oblique in the posteroventral direction), tapering towards the tip of the umbo, high (B ≥ D), slightly inequilateral, inequivalvate (upper valve slightly higher than the bottom). The lower valve is convex to varying degrees; the attachment site is usually wide, slightly concave, adjacent directly to the tip of the umbo. The upper valve is moderately and uniformly convex. The dorsal margin is short, straight; the anterior, ventral and posterior margins are broadly rounded and gradually merge into each other. The anterior and posterior auricles are well developed on both valves.

The surface of both valves with large, very coarse, symmetrical, rounded in cross section, irregular, numerous (25–30), radial ribs and folds. The ribs vary in size, which is associated with their intercalation and bifurcation; sometimes, on the contrary, their merging is observed. The ribs are smooth or scaly, often with

Explanation of Plate 9

Fig. 1. *Prohinnites renevieri* (Coquand), specimen PIN, no. 5596/96, shell, ×1: (1a) external view, lateral view, lower valve view, (1b) fragment of the upper valve, view from inside; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956).

Figs. 2–7. *Entolium germanicum* (Wollemann): (2) specimen PIN, no. 5596/97, right valve, external view, lateral view, ×1; Sarysu River, village of Novoklyonovo; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1955); (3) specimen PIN, no. 5596/98, left valve, external view, lateral view, ×1.5; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962); (4) specimen PIN, no. 5596/99, left valve, external view, lateral view, ×0.75; Sarysu River, village of Novoklyonovo; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1955); (5) specimen TsNIGRM, no. 115/13220, right valve, external view, lateral view, ×1; the same locality, age and collector; (6) specimen PIN, no. 5596/100, left valve, external view, lateral view, ×1; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (7) specimen PIN, no. 5596/101, right valve, external view, lateral view, ×1; Sarysu River, village of Novoklyonovo; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1955).

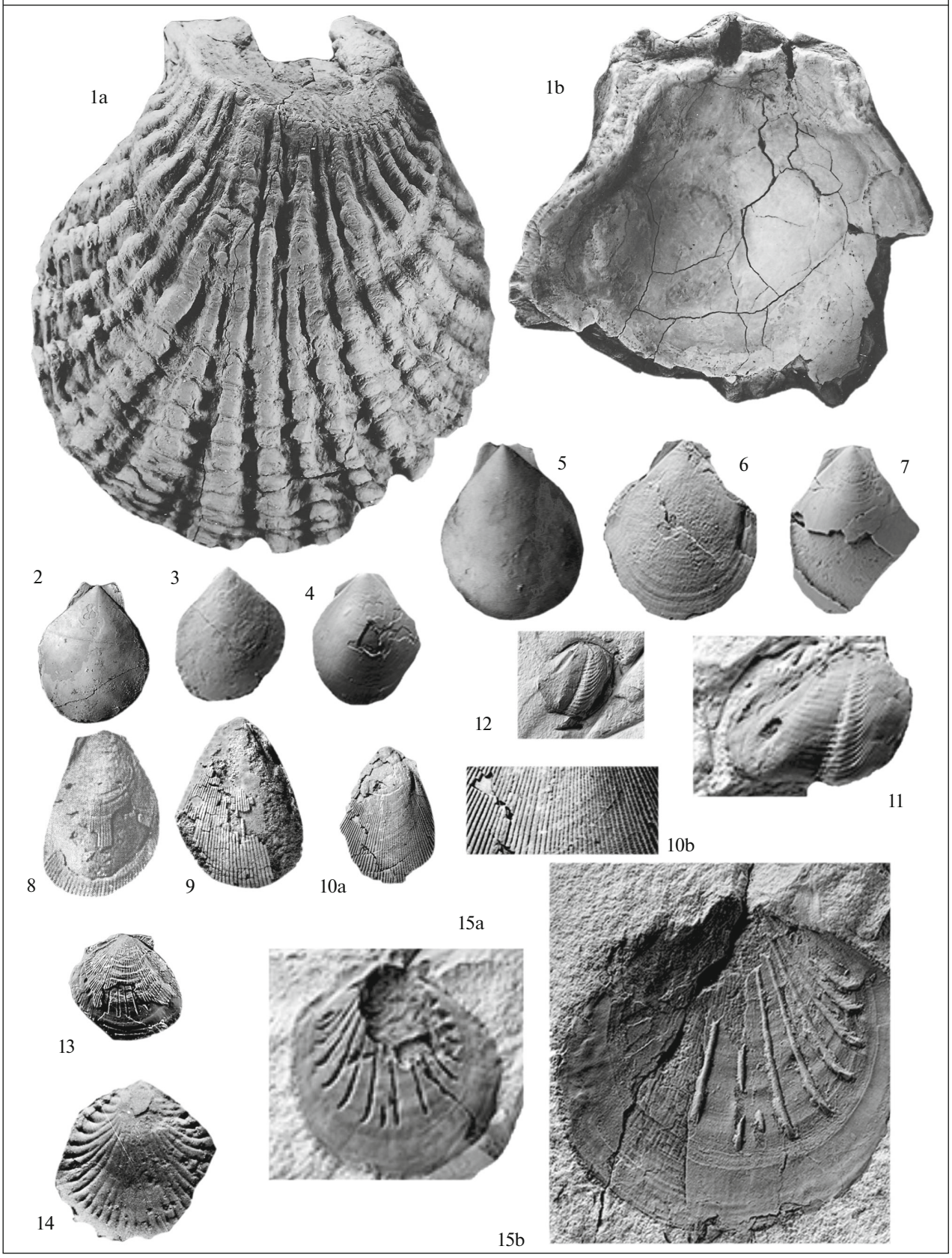
Figs. 8–10. *Acesta longa* (Roemer): (8) specimen MZMSU, no. 104/57, left valve, external view, lateral view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (9) specimen PIN, no. 5596/102, right valve, external view, lateral view, ×1; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1954); (10) specimen PIN, no. 5596/103, right valve: (10a) external view, lateral view, ×1; (10b) enlarged area of its surface, ×2; the same locality, age and collector (coll. 1962).

Figs. 11–12. *Turnus tonasensis* Yanin, sp. nov.: (11) specimen PIN, no. 5596/104, holotype, right valve mold on the clay tile surface, external view, lateral view, ×2; Tonas River, village of Krasnoselovka, Kuchuk-Uzen' Creek; Lower Berriasian, *grandis* Subzone (coll. T.N. Gorbachik, 1963); (12) specimen PIN, no. 5596/105, right valve mold with a broken posterior end on a clay plate, external view, lateral view, ×2; the same locality, age and collector.

Fig. 13. *Propeamussium sokolowi* (Retowski): specimen TsNIGRM, no. 116/13220, left valve, lateral view, with partially preserved shell layer, ×1; Tonas River, village of Krasnoselovka, Kuchuk-Uzen' Creek; Lower Berriasian, *grandis* Subzone (coll. T.N. Gorbachik, 1963).

Figs. 14–15. *Propeamussium pawlowi* (Retowski): (14) specimen TsNIGRM, no. 117/13220, left valve mol, lateral view, ×2; vicinity of Feodosia, southern coast of the bay; Lower Berriasian, *grandis* Subzone , "Feodosia marls" (coll. B.T. Yanin, 1968); (15) specimen PIN, no. 5596/106, scar and anti-scar of the right valve, split along the beds of marl: (15a) mold flaps with destroyed umbonal area, ×1; (15b) valve inner surface with radial ribs and wide limb ×2; the same age and locality (coll. V.V. Drushchits, 1968).

Plate 9



spiny outgrowths. In the middle part of the lateral surface of both valves, the ribs are straight, but at the anterior and posterior margins they are usually curved. The intercostal spaces are smooth, concave, usually narrower than ribs. In the umbonal region of the lower valve, numerous, very thin ribs or striae are often developed, which are characteristic of earlier stages of growth; they are absent in adults.

The ligamentous area is relatively wide, the resilifer is symmetrical, deep, usually highly triangular, equally developed on both valves; sometimes a longitudinal furrow is traced along the entire length of the area. The area surface on the lower valve is oriented almost parallel to the closure plane, while on the upper one it is located at some angle to it. The muscle imprint is rounded, large, smooth, located near the posterior margin of the valves. The margins are strongly serrated from the inside with the terminations of the ribs (folds).

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/92 (LWV)	33	32	0.9	–	–
PIN 5596/95 (LWV)	43	46	1.1	–	–
PIN 5596/91 (Sh)	47	60	1.2	28	0.5
PIN 5596/89 (Sh)	53	57	1.0	30	0.5
TsNIGRM 122/13220 (Sh)	57	67	1.2	28	0.4
MZMSU 84/57 (Sh)	60	66	1.10	29	0.48
PIN 5596/94 (LWV)	63	60	0.9	29	0.3
PIN 5596/93 (LWV)	63	65	1.0	22	0.34
PIN 5596/96 (Sh)	81	96	1.0	32	0.38

Comparison. The shape and ornamentation of the shell is similar to those in the following species: *P. leymeri* (Deshayes in Leymerie, 1842; Pictet and Campiche, 1868–1871; Hauterivian of Switzerland and France) and *P. favrinus* (Pictet et Campiche, 1868–1871; Urgonian of Switzerland), but differs in the strong constriction of the shell in the umbonal region; the shell somewhat oblique in the posterior-downward direction; stronger bifurcation and intercalation of the ribs; radiating arrangement of ribs at the anterior and posterior margins of the valves; sharp serration of the ventral margin of the valves and narrower intercostal spaces.

Remarks. F. Broili (see synonymy) described a new species *ponti*, placing it provisionally in the genus *Ctenostreon*. Judging by the morphology of the ligament area and the ribbing, the figured specimen of ?*C. ponti* (Pl. 1, figs. 9, 9a) differs considerably from true *Ctenostreon* in the following characters: (1) subtriangular resilifer, deep and straight; perpendicular to the lower margin of the area (in *Ctenostreon* it is shallow and oblique, almost parallel to the upper side of the posterior auricle); (2) radial ribs-folds are less regular, sometimes sinuous, and usually dichotomous in different areas of the valve surface (in representatives of the compared genus, the ribs are more regular, single). Based on the above specimen, described by F. Broili (1902) under the name *C. ponti*, it is here assigned to the genus *Prohinnites* and the species *renevieri*.

Occurrence. Berriasian–Hauterivian: Berriasian–Valanginian of the Crimea; Berriasian of Mangyshlak; Valanginian–Hauterivian of the Northern Caucasus; Berriasian of Switzerland (Sainte–Croix); Valanginian of Switzerland (listed from the lower and middle parts of the Valanginian stratotype section: Haefeli et al., 1965); Valanginian of France (Viller–le–Lac) and Spain.

Material. 11 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern slope of Aipetri Yaila (Bakhchisarai highway); northern slope of Dolgorukovskaya; Beshterek River (village of Solovjevka, "lower Solovjevka limestones"); the same Zone, *chaperi* Beds—Sarysu River (villages of Chernokamenka; Blagodatnoe; Saigin Ravine); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log).

Family Entoliidae Teppner, 1922

Subfamily Entoliinae Teppner, 1922

Genus *Entolium* Meek, 1865

Entolium germanicum (Wollemann, 1900)

Plate 9, figs. 2–7

Pecten germanicus: Wollemann, 1900, p. 41, pl. 8, figs. 13–19.

Syncyclonema germanica: Muromtseva, 1960, p. 186, pl. 8, figs. 4 and 5.

Entolium germanicum: Yanin in Arkadiev et al., 2012, p. 255, pl. 43, fig. 9.

Holotype. Not designated.

Description. The shell is from small to medium-sized (P ≤ 34 mm), smooth (if well preserved, finely striated), lenticular in shape, triangular-oval, broadly rounded in the lower part, narrowed, triangular in the upper part; usually, equilateral, very slightly and evenly convex, almost equivalvate, high (H ≥ L). The umbo orthogyrate, sharp, triangular in outline, not protruding above the dorsal margin; the apical angle is 85°–95°. The auricles are small, oblique and raised upwards (protruding above the tip of the umbo), with rounded corners, almost equal (the anterior is somewhat larger than the posterior). The ventral margin of the valves is broadly rounded and smoothly merges into the anterior and posterior margins.

The surface with thin concentric jets forming narrow flattened strips. Sometimes, on some specimens, a very thin radial striation is visible (especially when magnified), radiating from the umbo to the margins of the valves. The auricles bear only growth lines.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/98 (RV)	12	16	1.30	–	–
TsNIGRM 115/13220 (RV)	21	26	1.23	3	0.14
PIN 5596/100 (RV)	23	33	1.40	–	–
PIN 5596/99 (RV)	24	30	1.25	–	–
PIN 5596/101 (RV)	25	32	1.20	–	–
TsNIGRM 115/13220 (RV)	27	34	1.14	–	–

Comparison. This species differs from the closest *E. orbicularis* (Sowerby) (see Woods, 1899–1913; Albian-Cenomanian of Southern England) mainly in a higher shell; more acute umbonal angle (85°–95°, in the compared species 99°–115°); the absence of clearly defined wide concentric streaks on the surface of the right valve.

Occurrence. Berriasian–Hauterivian: Berriasian of the Crimea; Hauterivian of Germany.

Material. 60 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu River (village of Blagodatnoe, Novoklyonovo), Zuja (Balanovskoe Reservoir); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e); Upper Berriasian, *euthymi* Subzone—Sarysu River (village of Kozlovka) and *rjasonensis* Beds (Bel'bek River, village of Solnechnosel'e).

Family Propeamussiidae Abbot, 1954

Genus *Propeamussium* Gregorio, 1884

Propeamussium sokolowi (Retowski, 1893)

Plate 9, fig. 13

Pecten (Amusium) sokolowi: Retowski, 1893, p. 79, pl. 6, figs. 24–26.

Propeamussium sokolowi: Yanin in Arkadiev et al., 2012, p. 256, pl. 43, fig. 10.

Lectotype. TsNIGRM, no. 74/10916, specimen *Pecten (Amussium) sokolowi* (Retowski, 1893, pl. 6, fig. 25; left valve); Eastern Crimea (vicinity of Feodosia, St. Elijah); Tithonian; currently: Lower Cretaceous, Lower Berriasian, *jacobi* Zone, *grandis* Subzone (designated by Yanin in Arkadiev et al., 2012, p. 256).

Description. The shell (based on the left valve) small and medium-sized (Sh ≤ 31 mm), lenticular in shape, rounded in outline, thin-walled, slightly inequilateral (the posterior side is somewhat longer than the anterior), very slightly and evenly convex, and high.

The umbo is orthogyrate, pointed, not protruding from the dorsal margin; the apical angle is 110°. The auricles are well developed, almost identical, separated by deep grooves from the rest of the valve surface. The anterior, posterior and ventral margins are broadly rounded.

The surface with numerous (>50) very thin, symmetrical, sharply rounded radial ribs. Rib intercalation is well developed. The umbonal region of the valve is also covered with thin (filamentous) sharp, regular striae. A reticulate pattern is present at the intersection of radial and concentric elements. The intercostal spaces are flattened, equal in width or slightly wider than them. The auricles are covered with sparse longitudinal ribs and thin transverse striae. Eight (assumed 10–12) straight, deep, smooth, rounded grooved are observed on the mold, which are a reflection of large radial ribs covering the inner surface of the valve. The width between the ends of the grooves is 1.5–2 mm. The ribs on the internal surface do not reach the valve margins, leaving it smooth (limb width is about 5–7 mm). Usually found as molds with grooves left by internal ribs.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
TsNIGRM 116/13220 (LV)	12	20	1.6	1.5	0.12

Comparison. This species is distinguished from closely related species in the following: from *P. pawlowi* (see below), mainly by the presence of a relatively wide limb; fewer internal ribs (about 10–14 versus 30–34); the absence of a regular intercalation of internal ribs (in the *P. pawlowi*, a new rib appears in each intercostal space); from *P. ninae* (Karakash, 1897; Upper Albian of the Northern Caucasus, Georgia; Albian-Cenomanian of Crimea; Cenomanian of Moldavia)—straight (not fan-like) radial internal ribs; usually a higher shell and often more numerous external ribs.

Material. Two specimens; Crimea, Lower Berriasian, *jacobi* Zone, *grandis* Subzone—vicinity of Feodosia (southern coast of the Feodosia Bay); Tonas River (village of Krasnoselovka).

Propeamussium pawlowi (Retowski, 1893)

Plate 9, figs. 14, 15

Pecten (Amusium) pawlowi: Retowski, 1893, p. 80, pl. 6, figs. 27a, 27b.

Propeamussium pawlowi: Yanin in Arkadiev et al., 2012, p. 257, pl. 43, fig. 11.

Lectotype. TsNIGRM, no. 76/10916, specimen *Pecten (Amussium) pawlowi* from (Retowski, 1893, pl. 6, fig. 27b; mold of a valve with no umbonal region); Eastern Crimea (Feodosia, Cape St. Elijah); Tithonian; currently: Lower Cretaceous, Lower Berriasian, *jacobi* Zone, *grandis* Subzone (designated by Yanin in Arkadiev et al., 2012, p. 257).

Description. The shell is small (P ≤ 14 mm), lenticular, rounded, equilateral, flattened, high. The umbo orthogyrate, not pronounced; the preserved auricle is well separated, with a straight upper margin; the apical angle is 115°. The anterior, posterior and

ventral margins are convex, smoothly, along one curve, replacing each other. Surface of valves in umbonal region have thin radial and concentric ribs. As can be judged from the grooves on the mold, the inner radial ribs are numerous (33–34), smooth, rounded in cross section, fan-like radiating from the umbo (there are only a few straight ribs and they are located directly along the axial line of the valve); when approaching the anterior and posterior margins of the valves, the ribs bend upward, maintaining an orientation perpendicular to the margin. At their terminations, the ribs widen; this is especially noticeable at the anterodorsal and posterodorsal margins. Rib intercalation is widely developed. The width of the spaces between their terminations near the ventral margin of the valve does not exceed 1 mm. The ribs do not extend to the very margin of the valve, leaving a very narrow limb (about 1 mm). Usually found molds with grooves left by internal ribs.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
TsNIGRM 117/13/220 (mold)	12	14	1.1

Comparison. Comparison with *P. sokolowi*, see above. This species differs from *P. ninae* (Karakash, 1897; Upper Albian of the Northern Caucasus) in a large number of internal ribs (33–34 versus 12–16); more pronounced radiation in the arrangement of these ribs; and in the less acute apical angle.

Remarks. According to Retowski (1893, pl. 6, fig. 27a), the outer surface of the valve of P. *pawlowi* that he studied, at width of 15 mm, is covered with numerous (about 100) thin radial striae.

Material. Four specimens; Crimea, Lower Berriasian, *jacobi* Zone, *grandis* Subzone—vicinity of Feodosia (south coast of Feodosia Bay).

Family Neitheidae Sobetski, 1960

Subfamily Neitheinae Sobetski, 1960

Genus *Neithea* Drouet, 1824

Subgenus *Neitheops* Stewart, 1930

***Neithea (Neitheops) simplex* Mordvilko in Bogdanova et Lobacheva, 1966**

Plate 10, figs. 10–12

Neithea simplex: Bogdanova and Lobacheva, 1966, p. 82, pl. 8, figs. 11, 12, 18; Bogdanova, 1988, p. 139, pl. 31, fig. 9 and 10; 1997, p. 74, pl. 18, fig. 2; Bogdanova and Yanin, 2004, p. 68, pl. 25, fig. 12; Yanin in Arkadiev et al., 2012, p. 266, pl. 44, figs. 3, 4.

Neithea (Neithea) simplex: Bogdanova, 1993, p. 111, pl. 1, fig. 1, 2.

Neithea (Neitheops) simplex: Bogdanova and Yanin, 1995, p. 50, pl. 5, fig. 13, 14.

Holotype. TsNIGRM, no. 1/9576, specimen of *N. simplex* Mordvilko (in Bogdanova and Lobacheva, 1966, pl. 8, fig. 18; right valve); Northern Caucasus (Nalchik District); Lower Cretaceous, Berriasian (by original designation: Bogdanova and Lobacheva, 1966, p. 82).

Description. The shell is small (Sh ≤ 29 mm), subtriangular, coarsely ribbed, equilateral, inequivalvate (right valve strongly convex, while the left valve is flat), high (H > L). The umbo of the right valve is gryphoid, very high, strongly protruding above the dorsal margin; the tip of the umbo is straight, strongly turned inside the valve; the apical angle is 60°–65°. The auricles are almost equal, the anterior is sharp, the back is obtusely rounded; the byssal notch is not pronounced. The anterodorsal and posterodorsal margins slightly concave and of equal length; anteroventral and posteroventral margins of the valve are convex.

The surface of the right valve has radial ribs of two orders: six main ones are high, simple, smooth, symmetrical, with a rounded ridge, separated by intercostal spaces, each of with one additional rib, similar in morphology to the main ones, but lower than them. In the holotype, almost on the entire surface of the valve, the ribs are the same in height and width, only on the apex one can notice the alternation of the main and auxiliary ribs. On some specimens, the auxilliary ribs are different throughout the valve, they are always lower than the main ribs. The ends of the ribs, reaching the valve margin, form small identical wavy protrusions. The intercostal spaces are deep, narrow (narrower than ribs), and smooth. Concentric striae form a slightly undulating pattern in horizontal view; all radial ribs are crossed by concentric striae at a right angle. The auricles are covered with numerous thin transverse ribs.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN5596/111 (RV)	7	9	1.28	–	–
PIN 5596/112 (RV)	9	11	1.22	–	–
TsNIGRM20/12701(RV)	14	18	1.28	8	0.57
PIN 5596/110 (RV)	15	20	1.33	8.5	0.56
TsNIGRM21/12701(RV)	25	29	1.10	13	0.52

Comparison. This species differs from *N. (N.) valangiensis* (see below) in the almost equal main and auxiliary radial ribs; slightly undulating ventral margin (without sharp angular projections); more symmetrical and not beveled shell; almost equal auricles; from *N. (N.) atava* (Roemer) (d'Orbigny, 1843–1847; Neocomian of Germany and France) and from *N. (N.) morrisi* (Pictet et Renevier, 1858; Aptian of Switzerland) differs in the presence one rib in each intercostal space; in the slightly undulating (without projections) ventral margin.

Occurrence. Berriasian of the Crimea, Northern Caucasus, Kopetdag, Mangyshlak, and Japan.

Material. 19 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern slope of Aipetri Yaila (Bakhchisaray–Yalta Highway); the same Zone, *grandis* Subzone—northwestern margin of the Karabi–Yaila Plateau (highway in the village of Blagodatnoe, north of the "bulldozer clearing"); the same Zone, *chaperi* Beds–Sarysu River (village of Blagodatnoe) and Middle, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e).

***Neithea* (*Neitheops*) *subsimplex* Bogdanova et Yanin, 1995**

Plate 10, figs. 13–16.

Neithea (*Neitheops*) *subsimplex:* Bogdanova and Yanin, 1995, p. 51, pl. 5, figs. 15–18.

Neithea subsimplex: Yanin in Arkadiev et al., 2012, p. 267, pl. 44, figs. 5, 6.

Holotype. TsNIGRM, no. 27/12701, specimen *N. (N.) subsimplex* (Bogdanova and Yanin, 1995, pl. 5, fig. 16; right valve); Central Crimea, Sarysu River(village of Novoklyonovo); Lower Cretaceous, Lower Berriasian (by original designation by Bogdanova and Yanin, 1995, p. 51).

Description. The shell is small in size (P ≤ 18 mm), subtriangular in outline, coarsely ribbed, equilateral, rarely gently oblique, inequivalvate. The right valve is strongly convex, narrow and high. The anterior margin is short, slightly convex; the posterior margin is long, straight; the ventral margin is rounded, with weak angular projections. The umbo gryphoid, prominent; apical angle 53°–66°.

The surface with two types of radial ribs: six main ribs, strongly protruding, with rounded ridges; accessory ribs unequally developed, usually two in each intercostal space; one of them, stronger, and in anterior of it, practically in contact with it, a weak rib. In some specimens, the ribs bear sharp transverse scales. The auricles are almost the same, slightly oblique. The left valve is flat, inequilateral, with six wide smooth ribs and narrow intercostal spaces.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
TsNIGRM 27/12701 (RV) (holotype)	7.0	8.9	1.27	3.7	0.50
TsNIGRM 30/12701 (RV)	9.6	11.0	1.13	6.0	0.62
TsNIGRM 32/12701 (RV)	11.4	13.6	1.19	6.5	0.57
TsNIGRM 31/12701 (RV)	14.8	18.8	1.27	7.0	0.46

Comparison. This species differs: from *N. (N.) simplex* (see above) in the presence of two unequal auxiliary ribs in the intercostal spaces (*N. (N.) simplex* has only one such rib, almost no different from the main ones); from *N. (N.) valangiensis* (see below) differs in the presence of two auxiliary ribs (instead of three in the compared species); lesser shell obliqueness and less angular contours of the ventral margin of the valves; from *N. (N.) neocomiensis* (see below) it is distinguished by the presence in the intercostal spaces in adult forms of two auxiliary ribs (in the compared species, thin auxiliary ribs or strands are sometimes traced only in the umbo region) and a less sharp, not angular ventral shell margin.

Occurrence. Berriasian of the Crimea, Mangyshlak, and Afghanistan.

Material. 15 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *grandis* Subzone—northwestern margin of the Karabi-Yaila Plateau (Kazanlyk basin); the same Zone, *chaperi* Beds—Zuja River (Balanovskoe Reservoir) and Sarysu (village of Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e), Beshterek River (village of Solovjevka) and Sarysu River (village of Novoklyonovo).

***Neithea (Neitheops) valangiensis* (Pictet et Campiche, 1870)**

Plate 10, figs. 1–9

Janira valangiensis: Pictet, Campiche, 1868–1871, p. 242, pl. 181, figs. 1–3.

Neithea valangiensis: Muromtseva, 1960, p. 190, pl. 11, fig. 1–3; Bogdanova, 1966, p. 84, pl. 9, fig. 1, 2; 1993, p. 111, pl. 1, figs. 3–5; Yanin in Arkadiev et al., 2012, p. 265, pl. 44, figs. 1, 2; Yanin, 2020a, p. 10, pl. 1, fig. 7.

Neithea (*Neithella) valangiensis*: Dhondt, 1973, p. 70.

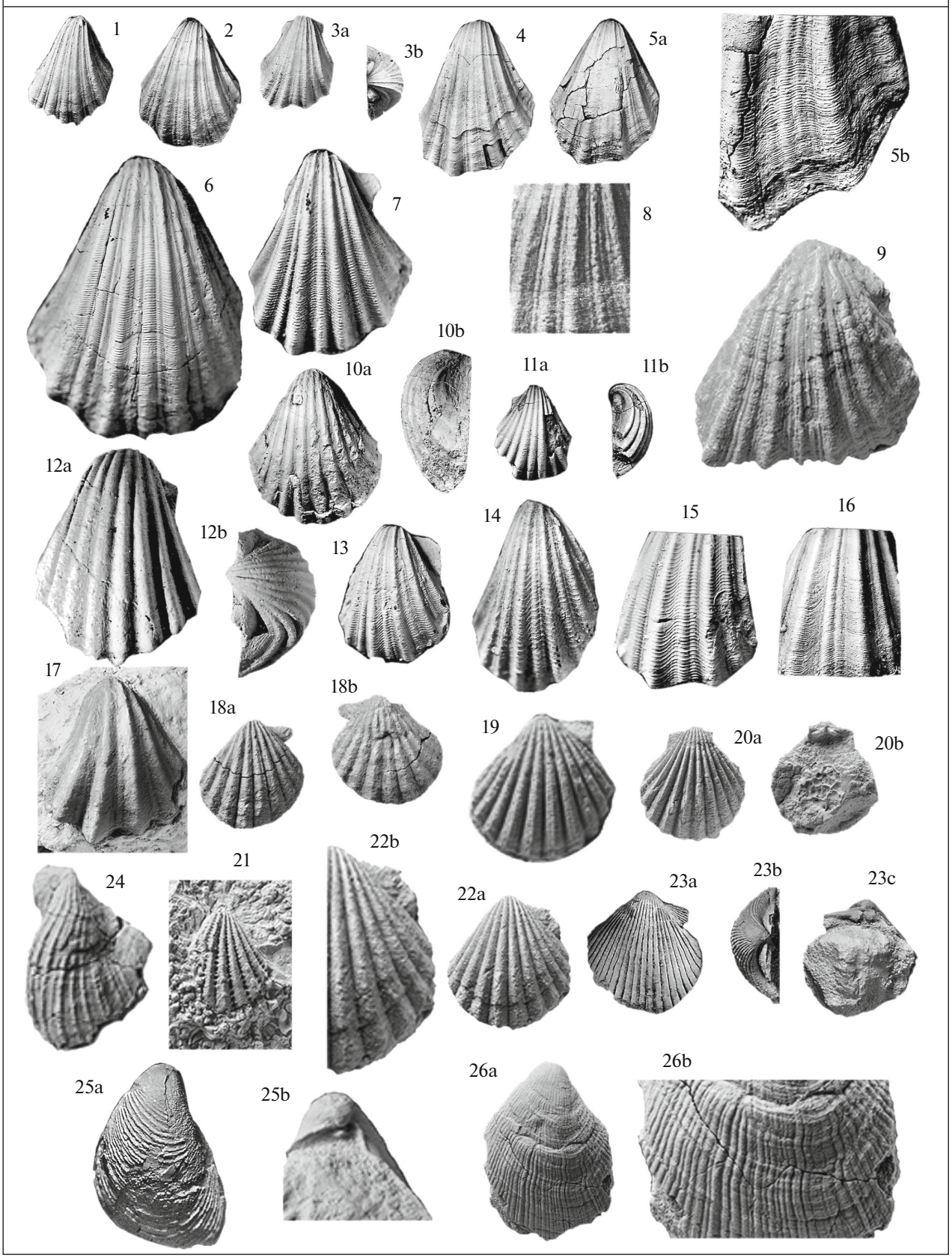
Neithea (Neitheops) valangiensis: Bogdanova and Yanin, 1995, p. 50, pl. 5, figs. 5–12.

Lectotype. A specimen of *Janira valangiensis* (in Pictet and Campiche, 1868–1871, pl. 181, figs. 1a–1c; shell); Geological Museum of Lausanne (Switzerland); specimen no. 17628; Switzerland (Sainte-Croix); Lower Cretaceous, Upper Valanginian (designated by Dhondt, 1973, p. 70).

Description. The shell is small and medium-sized (Sh ≤ 28 mm), subtriangular in shape, coarsely ribbed, inequivalvate, usually somewhat oblique. The right valve strongly and uniformly convex, high (H > L), narrow to moderately wide. Anterior margin straight or slightly concave; back are slightly concave; the ventral margin with deep angular protrusions (the largest protrusion is formed by the fourth rib).

The surface is covered with main and additional radial ribs: there are six main ribs, strong, smooth, with a sharp ridge and equal flattened slopes; auxiliary ribs, three in each intercostal space; they are smooth, lower and narrower than the primary ribs; also rounded and uniform; of these, the middle one is the strongest; in adult forms, the auxiliary ribs sometimes almost reach the size of the primary ones; with their endings they do not serrate the valve margins. On both sides of the auxiliary ribs are very narrow ribs (one on each side). Sometimes, instead of ribs, translucence of

Plate 10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23a
23b
23c
24
25a
25b
26a
26b

thin streams is noticeable. The concentric striae are very thin, sharp, of the same type of structure, forming an angular pattern. The umbo is orthogyrate, high, strongly projecting from the dorsal margin; its tip is straight, curved inwards; apical angle 55°–60°.

