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New Data on Stratigraphy of the Jurassic (Pliensbachian–Aalenian) Sediments of the Cape Tsvetkov Region, Eastern Taimyr

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Abstract—On the basis of the results of studying the faunal collections of bivalves and foraminifera collected in the period of 1976–2014 in the Cape Tsvetkov region in Eastern Taimyr, the knowledge of the Pliensbachian–Aalenian part of the section of the Tsvetkov geological region is expanded. The bedding in the section is described, and a comprehensive paleontological characteristic is given. For the first time for this section, the following taxa are included in the composition of characteristic bivalve assemblages: *Praemeleagrinella deleta*, *Siungiudella* cf. *parvula*, *Mytiloceramus (Lenoceramus) vilujensis*, *Mytiloceramus (Pseudomytiloides) oviformis*, *Oxytoma* ex gr. *kirinae*, *Arctotis (Praearctotis) similis*, and *Arctotis (Arctotis) tabagensis*. On the basis of the use of auxiliary biostratigraphic subdivisions—beds with bivalves and F-zones based on foraminifera—the section is correlated with the standard boreal ammonite scale. The age of the local stratigraphic units of the Eastern Taimyr structural-facies zone is refined. The Kiterbyutskaya Formation is considered within the Tiltoniceras antiquum–Dactylioceras commune zones, the Korotkinskaya Formation is considered within the Dactylioceras commune–Pseudolioceras falcodiscus zones, and the Aprelevskaya Formation is considered within the Pseudolioceras maclintocki Zone. For the first time, images of the leading species of bivalves are presented.

Keywords: Pliensbachian, Toarcian, Aalenian, ammonites, bivalves, foraminifera, Eastern Siberia
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INTRODUCTION

The Toarcian–Aalenian section in the region of Cape Tsvetkov in Eastern Taimyr is considered stratigraphically the most complete in Eastern Siberia. The lower and upper Toarcian and the lower and upper Aalenian were defined there (Knyazev et at., 2003; Nikitenko, 2009; Shurygin et al., 2000). The first data on the Toarcian–Aalenian sediments in Eastern Taimyr were obtained during the field works organized by the Glavsevmorput' trust in 1943 and 1944. T.P. Kochetkov identified the inferred Upper Lias (65 m) and Aalenian (115 m) in the region of Cape Tsvetkov and the Chernokhrebetnaya River. The Scientific Research Institute of Arctic Geology (NIIGA) performed a geological survey in the same area in 1949. I.M. Migai attributed the sediments up to 420 m thick, which included a terminal stratum of "mud-gray aleuritic argillites with interbeds (up to 20 cm) containing sideritized concretions," to the Middle Lias (upper Pliensbachian). He did not distinguish the Upper Lias (Toarcian) and dated the overlying section consisting of a 40-m sequence of gray siltstones in the lower part and a sequence of light gray fine-grained sandstones 75–80 m thick in the upper part to the Aalenian (Migai, 1952). Later on, on the basis of the revision of the faunal collection gathered by I.M. Migai in the region of Cape Tsvetkov in Eastern Taimyr, the stratigraphers from NIIGA assigned the stratum of "gray argillites with siltstone interbeds" with a total thickness of about 90 m to the Toarcian; the "Kiterbyut Horizon" represented by a clay sequence was identified at its base (Saks et al., 1959).

The monographic study of bivalves and foraminifera that was performed in the 1950s–1970s (Gerke, 1961; Koshelkina, 1963; Krymholts et al., 1953; Zakharov and Shurygin, 1978; etc.) made it possible to significantly refine the stratification and correlation of the sections. In the 1960s–1980s, the paradigm about the regional hiatus in sediment deposition at the Lower–Middle Jurassic boundary was prevailing and the presence of the Upper Toarcian in most sections of

Eastern Siberia was put in question (Mesezhnikov and Kirina, 1966; *Resheniya*..., 1981). The difficulties in drawing the Toarcian–Aalenian boundary were caused at that time by the absence of data on direct correlation of biostratons of the boreal upper Toarcian with the standard West European ammonite scale (Polubotko and Repin, 1992).

The further research into the Toarcian–Aalenian section of Eastern Taimyr was conducted in the 1970s–1990s by personnel of the All-Russia Petroleum Scientific Research Geological Survey Institute (VNIGRI), the Institute of Geology and Geophysics, Siberian Branch, USSR Academy of Sciences, and the Siberian Research Institute of Geology, Geophysics, and Mineral Resources (SNIIGGIMS) (Kaplan et al., 1974; Sapjanik, 1991a; Shurygin and Levchuk, 1982, 1985). The detailed description of the section outcropping in the sea cliffs of the west coast of Khatanga Bay, as well as in the adjacent glens, was carried out by specialists from VNIGRI, the Karpinsky Russian Geological Research Institute (VSEGEI), and the Institute of Geology and Geophysics (Siberian Branch, USSR Academy of Sciences) on the basis of materials of the field works in 1971. The stratum that includes a sequence of "aleuritic ferruginized argillites" with a thickness of 11.1 m at the base and a sequence of "dark gray splintered argillites with numerous horizons of carbonate concretions" with a thickness of 15.7 m in the upper part, the base of which was found to contain *Dactylioceras* ex gr. *commune Sow.*, and in the scree of the sequence comprising *Pseudomytiloides* cf. *jacuticus* (Petr.), was assigned to the Toarcian. This stratum with a total thickness of 26.8 m was correlated with the Dactylioceras commune Zone and inferentially with the Zugodactylites braunianus Zone. The 19.7-m-thick overlying sequence of "dark gray splintered argillites with horizons of fine red siderites and inclusions of limestone concretions" was attributed to the upper Toarcian and inferentially to the lower Aalenian. It was found to contain *Dacryomya* sp. nov. (= *Dacryomya gigantea* Zakh. et Schur.) (Kaplan et al., 1974; Zakharov and Shurygin, 1974).

In 1976, during the study of the section of the western coast of the Khatanga Bay in the region of Cape Tsvetkov, M.A. Levchuk and B.N. Shurygin, specialists at the Institute of Geology and Geophysics, Siberian Branch, USSR Academy of Sciences, conducted a detailed litho- and biostratigraphic stratification of the Toarcian and the Aalenian. A series of lithostratigraphic subdivisions was considered in the framework of early Toarcian ammonite zones. The sequence of "gray, gray yellowish, aleuritic, ... plastic clays" 27.7 m thick that directly overlie the Pliensbachian aleutitic stratum and the overlying sequence of "dark gray aleuritic, argillite-like clays ... with abundant horizons of pillow-shaped concretions of clay marls (argillites)" 10 m thick with scarce "*Dacryomya inflata* (Ziet.)" (= *D. jacutica* (Petr.))[1] were considered within the Harpoceras falcifer and Dactylioceras athleticum zones.

The higher sequence of "dark gray argillite-like clays" 14.1 m thick that contains bivalves *Pseudomytiloides marchaensis* (Petr.), "*Meleagrinella* ex gr. *sparsicosta* (Petr.)" (= *Arctotis marchaensis* (Petr.)),[2] "*Dacryomya inflata* (Ziet.)" (= *D. jacutica* (Petr.)), and *Camptonectes* s. str. was studied as a possible counterpart of the Zugodactylites moniestieri Zone. The overlying stratum, including a sequence of "argillite-like aleuritic clays" 37.4 m thick with *Dacryomya gigantea* Zakh. et Schur., *Liostrea* sp. ind., and *Arctotis* sp. ind. and a sequence of "aleuritic, silty, argillite-like clays" 26.7 m thick with *Dacryomya gigantea* Zakh. et Schur., *Arctotis* sp. ind., *Malletia* ex gr. *amygdaloides* (Sow.), *Paleonucula* sp., and *Propeamussim* (*Parvamussium*) *olenekense* (Bodyl.), was attributed to the nonstratified upper Toarcian and the lower Aalenian (Shurygin and Levchuk, 1982).

Over the last three decades, the zonal scales of the Toarcian Stage were developed for Eastern Siberia and northeastern Russia on the basis of ammonites, bivalves, and microfauna (Knyazev, 1991; Knyazev et al., 2003; Nikitenko, 2009; Repin, 2016; Repin and Polubotko, 1993; Sapjanik, 1991a, 1991b; Shurygin et al., 2011). In accordance with the most complete analytical record of the Jurassic stratigraphy for Sibe-

[1] In the first half of the 20th century, Toarcian ctenodontides of Siberia were named *Leda acuminata* (Goldf.) and *Leda jacutica* (Petr.) (*Atlas*..., 1947). Starting from the middle of the 1970s, Siberian "*Leda*" were attributed to the genus *Dacryomya* Agassiz, 1839 (Sanin, 1976; Zakharov and Shurygin, 1978). On the basis of a comparative study of the representative samples of dacryomya shells from the Siberian sections by biometric methods, Toarcian dacryomyas were joined under the species name *Dacryomya inflata* (Zieten), and the species *Leda jacutica* was reduced to synonymic (Shurygin, 1983). Later on, the name *D. inflata* became widely used in research practice; this species was chosen as an index of the lower Toarcian D-zone (joint distribution) Dacryomya inflata–Tancredia bicarinata (Shurygun, 1987b). However, this name is not valid: K. Zieten did not recognize species *inflata* and just assigned his images of the specimens to the English species *Nucula inflata* J. de C. Sowerby (Zieten, 1830). The type series of the species described by J. Sowerby and J.D.C. Sowerby (1829) originates from the lower Eocene "London clays." The Jurassic and Paleogenic taxa significantly differ; therefore, later on, D. Brauns introduced a new name *Leda zieteni* for "*Nucula inflata* sensu Zieten" (Brauns, 1871). Cox (1960) indicated that *Leda zieteni* is a homonym of *Leda zietenii* d'Orbigny, 1850 and proposed a new name for this taxon: *Nucula (Dacryomya) gaveyi*. The material of K. Zieten, D. Brauns, and L. Cox, which was the basis for describing this species, originates from the Pliensbachian; the structure of the hinge ligament and the pallial line of this taxon is unknown; therefore, we use a valid name *Dacryomya jacutica* (Petr.) instead of "*D. inflata* (Ziet.)" in this work to designate Toarcian ctenodontides of Siberia. In the historical review, the names of bivalves whose taxonomic membership and framework were changed by the authors were enclosed in quotation marks in their original.

[2] In making a revision of Jurassic oxytomids, it was established that the stratigraphic range of species *Meleagrinella sparsicosta* is confined to the upper Pliensbachian, and the species *Arctotis (Praearctotis) marchaensis* is confined to the upper Toarcian (Lutikov and Shurygin, 2010).

ria, in the region of Cape Tsvetkov, the Anradulonectites incertus b-zone is identified in the upper Pliensbachian; the Toarcian–Aalenian stratum is stratified into b-zones: Dacryomya inflata, Tancredia bicarinata (lower Toarcian), Pseudomytiloides marchaensis (upper Toarcian), Dacryomya gigantea (upper Toarcian–lower Aalenian), Maclearnia kelimyarensis (lower Aalenian), and Retroceramus elegans (lower Aalenian–upper Aalenian) (Shurygin et al., 2000).

The zonal scales of the Lower and Middle Jurassic based on bivalves and brachiopods were developed outside Russia in Argentina (Damborenea, 1994; Riccardi et al., 2011).

According to the conventional foraminiferal biostratigraphy, V.V. Sapjanik revealed f-zones (phylogenetic substantiation) in the region of Cape Tsvetkov in the Pliensbachian–Aalenian part of the section: Trochammina sablei (upper Pliensbachian), Trochammina kisselmani (lower Toarcian), Trochammina taimyrensis (upper Toarcian–lower Aalenian), Trochammina praesquomata (lower Aalenian–upper Bajocian) (Sapjanik, 1991b). B.L. Nikitenko detected f-zones (joint distribution) in the same section: Recurvoides taimyrensis (upper Pliensbachian–lower Toarcian), Ammobaculites lobus–Trochammina kisselmani (lower Toarcian), Astacolus praefoliaceus–Lenticulina multa (lower Toarcian–lower Aalenian), Vernuilinoides syndasscoensis (lower Aalenian), Astacolus zwetkovi (lower–upper Aalenian), and Lenticulina nordvikensis (upper Aalenian) (Nikitenko, 2009).

In the period of 1993–1996, during the geological survey at the scale 1 : 200000 carried out by Sevmorgeologiya Production Geological-Geophysical Association Central Arctic Geologcal Expedition in the northeast of Taimyr Peninsula in the water area of Teresa Klavenes Bay, the boreholes encountered the Lower–Middle Jurassic deposits. The stratum, which was assigned to the counterparts of the Unginskaya Formation according to the data of the VSEGEI specialists (St. Peterbsurg), was found to have a succession of foraminiferal complexes typical of f-zones, such as Trochammina kisselmani, Trochammina taimyrensis, and Trochammina praesquomata (Alekseev and Schneider, 2020).

In terms of structure and completeness of the sections, the Jurassic strata in the region of Cape Tsventkov belong to the Eastern Taimyr structural-facies zone (SFZ) (*Resheniya*..., 1981); by the paleogeographic criterion, to the Eastern Taimyr facies region (Shurugin et al., 2000); and by the tectonic criterion, to the Chernokhrebetnyi-Nordvik geological area (*Gosudarstvennaya*..., 2009). The following formations were recognized in the section of the Cape Tsvetkov region: Airkatskaya (upper Pliensbachian), Kiterbyutskaya (lower Toarcian), Korotkinskaya (lower Toarcian–lower Aalenian), Aprelevskaya (lower Aalenian–upper Aalenian), and Arangastakhskaya (upper Aalenian–lower Bajocian) (*Gosudarstvennaya*..., 2009; Shurugin et al., 2000).

The integrated results of the lithological and biostratigraphic studies of the Lower–Middle Jurassic sediments in the region of Cape Tsvetkov served as the material for this work (Fig. 1).

The section was studied by a team from the Institute of Geology and Geophysics, Siberian Branch, USSR Academy of Sciences, in 1976 and teams from SNIIGGIMS during the field seasons of 1987 and 2014. Owing to the decrease in the thickness of coastal ice and permafrost thaw in the glens, the outcrops of the Lower–Middle Jurassic bedrocks, earlier not always explorable, along the sea cliffs and in several glens formed by brooks flowing into the Khatanga Bay were exposed in a large segment from Cape Tsvetkov southwestward to the Chernokhrebetnaya River estuary. This made it possible to take photos and make videos and to compare the data on the regional stratigraphy obtained in different years.

