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New Zonal and Infrazonal Scales for the Kimmeridgian in Westarn Siberia based on Cardioceratid Ammonites

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Abstract—It is proposed to use a Boreal scale based on the succession of cardioceratids (with the Bauhini, Kitchini, Sokolovi, and Decipiens zones) for the subdivision of the Kimmeridgian of Western Siberia instead of the aulacospephanid-based Subpolar Urals scale which was traditionally used in this region. It is shown that the use of the Boreal scale allows a finer subdivision and correlation of the Kimmeridgian of Western Siberia. A complete succession of zones and subzones based on cardioceratids and several biohorizons previously established in western Arctic are confirmed. The infrazonal Kimmeridgian scale of Western Siberia is correlated with the scales of Franz Josef Land, Spitsbergen, and northern Central Siberia. The diagnosis and ranges of *Plasmatites zieteni* (Rouill.), characteristic of the basal part of the Kimmeridgian (zieteni biohorizon), are given. The new species *Amoeboceras (?) klimovae* Rogov, sp. nov. and *Amoebites peregrinator* Rogov, sp. nov. (index species of the biohorizons recognized by the present author) are described.

Keywords: Kimmeridgian, ammonites, Cardioceratidae, Western Siberia, infrazonal stratigraphy

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INTRODUCTION

In Western Siberia, Kimmeridgian deposits are found virtually everywhere (figure), but their sections are incomplete. The upper part of the Kimmeridgian (one to two zones) in most boreholes is either absent or does not contain ammonites, whereas the basal part of the stage is poorly characterized by ammonites. The Kimmeridgian is mainly represented by shale and glauconitic siltstone, sometimes by sandstone (Barabinsk Member at the base of the Georgievka Formation). The thickness of the Kimmeridgian in most boreholes is small, not exceeding 10 m (Vyachkileva et al., 1990). For example, in the Tomsk oblast in Western Siberia, the thickness of the Georgievka Formation is mainly limited to 3–5 m, and only in the extreme south does it increase to 18–22 m (Danenber et al., 2006). In the lower reaches of the Yenisei River, the thickness of the Kimmeridgian exceeds 200 m (Bodylevskii and Shulgina, 1958; Mesezhnikov, 1984, text-fig. 7), but its fundamental structure is the same as in some other parts of the Western Siberian basin (coarser grained rocks in the lower part of the stage replaced by fine-grained sediments up the section).

The wide distribution of the Kimmeridgian beds in Western Siberia was established in the 1950s when large-scale drilling began in this region. Even early publications (Saks and Ronkina, 1953; *Stratigrafiya*..., 1957; Bodylevskii and Shulgina, 1958; Klimova and Korneva, 1959; Klimova, 1961, 1962; Klimova and Turbina, 1961; etc.), apart from providing records of Kimmeridgian ammonites, attempted to outline the presence of various zones known in the adjacent regions. Shortly thereafter, zonal successions were proposed for the entire Upper Jurassic (mainly on the basis of data obtained from studies in the Subpolar Urals; Mesezhnikov and Shulgina, 1961) and for the Kimmeridgian Stage of Western Siberia (Klimova and Zaitseva, 1965). In the 1960s–1990s, the understanding of the Kimmeridgian and Volgian scales by ammonites gradually became more detailed (Klimova and Zaitseva, 1965; Mesezhnikov et al., 1984; Vyachkileva et al., 1990). Recently, a zonal scale similar to that of the Subpolar Urals was introduced in this area, except for the Kimmeridgian–Volgian boundary beds, the presence of which in Western Siberia remained unconfirmed (Shurygin et al., 2000; *Reshenie*..., 2004; Meledina, 2005). It was indicated that the zones of the upper Kimmeridgian could not be recognized in geological practice owing to the scarcity of aulacostephid occurrences and their poor preservation (Meledina, 2005), and the upper Kimmeridgian scale of the Subpolar Urals for Western Siberia was used as a "guide to obtaining the possible high precision of dating if these ammonites are found in the borehole core" (Meledina, 2005). The only difference of the Western Siberian scale was the presence in the lower Kimmeridgian of the Kitchini Zone, which was recognized parallel to the zones established on the basis of aulacostephanids. For a long time, most Kimmeridgian ammonites were mentioned only in lists (Poplavskaya and Lebedev, 1973; Yasovich and Poplavskaya, 1975; Braduchan et

(Location of boreholes mentioned in the text and Table 1. (1) Kharasaveiiskaya 48; (2) Novoportovskaya 104; (3) Obskii Profile 12-K; (4) Voikarsky Profile; (5) Otorinskaya 42r; (6) Mapasiiskaya-11203; (7) Danilovskaya-10554; (8) Trekhozernaya 12; (9) Vladimirskaya 2, 3; (10) Karabashskaya 3; (11) Omskaya 1; (12) Tatarskaya 1; (13) Malobalykskaya 110; (14) Tagrinskaya 59; (15) Kholmistaya 667, 695; (16) Eloguiskaya Reference; (17) Verkhne- Karalkinskaya 104; (18) Urengoiskaya 510; (19) Zapolyarnaya 87; (20) Vostochno-Rarkosalinskaya 72; (21) Ust-Chaselskaya 199, 202, 204, 208, 210; (22) Kharampurskaya 303; (23) Verkhnechaselskaya 153; (24) Kynskaya 210, 211, 216; (25) Tukulundo-Vadinskaya 320; (26) Voctochno-Kubalakhskaya 357; (27) Payakhskaya 11; (28) Sukhodudinskaya 1; (29) Malokhetskaya 1-P, 10-P.

al., 1984; Mesezhnikov et al., 1984), and only a few specimens were described in publications. Descriptions and illustrations of many Kimmeridgian ammonites were published in a large monograph (Vyachkileva et al., 1990), also containing data on the lithology of several sections. Meledina (2005) revised the Kimmeridgian ammonites of Western Siberia. Concurring with Mesezhnikov et al. (1984), she noted that the western and eastern regions of the basin were characterized by somewhat different assemblages: in the west and south, in the lower Kimmeridgian, aulacostephanids were relatively common, while in the east cardioceratids were the dominant group. Shortly thereafter, Meledina (2006) also depicted and described several new occurrences of Kimmeridgian ammonites. Very recently, a few more Kimmeridgian ammonites were described, including those assigned to the genus *Plasmatites* (Alifirov et al., 2016). However, the substantiation of the existing zonal scale of the Kimmeridgian of Western Siberia up to now remains low. No zonal taxa are found in this area, and the very possibility of using the Subpolar Urals scale for Western Siberia is doubtful because of substantially different ammonite assemblages. At the same time, the last decades saw considerable success in the development of zonal and infrazonal scales of the Kimmeridgian stage based on the succession of cardioceratids (Birkelund and Callomon, 1985; Wierzbowski and Smelror, 1993; Wierzbowski et al., 2002; Rogov and Wierzbowski, 2009; Wierzbowski and Rogov, 2013; Rogov, 2014). These zonal and infrazonal successions (distinct from the highly endemic successions of aulacostephanids) are readily recognized in various regions of the Arctic, whereas some biohorizons can be recognized up to the Submediterranean sections (Schweigert, 2000). In this paper, I revise the data on the distribution of the Kimmeridgian ammonites in Western Siberia and, on the basis of these data, propose a zonal and an infrazonal scale taking into account the succession of genera and species of cardioceratids.

As the Kimmeridgian deposits in Western Siberia are only studied in deep boreholes and are not exposed, the proposed zonal and infrazonal subdivisions are based in some cases on isolated occurrences of the index species known from adjacent regions. However, this applies to all previously proposed zonal schemes for the Upper Jurassic of this region. In addition, the material from the borehole core is usually significantly distorted (except for ammonites found in early diagenetic carbonate nodules) and is mainly represented by microconchs and/or small macroconchs, whereas the occurrences of large macroconchs in the borehole core are extremely rare and almost unidentifiable.