The left valve is flat or slightly concave, oblique. The anterior and posterior margins are straight; the ventral margin is rounded, strongly serrated. There are six main ribs, two additional ribs in each gap. The auricles of both valves ate well delineated, unequal (anterior auricle long and pointed, the posterior is short, obtusely rounded); the anterior auricle is covered with thin oblique riblets, the posterior bears transverse riblets. The byssal notch is clearly expressed, located under the anterior auricle of the right valve.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
TsNIGRM17/12701 (RV)	9.9	14	1.41	6	0.62
TsNIGRM11/12701 (RV)	10	12	1.20	4	0.40
PIN 5596/107 (RV)	13	14	1.0	6	0.50
TsNIGRM13/12701 (RV)	13	17	1.30	6	0.46
TsNIGRM16/12701 (RV)	15	18.5	1.23	7	0.46
TsNIGRM19/12701 (LV)	16	16.8	1.04	–	–
TsNIGRM18/12701 (LV)	17	19.5	1.14	–	–
TsNIGRM12/12701 (RV)	22	28	1.27	10	0.45

Comparison. This species is distinguished from *N. (N.) neocomiensis* (see below) by the presence of auxiliary ribs in the intervals between the main ones

Explanation of Plate 10

Figs. 1–9. *Neithea (Neitheops) valangiensis* (Pictet et Campiche): (1) specimen TsNIGRM, no. 9/12701, right valve, external view, lateral view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (2) specimen TsNIGRM, no. 10/12701, right valve, external view, lateral view, ×1; the same locality, age and collector; (3) specimen TsNIGRM, no. 15/12701, right valve, external view, ×1: (3a) lateral view, (3b) umbonal view; the same locality, age and collector ; (4) specimen TsNIGRM, no. 8/12701, right valve, external view, lateral view, ×1; the same locality, age and collector; (5) specimen TsNIGRM, no. 14/12701, right valve, external view: (5a) lateral view, ×1; (5b) enlarged area of its surface near the posterior margin, ×3; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (6) specimen TsNIGRM, no. 13/12701, right valve, external view, lateral view, ×3; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. G.K. Kabanov); (7) specimen TsNIGRM, no. 11/12701, right valve, external view, lateral view, ×3; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1956); (8) specimen TsNIGRM, no. 8/12701, enlarged area of the surface of the right valve; the same age and locality (coll. B.T. Yanin, 1959); (9) specimen PIN, no. 5596/107, right valve, external view, lateral view, ×3; northern slope of Aipetri Yaila, Bakhchisaray-Yalta highway; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1986).

Figs. 10–12. *Neithea (Neitheops) simplex* Mordvilko: (10) specimen TsNIGRM, no. 21/12701, right valve, external view, ×2: (10a) lateral view and (10b), anterior view; Bel'bek River, village of Bogatoe Ushchel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (11) specimen TsNIGRM, no. 20/12701, right valve, external view, ×1; Kuibyshevo, Kabaniy Log; the same age and collector; (12) specimen PIN, no. 5596/110, right valve, external view, ×2: (12a) lateral view and (12b) umbonal view; Bel'bek River, village of Solnechnosel'e; the same age (coll. G.K. Kabanov, 1961).

Figs. 13–16. *Neithea (Neitheops) subsimplex* Bogdanova et Yanin: (13) specimen TsNIGRM, no. 27/ 12701, right valve, external view, lateral view, ×1; northern slope of the Karabi-Yaila Massif, Kazanlak Depression; Lower Berriasian, *grandis* Subzone (coll. B.T. Yanin, 1962); (14) specimen TsNIGRM, no. 26/12701, right valve, external view, lateral view, ×2; Sarysu River, village of Novoklyonovo; Lower Berriasian, *chaperi* Beds (coll. the same); (15) specimen TsNIGRM, no. 28/12701, enlarged area of the surface of the right valve, ×3; Zuja River, Balanovskoe Reservoir; the same age and collector; (16) specimen TsNIGRM, no. 29/12701, enlarged area of the surface of the right valve, ×3; the same locality, age and collector.

Fig. 17. *Neithea (Neitheops) neocomiensis* (d'Orbigny), specimen PIN, no. 5596/113, right valve on limestone plate surface, external view, lateral view, ×2; Malyi Salgir River, village of Ivanovka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1975).

Figs. 18–22. *Spondylopecten subspinosus* (Schlotheim): (18) specimen PIN, no. 5596/115, shell, external view, lateral view, ×2: (18a) right valve view and (18b) left valve view; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. G.K. Kabanov, 1961); (19) specimen PIN, no. 5596/116, right valve, external view, ×1.5; the same age and locality (coll. B.T. Yanin, 1956); (20) specimen PIN, no. 5596/117, right valve, ×1.5: (20a) external view, lateral view and (20b) from inside; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962); (21) specimen PIN, no. 5596/118 , right valve on limestone plate surface, external view, lateral view, ×1.5; Tonas River, village of Krasnoselovka; Lower Berriasian, *jacobi* Zone (coll. V.V. Drushchits, 1954); (22) specimen PIN, no. 5596/119, left valve, external view, lateral view: (22a) ×2, (22b) enlarged section of the anterior side of the valve, ×4; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1961).

Fig. 23. *Spondylopecten aequatum* (Quenstedt), specimen PIN, no. 5596/123, left valve, ×1: (23a) external view, lateral view, (23b) umbonal view, (23c) from inside; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1961).

Fig. 24. *Oxytoma cottaldina* (d'Orbigny), specimen PIN, no. 5596/124, left valve, external view, lateral view, ×1.2; Beshterek River, village of Solovjevka; Middle Berriasian, Zone *tauricum* (coll. V.V. Drushchits).

Fig. 25. *Buchia uncitoides* (Pavlow, 1907), specimen PIN, no. 5596/125, left valve: (25a) external view, lateral view, ×1.5, (25b) from inside, ×2; Bel'bek River, Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962).

Fig. 26. *Buchia striata* Yanin, sp. nov., specimen PIN, no. 5596/126, holotype, left valve, external view, lateral view: (26a) ×1.5, (26b) enlarged area of its surface, ×3; Sarysu River, village of Novoklyonovo; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956).

(the compared species has only the main ribs); a greater degree of unevenness of the auricles; by the narrower right valve and slightly oblique shell; it differs from *N. (N.) atava* (Roemer, 1839; Neocomian of Germany) by the presence of only three auxiliary ribs in one intercostal space on the right valve instead of five or seven in *N. (N.) atava* and smaller shell size; from *N. (N.) subsimplex* (see above) mainly by a strong oblique shell; the presence of symmetrically arranged ribs of three orders (on each side of the accessory rib there are thin ribs of the third order; in *(N. (N.) subsimplex* ribs of the third order are traced only on the anterior side of the auxiliary rib); it is also distinguished by a strongly angular ventral margin of the shell.

Remarks. One cannot agree with Dondt (1973), who attributed the described species to the subgenus *Neithella*, since the latter is characterized by four to five main ribs and a very strongly pronounce difference in auricles.

Occurrence. Berriasian–Hauterivian: Berriasian of the Crimea, Northern Caucasus; Hauterivian of Kopetdag; Upper Valanginian of Switzerland.

Material. 60 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern slope of Aipetri Yaila (Bakhchisarai highway, Malyi Salgir River (village of Glubokoe); the same Zone, *chaperi* Beds—Zuja River (Balanovskoe Reservoir), Sarysu River (village of Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e), Beshterek River (village of Solovjevka).

***Neithea (Neitheops) neocomiensis* (d'Orbigny, 1846)**

Plate 10, fig. 17

Janira neocomiensis: d'Orbigny, 1843–1847, p. 629, pl. 442, fig. 4, 6–9;

Loriol, 1861, p. 104, pl. 14, fig. 2, 3.

Neithea (Neithea) atava: Dhondt, 1973, p. 40 (pars).

Neithea (Neitheops) neocomiensis: Bogdanova and Yanin, 1995, p. 51, pl. 5, figs. 19–23; pl. 6, fig. 1, 2.

Neithea neocomiensis: Yanin in Arkadiev et al., 2012, p. 267, pl. 44, fig. 7.

Lectotype. A specimen of *Janira neocomiensis* (d'Orbigny, 1843–1847, pl. 442, figs. 6–8; shell); housed at the National Museum of Natural History (Paris), no. 5136B; France; Lower Cretaceous, Hauterivian (designated by Yanin in Arkadiev et al., 2012, p. 268).

Description. The shell (based on the right valve) is small and medium-sized (H = 34 mm), coarsely ribbed, subtriangular, high (H > L), strongly convex. The umbo is gryphoid, prominent; the apical angle is 60°–64°. The auricles are delineated, almost equal. There are six main radial ribs, simple, smooth, coarse, high, triangular-rounded in section; the auxiliary ribs are weakly expressed, they are present only in the umbonal region. The intercostal spaces are wide, usually flattened, and smooth. The ventral margin of the valves is sharply serrated at the ends of the primary ribs.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/113 (RV)	13	16	1.2	–	–
PIN 5596/114 (RV)	30	34	1.1	20	0.6

Comparison. This species differs from all Lower Cretaceous species in the absence of auxiliary ribs in the intercostal spaces (between the main ribs) on adults.

Occurrence. Berriasian–Aptian: Middle Berriasian–Hauterivian of the Crimea; Lower Aptian of Mangyshlak; Valanginian–Hauterivian of Afghanistan; Hauterivian of France, Switzerland.

Material. Two specimens; Crimea, Middle Berriasian, *tauricum* Subzone—Malyi Salgir River (village of Ivanovka).

Family Spondylopectinidae Kasum-Zade et Romanov, 1987

Subfamily Spondylopectininae Kasum-Zade et Romanov, 1987

Genus *Spondylopecten* Roeder, 1882

***Spondylopecten subspinosus* (Schlotheim, 1820)**

Plate 10, figs. 18–22; Fig. 29.4

Pectinites subspinosus: Schlotheim, 1820, p. 223.

Pecten subspinosus: Quenstedt, 1858, p. 500, pl. 67, figs. 3, 4; Boehm, 1883, p. 612, pl. 67, figs. 40, 41.

Spondylopecten subspinosus: Pchelincev, 1931, p. 53; Yamani, 1975, p. 59, pl. 3, figs. 3–6; Bogdanova, 1997, p. 73, pl. 18, fig. 1.

Spondylopecten (*Plesiopecten*) *subspinosus*: Abdulkasumsade and Gasanov, 1956, p. 52, pl. 3, fig. 10.

Plesiopecten subspinosus: Bogdanova in Arkadiev et al., 2005, p. 129, pl. 2, figs. 1–10 (sine descript.); Yanin in Arkadiev et al., 2012, p. 445, figs. 7, 8 (sine descript.).

Holotype. Not designated.

Description. The shell is small (P ≤ 14 mm), ribbed, rounded-triangular, equilateral, slightly inequivalvate: the right valve is more convex than the left. The umbo is orthogyrate. The auricles are large, unequal, the anterior is longer than the posterior; they are separated from the lateral surface by deep depressions on both valves. Both valves have 11–13 strong radial ribs, which (depending on the preservation of the specimens) have different shapes: from rounded to pointed, crested in cross section; often granules or small spines remain on the crests of the ribs. The anterior ear of the right valve is covered with three ribs with granules; on some specimens, the upper margin of the auricle has very fine spines. The cardinal area on both valves is very small, subtriangular. The hinge is isodont (Fig. 29.4): on the right valve with two hook-shaped teeth, one on each side of the slit-like resilifer; the tooth sockets correspond to them on the left valve.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
PIN 5596/118 (RV)	8	13	1.6
PIN 5596/120 (RV)	9	9	1.0
PIN 5596/121 (RV)	9	10	1.1
PIN 5596/115 (Sh)	10	10	1.0
PIN 596/119 (RV)	12	14	1.1
PIN 5596/117 (RV)	12	14	1.1
PIN 5596/116 (RV)	13	13	1.0
PIN 5596/122 (RV)	16	–	–

Comparison. This species differs from *S. aequatus* (see below) in the smaller number of radial ribs (11–13 versus 25); in the rounded, non-carinate crest; coarsely serrated valve margins; from *S. roederi* (Loriol) (see Cox and Newell, 1969; Oxford France and Switzerland) differs in the less numerous radial ribs; narrower resilifer (in *S. roederi* it is wide, triangular; and in the more distinctly serrated shell margin).

Occurrence. Middle Jurassic–Berriasian: Berriasian of the Crimea; Kimmeridgian– Tithonian of the Northern Caucasus; Callovian–Tithonian of Southern France, Switzerland, Germany, Poland; Upper Tithonian of the Czech Republic (Štramberk).

Material. 18 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *grandis* Subzone—Tonas River (village of Krasnoselovka, Kuchuk-Uzen' Creek; Krasnoselovka–Povorotnoe highway); Middle Berriasian, *tauricum* Subzone—the northern side of the Baidar Depression (the village of Peredovoe, Biyuk-Uzen' Ravine); Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e) and Beshterek River (village of Solovjevka); Upper Berriasian, *euthymi* Subzone—Bel'bek River (Kuibyshevo, Kabaniy Log).

Spondylopecten aequatus (Quenstedt, 1858)

Plate 10, fig. 23

Pecten aequatus: Quenstedt, 1858, p. 755, pl. 92, fig. 12.

Spondylopecten aequatus: Bogdanova in Arkadiev et al., 2005, p. 127, pl. 2, fig. 11, 12 (sine descript.); Yanin in Arkadiev et al., 2012, p. 445, pl. fig. 9 (sine descript.).

Holotype. A specimen of *Pecten aequatus* in (Quenstedt, 1858, pl. 92, fig. 12; left valve); Germany (Kelheim, "Diceratenkalken"); Upper Jurassic (designated by monotypy herein).

Description. The shell is small (H = 22 mm), ribbed, rounded, with evenly convex margins; in the upper part, the anterior and posterior margins are straight or slightly concave; strongly and evenly convex, equally folded; equilateral. The umbo is orthogyrate, strongly prominent; its tip hangs over the cardinal platform. The auricles are well developed, the anterior ones are longer than the posterior ones, its external angle is 90°; the posterior auricle is oblique, its angle is 130°; the auricles are delineated from the lateral surface of the valve: the anterior auricle is separated by a deep groove; the posterior auricle is separated by a narrow smooth concave stripe.

The surface of right valve with 25 equal, smooth, rounded, symmetrical radial ribs separated by narrow (narrower than ribs), smooth, concave, or flattened intercostal spaces. The anterior auricle bears seven radial smooth ribs subparallel to the dorsal margin. The byssal notch is located under the anterior auricle, deep, separated from the auricle by the seventh rib, bearing small granules acting as a ctenolium. The posterior auricle on our specimens is broken off.

The cardinal area is broadly triangular, its upper end touching the tip of the umbo. The isodont hinge consists of two tubercular teeth on the right valve, located on both sides of the narrow resilifer, and two corresponding tooth pits on the opposite valve. The margins of the valves are finely and undulately serrated from the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
TsNIGRM 17/13139 (RV)	19	19	1.0
PIN 5596/123 (LV)	20	22	1.1

Comparison. This species differs from *S. subspinosus* (see above) in a large number of ribs (25 versus 11–13), which are thinner, smooth, oval in cross-section (in *S. subspinosus*, the ribs are angular in cross-section, often with a sharp ridge covered with small spikes or granules); fine wavy serration of valve margins; from *S. roederi* (Loriol) (see Cox and Newell, 1969; Oxford France) it differs in the thinner, smooth, rounded ribs (in *S. roederi*, they are angular in section and usually with spines and granules).

Occurrence. Kimmeridgian–Berriasian: Berriasian of the Crimea; Upper Kimmeridgian–Tithonian of Germany, Switzerland, Italy (Sicily), Czech Republic (Štramberk); Tithonian of France (Mont Salève). As indicated by Pchelintsev, one redeposited specimen was found at the base of the Maastrichtian on the southern slope of the Greater Caucasus.

Material. Four specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *grandis* Subzone—Tonas River (village of Krasnoselovka, Kuchuk-Uzen' Creek); Middle Berriasian, *tauricum* Subzone—Chernaya and Balaklava rivers, flux quarry) and Bel'bek (village of Kuibyshevo, Kabaniy Log).

Suborder Aviculopectinida Waterhouse, 2001

Superfamily Aviculopectinoidea Meek et Hayden, 1864

Family Oxytomidae Ichikawa, 1958

Genus *Oxytoma* Meek, 1964

***Oxytoma cottaldina* (d'Orbigny, 1845)**

Plate 10, fig. 24.

Avicula cottaldina: d'Orbigny, 1843–1847, p. 470, pl. 389, figs. 1, 2.

Lectotype. A specimen of *Avicula cottaldina* (d'Orbigny, 1845, pl. 389, fig. 1; shell); France (l'Yonne); Lower Cretaceous, Neocomian (designated herein).

Description. The shell (based on a left valve) is small in size (P ≤ 25 mm), pterygoid in shape, with well-defined anterior and posterior auricles, inequilateral, with protruding umbo. The anterior auricle is shorter than the posterior and narrower (the tips of both auricles are broken off). The auricles are separated from the lateral field by distinct depressions. The lateral field is uniformly convex. The entire surface of the valve is covered with primary and secondary radial ribs, extending obliquely from the apex of the umbo to the posterior and ventral margins. The ribs are carinate, the main ones are separated by wide, flat, smooth intervals; the coarsest ribs are on the anterior side of the valve. On the anterior auricle, the ribs are short, subconcentric; on the posterior auricle, they are thin, radial.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
PIN 5596/124 (LV)	16	16	1.0

Comparison. This species differs from the most similar species in the following: from O. cornueliana (d'Orbigny, 1843–1847; Neocomian of France)—in the higher and more oblique valve; larger auricles; less ordered arrangement of main and auxiliary ribs; from *O. carteroni* (d'Orbigny, 1843–1847; Neocomian, France)—in the more strongly oblique and lower valve (H/L = 0.8 versus 1.6); longer auricles and smooth ribs (no scales).

Remarks. In the original description (d'Orbigny, 1843–1847, p. 470), it was indicated that Plate 389 shows one specimen in two views (lateral and top views), but as we have established, this plate called *Avicula cottaldina* shows two specimens; both in the left side view. Of these, we chose the valve no. 1 as the lectotype. The lectotype is much larger than the Crimean specimen described here (D = 77 mm, V = 75 mm versus 16 and 16 mm, respectively).

Occurrence. Berriasian–Aptian: Berriasian of the Crimea, Neocomian of France, Hauterivian–Lower Aptian of southern England.

Material. One specimen; Crimea, Middle Berriasian, *tauricum* Subzone—Beshterek River (village of Solovjevka).

Superfamily Buchioidea Cox, 1953

Family Buchiidae Cox, 1953

Genus *Buchia* Rouillier, 1845

***Buchia uncitoides* (Pavlow, 1907)**

Plate 10, fig. 25

Aucella uncitoides: Pavlow, 1907, p. 61, pl. 5, fig. 14, 15; Sokolov, 1908, p. 11, pl. 1, figs. 10–14; Mordvilko et al., 1949, p. 146, pl. 81, fig. 3.

Buchia uncitoides: Jeletzky, 1964a, p. 36, pl. 4, figs. 2–4; 1964b, p. 6, pl. 2, figs. 1, 2, 4, 6, 7; Jones et al., 1969, p. A14, pl. 3, figs. 1–19; Bogdanova, 1988, p. 142, pl. 19, figs. 3–10; pl. 20, fig. 9; pl. 21, fig. 1–5; Bogdanova and Yanin, 2004, pl. 27, figs. 8–14 (sine descript.).

Holotype. Not designated.

Description. The shell (along the left valve) is small (H = 24 mm), obliquely triangular in outline, inequilateral (anterior side is almost two times shorter than the posterior one, obliquely drawn in a postero-ventral direction); moderately and evenly convex (the line of greatest convexity extends obliquely from the umbo to the posteroventral margin). The anterior margin weakly convex, gradually changing into strongly convex ventral margin; the posterior margin is almost straight; the postero-ventral margin is strongly convex, steeply rounded. The umbo prosogyrate, narrow, strongly protruding; its sharp tip is bent inward and forward. The auricles are not preserved. The ligament area is obliquely triangular, with a narrow resilifer directed backwards. The surface possesses numerous regular, thin, smooth concentric ribs.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
PIN 5596/125 (LV)	17	24	1.4

Comparison. The Crimean specimen of *B. uncitoides* differs (based on the left valve) differs from the most similar *B. lahuseni* (Pavlow, 1907; Upper Volgian and Neocomian Substage of the East European Platform) in the narrower umbo region; more inward-curved umbo tip; more oblique valves and more regular concentric ribs.

Occurrence. Berriasian of the Crimea, East European Platform (Izhma River), Mangyshlak, Kopetdag, North Siberia, Northeast Eurasia, USA (California), Canada.

Material. One specimen; Crimea, Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Solnechnosel'e).

***Buchia striata* Yanin, sp. nov.**

Plate 10, fig. 26

Etymology. From the Latin *striata* (striate).

Holotype. PIN, no. 5596/126, left valve; Central Crimea, Sarysu River (village of Novoklyonovka); Lower Cretaceous, Lower Berriasian, *jacobi* Zone, *chaperi* Beds.

Description. The shell (based on the left valve) is small (H = 16 mm), finely radially striate, triangular-oval, weakly unequal, moderately and uniformly convex (the line of greatest convexity extends from the umbo to the middle of the ventral margin). The anterior margin is weakly convex, gradually changing into strongly convex ventral margin; the posterior one is straight in the upper part, broken off in the lower part, but judging from the growth lines, it is not extended in the posteroventral direction. The umbo is orthogyrate, narrow, strongly protruding, its sharp tip curved inward and forward. The ligament pit is small, rounded in outline.

The surface has concentric growth lines and numerous very thin, smooth, rounded, densely spaced radial striae, dichotomizing, in places sinuous; spaces between them are smooth, concave or flattened, of varying widths.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
PIN 5596/126 (LV) holotype	13	16	1.2

Comparison. In terms of general shell shape, it is very close to *B. terebratuloides* (Lahusen, 1888), which is widespread in the Volgian, Berriasian, and Valanginian deposits of Northern Eurasia, but differs from it in the absence of regular concentric ribbing and the presence of fine radial striation.

Material. One specimen from the type locality.

Superfamily Limoidea Rafinesque, 1815

Family Limidae Rafinesque, 1815

Genus *Limatula* Wood, 1839

***Limatula tombeckiana* (d'Orbigny, 1845)**

Plate 11, figs. 1–4

Lima tombeckiana: d'Orbigny, 1843–1847, p. 534, pl. 415, fig. 13–16; Loriol, 1861, p. 95, pl. 11, fig. 11; Pictet and Campiche, 1868–1871, p. 148.

Lima tombecki: Karakash, 1897, p. 39, pl. 1, figs. 6a, 6b.

Lima (Limatula) tombeckiana: Woods, 1899–1913, p. 45, pl. 7, fig. 7–9.

Limatula tombeckiana: Muromtseva, 1960, p. 194, pl. 12, fig. 11, 12; Bogdanova, 1966, p. 99, pl. 9, fig. 17; Yanin in Arkadiev et al., 2012, p. 260, pl. 43, fig. 14.

Holotype. Specimen *Lima tombeckiana* (d'Orbigny, 1843–1847, pl. 415, figs. 13–15; shell); Switzerland (vicinity of Neuchatel); Lower Cretaceous, Neocomian (designated by monotypy: Yanin in Arkadiev et al., 2012, p. 260).

Description. The shell is small (P ≤ 12.5 mm), suboval in outline, very slightly oblique (angle 110°–115°), strongly convex, inequivalvate, high (H > L). The umbo is prominent, pointed, almost central; the apical angle is 67°–70°. The anterior margin is long, slightly convex; the ventral margin is short, sharply rounded; with is a clear inflection between ventral and anterior margins; the posterior margin is long, weakly and uniformly convex, smoothly turning into ventral; the dorsal margin is short and straight. The auricles are very small, almost identical (the anterior one is only slightly longer than the posterior one); the angle of both auricles is about 115°. There is no depression under the anterior auricle.

The surface of both valves with 13–17 identical, straight, sharply rounded, finely scaly (granular), symmetrical radial ribs. The ribs are developed in the middle part of the valve, they thin out towards the margins and quickly disappear, leaving the anterior and posterior sides of the valve smooth. The intercostal spaces are narrow (equal in width to ribs), deep, concave, smooth. The posterior margin of the valve is weakly and uniformly convex; the anterior margin is flattened, especially in the upper part. In some forms, at high magnification, fine radial striations are visible on both sides of the valves. The ligament area is very small, triangular, narrow, slightly concave, smooth; the resilifer is deep, in the form of an asymmetric, slightly oblique forward triangle. The ventral margin is finely serrated on the inside by the rib terminations.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/129 (RV)	7	10	1.4	–	–
PIN 5596/127 (RV)	8	12	1.50	6	0.74
PIN 5596/130 (RV)	8	13	1.6	–	–
PIN 5596/128 (RV)	10	12.5	1.25	8	1.80

Comparison. This species differs from the most similar species *L. dupiniana* (d'Orbigny, 1843–1847; Neocomian of France) in the more rounded shell outline; lower and wider shell (H/L 1.25–1.6 versus 1.70); less symmetrical, noticeably anteroventral oblique shell; coarser, rounded, granular ribs (in the compared species, the ribs are smooth); narrower intercostal spaces; it is distinguished from *L. gajurensis* Bogdanova (Bogdanova and Lobacheva, 1966; Barremian of Kopetdag) by a significantly fewer ribs (13–17 versus 40); development of ribs only on the middle part of the valve; the presence of small granules on the ribs (shells of *L. gajurensis* have smooth ribs).

Occurrence. Berriasian–Aptian: Berriasian–Valanginian of the Crimea; Berriasian–Hauterivian of the Northern Caucasus; Hauterivian–Lower Barremian Kopetdag; Valanginian–Lower Aptian of France, Switzerland; Lower Aptian of England.

Material. Four specimens; Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu River (village of Blagodatnoe); Middle Berriasian, *tauricum*

Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log, village of Solnechnosel'e).

Genus *Plagiostoma* J. Sowerby, 1814

Plagiostoma dubisiensis **(Pictet et Campiche, 1868)**

Plate 11, figs. 5–10

Lima dubisiensis: Pictet, Campiche, 1868–1871, p. 124, pl. 161, figs. 2, 3; Renngarten, 1926, p. 52, pl. 3, fig. 3, 4; Muromtseva, 1960, p. 192, pl. 12, fig. 1.

Lima (Plagiostoma) dubisiensis: Bogdanova, 1961, p. 136, pl. 1, fig. 10–12.

Antiquilima dubisiensis: Bogdanova, 1997, p. 76, pl. 18, figs. 4, 5.

Plagiostoma dubisiensis: Yanin in Arkadiev et al., 2012, p. 261, pl. 43, fig. 15; Yanin, 2020a, p. 9, pl. 1, figs. 5, 6.

Lectotype. A specimen of *Lima dubisiensis* (Pictet and Campiche, 1868–1871, pl. 161, figs. 2a, 2b, 2c; shell); Switzerland (Sainte-Croix); Lower Cretaceous, Valanginian (designated by Yanin in Arkadiev et al., 2012, p. 261).

Lima dubisiensis (Pictet and Campiche, 1868–1871, pl. 161, fig. 2a, 2b, 2c; shell); Switzerland (Sainte-Croix); Lower Cretaceous, Valanginian (designated by Yanin in Arkadiev et al., 2012, p. 261).

Description. The shell is from small to medium-sized (L ≤ 36 mm), finely ribbed, oval-elongated in outline, considerably inqeuilateral, strongly oblique in the anteroventral direction, slightly convex, of moderate height (H ≥ L). The umbo is opisthogyrate, strongly shifted towards the posterior margin. The anterior margin is long and straight in the upper part, short and steeply rounded in the lower part, with a smooth transition between them; the ventral margin is smoothly rounded; the posterior margin is uniformly convex throughout, very slightly projecting beyond the edge of the posterior auricle, forming a smooth curve with the ventral margin; the dorsal margin is straight, short to moderate in length. The auricles are small, almost equal in size, but different morphologically: the anterior auricle is somewhat longer, its angle is obtuse; the posterior one is shorter, with a slightly retracted tip, the angle is almost straight. The anterior depression is well-defined, wide, moderately and uniformly concave, separated from the rest of the valve surface by a sharp or rounded bend, clearly expressed only in the umbonal region. The ligament area is obliquely triangular, narrow, smooth, and flattened. The resilifer is relatively large, shaped as a low, wide asymmetrical triangle, the anterior side of which is longer than the posterior one. There is a narrow byssal gaping; no byssal notch is present under the anterior auricle.

The shell surface possesses numerous (>50) radial ribs. The ribbing is very variable, both in different individuals and in different parts of the surface of the

Explanation of Plate 11

Figs. 1–4. *Limatula tombeckiana* (d'Orbigny): (1) specimen PIN, no. 5596/127, right valve: (1a) external view, lateral view, ×2; (1b) view from inside, ×3; Bel'bek River village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (2) specimen PIN, no. 5596/128, right valve, external view, lateral view, ×2; the same area, village of Solnechnosel'e; the same age and collector; (3) specimen PIN, no. 5596/129, right valve, external view: (3a) lateral view, (3b) enlarged area of its surface, ×7; Sarysu River, village of Blagodatnoe, roadside spring; Lower Berriasian, *chaperi* Beds (coll. B.T. Yanin, 1986); (4) specimen PIN, no. 5596/130, left valve, external view, lateral view: (4a) ×2, (4b) enlarged area of its surface, ×4; the same locality, age and collector.

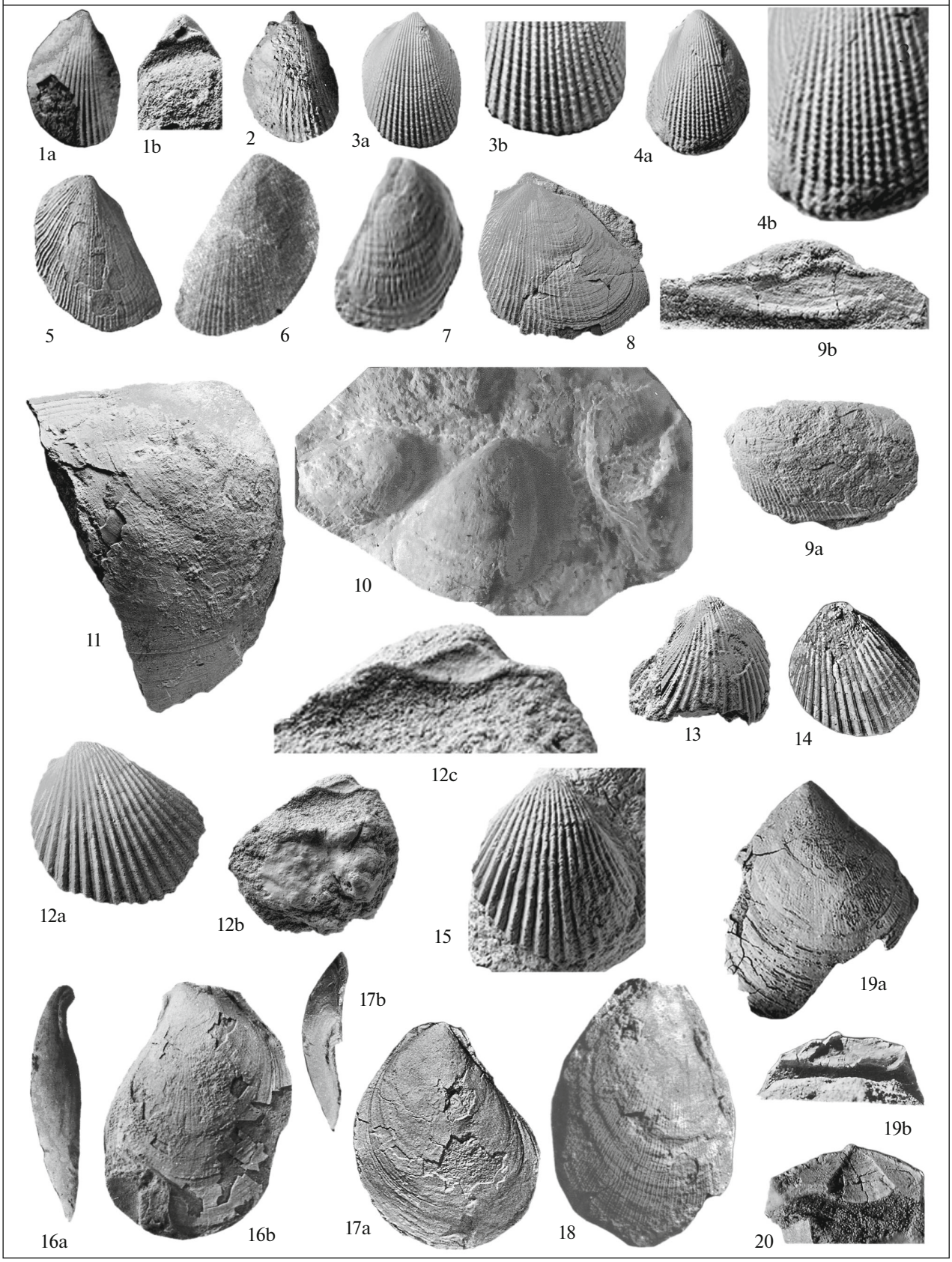
Figs. 5–10. *Plagiostoma dubisiensis* (Pictet et Campiche): (5) specimen MZMSU, no. 100/57, right valve, external view, lateral view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (6) specimen TsNIGRM, no. 120/13220, left valve, external view, lateral view, ×1; the same age and locality (coll. V.V. Drushchits, 1955); (7) specimen PIN, no. 5596/131, left valve, external view, lateral view, ×1; northern slope of Aipetri Yaila, Bakhchisarai-Yalta highway; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1987); (8) specimen PIN, no. 5596/132, shell displaced valves; external view, right valve view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (9) specimen PIN, no. 5596/133, right valve: (9a) external view, lateral view, ×1, (9b) umbonal region from inside, ×3.5; the same locality, age and collector; (10) specimen PIN, no. 5596/134, the weathered surface of a slab of clayey limestone with eight molds of isolated valves, oriented with a convexity upwards ("shell pavement"); northern slope of Aipetri Yaila, Bakhchisarai-Yalta highway; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1987).