The section was described with respect to the paleontological determinations by O.A. Lutikov and V.V. Sapjanik on the basis of the data of 1987 and was complemented by the data obtained by B.N. Shurygin, A.N. Aleinikov, and A.S. Alifirov in 1976 and 2014. The coordinates of the outcrops and exposures of the beds were determined by A.N. Aleinikov in 2014. The correlation was performed between the beds and the sequences identified by Levchuk (1985). On the basis of the existing and new data on the distribution of ammonites, bivalves, and foraminifera, the age of earlier detected local stratigraphic subdivisions (formations) was refined (Shurygin et al., 2000). The existing stratigraphic sectional planes of the upper Pliensbachian, Toarcian, and Aalenian of Eastern Taimyr were correlated with the new variant of the sectional plane (Fig. 2).

MATERIAL

The basic material for the studies was the macro- and microfaunal collections gathered by O.A. Lutikov and V.V. Sapjanik in the natural Toarcian–Aalenian sections of Eastern Taimyr in 1987. Additionally, during the biostratigraphic analysis, we used the collections assembled by O.A. Lutikov and V.V. Sapjanik in 1980–1986 in the sections of the Upper Yana foredeep (Motorchuna, Syungyude, and Molodo rivers), the Lena-Anabar Trough (Kelimyar River), the Yenisei–Khatanga Trough (Anabar Bay, Anabar River), the Vilyui Syneclise (Markha, Tyung, and Vilyui rivers), and the Omolon massif (Astronomicheskaya, Brodnaya, Start, and Saturn rivers) and the collections gathered in 2014 (Eastern Taimyr) by B.N. Shurygin (Eastern Taimyr, Anabar Bay), V.G. Knyazev (Tyung, Markha, Vilyui, Syungyude, and Molodo rivers), and A.N. Aleinikov.

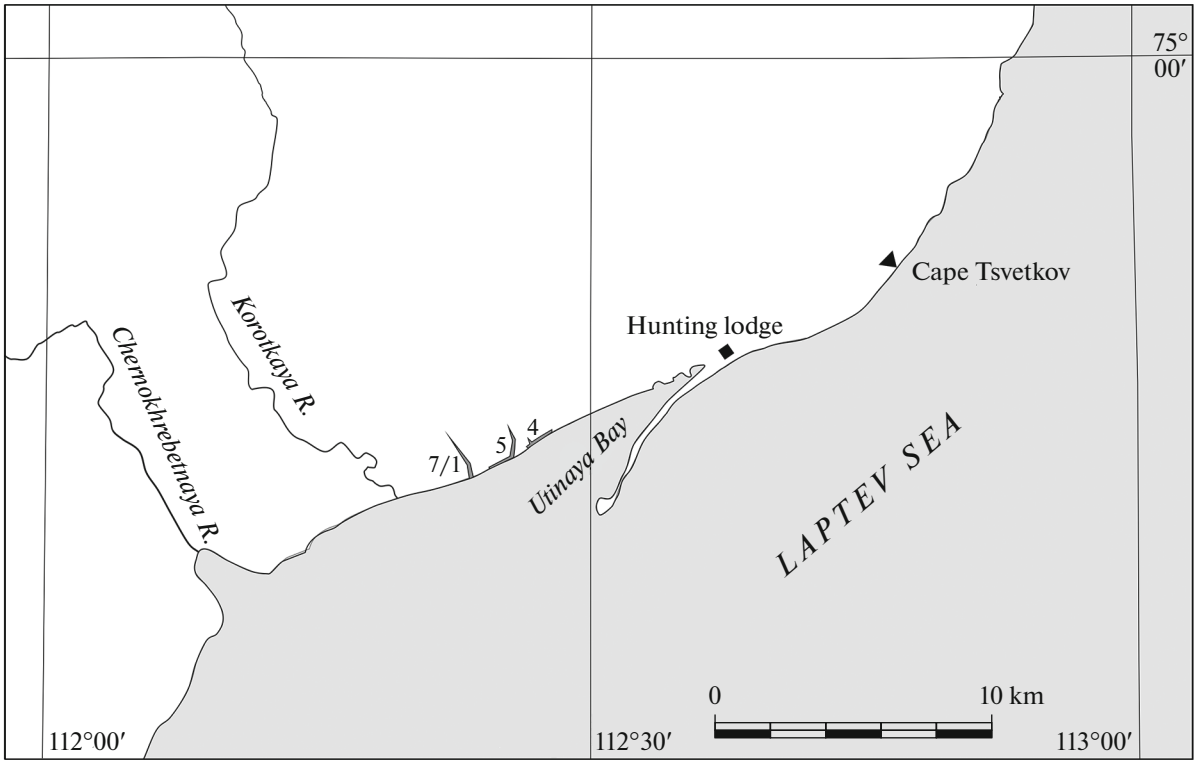


Fig. 1. Diagram of location of outcrops on the west coast of the Khatanga Bay (Cape Tsvetkov region).

The plates show the images of bivalves from the section of the region of Cape Tsvetkov, Eastern Taimyr, from the collections of O.A. Lutikov and A.N. Aleinikov. As a comparative material, we provided the images of bivalves from the sections of the Kelimyar River and Anabar Bay from the collections of O.A. Lutikov and B.N. Shurygin.

METHODS

Field studies. The correlation of the natural outcrops of Jurassic sediments in the region of Cape Tsvetkov was carried out on the basis of the principles of comparing the bedding in the separated sections of the rhythmic terrigenous strata (Zakharov and Yudovnyi, 1967).

Laboratory studies. The biostratigraphic stratification of the studied sections was performed on the basis of the evolutionary method proposed by D.L. Stepanov and M.S. Mesezhnikov (Stepanov and Mesezhnikov, 1979). The stratification was carried out with respect to the data on bivalves related to the families Oxytomidae Ichikawa, 1958 and Retroceramidae Koschelkina, 1971 and the data on foraminifera related to the family Trochamminidae, Schwager, 1877. The biostartigraphic analysis was conducted by comparing the teilzones of the species from the same phylogenetic lines to the levels of finds of ammonites in the studied section, as well as in the other sections of Eastern Siberia and northeastern Russia on the basis of our own research and using the materials obtained by colleagues (Knyazev et al., 1991, 2003; Nikitenko, 2009; Polubotko and Repin, 1966, 1974; Repin and Polubotko, 1992, 1993, 2015; Shurygin et al., 2000; *Stratigrafiya*..., 1976).

DESCRIPTION OF THE SECTIONS

Pliensbachian, Toarcian, and Aalenian sediments crop out in the coastal cliff of Eastern Taimyr along the west coast of the Khatanga Bay and in the coastal glens 4.1–6.2 km southwestward from the head of the Utinaya Bay (Fig. 3).

Outcrop no. 4

Outcrop no. 4 is represented by the sea cliff extending for 1 km along the western coast of the Khatanga Bay southwestward from the head of the Utinaya Bay. The outcrop exposes Pliensbachian and lower Toarcian sediments. The description starts at the site located 4.9 km from the head of the Utinaya Bay (Fig. 4).

Pliensbachian sediments crop out in the sea cliff about 15 m high; they are a part of the Airkatskaya Formation.

The Airkatskaya Formation. It is composed of alternating sequences of dark gray clays, clayey siltstones, light gray sandstones, and sandy siltstones. Concretions and nodules of pyrite, pieces of wood, and fine

Levchuk, 1985; Shurygin and Levchuk, 1984

Stage	Substage	Zone	Beds with bivalves	Sequence	Lithology and fauna
Aalenian	Upper		*Arctica humiliculminata–Mytiloceramus elegans*	22	Sand-aleurite-clayey rock, with pebbles, a sandstone stratum (1 m) at a level of 0.5 m, with ball-shaped concretions (1.8 m) *Arctotis lenaensis*, *Arctica humiliculminata*, *Mytiloceramus* cf. *elegans* 7.1 m
				21	Clayey siltstones. At the base is a concretion stratum (0.8 m) of calcareous siltstone with stellate calcite formations. *Arctolis lenaensis*, *Arctica humiliculminata*, *Mytiloceramus* sp. ind. 21.8 m
				20	Silty clays with cake-shaped pyrite. *Arctica humiliculminata*, *Nuculana acuminata* 19 m
Upper Toarcian–lower Aalenian			*Dacryomya gigantea–Arctotis*	19	Siltstones and silty clays. *Boreionectes kelymiaresis*, *Oxytoma* ex gr. *jacksoni*, *Arctica humiliculminata*, *Arctotis lenaensis*, *Astarte meeki*, *Propeamussium olenekense*, *Nuculana* cf. *acuminata*, *Musculus* sp., *Malletia* sp. ind. 11.5 m
				18	Aleurite clays. Three continuous concretion strata of calcareous siltstone (to 0.4 m) and four horizons of concretions of bun-shaped calcareous clays. *Dacryomya gigantea*, *Arctotis* sp. ind., *Malletia* ex gr. *amygdaloides*, *Paleonucula* sp., *Propeamussium olenekense* 26.7 m
				17	Argillite-like silty clays with abundant horizons of calcareous argillite concretions (10 × 30 cm) with cake-shaped nodules and globules of pyrite. *Dacryomya gigantea*, *Liostrea* sp. ind., *Arctotis* sp. ind.—12 m from the base and higher, *Phylloceras* sp. ind.—at the base 40.8 m
Toarcian	Lower	Zugodactylites braunianus	*Pseudomytiloides marchaensis*	16	Argillite-like clays with horizons of calcareous argillite concretions. Pseudomytiloides marchaensis, *Meleagrinella* ex gr. *sparsicosta*, *Dacryomya inflata*, *Camptonectes* s. str. 14.6 m
		Dactylioceras commune–Harpoceras falciferum	*Dacryomya inflata*	15	Silty clays with abundant horizons of pillow-shaped concretions (10 × 50 cm) of calcareous clays. At the base are lense-shaped interbeds of yellowish clays. *Dacryomya inflata* 10 m
				14	Gray silty clays jarositized with horizons of pillow-shaped concretions of calcareous clays. At the base is dark gray fine-grained coarse-platy (up to 0.5 m) siltstone. In the upper part is *Dacryomya inflata* 27.7 m
Pliensbachian	Upper		*Radulonectites*	13	Dark gray siltstone clays with pebbles and gravel. At the base is the concretion stratum of calcareous siltstone with pebbles 6.6 m

Knyazev et al., 2003; Shurygin et al., 2000

Stage	Substage	Zone	b-zone	Formation	Sequence
Aalenian	Upper		Retroceramus elegans	Arangas-takhskaya	22
				Aprelevskaya	21
	Lower				20
			Maclearnia kelimyarensis		19
				Korotkinskaya	18
Toap	Upper	Psedolioceras falcodiscus	Dacryomya gigantea		17
			Pseudomytiloides marchaensis		16
	Lower	Pseudolioceras lythense–Harpoceras subplanatum	Dacryomya inflata–Tancredia bicarinata		15
				Kiterbyutskaya	14
Pliensbachian	Upper		Anradulonectites incertus	Airkatskaya	13

This work

Stage	Substage	Zones of boreal standard (Shurygin et al., 2011)	Beds with oxytomids	Beds with retroceramids	Formation	Bed	Lithology and fauna
Aalenian	Lower	Pseudolioceras maclintocki	*Arctotis tabagensis*	*Retroceramus elegans*	Arangas-takhskaya	9	Sandy siltstones. At the base is the interbed of pebbles and boulders. At the level of 1.0 m is the horizon of concretions (0.5 × 1.5 m). *Retroceramus elegans*, *Retroceramus menneri*, *Arctotis tabagensis*, *Trochammina taimyrensis* 7.5 m
					Aprelevskaya	8	Sandy siltstones. At the base is the horizon of concretions (0.6 × 2.0 m). *Arctotis tabagensis*, *Retroceramus* sp. ind. 34 m
						7	Gray sandy aleurites with pyrite nodules. At the base is a thin interbed (0.1 m) of calcareous siltstone. *Arctotis tabagensis* 15 m
						6	Gray aleurites. At the base is the stratum (1.0 m) of lithified aleurite with pebbles, boulders, and pieces of wood. At the level of 1.5 m is the horizon of concretions. At the base are *Arctotis* ex gr. *tabagensis*, *Propeamussium olenekense*, *Trochammina taimyrensis*. From the level of 2.5 m is *Lenticulina multa* 9 m
Toarcian	Upper	Pseudolioceras falcodiscus	*Praearctotis similis*		Korotkinskaya	5	Dark gray clayey aleurites. At the base is the horizon of concretions (0.4 × 2.0 m). At the level of 3.7 m are *Pseudolioceras* cf. *falcodiscus*, *Propeamussium olenekense*, *Mclearnia kelimyarensis*, *Praearctotis similis*, and *Trochammina taimyrensis* 6 m
						4	Dark gray clayey aleurites with horizons of concretions. At the base is a marker horizon (0.4 m) of calcareous siltstone. *Dacryomya gigantea*, *Trochammina taimyrensis* 9.5 m
						3	Dark gray clayey aleurites with numerous horizons of concretions. *Praearctotis similis*, *Verneuilinoides syndascoensis* 9.6 m
						2	Dark gray clayey aleurites. At the base is the horizon of concretions (1.0 m). At the levels of 2.2 and 4.3 m are the horizons of concretions. *Dacryomya gigantea*, *Praearctotis* sp., *Lenticulina praemulfa* 41.9 m
		Pseudolioceras wuerttenbergeri	*Praearctotis marchaensis*	*Pseudomytiloides marchaensis*		1	Dark gray silty clays with horizons of brown concretion. *Pseudomytiloides marchaensis*, *Praearctotis marchaensis*, *Lenticulina praemulta*, *Saccammina compacta*, *Trochammina taimyrensis* 20.6 m
		Pseudolioceras compactile					
	Lower	Zugodactylites braunianus		*Pseudomytiloides oviformis*; *Lenoceramus vilujensis*		18	Dark gray silty clays. At the base is the horizon of concretions (0.3 × 1.2 m). *Phylloceras* sp. ind., *Pseudomytiloides marchaensis*, *Pseudomytiloides oviformis*, *Lenoceramus vilujensis*, *Astacolus praefoliaceus* 2.8 m
		Dactylioceras commune				17b	Dark gray silty clays. At the base is the horizon of cake-shaped concretions (0.3 × 1.5m). *Catacoeloceras crassum*, *Dacryomya jacutica*, *Globulina jurensis* 4.9 m
						17a	Gray ocherized silty argillite. At the base is the lense of yellowish plastic clays. *Dacryomya jacutica* 4.9 m
						16c	Dark gray ocherized clays with interbeds of plastic clays, with horizons of bun-shaped and ball-shaped concretions. *Dacryomya jacutica* 6.5 m
		Harpoceras falciferum			Kiterbyutskaya	16b	Gray clays with jarosite and ocher patches, with horizons of concretions. *Dacryomya jacutica* 11 m
		Tiltoniceras antiquum				16a	Dark gray, gray foliated and fine-flaky clays. At the base is the lense of pink plastic clays with belemnites. *Dacryomya jacutica*, *Triplasia kingakensis* 6 m
						15b	Dark gray clays with horizons of ball-shaped concretions. *Trochammina kisselmani*, *Ammobaculites lobus* 3.7 m
Pliensbachian	Upper	Amaltheus viligaensis	*Praemeleagrinella deleta*		Airkatskaya	15a	Dark gray clayey aleurites, with interbeds of pebbles. *Praemeleagrinella deleta*, *Trochammina sablei*, *Recurvoides taimyrensis* 2.5 m
						14	Dark gray sandy aleurites, with lenses of coarse gravel. *Harpax laevigatus*, *Trochammina sablei*, *Recurvoides taimyrensis*, *Kutzevella barrowensis* 5 m

Fig. 2. Correlation of the stratigraphic sectional planes of the Pliensbachian–Aalenian sediments of the Cape Tsvetkov region (Eastern Taimyr).

