ISSN 0869-5938, Stratigraphy and Geological Correlation, 2006, Vol. 14, No. 3, pp. 302–330. © MAIK "Nauka/Interperiodica" (Russia), 2006.
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Biostratigraphy of Jurassic–Cretaceous Boundary Sediments in the Eastern Crimea

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Received December 20, 2004; in final form, March 22, 2005

Abstract—The Dvuyakornaya Formation section in the eastern Crimea is described and subdivided into biostratigraphic units based on ammonites, foraminifers, and ostracodes. The lower part of the formation contains first discovered ammonites of the upper Kimmeridgian (*Lingulaticears* cf. *procurvum* (Ziegler), *Pseudowaagenia gemmellariana* Olóriz, *Euvirgalithacoceras* cf. *tantalus* (Herbich), *Subplanites* sp.) and Tithonian (?(*Lingulaticeras efimovi* (Rogov), *Phylloceras consaguineum* Gemmellaro, *Oloriziceras* cf. *schneidi* Tavera, and *Paraulacosphinctes* cf. *transitorius* (Oppel)). Based on the assemblage of characteristic ammonite species, the upper part of the formation is attributed to the Berriasian *Jacobi* Zone. Five biostratigraphic units (zones and beds with fauna) distinguished based on foraminifers are the *Epistomina ventriosa–Melathrokerion eospirialis* Beds and *Anchispirocyclina lusitanica–Melathrokerion spirialis* Zone in the upper Kimmeridgian–Tithonian, the *Protopeneroplis ultragranulatus– Siphoninella antiqua, Frondicularia cuspidiata–Saracenaria inflanta* zones, and *Textularia crimica* Beds in the Berriasian. The *Cyrherelloidea tortuosa–Palaeocytheridea grossi* Beds of the Upper Jurassic and *Raymoorea peculiaris–Eucytherura ardescae–Protocythere revili* Beds of the Berriasian are defined based on ostracodes. A new biostratigraphic scale is proposed for the upper Kimmeridgian–Berriasian of the eastern Crimea. The Dvyyakornaya Formation sediments are considered as deepwater facies accumulated on the continental slope.

DOI: 10.1134/S0869593806030063

Key words: Eastern Crimea, upper Kimmeridgian, Tithonian, Berriasian, ammonites, foraminifers, ostracodes, biostratigraphy, correlation.

INTRODUCTION

The problem of the Jurassic–Cretaceous boundary in the Tethyan realm debated by many researchers for a long time remains unsolved nevertheless. According to resolutions of the Lion–Neufchatel symposium of 1973, the lower Berriasian boundary is placed at the base of the ammonoid *Berriasella jacobi–Pseudosubplanites grandis* Zone (*Colloque*…, 1975). Later on, it was termed first the *Euxinus* Zone (Allemann et al., 1975) and then the *Jacobi* Zone (Hoedemaeker and Bulot, 1990).

The eastern Crimea is one of the areas with widespread marine sediments of the Jurassic–Cretaceous transition. In this region, clay–carbonate flyschoid sediments of the Dvuyakornaya Formation are exposed near Feodosiya at the Cape Svatogo Il'I, the Dvuyakornaya Bay, and near Ordzhonikidze and Yuzhnoe settlements (Permyakov et al., 1984).

STUDY OF JURASSIC–CRETACEOUS BOUNDARY SEDIMENTS IN THE EASTERN CRIMEA: HISTORICAL REVIEW

First limited information on fossils from the Feodosiya Marl can be found in the work by Verneuil (1838) who pictured *Ammonites theodosia* Desh. (=*Spiticeras*) and *Aptychus theodosia* Desh. (=*Punctaptychus punctatus*. (Voltz)).

Based on the sampled fauna, Sokolov (1886) argued for the Tithonian age of Feodosiya Marl and limestones. Retowski (1893) described a diverse assemblage of ammonites, belemnites, bivalves, gastropods, and brachiopods from the Feodosiya Marl attributing them to the Tithonian. Unfortunately, position of these fossils in the section has not been described, and according to subsequent reexamination, they represent a mixture of specimens from different stratigraphic levels.

Kilian (1907–1913) who established similarity between the Berriasian faunas from southeastern France and Feodosiya Marl attributed the later to the Berriasian. Muratov (1960), who also noted that fauna from the Feodosiya Marl corresponds to that from the "Berriasian Horizon" of southeastern France (not stage at that time), included them into the Valanginian Stage of the Lower Cretaceous. Later on, Druschits (1975) attributed the Feodosiya Marl to the Berriasian, considering this subdivision, however, as the upper substage of the Tithonian Stage (Table 1). Analyzed thoroughly

Table 1. Evolution of views on zonation of Jurassic–Cretaceous boundary sediments in the eastern Crimea

<table>
<tr><th colspan="3">Sazonova and Sazonov, 1974</th><th colspan="3">Druschits, 1975</th><th colspan="4">Kvantaliani and Lysenko, 1979</th><th colspan="3">Bogdanova et al., 1981</th><th colspan="3">Bogdanova et al., 1999</th><th colspan="4">Arkad'ev and Savel'eva, 2002</th><th colspan="4">This work</th></tr>
<tr><th>System</th><th>Stage</th><th>Zone</th><th>System</th><th>Stage</th><th>Zone</th><th>System</th><th>Stage</th><th colspan="2">Zone</th><th>System</th><th>Stage</th><th>Zone</th><th>System</th><th>Stage</th><th>Zone</th><th>System</th><th>Stage</th><th colspan="2">Zone</th><th>System</th><th>Stage</th><th colspan="2">Zone</th></tr>
<tr><td rowspan="4">Cretaceous</td><td rowspan="4">Berriasian</td><td rowspan="2">Occitanica</td><td rowspan="11">Jurassic</td><td rowspan="2">(upper Tithonian) Berriasian</td><td rowspan="2">Privasensis-spitiense</td><td rowspan="5">Cretaceous</td><td rowspan="5">Berriasian</td><td colspan="2">Spitiense</td><td rowspan="5">Cretaceous</td><td rowspan="5">Berriasian</td><td rowspan="2">Malbosiceras sp. Beds</td><td rowspan="5">Cretaceous</td><td rowspan="5">Berriasian</td><td rowspan="2">Occitanica</td><td rowspan="5">Cretaceous</td><td rowspan="5">Berriasian</td><td colspan="2" rowspan="2">Occitanica</td><td rowspan="5">Cretaceous</td><td rowspan="5">Berriasian</td><td colspan="2" rowspan="2">Occitanica</td></tr>
<tr><td rowspan="4"></td><td>Malbosi</td></tr>
<tr><td rowspan="2">Grandis</td><td rowspan="9">middle Tithonian (Ardesh)</td><td>?</td><td rowspan="2">Euxinus</td><td rowspan="3">Ponticus-grandis</td><td rowspan="3">Jacobi-grandis</td><td rowspan="3">Jacobi-grandis</td><td rowspan="2">Grandis</td><td rowspan="3">Jacobi</td><td rowspan="2">Grandis</td></tr>
<tr><td rowspan="2">Ponticus-euxinus</td></tr>
<tr><td rowspan="7">Jurassic</td><td rowspan="7">Tithonian</td><td>Jacobi</td><td>Grandis</td><td>Chomeracensis</td><td>Jacobi</td></tr>
<tr><td rowspan="3">Transitorius</td><td>?</td><td rowspan="6">Jurassic</td><td rowspan="6">Tithonian</td><td colspan="2">?</td><td rowspan="6">Jurassic</td><td rowspan="6">Tithonian</td><td rowspan="6">?</td><td rowspan="6">Jurassic</td><td rowspan="6">Tithonian</td><td rowspan="6">?</td><td rowspan="6">Jurassic</td><td rowspan="6">Tithonian</td><td colspan="2" rowspan="6">?</td><td rowspan="6">Jurassic</td><td rowspan="5">Tithonian</td><td colspan="2">?</td></tr>
<tr><td rowspan="2">Transitorius</td><td colspan="2" rowspan="2">Transitorius</td><td colspan="2">P. transitorius Beds</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="3">?</td><td rowspan="3">?</td><td colspan="2" rowspan="3">?</td><td colspan="2">O. scheidi Beds</td></tr>
<tr><td colspan="2">?L. efimovi Beds</td></tr>
<tr><td>Kimmeridgian</td><td colspan="2">E. cf. tantalus Beds</td></tr>
</table>

the list of taxa determined by Retowski, Khimshiashvili (1967) emphasized: "one can be certain enough stating that Retowski described a mixed Tithonian and Berriasian fauna" (p. 56). It should be noted that the ammonite assemblage described by Retowski is from the 13-m-thick member of the Feodosiya Marl section exposed in the Cape Svyatogo Il'I and accessible nowadays for examination and, probably, from higher layers, which are now in the town development area and cannot be observed.

Sazonova and Sazonov (1974) proposed the first zonation for the Tithonian–Berriasian boundary sediments of the Feodosiya area, where they defined two upper Tithonian zones and all zones of the French Berriasian (Le Hégarat, 1973). Unfortunately, their work is lacking the bed-by-bed description of the section, but absence of *Virgatosphinctes transitorius* (Oppel.), an index species of the upper Tithonian zone, has been emphasized.

Permyakov et al. (1984) defined the Dvuyakornaya Formation of the eastern Crimea and its stratotype in the eponymous ravine near Feodosiya. The stratotype has nor been described properly; it was noted only that the formation 800 m thick is represented by flyschoid alternation of calcareous clays, marls, and brecciated limestones. Based on foraminiferal, coral, brachiopod, bivalve, gastropod, and cephalopod assemblages, the authors defined the formation range as corresponding to the late Tithonian–Berriasian. The list of ammonites cited in that work is lacking typical Tithonian forms however. Tithonian species *Paraulacosphinctes transitorius* and *Richterella richteri* from the lower Dvuyakornaya Subformation have been mentioned in the later work only (Permyakov et al., 1991b),.

Bogdanova et al. (1981, 1984) who reexamined the Cape Svyatogo Il'i section attributed the relevant ammonite assemblage to be the Berriasian Stage. They defined the *Ponticus–grandis* local zone (Table 1) and proposed subsequently to replace the first species by *Berriasella jacobi* (Bogdanova et al., 1999). After revision and new description of ammonite collection sampled by Retowski (1893), they established the overlying *Tirnovella occitanica* Zone in the Berriasian succession of Feodosiya site. The lower boundary with Tithonian Stage was not substantiated by fossils. In 1996, A.Yu. Glushkov and A.V. Shvitkii examined the Cape Svyatogo Il'i section. Glushkov (1997) was the first to describe and reproduce figures of *Pseudosubplanites grandis* (Mazenot), an index species from this section.

All the mentioned researchers paid main attention to the upper part of the Dvuyakornaya Formation in the Cape Svyatogo Il'i area, where the exposed section 80 m thick includes the 13-m-thick member of Feodosiya Marl containing peculiar ammonite assemblage. Below this member, ammonites have not been found until recently, and lower strata exposed further landward in the Dvuyakornaya Bay outcrops remained practically unstudied.

In 2001–2004, V.V. Arkad'ev, Yu.N. Savel'eva, A.A. Fedorova, and G.K. Solov'ev comprehensively studied the Tithonian–Berriasian transitions in the eastern Crimea. In 2001, Arkad'ev and Savel'eva described section of the Cape Svyatogo Il'i area (Fig. 1). They were first to find Berriasian ammonites 60 m below the Feodosiya Marl, which enhance paleontological characterization of the *Jacobi* Zone in the Crimean Mountains. The zone of enlarged range wad divided into the *chomeracensis* (lower) and *grandis* (upper) subzones (Arkad'ev and Savel'eva, 2002; Arkad'ev, 2003). Savel'eva discovered an ostracode assemblage in this section. In 2002–2003, investigation of sections near the Ordzhonikidze and Yuzhnoe settlements yielded new data on lithology and fossils of the Dvuyakornaya Formation (Arkad'ev et al., 2004a, 2004b, 2004c). Based on the found ammonites, the index species *Paraulacosphinctes transitorius* (Oppel) inclusive, the late Tithonian age of the formation lower part was first substantiated. Arkad'ev, Fedorova, and Savel'eva who carried out additional sampling of ammonites in 2004 recognized the upper Kimmeridgian and lower Tithonian strata in this section. Results of these investigations expounded in this work specify biostratigraphic scale of the Jurassic–Cretaceous boundary sediments, which has been proposed earlier for the eastern Crimea (Arkad'ev and Bogdanova, 2004).

The Jurassic–Cretaceous boundary sediments are exposed in the Sultanovka syncline near the Yuzhnoe Settlement. Kvantaliani and Lysenko (1979; Kvantaliani, 1989) described only the Berriasian part of this section, which they referred to the *Jacobi–grandis* Zone based on found specimens of *Berriasella jacobi* Mazenot and *Pseudosubplanites grandis* (Mazenot).

The micropaleontological study of the Upper Jurassic and Lower Cretaceous sediments in the eastern Crimea commenced in the 1950s only. Gofman (1956, 1961) described the foraminiferal assemblage from the Karabi-Yaila section. The assemblage attributed to the Tithonian includes *Textularia densa* Hoff., *Lagena hispida* Reuss, *Nodosaria biloculina* Terg., *Lenticulina ponderosa* Mjatl., *L. rotulata* Lam., *L. magnifica* (Kueb. et Zwin.), *L. pygio* (Kubl. et Zw.), *Ramulina* sp., *Discorbis speciosus* Dain, *Trocholina travarsarii* Paalzow, *T. nidiformis* Bruckm.

Several works of the late 1960s and early 1970s are dedicated to study of the Upper Jurassic and Lower Cretaceous foraminifers from the Crimean Plain and eastern Crimea (Voloshina, 1974, 1976, 1977; Plotnikova, 1975, 1976, 1978, 1979; Plotnikova et al., 1976). In opinion Voloshina, species *Anchispirocyclina lusitanica* (Egger) dominant in the eastern sections is indicative of the Tithonian; besides, she defined here foraminiferal assemblages characteristic of the Tithonian and Berriasian.

Kuznetsova (1983) who studied siliciclastic and siliciclastic–carbonate sections of the Sudak synclinorium proposed foraminiferal zonation for the Callov-

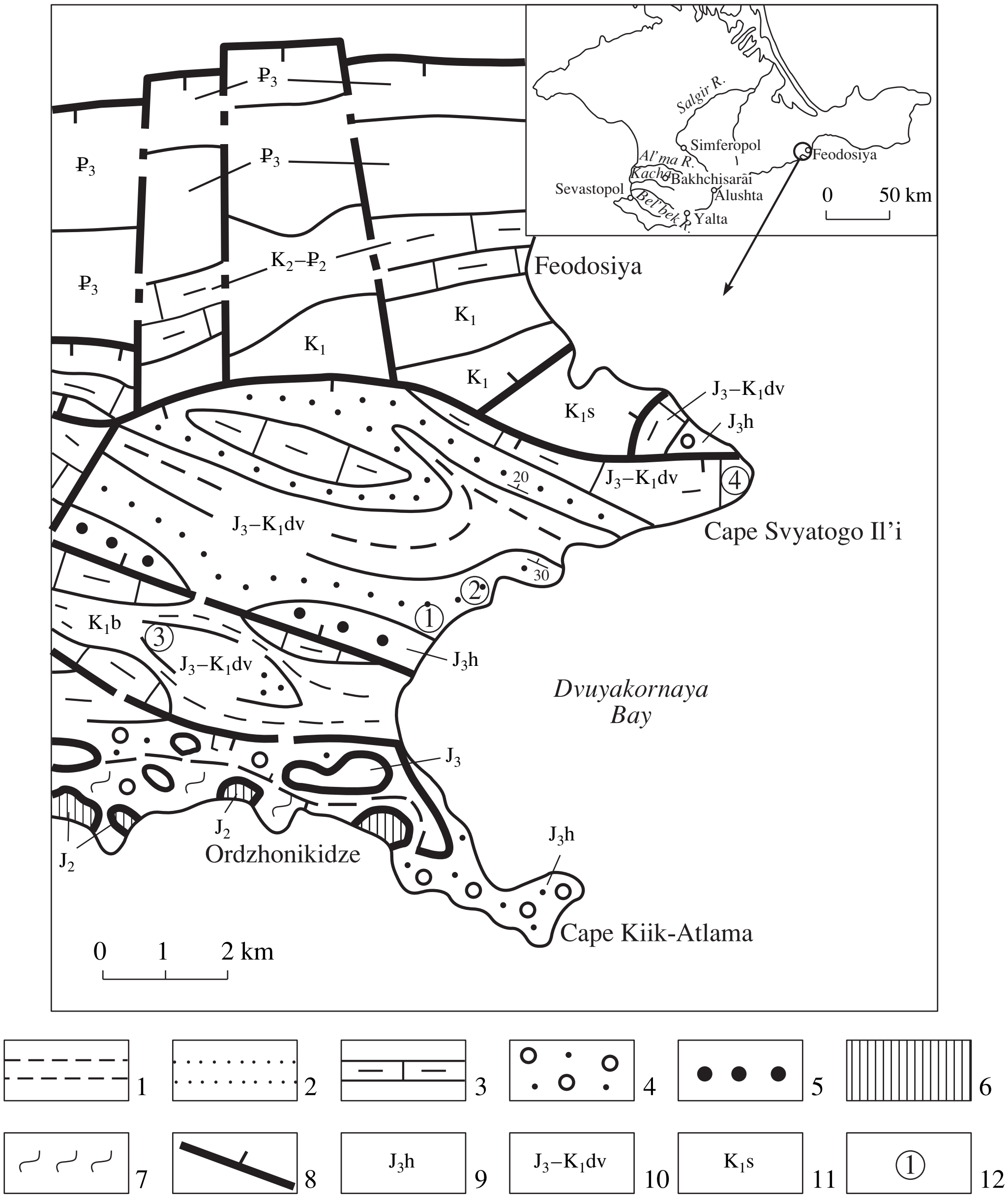


Fig. 1. Schematic geological structure of the Feodosiya area (after Kazantsev et al., 1989) and location of examined Dvuyakornaya Formation sections: (1) clays, siltstones; (2) sandstones; (3) marls; (4) block conglomerates; (5) conglomerates; (6) volcanosedimentary rocks; (7) tectonites; (8) thrusts; (9) Khutoran Formation; (10) Dvuyakornaya Formation; (11) Sultanovka Formation; (12) numbers of examined sections: (1) Section 1, Dvuyakornaya Bay, (2) Section 2, Dvuyakornaya Bay, (3) Section 3 1 km southeast of the Yuzhnoe Settlement, (4) Section 4 in the Cape Svyatogo Il'i area.

ian–Tithonian interval. Paleontological data on the upper Kimmeridgian have not bee obtained, however, in the Crimean Mountains, and this is explained by erosion in the pre-Tithonian time (Kuznetsova and Gorbachik, 1985, p. 17). Later on, Kuznetsova and Gorbachik (1985) examined also the Feodosiya section and proposed the first zonation for the Upper Jurassic–Lower Cretaceous deposits of the Crimea.

The *Epistomina ventriosa–Textularia densa* Beds and *Anchispirocyclina lusitanica–Melathrokerion spirialis* Zone have been distinguished in the Tithonian (Kuznetsova, 1983). Afterward, the latter unit was divided into the *Astacolus laudatus–Epistomina omninoreticulata* and *Anchispirocyclina lusitanica–Melathrokerion spirialis* zones (Kuznetsova and Gorbachik, 1985).