MATERIAL

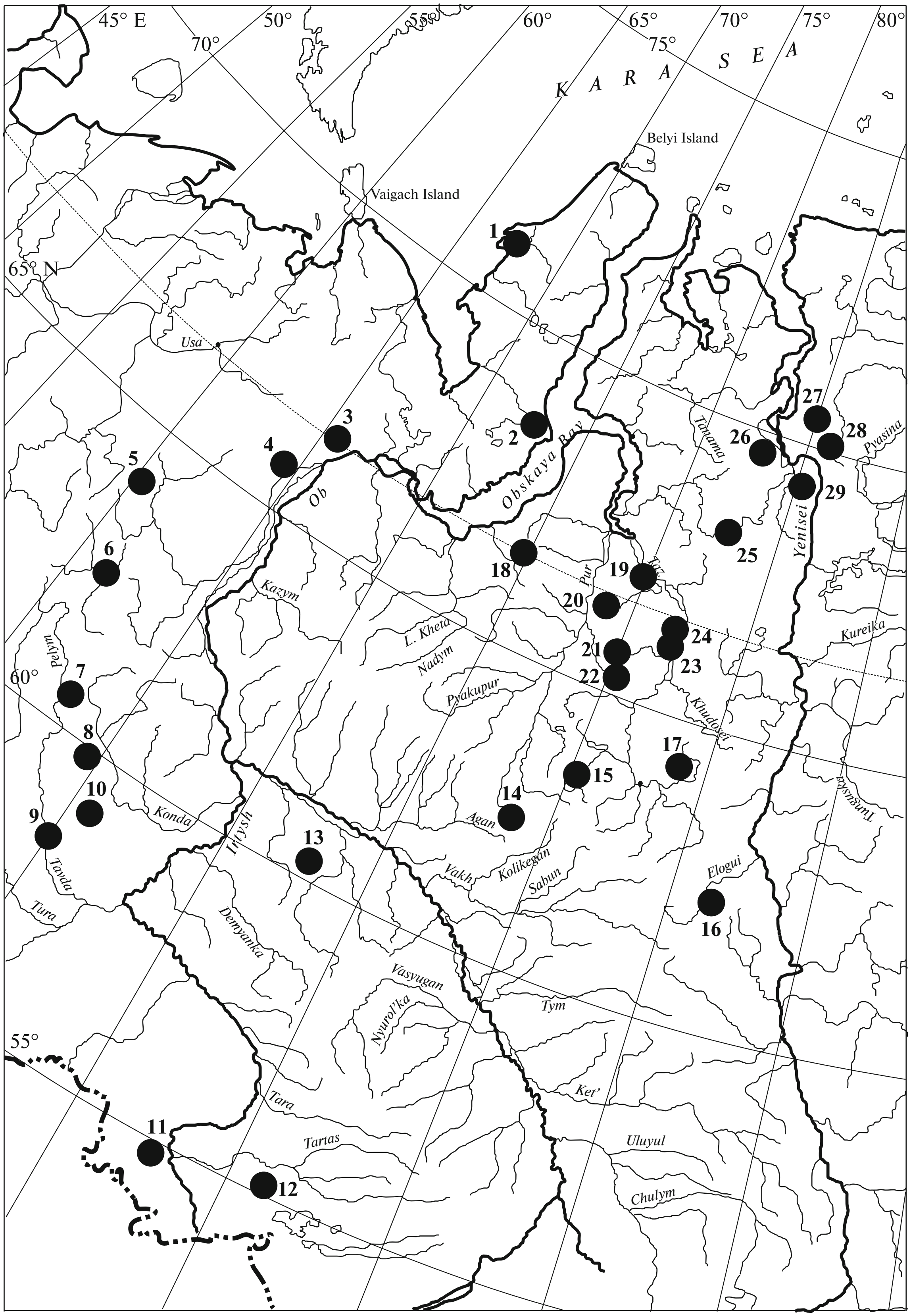
Ammonites described in this paper are housed at the Trofimuk Institute of Petroleum Geology and Geophysics, Siberian Branch of the Russian Academy of Sciences (INGG) (Novosibirsk); the Vernadsky State Geological Museum, Russian Academy of Sciences (Moscow); the West Siberian Research Institute of Geology and Geophysics (ZapSibNIGNI) (Tyumen); and the Central Scientific Research Geological Survey Museum (TsNIGR Museum) (St. Petersburg).

STRATIGRAPHY

Kimmeridgian Stage, Lower Substage

As mentioned above, a scale developed in the sections of the Subpolar Urals is currently used for the stratigraphic subdivision of the lower Kimmeridgian of Western Siberia (*Reshenie*..., 2004; Meledina, 2005, 2006). However, its use appears not to be sufficiently substantiated, especially in the eastern regions of the basin, where aulacostephanids are virtually unknown. Of the representatives of the genus *Pictonia* found in Western Siberia, only one specimen *(P. (Mesezhnikovia) ronkinae* Mesezhn.: Bodylevskii and Shulgina, 1958, pl. 2, fig. 1, Borehole Malokhetskaya 1-P[1]) can be confidently assigned to the subgenus *P. (Mesezhnikovia)*, characterizing the Involuta Zone, whereas other *Pictonia* either are represented by juvenile specimens (*Pictonia* sp. juv.: Klimova, 1961, pl. 2, fig. 5, Borehole Tatarskaya 1) or belong to the subgenus *Pictonia (Pictonia),* the stratigraphic range of which is not the same as that of *P. (Mesezhnikovia)* (Wierzbowski and Rogov, 2013). However, occurrences of *Pictonia* allow the recognition of the standard Baylei Zone with the Baylei and Densicostata subzones in Western Siberia on the basis of records of index species related ammonite taxa. These assemblages include *P. (P.)* cf. *baylei* Salf. (*Stratigraphiya*..., 1957, pl. 20, fig. 3, Borehole Omskaya 1; Meledina, 2006, plate, fig. 7, Borehole Danilovskaya-10554; specimens in the collection of Yu.V. Braduchan from Boreholes Kholmistaya 667 and Kholmistaya 695) and *(P.)* cf. *densicostata* Buckm. (specimens in the collection of Yu.V. Braduchan from Borehole Malobalykskaya 110). All occurrences of *Pictonia*, apart from the specimen described by Bodylevsky and Shulgina (1958), come from the western or

[1] Only the most important occurrences are mentioned when the strata are characterized. The revised list of ammonite identifications from the Kimmeridgian Stage of Western Siberia, except isolated, poorly preserved occurrences, is given in Table 1.


45° E
50°
55°
60°
65°
70°
75°
80°
70°
75°
K A R A S E A
Belyi Island
Vaigach Island
65° N
60°
55°
Usa
Ob
Obskaya Bay
Taz
Pur
Kazym
L. Kheta
Nadym
Pyakupur
Tanama
Pyasina
Yenisei
Kureika
Khudosei
Tunguska
Pelym
Konda
Tavda
Tura
Irtysh
Demyanka
Agan
Vakh
Kolikegan
Sabun
Elogui
Vasyugan
Nyurol'ka
Tym
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southern parts of the Western Siberian Basin. It should be noted that aulacostephanids in the Kimmeridgian of Western Siberia are distributed unevenly and are quite frequently present only at the base of the upper Kimmeridgian. In the lower Kimmeridgian, they are less common and are often represented by unidentifiable juvenile specimens or microconchs of *Prorasenia*, whereas cardioceratids are found across the entire stage. At the same time, the basal part of the Kimmeridgian in different boreholes can contain either only cardioceratids or only aulacostephanids. These differences in the assemblages can be related either to biogeographic reasons or to the fact that assemblages with dominant aulacostephanids or cardioceratids, despite being from the same zone, could in fact be of slightly different ages, and in that case the difference could have resulted from a short-term change in the ranges of ammonites of different biogeographical affinities.