Fig. 3. General view of the Pliensbachian–Aalenian sediments located along the west coast of the Khatanga Bay. Photo by N.N. Sobolev (VSEGEI), 2007.

Fig. 4. Outcrop 4. Exposures of beds 11–15a of the Airkatskaya Formation. Photo by A.S. Alifirov, 2014.

plant detritus are spread across the section. The thickness of the formation in the region of Cape Tsvetkov is 268 m (Saks et al., 1978). This work characterizes the upper sequence of the formation (outcrop 5, sequence 13, beds 10–16; Levchuk, 1985).

Bed 11. It begins with the horizon of reddish brown concretions of calcareous siltstone on the surface (~1.0 m thick). Above is the alternation of sandy siltstones and firm siltstones. At the level of 1.2 m from the base is the horizion of concretions (up to 0.5 m thick) of calcareous siltstone. The bed contains a lot of pebbles, jarositization patches, and round concretions of greenish gray sandstone. The thickness is 2.0 m.

Bivalves: *Homomya* sp.

Foraminifera: *Hyperammina neglecta* Gerke et Sossip., *Glomospira* ex gr. *gordialis* (Park. et Jon.), *Trochammina sablei* Tappan, *Astacolus* ex gr. *varians* (Borneman), *Dentalina* ex gr. *communes* Orbigny.

Bed 12. Dark gray massive siltstones with pebbles and boulders. The thickness is 2.5 m.

Bivalves: *Harpax laevigatus* (Orb.).

Bed 13. Finely splintered sandy siltstones with jarositization patches and pebbles. At the base is the interbed (1.0 m) of gravel with large boulders (up to 1.0 m). Above lie dark gray massive siltstones with a bluish shade. The bed thickness is 3.0 m.

Bivalves *Harpax laevigatus* (Orb.).

Bed 14. Dark gray splintered sandy siltstones with numerous lenses of gravel and scattered pebbles. Many jarositization patches. At several levels are concretions (0.2 × 0.5 m) of calcareous siltstone. The thickness is 5.0 m.

Bivalves: *Harpax laevigatus* (Orb.).

Foraminifera: *Recurvoides taimyrensis* Nikitenko, *Saccammina ampulacea* Schleifer, *Hyperammina neglecta* Gerke et Sossip., *Glomospira* ex gr. *gordialis* (Park. et Jon.), *Ammodiscus siliceus* (Terquem), *Trochammina sablei* Tappan, *Kutzevella barrowensis* (Tappan), and *Bulbobaculites strigosus* (Gerke et Sossip).

Above lies a sratum that was described as single bed 15 during the field works. In the period of laboratory studies, lithologocally and paleontologically, the bed was stratified into two parts. Bed 15a was attributed to the Airkatskaya Formation; bed 15b was attributed to the Kiterbyutskaya Formation.

Bed 15a. Dark gray splintered clayey siltstones with numerous jarosite patches, pebble interbeds, bivalves, and gastropods. In the upper part of the bed (0.5 m), numerous *Homomya* shells are buried in the position of being alive. This part of the bed, according to M.A. Levchuk, belongs to the Kiterbyutskaya Formation (sequence 14, bed 9; Levchuk, 1985); according to our data, it belongs to the Airkatskaya Formation. The thickness is 2.5 m.

Bivalves: *Praemeleagrinella deleta* (Dumortier), *Neocrassina (Siungiudella)* cf. *parvula* Lutikov (specimen TF-11), *Homomya* sp. (according to B.N. Shurygin).

Foraminifera: at the level of 2.0 m from the base of the bed are *Hyperammina neglecta* Gerke et Sossip., *Glomospira* ex gr. *gordialis* (Parker et Jones), *Ammodiscus siliceus* (Terquem), *Trochammina sablei* Tappan, *Kutzevella barrowensis* (Tappan), and *Recurvoides taimyrensis* Nikitenko.

Higher in the succession is the stratum that, according to the data of field works in 1976, was described as a single sequence (outcrop 5, sequence 14, beds 5–8; Levchuk, 1985). Lithologically and paleontologically, we divided the stratum into several beds. Beds 15b, 16a, and 16b are regarded as a part of the

Fig. 5. Outcrop 4. Exposures of beds 15b–16b of the Kiterbyutskaya Formation. Photo by A.S. Alifirov, 2014.

Kiterbyutskaya Formation. Bed 16c pertains to the Korotkinskaya Formation (Fig. 5).

The Kiterbyutskaya Formation. Gray to black, yellowish gray finely splintered clays; in the outcrops, they are with a brownish shade, in places plastic, with carbonate concretions, in areas strongly jarositized. According to M.A. Levchuk, the thickness of the formation in the region of Cape Tsvetkov is 27.7 m (sequence 14, beds 5–9; Levchuk, 1985); according to our data, the thickness is 20.7 m.

Bed 15b. Dark gray finely splintered clays with jarosite patches. At a level of 0.5 m from the base is a horizon of ball-shaped concretions of calcareous siltstone, yellowish gray on the surface. At a level of 2.5 m is a horizon of pillow-shaped concretions (0.15 × 0.4 m) of calcareous siltstone. The thickness is 3.7 m.

Foraminifera: *Trochammina kisselmani* Sapjanik et Sokolov (dominant), *Saccammina inanis* Gerke et Sossip., *Ammodiscus glumaceus* Gerke et Sossip., *Ammobaculites lobus* Gerke et Sossip., *Bulbobaculites strigosus* (Gerke et Sossip.), *Lenticulina toarcense* (Payard), and *Recurvoides taimyrensis* Nikitenko.

Bed 16a. At the base are dark gray strongly ocherized foliated clays that turn into fine-flaky (1.0 m). Above is an alteration of foliated clays, yellowish brown on the surface, light gray on fresh fracture and clayey siltstones, reddish on the surface, dark gray and gray on fresh fracture. At the base is a lense of very sticky pinkish clays with belemnite rostra. At 2.0 m from the base is a horizon of light gray concretions (0.4 × 0.15 m) of calcareous clays that are brownish gray on the surface. At a level of 2.5 m is a horizon of concretions reaching 1 m in diameter. At a level of 3.0 m is a horizon of scattered pillow-shaped concretions with *Dacryomya*. The bed thickness is 6.0 m.

Bivalves: *Dacryomya jacutica* (Petr.), abundant from 2.5 m.

Foraminifera: *Saccammina inanis* Gerke et Sossip., *Ammodiscus glumaceus* Gerke et Sossip., *Bulbobaculites strigosus* (Gerke et Sossip.), *Hyperammina neglecta* Gerke et Sossip., *Ammobaculites lobus* Gerke et Sossip., *Trochammina kisselmani* Sapjanik et Sokolov, *Triplasia kingakensis* Loeblich et Tappan.

Bed 16b. In 1987, the bed was covered by a glacier; the description was made according to the data for 1976. The clays are gray splintered, with jarosite patches, and in places are strongly ocherized. At 1.0, 1.9, 2.4, and 3.5 m from the base, there are horizons of pillow-shaped concretions (0.2 × 0.7 m) of calcareous clays. At 1.0 m below the roof is an interbed of platy siltstone argillite. At the bottom of the bed are scattered small compressed bivalve shells. In the middle of the bed are whole ferruginized belemnite rostra; in the upper part (at 1.0 m from the roof) are bivalve shells buried without orientation, sometimes in the position of being alive but compressed from the side of umbones. The thickness is 11.0 m.

Bivalves: *Dacryomya jacutica* (Petr.).

The Korotkinskaya Formation. The monotonous stratum of dark gray clays and argillites (siltsone and silty) with numerous rows of calcareous-clayey concretions, pyrite nodules (Shurygin et al., 2000). The total thickness of the formation in the region of Cape Tsvetkov is 92.1 m according to Levchuk (1985) and 103.5 m according to the new data. The difference in the thickness estimate is explained by the error in measuring the stratum covered partially by glaciers and by adding bed 16c to the formation. The coordinates of the glen estuary: 74°54.548′ N, 112°28.39′ E. Bed 16c was discovered in a wall of the sea cliff northeast from the glen; beds 17b–18 were studied in a wall of the sea cliff southwest from the glen; bed 17a is exposed on the right side of the glen (Fig. 6).

Bed 16c. In 1987, the bed was covered by a glacier; the description was made according to the data for 1976 and 2014. The clays are dark gray splintered, ocherized, in places with ochre patches, with interbeds of plastic clays. At the base is a horizon of calcareous gray irregular-shaped concretions (0.05 × 0.3 m). From the base to a level of 1.1 m, the bed is filled with small different-shaped concretions, including ball-shaped ones. At 1.1 and 2.0 m from the base, there are horizons of bun-shaped concretions ~0.15 m thick. At 1.3 m and 1.6 m from the base, there are two thin platy concretion horizons. At 2.3 m from the base, there are carbonaceous wood and concretion (~1.5 m in diameter). Under the crest of the slope, there are gray concretions up to 0.3 m long. The concretions crop out in the glen (higher in the succession). The stratum contains many belemnite rostra and compressed *Dacryomya* shells; in the lower part of the bed, there are shell deposits with abundant whole *Dacryomya* shells. The bed pertained to the Kiterbyutskaya Formation (outcrop 5, sequence 14, bed 5; Levchuk, 1985); according to our data, it belongs to the Korotkinskaya Formation (Fig. 5). The thickness is 6.5 m.

Fig. 6. Outcrop 4. Exposures of beds 16c–18 of the Korotkinskaya Formation. The location of the found ammonite *Catacoeloceras crissum* is designated by the arrow. Photo by A.S. Alifirov, 2014.

Fig. 7. Outcrop 5. Exposures of beds 1–3 at the left edge of the glen. Photo extract from video by A.N. Aleinikov, 2014.

Bivalves: *Dacryomya jacutica* (Petr.).

Bed 17a. Gray splintered silty argillite, in places ocherized, with a mass of bivalves and scattered belemnites. At the base of the bed is a lense of yellowish plastic clays. Bivalves: *Dacryomya jacutica* (Petr.). The thickness is 1.7 m.

Bed 17b. Dark gray lumpy clayey aleurites with ocher patches. At the base is a horizon of thick cake-shaped concretions (0.3 × 1.5 m) of calcareous siltstone with bivalves and remains of fish fins. At the levels of 1.2, 1.8. 3.2, and 4.5 m from the base are the horizons of ellipsoidal concretions (0.3 × 0.4 m) composed of calcareous aleurite, brown on the surface, dark gray on fresh fracture, with fauna. The thickness is 4.9 m.

Ammonite assigned to *Catacoeloceras crassum* (Y. et B.) was found at a level of 1.8 m from the base (specimen TF-12) by O.A. Lutikov in 1987 (Knyazev et al., 1993). Bivalves: *Dacryomya jacutica* (Petr.) (specimen TF-13, the base of the bed; 3.2 and 4.5 m above the base). Foraminifera: *Saccammina inanis* Gerke et Sossip., *Ammodiscus glumaceus* Gerke et Sossip., *Hyperammina neglecta* Gerke et Sossip., *Trochammina kisselmani* Sapjanik et Sokolov, and *Globulina jurensis* Kisselman.

Bed 18. Dark gray ocherized clayey aleurites. At the base is a horizon of pillow-shaped concretions (0.3 × 1.2 m). At a level of 1.2 m from the base are bun-shaped concretions, brown on the surface, light gray on fresh fracture, with shelly aggregations of bivalves and gastropods. At a level of 2.0 m from the base is a horizon of pillow-shaped concretions with spheroidal weathering. The bed thickness is 2.8 m.

Bivalves: *Mytiloceramus (Lenoceramus) vilujensis* (Polub.), *Oxytoma* sp. ex gr. *kirinae* Velikzch., belemnites, gastropods (specimen TF-14, a level of 1.2 m from the base); *Mytiloceramus (Pseudomytiloides) oviformis* (Khudyaev in Krymholts et al., 1953), *Oxytoma* sp. ex gr. *kirinae* Velikzch., *Dacryomya jacutica* (Petr.), *Malletia* aff. *amygdaloides* (Sow.) (specimen TF-15/1, a level of 2.0 m from the base). Ammonites *Phylloceras* sp. ind. were encountered at the top of the bed (collected by A.N. Aleinikov in 2014). Bivalves: *Mytiloceramus (Pseudomytiloides) marchaensis* (Petr.) (specimen TF-15/2, the interval of 2.0–2.8 m from the base).

Foraminifera: *Saccammina inanis* Gerke et Sossip., *Astacolus praefoliaceus* (Gerke), *Bulbobaculites strigosus* (Gerke et Sossip.), *Evolutinella barrowensis* (Tappan), *Lenticulina praemulta* Sapjan.

Beds 17a, 17b, and 18 pertain to sequence 15 (outcrop 5, sequence 15, beds 1–4; Levchuk, 1985).

The overlying stratum was studied in outcrop no. 5 (Figs. 7–10).

Outcrop no. 5

The outcrop is located in the glen of an unnamed brook flowing into the Khatanga Bay. The brook estuary is found 5.4 km southwestward from the head of the Utinaya Bay. The place of beginning of description of bed 1 is situated ~150 m from the estuary (Fig. 7).

In terms of paleontological-taphonomic characteristics, outcrop no. 5 superstructs outcrop no. 4 without a hiatus. The coordinates of the place where the description begins: 74°54.491′ N, 112°27.569′ E.