In the Berriasian, there were established the *Protopeneroplis ultragranulatus–Siphoninella antiqua* and *Quadratina tunassica–Siphoninella antiqua* beds, and the *Conorboides hofkeri–Conorbina heteromorpha* Zone. The last zone consisted of the *Triplasia emslan-*

densis (lower) and *Triplasia emslandensis–Palaeotextularia crimica* subzones.

Based on foraminifers, Kuznetsova and Gorbachik determined the Tithonian–Berriasian age of the Dvuyakornaya Formation, but they omitted from consideration any other fossils (ammonites included) when describing the Cape Svyatogo Il'i section. In their estimates, this section is 800 m thick, although in fact it is 80 m thick (Bogdanova et al., 1984; Arkad'ev, 2003). Because of this contradiction, it is difficult to correlate beds and members of our scheme with those defined by Kuznetsova and Gorbachik.

Ostracodes from the Jurassic–Cretaceous boundary sediments of the Crimean Mountains are insufficiently studied. Neale (1966) who described nine new species from the central Crimea was first to initiate study of these fossils. Rachenskaya (1968a, 1968b, 1969a, 1969b; Druschits et al., 1968) and Tesakova (Tesakova and Rachenskaya, 1996a, 1996b) continued systematic investigation of ostracodes from that area. Tesakova described 11 new species of the Berriasian Stage. First data on the Tithonian ostracodes from Crimea appeared in 1991 only (Permyakov et al., 1991a). M.N. Permyakova determined 14 ostracode species from the Deimen–Dere Formation of the Baidarskaya depression in the southwestern Crimea, which indicate the Tithonian age of host deposits. Prior to our works, Tithonian and Berriasian ostracodes of the eastern Crimea remained practically unknown. Savel'eva and Tesakova carried out their preliminary determination (Arkad'ev and Savel'eva, 2002; Arkad'ev et al., 2004; Tesakova et al., 2004).

We studied foraminifers and ostracodes in unlithified sediments (collected samples 200 g in weight are spaced for 1.5–5.0 m in the section). In addition, foraminifers were determined in differently oriented thin sections of limestones. As for the other fossils, ammonites were determined by V.V. Arkad'ev and M.A. Rogov (GIN RAS), belemnites by V.B. Ershova (St.PSU), aptychi by N.V. Myshkina (VSEGEI), bivalves by T.N. Bogdanova (VSEGEI), brachiopods by S.V. Lobacheva (VSEGEI), foraminifers by A.A. Fedorova), and ostracodes by Yu.N. Savel'eva and E.M. Tesakova.

Collections of upper Kimmeridgian and Tithonian ammonites (nos. 376, 378) are stored at the museum of the Historical Geology Chair (St. PSU). Berriasian ammonites of the *Jacobi* Zone (see the plates) are deposited at the TSNIGRMuseum (collection nos. 13055, 13077, 13098); foraminifers at the VNIGRI Museum (collection nos. 23-F, 24-F), and ostracodes at the Paleontology Chair of the MSU (collection no. 310).

GEOLOGY OF THE STUDY AREA

The Crimean Mountains are considered now as an imbricated fold-and-thrust orogen (Kazantsev et al., 1989; Yudin, 2000; Mileev et al., 2004).

Muratov (1937) who studied in detail geological structure of the eastern Crimea defined the Feodosiya block consisting of the Teteobinskaya, Sultanovka, and Dvuyakornaya synclines in the schematic tectonic map of the region. In terms of the present-day tectonic concept, the study area is a part of the Ortasyrt nappe (Kazantsev et al., 1989), and the Dvuyakornaya Bay area corresponds to the Teteobinskaya allochthon (Fig. 1). The Upper Jurassic–Berriasian flyschoid clay–carbonate rocks of the allochthon are deformed into folds of different amplitude and size, which are complicated by faults. The faults are hardly detectable in clayey rocks, and thickness of the Dvuyakornaya Formation was overestimated probably because of this situation. Initially defining the formation, Permyakov et al. (1984) estimated it to be 800 m thick, but according to our data, the unit is only 360 m thick. The formation beds dip northeast in general under angles of 20–30°. With such an attitude, oldest layers of the formation are exposed in the southern limb of the Teteobinskaya allochthon; youngest strata in its northern limb within the Cape Svyatogo Il'i area.

Structure of Sections

Lowest layers of the Dvuyakornaya Formation are exposed in the coastal cliff of the eponymous bay approximately 2 km north of the Ordzhonikidze Settlement (Figs. 1, 2, Section 1). The following members are exposed here (from the base upward):

Member 1: green gray clays, compact, with local parallel bedding and ferruginate brown bedding planes; clays contain bun-shaped and lenticular concretions of more compact calcareous clay, being intercalated with rare thin (up to 0.5 cm) interbeds of brown limy sandstones. Ammonite species *Euvirgalithacoceras* cf. *tantalus* (Herbich) and *Subplanites* sp. were found 8 m above the member base; *Pseudowaagenia gemmellariana* Oloriz and *Lingulaticeras* cf. *procurvum* (Ziegler) 2 and 4 m above these finds. At all levels, ammonites are accompanied by abundant bivalves *Bositra somaliensis* (Cox). The member yields also microfossils: foraminifers *Reophax giganties* A.-V., *Haplophragmoides chapmani* Crespin, *Melathrokerion eospirialis* Gorb., *Charentia evoluta* Gorb., *Textularia notcha* Gorb., *Textularia* sp., *Trochammina* sp., *Lenticulina dilecta* Putria, *L. attenulata* (Kueb. et Zwin.), *Spirillina kubleri* Mjatl., *Trocholina alpina* (Leup.), *Discorbis* sp., *Epistomina ventriosa* Esp. et Sig., and ostracodes *Bairdia* sp. nov., *B.* sp. 6, *Cytherella krimensis* Neale, *C. tortuosa* Lubimova, and *Palaeocytheriodea groissi* Schudack. The thickness is 20 m.

Member 2: greenish gray clays and dark to light gray siltstones with rare interbeds (1–3 cm in the lower part and up to 20–30 cm higher) of brownish gray fine- to medium-grained compact calcareous sandstones; siderite lenses and interbeds (20–30 cm) in sandstone have brown surface. At the level 10 m above the member base, sediments yield ammonites *?Lingulaticeras efimovi* (Rogov), *Phylloceras consanguineum* Gemmellaro, *Lytoceras* sp., and bivalves *Aulacomiella problematica* (Furlani). Foraminifers identified in this member are *Reophax* sp., *Reophax* sp. 1, *Reophax* sp. 2, *Haplophragmoides vocontianus* Moullade, *Ammobaculites* sp. 1, *Ammobaculites* sp. 2, *A.* ex gr. *inconstans* Bart. et Brand, *A.* sp., *Melathrokerion eospirialis* Gorb., *Everticycla-*

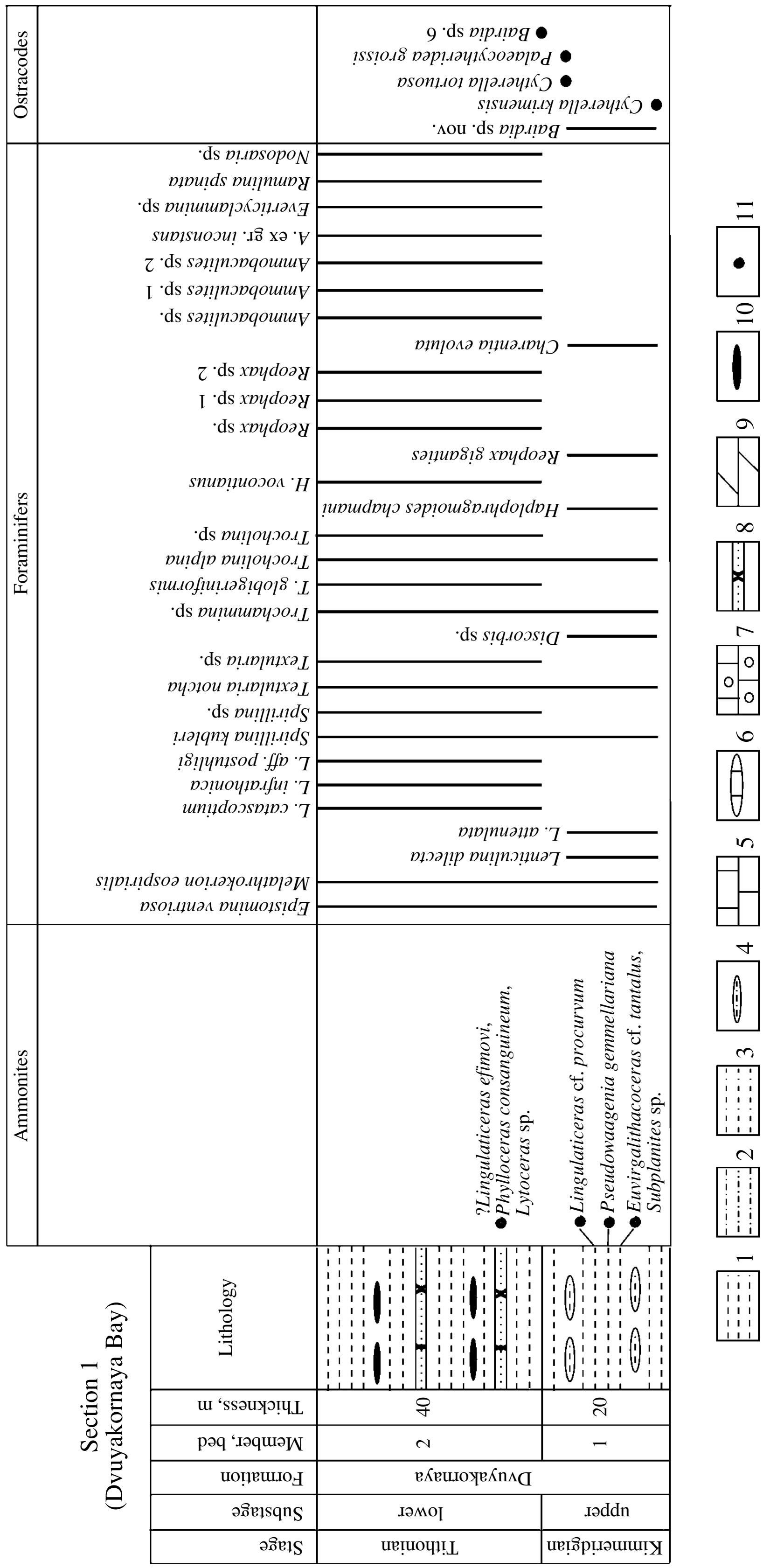


Fig. 2. Distribution of ammonites, foraminifers, and ostracodes in Section 1: (1) clays; (2) siltstones; (3)sandy clays; (4) siltstone lenses; (5) limestones; (6) limestone lenses; (7) conglomeratic limestones; (8) calcareous sandstones; (9) marls; (10) siderite concretions; (11) ammonite and ostracode finds.

mmina sp., *Textularia* sp., *T. notcha* Gorb., *Trochammina globigeriniformis* (Parker et Jones), *T.* sp., *Nodosaria* sp., *Lenticulina catascoptium* (Mitjanina), *L. infrathonica* K. Kuzn., *L.* aff. *postuhligi* K. Kuzn., *Ramulima spinata* Ant., *Spirillina* sp., *S. kubleri* Mjatl., *Miliospirella* sp., *Trocholina alpina* (Leup.), *T.* sp., *Epistomina ventriosa* Esp. et Sigal, and undeterminable planktonic forms. The thickness is 40 m.

The next interval is unexposed. Higher layers are studied near the benchmark 90.0 m inside the Dvuyakornaya Bay (Figs. 1, 3, Section 2), where the following succession is exposed from the water level upward:

Member 3: greenish gray splintery clays (0.3–0.5 m) with parallel bedding, brown siderite concretions, and black plant detritus; they are intercalated with more compact sandy varieties and pinkish gray fine-grained detrital limestones (0.10–0.15 cm). Small poorly preserved ammonites *Ptychophylloceras* sp., *Holcophylloceras* sp., *Haploceras* sp., *Lytoceras* sp., and aptychi *Punctaptychus* cf. *punctatus* (Voltz), and *P. cinctus* Trauth. are found 1 m above the base. Foraminifers of the member are represented by *Haplophragmoides* sp. 1, *H.* sp. 2, *Ammobaculites* ex gr. *inconstans* Bart. et Brand, *Textularia notcha* Gorb., *T. densa* Hoff., *Gaudryina chettabaensis* Sig., *Lenticulina* sp.1, *Lenticulna* sp. 2, *Spirillina helvetica* (Keub. et Zwin.), *S. kubleri* Mjatl., and *S.* sp.; ostracodes by *Bairdia* sp. nov. The thickness is 12 m.

4: interval 8 m wide is unexposed.

Member 5: alternating dark greenish gray splintery clays and cream-colored fine-grained detrital compact limestones (0.05–0.10 m) with abundant fucoids; limestone beds have the sharp lower and frequently ocherous upper boundary. In the uppermost part of the member, a bed of massive limestone is 0.5 m thick. Sediments yield diverse fossils: poorly preserved ammonites *Haploceras* sp., *Lytoceras* sp.; aptychi *Punctaptychus cinctus* Trauth.; foraminifers *Haplophragmoides* sp. 2, *Ammobaculites* ex gr. *inconstans* Bart. et Brand, *Everticyclammina* sp., *Textularia notcha* Gorb., *Spirillina helvetica* (Keub. et Zwin.), *S. minima* Schaco, *S.* sp., *Patellina turriculata* Dieni et Massari; and ostracodes *Bairdia* sp. nov., *Bairdia* sp. 7, *Bairdia* sp. 8, *Cytherella krimensis* Neale, *"Cythereis"* sp. 2, *?Mantelliana purbeckensis* (Forb.), *Hechticythere* sp. The thickness is 13.5 m.

Member 6: alternating dark greenish gray splintery clays (0.5–1.0 m), more compact lenticular siltstones (0.03–0.10 m), and pinkish gray fine-grained detrital compact limestones (0.03–0.10 m); some clay interbeds are highly ferruginate, ocherous, brown to yellow in color. Ammonite *Ptychophylloceras* sp. is found in the middle of the member. Foraminiferal assemblage consists of *Reophax giganties* A.-V., *Haplophragmoides* sp. 2, *Ammobaculites* ex gr. *inconstans* Bart. et Brand, *Everticyclammina* sp., *Textularia densa* Hoff., *Spirillina helvetica* (Keub. et Zwin.), *S.* sp., and *Patellina turriculata* Dieni et Massari. The thickness is 12 m.

Member 7 is lithologically similar to the previous one, though comprising a relatively thick (0.4 m) bed of cream-colored fine-grained detrital limestones at the top. Among microfossils, there are foraminifers *Reophax giganties* A.-V., *Ammobaculites* ex gr. *inconstans* Bart. et Brand, *Everticyclammina* sp., *Spirillina helvetica* (Keub. et Zwin.), *S.* sp., *Trocholina burlini* Gorb., and ostracodes *Bairdia* sp. nov., *Bairdia* sp. 7, *Cytherelloidea mandelstami blanda* Neale, *C. mandelstami mandelstami* Neale, *Schuleridea juddi* Neale, *Cypridina* sp., *Macrocypris* sp., and others. The thickness is 15 m.

8: interval 15 m wide is unexposed.

Member 9: alternating greenish gray splintery and compact parallel-bedded clays (0.3–1.0 m), cream-colored to brown detrital compact limestones (0.1–0.5 m), and rare gray detrital calcareous sandstones (0.10–0.15 m); some limestones beds consist of lenses up to 0.5 m long. Ammonites *Oloriceras schneidi* Tavera, *Ptychophylloceras* sp., and aptychi *Punctaptychus punctatus longa* Trauth. are found 2 m below the member top. The following foraminifers are dispersed through the member: *Ammobaculites* ex gr. *inconstans* Bart. et Brand, *Melathrokerion eospirialis* Gorb., *Gaudryina chettabaensis* Sig., *G.* sp., *Lenticulina dilecta* Putria, *L.* cf. *macra* Gorb., *L. muensteri* (Roem.), *L.* sp., *Astacolus planiusculus* (Reuss), *Vaginulina duestensis* Reuss, *Spirillina kubleri* Mjatl., *S.* sp., *Discorbis crimicus* Schok., *D.* sp., and *Epistomina ventriosa* Esp. et. Sig. The ostracode assemblage consists of *Bairdia* sp. nov., *Quasihermanites implicata* Donze, and *Macrocypis* sp. The thickness is 16 m

10: interval 10 m wide is unexposed.

Member 11: irregularly alternating greenish gray splintery clays (0.3–1.0 m) and cream-colored detrital limestones (0.03–0.40 m), which are intercalated with brown siderite interbeds. Identified foraminifers are *Haplophragmoides globigerinoides* (Haeusler), *Trochammina neocomiana* Mjatl., *T. globigeriniformis* (Parker et Jones), *Lenticulina immense* K. Kuzn., *L. gutata gutata* (ten Dam), *L. muensteri* (Roem.), *L. undorica* K. Kuzn., *L. uspenskajea* K. Kuzn., *L.* sp., *Astacolus planiusculus* (Reuss), *Vaginulina duestensis* Reuss, *Spirillina helvetica* (Keub. et Zwin.), *S.* sp., *Trocholina infragranulata* Noth, and *Patellina turriculata* Dieni et Massari. Ostracodes are represented by *Bairdia* sp. nov., *Bairdia* sp. 7, *Cytherella krimensis* Neale, *Cytherelloidea tortuosa* (Lub.), *C.* ex gr. *tortuosa* (Lub.), *C. mandelstami blanda* Neale, *Quasihermanites implicata* Donze, *Tethysia chabrensis* Donze, *"Xestoleberis"* sp. 1, *Macrocypris* sp., *Macrocypris* sp. 3, and others. Thickness is 20 m.

Member 12 is lithologically similar to the previous one, though lacking siderite interbeds; limestone beds are relatively thicker (0.3–0.4 m). Characteristic foraminifer species are *Melathrokerion spirialis* Gorb., *Trochammina globigeriniformis* (Parker et Jones), *Lenticulina uspenskajea* K. Kuzn., *L.* sp.1, *L.* sp. 2, *Vaginulina duestensis* Reuss, *Spirillina helvetica* (Keub. et Zwin.), *Trocholina infragranulata* Noth, *T. alpina* (Leup.), and *T. elongata* (Leup.). The ostracode assemblage includes *Cytherella krimensis* Neale, *Cytherelloidea mandelstami blanda* Neale, *C. tortuosa* (Lub.), *Cypridina* sp., *Bairdia* sp. nov., *Macrocypis* sp., and *"Xestoleberis"* sp. 1. The thickness is 10 m.

Belemnite *Pseudoduvalia tithonica* (Opp.) is found in talus derived from the section lower part.