Bauhini Zone Sykes et Callomon, 1979

Until recently, this zone was recognized in Western Siberia, and the presence of the ammonite genus *Plasmatites* in this region was not confirmed (Meledina et al., 2014). Only recently was it suggested that this zone could be recognized in this region (Alifirov et al., 2016). At the same time, the analysis of the published materials and the examination of Yu.V. Braduchan's collection showed that occurrences of *Plasmatites* at the base of the Kimmeridgian of Western Siberia are relatively abundant, so the Bauhini Zone can be positively recognized here, although all these ammonites can only be identified in open nomenclature as they are poorly preserved. *Plasmatites* sp. were found in Boreholes Verkhne-Karalkinskaya 104 (collection of Yu.V. Braduchan), Verkhnechaselskaya 153 (Vyachkileva et al., 1990, pl. 50, figs. 7, 10), and 12-K of Obskii profile (Klimova, 1961, pl. 1, figs. 11–12). In Borehole Danilovskaya-10554, *P. lineatum* (Quenst.) (Meledina, 2006, plate, fig. 2) was found 2.6 m below *Pictonia* (*P.*) cf. *baylei* Salf. (Meledina, 2006, plate, fig. 7). Very interesting associated occurrences of *Amoeboceras (?) klimovae* Rogov, sp. nov., similar to the specimens from the terminal part of the Bauhini Zone of Northeastern Europe (*Stratigrafiya*..., 1957, pl. 20, fig. 4), and *Pictonia (P.)* cf. *baylei* Salf. (*Stratigrafiya*..., 1957, pl. 20, fig. 3) were found in Borehole Omskaya 1. Numerous *Plasmatites* sp. (Vyachkileva et al., 1990, pl. 48, figs. 23, 25; and specimens in the collection of Yu.V. Braduchan), as well as *P.* cf. *bauhini* (Opp.) (Vyachkileva et al., 1990, pl. 48, fig. 21), are present in Borehole Kynskaya 216, where the thickness of the Bauhini Zone is about 10 m. An occurrence of *P. zieteni* (Rouill.) is found in Borehole Ust-Chaselskaya 210 (this paper, Plate I, fig. 9). I discovered photographs of two specimens of *Plasmatites zieteni* (Rouill.) from the collection of Yu.V. Braduchan found in Borehole Otorinskaya 42r at a depth of 60.6 m (this paper, Plate I, figs. 1, 2). This species, which unlike typical *Plasmatites* shows a weak development of secondary ribs and their disappearance long before the keel, is the index species of the Plasmatites zieteni Biohorizon at the base of the Bauhini Zone of European Russia (Rogov, 2015). Actual specimens were unfortunately not found, but Alifirov et al. (2016) described another two specimens of *P. zieteni* (Rouill.) from the same level in the same borehole. On the basis of cardioceratids, two biohorizons—zieteni and klimovae—can be established in the Bauhini Zone of Western Siberia.

Zieteni biohorizon (Mesezhnikov et al., 1989) emend herein

Gerassimovi horizon: *Middle and Upper Oxfordian*..., 1989.

Index Species. *Plasmatites zieteni* (Rouillier) (see the paleontological section).

Stratotype. Mesezhnikov et al. (in *Middle and Upper Oxfordian* ..., 1989) recognized the gerassimovi biohorizon in the upper Oxfordian of the Russian Platform. No diagnosis was given for this stratigraphic unit, and a stratotype was not designated. However, the presence of the biohorizon (with the index species *Amoeboceras gerassimovi* Mesezhn. et Kalacheva = *Plasmatites zieteni* (Rouill), see paleontological section) was clearly established only in the Makariev sec-

Plate I. Some Kimmeridgian ammonites from Western Siberia and European Russia. (1, 2, 9, 11–16, 18) *Plasmatites zieteni* (Rouill.), lower Kimmeridgian, Bauhini Zone, zieteni biohorizon: (1, 2) Borehole Otorinskaya 42r, depth 60.6 m (specimens lost, photographs from the collection of Yu.V. Braduchan (×2)); (9) Borehole Ust-Chaselskaya 210, depth 2753.4 m (specimen from the collection of Yu.V. Braduchan) (×2); (11–14) Mnevniki (Moscow), collection of S.V. Nikitin, TsNIGR Museum: (11) specimen no. 28/5247, (12) specimen no. 30/5247, (13) specimen no. 29/5247, (14) specimens nos. 32/5247; (15, 16) Lipitsy (Kaluga oblast): (15) SGM MK4760, (16) SGM MK4761; (18) Yakimikha (Ivanovo oblast); (3) *Pictonia (P.)* aff. *normandiana* (Tornq.) sensu Birkelund et Callomon, specimen no. SGM MK 6224, Borehole Shushminskaya 10683, depth 2016.2 m, lower Kimmeridgian, Kitchini Zone, Bayi Subzone (×2); (4) *Amoebites* cf. *modestum* (Mesezhn. et Romm), Borehole Verkhne-Karalkinskaya 104, depth 2221.7 m, upper Kimmeridgian, Kitchini Zone, Modestum Subzone, sachsi biohorizon, collection of Yu.V. Braduchan; (5) *Amoebites bayi* (Birk. et Call.), Borehole Kholmistaya 695, depth 2876.7 m, lower Kimmeridgian, Kitchini Zone, Bayi Subzone and Biohorizon, collection of Yu.V. Braduchan; (6) *Zenostephanus (Xenostephanoides)* sp., Borehole Verkhne-Karalkinskaya 104, depth 2222 m, upper Kimmeridgian, Kitchini Zone, Modestum Subzone, sachsi Biohorizon, collection of Yu.V. Braduchan; (7) *Zenostephanus (Z.) sachsi* (Mesezhn.), Borehole Verkhne-Karalkinskaya 104, depth 2221.7 m, upper Kimmeridgian, Kitchini Zone, Modestum Subzone, sachsi Biohorizon, collection of Yu.V. Braduchan; (8, 19, 20) *Amoebites peregrinator* Rogov, sp. nov., upper Kimmeridgian, Kitchini Zone, Modestum Subzone, peregrinator Biohorizon: (8) Borehole Payakhskaya 4, interval 3890– 3900, lower part, collection INGG; (19, 20) Tarkhanovskaya pristan (Tatarstan): (19) holotype SGM MK4223, 5.1 m from the base of Member 4; (20) SGM MK4213, 3.2–3.4 m from the base of Member 4; (10) *Plasmatites (?) mossolovoense* (Sasonov), holotype SGM VI-100/71, village of Mosolovo (Ryazan oblast), ?lower Kimmeridgian, Bauhini Zone; (17) *Plasmatites tuberculatoalternans* (Nikitin), lectotype TsNIGR 16/5247, Mnevniki (Moscow), collection of S.V. Nikitin.

Plate I


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10a
10b
10c
11a
11b
12a
12b
13a
13b
15
16
1 cm
17a
17b
17c
14a
14b

tion (Beds 7g–7d, after *Middle and Upper Oxfordian*…, 1989); this section can be considered as the stratotype by monotypy.

P a l e o n t o l o g i c a l   c h a r a c t e r i z a t i o n. Apart from the index species (*Middle and Upper Oxfordian*…, 1989, pl. 26, figs. 3–8), the unit contains *Plasmatites cf. bauhini* (Opp.) (*Middle and Upper Oxfordian*…, 1989, pl. 24, figs. 6–7), *Amoeboceras* ex gr. *rosenkrantzi* Spath, early *Pictonia (Pictonia)* [M], *Vineta* [M], *Prorasenia* sp. [m], and *Amoeboceras schulginae* Mesezhn. [M] (Głowniak et al., 2010, pl. 4, fig. 7). In sections of European Russia, *P. zieteni* (Rouill.) (this paper, Plate I, figs. 11–16) distinctly dominate at the base of the Kimmeridgian and in the ribbing are readily distinct from the typical *P. bauhini* (Opp.), with which some authors have compared *P. gerassimovi*.

S t r a t i g r a p h i c   p o s i t i o n. Mesezhnikov assigned the gerassimovi Horizon to the upper Oxfordian Ravni Zone, but the index species of this zone appears poorly selected, whereas its age encompasses the upper Oxfordian and the lower zone of the Kimmeridgian. The only specimen of "*A. ravni*" that Mesezhnikov (1967) had from the type locality is very different from all other ammonites from the type series of this species and is Kimmeridgian (Wierzbowski and Rogov, 2013; see also the paleontological section). The zieteni Biohorizon is the most common in the sections of European Russia, where the base of the Kimmeridgian Stage is placed at its base. Judging from occurrences in this biohorizon of uncommon *Amoeboceras* ex gr. *rosenkrantzi* and early *Pictonia (Pictonia)* and from the presence of *P.* cf. *zieteni* in the flodigarriensis Biohorizon of Scotland, this biohorizon approximately correlates to the flodigarriensis Biohorizon. However, the rarity of the occurrences of aulacostephanid macroconchs and their poor preservation do not allow positive correlation of the upper boundary of the zieteni Biohorizon to any aulacostephanid-based biohorizon. In Franz Josef Land, the zieteni Biohorizon correlates with the assemblage recently found in Wilczek Land, containing *Plasmatites* sp. juv. and *Amoeboceras* ex gr. *rosenkrantzi* (Wierzbowski et al., 2016). Isolated occurrences of *P. zieteni* in Submediterranean sections (northern Switzerland) are assigned to the Bimammatum Zone and Subzone (Gygi, 2000).