The Korotkinskaya Formation. At the time of performing the works, the interface between the Korotkinskaya and the Kiterbyutskaya Formations was covered by a glacier. Directly above the glacier, silty clays with bun-shaped concretions crop out (Fig. 7). In

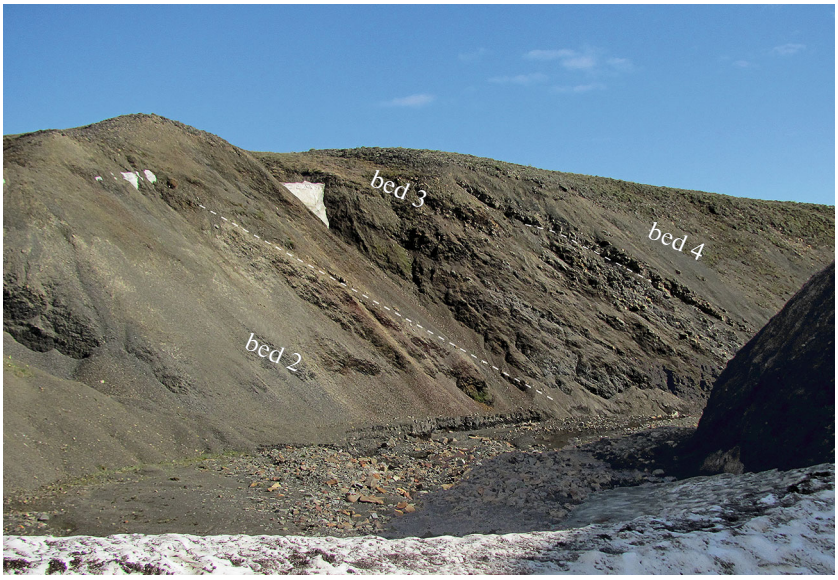


Fig. 8. Outcrop 5. Exposures of beds 2–4 at the left edge of the glen. Photo by A.S. Alifirov, 2014.

terms of paleontological-taphonomic characteristic, the upper part of bed 18 from outcrop no. 4 correlates with the base of bed 1 in outcrop no. 5. Bed 1 in outcrop no. 5 superstructs bed 18 in outcrop no. 4.

Bed 1. Dark gray fine-splintered silty clays. At the base of the bed and at the levels of 2.0, 6.0, 7.3, and 9.2 m from the base, there are horizons of concretions composed of calcareous siltstone, red brown on the surface and gray on fresh fracture. Individual concretions were found at the levels of 8.5 and 10 m. Bed 1 pertains to sequence 16 (outcrop 5, beds 2–5; Levchuk, 1985) (Fig. 2). The exposed thickness is 20.6 m.

A fragment of ammonite *Phylloceras* sp. ind. was found in the concretions of the base of the bed.

Bivalves: *Mytiloceramus (Pseudomytiloides) marchaensis* (Petr.) and *Oxytoma* sp. ex gr. *kirinae* Velikzch. in the concretion interbeds (specimen TF-16, the interval of the base of the bed is 2.0 m). *Dacryomya jacutica* (Petr.) and *Liostrea Taimyrensis* Zakh. et Schur. (specimen TF-17) are distributed across the bed.

The upper part of sequence 16 was found to contain bivalves*: Pseudomytiloides marchaensis* (Petr.), *"Meleagrinella* ex gr. *sparsicosta* (Petr.)*"* (= *Arctotis (Praearctotis) marchaensis* (Petr.)), *"Dacryomya inflata* (Ziet.)*"* (= *Dacryomya jacutica* (Petr.)), and *Camptonectes* s. str. (Shurygin and Levchuk, 1982).

Foraminifera: *Ammodiscus glumaceus* Gerke et Sossip., *Saccammina inanis* Gerke et Sossip., *Astacolus praefoliaceus* (Gerke), *Lenticulina praemulta* Sapjan, L. orbigny (Roemer), and *L. toarcense* (Payard). At a level of the second concretion horizon (6.0 m from the base), there is the appearance of *Saccammina compacta* Gerke and *Trochammina taimyrensis* Sapjan.

Bed 2. Dark gray clayey aleurites, in places ferruginized, finely splintered. At the base is the horizon of cake-shaped (1.0 × 0.1 m) and bun-shaped concretions of calcareous siltstone, well persistent along strike, containing bivalves. At the levels of 2.2 and 4.3 m from the base are horizons of concretions composed of calcareous siltstone, red brown on the surface, gray on fresh fracture. Bed 2 pertains to sequence 17 (outcrop 5, beds 6–9; Levchuk, 1985) (Fig. 2). The thickness is 41.9 m.

Bivalves: *Oxytoma* ex gr. *jacksoni* (Pomp.), whole shells in concretions (specimen TF-18, the base of the bed). *Dacryomya gigantea* Schur. and *Liostrea taimyrensis* Zakh. et Schur. (specimen TF-19; specimens 100f, 102f, 103f) are spread across the bed.

The data on bivalves *Acrtotis* sp. ind. from the upper part of sequence 17 were reported (Shurygin and Levchuk, 1982). The representatives of the genus *Acrtotis* inferentially pertain to *Arctotis (Praearctotis) similis* Velikzh.

Foraminifera: *Saccammina* ex gr. *inanis* Gerke et Sossip., *Ammodiscus glumaceus* Gerke et Sossip., *Astacolus praefoliaceus* (Gerke), *Lenticulina praemulta* Sapjan.

The overlying sediments are exposed in the left and right edges of the glen ~80–40 m from the coast of the Khatanga Bay (Figs. 8, 9).

Bed 3. Dark gray finely splintered aleurites. At the base is a persistent horizon of concretions of calcareous siltstone (0.1 × 0.4 m). At the levels of 7.6, 7.9, 8.3, and 9.0 m from the base are the horizons of ellipsoidal concretions of calcareous siltstone. At the level of 9.35 m are ball-shaped concretions (0.15 m in diameter) of calcareous siltstone. Bed 3 is attributed to

Fig. 9. Outcrop 5. Exposures of beds 3–4 at the right edge of the glen. Photo by A.S. Alifirov, 2014.

sequence 17 (outcrop 5, beds 10–11; Levchuk, 1985) (Fig. 2). The thickness is 9.6 m.

Bivalves: *Arctotis (Praearctotis) similis* Velikzh., forming nestlike clusters of well-preserved individual valves (near the roof); *Liostrea taimyrensis* Zakh. et Schur. (specimen TF-19, specimen 107f) and *Dacryomya gigantea* Schur. (specimen 108f) are spread across the bed. *Dacryomya gigantea* Zakh. et Schur., *Nuculana (Jupiteria)* ex gr. *acuminata* (Goldf.) (specimen 110f), *Dacryomya gigantea Zakh*. et Schur., *Luciniola* sp., and *Pleuromya* sp. (specimen 111f) were found in the upper part of the bed (collected by A.N. Aleinikov).

Foraminifera: *Saccammina compacta* Gerke, *Ammodiscus glumaceus* Gerke et Sossip., *Astacolus praefoliaceus* (Gerke).

Bed 4. Dark gray finely splintered clayey aleurites. At the base is a persistent marker horizon (0.4 m) of calcareous siltstone, gray on fresh fracture, reddish yellow on the surface, strongly fractured. At a level of 0.2 m higher is a persistent horizon of calcareous bun-shaped concretions. At the levels of 4.0 and 7.0 m from the base are the horizons of concretions of calcareous siltstone. Bed 4 pertains to sequence 18 (outcrop 5, bed 12; Levchuk, 1985) (Fig. 2). The thickness is 9.5 m.

Bivalves: *Dacryomya gigantea* Zakh. et Schur were found at the bottom of the bed. Foraminifera: *Ammodiscus glumaceus* Gerke et Sossip., *Verneuilinoides syndascoensis* (Scharovskaja), *Saccammina compacta* Gerke, *Trochammina taimyrensis* Sapjan., and *Lenticulina praemulta* Sapjan.

Bed 5. Dark gray finely splintered clayey aleurites. At the base is a persistent horizon of concretions (2.0 × 0.4 m) of calcareous siltstone, gray on fresh fracture, reddish on the surface. At the level of 3.7 m from the base is a horizon of ellipsoidal concretions (0.3 × 0.15 m) of calcareous siltstone, bluish on the surface, gray on fresh fracture, containing bivalves. From the level of 4.0 m, the bed is traced from the estuary of the glen along the coast of the bay (Fig. 10). Bed 5 pertains to sequence 18 (outcrop 5, beds 13–14; Levchuk, 1985) (Fig. 2). The thickness is 6.0 m.

Ammonite was discovered in the concretion at the level of 3.7 m from the base of the bed by O.A. Lutikov and was identified as *Pseudolioceras* cf. *falcodiscus* (Quenst.) (specimen TF-20-A; Knyazev, 1991). Bivalves: *Malletia* ex gr. *amygdaloides* (Sow.) (specimem TF-21, the base); *Propeamussium olenekense* Bodyl., *Mclearnia kelimyarensis* (Zakh. et Schur.) (very often), gastropods (specimen TF-20, 3.7 m from the base); *Arctotis (Praearctotis) similis* Velikzh., forming nestlike clusters of poorly preserved individual valves in calcareous concretions (specimen TF-22, 4.0 m from the base). At the level of 5.0 m, *Arctotis (Praearctotis) similis* Velikzh. and *Propeamussium olenekense* Bodyl. (specimen 113f) were recorded by A.N. Aleinikov in 2014.

Foraminifera: *Ammodiscus glumaceus* Gerke et Sossip., *Saccammina compacta* Gerke, *Trochammina taimyrensis* Sapjan., *Verneuilinoides syndascoensis* (Scharovskaja).

The overlying beds 6–9 were encountered in the outcrop traced along the west coast of the Khatanga Bay. The outcrop represents a sea cliff about 15 m high (Fig. 10). The description of bed 6 starts at about 20 m from the near-estuary part of the glen toward the southwest. The near-estuary part of the glen is located 5.4 km from the head of the Utinaya Bay. The coordinates of the near-estuary part of the glen: 74°54.417′ N, 112°27.561′ E.

Fig. 10. Outcrop 5. Exposures of beds 4–7 at the right edge of the glen and at the sea cliff. The location of the found ammonite *Pseudolioceras* cf. *falcodiscus* (Quenst.) is designated by the arrow. Photo by A.S. Alifirov, 2014.

Fig. 11. Outcrop 5. Exposures of the boundary beds of the Korotkinskaya and Aprelevskaya formations. Photo by A.S. Alifirov, 2014.

The Aprelevskaya Formation (beds 6–8). The formation is composed of cyclically interbedded clays and coarse-grained and clayey siltstones, with interbeds and lenses of fine-grained sands with pebbles and plant detritus (Shurygin et al., 2000). The thickness of the formation according to Levchuk (1985) is 52.3 m; according to the new data, it is 58 m. The beds are exposed in the outcrop located on the west coast of the Khatanga Bay (Fig. 11).

Bed 6. Dark gray finely splintered aleurites, in places ferruginized. At the base is a persistent double horizon (up to 1.0 m) of calcareous siltstone, with pebbles and boulders (up to 0.15 m) and pieces of wood. At the level of 1.5 m from the base is a horizon of concretions of calcareous siltstone. In the upper part of the bed, the rocks contain impurity of sand material. Bed 6 pertains to sequence 19 (outcrop 5, beds 15–17; Levchuk, 1985) (Fig. 2). The thickness is 9.0 m.

Bivalves: *Arctotis (Arctotis)* ex gr. *tabagensis* (Petr.), *Propeamussium olenekense* Bodyl., *Malletia* ex gr. *amygdaloides* (Sow.), and *Nuculoma* sp. were encountered at the base of the bed (specimen TF-23). This bed was found to contain *Oxytoma* ex gr. *jacksoni* (Pomp.), *Arctica humiliculminata* Schur., *Astarte meeki* Stant., and *Musculus* sp. (Shurygin and Levchuk, 1982).

The glen of an unnamed brook (outcrop no. 7/1) had a complex of bivalves including *Propeamussium olenekense* Bodyl. and *Oxytoma* ex gr. *jacksoni* (Pomp.) 311 m from the estuary (specimen 81f; collected by A.N. Aleinikov).

Foraminifera: *Ammodiscus glumaceus* Gerke et Sossip., *Saccammina compacta* Gerke, *Trochammina taimyrensis* Sapjan., *Verneuilinoides syndascoensis* (Scharovskaja), and *Lenticulina praemulta* Sapjan. were encountered at the base of the bed; *Lenticulina multa* Schleifer appear starting from the level of 2.5 m.

Bed 7. Dark gray finely splintered sandy aleurites with numerous cake-shaped and ball-shaped pyrite nodules. At the base is a thin interbed (0.1 m) of calcareous siltstone. Bed 7 pertains to sequence 20 (outcrop 5, beds 18–19; Levchuk, 1985) (Fig. 2). The thickness is 15.0 m.

Bivalves: *Luciniola* sp., *Malletia* ex gr. *amygdaloides* (Sow.) (specimen TF-24). According to B.N. Shurygin and A.S. Alifirov, *Arctica humiliculminata* Schur. and *Arctotis (Arctotis) tabagensis* (Petr.) are distributed in this bed (Fig. 12).

Foraminifera: *Astacolus praefoliaceus* (Gerke), *Saccammina* sp., *Globulina* sp., *Marginulina* sp. (collected by A.N. Aleinikov).

Bed 8. Dark gray massive sandy siltstones. At the base is a thick horizon of concretions (0.6 × 2.0 m) of calcareous siltstone, gray on fresh fracture, reddish on the surface. Bed 8 corresponds to sequence 21 (out-

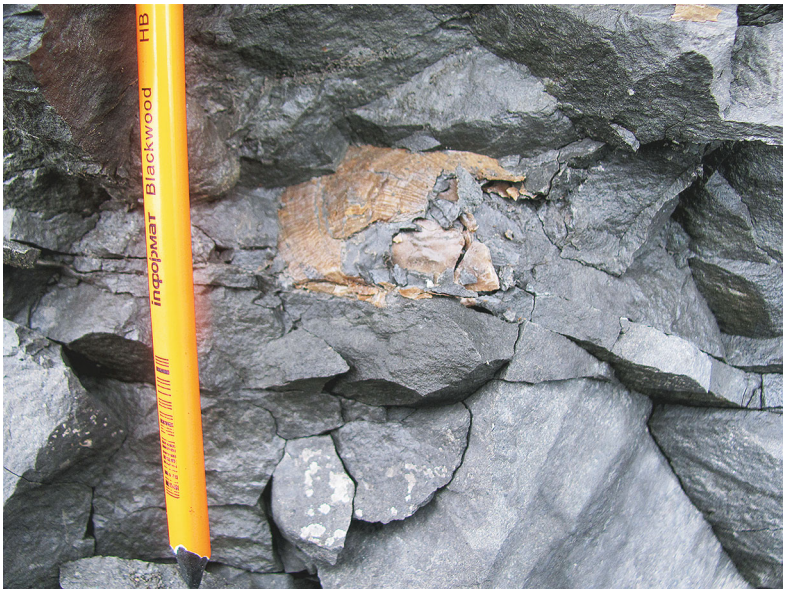


Fig. 12. Burial of *Arctotis (Arctotis) tabagensis* (Petr.) shells in bed 7. Photo by A.S. Alifirov, 2014. The length of the pencil is 15 cm.