The section continues further approximately 1 km southeast of the Yuzhnoe Settlement in the southern limb of the Sultanovka syncline (Figs. 1, 4, Section 3). The following sediments are exposed in several small hills:

Member 13: dark green to locally gray clays, parallel-bedded, splintery, intercalated with light gray coarse-grained calcareous sandstones (0.05–0.15 m) and containing lens-like siderite concretions up to 20–30 cm thick. The layer near the member base, clays contain bivalves *Aulacomiella problematica* (Furlani), plant detritus, and foraminifers *Haplophragmoides* sp., *Ammobaculites* sp., *Charentia evoluta* (Gorb.), *Stomatostoecha compressa* Gorb., *S.* sp., *Pseudocyclammina lituus* (Yok.), *P. spharaedalis* Hott., *Anchispirocyclina lusitanica* (Egg.), *Spirillina kubleri* Mjatl., *Trocholina*

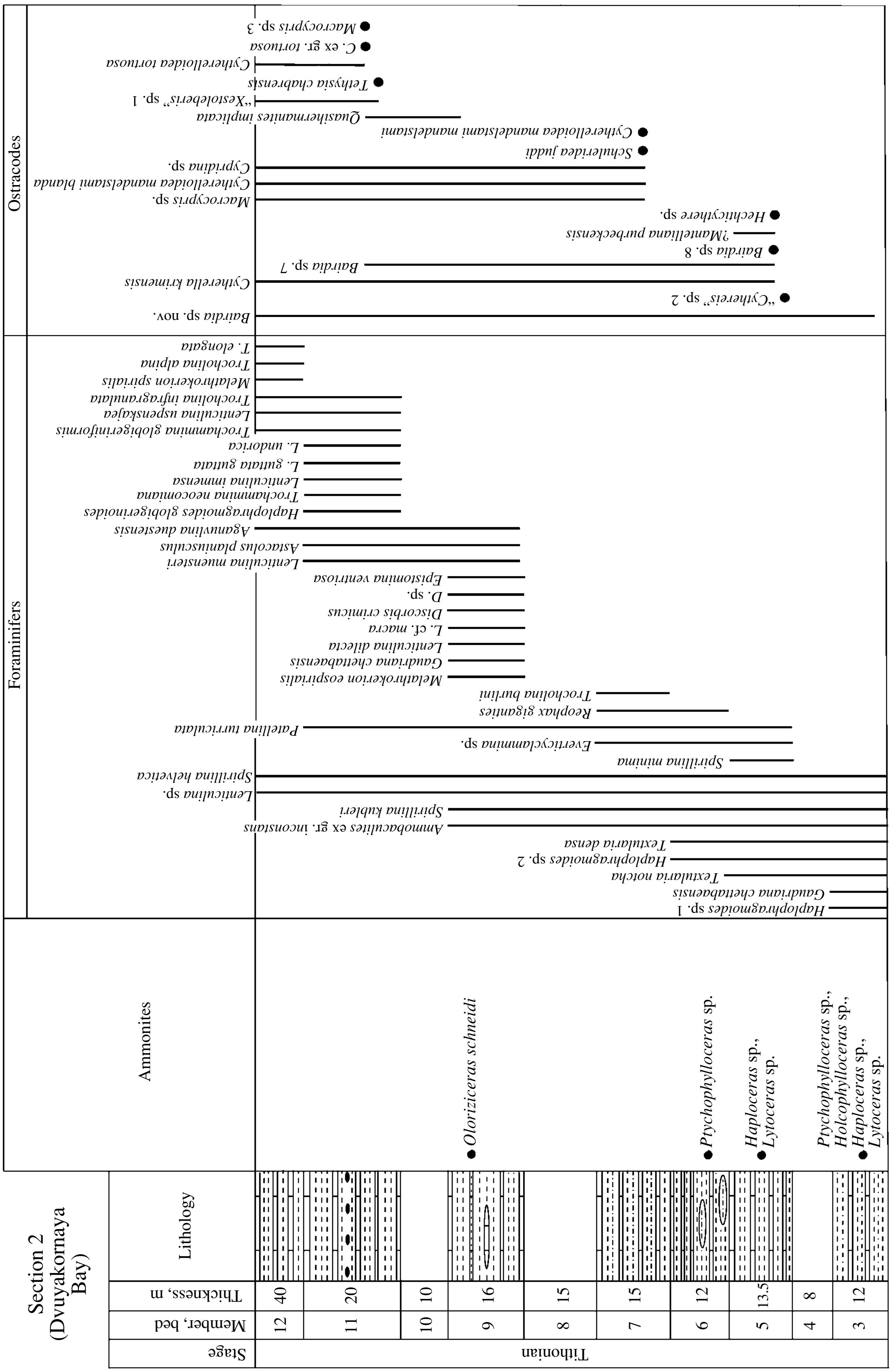


Fig. 3. Distribution of ammonites, foraminifers, and ostracodes in Section 2 (see Fig. 2. for legend).

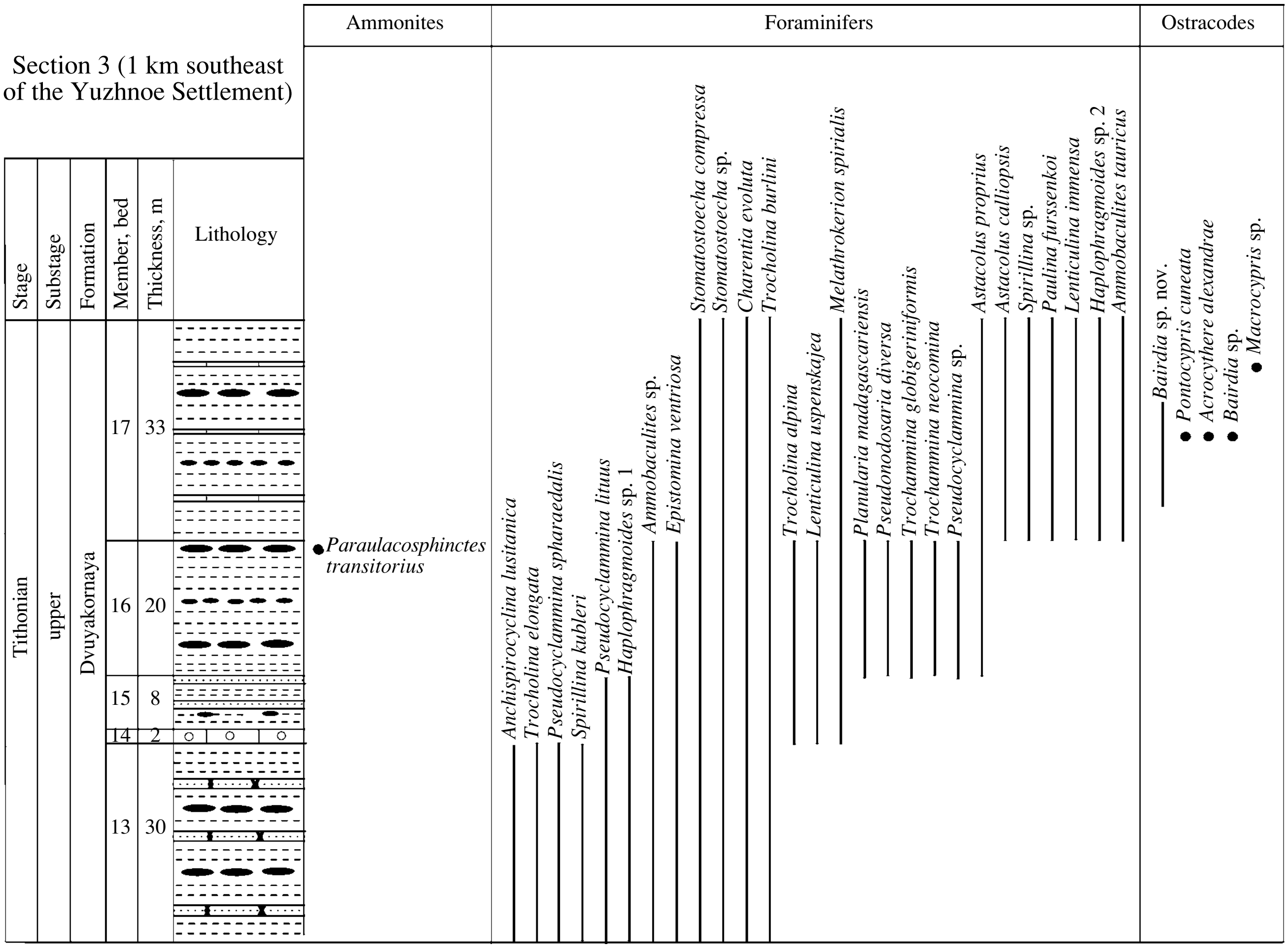


Fig. 4. Distribution of ammonites, foraminifers, and ostracodes in Section 3 (see Fig. 2. for legend).

alpina (Leup.), *T. burlini* Gorb., and *Epistomina ventriosa* Esp. et Sig. The thickness is 30 m.

Member 14: light gray limestone, massive to conglomeratic, is containing small subangular sandstone and limestone pebbles. The thickness is 2 m.

Member 15: dark greenish gray clay, fine-grained, splintery, is containing thin (5–10 cm) interbeds of gray sandstones and lenses of siderites with the brown surface. The member is crowned by a bed (0.5 m) of light gray massive fine- to medium-grained sandstone grading into brown siderite. The top plane of the bed is uneven, hummocky. Fossils are represented by foraminifers *Haplophragmoides* sp., *Melathrokerion spirialis* Gorb., *Charentia evoluta* (Gorb.), *Pseudocyclammina lituus* (Yok.), *Lenticulina uspenskajea* K. Kuzn., and *Trocholina alpina* (Leup.). The thickness is 8 m.

Member 16: greenish gray clays, splintery, with siderite lenses and interbeds; a siderite lens in the uppermost part of the member yielded ammonite *Paraulacosphinctes transitorius* (Oppel). The thickness is 20 m.

Member 17: dark gray clays, fine-grained, splintery, with interbeds (3–5 cm) of pinkish gray very compact cryptocrystalline limestones; hosting brown siderites lenses (up to 30 cm) occur as well. Foraminifers found in the member are *Ammobaculites* sp., *Melathrokerion spirialis* Gorb., *Charentia evoluta* (Gorb.), *Stomatostoecha compressa* Gorb., *S.* sp., *Pseudocyclammina* sp., *Trochammina globigeriniformis* (Parker et Jones), *T. neocomiana* Mjatl., *Pseudonodosaria diversa* (Hoff.), *Lenticulina uspenskajea* K. Kuzn., *Astacolus proprius* K. Kuzn., *Planularia madagaskariensis* Esp. et Sig., *Trocholina burlini* Gorb., *T. alpina* (Leup.), and *Epistomina ventriosa* Esp. et Sig. The ostracode assemblage includes poorly preserved *Bairdia* sp. nov., *B.* sp., *Pontocypris cuneata* Neale, *Acrocythere alexandrae* Neale et Kolp., and *Macrocypris* sp. The thickness is 33 m.

The overlying sediments are much better exposed and studied in paleontological aspect in the Cape Svyatogo Il'i section (Figs. 1, 5, Section 4). A thick (2. 5 m) bed of conglomeratic limestones with angular and subrounded pebbles (up to 2–3 cm across) of limestone and other rocks is exposed immediately above the water level in a cliff 200 m west of the lighthouse. The upper boundary of the bed is sharp, eroded. Its uppermost part (10–15 cm) is true conglomerate, which yielded an echinoid plate and poorly preserved cast of ammonite *Haploceras* sp. Foraminifers *Pseudocyclammina spharaedalis* Hott., and *Anchispirocyclina lusitanica* (Egg.) are identified in thin sections.

No other limestone beds of similar thickness have been observed in examined sections, and their correlation is problematic. Judging from the foraminiferal assemblage, this bed belongs still to the Tithonian Stage. Its upper erosional surface is overlain by the following members:

Member 18: alternating clays (1.5–2.0 m) and limestones (0.10–0.15 m); dominant clays are greenish gray, compact, splintery, frequently soft with limonitized pyrite nodules and parallel bedding. Synsedimentary flattened clay pebbles are concentrated in places. Limestones are light gray to light brown, compact, detrital, lenticular in the lower part of the member; numerous fucoids are confined to bedding planes. Aptychi *Punctaptychus* aff. *malbosi* (Pict.) and *P.* aff. *imbricatus* (Meyer) are found at the member base. Sediments 4 m higher contain diverse fossils: ammonites *Berriasella chomeracensis* (Touc.), *B.* sp., *Fauriella* cf. *floquinensis* Le Hég., *Ptychophylloceras* cf. *semisulcatum* (d'Orb.), *Haploceras* sp.; belemnite *Duvalia* sp.; bivalve *Amusium sokolovi* Ret.; brachiopod *Tonasirhynchia janini* Lobatsch. et Smirn.; aptychi *Punctaptychus punctatus rectecostatus* Cuzzi, *P. punctatus flactocostatus* Trauth., *P. imbricatus* (Meyer), *P.* cf. *monsalvensis* Trauth, and *P. malbosi* (Pict.). The very diverse foraminiferal assemblage consists of *Reophax* sp., *Haplophragmoides* cf. *vocontianus* Moull., *H.* sp. 1, *H.* sp. 2, *Ammobaculites inconstans inconstans* Bart. et Brand, *A. inconstans gracilis* Bart. et Brand, *A.* cf. *eocretaceous* Bart. et Brand, *A.* sp. 1, *A.* sp. 2, *Triplasia emsladensis acuta* Bart. et Brand, *Melathrokerion spirialis* Gorb., *M.* sp., *Charentia evoluta* (Gorb.), *C.* sp., *Stomatostoecha enisalensis* Gorb., *S. rotunda* Gorb., *S. compressa* Gorb., *Pseudocyclammina lituus* (Yok.), *P.* sp., *Everticyclammina* sp., *Rectocyclammina* sp., *Textularia crimica* (Gorb.), *T.* sp., *Trochammina* sp., *Dorothia* sp., *Quinqueloculina* sp., *Isytriloculina* sp. 1, *I.* sp. 2, *Nodosaria paupercula* Reuss, *N.* sceptrum Reuss, *N.* sp., *Pseudonodosaria diversa* (Hoff.), *P. humulis* (Roem.), *P. mutabilis* (Reuss), *Frondicularia* sp., *Lenticulina* cf. *ambanjabensis* Esp. et Sig., *L. neocomiana* Rom., *L. macra* Gorb., *L.* ex gr. *gutata* (ten Dam), *L. nimbifera* Esp. et Sig., *L. colligoni* Esp. et Sig., *L.* sp. 1, *L.* sp. 2, *Astacolus laudatus* (Hoff.), *A.* cf. *favoritus* Gorb., *A. calliopsis* (Reuss), *A. planiusculus* (Reuss), *A.* sp., *Planularia crepidularis* Roem., *Dentalina nana* Reuss, *Spirillina kubleri* Mjatl., *S.* sp., *Globospirillina neocomiana* (Moull.), *G. caucasica* (Hoff.), *Miliospirella* cf. *caucasina* Ant., *Trocholina elongata* (Leup.), *T. alpina* (Leup.), *T. giganta* Gorb. et Manz., *T. molesta* Gorb., *T. burlini* Gorb., *Discorbis crimicus* Schok., *Siphoninella antiqua* Gorb., *Epistomina* cf. *ornota* (Roem.), *E. caracolla caracolla* (Roem.), *Protopeneroplis ultragranulatus* (Gorb.), *Pseudolamarckina* sp., *Conorotalites* ex gr. *bartensteni* (Bett.), *Ticinella roberti* Gand. Similarly diverse is also the ostracode assemblage: *Bairdia* sp. nov., *B.* sp. nov. 1, *Tethysia chabrensis* Donze, *Cytherelloidea mandelstami blanda* Neale, *C. flexuosa* Neale, *Acrocythere aspera* Donze, *A.* cf. *aspera* Donze, *A. alexandrae* Neale et Kolp., *Cytherella* cf. *krimensis* Neale et Kolp., *C. lubimovae* Neale, *?Mandocythere (Costacythere) frankei* (Trieb.), *"Orthonatacythere"* sp. nov., *"O."* sp. nov. 1, *Prodeucythere eocretacea* Neale et Kolp., *Eucytherura ardescae* Donze, "*Cytherura*" sp. nov., *?Clitrocytheridea paralubrica* Neale et Kolp., *Palaeocytheridella teres* Neale, *Macrocypris* sp. B Neale, *?Neocythere* sp., and others. The thickness is 16.6 m.

Member 19: light green clays intercalated with centimeters-thick laminae of light brown compact detrital limestones with abundant fucoids. Foraminiferal assemblage consists of *Reophax* sp., *Ammobaculites inconstans inconstans* Bart. et Brand, *A.* sp., *Melathrokerion spirialis* Gorb., *Charentia evoluta* (Gorb.), *C.* sp., *Stomatostoecha compressa* Gorb., *Trochammina* sp., ., *Isytriloculina* sp. 2, *Lenticulina* cf. *ambanjabensis* Esp. et Sig., *L. neocomiana* Rom., *L. macra* Gorb., *L.* ex gr. *gutata* (ten Dam), *Spirillina kubleri* Mjatl., *Globospirillina neocomiana* (Moull.), *Discorbis crimicus* Schok., and *Epistomina caracola caracola* (Roem.). Ostracodes are represented by *Bairdia* sp. nov., *Acrocythere aspera* Donze, *A.* cf. *aspera* Donze, *A. alexandrae* Neale et Kolp., *Tethysia chabrensis* Donze, *Cytherelloidea mandelstami blanda* Neale, *Cytherelloidea* sp. 2, *Cytherella krimensis* Neale, *Cythereis* aff. *senckenbergi* Trieb., *Prodeucythere eocretacea* Neale et Kolp., *Pontocypris* aff. *arcuata* Lub., *Schuleridea juddi* Neale, *"Orthonatacythere"* sp. nov. 1, *Procytherura* sp., *"Bythocypris"* sp., and others. The thickness is 8 m.

Member 20: alternating greenish gray splintery clays (dominant, 2–3 m thick) and light brown compact detrital limestones (0.3–0.5 m, mainly in the middle part of the member); the uppermost part encloses interbeds (0.1–0.2 m) of dark gray and dark green parallel-bedded marls. The marls contain various fossils: ammonites *Haploceras* cf. *carachtheis* (Zeus.), *H.* sp.; aptychi *Punctaptychus* cf. *punctatus* (Voltz), *P.* cf. *malbosi* (Pict.), *P.* cf. *imbricatus* (Meyer); foraminifers *Ammobaculites* sp., *Stomatostoecha enisalensis* Gorb., *Rectocyclammina* sp., *Feurtilia frequensis* Maync, *Pseudocyclammina lituus* (Yok.), *Textularia crimica* (Gorb.), *Nodosaria sceptrum* Reuss, *Trochammina* sp., *Dorothia* sp., *Sigmoilina* sp., *Pseudonodosaria mutabilis* (Reuss), *Lenticulina neocomiana* Rom., *L. macra* Gorb., *L.* sp. 1, *Astacolus* cf. *favoritus* Gorb., *A. calliopsis* (Reuss), *A. planiusculus* (Reuss), *A. laudatus* (Hoff.), *A. proprius* K. Kuzn., *Saracenaria latruncula* (Chal.), *Spirillina kubleri* Mjatl., *Miliospirella* cf. *caucasina* Ant., *Trocholina alpina* (Leup.), *T. giganta* Gorb. et Manz., *T. molesta* Gorb., *Discorbis crimicus* Schok., *Epistomina* cf. *ornota* (Roem.), *Protopeneroplis ultragranulatus* (Gorb.); ostracodes *Bairdia* sp. nov., *B.* sp. nov. 1, *Acrocythere aspera* Donze, *Cytherella krimensis* Neale, *C. lubimovae* Neale, *Cytherelloidea mandelstami blanda* Neale, *C. mandelstami mandelstami* Neale, *C. flexuosa* Neale, *Cythereis* aff. *senckenbergi* Trieb., *"Cytherura"* sp. nov., *Eucytherura ardescae* Donze, *"Orthonatacythere"* sp. nov. 1, *Protocythere revili* Donze, *Procytheropteron barkeri* And., *Pontocypris cuneata* Neale, *Macrocypris* sp., *?Neocythere* sp., and others. The thickness is 17 m.