Fig. 11. *Plagiostoma aubersonensis* (Pictet et Campiche), specimen PIN, no. 5506/139, left valve fragment, external view, lateral view, ×1; Tonas River, village of Krasnoselovka, Three pipes Ravine; Lower Berriasian, *grandis* Subzone (coll. B.T. Yanin,1987).

Figs. 12–15. *Pseudolimea royeriana* (d'Orbigny): (12) specimen PIN, no. 5596/140, right valve: (12a) external view, lateral view, ×2; (12b) and (12c) from inside, magnification ×2 and ×6, respectively ; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955); (13) specimen PIN, no. 5596/141, right valve with broken ventral margin, external view, lateral view, ×1.5; the same locality, age and collector; (14) specimen PIN, no. 5596/142, right valve with a destroyed ornamentation in the umbonal region, lateral view, ×1; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, Subzone *tauricum* (coll. G.K. Kabanov, 1961); (15) specimen PIN, no. 5596/143, right valve on limestone tile surface, external view, lateral view, ×1.2; the same age and locality (coll. B.T. Yanin, 1956).

Figs. 16–20. *Acesta orbignyana* (Matheron): (16) specimen MZMSU, no. 107/57, left valve, external view: (16a) lateral view, (16b) anterior view, ×1; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1954); (17) specimen TsNIGRM, no. 118/13220, right valve, ×1: (17a) lateral view, (17b) umbonal view; the same locality, age and collector; (18) specimen PIN, no. 5596/145, shell, external view, right valve view, ×1; Sarysu River, vicinity of the village of Novoklyonovo, Enisarai Ravine; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1955);(19*)* specimen PIN, no. 5596/146, right valve with a broken ventral margin: (19a) external view, lateral view, ×1.5, (19b) umbonal region from inside, ×2; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1954); (20) specimen PIN, no. 5596/147, fragment of the umbo region of the right valve, from inside; the same age and locality (coll. B.T. Yanin, 1962).

Plate 11


1a
1b
2
3a
3b
4a
4b
5
6
7
8
9b
9a
10
11
12c
13
14
12a
12b
15
19a
17b
19b
16a
16b
17a
18
20

same valve. The ribs are usually low, sharp, with a crested top and smooth slopes; the largest ribs are concentrated on the posterior side of the valve, here they are always asymmetrical (the anterior slope is wide and gentle, the posterior slope is narrow and steep); along the line of the greatest convexity of the valve and near the anterior-lower edge, the ribs become thinner and become more symmetrical. Toward the anterior margin, the ribs gradually become very thin, barely visible ribs or striae; the latter cover only the near-carina part of the anterior depression (this is seen only in well-preserved specimens) and, emerging at the shell margin, do not serrate it. Intercalation of radial elements is observed over the entire surface, and therefore the width of the intercostal spaces varies; at the posterior margin they are concave and narrower than ribs, along the median line and at the anterior lower margin they are flattened and wider than ribs. Almost all ribs along the valve margins are approximately the same size. In some parts of the surface they are weakly and unevenly wavy; sometimes weakly serrated along the ridge at the points of intersection with growth lines. The auricles are smooth or finely ribbed. The margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/136 (Sh)	24	22	0.90	11	0.45
PIN5596/148 (RV)	28	37	1.30	–	–
PIN 5596/138 (Sh)	30	34	1.10	13	0.40
PIN 5596/131 (LV)	30	36	1.20	13	0.40
PIN 5596/132 (Sh)	34	34	1.00	15	0.44
TsNIGRM120/13220(LV)	35	30	0.85	–	–
PIN 5596/135 (Sh)	35	31	0.88	18	0.51
PIN 5596/137 (RV)	36	35	0.97	–	–

Comparison. This species differs from the most similar *P. carteroniana* (d'Orbigny, 1843–1847; Hauterivian France) mainly in the nature of the outline of the posterior and ventral shell margins (in the studied species, these margins are convex, gradually passing into each other, forming a smooth arc; in the compared the posterior margin is straight, forms a noticeable inflection with the ventral margin); coarser ribs on the back of the valves; the presence of various radial sculptural elements (ribs, ribs, and striae; often, additional ribs or striae are developed in the spaces between the ribs, which are the same on the entire surface of the valve).

Occurrence. Berriasian–Valanginian: Berriasian of the Crimea, Northern Caucasus, Mangyshlak, Kopetdag; Upper Valanginian of Switzerland (known in the Valanginian stratotype section near the village of Valangin: Haefeli et al., 1967).

Material. 95 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern slope of Aipetri Yaila (Bakhchisarai highway), Malyi Salgir River (village of Glubokoe, Terenair Ravine); the same Zone, *chaperi* Beds—Sarysu River (village of Novoklyonovo, Enisarai Ravine); Middle Berriasian, *tauricum* Subzone—pp. Bel'bek (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e), Beshterek River (village of Solovjevka) and Zuja River (Balanovskoe Reservoir).

***Plagiostoma aubersonensis* (Pictet et Campiche, 1868)**

Plate 11, fig. 11

Lima aubersonensis: Pictet and Campiche, 1868–1871, p. 140, pl. 164, fig. 1, 2; Muromtseva, 1960, p. 193; pl. 12, fig. 8.

Acesta aubersonensis: Dimitrova, 1974, p. 86, pl. 44, fig. 1.

Plagiostoma aubersonensis: Bogdanova, 1997, p. 77, pl. 18, fig. 7; Yanin in Arkadiev et al., 2012, p. 262, pl. 43, fig. 7.

Lectotype. Specimen of *Lima aubersonensis* (Pictet, Campiche, 1868–1871, pl. 164, figs. 1a, 1b; shell); Switzerland (Sainte-Croix); Lower Cretaceous, Valanginian (designated by Yanin in Arkadiev et al., 2012, p. 262).

Description. The shell (along the left valve) is large (H > 60 mm), moderately and evenly convex. The umbo is slightly protruding, moderately close to the posterior margin of the valve; apical angle is 105°. The anterior margin at the top is straight; the posterior margin is slightly convex, noticeably projecting beyond the posterior auricle; the dorsal margin is short, slightly convex. The auricles are small, obtuse, almost equal (anterior somewhat larger than posterior). The angle between the line of the auricles and the anterior margin of the valve is about 90°. A well-developed long (about 30 mm), wide (up to 3 mm), flattened depression (lunule) extends from the anterior auricle along the anterior margin, separated from the rest of the valve surface by a sharp crested carina.

The posterior and lateral valve surfaces with numerous, smooth, concentric growth lines. Five radial, smooth, flattened ribs with filiform intercostal spaces are traced along the anterior margin. The ligament area is broadly triangular, almost symmetrical, smooth, slightly concave. The resilifer is not clearly expressed. The byssal notch is below anterior auricle, weakly expressed. The margins are smooth on the inside.

Dimensions in mm and ratios:

on a fragment of the left valve (PIN, no. 5596/139), only H ~ 60 and T ~ 19 could be approximately measured.

Comparison. In its large size, the presence of a large anterior alveolus and a slightly protruding umbo, this species is similar to *P. clypeiformis* (d'Orbigny, 1843–1847; Lower Turonian) and *P. santonensis* (d'Orbigny, 1843–1847; Santon France), but differs from them by the presence of radial sculpture; from the second species, in addition, by the development of a sharp carina separating a deeper and longer hole, as well as larger auricles. In the rib morphology and intercostal spaces, this species is similar to *P. orbig-*

nyana (Matheron) (see d'Orbigny, 1843–1847; Pictet and Campiche, 1868–1871; Upper Hauterivian–Lower Barremian of France and Switzerland), but differs from its larger shell sizes; less prominent, non-terminal umbos; the presence of the anterior hole; very small anterior byssal gaping of the shell (in the compared species, the gaping is large).

Occurrence. Berriasian–Barremian: Berriasian–Hauterivian of the Crimea; Barremian of Switzerland and France; Valanginian–Hauterivian of Bulgaria.

Material. One specimen; Crimea, Lower Berriasian, *jacobi* Zone, *grandis* Subzone—Tonas River (village of Krasnoselovka).

Genus *Pseudolimea* Arkell in Douglas et Arkell, 1932

Pseudolimea royeriana (d'Orbigny, 1845)

Plate 11, figs. 12–15

Lima royeriana: d'Orbigny, 1843–1847, p. 527, pl. 414, fig. 5–7; Pictet and Campiche, 1868–1871, p. 142, pl. 164, figs. 4, 5; Wollemann, 1900, p. 33.

Lima royeri: Karakash, 1897, p. 125, pl. 1, fig. 4.

Limea royeriana: Dimitrova, 1974, p. 90, pl. 44, fig. 9, 10.

Pseudolimea royeriana: Bogdanova, 1997, p. 77, pl. 18, fig. 6.

Holotype. A specimen of *Lima royeriana* (d'Orbigny, 1843–1847, pl. 414, figs. 5–7; shell); France; Lower Cretaceous, Neocomian (designated by monotypy herein).

Description. The shell is small and medium-sized in size (Sh ≤ 28 mm), ribbed, equal-valve, moderately oblique (150° oblique angle), oval outline, slightly convex, high (H = D). The tops are prominent, pointed, close to the rear edge; apical angle 85°–90°. Anterior margin weakly convex in upper part, sometimes almost straight; at the bottom, steeply rounded, smoothly turning into a moderately convex ventral margin; posterior margin is convex, strongly protruding beyond the posterior auricle; the dorsal margin is short and straight. The anterior auricle is somewhat longer than the posterior; the angle of the posterior auricle is about 65°, of the anterior it is 135°–140°. The anterior depression is well defined, flattened or slightly concave under the auricle. The anterior carinate bend is obtusely rounded, distinct only in the umbonal region.

The surface has numerous (20–24) identical, high, coarse, sharply rounded or pointed, tectiform, smooth, straight radial ribs. At the anterior and posterior margins, the ribs are thinner. The transition from coarse ribs to thin ribs is not the same in different forms. At the posterior margin, the ribs are usually asymmetrical (the anterior slope is wider than the posterior one). In some forms, several extreme ribs along the ridge itself are serrated. The posterior auricle and anterior depression are covered with fine radial ribs; anterior is smooth. The intercostal spaces are deep, concave, often V-shaped, equal in width to ribs; bearing one thin median rib. In some places on the well-preserved specimens on the slopes of the ribs, with magnification, one can also observe several radial striae.

The ligament area are narrow, concave, smooth; the resilifer is large, in the form of a slightly asymmetric triangle. The anterior and posterior gaping was not observed. The byssal notch is absent. The ventral margin is coarsely and undulatory serrated on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/144 (RV)	9	9	1.0	–	–
PIN 5596/140 (RV)	15	15	1.0	10	0.66
PIN 5596/141 (LV)	15	–	–	–	–
PIN 5596/142 (RV)	23	24	1.0	9	0.30
PIN 5596/143 (RV)	24	28	1.16	9	0.37

Comparison. In terms of the general shape of the valves and the nature of the ornamentation, it is very close to *P. cottaldina* (d'Orbigny, 1843–1847; Aptian of France) and (Pictet and Campiche, 1868–1871; Aptian of Switzerland), but differs from it in the presence of ribs and striae on the anterior side valves (in the compared species, this part of the shell is smooth); weaker and less regular ribs of the second order; the presence of fine radial striation in the intercostal spaces in the middle of the valve (in *P. cottaldina*, the slopes of the intercostal spaces are smooth); similar in ornamentation to *P. sculpta* (Pictet and Campiche, 1868–1871; Valanginian of Switzerland), but differs in the more elongated shell shape (the angle between the auricles line and the anterior margin is 150° in the described species and 120° in the comparable species).

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Hauterivian of Germany; Hauterivian–Barremian of France and Switzerland (indicated from the middle part of the Hauterivian stratotype section near the village of Valangin in Switzerland: Haefeli et al., 1965); Hauterivian–Barremian of Central Asia; Hauterivian–Lower Aptian Northern Caucasus; Aptian of Bulgaria.

Material. Eight specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—the northern side of the Baidar Depression (the village of Peredovoe, Urkusta Hill); the same Zone, *chaperi* Beds—Sarysu River (village of Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e) and Sarysu River (village of Kozlovka).

Genus *Ctenostreon* Eichwald, 1862

Ctenostreon balkiensis Yanin, 1980

Plate 12, fig. 1

Ctenostreon balkiensis: Yanin, 1980a, p. 23, pl. 7, fig. 18; pl. 8, fig. 2.

Holotype. MZMSU, no. 1/43, shell); Central Crimea (Sarysu River, vicinity of the village of Balki); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone (by original designation: Yanin, 1980a, p. 23).

Description. The shell is large (H = 69 mm), lenticular, thick-walled, rounded, coarsely ribbed, high (H = D), equilateral; both valves are moderately and evenly convex. The dorsal margin is elongated, weakly and irregularly convex; anterior, ventral and posterior margins are widely rounded and gradually merge into each other, forming an arc of approximately the same radius. The umbos are orthogyrate, small, slightly protruding above the margin, with very sharp beaks. The anterior auricles are narrow and short; the outer margin of auricles parallel to anterior margin of ligamentous area. The hind auricles are larger than the anterior, angular in outline. There is a byssal gaping under the anterior auricles of both valves.

The surface of both valves possesses 12 large, regular, very coarse, symmetrical, rounded radial ribs in cross section. In the umbonal region, the ribs are thin, sharp, uniformly serrated towards the valve margins. Bifurcation and intercalation of ribs are absent. All ribs bear several tubular spines. As can be judged from the preserved bases of the spines, they are thin and frequent in the umbonal region and large, sparse, unequally developed on the rest of the valve surface; the largest spines are located near the ventral margin of the left valve. The intercostal spaces are flattened, smooth, usually equal in width to ribs. The ribs and intercostal spaces are crossed by coarse concentric wavy lines of growth: on the ribs, curving towards the umbo, in the intercostal spaces, towards the margins of the valves; in places the rise lines are greatly reduced by series. The squamosity of the ribs is especially developed near the margins of the valves.

The ligamentous area is relatively wide (its width is equal to a quarter of the height of the shell), triangular in shape, longitudinally lamellar (wrinkled), with an uneven surface. The resilifer is indistinct, shallow, flattened, triangular in shape. From the anterior, the area is bounded by an obliquely curved ridge separating it from the byssal notch. The latter is wide, smooth, obliquely elongated, deeper on the right valve. Based on this characters, it can be concluded that the mollusk was attached to the substratum by the byssus and lay on the ground precisely on this valve. The surface of the ligament area on the left valve is oriented parallel to the closure plane, on the right valve it is located at an angle to it.

The muscle scar is obliquely oval in shape, medium-sized (length 20, width 13 mm), smooth, flattened, bounded below by a barely visible ridge; located near the posterior margin of the valves. The margins are coarsely undulatory serrated on the inside with rib terminations.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
MZMSU 1/43 (Sh)holotype	67	69	1.0	38	0.56

Comparison. This species differs from the closely related *C. proboscideum* (Sowerby, 1812–1846; Upper Jurassic of southern England) in the rounded shell outlines and more regular ribbing (ribs become evenly serrated and do not curve at the edges); from *C. pectiniforme* (Schlotheim in Knorr, 1820; Middle Jurassic of Germany it is distinguished by the more rounded shell outlines; smaller anterior auricle; rounded and uniformly convex ribs (in *C. pectiniforme*, the ribs are rectangular in cross section).

Material. One specimen from the type locality.

Genus *Acesta* H. et A. Adams, 1858

Acesta longa (Roemer, 1836)

Plate 9, figs. 8–10

Lima elongata: Roemer, 1836, p. 79, pl. 13, fig. 11a–11c.

Lima longa: d'Orbigny, 1843–1847, p. 529, pl. 414, fig. 13–16; Pictet and Campiche, 1868–1871, p. 128, pl. 161, fig. 6, 7; Loriol, 1868, p. 41, pl. 3, fig. 11a, 11b; Wollemann, 1900, p. 27; Muromtseva, 1960, p. 193, pl. 12, fig. 5.

Acesta longa: Yanin in Arkadiev et al., 2012, p. 258, pl. 43, fig. 2.

Holotype. Specimen of *Lima elongata* (Roemer, 1836, pl. 13, figs. 11a, 11b; right valve); Germany; Lower Cretaceous, Hauterivian (designated by monotypy Yanin in Arkadiev et al., 2012, p. 258).

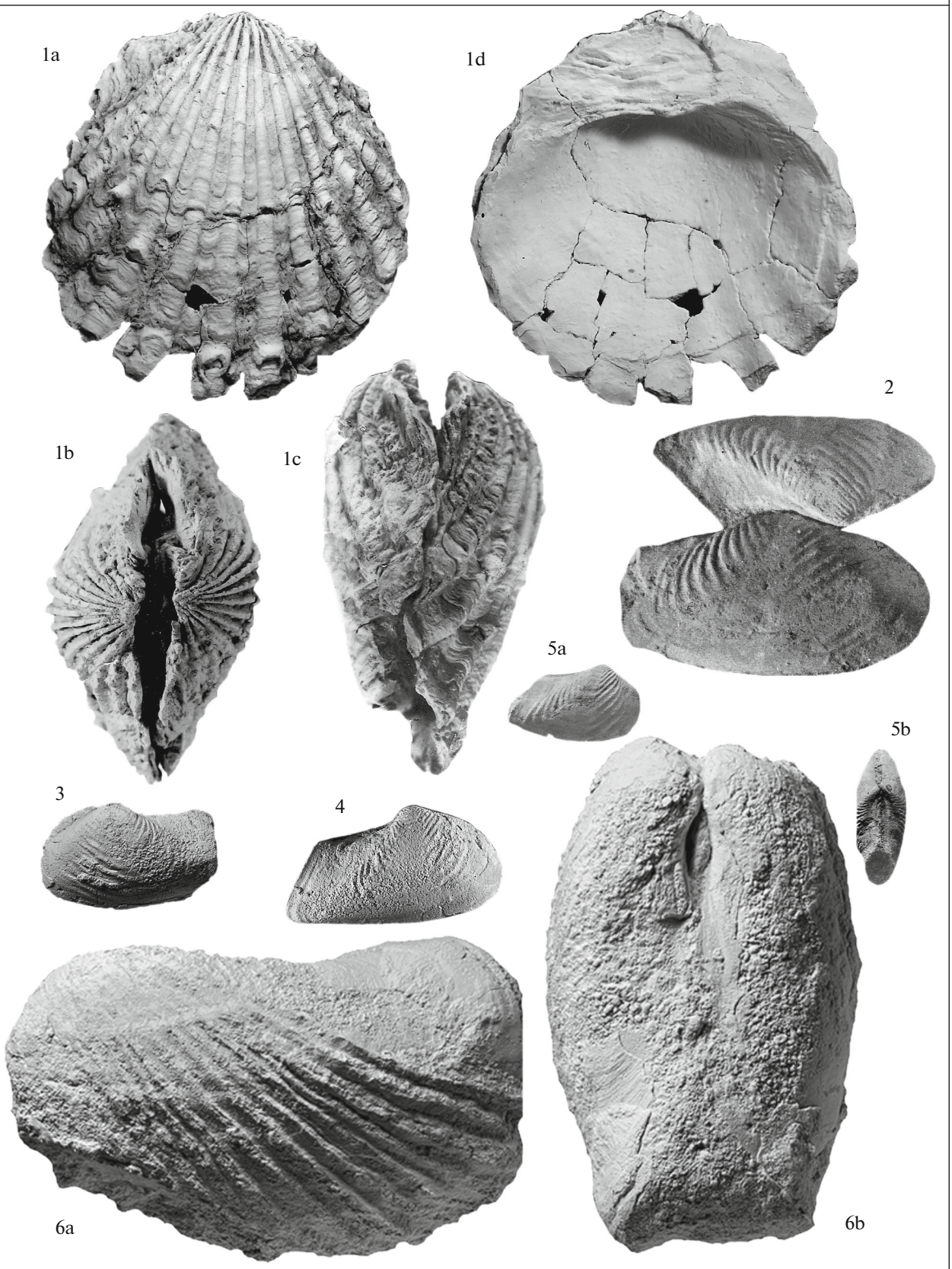
Explanation of Plate 12

Fig. 1. *Ctenostreon balkiensis* Yanin: specimen MZMSU, no. 1/43, holotype, shell, external view: (1a) lateral view, left valve view, (1b) umbonal view, (1c) anterior view, (1d) from inside, ×1; Sarysu River, vicinity of the village of Kozlovka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962).

Figs. 2–5. *Goniomya (Goniomya) villersensis* (Pictet et Campiche): (2) specimen MZMSU, no. 237/57, shell with open valves, external view, lateral view, ×1; Malyi Salgir River, village of Ivanovka; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1954); (3) specimen PIN, no. 5596/150, shell, external view, left valve view, lateral view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (4) specimen TsNIGRM, no. 123/13220, shell, external view, right valve view, ×1; the same locality, age and collector; (5) specimen MZMSU, no. 239/57, shell, external view, ×1: (5a) lateral view, right valve view, (5b) umbonal view; the same region, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1961).

Fig. 6. *Pholadomya gigantea* (Sowerby), specimen PIN, no. 5596/152, mold, external view, ×1: (6a) lateral view, left valve view, (6b) umbonal view; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1961).

Plate 12



D e s c r i p t i o n. The shell is small and medium-sized (Sh ≤ 34 mm), very slightly oblique (the angle between the line of auricles and the anterior margin is 105°), finely ribbed, oval-elongated in shape, slightly drawn in the anterior–inferior direction, slightly convex, very high (B > D). The umbo is opisthogyrate, prominent, sharp, somewhat closer to the posterior margin; the apical angle is 70°. The anterior margin is straight at the top; at the bottom, it is rounded, gradually merging with a strongly convex, relatively short ventral margin; the posterior auricle is long, smoothly rounded, strongly protruding beyond posterior auricle. The dorsal margin is short, slightly convex. The auricles are nearly equal; the angle of the posterior auricle is 135°, the anterior one is 120°. The anterior depression and carina are absent. A narrow, slightly concave groove separating the anterior auricle from the rest of the valve surface is clearly expressed. The shell surface has numerous (up to 70), identical, thin, rounded, symmetrical, smooth, in places slightly wavy, radial ribs. At the posterior margin, the ribs become sharper and often asymmetrical. All ribs reach the valve margins. At the posterior margin of the valves, the ribs sometimes bifurcate. The posterior auricle is covered with thin ribs, the anterior is smooth. The intercostal spaces are very narrow, filiform, bearing small, punctate depressions, visible only under strong magnification.

The ligament area is relatively wide, short, very slightly concave, smooth. Resilifer large, triangular, asymmetric (slightly oblique posteriorly). The byssal notch is well developed under the anterior auricle on both valves. The anterior auricle, in connection with this notch, is strongly serialized, transversely rugose. The ventral margin of the valves is finely serrated from the inside because of the rib terminations.

D i m e n s i o n s i n m m a n d r a t i o s:

Specimen no.	L	H	H/L
PIN 5596/103 (LV)	~23	31	~1.37
PIN 5596/102 (RV)	~27	34	~1.26
MZMSU 104/57 (LV)	28	34	1.20

C o m p a r i s o n. This species from: *A. orbignyana* (see below) in the more elongated, strongly narrowed shell in the umbonal area; less oblique valves in the anterior-inferior direction; a smaller apical angle equal to 70° vs. 80°–85°; rounded, not flattened ribs, not weakening towards the margins of the valves; clearer deep intercoastal spaces; the presence of fine serrations on the ventral margin of the valves; from *A. villersensis* (Pictet and Campiche, 1868–1871; Valanginian of Switzerland) it is distinguished by the relatively more elongated, strongly narrowed in the upper part of the shell; sharper umbos (apical angle 70° vs. 95°); more numerous (70 vs. 30–35) and narrower ribs.

O c c u r r e n c e. Berriasian–Barremian: Berriasian of the Crimea; Valanginian–Barremian of Switzerland (this species is recorded from the upper Valanginian stratotype section near the village of Valangin: Haefeli et al., 1965); Neocomian of France; Hauterivian of Germany.

M a t e r i a l. Five specimens; Crimea, Middle Berriasian, *tauricum* Subzone; Bel'bek River (village of Kuibyshevo, Kabaniy Log) and Beshterek River (village of Solovjevka).

Acesta orbignyana (Matheron, 1842)

Plate 11, figs. 16–20

Lima orbignyana: Matheron, 1842, p. 182, pl. 29, fig. 3, 4; d'Orbigny, 1843–1847, p. 530, pl. 415, figs. 1–4; Pictet and Campiche, 1868–1871, p. 126, pl. 161, figs. 4a–4c; Muromtseva, 1960, p. 193, pl. 12, figs. 6a, 6b; Bogdanova, 1966, p. 95, pl. 10, figs. 4a, 4b; 5a–5c.

Acesta orbignyana: Yanin in Arkadiev et al., 2012, p. 259, pl. 43, fig. 13.

H o l o t y p e. A specimen of *Lima orbignyana* (Matheron, 1842, pl. 29, figs. 3, 4; right valve); France (Orgon); Upper Jurassic, Portlandian (designated by monotypy Yanin in Arkadiev et al., 2012, p. 259).

D e s c r i p t i o n. The shell is small and medium-sized (Sh ≤ 45 mm), oval-elongated in outline, moderately extended in anterior-inferior direction, moderately and evenly convex, high (H > L), finely ribbed. The umbo opisthogyrate, prominent, close to the posterior margin; apical angle 85°. The anterior margin is slightly concave in the upper part, convex in the lower part, widely rounded; the transition between them is gradual; ventral and posterior margins also broadly rounded, smoothly merging with each other; the posterior margin strongly protrudes beyond the auricle; the dorsal margin is very short, slightly convex. The auricles are small, unequal: the posterior auricle is somewhat longer and thinner, its tip is not retracted; the anterior auricle is thickened, sometimes wrinkled, often rounded. The anterior carina is absent. The anterior depression is shaped as a narrow deep groove.

The shell surface has numerous (>70), identical, thin, flattened, smooth, slightly undulating radial ribs. From umbo to the margins of the valve, their number increases due to bifurcation; they become slightly wider, often flattening near the margin, leaving the lower part of the leaf smooth. The posterior auricle is covered with ribs, the anterior is smooth. The intercostal spaces are very narrow, filiform, bearing punctate depressions, visible only under magnification.

The ligament area is relatively wide, slightly concave, smooth. The resilifer is large, subtriangular in shape, asymmetric (oblique backwards). The byssal notch is well developed under the anterior auricle on both valves; because of this notch, the anterior auricle is strongly flattened and transversely rugose. The margins of the valves are smooth from the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN5596/147 (LV)	25	34	1.25	6	0.2
PIN 5596/149 (Sh)	27	33	1.22	13	0.45
PIN 5596/146 (LV)	29	~40	~1.36	–	–
TsNIGRM 118/13220 (RV)	35	43	1.20	14	0.40
MZMSU 107/57 (LV)	40	45	1.10	10	0.50

Comparison. This species differs from *A. longa* (see above) in having a relatively broader and more oblique shell; less acute umbos (apical angle 85° versus 70°); flat ribs flattening towards the valve margins (in the compared species, the ribs are rounded and extend without weakening towards the shell margins); fuzzy, shallow intercostal spaces; smooth margins from the inside of the valves.

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Hauterivian–Lower Barremian of Kopetdag; Barremian of Switzerland; Hauterivian–Lower Aptian of France.

Material. Five specimens; Crimea, Berriasian: Lower Barremian, *jacobi* Zone, *chaperi* Beds—Sarysu River (village of Novoklyonovka; Middle Barremian, *tauricum* Subzone)—Beshterek River (village of Solovjevka), Sarysu River (village of Kozlovka), Bel'bek River (village of Solnechnosel'e).

Order Pholadomyida Newell, 1965

Superfamily Pholadomyoidea Gray, 1847

Family Pholadomyidae Gray, 1847

Genus *Pholadomya* G.B. Sowerby, 1823

***Pholadomya gigantea* (G.B. Sowerby in Fitton, 1836)**

Plate 12, fig. 6; Plate 14, fig. 1

Pholas giganteus: Sowerby in Fitton, 1836, p. 338, pl. 14, fig. 1.

Pholadomya giganteus: Woods, 1899-1913, p. 246, pl. 40, fig. 14; pl. 41, fig. 1; Renngarten, 1926, p. 83; Mordvilko, 1949, p. 142, pl. 29, fig. 9; Muromtseva, 1960, p. 221, pl. 28, figs. 5–7; Bogdanova, 1997, p. 91, pl. 21, fig. 6.

Pholadomya elongata: Münster in Goldfuss, 1840, p. 270, pl. 157, fig. 3–6; Agassiz, 1842, p. 57, pl. 1 (I), figs. 16 and 17; pl. 2 (II), fig. 1–6; d'Orbigny, 1843–1847, p. 350, pl. 362, fig. 1–3; Pictet and Campiche, 1864–1867, p. 74, pl. 104, fig. 1–4; Karakash, 1897, p. 81, pl. 2, fig. 9;

Pholadomya scheuchneri: Agassiz, 1842, p. 58, pl. 2 (I), fig. 6; pl. 2 (II), fig. 7.

Holotype. A specimen of *Pholas giganteus* in (Fitton, 1836, pl. 14, fig. 1; shell); southern England; Lower Cretaceous, Lower Aptian (designated by monotypy herein).

Description. The shell is large (L > 95 mm), subcylindrical, elongated-oval, coarsely ribbed, strongly unequal; moderately and evenly convex, equally folded. The umbos are prosogyrate, obtusely and broadly rounded, slightly protruding, very close to the anterior margin. The dorsal margin is long, straight or slightly and widely concave; smoothly, along a wide curve, passes into a uniformly convex posterior margin, which is gradually replaced by a long, slightly convex ventral margin. The ligament is external; the escutcheon is elongated, the nymphs are thickened.

The shell surface bears numerous (>45) coarse, symmetrical, sharply rounded, crested ribs; towards the posterodorsal margin of the valves, the ribs become thinner, flattened out and disappear, leaving the dorsal margin and the upper part of the posterior margin smooth. The ventral margin is all jagged with coarse ribs. The intercostal spaces are smooth, widely concave or flattened, unequal in width; near the valve margins they are usually wider than the ribs. The ribs are intercalated towards the valve margins. The growth lines are clear, sometimes turning into coarse wrinkles intersecting with radial elements. The gaping of the shell is posterior, oval in outline, and wide (0.65–0.68 of the total convexity of the shell accounts for the gaping width). The ligament is external, opisthodetic; the escutcheon is elongated, the nymphs are strongly developed.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/152 (Sh)	>85	50	–	50	–
PIN 5596/153 (Sh)	>95	62	–	47	–

Comparison. Most authors note that this species differs from all Early Cretaceous *Pholadomya* in its elongated shape and very numerous sharp ribs. The described species shows some similarity with *P. royana* (d'Orbigny, 1843–1847; Cenomanian of France), but differs from it mainly in the more angular outline of the posterior margin and the relatively wider gaping of the shell.

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Valanginian Mangyshlak; Hauterivian of Bolshoi Balkhan; Valanginian–Barremian of Switzerland, France; Berriasian–Barremian of Switzerland, Barremian of the Northern Caucasus, Dagestan, Kopetdag; Lower Hauterivian of Mexico; Hauterivian–Aptian of Bulgaria; Hauterivian of Germany; Lower Aptian of southern England; Neocomian of Argentina.