Fig. 13. Outcrop 5. Exposures of the boundary beds of the Aprelevskaya and Arangastakhskaya formations. Photo by A.S. Alifirov, 2014.

crop 5, beds 19, 20; Levchuk, 1985) (Fig. 2). The thickness is 34.0 m.

Bivalves: *Malletia amygdaloides* (Sow.), *Pleuromya* sp. (specimen TF-25); clusters of shells of *Arctotis (Arctotis) tabagensis* (Petr.) (specimen TF-26, bottom). According to B.N. Shurygin, the bed includes *Retroceramus* sp. ind. and *Tancredia* sp. ind.

Arctotis (Arctotis) tabagensis (Petr.) were found in the glen of the unnamed brook (outcrop no 7/1) 200 m from the estuary (specimen 82f; collected by A.N. Aleinikov).

The Arangastakhskaya Formation. Composed of argillites and siltstones with thin sandstone interbeds in the lower part, light gray aleurites and siltstones with detritus in the upper part (Shurygin, 1978). The formation crops out in the cliff ~15 m high of the western coast of the Khatanga Bay (Fig. 13). The description of bed 9 starts at 5590 m from the head of the Utinaya Bay.

Bed 9. Dark gray sandy siltstones, greenish on the surface, with few jarosite patches. At the base is the interbed of greenish gray sandstone with pebbles, boulders, pieces of wood, and bivalves ~0.2–0.3 m thick. A concretion stratum (0.5 m) of calcareous siltstone is 0.5 m from the base. A horizon of concretions (0.5 × 1.5 m) of calcareous siltstone, gray on fresh fracture, reddish yellow on the surface, is found 1 m from the base. Ball-shaped concretions 0.5–0.7 m in diameter occur 1.8 m from the base. In the upper part are siltstones with pyrite nodules and pieces of wood. Bed 9 pertains to sequence 22 (outcrop 5, beds 21, 22; Levchuk, 1985) (Fig. 2). The thickness is 7.5 m.

Bivalves: *Retroceramus elegans* (Kosch.) (specimen TF-27, the base); in the scree of the upper part, there occur *Retroceramus menneri* (Kosch.), *Camptonectes* s. str. (specimen TF-27A), *Arctotis (Arctotis) tabagensis*, *Arctica humiliculminata* Schur., and *Nuculana (Jupiteria)* cf. *acuminata* (Goldf.).

Foraminifera: in the roof of the bed is *Trochammina taimyrensis* Sapjan. (collected by A.N. Aleinikov).

In the glen of the unnamed brook (outcrop no. 7/1) were found *Retroceramus elegans* Kosch. (bed 5, specimen 89f) at a distance of 115 m from the estuary and *Retroceramus menneri* Kosch. (bed 6, specimen 90f) at a distance of 95 m from the estuary (collected by A.N. Aleinikov).

Foraminifera *Trochammina praesquamata* Mjatliuk, *Lenticulina nordvikensis* (Mjatliuk), and *Ammodiscus arangastachiensis* appear in the higher parts of the Arangastakhskaya Formation (collected by A.N. Aleinikov).

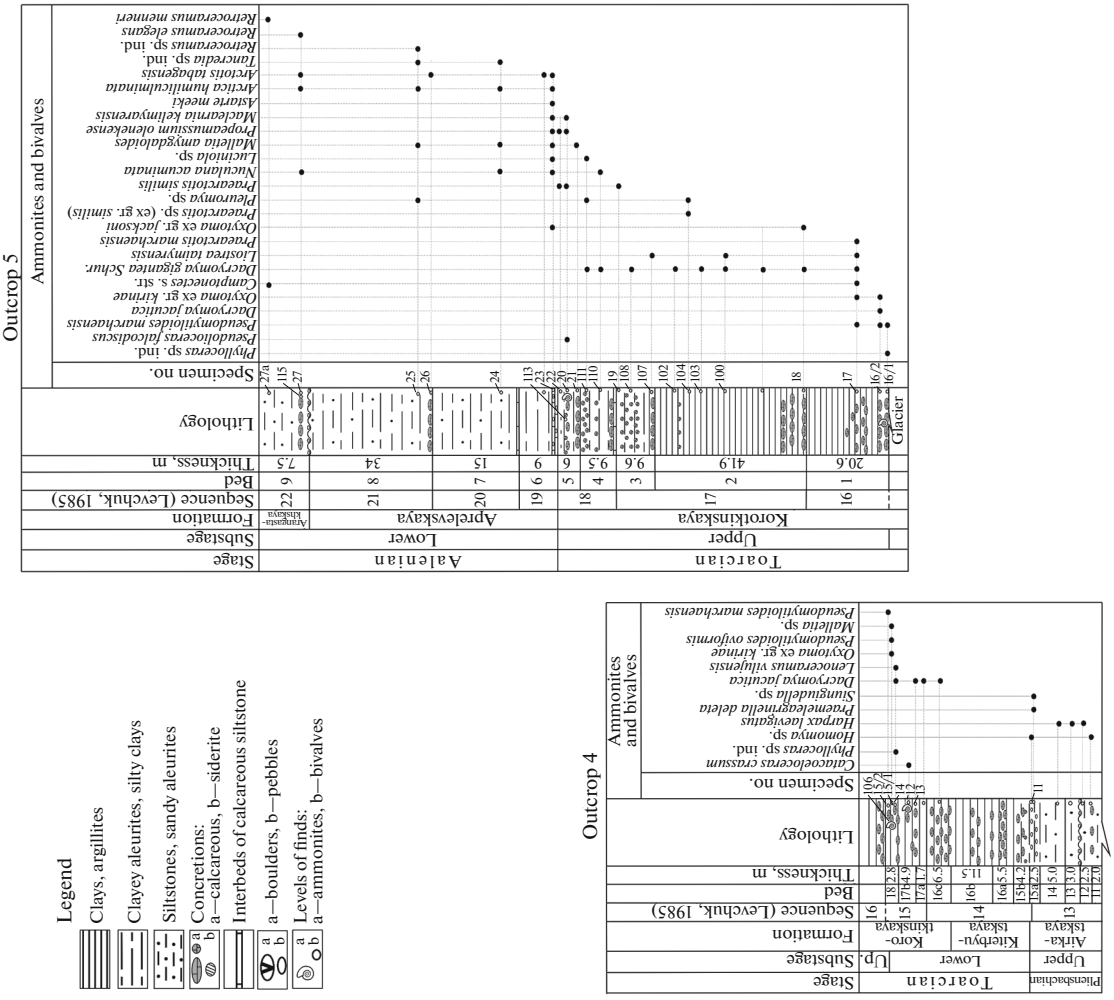


Fig. 14. Scheme of correlation of outcrops in the region of Cape Tsvetkov (Eastern Taimyr).

Figure 14 presents the correlation pattern of outcrops and paleontological characteristics of the beds.

RESULTS AND DISCUSSION

Lithostratigraphic subdivision of the section is based on the studies by M.E. Kaplan, M.A. Levchuk, B.N. Shurygin, and V.P. Devyatov (Kaplan et al., 1974; Shurygin and Levchuk, 1982, 1985; Shurygin et al., 2000). As a result of studying the collections of Early–Middle Jurassic fauna from the section of Cape Tsvetkov, which were gathered in the period of 1976–2014, new data appeared and allowed us to detail the biostratigraphy of the section and to refine the age-related framework of the formations. Next, we substantiate the age of the formations with their sequences and beds and identify the auxiliary biostratigraphic subdivisions: faunal beds.

The Airkatskaya Formation. The stratum in the framework of beds 11–15a contains a set of bivalves with *Harpax laevigatus* and *Homomya* sp., which is typical in the north of Siberia (the Anabar Bay, the Anabar and Tyung rivers) for the upper Pliensbachian Amaltheus stokesi and A. margaritatus zones (Shurygin, 1986; *Stratigrafiya*..., 1976). The stratum includes an aggregate of foraminifera: *Trochammina sablei*, *Saccammina ampulacea*, *Hyperammina neglecta*, *Glomospira* ex gr. *gordialis*, *Ammodiscus siliceus*, *Ammodiscus glumaceus*, *Kutzevella barrowensis*, *Bulbobaculites strigosus*, and *Recurvoides taimyrensis*. This aggregate is typical of the Trochammina sablei F-zone, whose stratigraphic framework in northern Siberia correlates with the Amaltheus margaritatus and Amaltheus viligaensis zones of boreal standard (Sapjanik, 1991b). Thus, beds 11–14 probably correspond to the Amaltheus margaritatus Zone.

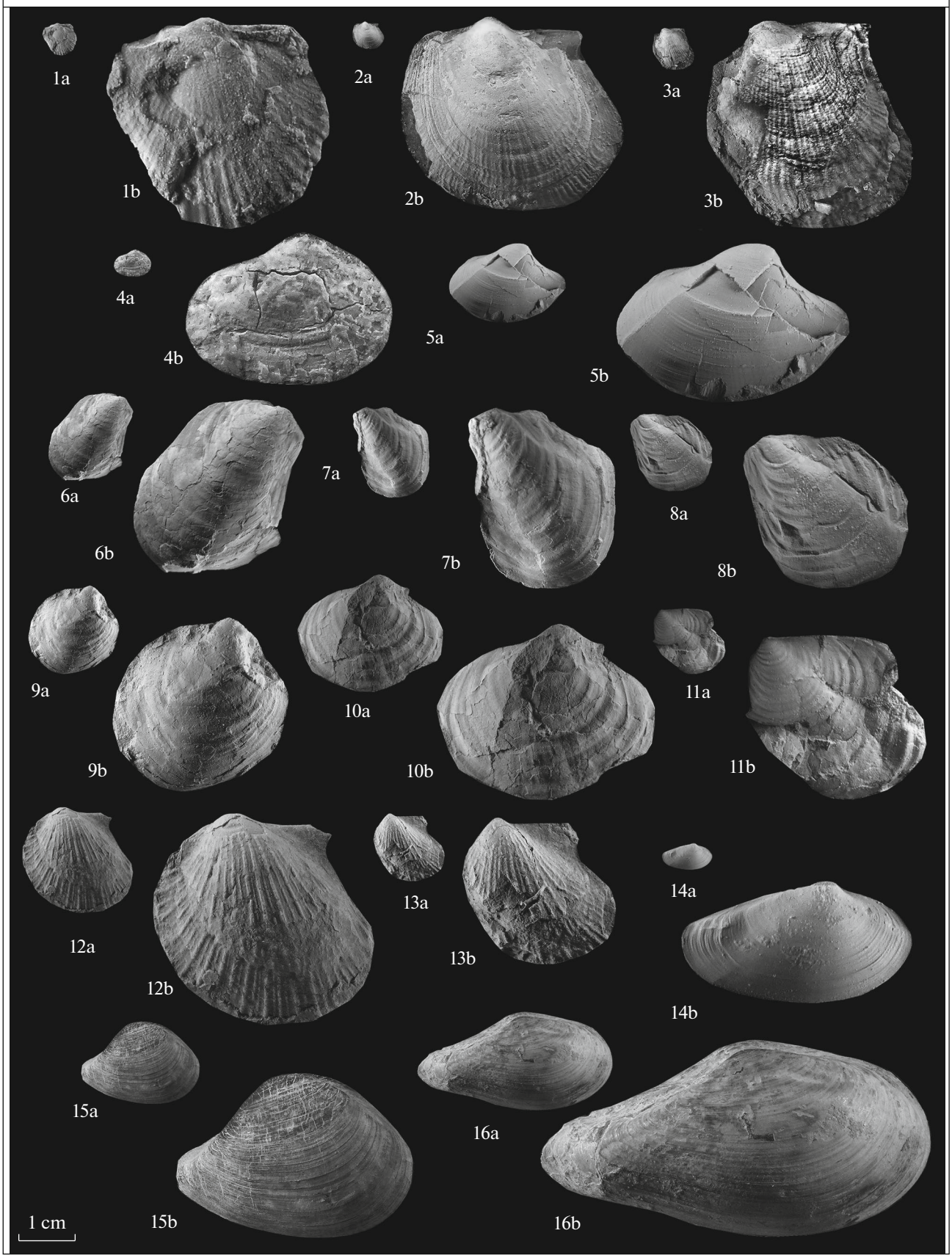
A unique assemblage of bivalves *Praemeleagrinella deleta*, *Neocrassina (Siungiudella)* cf. *parvula*, and *Homomya* sp. was encountered in bed 15a. Species *Praemeleagrinella deleta* is known from the upper Pliensbachian of France (Dumortier, 1869). Representatives of *Neocrassina (Siungiudella) parvula* are numerous in the upper Pliensbachian section in the Syungyude River (Lutikov, 1984), in which the *Amaltheus viligaensis* ammonites were found (Knyazev et al., 1991). The species *Recurvoides taimyrensis* occurs in large amounts in the assemblage of foraminfera. The *Recurvoides taimyrensis* epibole characterizes the f-zone (JF9), which corresponds in the north to the Amaltheus viligaensis and Tiltoniceras antiquum zones (*Resheniya*..., 2004). Thus, bed 15a probably corresponds to the Amaltheus viligaensis Zone.

A new biostraton was established for indexing the stratigraphic interval in the terminal part of the Pliensbachian.