Member 21: greenish gray splintery clays with rare interbeds (0.10–0.15 m) of cream-colored detrital limestones; in the middle, there is a thick (0.8 m) limestone bed with abundant rounded pebbles at bedding surfaces. Sediments yield ostracodes *Bairdia* sp. nov., *B.* sp. nov. 1, *Eucytherura ardescae* Donze, *Cytherella krimensis* Neale, *Protocythere revili* Donze, *Raymoorea peculiaris* (Donze), *?Rhinocypris jurassica* (Mand.), *?Clitrocytheridea paralubrica* Neale et Kolp., and others. The thickness is 10 m.

Member 22: bluish gray platy clays with subordinate interbeds (0.5–0.6 m) of dark brown massive detrital limestones. Sediments contain foraminifers *Reophax* sp., *Ammobaculites* sp. 1, *Haplophragmoides* cf. *vocontianus* Moull., *H.* sp., *Stomatostoecha enisalensis* Gorb., *S. compressa* Gorb., *Everticyclammina* sp., *Pseudocyclammina* sp., *Trochammina* sp., *Nodosaria paupercula* Reuss, *N.* sp., *Lenticulina nimbifera* Esp. et. Sig., *L.* sp. 2, *Astacolus laudatus* (Hoff.), *A.* sp., *Spirillina kubleri* Mjatl., *Trocholina alpina* (Leup.), *T. giganta* Gorb. et Manz., and *T. molesta* Gorb. The thickness is 13 m.

Member 23: yellowish gray splintery clays (1.0–1.5 m) enclosing six interbeds of yellowish gray platty marls (0.5–0.8 m); marls sandy, thin-platty in the lower part of the mem-

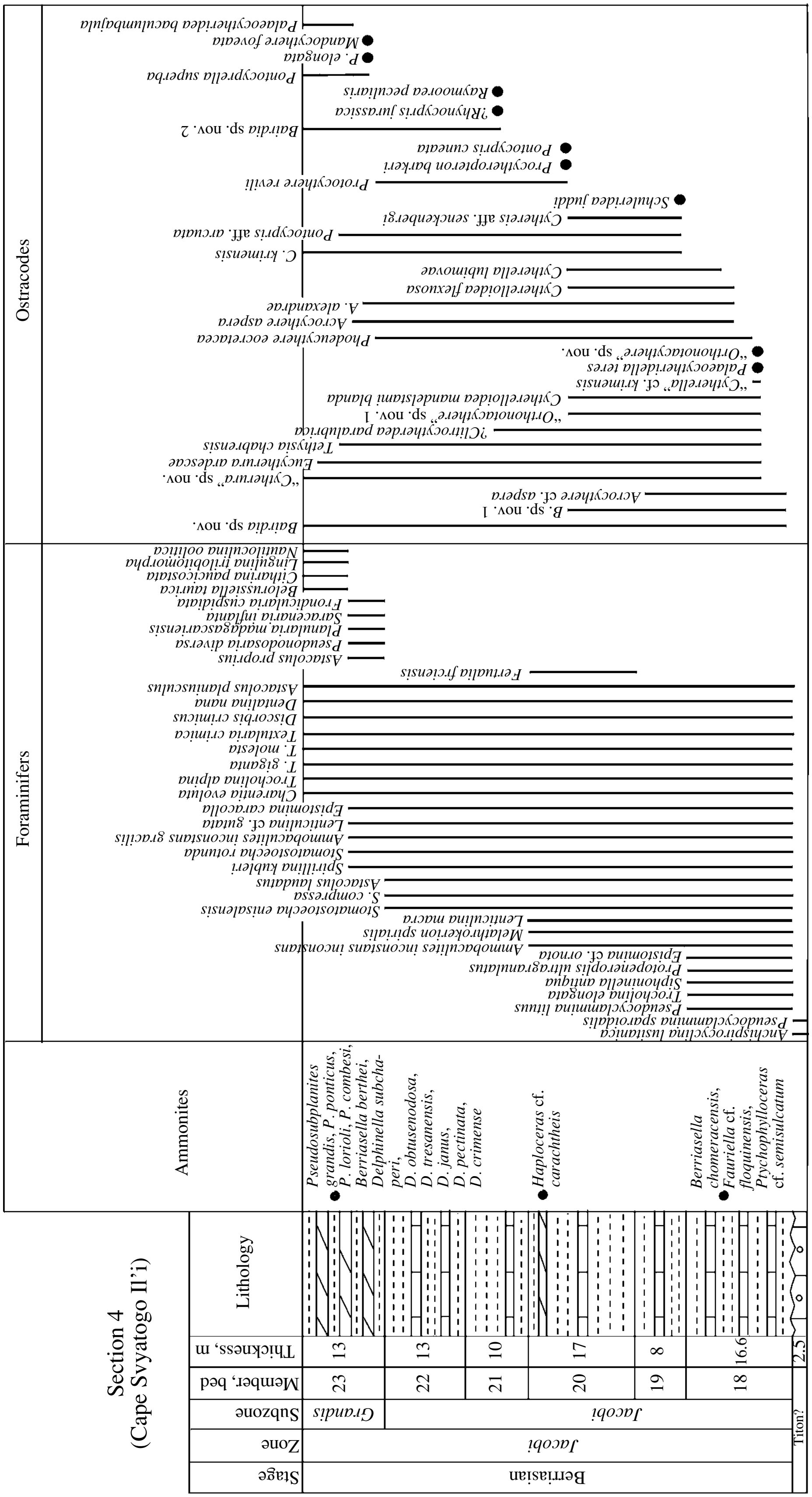


Fig. 5. Distribution of ammonites, foraminifers, and ostracodes in Section 4 (see Fig. 2. for legend).

ber are thicker and calcareous in the upper part. All the marl interbeds contain ammonites, aptychi forms, rare brachiopods, foraminifers, ostracodes, and abundant fucoids. Ammonites are represented by *Ptychophylloceas* sp. in the lowest marl bed, by *Delphinella* sp., *Biasaloceras liebigi* (Opp.) in the third bed from below, and by *Delphinella crimense* (Burck.) *Retowskiceras* sp., *Pseudosubplanites* sp., *Holcophylloceras tauricum* (Ret.), *Protetragonites tauricus* (Kulj.-Vor.), *Ptychophylloceas* sp. in the fourth bed. In the fifth marl bed, *Pseudosubplanites ponticus* (Ret.), *P. lorioli* (Zitt.), *P. combesi* Le Hég., *Haploceras carachtheis* (Zeusc.), *Ptychophylloceas semisulcatum* (d'Orb.), *Protetragonites tauricus* (Kulj.-Vor.), and *Biassaloceras* sp. occur in association with brachiopod *Tonasirhynchia janini* Lobatsch. et Smirn. Characteristic of the sixth marl bed are *Pseudosubplanites grandis* (Maz.), *P. lorioli* (Zitt.), *Delphinella* cf. *crimense* (Burck.), *Ptychophylloceas semisulcatum* (d'Orb.) associated with aptychus *Punctaptychus punctatus* (Voltz). Ammonites *Delphinella* sp., *Retowskiceras* sp., *Tirnovella* sp., *Biasaloceras* sp., *Spiticeras* sp., and aptychus *Punctaptychus cinctus* Trauth. are found in talus deriver from Member 23. The lower part of the member hosts foraminifers *Reophax gigantius* A.-V., *Haplophragmoides* sp., *Ammobaculites eocretaceous* Bart. et Brand, *A. inconstans gracilis* Bart. et Brand, *A.* sp. 1, *Melathrokerion* sp., *Charentia* sp., *Stomatostoecha rotunda* Gorb., *Textularia crimica* (Gorb.), *Dorothia pseudocostata* (Ant.), *D.* sp. 1, *D.* sp. 2, *Pseudonodosaria humulis* (Roem.), *P. diversa* Reuss, *P.* sp., *Frondicularia cuspidata* Pathy, *Lenticulina* ex gr. *gutata* (ten Dam), *L.* cf. *postuhlidi* K. Kuzn., *Astacolus* cf. *favoritus* Gorb., *A. planiusculus* (Reuss), *A. proprius* K. Kuzn., *A.* sp., *Planularia madagaskariensis* Esp. et Sig., *Saracenaria latruncula* (Chal.), *S. inflanta* Pathy, *Dentalina marginulina* Reuss, *D.* sp., *Spirillina kubleri* Mjatl., *S.* sp., *Globospirillina caucasica* (Hoff.), *Trocholina elongata* (Leup.), *T. molesta* Gorb., *Epistomina caracolla caracolla* (Roem.), and *Conorotalites* ex gr. *bartensteni* (Bett.).

Foraminiferal assemblage from the upper part is inherited partly from underlying sediments. It includes *Haplophragmoides* sp. 1, *Triplasia* sp., *Charentia evoluta* (Gorb.), *Pseudocyclammina* sp., *Textularia* sp., *Sigmoilina* sp., *Nodosaria sceptrum* Reuss, *Astacolus calliopsis* (Reuss), *A. planuisculus* (Reuss), *Planularia madagascariensis* Esp. et Sig., *Dentalina nana* Reuss, *Globospirillina neocomiana* (Moull.), *Trocholina alpina* (Leup.), *T. giganta* Gorb. et Manz., *T. molesta* Gorb., *T. burlini* Gorb., *Discorbis crimicus* Schok. and *Textularia crimica* (Gorb.) much more abundant than below. Species first appearing in the assemblage are *Belorussiella taurica* Gorb., *Lingulina trilobitomorpha* Pathy, *Citharina paucicostata* (Reuss), and *Nautiloculina oolitica* Moch. Concurrent ostracodes are represented by *Bairdia* sp. nov., *B.* sp. nov. 2, *Acrocythere aspera* Donze, *A. alexandrae* Neale et Kolp., *Pontocyprella superba* Neale, *P. elongata* Kub., *Tethysia chabrensis* Donze, *Cytherella krimensis* Neale, *"Cytherura"* sp. nov., *Eucytherura ardescae* Donze, *Protocythere revili* Donze, *Mandocythere foveata* Tes. et Rach., *Prodeucythere eocretacea* Neale et Kolp., *Pontocypris* aff. *arcuata* Lub., *Palaeocytherida baculumbajula* (Mand.), *?Neocythere* sp., and others. The thickness is 13 m.

The integral thickness of the Dvuyakornaya Formation in the examined sections is 360 m. Being determined in dismembered succession, the formation is likely incomplete. It is divisible in two parts of different lithology. The lower part (sections 1–3) is largely composed of clays with subordinate sandstone interbeds and abundant siderite concretions. The upper part (Section 4) is characterized by thin flyschoid alternation of clays and limestones. The uppermost part includes the "Feodosiya Marl" (Member 23 in Section 4). This member is traceable from the Cape Svyatogo Il'i along the Dvuyakornaya Bay shore for a distance of approximately 2 km to become unexposed northward. The same member is also exposed in the Berriasian sections near the Yuzhnoe and Nanikovo settlements in western outcrops of the study area. Retaining its lithological and paleontological properties, the member can be regarded as a stratigraphic marker.

DISTRIBUTION OF FOSSILS

Ammonites

The ammonite assemblage from Member 1, Section 1, is of stratigraphic significance. Species *Euvirgalithacoceras tantalus* (Herbich) (Plate I, fig. 3) is known from the *Setatum* Subzone of the upper Kimmeridgian *Beckeri* Zone of Germany (Schweigert, 1994). Representatives of the genus *Subplanites* (Plate II, fig. 2) are characteristic of the upper Kimmeridgian–basal Tithonian (*Hybonotum* Zone). Stratigraphic position of *Pseudowaagenia gemmellariana* Olóriz (Plate II, fig. 1) is unclear. Its holotype is described from the unknown level inside the uppermost lower–lowermost upper Kimmeridgian (Olóriz, 2002). Close species *P. haynaldi* (Herbich) and *P. sesquinodosum* (Fontannes) are of the relatively wide stratigraphic range from the uppermost Oxfordian to lowermost Tithonian. *Lingulaticeras* cf. *procurvum* (Ziegler) identified in Member 1 (Plate I, fig. 2) is typical of the *Subeumela* Subzone of the *Beckeri* Zone in southern Germany (Ziegler, 1958; Schlegelmilch, 1994). Representatives of the genus *Lingulaticeras* were unknown before in the Crimea. In opinion of M.A. Rogov, the ammonite assemblage from Member 1 characterizes, as a whole, the upper Kimmeridgian *Beckeri* Zone (Table 2).

The second member yielded *?Lingulaticeras efimovi* (Rogov) (Plate I, fig. 1) and *Phylloceras consanguineum* Gemmellaro. The last species range corresponds to the Kimmeridgian–lowermost Tithonian. The former species is of a higher stratigraphic significance. It is widespread in the Russian platform, where Rogov (2004) defined the *efimovi* faunal horizon correlated with the *Klimovi* and partly *Sokolovi* zones of the lower Volgian Substage of the platform and with the lower Tithonian *Hybonotum* Zone of the Submediterranean province.

Thus, ammonites imply that Section 1 hosts the Kimmeridgian–Tithonian boundary. Presence of upper Kimmeridgian sediments in the Crimean Mountains has been disputed (Permyakov et al., 1991b).

The upper part of Section 2 in the Dvuyakornaya Bay contains *Oloriceras schneidi* Tavera (Plate II, fig. 3) described from the upper Tithonian *Simplisphinctes* Zone of Spain (Tavera, 1985).

Plate I

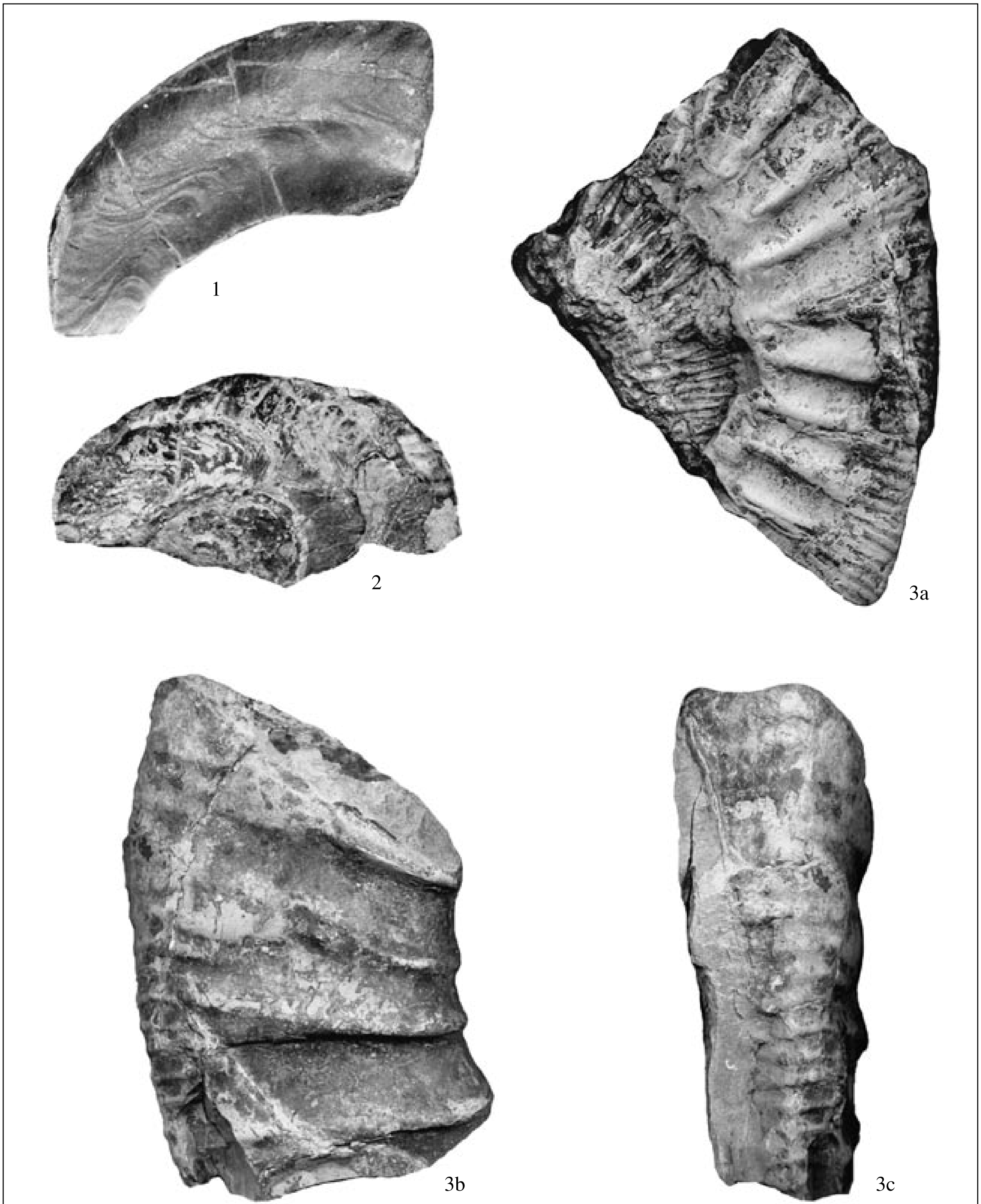


Plate I. Upper Kimmeridgian and lower Tithonian ammonites of the eastern Crimea.

(1) *?Lingulaticeras efimovi* (Rogov), Specimen 6/378, ×2, side view, outskirts of the Ordzhonikidze, Dvuyakornaya Bay (Section 1, Member 2), lower Tithonian, Beds with *?Lingulaticeras efimovi*; (2) *Lingulaticeras* cf. *procurvum* (Ziegler), Specimen 5/378, ×2, side view, outskirts of the Ordzhonikidze, Dvuyakornaya Bay (Section 1, Member 1), upper Kimmeridgian, Beds with *Euvirgalithacoceras* cf. *tantalus*; (3) *Euvirgalithacoceras* cf. *tantalus* (Herbich), Specimen 4/378, ×1: (a, b) side view, (c) ventral view, locality and age are the same.

Table 2. Zonation of Jurassic–Cretaceous boundary sediments in the eastern Crimea and its correlation with zonal scale of the Submediterranean Province

Zones of the Submediterranean Province (Geyssant, 1997; Hoedemaeker and Rawson, 2000)			Ammonites zones or beds in the eastern Crimea (this work)		Foraminiferal zones or beds in the eastern Crimea (this work)	Ostracode Beds in the eastern Crimea (this work)
Berriasian	*Occitanica*		*Occitanica*		*Textularia crimica–Belorussiella taurica* Beds	*Raymoorea peculiaris–Eucytherura ardescae* Beds
	Jacobi	*Grandis*	*Jacobi*	*Grandis*	*Frondicularia cuspidiata–Saracenaria inflanta*	
		Jacobi		*Jacobi*	*Protopeneroplis ultragranulatus–Siphoninella antiqua*	
Tithonian	*Durangites*		?		*Anchispirocyclina lusitanica–Melathrokerion spirialis*	*Cytherelloidea tortuosa–Palaeocytheridea grossi* Beds
	Microcanthum		*Paraulacosphinctes transitorius* Beds			
			?			
			Oloriziceras schneidi Beds			
	Ponti		?		*Epistomina ventriosa–Melathrokerion eospirialis* Beds	
	Fallauxi					
	Semiforme					
	Palatinus					
	Vimineus					
	Mucronatum					
	Hybonotum		?*Lingulaticeras efimovi* Beds			
Kimmeridgian	*Beckeri*		*Evirgalithacoceras* cf. *tantalus* Beds			

Plate II

In Section 3 near the Yuzhnoe Settlement, we have found first *Paraulacosphinctes transitorius* (Oppel) (Plate II, fig. 4) formerly considered in Spain as a zonal taxon of the upper Tithonian (Tavera et al., 1986) and, later on, as index species of the upper subzone in *Microcanthum* Zone (Geyssant, 1997).