R e m a r k s. The ammonite assemblage of the zieteni Biohorizon is significantly different in different parts of the biohorizon. In sections of European Russia, the assemblage of the biohorizon is relatively diverse. Although it is numerically dominated by the occurrences of the index species, the assemblage contains also aulacostephanids (mainly represented by microconchs or unidentifiable fragments of macroconchs) and also rare *Amoeboceras* s. str.

L o c a l i t i e s. European Russia (Kostroma oblast (Makariev, Mikhalenino), Ivanovo oblast (Malgino, Yakimikha), Kaluga oblast (Lipitsy), Moscow oblast (Rybaki, Borsheva), Moscow (boreholes 16-5, 17-4) Samara oblast (?) (Valy)); Western Siberia (Boreholes Ust-Chaselskaya 210, Otorinskaya 42r, specimens lost); north of Central Siberia (Levaya Boyarka River, outcrops 21–22). It is possible that the biohorizon is present in Scotland (Flodigarry section).

Klimovae Biohorizon nov.

I n d e x   S p e c i e s. *Amoeboceras (?) klimovae* Rogov, sp. nov. (see the paleontological section).

S t r a t o t y p e. The Flodigarry section can be designated as the stratotype for the klimovae Biohorizon, where occurrences of this species are the most precisely dated (interval of ~0.5–0.7 m above the base of Bed 39 as in Matyja et al. (2006), although the succession has a considerable interval in which no ammonites of this group are found between the occurrences of *A. (?) schulginae* and *A. (?) klimovae*, where the boundary between the biohorizons fixed as the transition between the species can potentially be placed.

P a l e o n t o l o g i c a l   c h a r a c t e r i z a t i o n. Apart from index species, the biohorizon is characterized by *Plasmatites* spp. (*P. bauhini* (Opp.), *P. praebauhini* (Salf.), *P. lineatum* (Quenst.)), *Pictonia (Pictonia)* ex gr. *baylei* Salf., and *Prorasenia* spp.

S t r a t i g r a p h i c   p o s i t i o n. In most Boreal sections, aulacostephanids are not found in association with *A. (?) klimovae* sp. nov., whereas in the stratotype these ammonites are found between the intervals assigned to the densicostata and baylei biohorizons. Only in Western Siberia is *A. (?) klimovae* sp. nov. found together with *Pictonia (P.)* cf. *baylei* (Salf.). In the Submediterranean succession (southern Germany), *A. (?) klimovae* sp. nov. is found in the bauhini Biohorizon (Hauffianum Zone).

L o c a l i t i e s. Scotland (Flodigarry), Norwegian sector of the Barents Sea (Borehole 7231/01-U-01), Spitsbergen, Franz Josef Land (Cape Hofer, Wilczek Land), Western Siberia (Borehole Omskaya 1), northern Central Siberia (Levaya Boyarka River, outcrops 21–22; Kheta River, loc. 125005), southern Germany (Plettenberg, Lochen, Swabian Alb).

Kitchini Zone Schulgina, 1960

Bayi Subzone Wierzbowski et Rogov, 2013

Bayi Biohorizon Birkelund et Callomon, 1985

The Bayi Subzone and Biohorizon are established in Western Siberia on the basis of numerous occurrences of the index species. *A. bayi* (Birk. et Call.) was found in Boreholes Verkhnechaselskaya 151 (Vyachkileva et al., 1990, pl. 50, fig. 6), Omskaya 1 (Klimova, 1961, pl. 2, figs. 1–2; Vyachkileva et al., 1990, pl. 49, figs. 1–3), and Kholmistaya 695 (specimens in the collection of Yu.V. Braduchan found 0.4 m below *Pictonia (Pictonia)* cf. *baylei* Salf., see this paper, Plate I, fig. 5). The occurrences of *A. bayi* (Birk. et Call.)/cf. *bayi* (Birk. et Call.) are known from Boreholes Kynskaya 211 (Vyachkileva et al., 1990, pl. 48, fig. 19) and Malokhetskaya 1-P (Bodylevsky and Shulgina, 1958, pl. 1, figs. 6–7, pl. 2, figs. 2, 5); in the latter case they are found in association with *Pictonia* (*Mesezhnikovia*) *ronkinae* Mesezhn. Apparently, the occurrence of *Pictonia (P.)* aff. *normandiana* (Tornq.) sensu Birkelund et Callomon (Plate I, fig. 3) (Borehole Shushminskaya 10683) can be assigned to the Bayi Subzone as in the sections of Eastern Greenland. The occurrence of the coarsely ribbed *Amoebites* (?) aff. *schulginae* (Mesezhn.), indistinguishable from the ammonite from the bayi Horizon of Eastern Greenland (Birkelund and Callomon, 1985, pl. 4, fig. 1), can most likely be assigned to the bayi Biohorizon. This ammonite (Vyachkileva et al., 1990, pl. 50, fig. 5) was found in Borehole Ust-Chaselskaya 199 between the occurrences of *Rasenia* cf. *optima* Mesezhn. (Vyachkileva et al., 1990, pl. 53, fig. 2) and *Amoebites subkitchini* (Spath) (Vyachkileva et al., 1990, pl. 50, fig. 11). This specimen is also similar to ammonites from the lower part of the upper Kimmeridgian, such as *A. salfeldi* (Spath) (Spath, 1935, pl. 2, fig. 7).

Subkitchini Subzone Wierzbowski in Wierzbowski et Smelror, 1993

The Subkitchini Subzone in Western Siberia is characterized mainly by *Amoebites* ex gr. *subkitchini* (Spath). Aulacostephanids are much less common here, and they are represented either by early *Rasenia* (like *R. inconstans* Spath, *R. pseudouralensis* Mesezhn., or *R. optima* Mesezhn.) or by microconchs of *Prorasenia* sp. (less commonly *Rasenioides*). Occurrences of later members of *Rasenia* are not confirmed in Western Siberia.

Amoebites subkitchini (Spath)/cf. *subkitchini* (Spath) is one of the most abundant cardioceratid species in the lower Kimmeridgian of Western Siberia. However, at present, the stratigraphic range of this species is not clearly defined in relation to the similar species of *Amoebites*: e.g., in Spitsbergen and in northern Siberia it appears below *A. mesezhnikovi* (Sykes et Surlyk) and *A. pingueforme* (Mesezhn.), but is also found above these coarsely ribbed species (Wierzbowski, 1989; Wierzbowski and Rogov, 2013; Rogov, 2014). Most occurrences of *A. subkitchini* (Spath)/cf. *subkitchini* (Spath) are recorded in the eastern regions of Western Siberia (Borehole Tukulundo-Vadinskaya 320 (Meledina, 2006, plate, fig. 3), Boreholes Ust-Chaselskaya 199, 202, 210 (Vyachkileva et al., 1990, pl. 49, fig. 7, pl. 50, figs. 1–3, 11, pl. 51, fig. 6), Borehole Kharampurskaya 303 (Vyachkileva et al., 1990, pl. 49, fig. 4, pl. 51, fig. 4)), but these ammonites are also known in the northeast of the basin (Borehole Novoportovskaya 104; Vyachkileva et al., 1990, pl. 50, figs. 12–13). The species *A. subkitchini* (Spath) is sometimes found in association with infrequent *Rasenia* (*R. optima* Mesezhn.; Vyachkileva et al., 1990, pl. 53. fig. 1). Apparently, the equivalents of the subkitchini Biohorizon can be correlated with the intervals with the early *Rasenia* in those boreholes in western parts of the basin where cardioceratids are rare or absent (Eloguiskaya Reference Borehole—*Rasenia* cf. *pseudouralensis* Mesezhn.: Klimova and Korneva, 1959, pl. 1, fig. 4; Borehole Mapasiiskaya-11203—*Prorasenia* sp.: Meledina, 2006, plate, fig. 4; *Rasenioides* sp. [m]: Meledina, 2006, plate, fig. 8; and others).