Beds with Praemeleagrinella deleta. Bivalves attributed to "*Meleagrinella* cf. *substriata*" were found for the first time by B.N. Shurygin in the section of the Anabar Bay in the upper sequence of the Airkatskaya Formation represented by light gray siltstones that are intensely jarositized and contain stellate calcite formations (*Stratigrafiya*..., 1976). The similar forms are widely distributed in the upper Pliensbachian in the north of Russia and were found by O.A. Lutikov in the sections of the Kelimyar River in the "yellow bed" of the Kyrinskaya Formation and in the section of Cape Tsvetkov in the terminal bed of the Airkatskaya Formation (Plate I, figs. 1–3). In terms of the structure of the ligament block, these bivalves pertain to the subgenus *Praemeleagrinella* (Lutikov and Shurygin, 2010); they are very small in size, have a straight type of posterior wing and acute posterior auricle with a deep notch, and are close to *Praemeleagrinella deleta*

Plate I. Fig. 1. *Praemeleagrinella deleta* (Dum.), specimen no. TF-11/1: (1a) left valve, ×1; (1b) same, ×6; outcrop 4, bed 15, middle, specimen TF-11. Fig. 2. *Praemeleagrinella deleta* (Dum.), specimen no. 12/66/8: (2a) left valve, ×1; (2b) same, ×7; Anabar Bay, outcrop 5, bed 64, specimen no. 12/66 (collected by B.N. Shurygin). Fig. 3. *Praemeleagrinella deleta* (Dum.), specimen no. K-1012/202: (3a) left valve, ×1; (3b) same, ×7; the Kelimyar River, outcrop 5, bed 2, specimen no. K-1012. Fig. 4. *Siungiudella* cf. *parvula* Lutikov, specimen no. TF-11/2: (4a) right valve, ×1; (4b) same, ×6; outcrop 4, bed 15, middle, specimen TF-11. Fig. 5. *Dacryomya jacutica* (Petr.), specimen no. TF-15-1/3: (5a) view from the side of the right valve ×1; (5b) same, ×2; outcrop 4, bed 18, level 2.0 m from the base of the bed, specimen TF-15. Fig. 6. *Mytiloceramus (Lenoceramus) vilujensis* (Polub.), specimen no. TF-14/1: (6a) right valve, ×1; (6b) same, ×2; outcrop 4, bed 18, level of 1.2 m from the base of the bed, specimen TF-14. Fig. 7. *Mytiloceramus (Lenoceramus) vilujensis* (Polub.), specimen no. TF-14/2: (7a) left valve, ×1; (7b) same, ×2; outcrop 4, bed 18, level of 1.2 m from the base of the bed, specimen TF-14. Fig. 8. *Mytiloceramus (Lenoceramus) vilujensis* (Polub.), specimen no. TF-14/3: (8a) left valve, ×1; (8b) same, ×2; outcrop 4, bed 18, level of 1.2 m from the base of the bed, specimen TF-14. Fig. 9. *Mytiloceramus (Pseudomytiloides) oviformis* (Khudyaev in Krymholts et al., 1953), specimen TF-15-1/1: (9a) right valve, ×1; (9b) same, ×2; outcrop 4, bed 18, level of 2.0 m from the base of the bed, specimen TF-15/1. Fig. 10. *Mytiloceramus (Pseudomytiloides) oviformis* (Khudyaev in Krymholts et al., 1953), specimen no. TF-15-1/2: (10a) right valve, ×1; (10b) same, ×2; outcrop 4, bed 18, level of 2.0 m from the base of the bed, specimen TF-15/1. Fig. 11. *Mytiloceramus (Pseudomytiloides) marchaensis* (Petr.), specimen no. TF-15-2/1: (11a) left valve, ×1; (11b) same, ×2; outcrop 4, bed 18, from the interval of 2.0–2.8 m above the base, specimen TF-15/2. Fig. 12. *Oxytoma* ex gr. *kirinae* Velikzh., specimen no. TF-15-1/6: (12a) left valve, ×1; (12b) same, ×2; outcrop 4, bed 18, level of 2.0 m from the base of the bed, specimen TF-15/1. Fig. 13. *Oxytoma* ex gr. *kirinae* Velikzh., specimen no. TF-15-1/5: (13a) left valve, ×1; (13b) same, ×2; outcrop 4, bed 18, level of 2.0 m from the base of the bed, specimen TF-15/1. Fig. 14. *Malletia* aff. *amygdaloides* (Sow.), specimen no. TF-15-1/4: (14a) view from the side of the right valve, ×1; (14b) same, ×5; outcrop 4, bed 18, level of 20 m from the base of the bed, specimen TF-15. Fig. 15. *Dacryomya gigantea* Zakh. et Schur., specimen no. 103f/2, adolescent form: (15a) view from the side of right valve, ×1; (15b) same, ×2; outcrop 5, bed 2, middle, specimen 103f. Fig. 16. *Dacryomya gigantea* Zakh. et Schur., adult form, specimen no. 103f/3: (16a) view from the side of right valve, ×1; (16b) same, ×2; outcrop 5, bed 2, middle, specimen 103f.

Plate I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(Dumortier, 1869, pl. 35, fig. 5). This taxon was found in the upper Pliensbachian of France together with *Pleuroceras spinatum* ammonites (Dumortier, 1869, p. 293). The representatives of *Praemeleagrinella* from the *deleta* group were close to the forms from the Toarcian clays of the Kurungskaya sequence of the Kelimyar River section that were preliminarily recognized as "*Melleagrinella* aff. *substriata*" (Lutikov and Shurygin, 2010), but differ in the absence of bend on the external edge of the posterior wing. The species *Praemeleagrinella deleta* and "*Melleagrinella* aff. *substriata*" likely form a common phylogenetic succession. For the Eastern Taimyr SFZ, the beds with Praemeleagrinella deleta are identified as an auxiliary biostratigraphic subdivision for the first time and correlate with the Amaltheus viligaensis Zone of the boreal ammonite standard (Shurygin et al., 2011).

The Kiterbyutskaya Formation. The early Toarcian in Northeast Asia was characterized by transgressive filling of accumulative hollows and the formation of strata with uniform clayey composition in the lower part (Knyazev et al., 2003). The traces of the global early Toarcian transgression are represented by argillites of the Omolon massif (the northern Sea of Okhotsk region) and oil shales, clays, and argillites of the northern and eastern troughs of the Siberian Platform and reach the northeast of Western Siberia (Repin, 2020). In Eastern Siberia, the early Toarcian Kiterbyutskaya Formation occurs in the Eastern Taimyr SFZ and the Nordvik SFZ. It was assumed that, in the section of Cape Tsvetkov and the Anabar Bay, the Kiterbyutskaya Formation overlies the Pliensbachian sediments with a hiatus corresponding to the Dactylioceras tenuicostatum Zone of the northwest European standard (Knyazev et al., 2003; *Reshеniya...*, 1981; Shurygin et al., 2000).

Bed 15b in outcrop no. 4 of the Cape Tsvetkov section includes a transitional Pliensbachian–Toarcian assemblage of foraminifera, which, along with the species typical of the Pliensbachian (*Recurvoides taimyrensis*, *Ammodiscus siliceus*, *Ammodiscus glumaceus*, *Saccammina ampullacea*, *Jacullella jacutica*, and *Bulbobaculites strigosus*), contains the Toarcian species: *Trochammina kisselmani*, *Ammobaculites lobus*, *Saccammina inanis*, and *Lenticulina toarcense* (Sap'yanik, 1991a). In the reference section of the lower Toarcian in northeastern Russia (the Astronomicheskaya River), the first appearance of *Trochammina kisselmani* and *Saccammina inanis* is dated by the ammonites of the Tiltoniceras antiquum Zone (Knyazev et al., 2003). A similar mixed Pliensbachian–Toarcian assemblage of foraminifera was found at the base of the Kurungskaya sequence of the Kelimyarskaya Formation of the Kelimyar River section. In the opinion of B.L. Nikitenko, the presence of this assembladge may indicate the occurrence of counterparts for the Tiltoniceras antiquum Zone (Devyatov et al., 2010).

Bed 16a was found to contain bivalves *Dacryomya jacutica* and the assemblage of foraminifera represented by the early Toarcian species (*Trochammina kisselmani*, *Ammobaculites lobus*, *Saccammina inanis*, and *Triplasia kingakensis*) accompanied by a series of the Pliensbachian taxa *Ammodiscus glumaceus*, *Bulbobaculites strigosus*, and *Hyperammina neglecta*. The first appearance of bivalves *Dacryomya jacutica* and foraminifera *Triplasia kingakensis* in the reference section of the lower Toarcian (the Astronomicheskaya River) in northeastern Russia is dated by the ammonites of the Tiltoniceras antiquum Zone (Knyazev et al., 2003). Thus, beds 15b and 16a of the Kiterbyutskaya Formation may belong to the Tiltoniceras antiquum Zone of the boreal standard.

Bed 16b was found to contain bivalves *Dacryomya jacutica* and belemnites. The stratigraphic range of the *D. jacutica* distribution in the north of Russia covers the entire lower Toarcian (Shurygin, 1987). The Kiterbyutskaya Formation in the section of the Anabar Bay is considered in the framework of the Harpoceras falciferum Zone and the Dactylioceras commune Zone (Saks et al., 1963; Shurygin et al., 2000). Taking into account the position of bed 16b in the section and dating of the Kiterbyutskaya Formation in the Nordvik SFZ, we conventionally correlate this bed in the section of Cape Tsvetkov with the Harpoceras falciferum Zone and the Dactylioceras commune Zone of the boreal standard.

The Korotkinskaya Formation. The stratum including beds 17a–18 of outcrop no. 4 and the stratum represented by beds 1–7 of outcrop no. 5 were attributed to sequences 15 and 16 of the Korotkinskaya Formation (Levchuk, 1985; Shurygin et al., 2000). Bed 16c was earlier considered as a part of the Kiterbyutskaya Formation (sequence 14, bed 5; Levchuk, 1985). In the wall of the outcrop, this bed is visually different from the underlying stratum in dark gray color, well-manifested bedding, and persistent horizons of concretions (Figs. 5, 6). In its lithological characteristic, bed 16c corresponds to the sequence of "dark gray splintered mustones with numerous horizons of carbonate concretions," whose base contains ammonite *Dactylioceras* ex gr. *commune* (sequence 7; Kaplan et al., 1974). Bivalves *Dacryomya jacutica* were found in bed 16c. We assume that bed 16c should pertain to the Korotkinskaya Formation. The lower boundary of the bed is sharp and passes along the rock alteration; at the base of the bed is the horizon of flattened concretions.

In terms of the lithological and paleontological-taphonomic characterstic, beds 17a, 17b, and 18 in outcrop no. 4 (Fig. 6) belong to sequence 15 (outcrop 7, beds 1–4; Levchuk, 1985). At the base of bed 17a is a marker lense-shaped interbed of yellowish clays. Ammonite was discovered by O.A. Lutikov in bed 17b in the concretion horizon 1.8 m from the base in 1987 and was recognized as *Catacoeloceras crassum* (Knyazev et al., 1993). Retroceramids close to the species *Myti-*

loceramus (Lenoceramus) vilujensis, which is typical of sediments dated by the *Dactylioceras commune* ammonites in the Tyung, Markha, and Vilyui rivers and in the Anabar Bay, were encountered at the level of 1.2 m in bed 18 (Lutikov and Arp, 2020; Repin and Polubotko, 1992). At the level of 2.0 m from the base of bed 18, there are numerous retroceramids that are close to *Mytiloceramus (Pseudomytiloides) oviformis*, an abundant species in the Markha River in the beds with the known *Zugodactilites braunianus* (Knyazev et al., 2003). The foraminieral assemblage in beds 15b–18 in outcrop no. 4 including *Trochammina kisselmani*, *Ammobaculites lobus*, *Triplasia kingakensis*, *Astacolus praefoliaceus*, *Ammodiscus glumaceus*, and *Globulina jurensis* is typical of the Trochammina kisselmani F-zone, which is considered in the framework of the lower Toarcian in the north of Siberia (Sapjanik, 1991b).

Taking into account the dating of the beds with retroceramids and foraminifera in the sections of the Vilyui Syneclise and Yenisei-Khatanga Trough (Knyazev et al., 1983, 2003; Nikitenko, 2009; Polubotko, 1992; Repin and Polubotko, 1992), the stratum in the framework of beds 16c, 17, and 18 (0–2.0 m) in outcrop no. 4 pertains to the Dactylioceras commune and Zugodactilites braunianus zones.

Bed 18 in outcrop 18 in the interval of 2.0–2.8 m and bed 1 in outcrop no. 5 are characterized by retroceramids that are close to *Mytiloceramus (Pseudomytiloides) marchaensis*, a species distributed widely in Eastern Siberia and northeastern Russia in the sediments dated by the *Pseudolioceras compactile* and *Pseudolioceras wuerttenbergeri* ammonites (Knyazev et al., 2003).

In terms of lithological and paleontological-taphonomic characteristic, bed 1 in outcrop no. 5 (Fig. 7) is attributed to sequence 16 (outcrop 7, bed 1; Levchuk, 1985). In the upper part of sequence 16, *Mytiloceramus (Pseudomytiloides) marchaensis* were found together with *Arctotis (Praearctotis) marchaensis* and *Camptonectes* s. str. (Shurygin and Levchuk, 1982). In the sections of the Vilyui Syneclise (the Tyung and Markha rivers), the strata with joint distribution of *Pseudomytiloides marchaensis* and *Arctotis (Praearctotis) marchaensis* are dated by the ammonites of the Pseudolioceras wuerttenbergeri Zone (Knyazev et al., 2003). Taking into account the succession of bivalve assemblages in the sections of northeastern Russia and the Vilyui Sineclyse, sequence 16 of the Korotkinskaya Formation may be attributed to the counterparts of the Pseudolioceras compactile and Pseudolioceras wuerttenbergeri zones of the boreal standard.

The overlying stratum of the Cape Tsvetkov section including beds 2 and 3 of outcrop no. 5 (Figs. 7, 8) correlates with sequence 17 of the Korotkinskaya Formation (outcrop 5, beds 6–11; Levchuk, 1985) (Fig. 2). The lithological markers of the stratum are the horizon of the cake-shaped (1.0 × 0.1 m) and bun-shaped concretions of calcareous siltstone, which is well persistent along strike at the base of bed 2, and the upper part of bed 3 with numerous concretion horizons. Bed 2 is characterized by *Oxytoma* ex gr. *jacksoni*, *Dacryomya gigantea*, and *Liostrea taimyrensis*. *Arctotis* sp. ind. was found in sequence 17 (Shurygin and Levchuk, 1982).

Beds 4–5 in outcrop no. 5 correlate with sequence 18 of the Korotkinskaya Formation (outcrop 5, beds 12–14; Levchuk, 1975) (Fig. 2). A lithological marker is the horizon of concretions of calcareous siltstone ~0.4 m thick at the base of bed 4. Beds 4–5 are characterized by *Arctotis (Praearctotis) similis*, *Dacryomya gigantea*, *Propeamussium olenekense*, *Maclearnia kelimyarensis*, *Malletia* ex gr. *amygdaloides*, *Nuculana (Jupiteria) acuminata*, and *Luciniola* sp. The find of ammonite *Pseudolioceras* cf. *falcodiscus* in bed 5 of outcrop no. 5 (Fig. 10) indicates that sequence 18 pertains to the Pseudolioceras falcodiscus Zone of the boreal standard (Shurygin et al., 2011; Zakharov et al., 1997).