Material. Two specimens; Crimea, Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Solnechnosel'e).

Genus *Pachymya* J. Sowerby, 1826

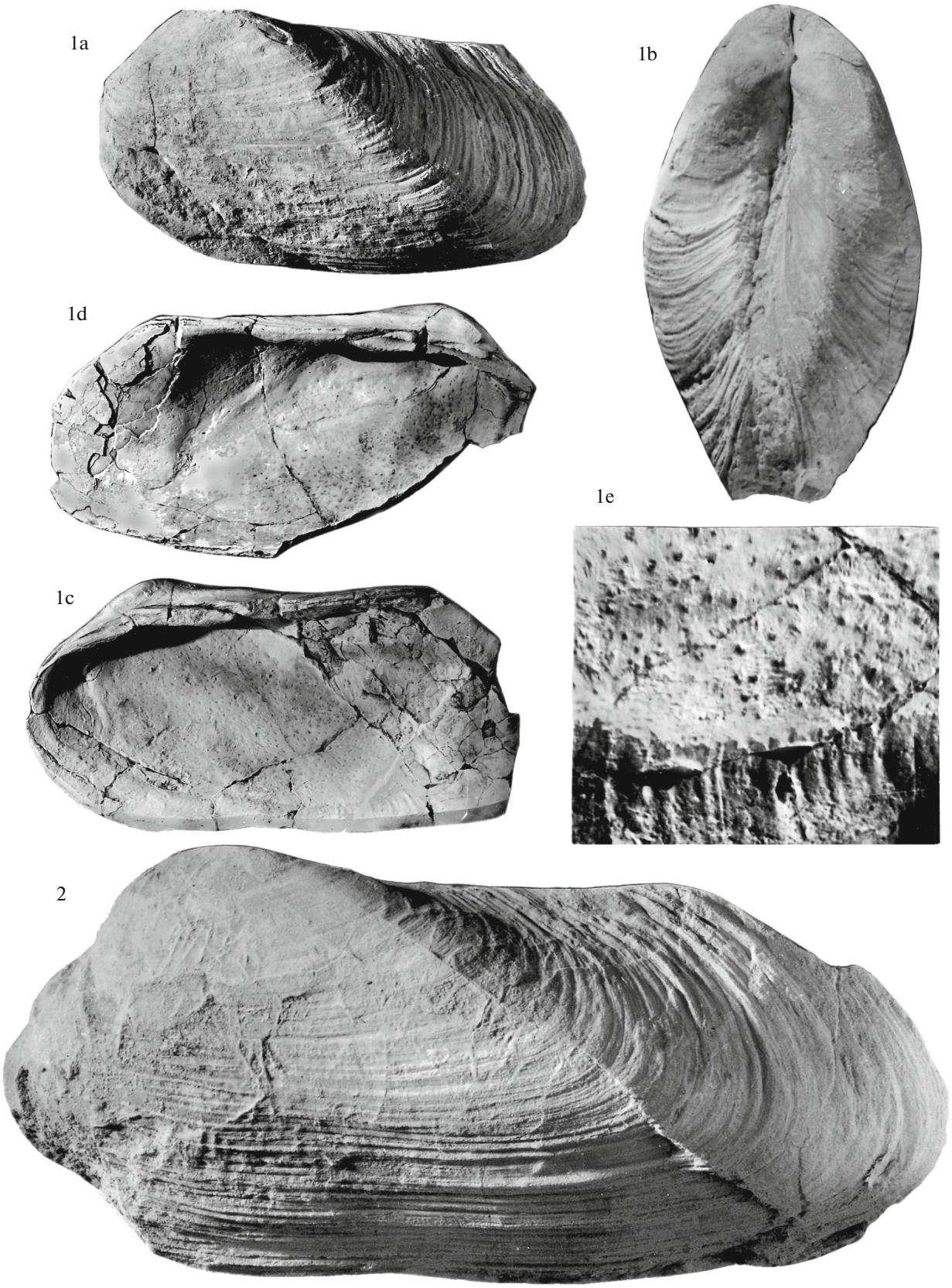
Subgenus *Pachymya* J. Sowerby, 1826

***Pachymya (Pachymya) crimica* Yanin, 1982**

Plate 13, fig. 1, 2

Pachymya (Pachymya) crimica: Yanin, 1982, p. 123, text-fig. 2a–2d.

Plate 13



Holotype. MZMSU, no. 47/1 (Yanin, 1982, text-figs. 2a–2d, shell and its isolated valves); Southwest Crimea, Bel'bek River (village of Solnechnosel'e); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone (by original designation Yanin, 1982, p. 123).

Description. The shell is very large (L = 186 mm), smooth, irregularly rectangular, strongly convex, elongated (L > half B). The umbos are prosogyrate, relatively small, slightly protruding, strongly pushed forward to the anterior margin. The anterior margin is broadly rounded, smoothly merging into a long, very slightly convex, almost straight ventral margin; the dorsal margin is long, almost straight, only very slightly concave in the middle; the posterior margin is widely rounded in the lower and obliquely truncated in the upper part, it forms a rounded bend of 70°–80° with the ventral margin, and of 140° with the dorsal margin. A pronounced umbilical carina extends from the umbo to the posteroventral margin; in the umbonal region it is sharp, crested, then gradually rounded.

The lateral field is very wide (its width is equal to shell height), flattened in middle part of valves and slightly concave near ventral margin, smooth, covered only with coarse, irregular growth wrinkles. The posterior field is one third of the shell length, weakly and evenly convex, with sharp irregular growth wrinkles. The lateral field is flattened, covered with very thin numerous radial striae (preserved only in places), bearing small granules; separated from the posterior field by a sharp carina.

The ligament is semiexternal, lodged in a deep (up to 5 mm), V-shaped depression, bounded by a strong crested nymph, 36 mm long. The cardinal platform is thickened, with coarse, short and long irregular tooth-like ridges radiating from the tip of the umbo, up to two in each valve. The adductor scars are distinct, large: the anterior scar is irregularly oval (length 30, width 21 mm), very close to the anterior margin (the smallest distance to the margin 8 mm), flat; above and behind is bounded by steep slopes; the posterior scar is slightly larger than anterior (length 37, width 31 mm), irregularly rounded, flattened, bounded in anterior and above by steep slopes, close to the dorsal margin (the smallest distance to the margin is 9 mm, to the posterodorsal corner of the valve is 18 mm), but distant from the posterior margin (distance between the median point of the posterior margin and the point of confluence with the pallial line 62 mm).

The anterior leg scar is deep, oval, small (maximum diameter 6 mm), located directly above the anterior muscle scar 3 mm from the valve margin. The rear foot scar is not observed. The pallial line is distinct, continuous, and wide (its width varies from 2 near the lower, 10 near the posterior, and up to 17 mm near the anterior margins), widens near the muscle scars (the band is 23 mm in the anterior part, and 15 mm near the ventral margin of the valve). The pallial sinus is sharply rounded; its sides form an angle of 45°, and the pointed end is separated from the ventral margin by a distance of 20 mm, from the posterior margin by 37 mm. Near the posterior margin, approximately in the middle between it and the confluence of the mantle line with the posterior muscle imprint, there is a short (16 mm) narrow ridge-like siphonal ridge. The angle between the axial line of the ridge and the dorsal margin of the valve is 45°. The siphonal ridge is most pronounced in its middle part; towards the ends it flattens out and merges with the valve surface, separating from the mantle line at a distance of 14 mm and from the posterior margin by 18 mm (following the axial line of the ridge).

The inner surface of the valves within the space bounded by the mantle line bears very numerous thin, punctate, randomly located depressions, visible visually. The posterior shell gaping is 14 mm wide, protruding from the posterior end of the escutcheon, about 22 mm from the obtuse posterodorsal angle of the valve, and to the posterior end of the ventral margin. The edges of the gaping are evenly and widely convex. The anterior gaping is absent. The valve margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
MZMSU 47/2 (Sh)	180	75	0.41	100	0.55
MZMSU 47/1 (Sh) holotype	186	92	0.49	94	0.50

Comparison. This species differs from: *P. (P.) gigas* (d'Orbigny, 1843–1847; Turonian of France) in the straight ventral margin; less concave dorsal margin; wider lateral field (0.49 versus 0.33); shorter escutcheon and less pronounced radial striation in the posterior field (possibly due to the state of

Explanation of Plate 13

Figs. 1–2. *Pachymya (Pachymya) crimica* Yanin: (1) specimen MZMSU, no. 47/1, holotype, shell with valves separated along the closing plane: (1a) external view, lateral view, left valve view and (1b) umbonal view, ×0.5; (1c) right valve from inside, ×0.5; (1d) left valve with a partially broken anterior margin, from inside, ×0.5, (1e) its enlarged area near the ventral edge, ×3; Bel'bek River, village Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (2) specimen MZMSU, no. 47/2, shell, external view, lateral view, left valve view, ×1; Bel'bek River, village of Kuibyshevo, area of Ulyanovsk bridge; the same age and collector.

preservation of the Crimean specimens); from *P. (P.) austinensis* (Shumard; Albian of Texas), it is distinguished by a smaller slope of the anterior branch of the hinge platform (the angle between the dorsal edge of the valve and the lower edge of the platform is 22°, in *P. (P.) austinensis*—40°); by the presence of a slight concavity of the dorsal margin; less pronounced concavity in the middle part of the ventral margin; less oblique posterior margin and more rounded posteroventral inflection of the valve.

Material. Three specimens from the type locality.

Genus *Goniomya* Agassiz, 1841

Subgenus *Goniomya* Agassiz, 1841

Goniomya (Goniomya) villersensis (Pictet et Campiche, 1865)

Plate 12, figs. 2–5

Pholadomya villersensis: Pictet, Campiche, 1864-1867, p. 86, pl. 106, fig. 7.

Goniomya archiaci: Muromtseva, 1960, p. 222, pl. 29, fig. 1–3; Dimitrova, 1974, p. 119, pl. 59, fig. 11; Bogdanova, 1997, p. 91, pl. 21, fig. 2 and 3.

Goniomya (Goniomya) villersensis: Yanin in Arkadiev et al., 2012, p. 268, pl. 44, fig. 8, 9.

Holotype. Specimen of *Pholadomya villersensis* (Pictet, Campiche, 1864–1867, pl. 106, fig. 7; mold of a right valve); eastern France (Villers-le-Lac); Lower Cretaceous, Valanginian (designated by monotypy Yanin in Arkadiev et al., 2012, p. 268).

Description. The shell is small to medium-sized (L ≤ 57 mm), elongated-oval, strongly elongated (L is twice H), moderately convex, inequilateral (the anterior part of the shell is 1.5 times shorter than the posterior one). The umbos are prosogyrate, small, slightly protruding, close to the anterior margin, with sharp, straight beaks slightly overhanging the valve margin. The dorsal margin is long, slightly convex in anterior part, slightly concave or straight in posterior part; the anterior margin is short, evenly and widely rounded, gradually turning into dorsal and ventral margins; the ventral margin is long, very slightly convex, parallel to the posterior side of the dorsal margin; the posterior one is short, obliquely truncated, slightly convex or almost straight, forms a clear obtuse angle with the dorsal one, and a sharply rounded bend, somewhat drawn back, with the ventral one. The umbilical carina is distinct, rounded, extending from the umbo to the posteroventral angle of the valve and divides it into a wide, uniformly convex lateral field and narrow, slightly concave posterior field.

The shell surface has two series of oblique, smooth, symmetrical rounded ribs: anterior and posterior. In the umbonal region, when the lower ends of the ribs of both series are connected, a V-shaped pattern can be observed. The anterior ribs, arising near the anterodorsal margin of the valve, extend obliquely backwards and downwards approximately parallel to the carina; in the umbonal region they are thin, frequent, straight, towards the ventral edge of the ribs coarsen, thin, often arcuately bent; with rare exceptions, the ribs do not reach the very margin, leaving a significant part of the anterior and ventral sides of the valves smooth. The posterior ribs, appearing directly on the posterior slope of the carina, are directed forward and downward from the umbonal area, downward and forward or vertically downward in the middle of the valve, and backward and downward near the posterior end of the carina. In the umbonal area, and sometimes on the lateral surface of the valves, the ends of the ribs of both series are connected by short horizontal ribs; in the middle of the valve and near the ventral margin, there is often an oblique smooth strip between them, extending from the umbo to the middle of the ventral margin. Well-preserved shells show oblique vertical rows of very small granules on the lateral field. Much of the back field is smooth.

The lunule is long, extending along the entire anterior branch of the dorsal margin, concave, narrow, smooth, delimited from the lateral surface of the valve by a sharp low carinate bend. The ligament is opisthodetic, external. The escutcheon is long, almost reaching the end of the posterior branch of the dorsal margin, concave, narrow, smooth, with strong nymphs. The hinge margin is smooth, narrow from the inside, without a cardinal platform. The anterior gaping is narrow, the posterior gaping is relatively wide.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
MZMSU 239/57 (Sh)	23	14	0, 60	14	0.60
PIN 5596/150 (Sh)	~32	18	~0.56	12	~0.43
MZMSU238/57 (LV)	~29	20	–	–	–
TsNIGRM 123/13220 (Sh)	34	19	0.55	15	0.30
PIN 5596/151 (RV)	34	19	0.55	–	–
MZMSU237/57 (RV)	57	29	0.50	–	–

Comparison. This species differs from: *G. (G.) archiaci* (Pictet et Renevier, 1855–1858; Lower Aptian of Switzerland) in coarser ribs developed throughout the lateral area (in *G. (G.) archiaci*, ribs are present only in the umbonal region); obliquely truncated posterior margin (in the compared species it is rounded); the presence of a sharply rounded posteroventral inflection of the valve margin; from *G. (G.) agassizi* (d'Orbigny, 1843–1847; Neocomian of France) it differs in the coarser oblique ribs on the valve surface; more strongly narrowed posterior side of the shell; almost straight and obliquely truncated posterior margin (in the *G. (G.) agassizi* it is rounded); the

presence of concavity of the posterior side of the dorsal margin; sharper carina; a sharp restriction of the socket and escutcheon from the rest of the surface of the valves; the presence of clearly expressed posterodorsal and posteroventral angles (in the compared species, the posterior margin of the shell is widely rounded and gradually, without angles, passes into the dorsal and ventral margins). The considered species has some similarities in the shape of the shell, the nature of the sculpture, the structure of the hole and the escutcheon with *G. (G.) mailleana* (d'Orbigny, 1843–1847; Turonian of France), but differs from it in the widely rounded (not pointed) anterior side; narrowing of the back side of the shell; less convex bottom edge; sharper carina. It differs from the Jurassic *G. (G.) duboisi* Agassiz, *G. (G.) marginata* Agassiz and many Cretaceous species mainly in that a smooth strip usually remains between the lower ends of the anterior and posterior ribs on the lateral side of the valves.

Occurrence. Berriasian–Hauterivian: Berriasian of the Crimea; Valanginian–Hauterivian of the Northern Caucasus; Valanginian of eastern France and Switzerland; Hauterivian of Bulgaria.

Material. Six specimens; Crimea, Middle Berriasian, *tauricum* Subzone, Bel'bek River (village of Kuibyshevo, Kabaniy Log), Beshterek River (village of Solovjevka) and Malyi Salgir River (village of Ivanovka).

Superfamily Myochamoidea Bronn, 1862

Family Laternulidae Hedley, 1918

Genus *Platymyoidea* Cox, 1964

***Platymyoidea marullensis* (d'Orbigny, 1844)**

Plate 14, figs. 2–6

Anatina marullensis: d'Orbigny, 1843–1847, p. 376, pl. 371, fig. 3, 4; Pictet and Campiche, 1864–1867, p. 101, pl. 107, figs. 2, 3.

Laternula agassizi: Muromtseva, 1960, p. 221, pl. 29, fig. 4, 5a, b.

Platymyoidea marullensis: Dimitrova, 1974, p. 120, pl. 59, fig. 10; Bogdanova and Yanin, 2004, p. 80, pl. 35, figs. 6a, 6b; Yanin in Arkadiev et al., 2012, p. 270, pl. 44, fig. 10.

Holotype. A specimen of *Anatina marullensis* in (d'Orbigny, 1843–1847, pl. 371, figs. 3, 4; shell mold); France (Aube, Marolles); Lower Cretaceous, Lower Neocomian (designated by monotypy: Yanin in Arkadiev et al., 2012, p. 270).

Description. The shell is small and medium-sized (L ≤ 51 mm), elongated-oval in outline, strongly laterally compressed, ribbed, weakly unequal (anterior side slightly shorter than the posterior one), with slightly protruding, blunt umbos, somewhat pushed to the anterior margin. Dorsal margin long, slightly convex before umbo; behind it, almost straight; the anterior and posterior margins are short, steeply rounded, smoothly merging into dorsal and ventral margins; the ventral margin is long, broadly and very slightly convex, only slightly concave in the area of the median sulcus. The greatest convexity falls on the middle part of the valves; the convexity is slight, distributed evenly over the entire valve, with the exception of a narrow transverse depression (along the median sulcus) and flattening near the posterior margin. The median sulcus is well developed, narrow, slightly concave, running from the umbo usually vertically downwards, less often obliquely downwards and forwards at an angle of 80°–83°.

The lateral surface of both valves in anterior of median sulcus possesses 20–22 coarse, symmetrical, smooth, rounded, concentric ribs with narrow, concave intercostal spaces. The median sulcus and posterior side of the shell have no concentric ribs, only in the umbonal region of the valves of some individuals do the ribs pass through the median sulcus and outline the umbo. In addition, the shell everywhere bears a granular ornament, represented by very thin (pointed) rounded tubercles (granules) located in radial rows; in the anterior and middle parts of the valves, the rows are very close (up to 4–6 rows per 1 mm) and the granules are located very close to each other (there are from 16 to 24 of them in 1 mm); towards the posterior margin of the valves, the space between the rows of granules increases to 1 mm and the granular ornamentation disappears near the margin; granules developed only on outer shell layer. The shell itself is very thin (about 1/3 mm). The growth lines are coarse, in places they turn into wrinkles. The gaping of the shell is oval-slit-shaped and narrow (about half of its width).

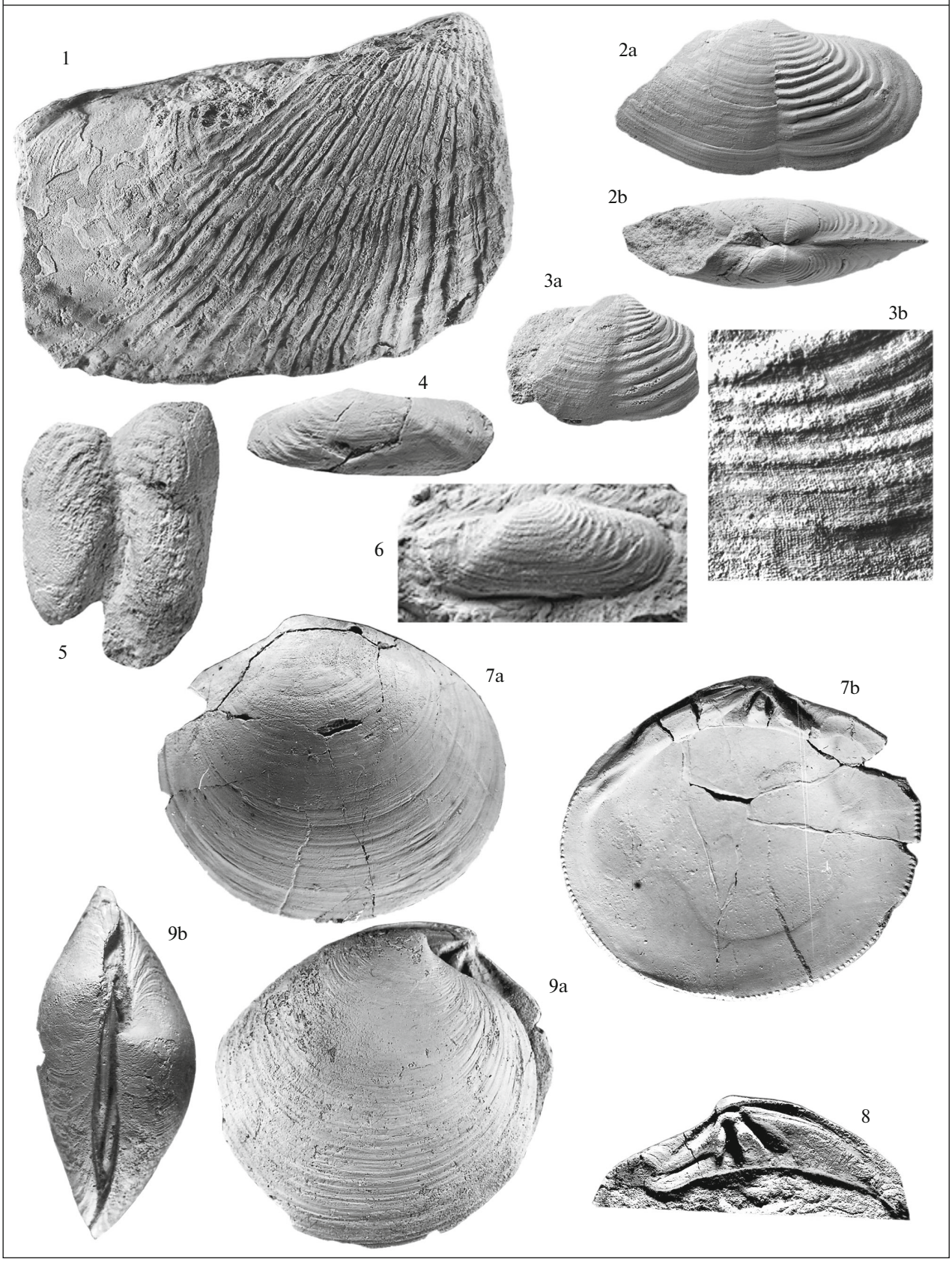
Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/156 (LV)	50	17	0.30	–	–
PIN 5596/160 (Sh)	50	22	0.44	13	0.26
PIN 5596/154 (Sh)	55	25	0.4	15	0.20
TsNIGRM 124/13220 (Sh)	51	~22	~0.43	13	0.25

Comparison. This species differs from *P. agassizi* (d'Orbigny, 1843–1847; Neocomian of France) and (Pictet and Campiche, 1864–1867, Urgon Switzerland), which is closest in shape and ornamentation, mainly in a less elongated shell (H/L 0.4–0.5 vs. 0.3); coarser and more oval concentric ribs, as well as the usually vertical arrangement of the median sulcus (in the compared species, it is usually oriented downwards and backwards).

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Aptian of the Northern Caucasus; Lower

Plate 14



Neocomian of France; Urgonian of Switzerland; Aptian of Bulgaria.

Material. 10 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern slopes of the Karabi-Yaila Plateau (ravine Lanchin) and Dolgorukovskaya Yaila; the same Zone, *chaperi* Beds—Zuja River (Balanovskoe Reservoir); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e) and Beshterek River (village of Solovjevka); Upper Berriasian, *euthymi* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log).

Order Lucinida Stoliczka, 1871 (=Astartida Scarlato et Starobogatov, 1971)

Superfamily Astartoidea D'Orbigny, 1844

Family Astartidae D'Orbigny, 1844

Genus *Eriphyla* Gabb, 1867

Subgenus *Eriphyla* Gabb, 1867

***Eriphyla (Eriphyla) mordvilkoae* Yanin, 1980**

Plate 14, figs. 7–9; Fig. 28.1a

Eriphyla mordvilkoae: Yanin, 1980b, p. 28, pl. 9, fig. 14; pl. 10, figs. 1–3; Bogdanova, 1997, p. 86, pl. 19, fig. 10 (non fig. 9); Yanin in Arkadiev et al., 2012, p. 271, pl. 45, figs. 1a, 1b.

Astarte gigantea: Bogdanova, 1997, p. 85, pl. 19, fig. 11.

Astarte moreausa: Bogdanova, 1997, p. 85, pl. 19, fig. 12.

Holotype. MZMSU, no. 1/42; left valve (Yanin, 1980b, pl. 10, figs. 1a, 1b); Southwest Crimea, Bel'bek River (village of Kuibyshevo, Kabaniy Log); Middle Berriasian, *tauricum* Subzone (by original designation: Yanin, 1980b, p. 28).

Description. The shell is medium-sized and large (L ≤ 83 mm), oval-rounded in outline, slightly elongated (H < L), moderately and evenly convex, slightly uneven. The anterior and posterior margins are strongly convex, broadly rounded, usually blending smoothly into the arcuate dorsal margin; sometimes there is a distinct posterodorsal inflection of the valve; the ventral margin is slightly convex, connected with anterior and posterior margins by a smooth curve. The umbos are prosogyrate, slightly protruding, small, pointed, sometimes slightly pushed back to the anterior margin. The lunule is deep, relatively wide, oval-triangular outline; on some specimens approximately in the middle it is divided by a small stepped bend into two parts, of which the more flattened one adjoins the edge of the valve. The ligament is external, on a deep, narrow, elongated escutcheon, extending along the entire posterior branch of the dorsal margin; with pronounced nymphs. The surface in the umbonal region with regular thin, rounded, symmetrical concentric ribs; towards the ventral margin, the ribs become irregular, inconsistent and often merge with coarse growth lines.

The cardinal platform is wide. The hinge (Fig. 28.1a): in the right valve (Pl. 14, fig. 8)—d3a narrow, elongated, oriented obliquely down and forward; its base is in contact with the posterior end of dAI; d3b is strong, highly triangular, oblique and flattened below, directed obliquely downwards and backwards; dPIII is weakly expressed, elongated, on the continuation of the site; in the left valve (Pl. 14, figs. 7b, 79a), d2 is massive, highly conical, vertical or slightly inclined; d4b is narrow, strongly oblique down and back; dAII is weakly expressed, elongated: dPII is slightly arched, on the continuation of the platform.

The muscle cars are large, smooth, slightly depressed; the anterior scar is oval in outline; the posterior is slightly larger than the anterior and has a rounded outline. The foot muscle scar muscle is located below the hinge area a few millimeters to the side of the upper end of the anterior scar. The shell margins are finely transversely serrated from inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
MZMSU1/42 (RV) (holotype)	65	56	0.86	15	0.23
MZMSU 3/42 (LV)	63	69	1.0	30	0.40
PIN 5596/162 (Sh)	45	43	0.90	43	0.90

Comparison. It is most similar in shell shape to *E. (E.) gigantea* (Deshayes in Leymerie, 1842; Neoco-

Explanation of Plate 14

Fig. 1. *Pholadomya gigantea* (Sowerby), specimen PIN, no. 5596/153, shell with a broken anterior margin edge, external view, right valve view, ×1; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1961).

Figs. 2–6. *Platymyoidea marullensis* (d'Orbigny): (2) specimen PIN, no. 5596/154, shell with broken posterior margin, external view, ×1: (2a) lateral view, right valve view, (2b) umbonal view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (3) specimen PIN, no. 5596/155, shell, external view, right valve view: (3a) ×1.5, (3b) enlarged area of its surface, ×5; the same locality, age and collector (coll. 1986); (4) specimen PIN, no. 5596/156, left valve on the surface of the marl tile, external view, lateral view, ×1; Dolgorukovskaya Yaila, 500 m north of Mount Kolbair; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1986); (5) specimen PIN, no. 5596/157, molds with open and displaced valves, ×1; the same locality, age and collector; (6) specimen PIN, no. 5596/158, right valve on the surface of the marl plate, external view, lateral view, ×2; the same locality, age and collector.

Figs. 7–9. *Eriphyla (Eriphyla) mordvilkoae* Yanin: (7) specimen MZMSU, no. 1/42, holotype, left valve, ×1: (7a) external view, lateral view, (7b) from inside; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (8) specimen MZMSU, no. 2/42, fragment of the umbonal region of the right valve, from inside, ×1.5; the same locality, age and collector; (9) specimen MZMSU, no. 3/42, shell with displayed valve, external view, ×1: (9a) lateral view, right valve view, (9b) umbonal view; the same locality, age and collector.

mian of France) and *E. (E.) obovata* (Sowerby) (Woods, 1899–1913; Aptian of southern England), but differs from them in a number of essential characters: from the first one, in the smaller size of the shell; a less protruding umbonal region and a more elongated shell (in *E. (E.) gigantea*, the shell has a triangular outline in the upper part); it differs from *E. (E.) obovata* in the slightly protruding umbos; less pronounced inequilaterality of the shell (in *E. (E.) obovata*, the umbo are very close to the anterior margin or almost hang over it); thinner and less pronounced ribbing.

Material. 20 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu River (villages of Blagodatnoe, Novoklyonovo, Chernokamenka); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log), Beshterek River (village of Solovjevka) and Zuja River (Balanovskoe Reservoir).

Eriphyla (Eriphyla) crimica Yanin, 1980

Plate 15, figs. 1–5; Fig. 28.1b

Eriphyla crimica: Yanin, 1980b, p. 29, pl. 9, fig. 7–9; Yanin in Arkadiev et al., 2012, p. 272, pl. 45, figs. 2, 3.

Eriphyla mordvilkoae: Bogdanova, 1997, p. 86, pl. 19, fig. 9 (non fig. 10).

Astarte buchi: Eristavi, 1957, p. 28, pl. 1, fig. 1.

Holotype. MZMSU, no. 4/42, left valve (Yanin, 1980b, pl. 9, figs. 11a, 11b); Southwest Crimea, Bel'bek River (Kuibyshevo, Kabaniy Log); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone (by original designation: Yanin, 1980b, p. 29).

Description. The shell is small and medium-sized (D ≤ 35 mm), elongated-oval, less commonly rounded-rectangular, slightly elongated (P ≤ D); moderately and evenly convex, weakly or strongly inequilateral, with a retracted and widely rounded posterior-underside. The anterior margin is short, forming a smooth curve or a sharply rounded bend with the short anterior branch of the dorsal margin; the posterior margin is broadly and smoothly rounded, forming with a slightly convex ventral margin, a smooth curve or a barely noticeable rounded bend; the posterior branch of the dorsal margin is convex, elongated, with a posterior margin forming a smooth bend. The umbos are prosogyrate, small, sharp, strongly shifted to the anterior margin, sometimes almost overhanging it. The lunule is deep, relatively wide, oval, and smooth. The ligament is external, on a deep, narrow, elongated escutcheon, extending along the entire posterior branch of the dorsal margin; with strong nymphs. The shell surface bears low, narrow, rounded, symmetrical concentric ribs; near the umbo and dorsal margin, the ribs are always more regular, thin and slightly undulating.

The cardinal platform is wide. The hinge (Fig. 28.1a): in the right valve (Pl. 15, fig. 2b)—d3a is small, very narrow, strongly oblique down and back; its anterior slope merges with the surface of the area; d3b is massive, highly triangular, flattened below, oblique down and back; dAI is narrow, elongated, parallel to the bottom edge of the platform; closely adjacent to d3a; dPI was not preserved, but judging by the posterior pit furrow on the left valve, it was elongated, oriented parallel to the posterior-upper margin of the valve; in the left valve (Table 15, fig. 4); d2 is massive, triangular-conical in shape, oblique and convex from below in the lower part and concave in the upper part; d4b is narrow, lamellar, elongated; its posterior slope merges with the surface of the area; dAII is narrow, elongated, represents the inner margin of the hole; dPII is elongated, on the continuation of the area. No muscle scars were observed. The shell margins are finely serrated on the inside.