The upper Kimmeridgian and Tithonian are first established in the Feodosiya section based on ammonite assemblages. Since ammonites were found in several isolated sections, not in a single succession, only units of beds rank can be defined (Table 2). These are the *Euvirgalithacoceras* cf. *tantalus* Beds of the upper Kimmeridgian, the *?Lingulaticeras efimovi* Beds of the lower Tithonian, and the *Oloriceras schneidi* and *Paraulacosphinctes transitorius* beds of the upper Tithonian. With some reservation, the *P. transitorius* and *O. schneidi* beds can be correlated respectively with the *transitorius* and *simplisphinctes* subzones of the upper Tithonian *Microcanthum* Zone in Spain (Geyssant, 1997). Levels corresponding to the middle Tithonian and the upper Tithonian *Durangites* Zone of Spain have not been determined in the established ammonite succession.

The upper part of the Dvuyakornaya Formation (Section 4, Cape Svyatogo Il'i) contains ammonites of genera *Pseudosubplanites, Delphinella, Berriasella*, and *Retowskiceras* (Plate III), which are characteristic of the *Jacobi* Zone at the base of the Berriasian Stage (Hoedemaeker and Rawson, 2000; Hoedemaeker et al., 2003). This zone can confidently be correlated with the synonymous unit of Spain (Tavera, 1985), but its subdivision into the *chomeracensis* (lower) and *grandis* (upper) subzones (Arkad'ev and Save'eva, 2002; Arkad'ev, 2003; Arkad'ev and Bogdanova, 2004) is inexpedient. During examination of the *Jacobi* Zone section of the Tonas River basin in 2003, Arkad'ev, Fedorova, and Savel'eva found *Berriasella jacobi* Maz. (Plate II, fig. 5) and *Pseudosubplanites grandis* (Maz.) in its lower and upper parts, respectively. Therefore, it is more logical to subdivide the *Jacobi* Zone into the *jacobi* (lower) and *grandis* (upper) sunbzones to attain a more confident correlation with the West European zonations.

Our results do not confirm inference by Kvantaliani (1989) who examined the Tithonian–Berriasian boundary sections near the Yuzhnoe Settlement in the eastern Crimea and defined the *Jacobi–grandis* Zone there. According to his data, *Pseudosubplanites grandis* occurs in the lowermost part of the zone, while *Berriasella jacobi* is found higher in association with *P. grandis* nevertheless. This contradiction is probably a result of ambiguous determination of both species described properly not long ago (Glushkov, 1997; Arkadiev and Bogdanova, 2004; Bogdanova and Arkadiev, 2005).

Belemnites

Belemnite *Pseudoduvalia tithonica* (Oppel) was found in talus of Section 2. This species is known from the Tithonian of Stramberg and the Alps (Oppel, 1865; Zittel, 1868). Later on, it was described from the Feodosiya section of the Crimea (Retowski, 1893), although without indication of the host bed. Krymgol'ts (1932) who described this species from the Staryi Krym site considered it as a form typical of the Tithonian Stage in Stramberg, Alpine, and Crimean sections.

Bivalves

Bivalves *Bositra somaliensis* (Cox) and *Aulacomiella problematica* (Fulani) are found in association with upper Kimmeridgian ammonites in Member 1, Section 1, and together with lower Tithonian ammonites in Member 2 . The last bivalve species is also found in Member 13 of Section 3. Romanov (1976) described both species from the Kongaz Formation, which is attributed in the Dniester–Prut interfluve to the upper Kimmeridgian and, probably, lower Tithonian based on rare ammonite finds. Besides, *Bositra somaliensis* is known from the Kimmeridgian Stage of Somalia, while *Aulacomiella problematica* is described from the Kimmeridgian of Somalia, Turkey, Mexico, from the Kimmeridgian–Tithonian of former Yugoslavia, and from the Kimmeridgian (Tithonian?) of the Crimea.

Bivalve species *Amusium sokolovi* Ret. found in the *jacobi* Subzone (Member 18 of Section 4) has been described from the Feodosiya section long ago (Retowski, 1893). This species is known from the Berriasian Stage only.

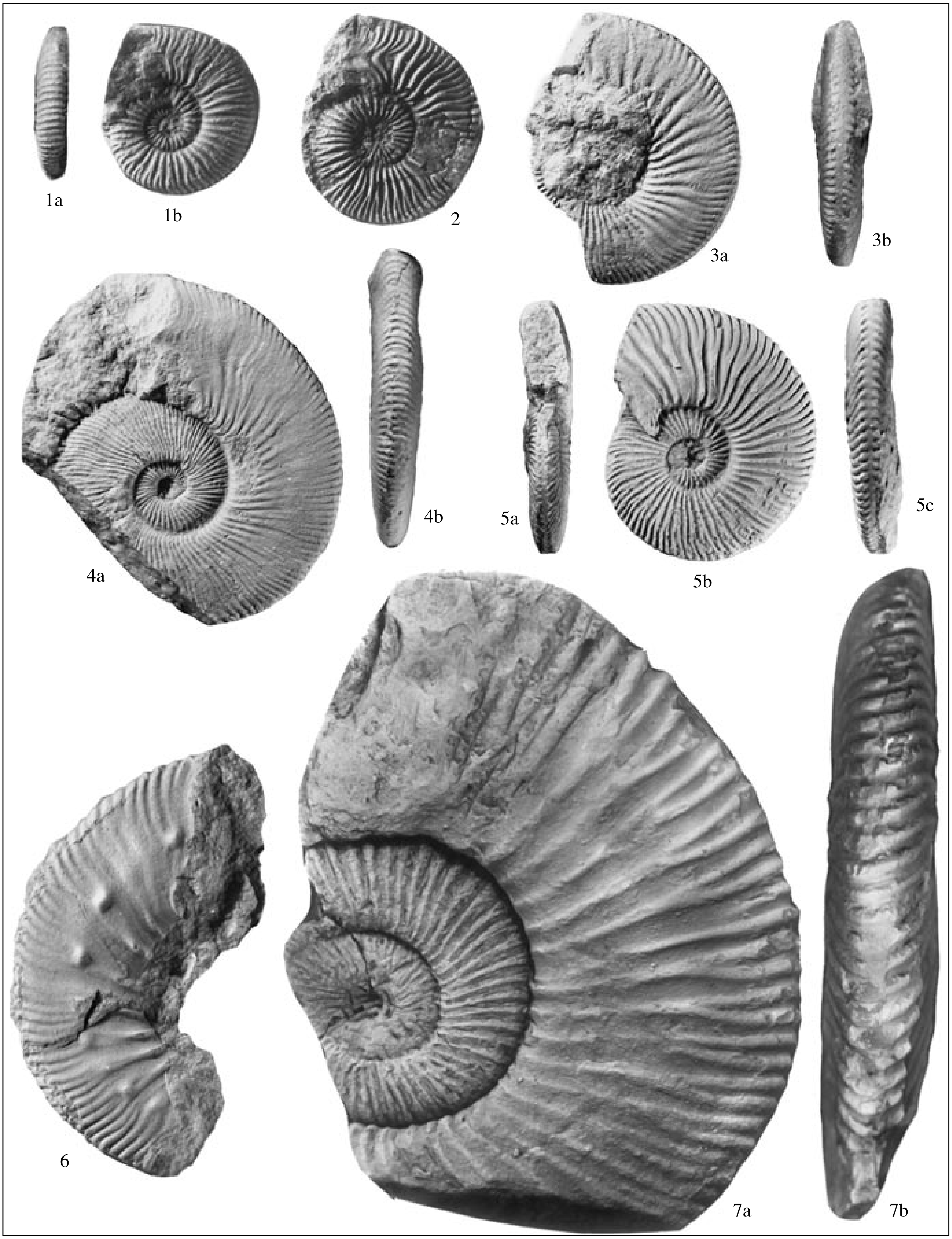
Brachiopods

In the Dvuyakornaya Formation, representatives of this faunal group are rarely occurring in its Berriasian

Plate II. Ammonites from the upper Kimmeridgian, Tithonian, and Berriasian *jacobi* Zone (*jacobi* Subzone) of the eastern Crimea.

(1) *Pseudowaagenia gemmellariana* Olóriz, Specimen 1/378, ×1, side view, outskirts of the Ordzhonikidze, Dvuyakornaya Bay (Section 1, Member 1), upper Kimmeridgian, Beds with *Euvirgalithacoceras* cf. *tantalus*; (2) *Subplanites* sp., Specimen 2/378, ×1, side view, locality and age the same; (3) *Oloriziceras schneidi* Tavera, Specimen 1/376, ×1, side view, Dvuyakornaya Bay (Section 2, Member 9), upper Tithonian; (4) *Paraulacosphinctes transitorius* (Oppel), Specimen 3/378, ×1, side view, ourscirst of the Yuzhnoe Settlement (Section 3, Member 16), upper Tithonian; (5) *Berriasella jacobi* Mazenot, Specimen 4/378, ×2, side view, central Crimea, Tonas River, Krasnoselovka Settlement, Berriasian, *jacobi* Zone, *jacobi* Subzone; (6, 7) *Berriasella chomeracensis* (Toucas): (6) Specimen 22/13098, ×4, side view, (7) Specimen 23/13098, ×1.5, side view, Feodosiya, Cape Svyatogo Il'i (Section 4, Member 18), Berriasian, *jacobi* Zone, *jacobi* Subzone.

Plate III



portion only. We found species *Tonasirhynchia janini* Lobatsch. et Smirn. only in the *grandis* Subzone (in the Feodosiya Marl member) and 60 m below in the *jacobi* Subzone (Member 18 of Section 4). The species was described from the Berriasian *Ponticus–grandis* Zone (= *grandis* Subzone) of the Crimea (Lobacheva and Smirnova, 1994). In the underlying *Jacobi* Subzones, it is detected for the first time.

Foraminifers

Five successive foraminiferal assemblages (Fig. 6, Table 2) are defined after thorough study of the Dvuyakornaya Formation sections.

According to Kuznetsova and Gorbachik (1985), the lower assemblage (sections 1, 2, members 1–7) is characteristic of the lower–middle Tithonian, although some its species occur also in the Kimmeridgian. The most representative species of the assemblage are *Reophax giganties, Haplophragmoides chapmani, Melathrokerion eospirialis, Textularia notcha, T. densa, Epistomina ventriosa, Lenticulina undorica, L. dilecta, L. attenuata, Spirillina kublieri*, and *S. helvetica.* Several of them are of stratigraphic significance. *T. densa* is described from sediments attributed to the Tithonian in the eastern Crimea (Hofman, 1961). *E. ventriosa* (Plate IV, fig. 1) is known from Kimmeridgian sediments of Madagascar (Espitali and Sigal, 1963), where it is distributed through the lower Kimmeridgian–basal Berriasian. Both taxa are index species of the *Epistomina ventriosa–Textularia densa* Zone (Kuznetsova, 1983). *Melathrokerion eospirialis* (Plate IV, figs. 5–7) is described from Tithonian sediments in the Feodosiya outskirts and Tonas River basin of the eastern Crimea (Kuznetsova and Gorbachik, 1985). Because of wide distribution and abundance in this interval of the examined section, *M. eospirialis* can be considered as one of index species of the *Epistomina ventriosa–Melathrokerion eospirialis* Beds. We failed to discriminate the upper Kimmeridgian from the lower Tithonan based on foraminifers, which most likely belong to a single assemblage characterizing both intervals.

Foraminifers characteristic of the upper Tithonian sediments in Crimea appear in members 8–10 of the Dvuyakornaya Formation section in the Dvuyakornaya Bay and near the Yuzhnoe Settlement. These are species *Anchispirocyclina lusitanica* (Plate IV, figs. 11–13), *Melathrokerion spirialis* (Plate IV, figs. 8–10), which are index species of the *Anchispirocyclina lusitanica–Melathrokerion spirialis* Zone according to Kuznetsova (1983), *Ammobaculites tauricus, Charentia evoluta, Pseudocyclammina spharaedalis, P. lituus, Lentculina uspenskajea, L. immense, Astacolus planuisculus, A. laudatus, Planularia madagascariensis, Pseudonodosaria diversa, Trochammina globigeriniformis, T. neocomiana, Trocholina alpina, T. elongata*, and *T. infragranulata.*

Members 11–15 of Section 2 in the Dvuyakornaya Bay contain the assemblage of *Stomatostoecha enisalensis, S. compressa, Charentia evoluta, Feurtillina frequens, Pseudocyclammina lituus, Trocholina alpina, T. elongata, T. molesta, Lenticulina* ex gr. *nodosa, L. vestulae*, and *Astacolus laudatus.* These forms are characteristic of the upper Tithonian–lower Berriasian (Kuznetsova and Gorbachik, 1985; Gorbachik and Kuznetsova. 1994).

In section 4 of the Cape Svyatogo Il'i area, the above assemblage is more diverse. In addition to listed species, it includes typical Berriasian species *Lenticulina macra, L.* cf. *gutata, Pseudonodosaria mutabilis, P. diversa, Trocholina giganta, Epistomina caracolla caracolla, E.* cf. *ornota, Protopeneroplis ultragranulatus*, and *Siphoninella antiqua.* The last two species are index forms of the lower Berriasian *Protopeneroplis ultragranulatus–Siphoninella antiqua* Zone (Kuznetsova and Gorbachik, 1985). *P. ultragranulatus* (Plate IV, figs. 18, 19) is described from the lower Berriasian (Gorbachik, 1971); *S. antiqua* (Plate IV, figs. 16, 17) from the Berriasian Stage of the eastern Crimea (Gorbachik, 1966). In upper Tithonian sediments, these species are rare. *P. ultragranulatus* is considered as senior synonym of *Protopeneroplis trochangulata* Septfontaine, 1974, (Kuznetsova and Gorbachik, 1985) described from the lower Berriasian of France, Italy and Iran. Based on the first occurrence of zonal species and disappearance of *Anchispirocyclina lusitanica* (Egg.), the index species of underlying zone, Fedorova defines the *Protopeneroplis ultragranulatus–Siphoninella antiqua* Zone in Section 4 of the Cape Svyatogo Il'i. This zone is narrower than the synonymous unit distinguished by Gorbachik is. It corresponds to the lower part of the *jacobi* Subzone in ammonite zonation.

The higher assemblage consists of *Dorothia pseudocostata, Pseudonodosaria diversa, Frondicularia cuspidiata, Saracenaria latruncula, S. inflanta, Lenticulina* cf. *postuhligi, Astacolus planiusculus,*

Plate III. Ammonites from the Berriasian *jacobi* Zone (*grandis* Subzone) of the central and eastern Crimea.

(1, 2) *Pseudosubplanites lorioli* (Zittel): (1) Specimen 28/13077, ×1: (a) ventral view, (b) side view, Feodosiya, Cape Svyatogo Il'i (Section 4, Member 23); (2) Specimen 26/13077, ×1, side view, central Crimea, Tonas River; (3) *Delphinella janus* (Retowski), (1) Specimen 32/13055, ×1: (a) side view, (b) ventral view, Feodosiya, Cape Svyatogo Il'i (Section 4, Member 23); (4) *Delphinella crimense* (Buckhardt), Specimen 4/13055, ×1: (a) side view, (b) ventral view, outskirts of Feodosiya, Barakol'skaya Valley; (5) *Delphinella obtusenodosa* (Retowski), Specimen 13/13055, ×1: (a) apertural view, (b) side view, (c) ventral view, Feodosiya, Cape Svyatogo Il'i (Section 4, Member 23); (6) *Delphinella subchaperi* (Retowski), Specimen 1/13055, ×1, side view, outskirts of the Yuzhnoe Settlement; (7) *Pseudosubplanites grandis* (Mazenot), Specimen 18/13077, ×1: (a) side view, (b) ventral view, Feodosiya, Cape Svyatogo Il'i (Section 4, Member 23). All specimens originate from the Berriasian, *jacobi* Zone, *grandis* Subzone.

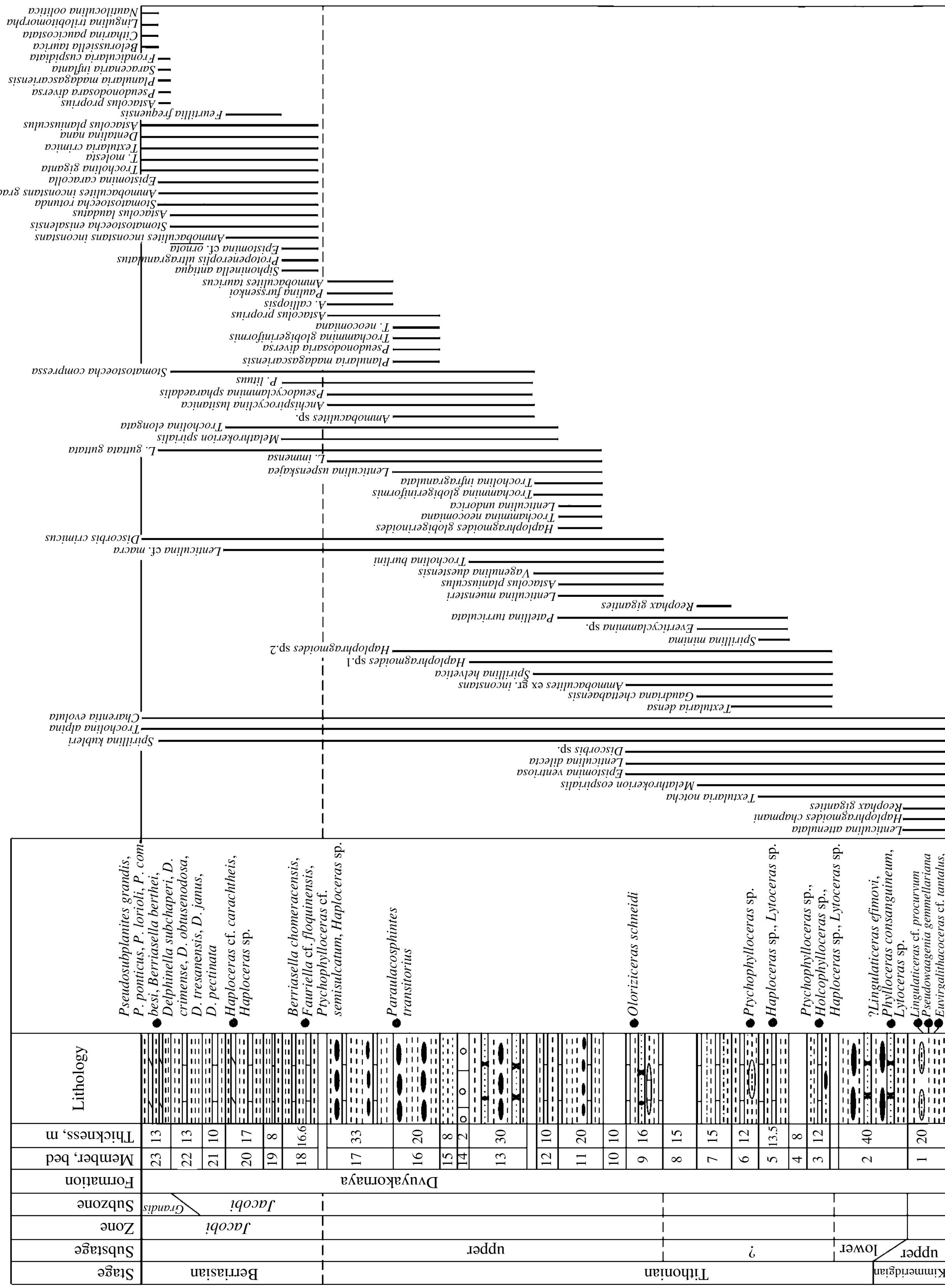


Fig. 6. Distribution of ammonites and stratigraphically most important foraminifer species in the composite section of the Dvuyakormaya Formation in the eastern Crimea (see Fig. 2. for legend).