The stratigraphic framework of the beds with Propeamussium olenekense, Oxytoma jacksoni, and "Arctotis marchaensis" in the Toarcian–Aalenian sediments in the north of Russia remained debatable until recently. In the existing unified regional stratigraphic sectional plane of Jurassic sediments in Central Siberia, the lower boundary of the beds with Propeamussium olenekense and Arctotis marchaensis was conventionally combined with the Aalenian base (*Resheniya*..., 1981). On the other hand, the upper Toarcian ammonites *Pseudolioceras compactile*, *P. falcodiscus* were found in the section of the Kelimyar River in the beds with Oxytoma jacksoni and Propeamussium olenekense assemblage (Knyazev et al., 1984, 2007). A similar assemblage of bivalves with *Propeamussium olenekense*, *Oxytoma* cf. *jacksoni*, and *Arctotis* cf. *marchaensis* in the section of the Viliga River originates from the sequence with ammonites *Pseudolioceras replicatum* Buckm., and the sequences with *Pseudolioceras beyrichi* and *Pseudolioceras maclintocki* were found to contain *Propeamussium olenekense* and *Oxytoma jacksoni* (Repin and Polubotko, 2015). In the modern ammonite scale of northeastern Russia, the species *Pseudolioceras replicatum* indexes the terminal Toarcian zone (Repin, 2016). From this, it follows that the stratigraphic framework of the beds with Oxytoma jacksoni and Propeamussium olenekense covers the upper Toarcian zone and the lower Aalenian zone in the north of Russia.

As a result of revision of the genus *Arctotis*, it was established that the stratigraphic range of the species *Arctotis (Praearctotis) marchaensis* and *Arctotis (Praearctotis) similis* correlates with the two upper Toarcian zones, and the distribution interval of species *Arctotis (Arctotis) tabagensis* correlates with the lower Aalenian zone (Lutikov and Shurygin, 2010). The species *Arctotis (Praearctotis) similis* is a biostratigraphic marker of the upper Toarcian in Eastern Siberia. In the section of the Motorchuna River, the representatives of *Arctotis*

(Praearctotis) similis Velikzh. occur in the upper part of the Suntarskaya Formation. These beds were found to include ammonites *Pseudolioceras falcodiscus* (Knyazev et al., 1991) and *Pseudolioceras motortschunense* (Repin, 2017). In the section of the Anabar Bay, the finds of *Arctotis (Praearctotis) similis* are confined to the beds of the Khorogonskaya Formation, containing *Pseudolioceras falcodiscus* in the scree (Knyazev, 1991).

Thus, beds 2–5 of the Korotkinskaya Formation are assigned to the Pseudolioceras falcodiscus Zone of the boreal standard on the basis of the assemblages of bivalves *Arctotis (Praearctotis) similis* Velikzh., *Oxytoma* ex gr. *jacksoni*, and *Propeamussium olenekense* and the presence of *Pseudolioceras* cf. *falcodiscus*.

The foraminiferal assemblage in beds 1–5 of outcrop no. 5 of the Korotkinskaya Formation, including *Trochammina Taimyrensis*, *Ammodiscus glumaceus*, *Astacolus praefoliaceus*, and *Verneuilinoides syndascoensis*, characterizes the *Trochammina taimyrensis* F-zone, which in northeastern Siberia is considered in the framework of the Pseudolioceras compactile and P. macklintocki zones (Sapjanik, 1991b).

For indexing individual stratigraphic Toarcian intervals, we established new biostratigraphic subdivisions based on bivalves.

Beds with Lenoceramus vilujensis. They are recognized for the first time for the Eastern Taimyr SFZ. As an auxiliary biostratigraphic subdivision, the beds with Lenoceramus vilujensis were recognized for the first time in the Suntarskaya SFZ (the Tyung, Markha, and Vilyui rivers) in the framework of two local lower Toarcian ammonite zones: Dactylioceras athleticum and Zugodactylites monestieri. As a regional stratigrapfic subdivision of Eastern Siberia, the beds with Lenoceramus vilujensis and Meleagrinella faminaestriata were proposed in the framework of the Dactylioceras athleticum and Zugodactylites monestieri zones (Repin and Polubotko, 1992). In the Tyung River, the first *Mytiloceramus (Lenoceramus) vilujensis* Polub. reliably appear at the level of the Dactylioceras athleticum Zone. In the section of Eastern Taimyr, the beds with Lenoceramus vilujensis are traced in sequence 15 (outcrop no. 4, bed 18, the level of 1.2 m). The beds with Lenoceramus vilujensis are considered in the framework of the Dactylioceras commune Zone of the boreal standard (Shurygin et al., 2011; Zakharov et al., 1997).

Beds with Pseudomytiloides oviformis. They are recognized for the first time for the Eastern Taimyr SFZ. According to the studies by G.T. Petrova, the initial definition of species "*Mytiloides*" *oviformis* belongs to E.I. Khudyaev (Krymholts et al., 1953, p. 55). A holotype of the species is represented by specimen no. 806/5393 from the section of the Markha River (Krymholts et al., 1953, pl. VII, fig. 6) and is kept at the Chernyshev Central Scientific Research Geological Survey Museum (St. Petersburg). O.A. Lutikov established that the specimens described by G.T. Petrova as "*Mytiloides*" *oviformis* belong to the subgenus *Pseudomytiloides* Koschelkina, 1963 by the presence of byssal auricle and by the sculpture type. In the Markha River, the appearance of *Pseudomytiloides* representatives with a smooth sculpture correlates with the level of distribution of ammonites *Zugodactilites braunianus* in the section. In the section of Cape Tsvetkov, the beds with *Pseudomytiloides oviformis* are traced in sequence 15 (outcrop no. 4, bed 18, the level of 2.0 m; outcrop no. 5, bed 1, base of the bed). In a series of the Lower Jurassic sections of Eastern Siberia (the Anabar Bay and the Vilyui, Tyung, and Markha rivers), species *Mytiloceramus (Pseudomytiloides) oviformis* (Khudyaev in Krymholts et al., 1953) replaces *Mytiloceramus (Lenoceramus) vilujensis* Polubotko. The beds with *Pseudomytiloides oviformis* are considered in the framework of the Zugodactilites braunianus Zone of the boreal standard (Shurygin et al., 2011; Zakharov et al., 1997).

Beds with Pseudomytiloides marchaensis. These beds were identified for the first time by B.N. Shurygin in the section of Cape Tsvetkov and conventionally correlated with the Zugodactylites monestieri Zone (Shurygin and Levchuk, 1982). In the standard scale based on bivalves, the Pseudomytiloides marchaensis b-zone correlates with the upper Toarcian Pseudolioceras compactile Zone (Shurygin et al., 2011). The beds are traced in sequences 15 and 16 of the Korotkinskaya Formation (outcrop no. 4, bed 18, interval of 2.0–2.8 m; outcrop no. 5, bed 1, interval of 2.0–20.6 m). The stratigraphic range of the species *Pseudomytiloides marchaensis* covers the Pseudolioceras compactile and Pseudolioceras wuerttenbergeri zones of the boreal standard (Knyazev et al., 2003); therefore, the beds with Pseudomytiloides marchaensis are regarded in this work within the two upper Toarcian zones: Pseudolioceras compactile and Pseudolioceras wuerttenbergeri of the boreal standard (Shurygin et al., 2011; Zakharov et al., 1997).

Beds with Praearctotis marchaensis. They are recognized for the first time in the section of Cape Tsvetkov. In the standard scale based on bivalves, the Pseudomytiloides marchaensis b-zone correlates with the two zones of the upper Toarcian and lower Aalenian (Shurygin et al., 2011). In the Lower Jurassic sections of Eastern Siberia (the Anabar Bay, the Vilyui, Tyung, and Markha rivers), species *Arctotis (Praearctotis) marchaensis* replaces *Arctotis (Praearctotis) milovae*. The beds with Praearctotis marchaensis occupy a smaller stratigraphic framework compared to the b-zone of Arctotis marchaensis as a result of the revision of species *Arctotis marchaensis* (Lutikov and Shurygin, 2010). In the Markha River, the teilzone of species *Arctotis (Praearctotis) marchaensis* is dated by ammonites *Pseudolioceras wuerttenbergeri* (Knyazev et al., 2003). The beds are traced in sequence 16 of the Korotkinskaya Formation. On the basis of the section of the Markha River, the beds with *Praearctotis marchaensis*

are recognized in the framework of the upper Toarcian Pseudolioceras wuerttenbergeri Zone of the boreal standard (Shurygin et al., 2011; Zakharov et al., 1997).

Beds with Praearctotis similis. They are recognized for the first time for the Eastern Taimyr SFZ. According to modern ideas, the Dacryomya gigantea b-zone correlating with a part of the upper Toarcian and the lower part of the Aalenian is distinguished in the section of Cape Tsvetkov (Shurygin et al., 2000). Species *Arctotis similis* Ve1ikzh. and *A. viluiensis* Ve1ikzh. were described for the first time by L.S. Velikzhanina from the upper part of the Suntarkskaya Formation of the Vilyui River section (Velikzhanina, 1966). Earlier both species were regarded as synomyms (Lutikov and Shurygin, 2010). In studying the type collection kept at the Chernyshev Central Scientific Research Geological Survey Museum (St. Petersburg), O.A. Lutikov determined the differences between the taxa. In this work, we regard species *A. viluiensis* as a synonym to *Arctotis (Praearctotis) marchaensis* (Petr.). In the Lower Jurassic sections of Eastern Siberia (the Anabar Bay, the Vilyui and Tyung rivers), species *Arctotis (Praearctotis) similis* replaces *Arctotis (Praearctotis) marchaensis*. In the section of Cape Tsvetkov, the teilzone of species *Arctotis (Praearctotis) similis* is dated by ammonite *Pseudolioceras cf. falcodiscus* found in bed 5 in outrop no. 5. The beds are traced in sequences 17 and 18 of the Korotkinskaya Formation. The beds with Praearctotis similis are recognized in the framework of the upper Toarcian Pseudolioceras falcodiscus Zone of the boreal standard (Shurygin et al., 2011; Zakharov et al., 1997).

The Aprelevskaya Formation. The stratum including beds 6–8 of outcrop no. 5 pertains to the Aprelevksya Formation (sequences 19–21, Levchuk, 1985; Shurygin et al., 2000).

Bed 6 is characterized by bivalve assemblage with *Oxytoma* ex gr. *jacksoni*, *Propeamussium olenekense*, *Malletia* ex gr. *amygdaloides*, *Maclearnia kelimyarensis*, *Nuculana acuminata*, and *Luciniola* sp. The foraminiferal assemblage comprises *Ammodiscus glumaceus* Gerke et Sossip., *Saccammina compacta*, *Trochammina taimyrensis*, *Verneuilinoides syndascoensis*, and *Lenticulina praemulta*. At the level of 2.5 m from the base, *Lenticulina multa* Schleifer appear.

Beds 7 and 8 are characterized by bivalves *Arctotis (Arctotis) tabagensis* (Petr.), *Malletia* ex gr. *amygdaloides* (Sow.), *Arctica humiliculminata* Schur., *Nuculana (Jupiteria) acuminata* (Goldf.), *Luciniola* sp., and *Tancredia* sp. ind. The first *Retroceramus* sp. ind. were reported from bed 7 (sequence 21; Shurygin and Levchuk, 1982).

The representatives of *Arctotis* from sequences 19–21 of the Eastern Taimyr section were attributed earlier to *Arctotis lenaensis* (Lah.) (Shurygin and Levchuk, 1982). On the basis of the features of the external morphology of the left valve, such as the occurrence of subrectangular anterior auricle separated from the remaining surface by a depression (Plate II, figs. 8–9), these bivalves are recognized as *Arctotis (Arctotis) tabagensis*. Species *Arctotis (Arctotis) tabagensis* (Petr.) is widely distributed in the north of Russia (the Anabar Bay, the Motorchuna, Molodo, Lena, Tyung, Markha, and Vilyui rivers). The first *Arctotis (Arctotis) tabagensis* in the Motorchuna River are widespread at the base of the Kystatymskaya Formation in the bed where ammonites *Pseudolioceras maclintocki* were discovered (*Stratigrafiya*..., 1976).

On the basis of the section of the Motorchuny River, the interbed of siltstone with pebbles and boulders at the base of the Aprelevskaya Formation in the section of Cape Tsvetkov with shell deposits including *Arctotis (Arctotis)* ex gr. *tabagensis* can be conventionally combined with the lower boundary of the maclintocki Zone. Consequently, the stratum recognized as *Arctotis tabagensis* (sequences 19–21) is a counterpart of the lower Aalenian Pseudolioceras maclintocki Zone of the boreal standard (Shurygin et al., 2011; Zakharov et al., 1997). This is evidenced by the accompanying foraminiferal assemblage with *Ammodiscus glumaceus* Gerke et Sossip., *Saccammina compacta*, *Trochammina taimyrensis*, *Verneuilinoides syndascoensis*, and *Lenticulina praemulta* that characterizes the F-zone of Trochammina taimyrensis, having the upper part dated by ammonites *Pseudolioceras maclintocki* in the Upper Yana region (Nikitenko, 2009) and by ammonites *Pseudolioceras beyrichi* on the Kelimyar River (Sapjanik, 1991b).

The Arangastakhskaya Formation. Bed 9 pertains to the Arangastakhskaya Formation (sequence 22; Levchuk, 1985; Shurygin et al., 2000) (Fig. 2). The lithological marker is the interbed of greenish gray sandstone with pebbles, boulders, pieces of wood, and bivalves with a thickness of ~0.2–0.3 m at the base of bed 9.

Bed 9 is characterized by an assemblage of bivalves: *Retroceramus elegans*, *Arctotis (Arctotis) tabagensis*, *Arctica humiliculminata* Schur., and *Nuculana (Jupiteria)* cf. *acuminata*. In the scree of the upper part of the bed are *Retroceramus menneri*, *Camptonectes* s. str. Foraminifera *Trochammina taimyrensis* were encountrered at the roof of the bed.

The correlation of the boreal lower Aalenian with the European standard is the subject of discussion (Knyazev et al., 2007; Repin, 2016). According to the modern ideas, the lower Aalenian in Eastern Siberia is regarded in the framework of the Pseudolioceras maclintocki Zone, where at the base the beds with P. beyrichi are recognized (Shurygin et al., 2011; Zakharov et al., 1997). The recognition of the lower Aalenian assemblage with bivalves in the north of Russia is also debatable. There is a viewpoint that the level at which retroceramids appear in the sections of the north of Russia coincides with the boundary of the Lower and Middle Juarassic. This is confirmed by the finds of retroceramids in the same strata together with

the lower Aalenian ammonites in the Upper Yana region and in northeastern Russia (Koshelkina, 1963, 1967, 1985; Repin and Polubotko, 2015). In the sectional plane of northeastern Russia, the Retroceramus elegans–Retroceramus jurensis Zone correlates with the lower and upper Aalenian (*Resheniya*..., 2009).