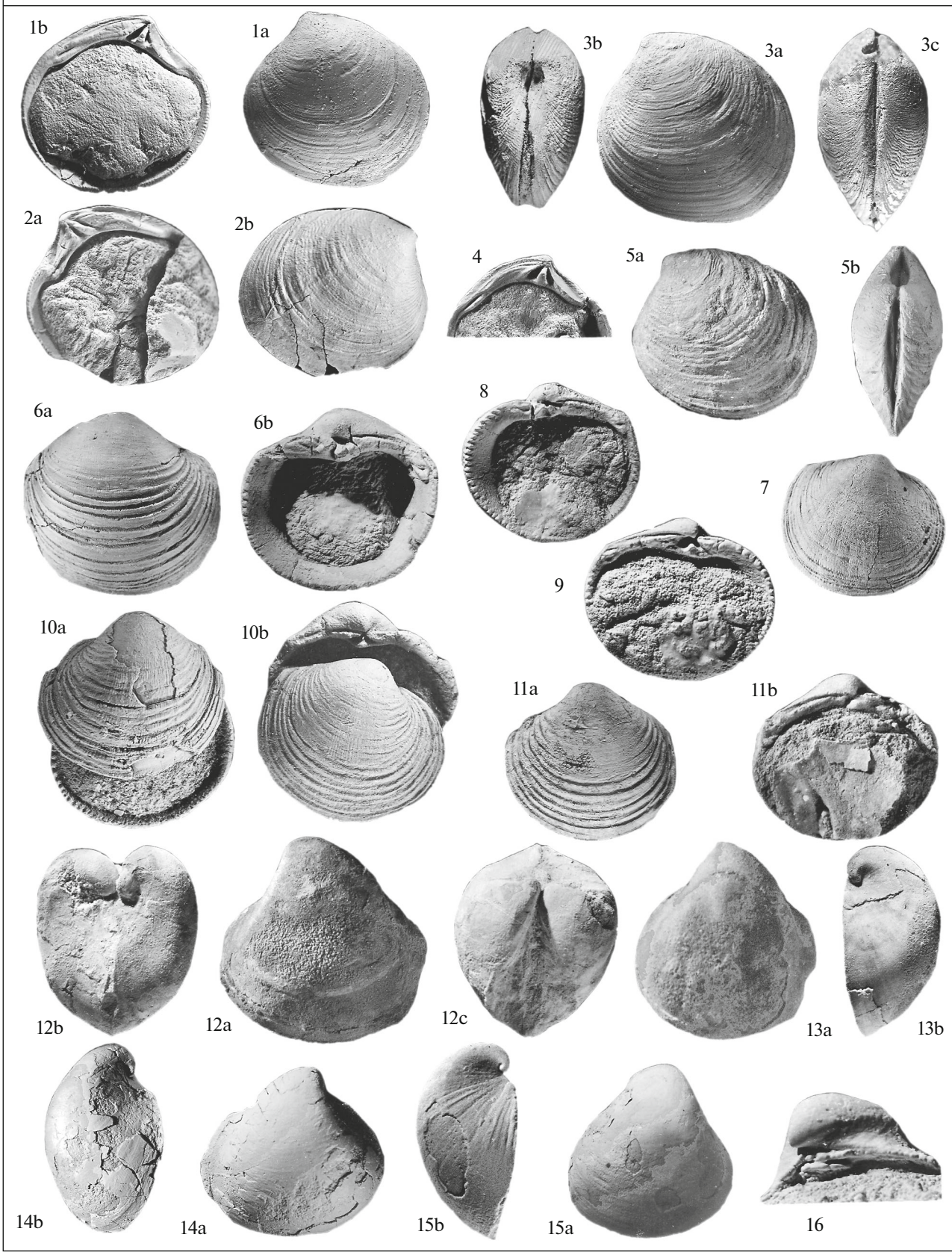
Explanation of Plate 15

Figs. 1–5. *Eriphyla (Eriphyla) crimica* Yanin: (1) specimen MZMSU, no. 4/42, holotype, left valve, × 1: (1a) external view, lateral view, (1b) view from inside; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (2) specimen MZMSU, no. 5/42, right valve, ×1: (2a) external view, lateral view, (2b) from inside; the same locality, age and collector; (3) specimen MZMSU, no. 6/42, shell, ×1: (3a) lateral view, left valve view, (3b) anterior view, (3c) umbonal view; the same locality, age and collector; (4) specimen PIN, no. 5596/163, umbonal region of the left valve from inside, ×1; the same locality, age and collector; (5) specimen PIN, no. 5596/164, shell, external view: (5a) left valve view, (5b) umbonal view, ×1; the same locality, age and collector.

Figs. 6–11. *Fimbria berriassica* Yanin, sp. nov.: (6) specimen PIN, no. 5596/165, holotype, right valve, ×1: (6a) external view, lateral view, (6b) view from inside; Sarysu River, village of Novoklyonovo; Lower Berriasian, *Chaperi* Beds (coll. V.V. Drushchits, 1955); (7) specimen PIN, no. 5596/166, shell, external view, right valve view, ×1; the same locality, age and collector; (8) specimen PIN, no. 5596/167, right valve, view from inside, ×1; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962); (9) specimen PIN, no. 5596/168, left valve, view from inside, ×1; the same locality, age and collector; (10) specimen PIN, no. 5596/169, shell with displayed valve, external view, ×1: (10a) left view and (10b) right valve; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (11) specimen PIN, no. 5596/170 , left valve, ×1: (11a) external view, lateral view, (11b) from inside; the same locality, age and collector.

Figs. 12–16. *Glossus neocomiensis* (Agassiz): (12) specimen MZMSU, no. 194/57, shell, ×1: (12a) lateral view, left valve view, (12b) anterior view, umbonal view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian *tauricum* Subzone (coll. B.T. Yanin, 1956); (13) specimen MZMSU, no. 195/57, left valve, external view, ×1: (13a) lateral view, (13b) anterior view; the same locality, age and collector; (14) specimen PIN, no. 5596/174, right valve, external view, ×1: (14a) lateral view, (14b) anterior view; the same age and locality (coll. V.V. Drushchits, 1954); (15) specimen PIN, no. 5596/175, right valve, external view, ×1: (15a) lateral view, (15b) anterior view, ×1; the same locality, age and collector; (16) specimen TsNIGRM, no. 130/13220, umbonal region of the right valve, from inside, ×1; the same age and locality (coll. B.T. Yanin, 1954).

Plate 15


1b
1a
3b
3a
3c
2a
2b
4
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5b
6a
6b
8
7
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10a
10b
11a
11b
12b
12a
12c
13a
13b
14b
14a
15b
15a
16

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/163 (LV)	28	28	1.0	9	0.30
PIN 5596/164 (Sh)	32	29	0.90	15	0.40
MZMSU 4/42 (LV) holotype	32	29	0.90	8.5	0.26
MZMSU 5/42 (RV)	33	30	0.90	9	0.27
MZMSU 6/42 (RV)	35	34	0.97	11	0.30

Comparison. This species is distinguished from *E. (E.) mordvilkoae* (see above) in the smaller size and higher shell (H/L > 0.90, in *E. (E.) mordvilkoae* <0.90); its greater inequilaterality; the umbos positioned closer to the anterior margin, often hanging over it; the hinge platform more arcuately curved and oblique down and forward; weaker d3a and very narrow posterior dental socket on the right valve; from *E. (E.) bodei* (Wollemann, 1900; Neocomian Germany) it differs in the less regular, inconsistent ribbing over the entire valve surface; sharper, narrower, slightly protruding umbos; less developed lunule; a narrower hinge area and a wider and smoothly rounded anterior margin; it differs from *E. (E.) spitiensis* (Stoliczka, 1870–1871; Cretaceous of India) in the presence of narrower, deeper and elongated alveolus and escutcheon (in the compared species, the alveolus is wider); uniform bulge throughout the shell; from *E. (E.) argentina* (Buckhardt, 1903; Weaver, 1931; Neocomian of Argentina) it differs in the higher and less elongated shell (H/L > 0.90 versus 0.80–0.83); thinner and less consistent ribbing.

Material. 57 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern slope of Aipetri Yaila (Bakhchisarai highway); the same Zone, *chaperi* Beds—Sarysu River (village of Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Chernaya Balaklava (flux quarry), Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e) and Beshterek River (village of Solovjevka).

Superfamily Mactromyoidea Cox, 1929

Family Fimbriidae Nicol, 1950

Genus *Fimbria* Megerle von Mühlfeld, 1811

***Fimbria berriassica* Yanin, sp. nov.**

Plate 15, figs. 6–11; Fig. 28.2

Etymology. From the Berriasian Stage.

Holotype. PIN, no. 5596/165 (Pl. 15, figs. 6a, 6b; right valve); Central Crimea (Sarysu River, village of Novoklyonovka); Lower Cretaceous, Lower Berriasian, *jacobi* Zone, *chaperi* Beds.

Description. The shell is small and medium-sized (L ≤ 36 mm), oval in shape, moderately convex, rarely swollen, low (H < L), ribbed, slightly inequivalvate. The anterior, ventral and posterior margins are convex, forming a smooth curve; the dorsal is almost straight, forms a clear obtuse angle with the posterior margin. The umbos are prosogyrate, small, slightly protruding, inclined towards the anterior margin. The ligament is external, on a narrow, elongated escutcheon, extending along the entire posterior branch of the dorsal margin; with strong nymphs.

The surface with concentric and radial ornamentation. Concentric ribs coarse, irregular, asymmetrical, ridge-like, well expressed on lateral side and near shell margins; weak or absent in the umbo region. Radial striae are very densely spaced, thin, weakly rounded or flattened, with very narrow, filiform intercostal spaces: they are especially well seen in the umbonal region and on the lateral part of the valve; gradually obscured towards the ventral margin, often absent near the upper part of the posterior margin; usually pronounced on the upper slopes of the concentric ribs. In some areas of the shell surface, at the intersection of concentric and radial elements, a reticulate ornamentation is observed.

The cardinal platform is narrow, sometimes almost non-delimited. The hinge (Fig. 28.2): in the right valve (Pl. 15, figs. 6b, 8), d3a and d3b are tuberculate, merging with each other with their lateral sides, at their base there is a rounded fossa for d2a of the left valve; dAI and dAIII small, short, almost merging with d3a; dPI and dPIII small, remote from cardinal teeth; in the left valve (Pl. 15, figs. 9, 10b), d2 is small, triangular in shape, with a pointed apex and wide base; oriented vertically; dAII poorly expressed (absent in some specimens); dPII and dPIV small, very short, distant from cardinal teeth. Muscular imprints are large, rounded. The margins are finely serrated on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/173 (LV)	19	17	0.80	–	–
PIN 5596/168 (LV)	22	19	0.80	8	0.34
PIN 5596/172 (LV)	23	21	0.90	8	0.34
PIN 5596/171 (LV)	26	23	0.80	–	–
PIN 5596/166 (Sh)	29	25	0.86	10	0.37
PIN 5596/170 (LV)	32	28	0.87	12	0.37
PIN 5596/167 (RV)	32	29	0.90	11	0.34
PIN 5596/169 (Sh)	33	29	0.87	12	0.36
PIN5596/165(RV) (holotype)	34	32	0.94	17	0.50

Comparison. This species is different from the shell of *F. michaillensis* (Pictet et Campiche, 1864–1867; Urgonian of Switzerland), which is most similar in outline, ornamentation, and size, in a shorter shell; the presence of a clear obtuse angle between the posterior and dorsal margins; less symmetrical umbos; more distinct, especially in the umbonal region, radial striae; the absence of a clearly expressed concentric ribbing in the umbo region; from *F. gaultina* (Pictet et

Roux) (see Pictet and Campiche, 1864–1867; Albian France and Switzerland) with a more oval shell shape; rounded posterior margin; the absence of a posterior-inferior inflection of the valves; very slightly protruding umbos and less swollen shell.

Material. Nine specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu River (village of Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log) and Beshterek (village of Solovjevka); Upper, *euthymi* Subzone—Sarysu River (vicinity of the village Balki).

Genus *Sphaera* Sowerby, 1822

Sphaera belbekensis Yanin in Bogdanova, 1997

Plate 16, figs. 1–3; Figs. 28. 3a, 3b

Sphaera corrugata: Yanin, 1960, p. 214, pl. 25, figs. 8a, 8b.

Sphaera belbekensis: Yanin in Bogdanova, 1997, p. 84, pl. 20, figs. 1, 2; Yanin in Arkadiev et al., 2012, p. 273, pl. 45, fig. 4, 5.

Holotype. MZMSU, no. 205/57; specimen *S. corrugata* (Yanin, 1960, pl. 25, fig. 8a, 8b; shell); Southeastern Crimea, Bel'bek River (village of Kuibyshevo, Kabaniy Log); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone (by original designation: Yanin in *Atlas* ..., 1997, p. 84).

Description. The shell is medium-sized (L ≤ 56 mm), spherical, round-oval or oval-elongated in shape, massive, thick-walled, strongly convex, sometimes swollen, moderately high (P ≤ L). The anterior and posterior margins are broadly rounded, forming a smooth curve with the ventral margin, while having noticeable, obtusely rounded bends with the dorsal margin, of which the anterior-upper is better expressed. The umbos are orthogyrate, prominent, usually almost central, rarely prosogyrate, slightly inclined forward. Often a more or less pronounced widely concave depression extends from the umbo to the anterior margin, separating the anterodorsal angle of the valve from the lateral surface. Sometimes there is a weaker depression on the posterior side of the valve, separating its posterodorsal angle from the rest of the surface. The degree of concavity of the upper part of the anterior margin depends on the size and depth of the umbonal depression. The ligament is external, on a narrow, flattened escutcheon, with strong nymphs.

The surface bears coarse, crested and smooth, asymmetrical concentric ribs (the lower slope of which is wide and gentle, the upper slope is steep), especially coarse near the valve margins; in the umbonal area they are weakened. The ribbing is mostly irregular: many ribs do not reach the anterior and posterior margins of the valve, sometimes additional short ribs appear. The intercostal spaces are narrow (narrower than ribs or equal in width), concave, smooth.

The cardinal platform is wide and massive. The hinge (Figs. 28, 3a, 3b): in the right valve (Pl. 16, fig. 2b), d3a and d3b are tuberculate, with rounded apices, merging their sides and together forming a short subhorizontal ridge; dAIII is strong, short, with an acute-angled apex, oriented subhorizontally and very close to d3a (separated from it by an oblique groove); dPI and dPIII are short, with rounded tops, oriented parallel to the bottom edge of the platform; in the left valve (Pl. 16, fig. 3b), d2 is low, triangular; dAII narrow, strongly elongated parallel to the lower edge of the anterior branch of the platform; dAIV elongated, ridgelike, separated from dAII by a deep pit for dAIII of the opposite valve; dPII and dPIV short, irregularly tuberculate. Muscle scars were not studied. The margins are smooth on the inside.

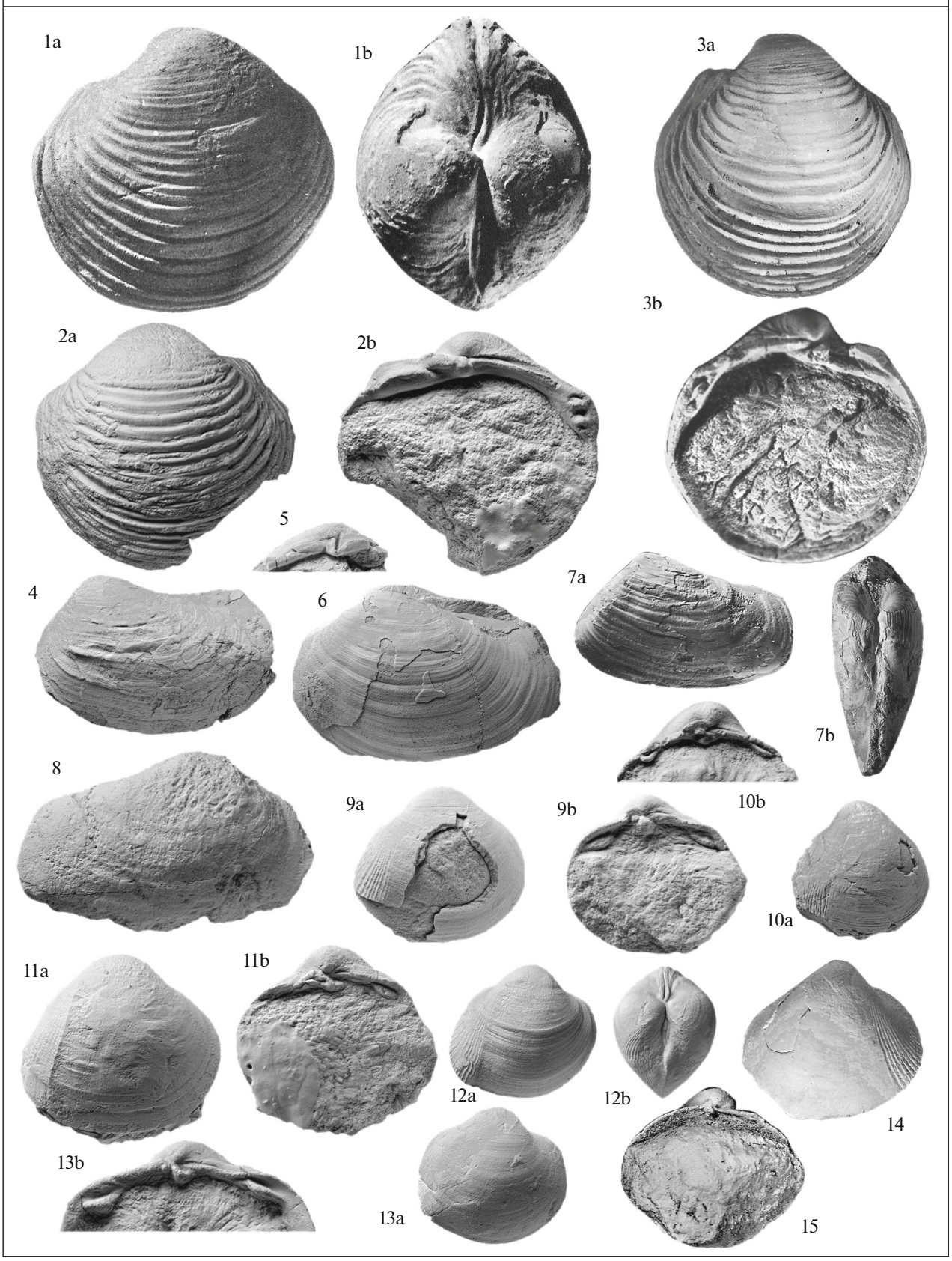
Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/180 (Sh)	40	36	0.9	32	0.70
PIN 5596/181 (Sh)	40	37	0.9	36	0.9
PIN 5596/182 (RV)	42	~38	0.9	–	–
TsNIGRM135/13220 (LV)	45	46	1.0	20	0.44
PIN 5596/183 (RV)	48	38	0.8	16	0.33
PIN 5596/178 (RV)	48	45	0.90	21	0.30
PIN 5596/179 (Sh)	53	46	0.88	37	0.69
MZMSU205/57 (Sh) (holotype)	56	53	0.94	42	0.75

Comparison. This species differs *S. corrugata* from the Aptian of southern England (Sowerby, 1822) and Barremiana Northern Caucasus (Mordvilko, 1949), which is closest in shape and sculpture, in smaller sizes; smaller and more asymmetrical crested ribs; absence of radial hatching on the shell surface; narrower, lower, strongly elongated dAII in the left valve (in contrast to the corresponding high short and irregularly conical tooth in the compared species); slightly protruding, low-conical d2 in the left and correspondingly weakly expressed oblique dental fossa on the right valves (in *S. corrugata*, it is very wide, rounded); tubercular posterior lateral teeth on the left valve (in *S. corrugate*, they are shaped as short ridges running parallel to the upper margin of the cardinal platform).

Material. 37 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Zuja (Balanovskoe Reservoir) and Sarysu River (village of Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e) and Beshterek River (village of Solovjevka).

Plate 16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Superfamily Hiatelloidea Gray, 1824

Family Hiatellidae Gray, 1824

Genus *Panopea* Menard, 1807

***Panopea neocomiensis* (Leymerie, 1842)**

Plate 16, figs. 4–8; Fig. 28.4

Pholadomya neocomiensis: Leymerie, 1842, p. 3, pl. 3, figs. 4a, 4b.

Panopea neocomiensis: d'Orbigny, 1843–1847, p. 329, pl. 353, figs. 3–8; Karakash, 1897, p. 80, pl. 2, fig. 8.

Panope neocomiensis: Yanin, 1960, p. 219, pl. 27, fig. 9a, b; Bogdanova, 1997, p. 90, pl. 21, figs. 4, 5.

Holotype. A specimen of *Pholadomya neocomiensis* (Leymerie, 1842, pl. 3, figs. 4a, 4b; shell); France (Aube); Lower Cretaceous, Neocomian (designated by monotypy herein).

Description. The shell is medium-sized to large (L ≤ 67 mm), elongated, irregularly oval (H < L), strongly unequal (anterior side three times shorter than the posterior), moderately convex. The umbos are subcentral, massive, obtuse, moderately protruding, strongly pushed forward to the anterior margin; their beaks are pointed, bent inward and forward. The anterior side of the shell is obtuse; often a clear carinate bend extends from the umbo to the anteroventral margin; the posterior margin is narrowed and laterally compressed. The point of greatest convexity is located in the middle of the valves directly behind the height line. The anterior branch of the dorsal margin is short, slightly convex, directed obliquely downward from the umbo; the posterior margin is long, straight or slightly concave. The anterior margin of the shell is broadly rounded, but sometimes slightly angular; the ventral margin is long, slightly or moderately convex, with the anterior margin often forms a distinct rounded bend (especially in specimen with a carina); the posterior margin is short, evenly rounded, gradually passing into the ventral and dorsal margins.

The surface has concentric, often coarse, wrinkled, irregular growth lines and very numerous thin radial rows of tiny, pointed, rounded granules (distinguishable only under magnification on well-preserved specimens); granules cover the entire surface of the valves, except for a narrow strip along the posterior branch of the dorsal margin.

The cardinal platform is absent. The cardinal teeth (one in each valve) are located directly on the dorsal margin under the tip of the umbos (Fig. 28.4). They are tall, lamellar, oriented vertically. There are no lateral teeth. The ligament is external, opisthodetic, on escutcheon with short nymphs. The anterior gaping is narrow, the posterior gaping is of moderate width. The margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/187 (Sh)	40	25	0.60	17	0.40
PIN 5596/189 (Sh)	42	24	0.57	20	0.47
PIN 5596/184 (Sh)	45	28	0.60	25	0.50
PIN 5596/188 (Sh)	52	30	0.57	22	0.42
PIN 5596/186 (Sh)	60	35	0.60	25	0.40
PIN 5596/190 (Sh)	58	36	0.60	26	0.40

Comparison. This species differs from *P. cylindrica* (Pictet et Campiche, 1864–1867; Hauterivian Switzerland), which is similar in shell shape and posi-

Explanation of Plate 16

Figs. 1–3. *Sphaera belbekensis* Yanin: (1) specimen MZMSU, no. 205/57, holotype, shell, external view, ×1: (1a) lateral view, left valve view, (1b) umbonal view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (2) specimen PIN, no. 5596/178, right valve, ×1: (2a) external view, lateral view, (2b) from inside; Sarysu River, village of Novoklyonovo; Enisarai Ravine; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1955); (3) specimen TsNIGRM, no. 125/13220, left valve, ×1: (3a) external view, lateral view, (3b) from inside; the same locality, age and collector.

Figs. 4–8. *Panopea (Panopea) neocomiensis* (Deshayes): (4) specimen PIN, no. 5596/184, shell, lateral view, left valve view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1954); (5) specimen PIN, no. 5596/185, umbonal region of the left valve, from inside, ×3; Sarysu River, vicinity of the village of Novoklyonovo, Enisarai Ravine; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1954); (6) specimen PIN, no. 5596/186, shell, external view, left valve view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (7) specimen PIN, no. 5596/187, shell, external view, ×1: (7a) lateral view, left valve view, (7b) umbonal view; the same age and locality (coll. V.V. Drushchits, 1954); (8) specimen PIN, no. 5596/188, mold, external view, lateral view, right valve view, ×1; Dolgorukovskaya Yaila, 500 m north of Mount Kolbair; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1986).

Figs. 9–15. *Protocardia broili* Yanin, sp. nov.: (9) specimen PIN, no. 5596/191, holotype, right valve, ×1.5: (9a) external, lateral view, (9b) from inside; northern slope of Aipetri Yaila, Bakhchisarai-Yalta highway; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1987); (10) specimen PIN, no. 5596/192, right valve: (10a) external view, lateral view, ×1, (10b) from inside, ×3; the same area, the upper reaches of the Kizil-Dere Ravine, the edge of the forest; the same age and collector (coll. 1987); (11) specimen PIN, no. 5596/193, right valve: (11a) external view, lateral view, ×1, (11b) view from inside, ×2; the same locality age and collector (coll. 1987); (12) specimen PIN, no. 5596/194, shell, external view, ×1.5: (12a) lateral view, right valve view, (12b) umbonal view; the same locality, age and collector; (13) specimen PIN, no. 5596/195, right valve: (13a) external view, lateral view, ×1.5, (13b) from inside, ×3; the same locality, age and collector; (14) specimen TsNIGRM, no. 126/13220, left valve, external view, lateral view, ×1.5; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (15) specimen TsNIGRM, no. 127/13220, right valve, from inside, ×1.5; the same locality, age and collector.

tion, in lesser shell swelling; evenly rounded posterior margin and smaller width of posterior gaping; from the similar *P. plicata* from the Aptian–Albian southern England (Sowerby, 1823) and Albian France (d'Orbigny, 1843–1847) with more forward umbos; the angular anterior margin; the presence of a clearly defined anterior carinate inflection; more rounded (not truncated) posterior margin; and a narrower posterior gaping.

Occurrence. Berriasian–Aptian: Berriasian–Valanginian of the Crimea; Berriasian–Barremian of the Northern Caucasus; Neocomian–Aptian of France, Spain, Switzerland; Hauterivian–Aptian of Bulgaria.

Material. 14 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern slope Dolgorukovskaya Yaila (Mount Kolbair area); the same Zone, *chaperi* Beds—Sarysu River (village of Novoklyonovo, Enisarai Ravine); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e).

Order Venerida H. et A. Adams, 1856

Superfamily Cardioidea Lamarck, 1809

Family Cardiidae Lamarck, 1809

Subfamily Protocardiinae Keen, 1951

Genus *Protocardia* Beyrich, 1845

Subgenus *Protocardia* Beyrich, 1845

***Protocardia (Protocardia) peregrina* (d'Orbigny, 1842)**

Plate 17, figs. 1–4

Cardium peregrinorsum: d'Orbigny, 1842, p. 46, pl. 3, fig. 6–8; 1843–1847, p. 16, pl. 239, fig. 1–3.

Cardium peregrinum: d'Orbigny, 1850, p. 79; Pictet, Campiche, 1864–1867, p. 254, pl. 121, figs. 1, 2; Karakash, 1897, p. 72, pl. 1, fig. 24.

Protocardium peregrinum: Pchelincev, 1927, p. 146.

Protocardia peregrina: Yanin in Arkadiev et al., 2012, p. 274, pl. 45, figs. 6 and 7.

Holotype. Specimen of *Cardium peregrinorsum* (d'Orbigny, 1842, pl. 3, figs. 1–3; shell); South America (Colómbia, New Grenada); Lower Cretaceous, Neocomian (designated by monotypy herein).

Description. The shell is small (Sh ≤ 23 mm), subtriangular in shape, moderately convex, equal-valved, almost equilateral, finely ribbed. The shell

Explanation of Plate 17

Figs. 1–4. *Protocardia (Protocardia) peregrina* (d'Orbigny): (1) specimen PIN, no. 5596/197, right valve: (1a) external view, lateral view, (1b) view from inside, ×1.5; (1c) enlarged umbonal area, from inside, ×3; Sarysu River, village of Novoklyonovo; Lower Berriasian, *chaperi* Beds (coll. V.V. Drushchits, 1955); (2) specimen PIN, no. 5596/198, left valve, external view, lateral view, ×1; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (3) specimen PIN, no. 5596/199, left valve, external view, lateral view, ×1; the same age and locality (coll. V.V. Drushchits, 1955); (4) specimen PIN, no. 5596/200, left valve, external view, lateral view, ×1; the same locality, age and collector.

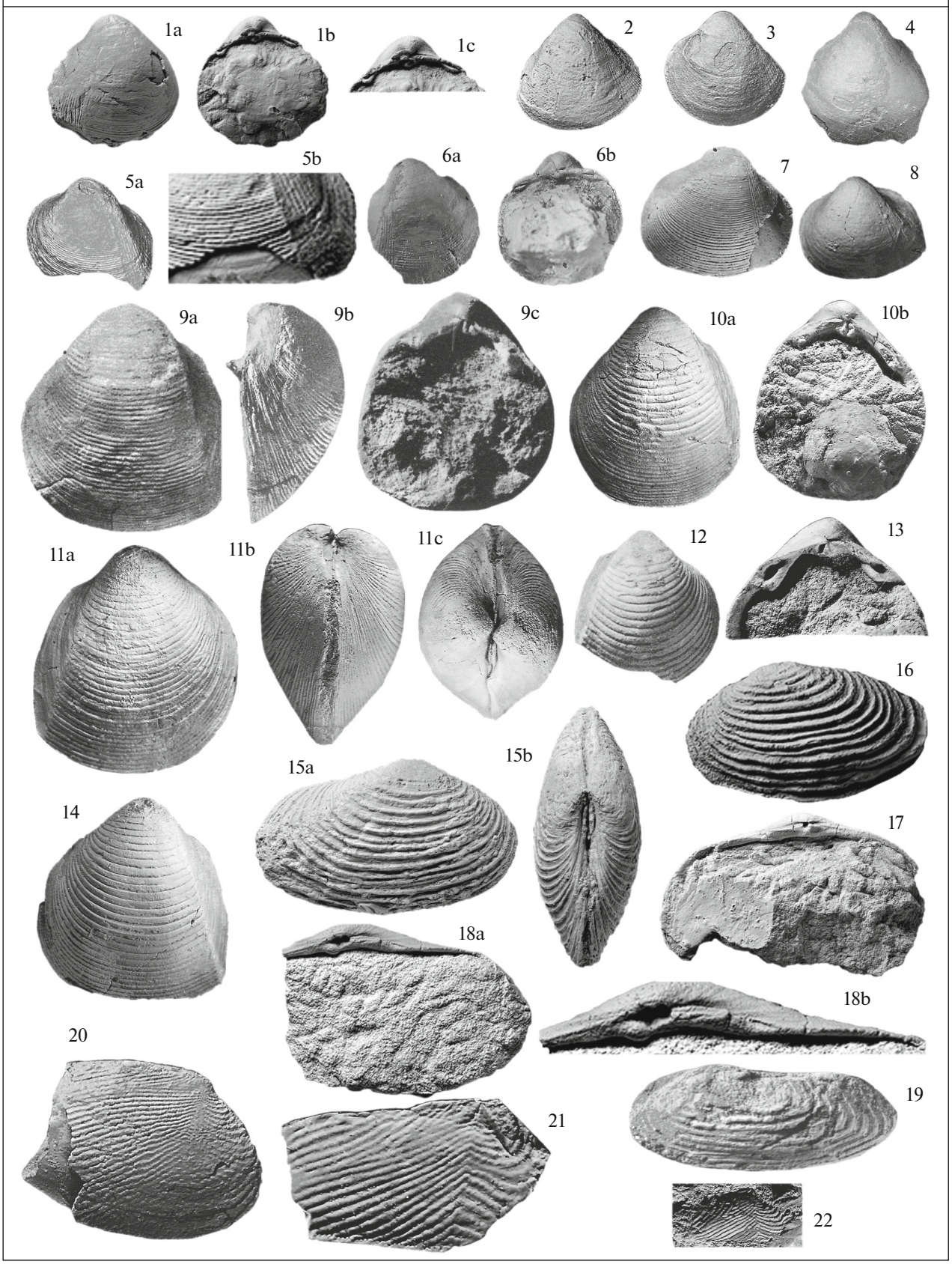
Figs. 5–8. *Protocardia (Protocardia) carinata* Yanin, sp. nov.: (5) specimen PIN, no. 5596/201, left valve, external view, lateral view: (5a) ×1.5, (5b) enlarged area of its surface, ×3; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955); (6) specimen PIN, no. 5596/202, holotype, right valve, ×1.5: (6a) external view, lateral view, (6b) view from inside; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962); (7) specimen PIN, no. 5596/203, left valve, external view, lateral view, ×1.5; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955); (8) specimen PIN, no. 5596/204, left valve, external view, lateral view, ×2; Zuja River, vicinity of the village of Krasnogor'e, Tau-Kipchak Cave area; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955).