Biohorizon mesezhnikovi Wierzbowski, 1989

The presence of the biohorizon can be tentatively recognized in Western Siberia by the occurrences of *Amoebites* cf. *mesezhnikovi* (Sykes et Surlyk). These early *Amoebites*, with dominant simple ribs, are found in Borehole Zapolyarnaya 87 (Vyachkileva et al., 1990, pl. 51, fig. 1) and Borehole Ust-Chaselskaya 210 (Vyachkileva et al., 1990, pl. 49, fig. 8). In Borehole Ust-Chaselskaya 210, the first *Amoebites* were found ~5 m above *Plasmatites*. Along with cardioceratids, there also aulacostephanids *Prorasenia* sp. (Vyachkileva et al., 1990, pl. 53. fig. 6) and *Rasenia* cf. *optima* Mesezhn. (Vyachkileva et al., 1990, pl. 53. fig. 3).

Kimmeridgian Stage, Upper Substage

Modestum Subzone Wierzbowski in Wierzbowski et al., 2002

Although occurrences of *Amoebites modestum* (Mesezhn. et Romm) are known in Western Siberia, some of these can also be assigned to the Subkitchini Subzone. The Modestum Subzone is fixed by the occurrence of late, relatively small (usually with a shell diameter of 3–5 cm) *Amoebites*, which generally have a coarse ribbing, whereas *A. modestum* (Mesezhn. et Romm) has closely spaced and fine ribs. This subzone has occurrences of *A. kitchini* (Salf.): Borehole Vladimirskaya 3 (Vyachkileva et al., 1990, pl. 52, fig. 6); Boreholes Ust-Chaselskaya 204, 208 (Vyachkileva et al., 1990, pl. 49, figs. 9, 11; pl. 52, fig. 2). Sometimes the Modestum Subzone, as in the section of the Khatanga Basin, can contain large *Amoebites* ex gr. *kitchini* (Salf.) (Vyachkileva et al., 1990, pl. 51, fig. 5). The subzone characteristically has numerous occurrences of aulacostephanids *Zonovia* and *Zenostephanus* spp. (see below), which are found in both the western and the eastern parts of the basin. These aulacostephanids almost exclusively belong to Boreal genera. Apart from these, there is only one occurrence of ?*Aulacostephanoides* sp. (Borehole Kharampurskaya 303; Vyachkileva et al., 1990, pl. 64, fig. 4). The position of the widely accepted boundary between the lower and upper Kimmeridgian, fixed in the Subboreal sections by the appearance of *Aulacostephanoides*, is not very clear in relation to the Modestum Subzone, but apparently this boundary occurs near the base of the Modestum Subzone.

Peregrinator Biohorizon nov.

Index Species. *Amoebites peregrinator* Rogov, sp. nov. (see the paleontological section).

S t r a t o t y p e. The section Tarkhanovskaya pristan-1 (Tatarstan, see the log in Shchepetova and Rogov, 2013, Fig. 1b), interval 3.2–5.5 m above the visible base of the outcrop.

P a l e o n t o l o g i c a l c h a r a c t e r i z a t i o n. Apart from the index species, the biohorizon contains *Aulacostephanoides* sp.

S t r a t i g r a p h i c p o s i t i o n. Judging from the occurrences of the index species in the stratotype along the first *Aulacostephanoides*, but below *Zenostephanus sachsi* (Mesezhn.), the biohorizon correlates with the basal part of the upper Kimmeridgian Mutabilis Zone. The position of the biohorizon in the Boreal scale (Modestum Subzone, Kitchini Zone) is determined by the presence of the index species below *Euprionoceras norvegicum* (Wierzb.) in Spitsbergen.

L o c a l i t i e s. England, Lincolnshire (in bullions); ? Eastern Greenland, Scotland (Flodigarry), European Russia (Tatarstan, Tarkhanovskaya pristan), Western Siberia (Borehole Payakhskaya 4—this is so far the only known locality of the biohorizon in Western Siberia).

Sachsi Biohorizon Rogov, 2014

Owing to poor preservation, many aulacostephanids of Western Siberia cannot be positively identified to species. Nevertheless, in the lower part of the upper Kimmeridgian, there is a clear interval with numerous *Zenostephanus* spp. (see pl. 53–54 in Vyachkileva et al., 1990), in association with *Zonovia* and *Amoebites* (*A. modestum* (Mesezhn. et Romm), *A. kitchini* (Salf.)). At first, this stratigraphic interval was recognized in the mid-1960s as "beds with *Aulacostephanus*," with a list of species presently assigned to the genus *Zenostephanus*, such as *Aulacostephanus* sp. indet. aff. *thurrelli* Ark. et Call. and *A.* (*Xenostephanus*) sp. indet. aff. *ranbyensis* Ark. et Call. (Klimova and Zaytseva, 1965). The occurrences in Borehole Verkhne-Karalkinsklaya 104 are very important as from a small interval there were identified *Zenostephanus* (*Z.*) *sachsi* (Mesezhn.) (Plate I, fig. 7), *Z. (Xenostephanoides)* sp. (Plate I, fig. 6), *Zonovia* sp., and *Amoebites* cf. *modestum* (Mesezhn. et Romm) (Plate I, fig. 4), as well as joint occurrences of aulacostephanids and cardioceratids in the Ust-Chaselskaya boreholes (Table 1). It should be noted that, in the Subpolar Urals, such an assemblage dominated by *Zenostephanus* is not established, whereas occurrences of the genus *Zenostephanus* from those localities could be at least partly lower Kimmeridgian.

Sokolovi Zone Spath, 1935 emend. Wierzbowski in Wierzbowski et Smelror, 1993

Aulacostephanids in Western Siberia are virtually absent above the Kitchini Zone, and here a Boreal scale based on cardioceratids can be used. There is only one published illustration of *Aulacostephanus* sp. (Borehole Urengoi 510; Vyachkileva et al., 1990, pl. 54, fig. 10). Other ammonites previously identified as *Aulacostephanus* (Vyachkileva et al., 1990; Meledina, 2005), are mainly assigned to *Zenostephanus*. This most likely applies to identifications given in the lists as *Aulacostephanus subundorae* (Pavl.) and *A. subeudoxus* (Pavl.) (Poplavskaya and Lebedev, 1973). The zones recognized in the upper Kimmeridgian of Western Siberia correspond to the ranges of the genera *Euprionoceras* (Sokolovi Zone) and *Hoplocardioceras* (Decipiens Zone).

Norvegicum Biohorizon Wierzbowski in Wierzbowski et Smelror, 1993

The earliest *Euprionoceras* (*E. norvegicum* (Wierzb.)) typically have a weak ribbing on the internal whorls, which is not observed in *Amoebites* from the Kitchini Zone. The occurrence of *E. norvegicum* (Wierzb.) is known from Borehole Kharasaveiiskaya 48 (Vyachkileva et al., 1990, pl. 52, fig. 12), in association with *Zenostephanus (Xenostephanoides)* sp. (Vyachkileva et al., 1990, pl. 54, fig. 7).

Sokolovi Biohorizon Callomon et Birkelund, 1982

Occurrences of *Euprionoceras sokolovi* (Bodyl.) have been known in Western Siberia from the late 1950s (Bodylevsky and Shulgina, 1958), but after that *Euprionoceras* have almost never been identified from that region (a single not depicted *Euprionoceras* sp. was mentioned by Meledina (2005), while representatives of this genus were recorded from Yamal by Mesezhnikov et al. (1984)). Nevertheless, the existing data are quite sufficient to recognize the sokolovi Biohorizon at least in the eastern regions of Western Siberia. Occurrences of the index species are known from Borehole Malokhetskaya 10P (Bodylevsky and Shulgina, 1958, pl. 6, figs. 4–5) and Borehole Ust-Chaselskaya 208 (collection of Yu.V. Braduchan).

Decipiens Zone Spath, 1935

So far, a single record of *Hoplocardioceras decipiens* (Spath) is known from Western Siberia (Bodylevsky and Shulgina, 1958, p. 31). Unfortunately, this specimen could not be located in the collection of V.I. Bodylevsky, so there is not sufficient evidence to recognize the decipiens Biohorizon in this region.