There is an opinion that retrocerams did not appear synchronously in the entire territory of north of Russia. In the existing unified regional stratigraphic sectional plane of Jurassic sediments in Eastern Siberia, it is accepted that the lower boundary of the beds with Retroceramus elegans passes above the boundary of the Lower and Middle series of the Jurassic (*Resheniya*..., 1981). In the standard scale based on bivalves, the b-zone of Retroceramus elegans is identified in the framework of the upper part of the lower Aalenian and the lower part of the upper Aalenian (Shurygin et al., 2011). The finds of ammonites and retroceramids in the Kelimyar River are consistent with these points of view. No retrocerams were recognized in the same bed with Pseudolioceras beyrichi in the outcrop on the Kelimyar River (Knyazev et al., 1984). Shell deposits with *Retroceramus elegans* were found by O.A. Lutikov in the scree of the higher beds in the same outcrop. *Retroceramus elegans* occurred together with *Retroceramus jurensis* in the condensed bed at the base of the Arangastakhskaya Formation in the Anabar Bay. The same bed also contained *Retroceramus menneri* (Koshelkina, 1974). This section was assumed not to contain the beds with Retroceramus elegans (Meledina and Shurygin, 2000). Thus, in the sections of the Lena-Anabar and Yenisei-Khatanga troughs, between the recent Toarcian ammonites *Pseudolioceras falcodiscus* and the first *Retroceramus elegans*, there is a part of the section not characterized by retroceramids. In the Kelimyar River, this part correlates with the upper part of the beds with Maclearnia kelimyarensis, Propeamussium olenekense, and Oxytoma ex gr. jacksoni and the beds with Pseudolioceras beyrichi (Knyazev et al., 1984, 2003); in the section of Cape Tsvetkov, it correlates with the upper part of the beds with Maclearnia kelimyarensis, Propeamussium olenekense, and Oxytoma ex gr. jacksoni (bed 6) and the beds with Arctotis (Arctotis) tabagensis (beds 6–8).

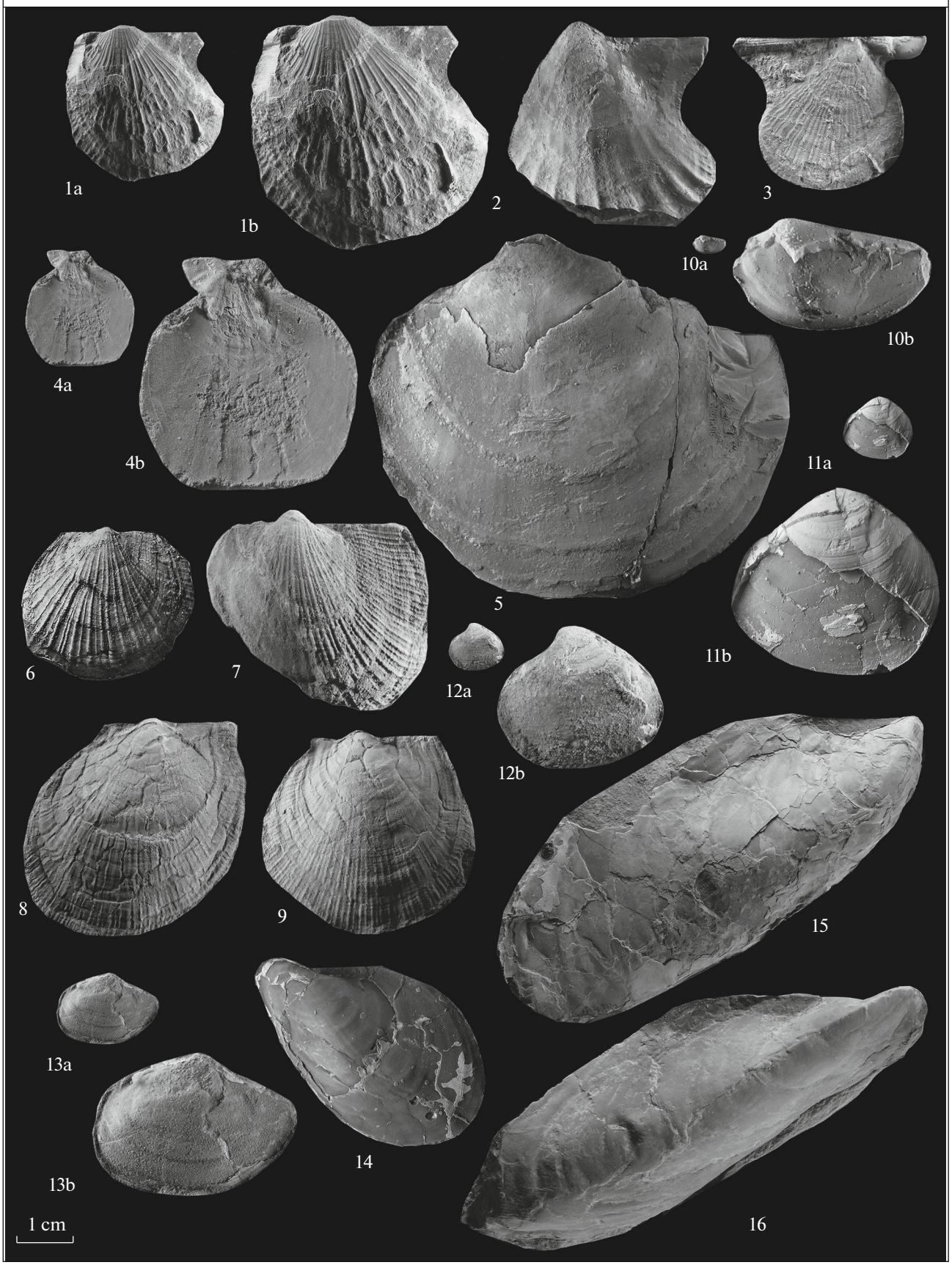
The first reliably recognized appearance of *Retroceramus elegans* is confined to bed 9 in the section of Cape Tsvetkov. The first *Retroceramus elegans* were encountered in the section of the Motorchuna River by O.A. Lutikov in the marker stratum of calcareous sandstone in the Lower Kystatymskaya Subformation together with *Arctotis (Arctotis) tabagensis*. *Pseudolioceras maclintocki* were found in the bed above this stratum (Bidzhiev, 1965; *Stratigrafiya*..., 1976). Thus, the lower sequence of the Arangastakhsksya Formation that comprises the assemblage of bivalves *Retroceramus elegans* and *Arctotis (Arctotis) tabagensis* likely belongs to the lower Aalenian. This inference is confirmed by the formaminiferal assemblages. The roof of bed 9 was found to have species *Trochammina taimyrensis*, characterizing the Trochammina taimyrensis F-zone (upper Toarcian–lower Aalenian). The higher beds of the Arangastakhsksya Formation were found to contain *Trochammina taimyrensis* and *Lenticulina nordvikensis* (collected by A.N. Aleinikov), which are the indices of the Trochammina praesquomata F-zone (lower Aalenian–upper Bajocian) (Sapjanik, 1991b) and the Lenticulina nordvikensis f-zone (upper Aalenian) (Nikitenko, 2009).

To index the stratigraphic interval in the framework of the lower Aalenian in the Tsvetkov geological region, a new biostraton was established on the basis of bivalves.

Beds with Praearctotis tabagensis. They are recognized for the first time as an auxiliary biostartigraphic subdivision for the Eastern Taimyr SFZ in the framework of the Pseudolioceras maclintocki Zone of the boreal standard (Shurygin et al., 2011; Zakharov et al., 1997). In some Lower Jurassic sections of Eastern

Plate II. Fig. 1. *Oxytoma* ex gr. *jacksoni* (Pomp.), specimen no. TF-18/2: (1a) left valve, ×1; (1b) same, ×1.5; outcrop 5, bed 2, base, specimen TP-18. Fig. 2. *Oxytoma* ex gr. *jacksoni* (Pomp.), specimen no. 81f/1, nucleus of left valve, ×1, outcrop 7/1, bed 3, VII concretion horizon, specimen 81d (collected by A.N. Aleinikov). Fig. 3. *Oxytoma* ex gr. *jacksoni* (Pomp.), specimen no. 81f/2, nucleus of right valve with remains of shelly layer, ×1, outcrop 7/1, bed 3, VII concretion horizon, specimen 81f (collected by A.N. Aleinikov). Fig. 4. *Propeamussium olenekense* Bodyl., specimen no. 113f/1: (4a) inner nucleus of right valve, ×1; (4b) same, ×2; outcrop 5, bed 6, level of 5.0 m from the base of the bed, specimen 113f (collected by A.N. Aleinikov). Fig. 5. *Maclearnia kelimyarensis* Zakh. et Schur., specimen no. TF-20/1, view from the side of left valve, ×1, outcrop 5, bed 5, level of 3.7 m from the base of the bed, specimen TF-20. Fig. 6. *Arctotis (Praearctotis) similis* Velikzh., specimen no. TP-19/1, left valve, ×1, outcrop 5, bed 3, near the roof, specimen TF-19. Fig. 7. *Arctotis (Praearctotis) similis* Velikzh., specimen no. 113f/2, left valve, ×1, outcrop 5, bed 6, level of 5.0 m from the base of the bed, specimen 113f (collected by A.N. Aleinikov). Fig. 8. *Arctotis (Arctoris) tabagensis* (Petr.), specimen no. TF-26/2, deformed nucleus of left valve, ×1, outcrop 5, bed 8, bottoms, specimen TF-26. Fig. 9. *Arctotis (Arctoris) tabagensis* (Petr.), specimen no. 82f/1, nucleus of left valve, ×1, outcrop 7/1, bed 3, roof, specimen 82f (collected by A.N. Aleinikov). Fig. 10. *Malletia* ex gr. *amygdaloides* (Sow.), specimen no. TF-21/1: (10a) nucleus of left valve with remains of shelly layer, ×1; (10b) same, ×6; outcrop 5, bed 5, base, specimen TF-21. Fig. 11. *Luciniola* sp., specimen no. TF-23/1: (11a) nucleus of right valve with remains of shelly layer, ×1; (11b) same, ×3; outcrop 5, bed 6, base, specimen TF-23. Fig. 12. *Arctica humiliculminata* Schurygin, specimen no. TF-24/2: (12a) right valve, ×1; (12b) same, ×3; outcrop 5, bed 7, specimen TF-24. Fig. 13. *Tancredia* sp., specimen no. TF-24/1: (13a) nucleus of right valve, ×1; (13b) same, ×2; outcrop 5, bed 7, specimen TF-24. Fig. 14. *Retroceramus elegans* Kosch., specimen TF 27/1, left valve of an adolescent specimen, ×1, outcrop 5, bed 9, specimen TF-27. Fig. 15. *Retroceramus elegans* Kosch., specimen TF 27/2, right valve of an adult specimen, ×1, outcrop 5, bed 9, specimen TF-27. Fig. 16. *Retroceramus menneri* Kosch., specimen 90f/1, right valve of an adult specimen, ×1, outcrop 7/1, bed 6, level of 1.5 m from the base of the bed, specimen 90f (collected by A.N. Aleinikov).

Plate II



Siberia (the Motorchuna River, the Anabar Bay, and Cape Tsvetkov), species *Arctotis (Arctotis) tabagensis* replaces *Arctotis (Praearctotis) similis*. The first appearance of *Arctotis (Arctotis) tabagensis* in the section of the Motorchuna River is dated by ammonite *Pseudolioceras maclintocki* (*Stratigrafiya*..., 1976). In the section of the western coast of the Anabar Bay, this species occurs in the condensed bed (1.4 m thick) at the base of the Arangastakhsksya Formation together with *Retroceramus elegans* Kosch. (below the level with *Pseudolioceras (Tugurites) whiteavesi* and *P. (T.) fastigatum*) (Lutikov and Shurygin, 2010; Meledina and Shurygin, 2000). The beds are traced in the Aprelevskaya and Arangastakhsksya formations of the Cape Tsvetkov section (sequences 19–22, Levchuk, 1985).

CONCLUSIONS

As a result of studying the faunal collections from the outcrops in the region of Cape Tsvetkov of Eastern Taimyr gathered in the period of 1976–2014, complex paleontological investigations of the Pliensbachian–Aalenian part of the section were carried out. On the basis of the analysis of the distribution of the found ammonites, bivalves, and foraminifera, the section was correlated with the subdivisions of the boreal standard ammonite scale (Shurygin et al., 2011; Zakharov et al., 1997) and the framework of the local stratigraphic subdivisions was refined.

To index the individual stratigraphic intervals as the auxiliary biostratigraphic subdivisions, the beds were recognized by bivalves from the family Oxytomidae Ichikawa, 1958 and the family Retroceramidae Koschelkina, 1971.

The beds with Praemeleagrinella deleta, which are an age-related counterpart of the Amaltheus viligaensis Zone, were identified in the terminal part of the Airkatskaya Formation. The associated foraminiferal assemblage is represented by the taxa of the Trochammina sablei F-zone.

The assemblage of the Recurvoides taimyrensis f-zone (JF9), which is correlated with the Amaltheus viligaensis Zone and the Tiltoniceras antiquum Zone, was recognized at the base of the Kiterbyutskaya Formation. In terms of correlation with northeastern Russia, the lower part of the Kiterbyutskaya Formation in the section of the Cape Tsvetkov region was inferentially assigned to the lower Toarcian Tiltoniceras antiquum ammonite zone. In this context, we propose to consider the Kiterbyutskaya Formation in the Eastern Taimyr SFZ in the framework of the Tiltoniceras antiquum and Harpoceras falciferum zones and the lower part of the Dactylioceras commune Zone of the boreal standard.

The stratigraphic framework of the Korotinskaya Formation was refined: the lower part is dated as the early Toarcian (= the Dactylioceras commune Zone); the upper part is dated as the late Toarcian (= the Pseudolioceras falcodiscus Zone). To index the upper part of the lower Toarcian, the beds with Lenoceramus vilujensis (= the Dactylioceras commune Zone) and the beds with Pseudomytiloides oviformis (= the Zugodactylites braunianus Zone) were identified. To index the lower part of the upper Toarcian, the beds with Pseudomytiloides marchaensis (= the Pseudolioceras compactile and P. wuerttenbergeri zones) and the beds with Praearctotis marchaensis (= the Pseudolioceras wuerttenbergeri Zone) were identified. To index the terminal part of the upper Toarcian, the beds with Praearctotis similis were distinguished (= the Pseudolioceras falcodiscus Zone).

We suggest considering the Aprelevskaya Formation and the lower sequence of the Arangastakhskaya Formation in the framework of the lower Aalenian (= the Pseudolioceras maclintocki Zone). To index the stratigraphic interval associated with the lower Aalenian, the beds with Arctotis tabagensis are identified.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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