Figs. 9–14. *Globocardium sphaeroideum* (Forbes): (9) specimen MZMSU, no. 209/57, left valve, ×1: (9a) external view, lateral view, (9b) anterior view, (9c) from inside; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (10) specimen TsNIGRM, no. 128/13220, left valve, ×1: (10a) external view, lateral view, (10b) view from inside; the same age and locality (coll. V.V. Drushchits, 1955); (11) specimen PIN, no. 5596/209, shell, external view, ×1: (11a) lateral view, right valve view, (11b) anterior view, (11c) umbonal view; the same age and locality (coll. B.T. Yanin, 1956); (12) specimen MZMSU, no. 210/57, right valve with a broken ventral margin, external view, lateral view, ×1; the same locality, age and collector; (13) specimen PIN, no. 5596/210, fragment of the umbonal region of the right valve, from inside, ×1; the same locality, age and collector; (14) specimen PIN, no. 5596/211, left valve, external view, lateral view, ×1; the same locality, age and collector.

Figs. 15–19. *Garum valangiensis* (Pictet et Campiche): (15) specimen PIN, no. 5596/214, shell, external view, ×1: (15a) lateral view, right valve view, (15b) umbonal view; Bel'bek River, vicinity of the village of Golubinka, southern slope of Mount Karatlykh, Orekhovyi Ravine; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956); (16) specimen PIN, no. 5596/215, shell, external view, lateral view, left valve view, ×1; the same locality, age and collector; (17) specimen PIN, no. 5596/216, left valve, view from inside, ×1.2; Sarysu River, village of Novoklyonovo; Middle Berriasian, *tauricum* Subzone (the same collector); (18) specimen PIN, no. 5596/217, right valve with broken front edge, on the inside: (18a) ×1.2; (18b) enlarged umbonal area, ×3; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962); (19) specimen PIN, no. 5596/218, shell with collapsed crown region, external view, left valve view, ×1; Bel'bek River, vicinity of the village of Golubinka, southern slope of Mount Karatlykh, Bezymyannyi Ravine; the same age and collector.

Figs. 20–22. *Ptychomya robinaldina* (d'Orbigny): (20) specimen PIN, no. 5596/220, fragment of the right wing with a broken back side, external view, lateral view, ×2; Beshterek River, village of Solovjevka; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1962); (21) specimen PIN, no. 5596/221, mold shells on a clay tile with a broken back edge, external view, right valve view, ×2; Sarysu River, village of Blagodatnoe; Lower Berriasian, *chaperi* Beds; the same locality, age and collector; (22) specimen PIN, no. 5596/222, mold on the surface of the marl plate, external view, right valve view, ×1; the same locality, age and collector.

Plate 17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margins are broadly rounded; the anterior margin is smoothly passes into a slightly convex ventral; the posterior margin forms a sharp bend with the latter; this inflection is most clearly expressed in more elongated forms; the dorsal margin is short, arcuately curved. The umbos orthgyrate, rarely slightly inclined towards the anterior margin, sharp, strongly protruding, incurved; the tip of the umbo is sometimes covered anteriorly by the pre-umbonal lapel of the dorsal margin of the valve. The ligament is external, on a short escutcheon, with thin nymphs. The carina is usually not pronounced.

The surface of the anterior and lateral sides of the valves has numerous, very thin (clearly visible under magnification), regular concentric striae. The intercostal gaps are very narrow. The surface of posterior side of the valves has 20–25 thin, flattened, smooth, radial ribs; they weaken near the posterodorsal edge and disappear near the edge. The ribbing covers not only the entire posterior margin, but also the posterior side of the ventral margin. On some specimens, thinner radial filaments are visible in the intercostal spaces. The posterior margin is finely serrated on the inside with rib ends; the anterior and ventral margins are smooth.

The cardinal platform is not isolated. The hinge consists of very thin teeth: in the left valve, d2 is very small, conical, bluntly rounded, merges with the edge of the valve in its anterior part; d4b is absent; dPII (judging by the dental fossa on the right valve) thin, elongated; in the right valve (Pl. 17, figs. 1b, 1c) d3a and d3b are very small, tuberculate; dAI and dPI small, arched, distant from cardinals.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/197 (RV)	16	16	1.0	13	0.70
PIN 5596/199 (LV)	21	19	0.90	7	0.33
TsNIGRM 127/13220 (RV)	22	19	0.86	7	0.30
PIN 5596/198 (LV)	22	20	0.99	8	0.36
TsNIGRM 126/13220 (LV)	22	20	0.99	8	0.36
PIN 5596/200 (LV)	23	22	0.95	–	–

Comparison. This species differs from *P. (P.) hillana* (Sowerby, 1813; Woods, 1908; Cenomanian of southern England), which is similar in shape and ornamentation, in smaller dimensions; a large number of thinner, sometimes longitudinally dissected radial ribs; thinner (visible only when magnified) concentric striae; the more rounded posterior margin bearing very fine serrations; from *P. (P.) carinata* (see below) in a larger size; more rounded shell outline; lack of a carina and a sharp posteroventral angle; thinner concentric striae; from *P. (P.) broili* (see below), in the finer concentric striations; the less protruding preumbonal lapel.

Remarks. The original specific name *peregrinorsum* (see synonymy) was later replaced by the author himself (d'Orbigny, 1850, p. 79) with the abbreviated name *peregrinum*.

Occurrence. Berriasian–Hauterivian: Berriasian of the Crimea; Berriasian–Hauterivian of the Northern Caucasus; Valanginian–Urgonian of Switzerland; Hauterivian of France; Neocomian of South America (Colómbia).

Material. Six specimens; Crimea, Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log) and Beshterek River (village of Solovjevka).

Protocardia (Protocardia) broili Yanin, 2020

Plate 16, figs. 9–15; Fig. 28.5

Protocardia sp.: Broili, 1902, p. 606, pl. 1, figs. 5a, 5b.

Protocardia broili: Yanin, 2020a, p. 11, pl. 1, figs. 9–11.

Holotype. PIN, no. 5596/191, right valve (pl. 1, figs. 9a, 9b); Southwest Crimea, basin of the Bel'bek River (northern slope of Aipetri Yaila, Bakhchisarai highway); Lower Cretaceous, Lower Berriasian, *jacobi* Zone (by original designation: Yanin, 2020a, p. 11).

Description. The shell is small in size (D ≤ 23 mm), oval in shape (H ≥ D), equivalvate, with moderately convex valves (sometimes spherical, T = H), slightly unequal. The valve margins are broadly rounded: the anterior margin is strongly convex, smoothly merging into slightly convex ventral; the posterior one is also slightly convex, forming a distinct rounded bend with the ventral margin. The umbos are orthogyrate or slightly prosogyrate, moderately protruding; the beaks are sharp, curved inwards; anterior covered with large preumbonal lapels of the dorsal margin. The ligament is external, on a short escutcheon with thin nymphs. The umbilical carina is absent. The anterior and central surfaces of the valves are smooth, with only thin lines (striae) of growth, their posterior side bears 13–16 thin radial ribs (in some specimens, they have clearly defined granulation. The valve margins are smooth from the inside. A smooth strip extends along the dorsal margin of the valves.

The cardinal platform is narrow. The hinge (Fig. 28.5) in the right valve (Pl. 16, figs. 9b, 10b, 11b, 13b, 15)—d3a very small, tuberculate, merges with the base of the preumbilical lapel; d3b—tuberculate, slightly larger than the anterior one and separated from it by a narrow bridge; dAI and dPI—strong, carinate, remote from the cardinal teeth; in the left valve (judging by the dental pits on the right), d2, d4b, dAII and dPII are present.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/192 (RV)	17	16	0.98	7	0.41
PIN 5596/195 (RV)	17	16	0.91	7	0.41
PIN 5596/196 (Sh)	18	17	0.94	14	0.77
PIN 5596/191 (RV) holotype	22	20	0.90	10	0.45
PIN 5596/194 (Sh)	24	22	0.91	19	0.79
PIN5596/193 (RV)	26	23	0.88	9	0.34

Comparison. This species differs from the shell of *P. (P.) peregrina*, which is very close in shape and sculpture (see above), in the more oval outlines of the valves (in the compared species, triangular–oval in outline); more developed preumbonal lapel; the presence of anterior lateral teeth on both valves; lack of fine concentric striation; it is distinguished from *P. (P.) carinata* (see below), a larger shell; the absence of a carina and the regular concentric ribbing.

Remarks. The species was named in memory of the Austrian paleontologist F. Broili, a participant in the field trip of the VII International Geological Congress in 1897 (see Section I.1). In 1902, from the "Lower Neocomian deposits" cropping out on the side of the highway between the Grand Canyon and the Ai-Petri Pass, he described *Protocardia* sp. (Broili, p. 606, pl. 1, figs. 5a, 5b). Both by description and images, the shells we collected from the same outcrop visited by the excursionists are identical to the specimen studied by F. Broili.

Material. 8 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern slope of Aipetri Yaila (Bakhchisaray–Yalta Highway); Middle Berriasian, *tauricum* Subzone—Sarysu River (village of Novoklyonovo).

***Protocardia (Protocardia) carinata* Yanin, sp. nov.**

Plate 17, figs. 5–8.

Etymology. From the Latin *carinata* (carinate).

Holotype. PIN, no. 5596/202, right valve (pl. 17, fig. 6); Central Crimea (Beshterek River, village of Solovjevka); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone.

Description. The shell is small (Sh ≤ 17 mm), oval-rounded (L ≥ H), carinate, with an angular posteroventral margin; thin-valved, strongly convex, slightly unequal. The anterior margin is widely rounded, forming a smooth curve with a slightly convex ventral margin; the posterior margin is also widely rounded, slightly convex, forming a sharply rounded inflection with the dorsal margin, and a distinct obtuse angle with the ventral margin, from which the valve has an angular outline. The umbo is orthogyrate or slightly prosogyrate, strongly protruding, leaning forward and curved inward; the tip of the umbo is covered anteriorly by the preumbonal lapel of the dorsal margin. The ligament is external, on very small escutcheon with weak nymphs.

The umbonal carina is distinct, especially in the umbonal region, flattening towards the posteroventral angle of the valve; divides its surface into two very unequal fields: the anterior is wide, evenly convex, covered (with the exception of its posterior side) with numerous, regular, thin, rounded, smooth concentric ribs, with very narrow, filiform, smooth intercostal spaces; the posterior one is narrow (three times narrower than the first one), flattened. The carina and narrow strip of the posterior side of the central field are covered with 20–22 thin, slightly convex or flattened radial ribs. The intercostal spaces contain narrower, thin, rounded additional radial striae bearing small spines (visible only at high magnification). In the middle of the valves, the field is smooth; on some young specimens, the ribs in the umbonal region are very thin, herringbone-shaped serrated. Posterior and posterior-inferior margins are finely serrated from inside; the anterior and ventral margins are smooth.

The cardinal platform is not delineated. Hinge: in the right valve (Pl. 17, fig. 6b), d3a and d3b are very small, tuberculate, pointed; the anterior tooth is located directly on the margin of the platform, slightly higher than the posterior one, at the base of the preumbonal lapel; d3b is under the tip of the umbo; between these teeth there is a very narrow bridge connecting their bases; dAI thin, short; dPI thin, elongated, straight; in the left valve (judging by the dental pits on the opposite valve), d2, dAII and dPII are present.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/208 (LV)	11	7	0.60	–	–
PIN 5596/204 (LV)	11	9	0.80	4	0.36
PIN 5596/205 (LV)	11	10	0.90	–	–
PIN 5596/206 (RV)	12	11	0.90	–	–
PIN 5596/201 (LV)	15	13	0.86	6	0.40
PIN5596/202(RV) holotype	16	16	1.0	7	0.43
PIN 5596/203 (LV)	19	17	0.89	7	0.36

Comparison. It differs from the ornamentation of *P. (P.) peregrina* (see above), which is similar in character, in having a more elongated shell; the presence of a carina and a clearly defined postero-inferior angle of the valve; greater convexity of the shell and more compact, clearly visible concentric ribs (in *P. (P.) peregrina*, the anterior surface of the valves is usually smooth, only sometimes with thin filiform concentric striae).

Material. 38 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu River (village of Blagodatnoe, Saigin Ravine); Middle Berriasian, *tauricum* Subzone—Chernaya Balaklava, flux quarry), Bel'bek River (village of Kuibyshevo,

Kabaniy Log), Beshterek River (village of Solovjevka) and Zuja River (Balanovskoe Reservoir).

Genus *Globocardium* Hayami, 1865

Globocardium sphaeroideum (Forbes, 1845)

Plate 17, figs. 9–14; Figs. 28.6a, 6b

Cardium sphaeroideum: Forbes, 1845, p. 243, pl. 2, fig. 8; Pictet and Renevier, 1855–1858, p. 77, pl. 9, fig. 3.

Cardium (Integricardium) sphaeroideum: Rollier, 1912, p. 129.

Protocardia sphaeroideum: Woods, 1899-1913, p. 195, pl. 31, figs. 2, 3; Renngarten, 1926, p. 80; Mordvilko, 1932, p. 57, pl. 6, fig. 1; 1949, p. 135, pl. 26, fig. 2; Yanin, 1960, p. 215, pl. 26, figs. 3–5; Bogdanova, 1997, p. 87, pl. 20, figs. 5, 6; Yanin in Arkadiev et al., 2012, p. 275, pl. 45, figs. 8, 9.

Protocardia (*Globocardium*) *sphaeroideum*: Cox, Newell, 1969, p. N 588.

Holotype. Specimen of *Cardium sphaeroideum* (Forbes, 1845, pl. 2, fig. 8; left valve); southern England; Lower Cretaceous, Lower Aptian (designated by monotypy: Yanin in Arkadiev et al., 2012, p. 275).

Description. The shell is small to large (Sh ≤ 71 mm), ribbed, thick-walled, rounded-angular in shape, high (H > L), strongly convex, often swollen, equal-valve, usually equilateral. The anterior margin is broadly rounded, with the ventral margin forming a smooth curve of almost the same radius; the ventral margin is slightly convex; the posterior one is almost straight, forms an obtuse angle with the ventral one, but merges smoothly with the dorsal one, along a rounded inflection; sometimes the posterior margin is very oblique; the dorsal margin is slightly arcuately curved. The umbos are orthogyratic, strongly protruding, almost central or slightly sloping forward. The ligament is external, on a narrow, short escutcheon, with strong nymphs. The umbilical carina is carinate, serrated by the posterior ends of the concentric ribs. The lateral field is broad, uniformly convex, with numerous, smooth, low, often flattened, striated concentric ribs, with very narrow, filiform, intercostal spaces; posterior field narrow (half to a third of the lateral field width), flattened or slightly concave, smooth, only with strong growth lines.

The cardinal platform is narrow. The hinge (Fig. 28.6a, 28.6b): in the right valve (Pl. 17, fig. 13)—d3a small, tubercular, vertically oriented; d3b is triangular, with a sharp top; dAI and dPI strong, arcuate, nearly equal; in the left valve (Pl. 17, figs. 9c, 10b)—d2 is narrow, conical; d4b narrow, highly conical, slightly larger than and parallel to d2; dAII and dPII large, massive, tuberculate; the rear is slightly smaller than the anterior. The margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/212 (RV)	15	16	1.0	–	–
MZMSU 210/57 (RV)	25	28	0.12	–	–
TsNIGRM128/13220 (LV)	31	37	1.17	15	0.47
PIN 5596/213 (LV)	34	39	1.10	–	–
PIN 5596/211 (LV)	35	37	1.34	14	0.40
MZMSU 209/57 (LV)	38	46	1.20	17	0.44

Comparison. This species is most similar in shape and ornamentation to *G. imbricataria* (Leymerie, 1842; Neocomian of France), but differs from it in the presence of a carina and a clearly demarcated posterior field; well-defined posteroventral valve angle; lack of ribbing on the posterior side of the shell.

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Barremian–Aptian of the Northern Caucasus; Lower Aptian of Switzerland and southern England; Middle–Upper Aptian of France.

Material. 112 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *grandis* Subzone—northern slope Karabi-Yaila Plateau (Lanchin Ravine); the same Zone, *chaperi* Beds—Sarysu River (village of Chernokamenka); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e).

Genus *Integricardium* Rollier, 1912

***Integricardium deshayesianum* (Loriol, 1861)**

Plate 18, figs. 1–5; Figs. 27.1a, 1b; 29.1a, 1b

Cyprina deshayesiana: Loriol, 1861, p. 78, pl. 10, fig, 2; Pictet, Campiche, 1864–1867, p. 215, pl. 113, fig. 5; Wollemann, 1900, p. 112.

Cyprina bernensis: Karakash, 1907, p. 199.

Cardium (Integricardium) deshayesianum: Rollier, 1912, p. 133, pl. 10, fig. 1 and 2.

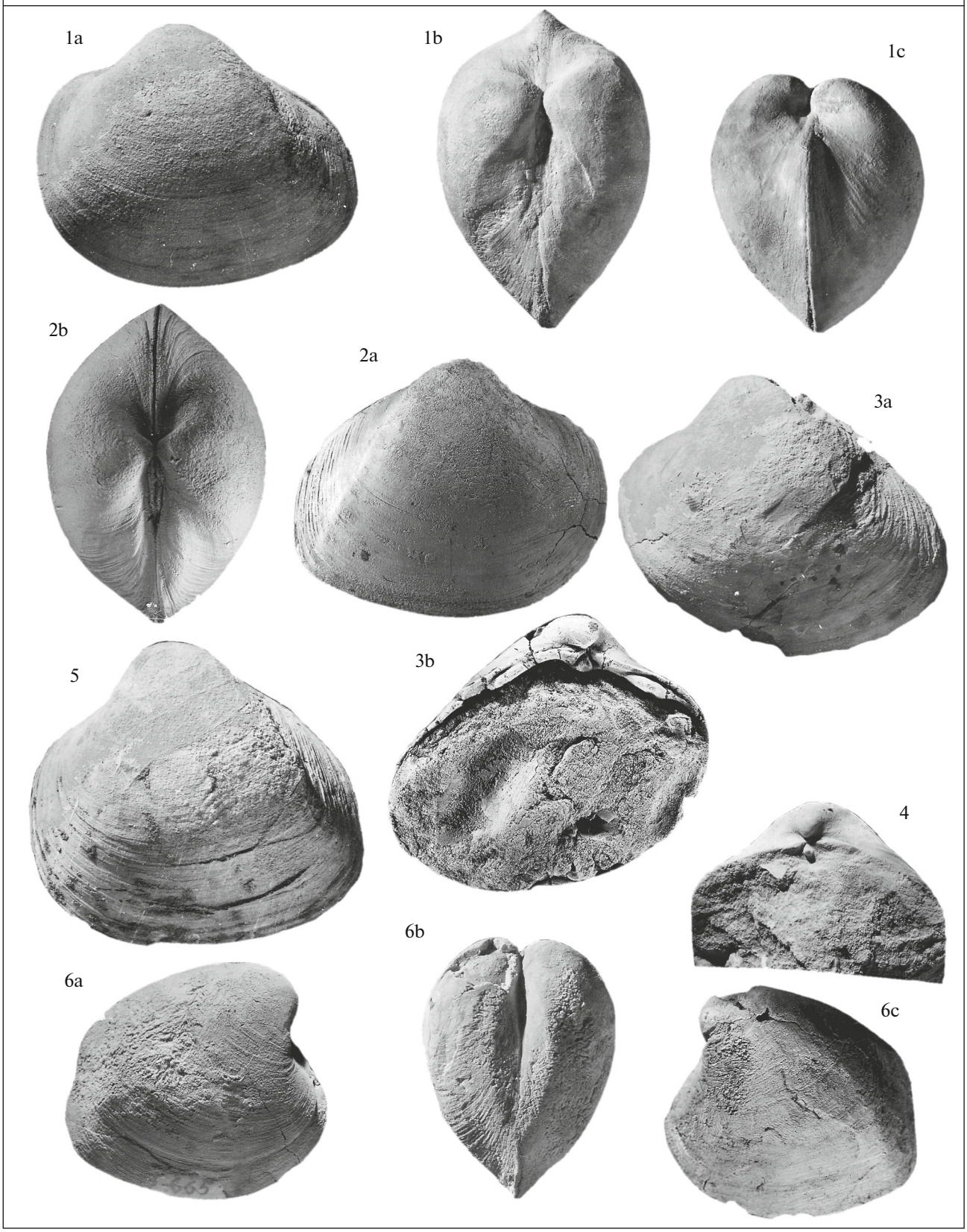
Integricardium deshayesianum: Yanin, 1960, p. 216, pl. 26, fig. 8; 2012, p. 276, pl. 46, fig. 1 and 2; Dimitrova, 1974, p. 112, pl. 41, fig. 3; Bogdanova, 1997, p. 87, pl. 20, fig. 7.

Explanation of Plate 18

Figs. 1–5. *Integricardium deshayesianum* (Loriol), ×1; (1) specimen MZMSU, no. 214/57, shell, external view: (1a) left valve view, (1b) umbonal view, (1c) anterior view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, Subzone *tauricum* (coll. V.V. Drushchits, 1955); (2) specimen PIN, no. 5596/224, shell, external view: (2a) right valve view, (2b) umbonal view; the same age and locality (coll. B.T. Yanin, 1956); (3) specimen PIN no. 5596/225, left valve: (3a) external view lateral view, (3b) view from inside; the same age and locality (coll. V.V. Drushchits, 1955); (4) specimen TsNIGRM, no. 129/13220, right valve from inside; the same locality, age and collector; (5) specimen PIN, no. 5596/226, shell, external view left valve view; the same age and locality (coll. B.T. Yanin, 1956).

Fig. 6. *Tortarctica weberi* (Mordvilko), specimen MZMSU, no. 198/57, shell, external view, ×1: (6a) from the right and (6c) left valves, (6b) dorsal view; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955).

Plate 18



Holotype. Specimen *Cyprina deshayesiana* in (Loriol, 1861, pl. 10, fig. 1, 2; mold); France (Mont-Salève); Lower Cretaceous, Middle Neocomian (designated by monotypy herein).

Description. The shell is medium-sized and large (L ≤ 70 mm), variable in shape: from elongated to almost rectangular (H < L), smooth, strongly convex, thick-walled, equivalve, inequilateral. The anterior margin is strongly convex, broadly rounded, smoothly merges into the dorsal margin or sometimes forms a clear obtusely rounded angle with it; very smoothly transitions into a slightly convex ventral margin; the posterior margin is short, slightly convex, truncated, smoothly or with a slight bend, gives way to dorsal, forming a clear, sharply rounded bend with the ventral margin; the dorsal margin is weakly and uniformly convex. The umbos are prosogyrate, massive, rounded, strongly protruding, usually pushed to the anterior margin, sometimes almost central. The ligament is external, on short, narrow escutcheon with strong nymphs. The umbilical carina is distinct, in the form of an obtusely rounded bend. The anterior field is wide, evenly convex; the posterior margin is a third of the anterior, slightly convex or flattened, rarely slightly concave. The surface of the valves is smooth, with only thin striae growing.

The cardinal platform is narrow, almost non-delimited. Lock (Fig. 29.1a, b): in the right wing (Plate 18, fig. 4)—d3a is weakly expressed, conical, touching the upper edge of the platform; d3b is strong, triangular in shape, with a pointed apex, oriented vertically, located just below the tip of the umbo; dAI is strong, elongated, ridge-shaped, plunging under the ground; dAIII weakly expressed, merges with the edge of the site; dPI is strong, carinate; in the left valve (Pl. 18, fig. 3b), d2a is strong, triangular in shape, with a rounded apex, descending directly from the tip of the umbo; d4b is small, short, lamellar, extending back and down from the tip of the umbo, merging with the edge of the valve with its lower end; dAII is elongated, with a rounded crest (dAII is not preserved). The margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/224 (Sh)	56	46	0.82	18.5	0.33
PIN 5596/225 (LV)	56	50	0.90	22	0.39
PIN 5596/226 (Sh)	57	57	1.00	20	0.35
MZMSU 214/57 (Sh)	58	47	0.80	38	0.65

Comparison. This species differs from the most similar species *I. inornatum* (d'Orbigny, 1843–1847; Aptian of France) in the less pronounced inequilateral shell; more symmetrical, almost central umbos, the beaks of which slope slightly forward and project strongly above the dorsal margin; more narrowed and oblique posterior shell margin and shorter escutcheon; from the similar *I. dupinianum* (d'Orbigny, 1843–1847; Albian of France) with a lower and more elongated shell; its less pronounced unevenness; more symmetrical, almost central and more projecting from the dorsal margin of the umbos; the presence of a clear carina; more steeply rounded posteroventral inflection of valves; slightly convex, sometimes flattened ventral margin.

Remarks. Previously, the author (Yanin in Arkadiev et al., 2012, p. 276) erroneously indicated that the specimen depicted by Loriol in 1861 (see synonymy) is a lectotype.

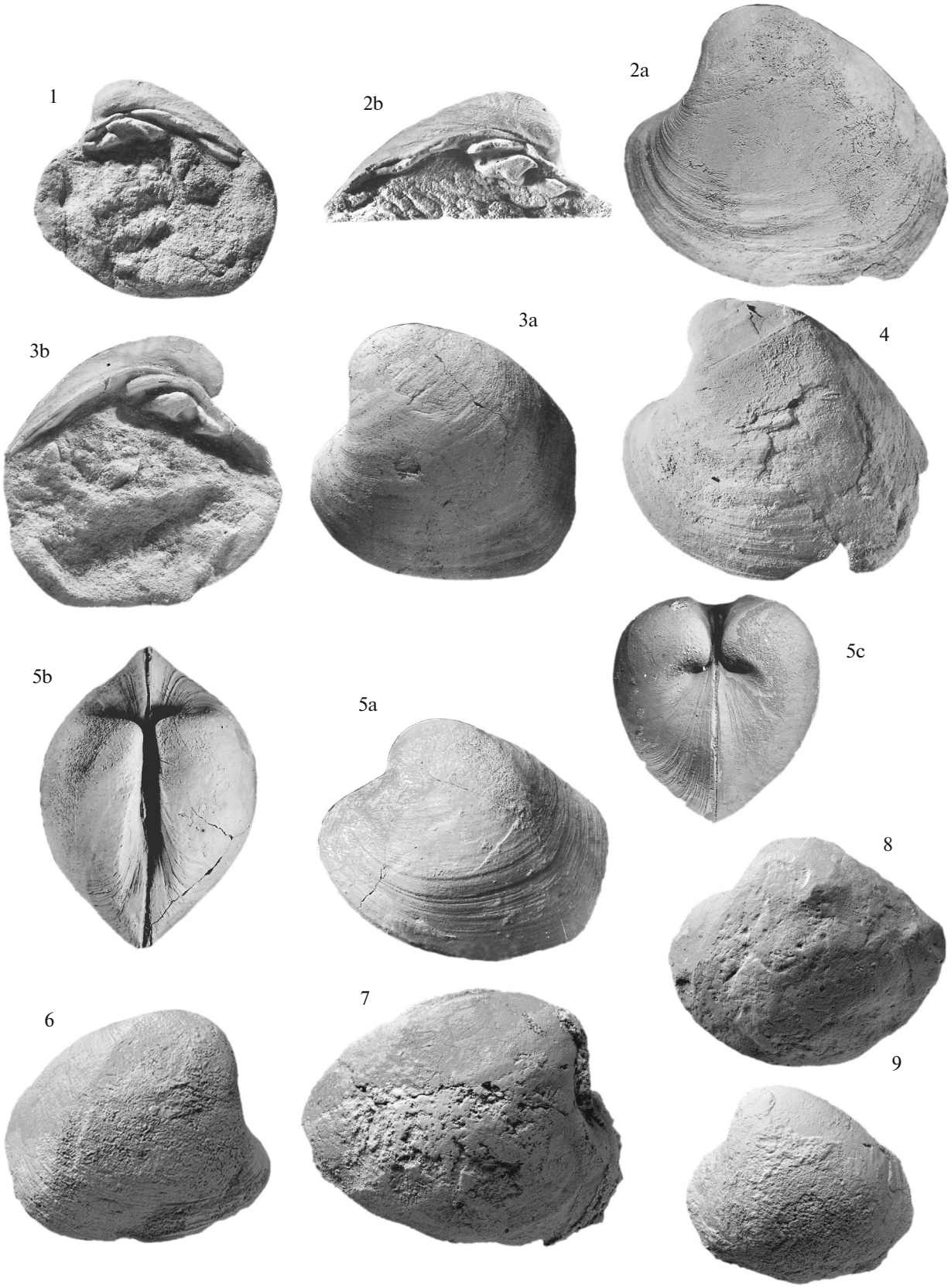
Occurrence. Berriasian–Hauterivian: Berriasian–Lower Valanginian of the Crimea; Hauterivian of the Northern Caucasus, Mangyshlak; Bulgaria, Germany; Valanginian–Hauterivian of Switzerland; Hauterivian of France.

Material. 305 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *grandis* Subzone—northern margin of the Karabi-Yaila Plateau (Kazanlak Depression); the same Zone, *chaperi* Beds—Sarysu River (villages of Blagodatnoe, Novoklyonovo) and Zuja (Balanovskoe Reservoir); Middle, *tauricum* Subzone—Chernaya Balaklava River, flux quarry), Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Solnechnosel'e) and Beshterek River (village of Solovjevka).

Explanation of Plate 19

Figs. 1–9. *Tortarctica weberi* (Mordvilko), ×1; (1) specimen MZMSU, no. 201/57: right valve from inside; Bel'bek River, village of Kuibyshevo, Kabaniy Log; Middle Berriasian, *tauricum* Subzone (coll. V.V. Drushchits, 1955); (2) specimen PIN, no. 5596/227, left valve: (2a) external view, lateral view, (2b) umbonal region, view from inside; locality, age the same (coll. B.T. Yanin, 1956); (3) specimen no. 200/57, left valve: (3a) external view, lateral view, (3b) view from inside; the same locality, age and collector; (4) specimen MZMSU no. 199/57, left valve, external view, lateral view; the same age and locality (coll. V.V. Drushchits, 1955); (5) specimen PIN no. 5596/228, shell, external view: (5a) left valve view, (5b) anterior view, (5c) umbonal view; the same locality, age and collector; (6) specimen PIN no. 5596/229, right valve, external view, lateral view; the same locality, age and collector; (7) specimen PIN no. 5596/230, right valve mold with a fragment of shell layer, external view, lateral view; Sarysu River, village of Blagodatnoe, Saigin Ravine; Lower Berriasian, *chaperi* Beds (coll. B.T. Yanin, 1986); (8) specimen PIN no. 5596/231, mold, external view, left valve view; northern slope of the Karabi-Yaila Massif, Kazanlak Basin, "bulldozer clearing" near the highway; Lower Berriasian, *grandis* Subzone (coll. B.T. Yanin, 1986); (9) specimen PIN no. 5596/232, mold, external view, left valve view; the same locality, age and collector.

Plate 17



Superfamily Arcticoidea Newton, 1891

Family Arcticidae Newton, 1891

Genus *Tortarctica* Casey, 1961

***Tortarctica weberi* (Mordvilko, 1949)**

Plate 18, fig. 6; Plate 19, figs. 1–9; Figs. 29.2a, 2b

Veniella weberi: Mordvilko, 1949, p. 138, pl. 28, figs. 3a–3c; 1960, p. 109, pl. 24, fig. 9, 10; 1979, p. 85, pl. 11, fig. 7, 8, text-fig. 21; Yanin, 1960, p. 213, pl. 25, figs. 1–4; Bogdanova, 1997, p. 89, pl. 20, fig. 9.

Tortarctica weberi: Yanin in Arkadiev et al., 2012, p. 277, pl. 46, figs. 3, 4.

Holotype. TsNIGRM, no. 8/5857, specimen *Veniella weberi* in (Mordvilko, 1949, pl. 28, figs. 3a–3c; left valve); Southwest Crimea, Bel'bek River (village of Kuibyshevo, Kabaniy Log); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone (by original designation: Mordvilko, 1949, in a plate explanation: pl. 28, figs. 3a–3c).

Description. The shell is medium-sized and large (L ≤ 63 mm), variable in shape (irregularly triangular, trapezoid, or round-oval), smooth, thick-walled, strongly convex, often swollen, elongated (L > H), strongly unequal, equivalve. The anterior margin is short, steeply rounded, gradually turning into a moderately convex ventral margin; the posterior margin is oblique, slightly convex, sometimes almost straight, forms a clear obtuse angle with ventral; the dorsal margin is elongated, convex, oblique, usually forms a bluntly rounded bend with the posterior. The umbonal region is strongly prominent, massive; the umbo is spiral, inclined forward and slightly turned inside. The lunule is distinct, shallow, widely flattened. The ligament is external, on an elongated escutcheon with short, strong nymphs. The umbilical carina is usually distinct, in the form of a bluntly rounded bend (sometimes weakly visible or absent); the anterior carina is sharper, carinate. Lateral field wide, uniformly convex; the posterior one is about twice as narrow as it is, slightly convex, flattened, or less often concave. The shell surface is smooth, only with concentric, often wrinkled growth lines.