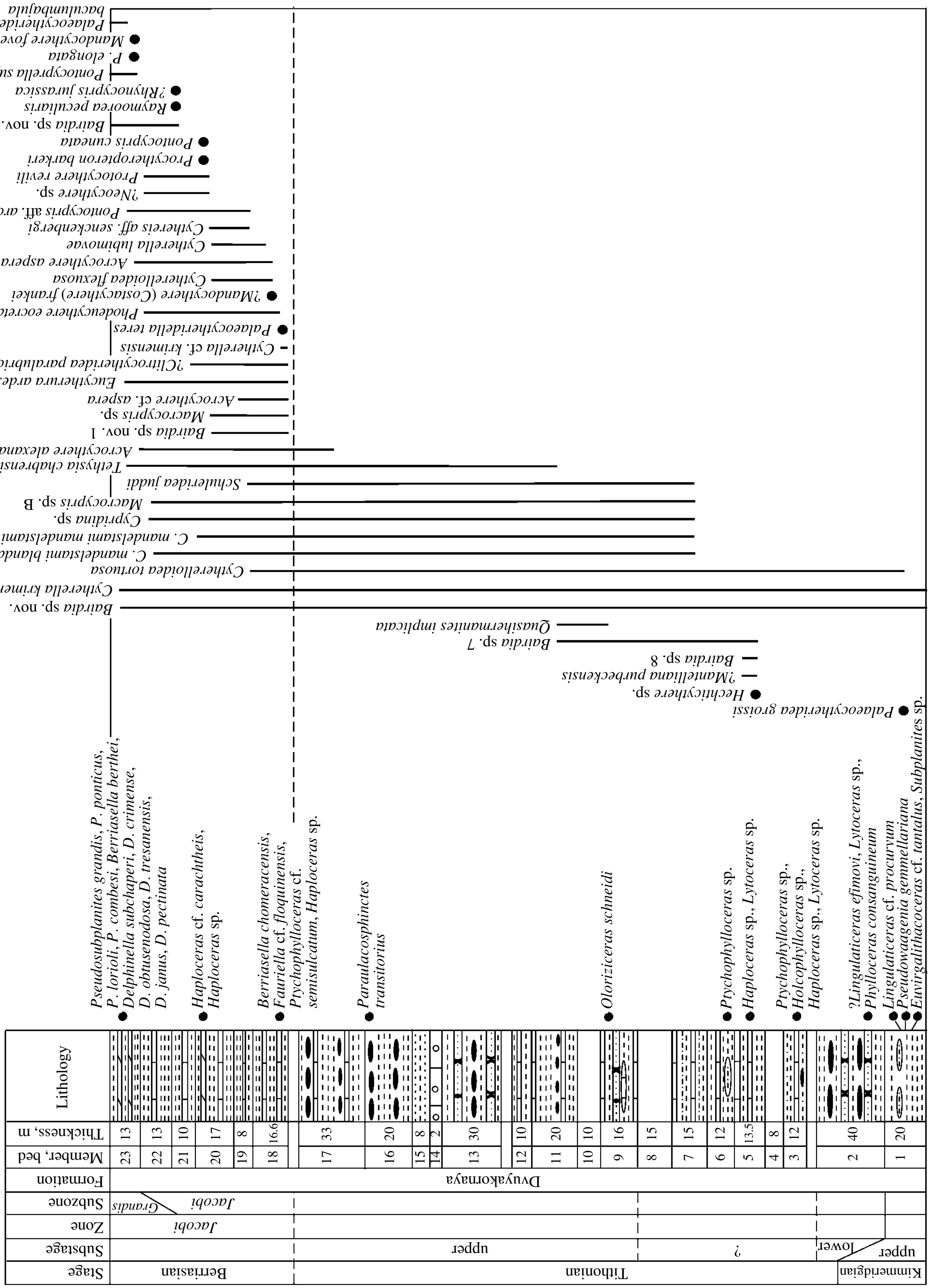
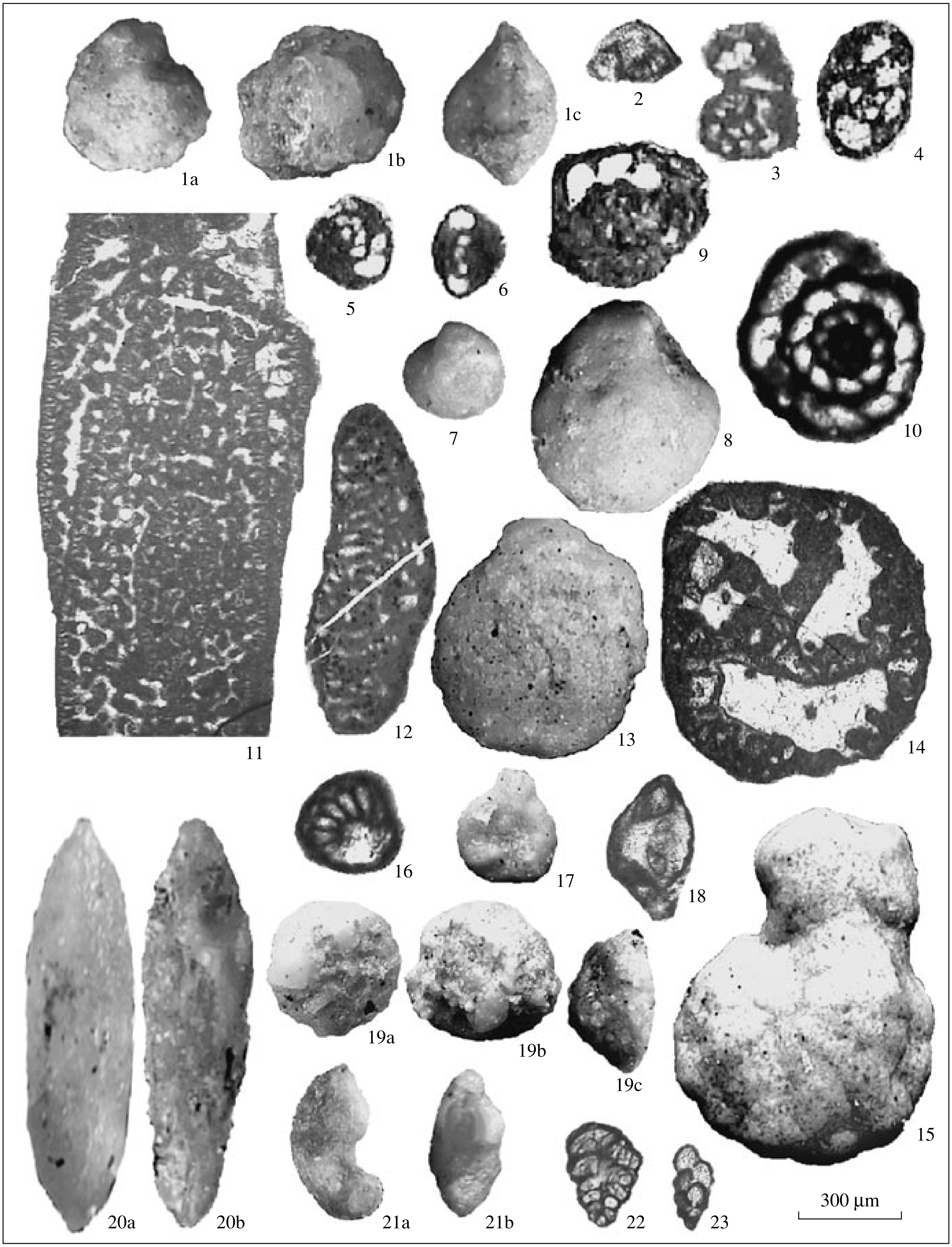


Fig. 7. Distribution of ammonites and stratigraphically most important ostracode species in the composite section of the Dvuyakomaya Formation in the eastern Crimea (see Fig. 2 for legend).

Plate IV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A. proprius, Planularia madagascariensis, and *Dentalina marginulina.* Species *Frondicularia cuspidiata* (Plate IV, fig. 20) and *Saracenaria inflanta* (Plate IV, fig. 21) are known from the upper Berriasian–Valanginian of the Crimea (Kuznetsova and Gorbachik, 1985). In the Cape Svyatogo Il'i section, they are abundant in the upper part of the *jacobi* Subzone and lower part of the *grandis* Subzone. Accordingly, the *Frondicularia cuspidiata–Saracenaria inflanta* foraminiferal zone can be discriminated.

The uppermost foraminiferal assemblage includes *Ammobaculites* ex gr. *inconstans, Texrularia crimica, Belorussiella taurica, Nautiloculina oolitica, Astacolus planiusculus, Lenticulina trilobitomorpha*, and *Istriloculina fabaria.* Scarce specimens of *Textularia crimica* (Plate IV, fig. 22) known from Tithonian sediments of the Crimea are characteristic of the upper Berriasian–Valanginian sediments in the region. It is one of index species of the *Paleotextularia (=Textularia) crimica–Triplasia emslandensis* Subzone correlative with the *Boisssieri* ammonite zone (Kuznetsova and Gorbachik, 1985). *Belorussiella taurica* (Plate IV, fig. 23) is typical of the Berriasian Stage in Switzerland, Poland, the Crimea, and Caspian Sea basin (Kuznetsova and Gorbachik, 1985; Gorbachik and Kuznetsova, 1994; Fedorova and Smirnov, 2004). Both species are described from Berriasian sediments of the eastern Crimea (Gorbachik, 1971). Based on abundant *T. crimica* associated with *B. taurica,* we discriminate the *Textularia crimica–Belorussiella taurica* Beds in the upper part of the *grandis* Subzone. This biostratigraphic unit extending upward is correlated with the *Occitanica* and *Boissieri* zones according to sections of the central Crimea (Fedorova, 2000).

As a whole, the foraminiferal assemblages studied by Fedorova are similar to those established earlier in the Cape Svyatogo Il'i section (Kuznetsova and Gorbachik, 1985). Of 130 species cited in the last work and 100 species determined by Fedorova, 60 forms are in common. The difference is in zonations and ranges of defined stratigraphic units. Kuznetsova and Gorbachik recognize six zones and beds with fauna, while Fedorova divides the section into five biostratigraphic units. The *Epistomina ventriosa–Melathrokerion eospirialis* Beds defined by Fedorova correspond in range to the *Astacoulus laudatus–Epistomina omninoreticulata* Zone and *Epistomina ventriosa–Textularia densa* Beds (Kuznetsova and Gorbachik, 1985) and include in addition the upper Kimmeridgian layers previously lacking paleontological characteristic. The *Anchispirocyclina lusitanica– Melathrokerion spirialis* Zone is of identical range in both zonations. The *Protopeneroplis ultragranulatus–Siphoninella antiqua* and *Frondicularia cuspidiata–Saracenaria inflanta* zones of Fedorova correspond to the *Protopeneroplis ultragranulatus–Siphoninella antiqua* Zone defined by Gorbachik (Kuznetsova and Gorbachik, 1985). The *Texrularia crimica–Belorussiella taurica* Beds in zonation by Fedorova are approximately correlative with the *Quadratina tunassica– Siphoninella antiqua* Zone and *Conorboides hofkeri–Conorbina heteromorpha* Beds after Kuznetsova and Gorbachik (1985).

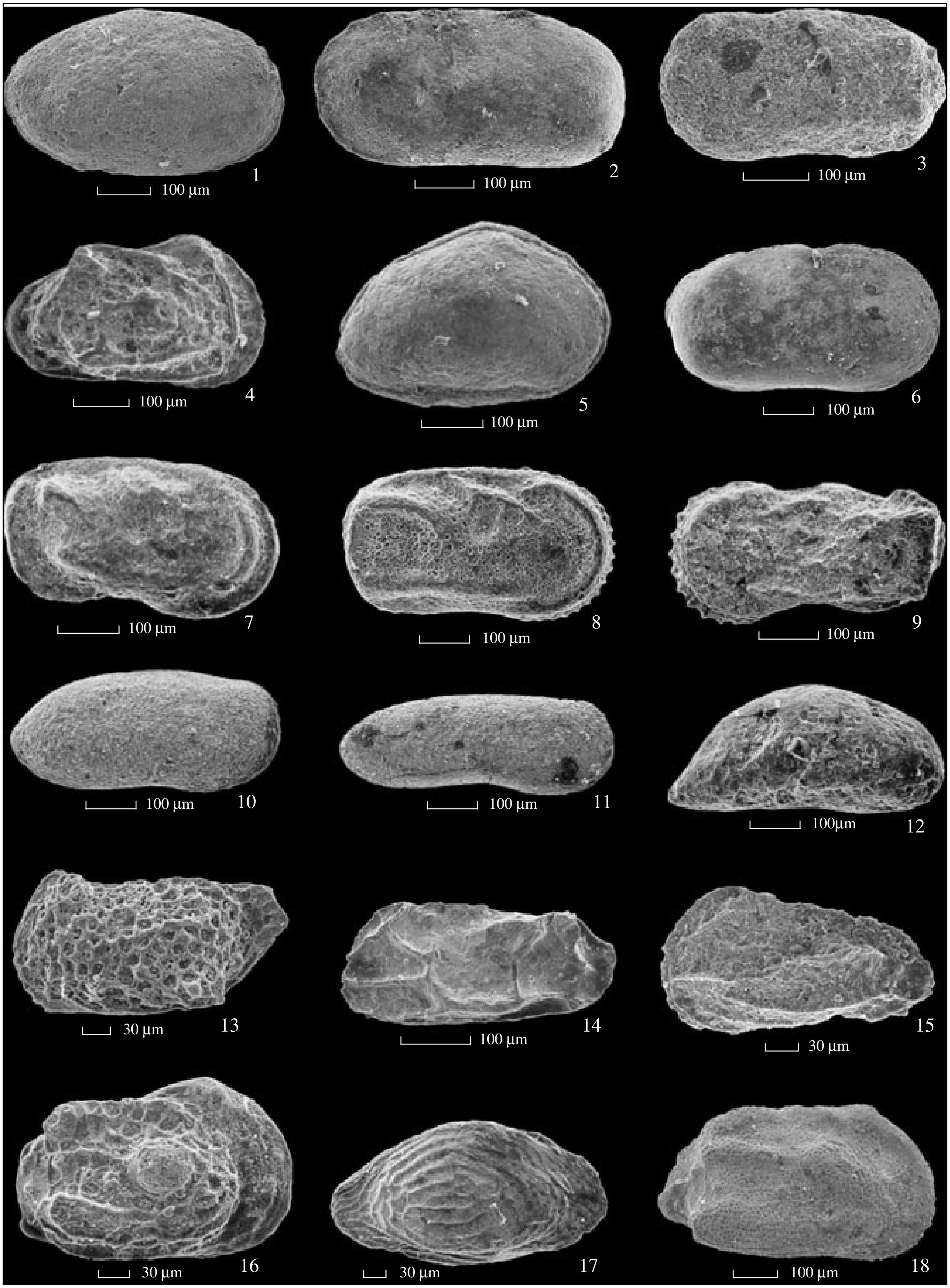
The distinguished foraminiferal assemblages are similar greatly to those from the Jurassic–Cretaceous boundary layers of France (Le Hégarat and Remane, 1973; Pelissie et al., 1984; Bassoullet, 1997), Italy (Azema et al., 1973; Septofontaine, 1974), Morocco (Hottinger, 1967), Syria, Turkey, Iran (Kuznetsova and Gorbachik, 1985; Gorbachik and Kuznetsova, 1994; Gorbachik and Mohammad, 1997, 1999), the Caucasus (*Practical Manual…,* 1991), and northern part of the Caspian Sea (Fedorova, 2004). In the Upper Jurassic part of the East Crimean succession, there are 27 species in common with foraminifers from the listed regions, and 18 similar forms occur in the Berriasian portion.

Unfortunately, foraminifers are unknown from the *Jacobi–Grandis* Zone of the Berriasian stratotype in France (Busnardo et al., 1965). This is likely a result of incomplete examination, because samples for foraminiferal analysis were collected from marl interbeds, while limestones remained unsampled. In the *Occitanica* and *Boissieri* zones, foraminifers are largely repre-

Plate IV. Some characteristic Tithonian–Berriasian foraminiferal species of the eastern Crimea.

(1a, b, c) *Epistomina ventriosa* (Espitalie et Sigal, Specimen 24-F/40-1-1; (2) *Protopeneroplis striata* Weyenschenk, thin section 23-F/300-5, Member 6; (3) *Everticyclammina* sp, thin section 23-F/300-3, Member 4; (4) *Everticyclammina* sp, thin section 23-F/300-6, Member 7; (5) *Melathrokerion eospirialis* Gorbatchik, thin section 23-F/300-6, Member 7; (6) *Melathrokerion eospirialis* Gorbatchik, thin section 23-F/300-6, Member 7; (7) *Melathrokerion eospirialis* Gorbatchik, Specimen 24-F/40-1-1; (8) *Melathrokerion spirialis* Gorbatchik, thin section 23-F/220-6; (9) *Melathrokerion spirialis* Gorbatchik, thin section 23-F/220-6; (10) *Melathrokerion spirialis* Gorbatchik, Specimen 24-F/20-1-1; (11) *Anchispirocyclina lusitanica* (Egger), thin section 23-F/201-6; (12) *Anchispirocyclina lusitanica* (Egger), thin section 23-F/201-1-4; (13) *Anchispirocyclina lusitanica* (Egger), Specimen 24-F/20-1-1, Yuzhnoe Settlement, Section 3, Member 13, upper Tithonian; (14) *Pseudocyclammina lituus* (Yokoyama), thin section 23-F/201-1-4; (15) *Charentia evoluta* (Gorbatchik), Specimen 24-F/1-4-1, Member 18; (16) *Siphoninella antiqua* Gorbatchik, thin section 23-F/15-12, Member 18; (17) *Siphoninella antiqua* Gorbatchik, Specimen 24-F/1-4-1, Member 18; (18) *Protopeneroplis ultragranulatus* (Gorbatchik), thin section 23-F/15-11, Member 19; (19a, b, c) *Protopeneroplis ultragranulatus* (Gorbatchik), Specimen 24-F/1-7-1, Member 21; (20a, b) *Frondicularia* cf. *cuspidiata* Pathy: (a) Specimen 24-F/1-10-14a, (b) Specimen 24-F/1-10-14b, Member 23; (21a, b) *Saracenaria* cf. *inflanta* (Pathy), Specimen 24-F/1-10-14, Member 23; (22) *Textularia crimica* (Gorbatchik), thin section 23-F/15-0, Member 23; (23) *Belorussiella taurica* Gorbatchik, thin section 23-F/15-1, Member 23. (1–7) Dvuyakornaya Bay: (1a, b, c, 7) Section 1, Member 2, lower Tithonian, (2–6) Section 2, Tithonian; (8–10) Yuzhnoe Settlement, Section 3, Member 17, upper Tithonian, (11, 12, 14) Feodosiya, Cape Svyatogo Il'i, Section 4, lower limestone layer, upper Tithonian, (15–23) Feodosiya, Cape Svyatogo Il'i, Section 4, Berriasian. All specimens: (a) dorsal (side) view, (b) ventral view, (c) peripheral view.