Elegans Biohorizon Callomon et Birkelund, 1982

This biohorizon is established on the basis of occurrences of the youngest representative of *Hoplocardioceras*, *H. elegans* (Spath) (Bodylevsky and Shulgina, 1958, pl. 7, fig. 2; Vyachkileva et al., 1990, pl. 50, figs. 14–15). Deposits in Borehole Kharasaveiiskaya 48 below the typical *H. elegans* (Spath) contain an ammonite characterized by a coarser ribbing (Vyachkileva et al., 1990, pl. 51, fig. 3) and identified

Table 1. Results of the revision of Kimmeridgian ammonites of Western Siberia

Borehole, Formation	Depth, m	Original identification	New identification	Source
Vladimirskaya 2. Danilovskaya Formation	1552.25–1555.75 (lower)	*Aulacostephanus* (?*Zonovia*) sp. indet.	*Zenostephanus* (Z.) cf. *saschi*	Vyachkileva et al., 1990, pl. 53, fig. 8
Vladimirskaya 3, Danilovskaya Formation	1641.7–1645.2	*Amoeboceras* sp. indet.	*Amoebites kitchini*	Vyachkileva et al., 1990, pl. 52, fig. 6
Vladimirskaya 3, Danilovskaya Formation	1659–1662 (upper)	*Zonovia* sp. juv.	?*Zenostephanus* sp. juv.	Vyachkileva et al., 1990, pl. 54, fig. 4
Verkhne–Karalkinskaya 104	2219–2228 (2.1)		*Zenostephanus* (*Xenostephanoides*) sp.	*Co.Yu.V. Braduchan*
Verkhne–Karalkinskaya 104	2219–2228 (2.3)		*Zenostephanus*/*Zonovia* sp.	*Co.Yu.V. Braduchan*
Verkhne–Karalkinskaya 104	2219–2228 (2.7)		*Amoebites* cf. *modestum*	**Pl. I, fig. 4**
Verkhne–Karalkinskaya 104	2219–2228 (2.7)		*Zenostephanus* (Z.) *sachsi*	**Pl. I, fig. 7**
Verkhne–Karalkinskaya 104	2219–2228 (3,0)		*Zenostephanus* (*Xenostephanoides*) sp.	**Pl. I, fig. 6**
Verkhne–Karalkinskaya 104	2219–2228 (3.1)		*Zenostephanus*/*Zonovia* sp.,	*Co.Yu.V. Braduchan*
Verkhne–Karalkinskaya 104	2219–2228 (3.1)		*Amoebites* cf. *modestum*	*Co.Yu.V. Braduchan*
Verkhne–Karalkinskaya 104	2219–2228 (3.1)		*Zenostephanus* (*Xenostephanoides*) cf. *staitonensis*	*Co.Yu.V. Braduchan*
Verkhne–Karalkinskaya 104	2219–2228 (1.8)		*Plasmatites* sp.	*Co.Yu.V. Braduchan*
Verkhnechaselskaya 151, Sigovoe Formation	2957–2971 (2.9)	*Amoeboceras* (*Amoebites*) sp. cf. *A. salfeldi*	*Amoebites bayi*	Vyachkileva et al., 1990, pl. 50, fig. 6
Verkhnechaselskaya 153, Sigovoe Formation	2962–2974 (0.9)	*Amoeboceras* (*Amoebites*) sp. cf. *A. mesezhnikovi* juv.	*Plasmatites* sp.	Vyachkileva et al., 1990, pl. 50, fig. 7
Verkhnechaselskaya 153, Sigovoe Formation	2962–2974 (2.6)	*Amoeboceras* (*Amoebites*) sp. cf. *A. mesezhnikovi* juv.	*Plasmatites* sp.	Vyachkileva et al., 1990, pl. 50, fig. 10
Verkhnechaselskaya 153, Sigovoe Formation	2962–2974 (4.8)	*Amoeboceras* sp. indet.	*Amoeboceras* sp.	Vyachkileva et al., 1990, pl. 48, fig. 17
Voikarskii profile, 2, DanilovskayaFormation	381.7–399.0	*Rasenia* sp. juv.	*Rasenia*/*Zenostephanus*	Vyachkileva et al., 1990, pl. 53, fig. 4
Voikarskii profile, 2, Danilovskaya Formation	399.0–404.5 (4.5)	*Amoeboceras freboldi*	*Amoeboceras freboldi*	Vyachkileva et al., 1990, pl. 48, fig. 15
Vostochno–Kubalakhskaya 357, Yanov Stan Formation	2296–2313	*Amoeboceras* sp. indet.	*Amoebites* sp.	Vyachkileva et al., 1990, pl. 52. fig. 4
Vostochno-Pugachevskaya 11119	1586.1–15899.1 (7.0)		*Zenostephanus* (?) sp./ *Aulacostephanus* sp.	Collective of authors

Table 1. (Contd.)

Borehole, Formation	Depth, m	Original identification	New identification	Source
Vostochno-Pugachevskaya 11119	1586.1–15899.1 (10.0)		*Euprionoceras* cf. *sokolovoi*	Collective of authors
Vostochno-Pugachevskaya 11119	1586.1–15899.1 (11.0)		*Rasenia* sp. juv., *Amoebites* sp. indet.	Collective of authors
Vostochno–Tarkosalinskaya 72, Georgievka Formation	3406–3421 (7.6)	*Amoeboceras* (*Amoebites*) ex gr. *kitchini*	*Amoebites* sp.ind.	Vyachkileva et al., 1990, pl. 49, fig. 5–6
Danilovskaya–10554, Danilovskaya Formation	1779.4	*Amoeboceras* (*Amoebites*) sp. juv.	*Plasmatites lineatum*	Meledina, 2006, pl., fig. 2
Danilovskaya–10554, Danilovskaya Formation	1782	*Rasenia* (*Rasenia*) cf. *suburalensis*	*Pictonia* cf. *baylei*	Meledina, 2006, pl., fig. 7
Eloguiskaya Reference, Yanov Stan Formation	1225–1231	*Rasenia* aff. *uralensis*	Aulacostephanidae indet.	Klimova and Korneva, 1959, pl. I, fig. 3
Eloguiskaya Reference, Yanov Stan Formation	1225–1231	*Rasenia* aff. *uralensis*	*Rasenia* cf. *pseudouralensis*	Klimova and Korneva, 1959, pl. I, fig. 4
Eloguiskaya Reference, Yanov Stan Formation	1237–1239	*Amoeboceras* cf. *kitchini*	*Amoeboceras* sp.	Klimova and Korneva, 1959, pl. I, fig. 5
Eloguiskaya Reference, Yanov Stan Formation	1239–1245	*Amoeboceras* aff. *alternans*	*Amoeboceras* sp.	Klimova and Korneva, 1959, pl. I, fig. 6
Zapadno–Krasnoselkupskaya 49, Sigovoe Formation	2717–2732 (8.3)	*Rasenia* (*Rasenia*) *evoluta*	*Prorasenia* sp.	Vyachkileva et al., 1990, pl. 52. fig. 15
Zapadno–Krasnoselkupskaya 49, Sigovoe Formation	2717–2732 (8.3)	*Rasenia* (*Eurasenia*) cf. *triplicata*	*Prorasenia* sp.	Vyachkileva et al., 1990, pl. 52. fig. 16
Zapolyarnaya 87, equivalent of the Georgievka Formation	3648–3662 (0,35)	*Amoeboceras* (*Amoebites*) sp. indet.	*Amoebites* cf. *mesezhnikovi*	Vyachkileva et al., 1990, pl. 51. fig. 1
Karabashskaya 3, Danilovskaya Formation	1844.05– 1845.35 (middle)	*Aulacostephanus* sp.	*Zenostephanus* (*Xenostephanoides*) sp.	Vyachkileva et al., 1990, pl. 54. fig. 2
Karabashskaya 3, Danilovskaya Formation	1844.05– 1845.35 (middle)	?*Aulacostephanus* sp. indet.	*Zenostephanus* (*Xenostephanoides*) sp.	Vyachkileva et al., 1990, pl. 54. fig. 5
Kynskaya 210, Sigovoe Formation	2862–2869	*Amoeboceras* sp. indet.	*Amoebites* sp.	Vyachkileva et al., 1990, pl. 52. fig. 1
Kynskaya 211, Sigovoe Formation	2860–2874 (1.5)	*Amoeboceras* sp. juv.	*Amoebites* sp.juv.	Vyachkileva et al., 1990, pl. 48, fig. 22
Kynskaya 211, Sigovoe Formation	2860–2874 (4.8)	*Amoeboceras* sp. juv.	*Amoebites* cf. bayi	Vyachkileva et al., 1990, pl. 48, fig. 19

Table 1. (Contd.)