The cardinal platform is wide and thickened. Castle (Figs. 29.2a, 29.2b): in the right valve (Plate 19, fig. 1)—d1 is small, subtriangular in shape, located near the lower margin of the platform; d3a is short, narrow, connected in an arcuate line with elongated, crested d3b with a median furrow at the posterior end and oriented parallel to the upper edge of the platform; dAI is very small, short, close to d1; dPI is powerful, elongated, carinate, located behind the nymph; in the left valve (Pl. 19, figs. 2b, 3b)—d2a is strong, tall, subtriangular in shape, slightly oblique backwards and downwards; d4b is elongated, ridge-shaped, slightly curved, subparallel to the upper margin of the platform; dAII is small, tuberculate or narrow, slightly oblique, forward and downward; located near the cardinal teeth; dPII is narrow, carinate. The shell margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
MZMSU 201/57 (RV)	42	38	0.90	–	–
PIN 5596/232 (Sh)	43	37	0.86	31	0.70
MZMSU 198/57 (Sh)	46	42	0.90	34	0.73
PIN 5596/231 (Sh)	47	38	0.80	29	0.66
PIN 5596/229 (RV)	48	41	0.85	17	0.35
MZMSU 200/57 (LV)	48	47	0.90	–	–
PIN 5596/228 (Sh)	50	40	0.80	18	0.45
MZMSU 199/57 (LV)	53	48	0.90	–	–
PIN 5596/233 (Sh)	53	42	0.70	–	–
PIN 5596/230 (RV)	55	48	0.80	23	0.40
PIN 5596/227 (LV)	56	47	0.80	23	0.40
PIN 5596/234 (Sh)	58	42	0.70	39	0.70
PIN 5596/237 (LV)	63	49	0.77	20	0.30

Comparison. Similar in shell shape to *T. obtruncata* (Stoliczka, 1871; Cretaceous of India), but differs from it in a less convex shell (T/L 0.73–0.83, in Indian forms, 0.80–1.00); narrower, strongly sloping and less convex dorsal margin, usually forming a distinct obtuse angle with the posterior margin; narrower posterior field.

Material. 130 specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone—northern slopes of Karabi-Yaila (Kazanlyk Depression, Lanchin Ravine) and Aipetri Yaila (Bakhchisaray-Yalta highway); the same Zone, *chaperi* Beds—Sarysu River (village of Blagodatnoe); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log) and Malyi Salgir (village of Ivanovka).

Genus *Veniella* Stoliczka, 1870

***Veniella carinata* Yanin, sp. nov.**

Plate 20, fig. 1

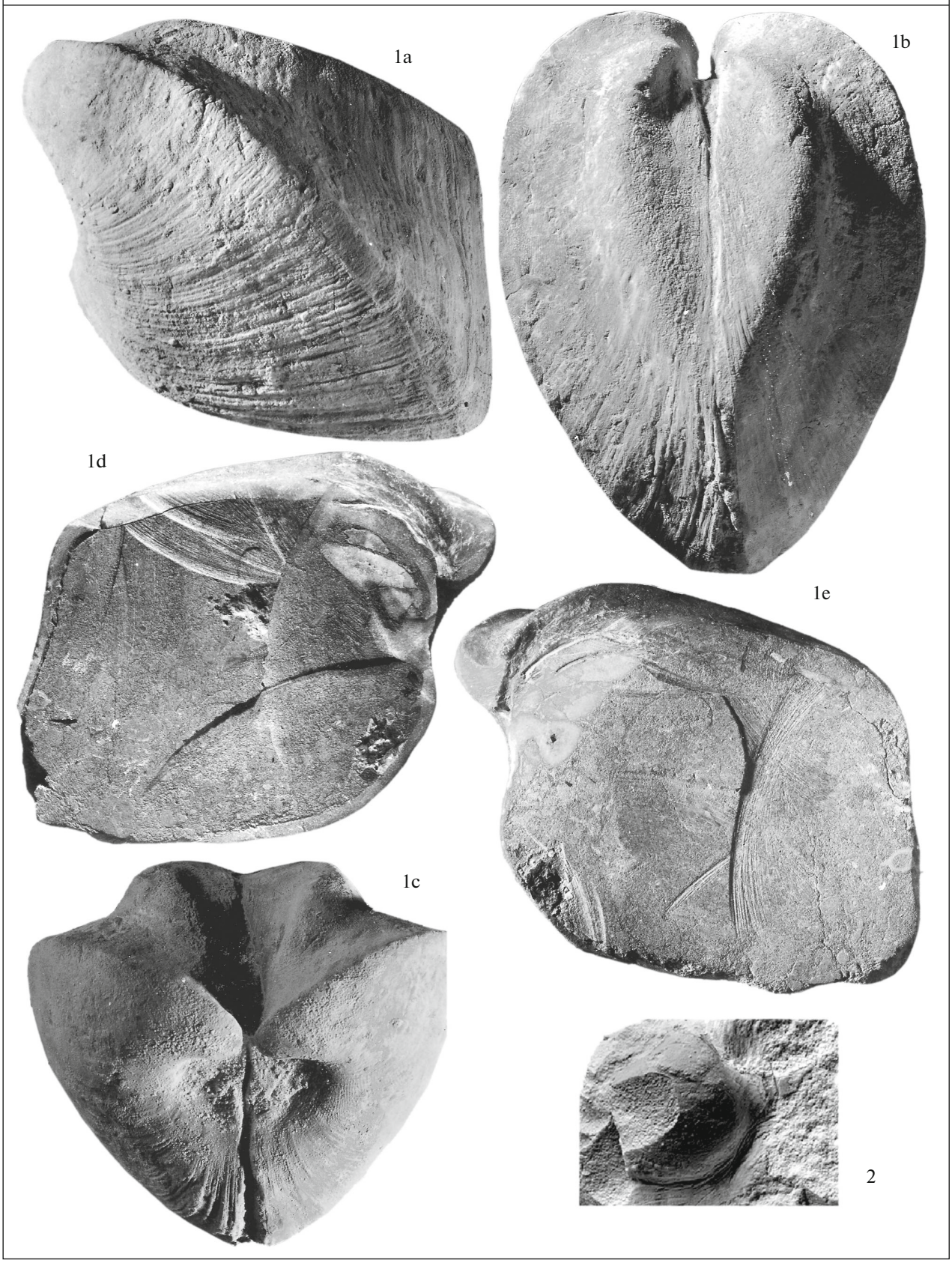
Etymology. From the Latin *carinata* (carinate).

Explanation of Plate 20

Fig. 1. *Veniella carinata* Yanin, sp. nov., specimen PIN, no. 5596/238, holotype, shell, ×1: (1a) external view left valve view, lateral view, (1b) escutcheon view, (1c) umbonal view, (1d) and (1e) from inside, respectively, left and right valves; Bel'bek River, village of Solnechnosel'e; Middle Berriasian, *tauricum* Subzone (coll. B.T. Yanin, 1956).

Fig. 2. *Cuspidaria theodosiana* (Retowski), specimen PIN, no. 5596/239, left valve mold with a broken front edge, on marl tile surface, external view, lateral view, ×3; vicinity of Feodosia, south coast of Feodosia Bay; Lower Berriasian, *grandis* Subzone (coll. V.V. Drushchits, 1968).

Plate 20



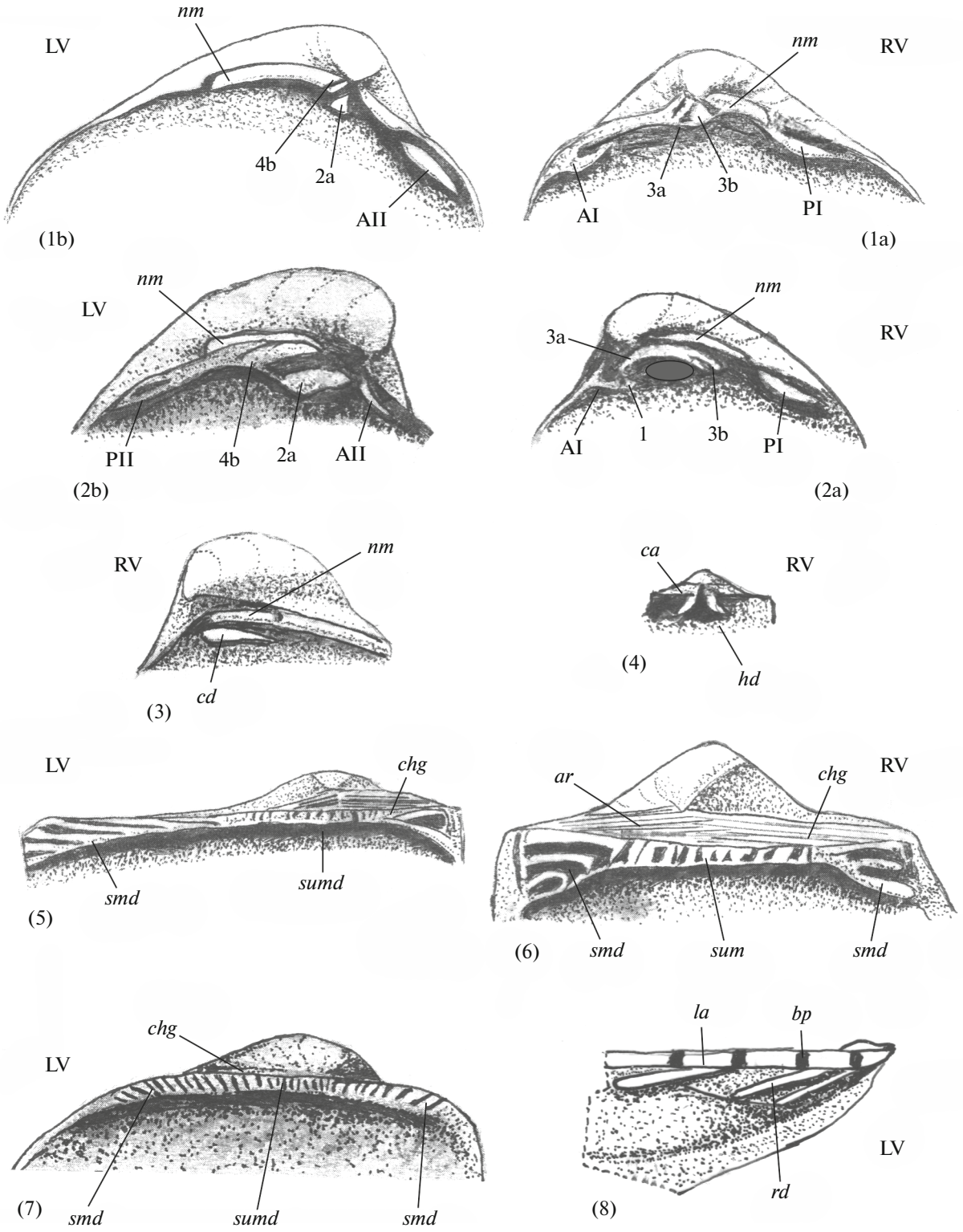


Fig. 29. Hinge of the shells on some species (interior view): (1) *Integricardium deshayesianum*: (1a) right valve, ×1.2; (1b) left valve, ×1.2 (Pl. 18, fig. 3b); (2) *Tortarctica weberi*: (2a) right valve (Pl. 19, fig. 2a), ×1.2; (2b) left valve, ×1.2 (Pl. 19, figs. 2b, 3b); (3) *Glossus neocomiensis*, right valve, ×1.2 (Pl. 15, fig. 16); (4) *Spondylopecten subspinosus*, right valve, ×4 (Pl. 10, fig. 20b); (5) *Cosmetodon carteroni*, left valve, ×2 (Pl. 7, fig. 2b); (6) *Idonearca forbesi*, right valve, ×1.5 (Pl. 7, fig. 10b); (7) *Barbatia marullensis*, left valve, ×3 (Pl. 6, fig. 7); (8) *Gervillella anceps*, left valve, ×1 (Pl. 5, fig. 1b). Explanations: (*ar*) area, (*ca*) cardinal area, (*cd*) cardinal teeth, (chg) chevron grooves, (*hd*) hook-like teeth, (*la*) ligament are a, (*lp*) ligament pits, (*nm*) nymph, (*rd*) crested teeth, (*smd*) submarginal teeth, (*sumd*) subumbonal teeth (for other explanations see Fig. 27 and 28).

Holotype. PIN, no. 5596/238 (pl. 20, figs. 1a–1e; shell); Southwest Crimea, Bel'bek River (village of Solnechnosel'e); Lower Cretaceous, Middle Berriasian, *tauricum* Subzone.

Description. The shell is large (L = 77 mm), thick-walled, massive, smooth, strongly swollen (T = L), irregularly rectangular in outline (in the form of a parallelogram with oblique posterior and anterior margins). The anterior margin is short, broadly rounded, smoothly merging into a slightly convex ventral margin; the posterior margin is oblique, almost straight, forms a sharply rounded angle of 80º with the ventral margin; the dorsal margin is elongated, almost equal in length to ventral and parallel to it, slightly convex; forms a clearly sharply rounded bend of 110° with the posterior. The umbo is prostrate, very massive, protruding, protruding beyond the anterior margin and overhanging it. The hole is slightly concave, wide, heart-shaped; separated from the lateral surface of the valve by a rounded bend. The ligament is external, on a short escutcheon with strong nymphs.

Two carinae are well developed. The umbonal carina is strong, coarse, carinated, sharp in umbonal region; divides the lateral surface of the valves into two unequal fields. Their planes meet at 90° on the crest of the carina. The anterior carina is also powerful, coarse, bluntly rounded. The antero-central field is wide, convex in the anterior and flattened along the carina. The posterior field is 1.5 times narrower than the anterior one, strongly concave in the middle part, due to which a wide depression forms between the carinae. The surface is smooth, only with coarse concentric growth wrinkles.

The cardinal platform is wide. The lock (Pl. 20, figs. 1d, 1e) is represented by strong cardinal teeth (the formula of the hinge could not be reconstructed, since the teeth were partially cut off as a result of shell having been cut along the plane of commissure). The margins are smooth on the inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/238 (Sh)	77	70	0.9	77	1.0

Comparison. It is very similar in shell shape to the Indian Cretaceous species V. forbesiana (Stoliczka, 1871, described by the author under the name *Caprina forbesiana*), but differs from it in almost rectangular outlines; the sharper crested umbilical carina; more swollen shell; almost straight posterior margin and the presence of a clear obtuse angle between it and the dorsal margin; more straight dorsal margin; lack of curvature in the posterior part of the ventral margin; very large concavity of the posterior field; the position of the umbo, which protrudes very far from the anterior margin.

Material. One specimen from the type locality.

Family Ptychomyidae Keen, 1969

Genus *Ptychomya* Agassiz, 1842

***Ptychomya robinaldina* (d'Orbigny, 1844)**

Plate 17, figs. 20–22

Crassatella robinaldina: d'Orbigny, 1843–1847, p. 75, pl. 264, fig. 10–13; Pictet and Renevier, 1855–1858, p. 90, pl. 11, figs. 2, 3.

Ptychomya robinaldina: Pictet and Campiche, 1864–1867, p. 352, pl. 127, fig. 2–6; Woods, 1899–1913, p. 179, pl. 27, fig. 24–26; Yanin, 1960, p. 217, pl. 27, figs. 4, 5; Dimitrova, 1974, p. 113, pl. 53, fig. 1, 2; Bogdanova, 1997, p. 89, pl. 20, figs. 10, 11.

Lectotype. A specimen of *Crassatella robinaldina* in (d'Orbigny, 1843–1847, pl. 264, fig. 10 and 11; shell); France (Aube); Lower Cretaceous, Neocomian (designated herein).

Description. The shell is small in size (D ≤ 25 mm), elongated-oval in shape, ribbed, strongly flattened laterally, equivalvate, inequilateral, widely rounded in front and gradually tapering towards the posterior margin. The anterior margin is convex, broadly rounded, smoothly merging into slightly convex or straight ventral margin; the dorsal margin is straight. The umbos are prosogyrate, very small, slightly protruding, very close to the anterior margin. The ligament is external, on a very narrow and elongated escutcheon. The umbilical carina is weakly expressed, almost non-delineated.

The lateral field is wide, flattened or slightly convex; covered with numerous thin, smooth, rounded ribs divaricately diverging in the form of chevrons, with intercostal intervals equal in width. The divergence line of the ribs is located in the anterior part of the field, straight or slightly curved, extending from the umbo to the anterior-lower edge. The anterior (from the midline of the valves) ribs are arcuately bent forward and at the very margin, bent up; the posterior ribs are straight. The ribs near the line of divergence are sometimes somewhat complicated: the anterior ribs are wavy, the posterior ribs are often with sawtooth bends. The posterior field is narrow, slightly concave or flattened. The field and umbilical carina are covered with straight, thin, smooth radial ribs; in the upper part of the field, along the dorsal margin, there are sparse, short, large, obliquely transverse, curved, bumpy folds, which serrate the dorsal margin with their terminations. The anterior and ventral margins are finely serrated on the inside.

Dimensions in mm:

Specimen no.	L	H
PIN 5596/222 (RV)	>16	8
PIN 5596/221 (RV)	>18	19
PIN 5596/223 (RV)	–	20
PIN 5596/220 (RV)	>30	22

Comparison. This species differs from *P. neocomiensis* Loriol (see Pictet and Campiche, 1864–1867; Hauterivian of Switzerland) in the strong laterally flattened valves; finer ribbing; weak, almost non-

isolated carina; from *P. germani* Pictet et Campiche (1864–1867; Valanginian of Switzerland), a shell more elongated and strongly narrowed behind; a different nature of the complexity of the anterior ribs on the lateral field (in the described species they are undulating, while in *P. germani* they are angular, with additional bends); less complicated ribs of the posterior field and the presence of large tuberous folds along the dorsal margin of the valves.

Occurrence. Berriasian–Aptian: Berriasian of the Crimea; Hauterivian–Aptian of France, Switzerland; Aptian of Turkmenistan, Bulgaria; Lower Aptian of England.

Material. Four specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu River (village of Blagodatnoe, Saigin Ravine); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log, village of Golubinka, Mount Karatlykh, Orekhovyi Ravine) and Beshterek River (village of Solovjevka).

Superfamily Tellinoidea Blainville, 1814

Family Psammobiidae Fleming, 1828

Subfamily Psammobiinae Fleming, 1828

Genus *Garum* Dall, 1898

***Garum valangiensis* (Pictet et Campiche, 1865)**

Plate 17, figs. 15–19; Figs. 28.7a, 28.7b.

Psammobia valangiensis: Pictet and Campiche, 1864–1867, p. 148, pl. 109, figs. 9 and 10.

Gari valangiensis: Yanin, 1960, p. 218, pl. 27, figs. 6–8; Bogdanova, 1997, p. 88, pl. 20, figs. 3 and 4.

Lectotype. A specimen of *Psammobia valangiensis* (Pictet, Campiche, 1864–1867, pl. 109, figs. 9 and 10; shell); Switzerland (Sainte–Croix); Lower Cretaceous, Valanginian, "orange limestones" (designated herein).

Description. The shell is medium-sized (L ≤ 53 mm), elongated-oval in shape (H < L), moderately convex, ribbed, equivalve, inequilateral (the length of the anterior side is 0.67 of that of the posterior side). The anterior margin of the shell is short, broadly rounded, smoothly blending into the dorsal and ventral margins; ventral—elongated, slightly convex; posterior—short, steeply rounded or slightly truncated (in this case, clear rounded bends form between it and the hinged edges); posterior branch of dorsal margin slightly convex (almost straight in some specimens). The umbos are prosogyrate, slightly protruding, pushed to the anterior margin, their terminations are straight. An umbilical carinate bend extends from the umbo to the lower posterior side of the valves. The surface has numerous concentric coarse, rounded or pointed ribs, curving sharply at the carinate bend. The intercostal spaces are smooth, concave, usually equal in width to the ribs.

The cardinal platform is not expressed, it is isolated only under umbos; the teeth are small, located directly on the dorsal margin of the valves. There are only cardinal teeth in the hinge (Fig. 28.7a, 28.7b): in the right valve (Pl. 17, fig. 18a, 18b), d3a us narrow, median, oriented vertically and extending practically from the tip of the umbo; on both sides of it there are clear pits for the teeth of the opposite valve; d3b is tubercular; in the left valve (Pl. 17, fig. 17) tuberculate d2a and d4b, separated by a narrow pit; of these, the posterior is at the end of the nymph. The ligament is external, on short escutcheon with strong nymphs; a narrow smooth strip extends behind the escutcheon along the dorsal margin. The gaping is posterior, very narrow.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/215 (Sh)	42	21	0.5	14	0.33
PIN 5596/217 (RV)	–	24	–	8	–
PIN 5596/216 (LV)	42	25	0.5	11	0.2
PIN 5596/214 (Sh)	46	27	0.58	18	0.4
PIN 5596/218 (LV)	53	21	0.38	–	–
PIN 5596/219 (RV)	–	33	–	–	–

Comparison. This species differs from shells similar in shape: from *G. gillieroni* (Pictet and Campiche, 1864–1867; Hauterivian Switzerland) in the umbos less advanced to the anterior margin and the development of coarser concentric ribs; it is distinguished from *G. tenuis* (ibid.) by the development of true concentric ribs (the compared species has a smooth shell).

Remarks. Some described Crimean specimens differ from the lectotype of the species from Valanginian of Switzerland in shorter shells and coarser ornamentation. We assigned the Crimean specimens to the genus *Garum* provisionally, since they differ from the typical species *Garum flosa* (Conrad) from the Middle Eocene of the USA (Cox and Newell, 1969, p. N631, text-fig. E115, 13) in the longer and less narrowed posterior shell side and in the coarser ribs.

Occurrence. Berriasian–Valanginian: Berriasian of the Crimea; Valanginian of the Northern Caucasus, Switzerland (Sainte-Croix) and southeastern France (Viller-le-Lac).

Material. Six specimens; Crimea, Berriasian: Lower Berriasian, *jacobi* Zone, *chaperi* Beds—Sarysu River (villages of Blagodatnoe, Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Bel'bek River (village of Kuibyshevo, Kabaniy Log; village of Golubinka, Orekhovyi Ravine), Beshterek River (village of Solovjevka).

Superfamily Glossoidea Gray, 1847

Family Glossidae Gray, 1847

Genus *Glossus* Poli, 1795

***Glossus neocomiensis* (Agassiz, 1842)**

Plate 15, figs. 12–16; Fig. 29.3

Ceromya neocomiensis: Agassiz, 1842, p. 35, pl. 8, figs. 11–16.

Isocardia neocomiensis: d'Orbigny, 1843–1847, p. 44, pl. 250, fig. 9–11; Pictet and Campiche, 1864–1867, p. 235, pl. 116, figs. 1–3; Wollemann, 1900, p. 113; Yanin, 1960, p. 212, pl. 23, figs. 5, 6.

Glossus neocomiensis: Bogdanova, 1997, p. 90, pl. 20, fig. 8; Yanin in Arkadiev et al., 2012, p. 278, pl. 46, figs. 5, 6.

Lectotype. A specimen of *Ceromya neocomiensis* in (Agassiz, 1842, pl. 8, figs. 14–16, shell); Switzerland (Neuchatel); Lower Cretaceous, Neocomian (designated herein).

Description. The shell is small to medium-sized (Sh ≤ 35 mm), heart-shaped, round-triangular, strongly convex, moderately high (H ≥ L), very thin-walled, equivalvate, inequilateral. The anterior side is steeply rounded, slightly and widely concave under the umbo. The point of greatest convexity is located in the middle of the lateral surface of the valves. The anterior margin is broadly rounded, merging with a smoothly rounded ventral margin; the posterior margin is slightly convex, also widely rounded, forming distinct bends with ventral and dorsal margins; the dorsal margin is short, very slightly curved, almost straight. The umbonal region is very prominent. The umbos are slightly moved to the anterior margin, slightly spirogyrate, turned forward and outward; the sharp tip of the umbos is somewhat moved away from the plane of valve closure. The umbilical carina in the form of a weak bend divides the surface of the valves into two unequal fields: the lateral one is wide, convex; the back is very narrow (one fifth of the front), concave. The shell surface is smooth, with only concentric growth lines. The ligament is external lodged in a very narrow, filiform groove.

The cardinal platform is very narrow, almost non-pronounced. The teeth on the studied shells are poorly preserved. In the right valve (Pl. 15, fig. 16; Fig. 29.3), there is a median cardinal tooth lamellar, elongated, parallel to the upper edge of the platform; above it there is a narrower, also elongated, socket for a tooth in the left valve. The lateral teeth were not observed (probably not preserved). The margins are smooth inside.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/176 (Sh)	27	23	0.8	–	–
PIN 5596/177 (RV)	28	29	1.0	–	–
TsNIGRM 130/13220 (RV)	31	31	1.0	14	0.45
PIN 5596/175 (RV)	~31	32	~1.0	15	~0.5
PIN 5596/174 (RV)	32	32	1.0	13	0.40
MZMSU 194/57 (Sh)	37	37	1.0	32	0.86
MZMSU 195/57 (LV)	31	35	1.12	18	0.58

Comparison. This species is most similar in shell shape to *G. gaultina* (Pictet et Campiche, 1864–1867; Albian of Switzerland), but differs from it in a more rounded shell shape; the widely rounded (undrawn) posterior margin of the valves; less massive and less high umbos, as well as the presence of an anterior carinate inflection.

Occurrence. Berriasian–Hauterivian: Berriasian–Lower Valanginian of the Crimea; Valanginian–Hauterivian of Switzerland; Lower Neocomian of France; Hauterivian of Germany.

Material. 34 specimens; Crimea, Berriasian: Lower, *jacobi* Zone, *chaperi* Beds—Sarysu River (village of Novoklyonovo); Middle Berriasian, *tauricum* Subzone—Bel'bek River (Kuibyshevo, Kabaniy Log), Zuja River (Balanovskoe Reservoir).

Superfamily Pholadoidea Lamarck, 1809

Family Teredinidae Rafinesque, 1815

Subfamily Martesiinae Thiele, 1934

Genus *Turnus* Gabb, 1864

***Turnus tonasensis* Yanin, sp. nov.**

Plate 9, figs. 11, 12

Etymology. From the Tonas River (Eastern Crimea).

Holotype. PIN, no. 5596/104 (pl. 9, fig. 11; right valve); Eastern Crimea, Tonas River (village of Krasnoselovka, Kuchuk-Uzen' Creek); Lower Cretaceous, Lower Berriasian, *jacobi* Zone, *grandis* Subzone.

Description. The shell is small (L = 14 mm), elongated-oval (H 1.5 times < D), thin-walled, moderately convex in the anterior and strongly compressed on the posterior side, unequal. The dorsal margin is long, slightly convex, passing into anterior in a wide arc; obliquely inclined towards the posterior margin; the anterior margin is widely rounded, smoothly merging with the ventral margin, which is convex in the anterior part, concave in the middle (along the median furrow), and straight in the posterior; the posterior margin is 0.67 of the anterior margin, slightly convex, forms a smooth bend with the dorsal margin, and a widely rounded angle of 110° with the ventral margin.

The relief of the valve is complex; it is divided by a sharp umbilical carina into anterior and posterior margins. In the anterior half of the lateral field, the valve is convex; in its middle part there is a wide depression represented by a radial median groove 0.5 mm wide; its front slope is steep, the back slope is very gentle; the groove angle is 100°; it corresponds to the thin median inner rib. The posterior half of the lateral field is convex; the line of the greatest convexity of the valve is directly along the carina. On the posterior field a shallow anal groove is traced: very deep in the middle part of the field, towards the posterior margin it gradually disappears and merges with the surface of the valve. The groove corresponds to a strong rounded inner rib extending from the umbo towards the lower

part of the posterior margin. Part of the posterior field adjoining the hinge margin is widely concave. The umbonal region is very prominent; the umbo is large, broadly rounded, close to the anterior margin.

The shell surface has 40–45 concentric ribs developed only on the anterior field. On the posterior half of this field, from the carina to the median furrow, there are scarcely visible, smoothed ribs parallel to the ventral margin. Without interrupting at the median sulcus, they enter the anterior part of the lateral field, where, immediately after the sulcus, they noticeably bend forward and upward and extend to the upper part of the anterior margin, without being parallel to the margin and without bending towards the umbo. The ribs are thin, symmetrical, rounded, densely spaced, with very narrow (filamentous) intercostal spaces. Near the median sulcus, the ribs coarsen and sometimes slightly widen due to bifurcation; the bifurcated ribs are observed in a narrow strip 1–2 mm wide, stretching from the umbo to the ventral margin directly along the median sulcus. Toward the anterior margin, the ribs become much thinner and become hardly noticeable, especially in the anterior lower part of the valve. The entire back field is smooth, with only thin growth lines. The gaping is anterior, very wide.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L	T	T/L
PIN 5596/104 (RV) holotype	14	10	0.7	3	0.2

Comparison. This species differs from: *T. dalasi* (Walker) (Woods, 1909; Aptian of southern England), which is most similar in shell shape and ornamentation, in a more elongated shell (H/L = 0.70 versus 0.76–0.80); in the more drawn posterior margin; smoothly and widely rounded (not truncated) anterior margin; the position of the median sulcus, closer to the anterior margin (the ratio of the anterior to posterior part of the shell, counting from the median sulcus, is 0.55 versus 0.84–0.87). It is distinguished from the closely related *T. thitonia* (Retowski, 1893; Lower Berriasian of Eastern Crimea)—mainly by a more elongated shell (H/L = 0.70, in *T. thitonia*—0.86); greater extension of its posterior side; by the median groove more shifted forward, tilted obliquely backwards and downwards (it is vertical in *T. thitonia*); softer curve of the ventral margin; from the similar *T. waldheimii* (d'Orbigny) (see Gerasimov, 1969; Volgian Stage of the East European Platform) it differs in the more rounded anterior margin (in *T. waldheimii*, it is truncated and notched); more gently curved ventral margin; more oblique posterior margin; the presence of a distinct posteroventral inflection of the shell (in the compared species, the posterior margin is correctly rounded and smoothly, without inflection, passes into the ventral margin).

Material. Two specimens from the type locality.

Order Hippuritida Newell, 1965

Suborder Diceratina Yanin, 1989

Superfamily Requienioidea Douvillé, 1914

Family Heterodiceratidae Pchelincev, 1959

Subfamily Heterodiceratinae Pchelincev, 1959

Genus *Heterodiceras* Munier-Chalmas in Hebert, 1870

***Heterodiceras bajdarense* Pchelincev, 1959**

Plate 22, fig. 1; Fig. 30.1

Heterodiceras bajdarense: Pchelintsev, 1959, p. 135, pl. 34, fig. 3; pl. 35, fig. 1, 2; pl. 36, fig. 1, 2; text-fig. 40, 54; Yanin, 1989, p. 159, pl. 4, fig. 1.

Holotype. TsNIGRM, no. 100/10913, specimen *H. bajdarense* (Pchelintsev, 1959, pl. 34, figs. 3a, 3b; upper valve); Southwest Crimea, Baidar Depression (village of Peredovoe, Urkusta Hill); Upper Jurassic, Upper Tithonian (by original designation: Pchelintsev, 1959, p. 135).

Description. The shell (based on the upper valve) is large (H = 94 mm), strongly convex, with a marginal carina close to the posterior margin of the valve; smooth; with a slightly prominent prosogyrate umbos are pressed against the lateral surface of the valve; the aperture is irregularly oval in outline, with a well-defined sharp bend between the lower and anterior margins; the lateral field is weakly convex or even flattened near antero-inferior angle of valve; the posterior field is convex; the carina forms an almost right angle in the umbonal region and in the middle.

The cardinal platform is wide (up to half the height of the aperture). The hinge is dextrodont (Pl. 22, fig. 1b; Fig. 5-1; Fig. 30.1): d1 is strong, cone-shaped; d3 is very large, powerful, tall, long, ear-shaped, with a crest strongly bent outwards; anterior end of tooth close to valve umbo, almost hanging over it; tooth fossa 2' deep and wide, horseshoe shaped. The anterior muscle scar is superficial, elongated-oval, at the level of the cardinal platform; the posterior plate is myophoral plate elongated, at the level of the cardinal area (the junction of the plate with the hinge area is destroyed); from the edge of the valve is separated by a deep hollow. The ligament groove extends from the tip of the umbo to the posterior end of d3.