Plate V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sented by transit forms. The list of foraminiferal taxa includes 27 species in common and only eight of them have been determined confidently.

Ostracodes

Of two ostracode assemblages defined in the examined sections (Fig. 7, Table 2), the lower one is characteristic of sections 1–3 (members 1–17). Being of a relatively low diversity, this assemblage consisting of 27 species, some of which are new. Most of them occur throughout the sections, i.e., characterize the upper Kimmeridgian–Berriasian interval. Nevertheless, the assemblage includes some species, which do not occur in higher layers. The lower part of the section contains *Palaeocytheridea groissi* established in the Tithonian of Germany (Schudack, 1997). Higher layers yield *?Mantelliana purbeckensis,* the species known from Upper Jurassic–Lower Cretaceous deposits of the Transbaikal region (Neustrueva et al., 1999) and from the lower Purbeckian of France (Colin and Oertli, 1985), and *Quasihermanites implicata* (Plate V, fig. 4) previously established in the Berriasian–lower Valanginian of France. Many species of the assemblage, which continue to occur in the Berriasian, are known also in other regions. *Cytherella krimensis* (Plate V, fig. 1), *Cytherelloidea mandelstami mandelstami, C. mandelstami blanda*, and *Macrocypris* sp. B occur in the Berriasian of central Crimea (Neale, 1966); *Cytherelloidea tortuosa* (Plate V, fig. 3) in the middle Volgian Substage of the Volga–Urals region (Lubimova, 1955); *Schuleridea juddi* (Plate V, fig. 5) in the Berriasian of Yorkshire (Neale, 1962) and Ryazanian Horizon of Holland (Witte and Lissenberg, 1994); *Acrocythere alexandrae* in the Berriasian of the North Caucasus (Kolpenskaya et al., 2000). Thus, ostracodes of the first assemblage are of a low stratigraphic significance. Tesakova and Savel'eva define in this part of the section the *Cytherelloidea tortuosa–Palaeocytheridea groissi* Beds.

The second assemblage sharply different from the first one is defined in Section 4 of the Cape Svyatogo Il'i area. In addition to 10 species inherited from the lower assemblage, it includes many new forms. The assemblage consists of 80 species, 35 of which are known from the Berriasian of England, France, central Crimea, and the Caucasus. *Acrocythere alexandrae* (Plate V, fig. 15), *?Clithrocytherida paralubrica, Cytherella* cf. *krimensis,* and *Phodeucythere eucretacea* are described from the Berriasian of the North Caucasus (Kolpenskaya et al., 2000); *?Mandocythere (Costacythere) frankei, Pontocyprella superba* (Plate V, fig. 10) from the lower Hauterivian and *Macrocythere* sp. B from the middle Hauterivian of Yorkshire (Neale, 1960); *Acrocythere aspera* from the lower Valanginian of Poland and France (Kubiatowich, 1983; Babinot et al., 1985); *Eucytherura ardescae* (Plate V, fig. 13) from the lower Valanginian of France (Donze, 1965); *Palaeocytheridella teres, Cythereis* aff. *senckenbergi* from the Berriasian of Yorkshire (Neale, 1962); *Cytherella lubimovae* (Plate V, fig. 6), *Cytherelloidea flexuosa* (Plate V, fig. 9), *?Neocythere* sp., *Pontocypris cuneata, Mandocythere foveata* (Plate V, fig. 18) from the Berriasian of the central Crimea (Neale, 1966; Tesakova and Rachenskaya, 1966b); *Pontocypris* aff. *arcuata* from the lower Volgian Substage of the Volga–Urals region (Lyubimova, 1955); *Protocythere revili* (Plate V, fig. 16) from the lower part of the Berriasian Stage of France (Babinot et al., 1985); *Raymoorea peculiaris* (Plate V, fig. 14) from the Berriasian and lower Valanginian of England and France (Neale, 1967; Babinot et al., 1985); *Procytheropteron barkeri* (Plate V, fig. 17) from the upper Kimmeridgian–lower Portlandian of Holland (Witte and Lissenberg, 1994); *?Rhinocypris jurassica* from the lower Purbeckian of France (Colin and Oertli, 1985); *Pontocyprella elongata* (Plate V, fig. 11) from the lower–middle Valanginian of Poland (Kubiatowich, 1983), and *Palaeocytheridea baculumbajula* from the upper Kimmeridgian of the Volga–Urals region (Lyubimova, 1955). Tesakova and Savel'eva propose to define in this part of the section the *Raymoorea peculiaris–Eucytherura ardescae–Protocythere revili* Beds corresponding to the ammonite *jacobi* Zone. The second assemblage is clearly of the Berriasian appearance.

Plate V. Some characteristic Tithonian–Berriasian ostracode species of the eastern Crimea.

(1) *Cytherella krimensis* Neale, Specimen 310-158, female right valve from outside, Section 2, Member 5, Tithonian; (2) *Cytherelloidea* ex gr. *tortuosa* (Lubimova), Specimen 310-176, female left valve from outside, Section 2, Member 11, upper Tithonian; (3) *Cytherelloidea tortuosa* (Lubimova), Specimen 310-173, female left valve from outside, Section 2, Member 11, upper Tithonian; (4) *Quasihermanites implicata* Donze, Specimen 310-169, right valve from outside, Section 2, Member 9, upper Tithonian; (5) *Schuleridea juddi* Neale, Specimen 310-165, intact shell from the right side, Section 2, Member 7, Tithonian; (6) *Cytherella lubimovae* Neale, Specimen 310-98, right valve from outside; (7) *Cytherolloidea mandelstami blanda* Neale, Specimen 310-88, male (?) right valve from outside; (8) *Cytherolloidea mandelstami mandelstami* Neale, Specimen 310-114, female right valve from outside; (9) *Cytherelloidea flexuosa* Neale, Specimen 310-99, male left valve from outside; (10) *Pontocyprella superba* Neale, Specimen 310-127, right valve from outside; (11) *Pontocyprella elongata* Kubiatowich, Specimen 310-128, right valve from outside; (12) *Macrocypris* sp. B Neale, Specimen 310-6, right valve from outside; (13) *Eucytherura ardescae* Donze, Specimen 310-24, left valve from outside; (14) *Raymoorea peculiaris* (Donze), Specimen 310-115, left valve from outside, Member 21; (15) *Acrocythere alexandrae* Neale et Kolpenskaja, Specimen 310-136, right valve from outside; (16) *Protocythere revili* Donze, Specimen 310-81, right valve from outside; (17) *Procytheropteron barkeri* Anderson, Specimen 310-60, right valve from outside; (18) *Mandocythere foveata* Tesakova et Rachenskaja, Specimen 310-134, female right valve from outside. (1–5) Dvuyakornaya Bay; (6–18) Feodosiya, Cape Svyatogo Il'i, Berriasian, Section 4: (6–9, 16) Member 20, (10, 11, 15, 18) Member 23, (12, 13, 17) Member 18.

SEDIMENTATION SETTINGS

The data obtained make can be used to reconstruct sedimentation environments in the late Kimmeridgian–Berriasian basin of the eastern Crimea. Flyschoid bedding (with prevalence of clays over limestones) and almost complete absence of benthic macrofossils are characteristic of the relevant sediments. Faunal remains are represented mainly by rare nektonic forms (ammonites, belemnites) and numerous benthic foraminifers and ostracodes. Up to 90% studied foraminifers and ostracodes bear signs of transportation. In addition, the lower part of the section contains pseudoplanktonic bivalves belonging to the genus *Bositra.* Limestones are lumpy, oolitic (of the grainstone type), detrital. In central parts of oolites, there are fragments of foraminiferal tests, ostracode carapaces, angular and subangular quartz grains. Frequently, oolites develop after limestone clasts. Detrital (conglomeratic) limestones include fragments of fine-grained limestones up to several centimeters across. Clays of the Dvuyakornaya Formation are kaolinite–hydromicaceous, usually laminated. Sediments show presence of slumping structures.

All the mentioned features suggest accumulation of these sediments below the waves base level, i.e., outside the shelf. According to different data (Murdmaa, 1979; Kuznetsov, 2003), sediments of this kind accumulate at depths ranging from 300–400 m to 1–3 km.

Conglomeratic limestones of the Dvuyakornaya Formation should probably be considered as rocks originated by redeposition of shallow-water carbonate material on the continental slope by debris flows. This is also evident from slumping structures and mostly rounded foraminiferal tests and ostracode carapaces.

The suggested deep-water sedimentation in the Tithonian–Berriasian basin of the eastern Crimea is well consistent with the general paleogeographic situation of that time. In the Jurassic–Early Cretaceous, epicontinental shelf seas with carbonate sedimentation of the Scythian and Turan plates sharply decreased in size (Kuznetsov, 2003). Deep-water sediments of the Dvuyakornaya Formation formed likely on the continental slope at depths of several hundreds meters or deeper near the narrow shelf of the Scythian plate. This part of the Tethys was characterized by high water temperatures (22–24°C), normal salinity, and Mediterranean fauna with relatively small quantity of endemic species (Baraboshkin, 2003). In the north, the basin was separated by a lowland from the sea covering the Russian plate.

CONCLUSIONS

The data obtained specify lithology and biostratigraphy of the Dvuyakornaya Formation in the eastern Crimea that was debatable among researchers in connection with the Jurassic–Cretaceous boundary position in this region of the Tethyan realm. A continuous section of the Jurassic–Cretaceous sediments is established in the Feodosiya area and, thus, the boundary between tow systems is not defined. We studied four dismembered sections of the Jurassic–Cretaceous succession.

Remains of ammonites, belemnites, bivalves, brachiopods, foraminifers, and ostracodes from the Feodosiya section are studied for the first time.

Presence of upper Kimmeridgian sediments in the Crimean Mountains, which have never been mentioned in earlier stratigraphic schemes (Permyakov et al., 1991b), is first substantiated by ammonites, and the Kimmeridgian–Tithonian boundary is detected in the continuous section. The following biostratigraphic units are defined based on ammonites: the *Euvirgalithacoceras* cf. *tantalus* Beds of the upper Kimmeridgian, the *?Lingulaticeras efimovi* Beds of the lower Tithonian, the *Oloriceras schneidi* Beds and the *Paraulacosphinetes transitorius* Beds of the upper Tithonian, and the *Jacobi* Zone of the Berriasian. Based on distribution of ammonites in the Svyatogo Il'i section, the latter unit is subdivided into the *jacobi* and *grandis* subzones. Stratigraphic level corresponding to the upper Tithonian *Durangites* zone of West European ammonite zonation is not established in the Feodosiya section. According to new data, the Dvuyakornaya Formation is of the late Kimmeridgian–Berriasian age.

Representatives of the genus *Lingulaticeras* found in the Feodosiya section imply connections between the early Tithonian sea basins of the Crimean Mountains region and Russian plate, where species of this genus have been described earlier (Rogov, 2002).

Five biostratigraphic units are recognized in the section based on foraminifers: the *Epistomina ventriosa–Malathrokerion eospirialis* Beds and *Anchispirocyclina lusitanica–Malathrokerion spirialis* zone in the upper Kimmeridgian–Tithonian interval and the *Protopeneroplis ultragranulatus–Siphoninella antiqua, Frondicularia cuspidiata–Saracenaria inflanta* zones and *Textularia crimica* Beds in the Berriasian. The last three units differ partly in ranges from biostratigraphic zones and beds previously distinguished in the Feodosiya section (Kuznetsova and Gorbachik, 1985).

Ostracodes first studied in the Feodosiya section are of a high taxonomic diversity (over 100 species, several tens of which are new). The Upper Jurassic ostracodes differ substantially from their Berriasian assemblage. Based on distribution of these fossils, the *Cytherelloidea tortuosa–Palaeocytheridea grossi* Beds are distinguished in the upper Kimmeridgian–Tithonian interval and the *Raymoorea peculiaris–Eucytherura ardescae–Protocythere revili* Beds in the Berriasian part of the section.

It is difficult to correlate boundaries inferable from distribution of microfossils and ammonites, because the latter are scarce (beyond the *Jacobi* Zone) and found in dismemberd succession. The *jacobi* and *grandis* ammonite subzones do not coincide with foraminiferal units (zones and beds) in the Svyatogo Il'i section only.

Taxonomic composition of fossils regularly changes throughout the Feodosiya section. The lower part of the Dvuyakornaya Formation is characterized by occurrence of upper Kimmeridgian and Tithonian ammonite species of genera *Euvirgalithacoceras, Lingulaticeras, Psedowaagenia, Subplanites, Oloriceras*, and *Paraulacosphinctes,* and by Late Jurassic bivalves of genera *Bositra* and *Aulacomiella.* In its upper part, the formation contains the diverse ammonite assemblage typical of the Berriasian (genera *Pseudosubplanites, Berriasella, Delphinella, Fauriella, Retowskiceras, Spiticeras*). The foraminiferal assemblages are not of so distinct age confinement, because they include many forms of the wider Kimmeridgian–Berriasian stratigraphic range. Despite abundance of long-ranging species, the Upper Jurassic and Berriasian assemblages of ostracodes are discriminated, although arbitrarily, based on distribution of these fossils. Of interest are of many new ostracode species that appear in the Berriasian part of the section being unknown at lower levels. All the data implay that the Jurassic–Cretaceous boundary in the Tethyan realm is at the base of the *Jacobi* Zone, as is accepted recently (Hoedemaeker et al., 2003).

The Dvuyakornaya Formation is considered as succession of deep-water sediments that accumulated on the continental slope near the narrow marginal shelf of the Scythian plate.

ACKNOWLEDGMENTS

When identifying Upper Jurassic ammonites, V.V. Arkad'ev consulted with E.D. Kalacheva (VSEGEI) and G. Schweigert from the Staatliches Museum für Naturkunde, Stuttgart, Germany. Prof. Schweigert helped to specify stratigraphic distribution and identification of Kimmeridgian ammonites. We are grateful to all researchers who helped us in this work. This work was supported by the Ministry of Education of the Russian Federation, grant E02-9.0-111, and by the Russian Foundation for Basic Research, project no. 03-05-64297.

Reviewers V.V. Mitta and M.A. Rogov

REFERENCES

1. F. Allemann, W. Grun, and J. Wiedmann, "The Berriasian of Caravaca (Prov. of Murcia) in the Subbetic Zone of Spain and Its Importance for Defining This Stage and The Jurassic–Cretaceous Boundary," Mém. Bur. rech. Géol. et Miniéres **86**, 14–22 (1975).
2. V. V. Arkad'ev, "The Berriasian *Berriasella jacobi–Pseudosubplanites grandis* Zone of the Crimean Mountains," Byull. Mosk. O–va Ispyt. Prir. Otd. Geol. **78** (6), 29–35 (2003).
3. V. V. Arkad'ev, "First Find of Late Tithonian Ammonite in the Feodosia Section of the Eastern Crimea," Paleontol. Zh., No. 3, 39–45 (2004a).
4. V. V. Arkad'ev, "New Finds of Late Tithonian Ammonites in the Eastern Crimea," in *Proceedings of Second All-Russian Meeting on Cretaceous System of Russia: Problems of Stratigraphy and Paleogeography*, (St. Petersburg Univ., St. Petersburg, 2004b), p. 16 [in Russian].
5. V. V. Arkad'ev and T. N. Bogdanova, "Genus *Berriasella* (Ammonoidea) and Ammonoid Zonation in the Berriasian in the Crimean Mountains," Stratigr. Geol. Korrelyatsiya **12** (4), 54–67 (2004) [Stratigr. Geol. Correlation **12**, 367–379 (2004)].
6. V. V. Arkad'ev and Yu. N. Savel'eva, "The *Berriasella jacobi* Zone in the Berriasian of the Crimean Mountains," in *Problems of Biochronology in Paleontology and Geology. Abstracts of 48th Session of the All-Russian Paleontological Society (April 8–12, 2002)* (VSEGEI, St. Petersburg, 2002), pp. 11–13 [in Russian].
7. V. V. Arkad'ev, A. A. Fedorova, Yu. N. Savel'eva, and E. M. Tesakova, "Biostratigraphy of Jurassic–Cretaceous Boundary Sediments in the Eastern Crimea," in *Proceedings of Second All-Russian Meeting on Cretaceous System of Russia: Problems of Stratigraphy and Paleogeography* (St. Petersburg Univ., St. Petersburg, 2004), p. 17 [in Russian].
8. J. Azema, G. Chabrier, E. Fourcade, et al., "Nouvelles donnes micropaleontologiques, stratigraphiques et paleogeographiques sur le portlandien et le neocomien de sardaigne," Revue de Micropaleontologie **20** (3) 125–139 (1973).
9. J.P. Bassoullet, "Foraminiferes," Bull. Centre Rech. Explor.-Prod. Elf-Aquitaine, Mém. 17, 293–304 (1997).
10. J.-F. Babinot, R. Damotte, P. Donze, et al., "Cretace inferieur," Bull. Centre Rech. Explor.-Prod. Elf-Aquitaine, Mém. 9, 163–210 (1985).
11. E. Yu. Baraboshkin, "Early Cretaceous Seaways of the Russian Plate," Byul. Mosk. O–va Ispyt. Prir. Otd. Geol. **78** (4), 35–48 (2003).
12. T. N. Bogdanova and V. V. Arkadiev, "Revision of the Genus *Pseudosubplanites* (Perisphinctidae, Ammonidea) from the Berriasian of the Mountainus Crimea," Cretaceous Res. **26**, 488–506 (2005).
13. T. N. Bogdanova, S. V. Lobacheva, V. A. Prozorovskii, and T. A. Favorskaya, "On Subdivision of the Berriasian Stage in the Crimean Mountains," Vestn. Leningrad. Gos. Univ., No. 6, 5–14 (1981).
14. T. N. Bogdanova, S. V. Lobacheva, V. A. Prozorovskii, and T. A. Favorskaya, "The Berriasian Stage in the Eastern Crimea and the Jurassic–Cretaceous Boundary," in *Boundary Stages of the Jurassic and Cretaceous Systems* (Nauka, Moscow, 1984), pp. 28–35 [in Russian].
15. T. N. Bogdanova, E. D. Kalacheva, and I. I. Sei, "On Presence of the *Tirnovella occitanica* Zone (Lower Cretaceous, Berriasian) in the Feodosiya Section of the Eastern Crimea," Region. Geol. Metallogeniya, No. 9, 27–32 (1999).
16. R. Busnardo, G. Le Hégarat, and J. Magné, "Le stratotype du Berriasien," Mém. Bur. Rech. Géol. Min. **34**, 5–33 (1965).
17. J.-P. Colin and H.J. Oertli, "Purbeckien," Bull. Centre Rech. Explor.-Prod. Elf-Aquitaine, Mém. 9, 147–161 (1985).

18. *Colloque sur la limite Jurassique–Crétacé. Lyon, Neuchatel, septembre 1973* Mém. Bur. rech. Géol. et Miniéres **86**, (1975).