Borehole, Formation	Depth, m	Original identification	New identification	Source
Kynskaya 216, Sigovoe Formation	2857–2868 (1.6)	*Amoeboceras* sp. juv.	*Plasmatites* cf. *bauhini*	Vyachkileva et al., 1990, pl. 48, fig. 21
Kynskaya 216, Sigovoe Formation	2857–2868 (4.26)	*Amoeboceras* sp. juv.	*Plasmatites* sp.	Vyachkileva et al., 1990, pl. 48, fig. 25
Kynskaya 216, Sigovoe Formation	2857–2868 (4.8)	*Amoeboceras* sp. juv.	*Plasmatites* sp.	Vyachkileva et al., 1990, pl. 48, fig. 23
Kynskaya 216, Sigovoe Formation (?)	2868–2880 (upper)		*Plasmatites* sp.	*Co. Yu. V. Braduchan*
Kynskaya 216, Sigovoe Formation (?)	2868–2880 (0.9)		*Plasmatites* sp.	*Co. Yu. V. Braduchan*
Kynskaya 216, Sigovoe Formation (?)	2868–2880 (2.0)		*Amoeboceras* cf. *rosenkrantzi*	*Co. Yu. V. Braduchan*
Malobalykskaya 110	2808–2820 (4.0)		*Pictonia* cf. *densicostata*	*Co. Yu. V. Braduchan*
Malobalykskaya 110	2808–2820 (4.0)		*Prorasenia* sp.	*Co. Yu. V. Braduchan*
Malobalykskaya 110	2808–2820 (4.25)		*Pictonia* cf. *densicostata*	*Co. Yu. V. Braduchan*
Malobalykskaya 110	2808–2820 (4.5)		*Prorasenia* sp.	*Co. Yu. V. Braduchan*
Malobalykskaya 110	2808–2820 (9.5)		*Pictonia* cf. *densicostata*	*Co. Yu. V. Braduchan*
Malokhetskaya 1–P, Yanov Stan Formation	1246–1252.2	*Pictonia* sp.	*Pictonia* (*Mesezhnikovia*) *ronkinae*	Bodylevsky and Shulgina, 1958, pl. II, fig. 1
Malokhetskaya 1–P, Yanov Stan Formation	1246–1252.2	*Amoeboceras* (?*Amoebites*) sp. no. 1	*Amoebites* cf. *bayi*	Bodylevsky and Shulgina, 1958, pl. II, fig. 2
Malokhetskaya 1–P, Yanov Stan Formation	1246–1252.2	*Amoeboceras* (?*Amoebites*) sp. no. 1	*Amoebites bayi*	Bodylevsky and Shulgina, 1958, pl. II, fig. 5
Malokhetskaya 1–P, Yanov Stan Formation	1246–1252.2	*Amoeboceras* (?*Amoebites*) sp. no. 1	*Amoebites bayi*	Bodylevsky and Shulgina, 1958, pl. I, fig. 7
Malokhetskaya 1–P, Yanov Stan Formation	1246–1252.2	*Amoeboceras* (?*Amoebites*) sp. no. 2	*Amoebites bayi*	Bodylevsky and Shulgina, 1958, pl. I, fig. 6
Malokhetskaya 1–P, Yanov Stan Formation	1246–1252.2	*Amoeboceras* sp. indet.	*Amoebites* (?) sp. indet.	Bodylevsky and Shulgina, 1958, pl. I, fig. 5
Malokhetskaya 10–P, Yanov Stan Formation	1251.1–1257.7	*Amoeboceras* (*Eupr.*) cf. *sokolovi*	*Hoplocardioceras elegans*	Bodylevsky and Shulgina, 1958, pl. VII, fig. 2
Malokhetskaya 10–P, Yanov Stan Formation	1293–1300	*Amoeboceras* (*Eupr.*) *sokolovi*	*Euprionoceras sokolovi*	Bodylevsky and Shulgina, 1958, pl. VI, fig. 4
Malokhetskaya 10–P, Yanov Stan Formation	1341.1–1347.4	*Amoeboceras* (*Eupr.*) cf. *kochi*	*Euprionoceras sokolovi*	Bodylevsky and Shulgina, 1958, pl. VI, fig. 5

Table 1. (Contd.)

Borehole, Formation	Depth, m	Original identification	New identification	Source
Malokhetskaya 10–P, Yanov Stan Formation	1372.5–1378.7	*Amoeboceras* (?*Amoebites*) sp. no. 3	*Amoeboceras* cf. *regulare*	Bodylevsky and Shulgina, 1958, pl. VI, fig. 2
Malokhetskaya 10–P, Yanov Stan Formation	1381.9–1388.9	*Amoeboceras* (?*Amoebites*) sp. no. 3	*Amoeboceras* sp.	Bodylevsky and Shulgina, 1958, pl. VI, fig. 1
Malokhetskaya 10–P, Yanov Stan Formation	1381.9–1388.9	*Amoeboceras* sp. no. 4	*Amoeboceras* (*Prionodoceras*) sp. [M]	Bodylevsky and Shulgina, 1958, pl. VI, fig. 3
Mapasiiskaya–11203, Lopsiya Formation	1321.15	*Prorasenia* cf. *hardyi*	*Prorasenia* sp.	Meledina, 2006, pl., fig. 4
Mapasiiskaya–11203, Lopsiya Formation	1321.7	*Rasenia* (*Eurasenia*) cf. *pseudouralensis*	*Rasenioides* (*R.*) sp.	Meledina, 2006, pl., fig. 8
Mapasiiskaya–11203, Lopsiya Formation	1324. 5	*Rasenia* (*Rasenia*) cf. *evoluta*	*R.* cf. *pseudouralensis*	Meledina, 2006, pl., fig. 6
Novoportovskaya 104, Danilovskaya Formation	2165.0–2175.7 (4.9)	*Amoeboceras* (*Amoebites*) *pulchrum*	*Amoebites* cf. sub*kitchini*	Vyachkileva et al., 1990, pl. 50, fig. 12
Novoportovskaya 104, Danilovskaya Formation	2165.0–2175.7 (4.9)	*Amoeboceras* (*Amoebites*) cf. *pulchrum*	*Amoebites* cf. *subkitchini*	Vyachkileva et al., 1990, pl. 50, fig. 13
Obskoi Profile 12, Danilovskaya Formation	280,2–284	*Zonovia* (*Xenostephanus*) sp.	*Zenostephanus* (*Z.*) cf. *sachsi*	Vyachkileva et al., 1990, pl. 53, fig. 5
Obskoi Profile 12, Danilovskaya Formation	296–298	*Amoeboceras* sp.	*Plasmatites* sp.	Klimova, 1961, pl. I, fig. 11–12
Obskoi Profile 12, Danilovskaya Formation	312–320	*Amoeboceras* ex gr. *kitchini*	*Amoeboceras*/*Plasmatites*	Klimova, 1961, pl. I, fig. 13–16
Obskoi Profile 12, Danilovskaya Formation	327–329	*Amoeboceras* ex gr. *alternans*	*Amoeboceras* sp.	Klimova, 1961, pl. I, fig. 5–6
Omskaya 1, Georgievka Formation	2377	*Cardioceras* ex gr. *alternans*	*Amoebites bayi*	*Stratigrafiya*..., 1957, pl. 20, fig. 6
Omskaya 1, Georgievka Formation	2377.2	*Amoeboceras* sp.	*Amoebites bayi*	Vyachkileva et al., 1990, pl. 49, fig. 1–3
Omskaya 1, Georgievka Formation	2387.0	*Amoeboceras* cf. *kostromense*	*Amoeboceras* (?) *klimovae* sp. nov.	Vyachkileva et al., 1990, pl. 48, fig. 7
Omskaya 1, Georgievka Formation	2387.0	*Perisphinctes* sp. ind.	*Pictonia* (P.) cf. *baylei*	*Stratigrafiya*..., 1957, pl. 20, fig. 3
Payakhinskaya 11	3790–3900 (lower)	*Amoebites* ex gr. *kitchini*	*Amoebites peregrinator* sp. nov.	**Pl. I, fig. 8**
Otorinskaya 42	60.6		*Plasmatites zieteni*	**Pl. I, fig. 1–2**

Table 1. (Contd.)