Dimensions in mm and ratios:

Specimen no.	Hu	Wap	Wap/Hu	T	T/Hu
PIN 5596/244 (UV)	94	64	0.6	55	0.6

Comparison. This species differs from *H. crimicus* Yanin (Yanin, 1989; Upper Berriasian of the Crimea) in the more pronounced, usually marginal carina; umbos slightly protruding, pressed to the surface of the valve (in *H. crimicus*, the valve is horn-shaped and spirally bent outwards); the angular outlines of the aperture (in *H. crimicus* the aperture is usually rounded); from *H. luci* (Defrance, 1816–1826;

Berriasian of France) it is distinguished by the more angular outline of the aperture; less prominent umbos, not turned outward, but pressed against the side surface of the valve; d3 more distant from the umbo area (it almost overhangs the valve margin near the umbo, and in *H. luci* its anterior tip is 1–1.5 cm away from the anteroventral margin of the aperture.

Occurrence. Upper Tithonian–Lower Berriasian of the Crimea.

Material. One specimen from the type locality.

***Heterodiceras luci* (Defrance, 1819)**

Plate 21, fig. 1–4; Fig. 30.2

Diceras luci: Defrance, 1819, p. 177; Favre, 1843, p. 163, pl. 1, fig. 1, 2; pl. 2, figs. 1–4; pl. 3, figs. 1–3; pl. 4, figs. 1–4; pl. 5, fig. 1; Bayle, 1873, p. 141, pl. 19, fig. 6; Boehm, 1883, p. 520, pl. 54, figs. 11–19; pl. 55, figs. 3–9; pl. 56, fig. 1–6.

Heterodiceras luci: Douvillé, 1910, pl. 173, figs. 1–4; pl. 173a, figs. 1, 2; pl. 173b, fig. 1; Favre in Joukowski, Favre, 1913, p. 424, pl. 34, figs. 5, 6; Cox and Newell, 1969, p. N778, text-fig. E244–1a; Yanin in Nevesskaja et al., 2013, p. 439, text-fig. 158a, 158b, non *Heterodiceras luci*: Yanin, 1958a, p. 128, pl. 1, figs. 1–4.

Holotype. Not designated.

Description. The shell is large (P ≤ 80 mm), with strongly convex carinate valves, with an oval-elongated angular opening; to varying degrees inequivalvate. The lower valve is larger than the upper one, with a horn-shaped, bent outward or spiral-shaped, pressed against the lateral surface of the umbos; the median carina is sharp, carinate, sometimes sharp near the umbo, divides valve into two equal fields: the lateral field is slightly convex, flattened or concave in umbonal area, representing attachment plate; the posterior field is evenly convex; in places, the outer shell layer has coarse radial ribbing preserved; the ligamental groove extends from the tip of the umbo to the posterior end of the dental socket; the anterior and lower margins of the aperture converge at a sharp angle corresponding to the end of the median carina; the anterior muscle scar is superficial, on valve wall; the posterior myophoral plate is elongated, lamellar, at the level of the hinge platform, approaches the posterior end of the tooth. The upper valve is less convex than the lower one; median carina carinate; lateral field flattened, slightly wider than uniformly convex posterior field; the umbo is spiral, pressed against the surface of the valve.

The cardinal platform is very wide, occupies about 1/3 of the apertural height. The hinge is dextrodont lock (Fig. 30.2; pl. 21, figs. 2b, 3b, 4b; Fig. 5.2): in the lower valve, d2 is elongated, carinate, with a rounded, slightly curved apex; its anterior slope merges with the margin of the valve; tooth socket 1' is shaped like a small wide depression on the lower slope of d2; socket 3' is deep and wide, curved parallel to the upper margin of the aperture; in the upper valve—d1 is conical, with a rounded apex; d3 is high, elongated, ear-shaped, with a rounded crest turned outwards; tooth socket 2' is deep, oval in outline.

Dimensions in mm and ratios:

Specimen no.	H	Conv. Sh	Hu	Wap
PIN 5596/242 (UV)	23	11	21	18
PIN 5596/243 (UV)	30	18	25	30
PIN 5596/240 (Sh)	65	50	47	45
PIN 5596/241 (LWV)	95	42	56	53

Comparison. It differs from *H. bajdarense* (see above) in the presence of a median carina (in *H. bajdarense* it is marginal); a smaller angle between the anterior and lower margins of the aperture; from *H. crimicus* (Yanin, 1989) from the upper Berriasian of the Crimea, it is distinguished by the presence of a carina on both valves; the spiral-shaped umbos, pressed against the lateral surface of the upper valve (in *H. crimicus*, the umbo is sometimes horn-shaped).

Occurrence. Upper Tithonian–Berriasian: Lower Berriasian of the Crimea; Upper Tithonian the Czech Republic (Štramberk); Berriasian of southeastern France (Mont-Salève).

Material. Four specimens; Crimea, Lower Berriasian, *jacobi* Zone—northern slope of Karabi-Yaila Plateau (Lanchin Ravine).

Suborder Hippuritina Newell, 1965

Superfamily Monopleuroidea Munier-Chalmas, 1873

Family Monopleuridae Munier-Chalmas, 1873

Genus *Monopleura* Matheron, 1842

***Monopleura taurica* Pchelincev, 1959**

Plate 22, figs. 2–5; Figs. 30.3a, 3b

Monopleura taurica: Pchelincev, 1959, p. 169, pl. 42, fig. 1–9; pl. 43, figs. 3–8; Yanin, 1960, p. 224, pl. 29, fig. 7; 1975, p. 73, pl. 1, figs. 1–6; 1989, p. 165, pl. 7, fig. 4–6.

Holotype. TsNIGRM, no. 127/10913, specimen *M. taurica* (Pchelintsev, 1959, pl. 42, fig. 1; shell); Central Crimea, Beshterek River (village of Solovjevka); Lower Cretaceous, Lower Berriasian, *jacobi* Zone (by original designation: Pchelintsev, 1959, p. 169).

Description. The shell is small and medium-sized (B up to 34 mm), moderately convex, with an oval or rounded aperture, sometimes with a slightly retracted anterior-lower margin; inequivalvate to varying degrees; finely ribbed, with two distinct siphonal zones on both valves, separated by a rounded intersiphonal ridge. The lower valve varies greatly in shape: varies from low, with the spirogyrate, not delineated umbo pressed against the lateral surface of the valve, to high, subplagioconic with a well-isolated umbo turned outward; the attachment scar is usually anterior-lateral, with a support platform, less commonly central, periumbonal. The upper valve is low,

Plate 21

cap-shaped, with a non-delineated, small, marginal umbo pressed against the lateral surface of the valve.

The cardinal platform is wide, about 1/3 of the apertural height. The hinge is sinistrodont (Figs. 30.3a, 3b): in the lower valve (Pl. 22, fig. 4): d3 is high, short, ear-shaped, with a crest slightly bent outwards; in the upper valve (Pl. 22, figs. 3, 5b), d2 is highly conical, with a pointed apex; d4 is obliquely triangular, elongated, with a carinate apex.

The anterior muscle scar on the upper valve is superficial, rounded; posterior myophoral base of elongated oval shape, on the continuation of the hinge platform. On the lower valve, the anterior and posterior myophoral bases are elongated-oval, on the continuation of the hinge platform, sometimes limited by a marginal ridge. The ligament groove on the upper valve is short, on the lower one it is long, extending from the upper edge of the aperture to the tip of the umbo.

Dimensions in mm and ratios:

Specimen no.	H	Hap	Wa	Wa/Hap
TsNIGRM 15/12658 (UV)	16	16	20	1.2
TsNIGRM 16/12658 (LWV)	19	13	13	1.0
TsNIGRM 14/12658 (Sh)	30	20	20	1.0
MZMSU 242/57 (Sh)	33	21	22	1.0
TsNIGRM 127/10913 (LV) (holotype)	34	20	18	0.9

Comparison. This species differs from *M. valangiensis* Pictet et Campiche (1864–1867; Upper Valanginian of Switzerland) in thinner ribbing; spirally wound umbo lower valve; the spiral arrangement of siphonal zones on the upper valve (in *M. valangiensis*, they diverge from the umbo along the radius); from *M. valdensis* Pictet et Campiche (1864–1867; Valanginian of Switzerland) it is distinguished by the more twisted, spiral umbos of both valves and the presence of distinct siphonal zones, which are not at all expressed in *M. valdensis*.

Material. Six specimens from the type locality.

Family Gyropleuridae Paquier, 1905

Genus *Valletia* Munier-Chalmas, 1873

***Valletia antiqua* Favre in Joukowsky et Favre, 1913**

Plate 22, figs. 8–10.

Valletia antiqua: Favre in Joukowsky, Favre, 1913, p. 415, pl. 25, fig. 3–12 (non fig. 1, 2); Yanin, 1989, p. 166, pl. 8, figs. 2, 3.

Lectotype. A specimen of *V. antiqua* in (Joukowsky and Favre, 1913, pl. 25, figs. 5a, 5b; upper valve); southeastern France (Mont-Salève); Lower Cretaceous, Lower Tithonian, Beds with *Matheronia salevensis* (designated herein).

Description. The shell is small and large in size (H up to 30 mm), horn-shaped, strongly swollen, inequivalvate to varying degrees; with sharply carinate valves, smooth or sculptured (coarse ribbing on well-preserved specimens): on flattened-concave lateral field, ribs are spiral, parallel to carina; on the convex back, obliquely transverse, extending from the carina to the edges of the valve. The lower valve is low exogyric to high, horn-shaped, with a separate spiral umbo; with a wide base, often in the entire lateral field. The upper valve is smaller, with an umbo moderately protruding, twisted forward and outward, non-isolated, pressed to the side surface. The aperture in both valves is strongly oblique in the anterior-inferior direction, with a sharp bend corresponding to the median carina.

The cardinal platform is wide, half the height of the aperture. The hinge is sinistrodont: in the upper valve (Pl. 22, fig. 9b), d2 is highly conical, perpendicular to the platform; d4 is small, elongated, ridge-like or in the form of an elongated tubercle; tooth socket 3' is deep, wide and short; in lower valve—d3 is strong powerful, high, short, arched, with apex slightly turned outwards; socket 2' is oval-elongated, deep, bordered by carina; socket 4' is weakly expressed, in the form of a shallow depression on a wide plate behind d3.

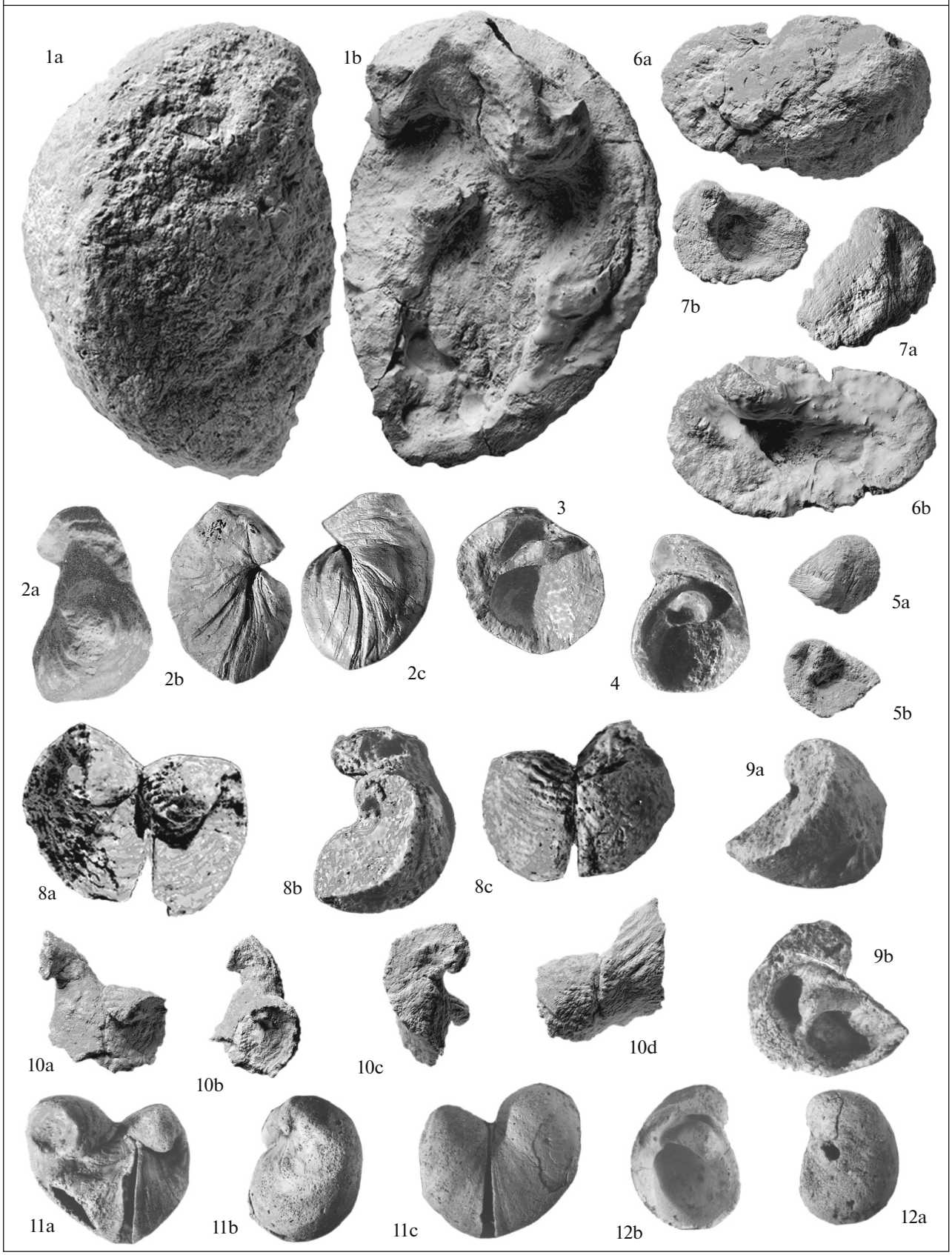
The anterior muscle scar of the upper valve is superficial, on the wall series, elongated, partially located in front of d2; the posterior myophoral plate on this valve is oval-elongated, wide, behind and below socket 3', at the level of the hinge platform. The anterior muscle scar and posterior myophoral pedestal on the lower leaflet are oblong-oval; the stand goes deep into the space behind d3. The ligament groove is short on the upper and long on the lower valves.

Explanation of Plate 21

Figs. 1–4. *Heterodiceras luci* (Defrance), (1) specimen PIN, no. 5596/240, shell, external view, ×1: (1a) anterior view, (1b) lateral view, lower valve view; northern slope of the Karabi-Yayla massif, Lanchin Ravine; Lower Berriasian, *jacobi* Zone; bioclastic limestones (coll. B.T. Yanin, 1986); (2) specimen PIN, no. 5596/241, lower valve, ×1: (2a) external view, lateral view and (2b) anterior view; (2c) from inside; the same locality, age and collector; (3) specimen PIN, no. 5596/242, upper valve of a young individual, ×1: (3a) external view, lateral view, (3b) view from inside; the same locality, age and collector; (4) specimen PIN, no. 5596/243, upper valve of a young shell, ×1: (4a) external view, lateral view, (4b) view from inside; the same locality, age and collector.

Fig. 5. *Valletia urkustensi*s (Pchelincev), specimen TsNIGRM, no. 20/12658, upper valve, ×0.75: (5a) external view, lateral view, (5b) view from inside; northern slope of the Karabi-Yayla massif, Lanchin ravine; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1986).

Plate 22


1a
1b
6a
7b
7a
6b
3
2a
2b
2c
4
5a
5b
8a
8b
8c
9a
9b
10a
10b
10c
10d
11a
11b
11c
12b
12a

Dimensions in mm and ratios:

Specimen no.	H	Hap	Wap
PIN 5596/248 (Sh)	25	–	–
TsNIGRM 17/12658 (UV)	28	19	30
TsNIGRM 18/12658 (Sh)	31	–	–

Comparison. This species differs from *V. tombecki* (Munier-Chalmas, 1882; lower Neocomian of France), *V. germani* Pictet et Campiche, 1868–1871; Valanginian of Switzerland) and *V. auris* Favre (1843; Upper Tithonian of Switzerland) in the presence of a sharp median carina on both valves, as well as, usually, coarse ribbing on them.

Remarks. Crimean specimens of this species differ from the specimen of *V. antiqua* described from the lower Tithonian type locality in the mountains of Mont-Salève (France) (Joukowsky and Favre, 1913) in the presence of coarse ribbing on both valves. The *V. antiqua* specimens described by Pchelintsev (1959, pl. 39, fig. 6; pl. 41, fig. 4; pl. 43, fig. 2), due to their poor preservation, are not included here in the synonymy. Pchelintsev when describing *V. antiqua* based on the collections of K.K. Focht (in the section "locality" indicates that they come from the Tithonian limestones in the region of the Manester Ravine (the Yalama-Kuchki Ridge and the peaks of Mount Machu). These limestones are currently dated Late Berriasian.

Previously, the author (Yanin, 1989, p. 16) indicated that representatives of the described species originate from the upper Tithonian Lanchin Ravine. At present, limestones with rudists in this locality are assigned by us to the Lower Berriasian (*jacobi* Zone).

Occurrence. Tithonian–Berriasian: Berriasian of the Crimea; Lower Tithonian of France (Mont-Salève).

Material. Three specimens; Crimea, Lower Berriasian, *jacobi* Zone—northern slope of the Karabi-Yaila Plateau (Lanchin Ravine).

Valletia urkustensis Pchelincev, 1959

Plate 21, fig. 5; Plate 22, fig. 6, 7; Figs. 30.4a, 4b

Valletia urkustensis: Pchelincev, 1959, p. 166, pl. 43, figs. 1a, 1b; Yanin, 1989, p. 167, pl. 8, figs. 4a, 4b.

Holotype. TsNIGRM, no. 126/10913, specimen *V. urkustensis* (Pchelintsev, 1959, pl. 43, figs. 1a, 1b; upper valve); Southwest Crimea, Baidar Hill (village of Peredovoe, Urkusta Hill); Upper Tithonian (by original designation: Pchelintsev, 1959, p. 166).

Description. The shell (upper valve) is medium-sized (H is up to 48 mm), with an small umbo, slightly protruding, curved forward and pressed against the valve surface; uniformly convex or with a clear carinate bend, the locality of which varies; smooth; with an oval-elongated aperture extended forward and downward, with rounded edges.

The cardinal platform is wide, occupies 1/3 of the apertural height. The hinge is synistrodont (Figs. 30.4a, 30.4b; pl. 21, fig. 5b; pl. 22, fig. 6b): d2 powerful, high, variable shape: from conical to spatulate, from straight to oblique, very strongly inclined towards the apex of the valve, sometimes protruding beyond the upper edge of the aperture with its apex (the outline of the tooth depends on the state of pres-

Explanation of Plate 22

Fig. 1. *Heterodiceras bajdarense* Pchelincev, specimen, no. PIN, 5596/244, upper valve, ×1: (1a) external view, lateral view, (1b) view from inside; northern side of Baidar Depression, village, Urkusta Hill, gray limestones three meters above the top of the hardground surface; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1986).

Figs. 2–5. *Monopleura taurica* Pchelincev: (2) specimen TsNIGRM, no. 14/12658, shell, external view, ×1: (2a) lateral view, upper valve view, (2b) anterior view, (2c) posterior view; Beshterek River, village of Solovjevka, "Lower Solovjevka limestones"; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1986); (3) specimen TsNIGRM, no. 15/12658, upper valve, view from inside, ×1.5; the same locality, age and collector; (4) specimen TsNIGRM, no. 16/12658, lower valve, view from inside, ×1; the same locality, age and collector; (5) specimen PIN, no. 5596/245, upper valve of a juvenile with a broken posterior margin, ×1: (5a) external view, lateral view, (5b) view from inside; the same locality, age and collector.

Figs. 6–7. *Valletia urkustensis* Pchelincev: (6) specimen PIN, no. 5596/246, upper valve, ×1: (6a) external view, lateral view, (6b) view from inside; north side of the Baidar Depression, village of Peredovoe, Urkusta Hill; Lower Berriasian, *jacobi* Zone, three meters above the surface of hardground (coll. B.T. Yanin, 1986); (7) specimen PIN, no. 5596/247, upper valve, ×1: (7a) external view, lateral view, (7b) view from inside; northern slope of the Karabi-Yaila Massif, Lanchin Ravine; "white rudist-gastropod limestones"; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1986).

Figs. 8–10. *Valletia antiqua* (Favre): (8) specimen TsNIGRM, no. 18/12658, shell, external view, ×1: (8a) anterior view, (8b) lateral view, upper valve view, (8c) posterior view; northern slope of the Karabi-Yaila Massif, Lanchin Ravine; "white rudist-gastropod limestones"; Lower Berriasian, *jacobi* Zone (coll. B.T. Yanin, 1989); (9) specimen TsNIGRM, no. 17/12658, upper valve, ×1: (9a) external view, lateral view, (9b) view from inside; the same locality, age and collector; (10) specimen PIN, no. 5596/248, shell, ×1: (10a) anterior view, (10b) lateral view, upper valve view, (10c) anterior view, (10d) posterior view; the same locality, age and collector.

Figs. 11–12. *Valletia auris* (Favre): (11) specimen PIN, no. 5596/ 49, shell, external view, ×1: (11a) anterior view, (11b) upper valve view, (11c) posterior view; northern slope of the Karabi-Yaila Massif, Lanchin Ravine; "white rudist-gastropod limestones"; Lower Berriasian, *jacobi* Zone; "white rudist-gastropod limestones" (coll. B.T. Yanin, 1989); (12) specimen PIN, no. 5596/250, upper valve, ×1: (12a) external view, lateral view (hole drilled by a predatory gastropod), (12b) view from inside; the same locality, age and collector.

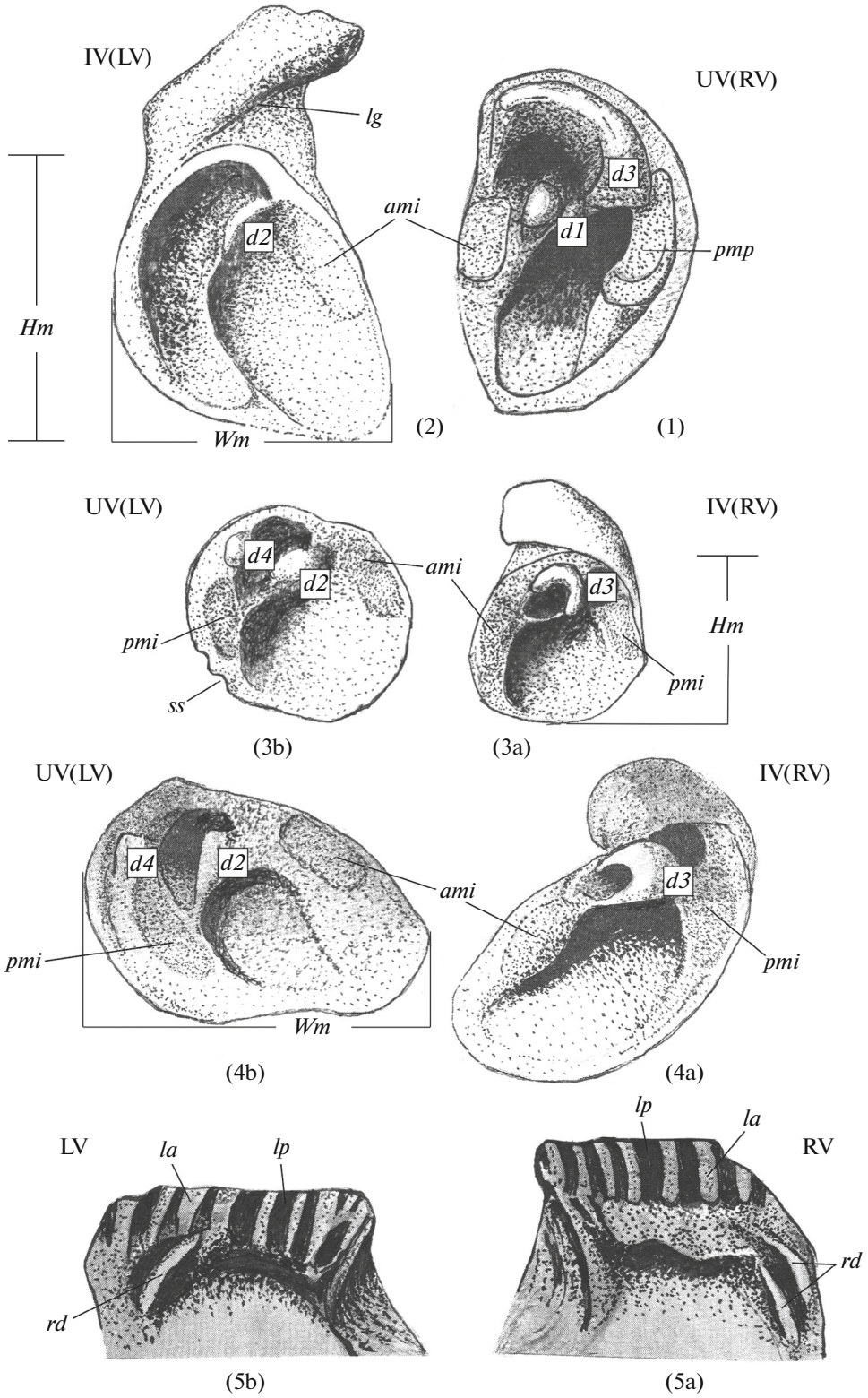


Fig. 30. Hinge of the shells in some species (interior view): (1) *Heterodiceras bjdarense*, upper (right) valve, ×0.75 (Pl. 22, fig. 1b); (2), *H. luci*, inferior (left) valve, ×0.75 (Pl. 21, fig. 2c); (3) *Monopleura taurica*: (3a) inferior (right) valve, ×1.2 (Pl. 22, fig. 4); (3b) upper (left) valve, ×2 (Pl. 22, fig. 3); (4) *Valletia urkustensis*: (4a) lower (right) valve, ×1.2; (4b) upper (left) valve, ×0.75 (Pl. 21, fig. 5b); (5) *Isognomon ricordeanum*: (5a) right valve, ×1.2 (Pl. 2, fig. 15); (5b) left valve, ×1.2 (Pl. 2, fig. 13c). Explanations: (*ami*) anterior superficial insertion, (*Hm*) height of aperture, (*la*) ligament area, (*lg*) ligament groove, (*lp*) ligament pits, (*pmi*) posterior superficial insertion, (*pmp*) posterior myophoral plate, (*rd*) ridge-like teeth, (*ss*) siphonal sinus, (*Wm*) width of aperture; VV ventral, UV upper valve (for other explanations see Fig. 27–29).

ervation of the valves); d4 is strong, slightly smaller than d2; elongated and curved parallel to the upper-posterior edge of the aperture; oblique-triangular in shape, with steep lower and gentle upper slopes; socket 3' relatively wide, short and deep, slightly curved in the upper part.

The anterior myophoral base of elongated oval shape, slightly elevated above the surface of the limb, bounded by myophoric ridges; partially enters the lock area in front of d2; separated from the apertural margin by a limb; its plane is parallel to the plane of the commissure; the posterior myophoral plate is angular in outline, with a pointed lower anterior angle, it is bounded on all sides by ridges; adjoins d4 in the upper part; separated from the apertural margin by a wide limb. There are no lower valves in the collection.

Dimensions in mm and ratios:

Specimen no.	H	Hap	Wap
PIN 5596/247 (UV)	17	15	24
PIN 5596/246 (UV)	32	27	48
TsNIGRM 20/12658 (UV)	48	43	61
TsNIGRM 126/10913 (UV) (holotype)	45	35	50

Comparison. This species differs from all known species of the genus *Valletia* in the larger, slightly convex, oval, wide upper valve with an elongated rounded anterior side and a very slightly protruding umbo.

Remarks. In my previous monograph (Yanin, 1989, p. 168), it is indicated that the shells of this species from the Lanchin Ravine come from the Upper Tithonian. At present, limestones with rudists in this outcrop are assigned to the Lower Berriasian.

Material. Six specimens; Crimea, Upper Tithonian–Lower Berriasian, *jacobi* Zone—the northern side of the Baidar Hill (village of Peredovoe, Urkusta Hill); northern spur of the Karabi-Yaila Plateau (Lanchin Ravine).

Valletia auris **Favre in Favre et Richard, 1927**

Plate 22, figs. 11, 12

Valletia auris: Favre, Richard, 1927, p. 26-28, pl. 1, fig. 5–10.

Valletia auris var. *crassa*: Favre, Richard, 1927, p. 28, pl. 1, fig. 11–16.

Holotype. Not designated. The type locality is Pierre Châtel, Département Ain, France, Upper Kimmeridgian.

Description. The shell is small (H is up to 27 mm), with uniformly convex, smooth, non-carinate valves; weakly inequivalvate. The lower valve has a moderately protruding exogyrical umbo pressed against the surface with a small attachment area. The upper valve is smaller, ear-shaped, with a small, slightly protruding umbo pressed against the surface of the valve. The aperture is oval in shape (without folds of the margins).

The cardinal platform occupies about a quarter of the height of the aperture. The hinge is sinistrodont: in the upper valve (Pl. 22, fig. 12b) there is a large, conical d2; d4 is small, elongated parallel to the posterior-upper margin of the orifice; socket 3' elongated, arched. The anterior and posterior muscle scars on both valves are superficial, oval in shape. The ligament groove on both valves is weakly expressed.

Dimensions in mm and ratios:

Specimen no.	H	Hap	Wap
PIN 5596/249 (Sh)	26	–	–
PIN 5596/250 (UV)	26	18	20

Comparison. This species differs from other species with small-sized shells in the smooth surface; uniform convexity of both valves (lack of a carina or carinate bend) and in the rounded aperture.

Occurrence. Upper Jurassic of Switzerland (Jura Region), Lower Berriasian of the Crimea.

Material. Two specimens; Crimea, Lower Berriasian, *jacobi* Zone—northern slope of the Karabi-Yaila Plateau (Lanchin Ravine, "white rudist-gastropod limestones").

Superorder Septibranchia Pelseneer, 1889

Order Cuspidariida Scarlato et Starobogatov, 1971

Superfamily Cuspidarioidea Dall, 1886

Family Cuspidariidae Dall, 1886

Genus *Cuspidaria* Nardo, 1840

Cuspidaria theodosiana **(Retowski, 1893)**

Plate 20, fig. 2

Neaera theodosiana: Retowski, 1893, p. 73, pl. 14, figs. 13, 14.

Lectotype. A specimen of *Neaera theodosiana* in (Retowski, 1893, pl. 14, fig. 14; TsNIGRM, no. 195/534; left valve; Eastern Crimea, vicinity of Feodosia (south coast of Feodosia Bay); Lower Cretaceous, Lower Berriasian, *jacobi* Zone, *grandis* Subzone (designated herein).

Description. The shell is very small (L = 14 mm), teardrop-shaped, strongly convex, unequal. The front side is wide; the posterior side is very narrow, rostral. The anterior margin is rounded, smoothly turning into a convex ventral along one curve; the posterior margin has a very sharp, narrow rostrum (4 mm long), separated from the ventral margin by a distinct concave sinus, merging into a depression towards the umbo. The umbo is strongly protruding, central, orthogyrate. The surface of the mold is smooth. The ligament area and hinge are covered by the rock matrix.

Dimensions in mm and ratios:

Specimen no.	L	H	H/L
PIN 5596/239 (LV)	14	8	0.57

Comparison. This species differs from *C. glabra*, similar in shape and size shell (Retowski, 1893; Lower Berriasian of the Crimea) in its longer and narrower, pointed rostrum; the presence of a distinct sinus between it and the ventral margin of the valve; it differs from *C. lorioli* Neumayr (see Boehm, 1883, Upper Tithonian of the Czech Republic, Štramberk) in the wider anterior margin and a narrower, pointed rostrum (in *C. lorioli*, the rostrum is rounded at the end and there is no sinus between it and the ventral margin).

Material. One specimen.

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CONFLICT OF INTERESTS

The author declares he has no conflict of interests.

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