19. P. Donze, "Espèces nouvelles d'ostracodes des couches de base du Valanginien de Berrias (Ardèche)," Trav. Lab. Gèol. Fac. Sc. Lyon. N.S., No. 12, 87–107 (1965).

20. V. V. Druschits, "The Berriasian of the Crimea and Its Stratigraphical Relations," Mém. Bur. rech. Géol. et Miniéres **86**, 337–341 (1975).

21. V. V. Druschits, B. T. Yanin, T. N. Gorbachik, et al., "Berriasian and Valanginian Basins of the Crimea and Their Inhabitants," Byull. Mosk. O-va Ispyt. Prir. Nov. Ser. Otd. Geol. **73** (2), 158 (1968).

22. J. Espitalie and J. Sigal, "Contribution a l'etude des Foraminiferes du Jurassique superieur et du Neocomien di Bassin de Majunga (Madagaskar)," Ann. Geol. Madagaskar, No. 32, 1–100 (1963).

23. A. A. Fedorova, "Stratigraphic Significance of Foraminifers from Jurassic–Cretaceous Boundary Carbonate Sediments of the Baidarskaya Valley (Southwestern Crimea)," Nauchn. Zap. Kafedry Istor. Geol. **1**, 27–37 (2000).

24. A. A. Fedorova, "Reference Sections of Jurassic–Cretaceous Boundary Sediments in the Crimea as a Basis for Detailed Stratification and Correlation of Productive Sequences in the Caspian Shelf," in *Stratigraphy of Hydrocarbon Basins in Russia* (Nedra, St. Petersburg, 2004), pp. 61–80 [in Russian].

25. A. A. Fedorova and M. V. Smirnov, "Biostratigraphy of Jurassic–Lower Cretaceous Boundary Sediments Bearing Hydrocarbon in the Caspian Shelf," in *The Present and Future of Mineral Reserves of the Marine Oil and Gas Industry of Russia* (VNIGRI, St. Petersburg, 2004), pp. 70–72 [in Russian].

26. P. J. Hoedemaeker and L. Bulot, "Preliminary Ammonite Zonation for the Lower Cretaceous of the Mediterranean Region," Géol. Alpine **66**, 123–127 (1990).

27. P. J. Hoedemaeker and P. F. Rawson, "Report on the 5th International Workshop of the Lower Cretaceous Cephalopod Team (Vienna, 5 September 2000)," Cretaceous. Res., No. 21, 857–860 (2000).

28. P. J. Hoedemaeker, S. Reboulet, M. B. Aguirre-Urreta, et al., "Report on the 1st International Workshop of the IUGS Lower Cretaceous Ammonite Working Group, the "Kilian Group" (Lyon, 11 July 2002)," Cretaceous Res. **24**, 89–94 (2003).

29. L. Hottinger, "Foraminiferes imperfores du Mesozoique Maroccain," Notes et Mem. Serv. Geol. Marocc. (Rabat), No. 209 (1967).

30. J. Geyssant, "Tithonien," Bull. Centre Rech. Elf Explor. Prod. **17**, 97–102 (1997).

31. A. Yu. Glushkov, "On First Find Index Species of the Lower Zone of Berriasian Stage in the Crimea," Vestnik SPbGU, Ser. 7, Issue 1, No. 7, 90–93 (1997).

32. E. A. Gofman, "Some Data on the Jurassic Foraminiferal Fauna of the Southeastern Crimea," Vestn. Mosk. Gos. Univ. Ser. Biol.–Pochv., Geol. Geogr., No. 1, 135–137 (1956).

33. E. A. Gofman, "Some Jurassic Foraminifers of the Southeastern Crimea," Geol. Zh. **21** (2), 97–101 (1961).

34. T. N. Gorbachik, "First Find of the Genus *Siphoninella* in the Valanginian of the Crimea," Paleontol. Zh., No. 3, 133–136 (1966).

35. T. N. Gorbachik, "On Early Cretaceous Foraminifers of the Crimea," Vopr. Mikropaleontol., Issue 14, 125–139 (1971).

36. T. N. Gorbachik and K. I. Kuznetsova, "Comparative Analysis of Tithonian Foraminifers of the Crimea and Syria," Stratigr. Geol. Korrelyatsiya **2** (2), 51–63 (1994) [Stratigr. Geol. Correlation **2** (2), 146–158 (1994)].

37. T. N. Gorbachik and G. K. Mohammad, "New Species of Lituolidae (Foraminifera) from Tithonian and Berriasian Sediments of the Crimea," Paleontol. Zh., No. 4, 3–9 (1997).

38. T. N. Gorbachik and G. K. Mohammad, "Tithonian and Berriasian Lituolidae (Foraminifera) of the Crimea. Morphology, Stratigraphic and Paleobiogeographic Significance," in *Problems of Mesozoic Stratigraphy and Paleontology* (VNIGRI, St. Petersburg, 1999), pp. 165–186 [in Russian].

39. Yu. V. Kazantsev, T. T. Kazantseva, M. Yu. Arzhavitina, et al., *Structural Geology of the Crimea* (BNTS URO AN SSSR, Ufa, 1989) [in Russian].

40. N. G. Khimshiashvili, *Late Jurassic Molluscan Fauna of the Crimea–Caucasus Region* (Metsniereba, Tbilisi, 1967) [in Russian].

41. W. Kilian, *Letaea Geognostica. Das Mesozoicum. Kreide* (Stuttgapt, 1907–1913), Bd. 3.

42. N. N. Kolpenskaya, E. V. Nikiforova, O. A. Sochevanova, et al., "Berriasian of the North Caucasus (Urukh Section)," in *Phanerozoic Biochronology and Correlation of Hydrocarbon-Bearing Basins of Russia* (VNIGRI, St. Petersburg, 2000), Issue 2, p. 273 [in Russian].

43. G. Ya. Krymgol'ts, *Jurassic Belemnites of the Crimea and Caucasus* (Glavnoe Geol.–Razved. Upravlenie, Moscow, 1932), Issue 2 [in Russian].

44. V. G. Kuznetsov, *Evolution of Carbonate Accumulation in the Earth's History* (GEOS, Moscow, 2003) [in Russian].

45. K. I. Kuznetsova, "Development and Distribution of Late Jurassic Foraminifers in the Crimea," Voprosy Mikropaleontologii, Issue 26, 25–36 (1983).

46. K. I. Kuznetsova and T. N. Gorbachik, *Upper Jurassic and Lower Cretaceous Stratigraphy and Foraminifers of the Crimea* (Nauka, Moscow, 1985) [in Russian].

47. I. V. Kvantaliani, *Early Cretaceous Ammonitids of the Crimea and Caucasus and Their Biostratigraphic Significance* (Geol. Inst AN GSSR, 1989) [in Russian].

48. I. V. Kvantaliani and N. I. Lysenko, "To the Problem of Berriasian Zonation in the Crimea," Soobshcheniya AN GruzSSR **94**, 629–632 (1979).

49. G. Le Hégarat, "Le Berriasien du Sud-East de la France," Doc. Lab. Géol., Fac. Sci. **43/1**, (1973).

50. G. Le Hégarat and J. Remane, "Tithonique superieur et Berriasien du la bordure cevenole," Geobios, No. 1, 7–70 (1973).

51. S. V. Lobacheva and T. N. Smirnova, "New Genus of the Brachiopod Family Ochotorhynchiidae from Lower Cretaceous Sediments of the Crimea," Paleontol. Zh., No. 3, 131–135 (1994).

52. P. S. Lyubimova, "Ostracodes from Mesozoic Sediments of the Middle Volga and Obshchii Syrt Regions," Tr. VNIGRI. Nov. Ser., Issue 84, 3–190 (1955).

53. V. S. Mileev, E. Yu. Baraboshkin, S. B. Rozanov, et al., {Position of the Karadag Paleovolcano in the Structure of the Crimean Mountains," in *History, Geology, Botany, Zoology (Collection of Papers Dedicated to the 90 Anniversary of the T.I. Vyazemskii Karadag Scientific Station and 25 Anniversary of the Crimean Natural Reservation)*, Ed. by A.L. Morozova and V.F. Gnyubkin (Sonat, Simferopol, 2004), pp. 68–93 [in Russian].

54. M. V. Muratov, "Geology of the Crimean Mountains Eastern Extremity," Tr. MGRI **7**, 21–122 (1937).

55. M. V. Muratov, *Geological Review of the Crimean Peninsula* (Gosgeoltekhizdat, Moscow, 1960) [in Russian].

56. I. O. Murdmaa, "Accumulation Settings of Sedimentary Formations," in *Geological Formations of the Northwestern Atlantic* (Nauka, Moscow, 1979), pp. 167–185 [in Russian].

57. I. Yu. Neustrueva, I. A. Nikolaeva,Yu. N. Andreev, et al., "Superfamily Cypridacea Baird, 1845," in *Practical Manual on Microfauna. Vol.7. Mesozoic Ostracodes* (VSEGEI, St. Petersburg, 1999), pp. 31–42 [in Russian].

58. G. B. Neale, "Ostracodes from the Lower Valanginian of the Central Crimea," Paleontol. Zh., No.1, 87–100 (1966).

59. J. W. Neale, "Marine Lower Cretaceous Ostracoda from Yorkshire, England," Micropaleontology **6**, 203–224 (1960).

60. J. W. Neale, "Ostracoda from Type Speeton Clay (Lower Cretaceous)," Micropaleontology **8**, 425–486 (1960).

61. J. W. Neale, "Ostracodes from the Type Berriasian (Cretaceous) of Berrias (Ardeche, France) and Their Significance," Essay in Paleontology, Stratigraphy. University of Kansas, No. 3, 539–569 (1967).

62. F. Olóriz, "*Pseudowaagenia gemmellariana n. sp.,*" Quad. Museo G.G. Gemmellaro **6**, 350–352 (2002).

63. A. Oppel, "Die tithonische Etage," Zeitschr. Deutschen Geol. Gesellschaft **17**, 535–558 (1865).

64. T. Pelissie, B. Peybernes, and J. Rey, "Foraminifers benthique du Jurassic SW France," Lab. Geol. Sediment. Paleontol., Univ. Paul-Sabatier, June 7, 479–489 (1984).

65. V. V. Permyakov, L. S. Borisenko, M. V. Vanina, et al., "The Jurassic System," in *Geology of the Ukrainian Shelf. Stratigraphy (Shelf and Black Sea Coast)* (Naukova Dumka, Kiev, 1984), pp. 42–58 [in Russian].

66. V. V. Permyakov, M. N. Permyakova, and B. P. Chaikovskii, "Tithonian Fauna from Reference Sections of the Southwestern Crimea," in *Paleontological and Biostratigraphic Studies in Ukraine*, Ed. by O.S. Vyalov (Naukova Dumka, Kiev, 1991a), pp. 84–87 [in Russian].

67. V. V. Permyakov, M. N. Permyakova, and B. P. Chaikovskii, *New Stratigraphic Scheme of Jurassic Sediments of the Crimean Mountains* (Inst. Geol. Nauk, Kiev, 1991b) [in Russian].

68. L. F. Plotnikova, "Some New and Poorly Known *Gaudryina* Species from Cretaceous Sediments of the Southern USSR," Paleontol. Sbornik L'vov. Geol. O–va, No. 13, 11–16 (1975).

69. L. F. Plotnikova, "*Gaudriyadhella*, the New Genus of the Family Ataxophragmiidae (Foraminifera)," Dokl. Akad. Nauk USSR. Ser. B, No. 2, 115–117 (1976).

70. L. F. Plotnikova, "On the Genus *Belorussiella* (Foraminifera)," Dokl. Akad. Nauk USSR. Ser. B, No. 5, 401–403 (1978).

71. L. F. Plotnikova, "*Tritaxia* and Relative Forms from Cretaceous Sediments of the Crimea and Black Sea Region," Paleontol. Sbornik L'vov. Geol. O–va **16**, 12–19 (1979).

72. L. F. Plotnikova, E. P. Cherepanova, A. V. Paryshev, et al., "New Data on Berriasian Sediments of the Northern Slope of the Dolgorukovskaya Mountain Pasture (Mountainous Crimea)," in *Tectonics and Stratigraphy* (Naukova Dumka, Kiev, 1976), pp. 81–85 [in Russian].

73. *Practical Manual on the Microfauna of the USSR. Vol. 5. Mesozoic Foraminifers,* Ed. by B.S. Sokolov (Nedra, Leningrad, 1991) [in Russian].

74. L. P. Rachenskaya, "Families Bairdiidae and Cytherellidae (Ostracodes) as Indicators of Environments in the Berriasian and Valanginian Basins of the Crimea," Vestn. Mosk. Gos. Uunv. Ser. Geol., No. 5, 104–106 (1968a).

75. L. P. Rachenskaya, "Ontogenetic Development of Some Early Cretaceous Ostracodes in the Crimea," in *Proceedings of Moscow Conference of Young Geologists Dedicated to the 50th Anniversary of the Komsomol. Issue 1. Section Geol. Mineral Resources* (Moscow, 1968b), pp. 6–7 [in Russian].

76. L. P. Rachenskaya, "Manifestation of the Sexual Dimorphism in Shells of the Genus *Bairdia*," Byull. Mosk. O–va Ispyt. Prir. Otd. Geol., No. 4, 150–151 (1969a).

77. L. P. Rachenskaya, "Berriasian and Valanginian Ostracodes of the Crimea, Their Morphological Peculiarities and Stratigraphic Significance," in *Proceedings of IV Scientific Conference of Geol. Faculty* (MGU, Moscow, 1969b), pp. 166–169 [in Russian].

78. L. P. Rachenskaya, Candidate's Dissertation in Geology and Mineralogy (Moscow, 1970).

79. O. Retowski, "Die tithonischen Ablagerungen von Theodosia," Bull. Soc. Natur. Mosc. N. ser. **7**, 206–301 (1893).

80. M. A. Rogov, "Stratigraphy of Lower Volgian Deposits of the Russian Plate and Correlation between Volgian and Tithonian Stages," Geol. Korrelyatsiya **10** (4), 35–51 (2002) [Stratigr. Geol. Correlation **10**, 348–354 (2002).

81. M. A. Rogov, "Ammonite-Based Correlation of the Lower and Middle (*Panderi* Zone) Volgian Substages with the Tithonian Stage," Geol. Korrelyatsiya **12** (1), 41–66 (2004) [Stratigr. Geol. Correlation **12**, 35–57 (2004).

82. L. F. Romanov, *Mesozoic Variegated rocks of the Dniester–Prut Interfluve* (Shtiintsa, Kishinev, 1976) [in Russian].

83. I. G. Sazonova and N. T. Sazonov, "Comparative Stratigraphy and Fauna of Jurassic–Cretaceous Boundary Beds of East Europe," Tr. VNIGRI **152**, 194–214 (1974).

84. R. Schlegelmilch, *Die Ammoniten des süddeutsche Malms: ein Bestimmungsbuch für Geowissenschaftler und Fossiliensammler* (G. Fisher Verlag, Stuttgart, 1994).

85. G. Schweigert, "Über einige bemerkenswerte Ammoniten im Oberkimmeridgium der Schwäbischen Alb (Südwestdeutschland)," Stuttg. Beitr. Naturk. Ser. B, No. 203, 1–15 (1994).

86. U. Schudack, "*Paleocytheridea grossi* n. sp. (Ostracoda) aus den Mornsheimer Schichten (Tithonium) von Oberhartheim bei Vohburg (Donau)," Geol. Bl. NO-Bayern **47** (1–4), 17–24 (1997).
87. M. Septfontaine, "Presence de *Protopeneroplis trochangulata* sp. nov. (Foraminifers) dans le Cretace inferieur du Jura meridional et revision de*Protopeneroplis* Weynschenk, 1950," Eclogae geol. Helv. **67/3**, 605–628 (1974).
88. V. D. Sokolov, "Materials on Geology of the Crimea. The Crimean Tithonian," Izv. Mosk. O–va Lyubit. Estestvozn., Antropolog. Etnografii **14**, 1–43 (1886).
89. J. M. Tavera, *Los ammonites del tithonico superior–berriasense de la zona Subbetica (Cordilleras Beticas)* (Univ. de Granada, Granada, 1985).
90. J. M. Tavera, F. Oloriz, M. Company, and A. Checa, "Mediterranean Ammonites and the Jurassic–Cretaceous Boundary in Southern Spain (Subbetic Zone)," Acta Geol. Hungarica **29** (1–2), 151–159 (1986).
91. E. M. Tesakova and L. P. Rachenskaya, "New Ostracodes (Crustacea, Ostracoda) of the Genus *Costacythere* Gründel from Berriasian Sediments of the Crimea," Paleontol. Zh., No. 3, 62–68 (1996a).
92. E. M. Tesakova and L. P. Rachenskaya, "New Ostracodes (Crustacea, Ostracoda) of the Genera *Bairdia* M'Coy, *Neocythere* Mertens, *Macrodentina* Martin, *Hechticythere* Gründel and *Cypridea* Bosquet from Berriasian Sediments of the Crimea," Paleontol. Zh., No. 4, 48–54 (1996b).
93. E. M. Tesakova, Yu. N. Savel'eva, and V. V. Arkad'ev, "Tithonian and Berriasian Ostracodes of the Eastern Crimea," in "*Proceedings of Scientific Conference: Lomonosov Lecturers of 2004, Geol. Section"* (MGU, Moscow, 2004), p. 27 [in Russian].
94. M. Verneuil, de, "Mémoire géologique sur la Crimeé," Mém. Soc. Geol. France. Ser. I **3** (1), 1–36 (1838).
95. A. M. Voloshina, "On Find of Intricate Lituolidae (Foraminifera) in Upper Jurassic–Lower Cretaceous Sediments of the Eastern Crimea," Paleontol. Sbornik L'vov. Geol. O–va, No. 10, Issue 1, 17–23 (1974).
96. A. M. Voloshina, "Two New Species of the Genus *Pseudocyclammina* (Foraminifera) from Berriasian Sediments of the Tambovskaya Borehole (Eastern Crimea)," Dokl. Akad. Nauk USSR, Ser. B, No. 4, 295–298 (1976).
97. A. M. Voloshina, "Microfauna and Stage Subdivision of Upper Jurassic and Lower Cretaceous Sediments in Two Boreholes of the Eastern Crimea," Dokl. Akad. Nauk USSR, Ser. B, Issue 3, 195–298 (1977).
98. L. Witte and Th. Lissenberg, "Ostracods from Callovian to Ryazanian Strata (Upper Jurassic) in the Central North Sea Graben (Netherlands Offshore)," Meded. Rijks Geol. Dienst., No. 51, 1–69 (1994).
99. V. V. Yudin, *Geology of the Crimea Based on Geodynamics* (Komi Nauschn. Tsentr URO RAN, Syktyvkar, 2000) [in Russian].
100. B. Ziegler, "Monographie der ammonitengattung *Glochiceras* im epicontinentalen Weissjura Mitteleuropas," Paleontographica. Abt. A **110** (4–6), 93–164 (1958).
101. K. A. Zittel, *Die Cephalopoden der Stramberger Schichten* (Museum Kon. Bayer Staates, Stuttgart, 1868), Bd. 2, Abt. 1.
102. V. A. Zakharov, P. Bown, P. F. Rawson, "*The Berrisian Stage and the Jurassic-Cretaceous Boundary*," Bull. Inst. Royal Sc. Nat. Belgique. Sc. d. 1. Terre. **66**, 7–10 (1996).