Borehole, Formation	Depth, m	Original identification	New identification	Source
Otorinskaya 42	60.6	*Amoeboceras* (*Plasmatites*/*Amoebites*) sp. juv.	*Plasmatites zieteni*	Alifirov et al., 2016, fig. 2.7
Otorinskaya 42	60.6	*Amoeboceras* (*Plasmatites*) *gerassimovi*	*Plasmatites* cf. *zieteni*	Alifirov et al., 2016, fig. 2.8
Spasskaya 21	2880.2	*Rasenia* cf. *optima*	*Rasenia coronata*	Alifirov et al., 2016, fig. 2.10
Sukhodudinskaya 1. Sigovoe Formation	1130.7–1143.1	*Amoeboceras* (*Amoebites*) cf. *modestum*	*Amoebites* cf. *modestum*	Vyachkileva et al., 1990, pl. 50, fig. 4
Symor'yakhskaya 7939	2070.3–2088.3 (9.20)		*Zonovia* cf. *evoluta*	Collective of authors
Symor'yakhskaya 7919/5	2089.5–2106.3 (3.0)		*Zonovia* cf. *evoluta*	Collective of authors
Symor'yakhskaya 7919/5	2089.5–2106.3 (3.75)		*Amoebites* cf. *subkitchini*, *Prorasenia* sp.	Collective of authors
Symor'yakhskaya 7919/5	2089.5–2106.3 (9.0)		*Amoeboceras* (?) cf. *schulginae*	Collective of authors
Tanginskaya 11130	1445.5–1451.0 (0.8)		*Amoebites*/*Euprionoceras* sp. juv.	Collective of authors
Tanginskaya 11130	1445.5–1451.0 (2.9)		*Amoebites* ex. gr. *kitchini*, *Zenostephanus* sp.	Collective of authors
Tatarskaya 1, Maryanovsk Formation	2454–2460	*Pictonia* sp. juv.	*Pictonia* sp. juv.	Vyachkileva et al., 1990, pl. 52, fig. 14
Tatarskaya 1, Maryanovsk Formation	2454–2460	*Prorasenia* sp.	*Prorasenia* sp.	Klimova, 1961, pl. II, fig. 4
Tatarskaya 1, Maryanovsk Formation	2454–2460	*Rasenia* aff. *orbignyi*	*Rasenia* cf. *inconstans*	Klimova, 1961, pl. II, fig. 3
Tagrinskaya 59, Georgievka Formation	2795–2801 (0.2)	*Amoeboceras* (*Nannocardioceras*) sp.	*Nannocardioceras* cf. *krausei*	Vyachkileva et al., 1990, pl. 52, fig. 13
Trekhozernaya 12, Abalak Formation	1538–1541 (lower)	*Aulacostephanus* sp. sp. indet.	*Zenostephanus* (*Xenostephanoides*) sp.	Vyachkileva et al., 1990, pl. 54, fig. 6
Tukulundo–Vadinskaya 320, Sigovoe Formation	4130–4144 (4.5)	*Amoeboceras* (*Amoebites*) cf. pulchrum	*Amoebites* sub*kitchini*	Meledina, 2006, pl., fig. 3
Urengoiskaya 510, Bazhenov Formation (basal)	3640–3649 (2.3)	*Aulacostephanus* sp. sp. indet.	?*Aulacostephanus* s.l.	Vyachkileva et al., 1990, pl. 54, fig. 10
Urengoiskaya 510, Danilovskaya Formation	3640–3649 (3,3)	?*Aulacostephanus* sp. indet.	*Zenostephanus* (Z.) cf. sachsi	Vyachkileva et al., 1990, pl. 54, fig. 9

Table 1. (Contd.)

Borehole, Formation	Depth, m	Original identification	New identification	Source
Ust–Chaselskaya 199, Sigovoe Formation	2649–2664 (2.1)	*Amoeboceras* (*Amoebites*) cf. *alticarinatum*	*Amoebites* cf. *subkitchini*	Vyachkileva et al., 1990, pl. 50, fig. 3
Ust–Chaselskaya 199, Sigovoe Formation	2649–2664 (2.7)	*Amoeboceras* (*Amoebites*) sp. indet.ex gr. *A. rasenense*	*Amoebites subkitchini*	Vyachkileva et al., 1990, pl. 50, fig. 11
Ust–Chaselskaya 199, Sigovoe Formation	2649–2664 (4.5)	*Amoeboceras* (*Amoebites*) sp. cf. *A. salfeldi*	*Amoebites* aff. *schulginae*	Vyachkileva et al., 1990, pl. 50, fig. 5
Ust–Chaselskaya 199, Sigovoe Formation	2649–2664 (9.8)	*Rasenia* (*Rasenia*) cf. *optima*	*Rasenia* cf. *optima*	Vyachkileva et al., 1990, pl. 53, fig. 2
Ust–Chaselskaya 202, Sigovoe Formation	2623–2633 (5.8)	*Amoeboceras* (*Amoebites*) ex gr. *kitchini*	*Amoebites* sp.	Vyachkileva et al., 1990, pl. 49, fig. 10
Ust–Chaselskaya 202, Sigovoe Formation	2623–2633 (5.8)	*Amoeboceras* (*Amoebites*) sp. indet.	*Amoebites subkitchini*	Vyachkileva et al., 1990, pl. 51. fig. 6
Ust–Chaselskaya 202, Sigovoe Formation	2623–2633 (5.9)	*Rasenia* sp. cf. *R. optima*	*Rasenia optima*	Vyachkileva et al., 1990, pl. 53, fig. 1
Ust–Chaselskaya 202, Sigovoe Formation	2623–2633 (7.8)	*Amoeboceras* (*Amoebites*) cf. *alticarinatum*	*Amoebites subkitchini*	Vyachkileva et al., 1990, pl. 50, fig. 1–2
Ust–Chaselskaya 204, Yanov Stan Formation	2732–2738 (3,0)	*Amoeboceras* sp. indet.	*Amoebites* cf. *kitchini*	Vyachkileva et al., 1990, pl. 52, fig. 2
Ust–Chaselskaya 204, Yanov Stan Formation	2732–2738 (4.8)	?*Rasenia* (?*Zonovia*) sp. indet.	*Zonovia* sp.	Vyachkileva et al., 1990, pl. 54, fig. 1
Ust–Chaselskaya 208, Yanov Stan Formation	2695–2710 (0.1)		*Euprionoceras sokolovi*	*Co.Yu.V. Braduchan*
Ust–Chaselskaya 208, Yanov Stan Formation	2695–2710 (1.2)	*Amoeboceras* sp. juv.	*Amoebites* sp. juv.	Vyachkileva et al., 1990, pl. 48, fig. 24
Ust–Chaselskaya 208, Yanov Stan Formation	2695–2710	*Amoeboceras* (*Amoebites*) ex gr. *kitchini*	*Amoebites* cf. *kitchini*	Vyachkileva et al., 1990, pl. 49, fig. 9
Ust–Chaselskaya 208, Yanov Stan Formation	2695–2710 (2.8)	*Amoeboceras* (*Amoebites*) cf. *subkitchini*	*Amoebites* cf. *kitchini*	Vyachkileva et al., 1990, pl. 49, fig. 11

Table 1. (Contd.)

Borehole, Formation	Depth, m	Original identification	New identification	Source
Ust–Chaselskaya 208, Yanov Stan Formation	2695–2710 (2.8)	*Amoeboceras* (*Amoebites*) sp. indet.	*Amoebites* cf. *kitchini*	Vyachkileva et al., 1990, pl. 51, fig. 5
Ust–Chaselskaya 208, Yanov Stan Formation	2695–2710 (3.3)		*Zenostephanus* (*Xenostephanoides*) sp.	*Co. Yu. V. Braduchan*
Ust–Chaselskaya 208, Yanov Stan Formation ?	2773–2788 (9.9)		*Pictonia*/*Prorasenia* ind.	*Co. Yu. V. Braduchan*
Ust–Chaselskaya 210, Sigovoe Formation	2660–2669 (3.5)	*Amoeboceras* (*Amoebites*) ex gr. *kitchini*	*Amoebites* cf. *subkitchini*	Vyachkileva et al., 1990, pl. 49, fig. 7
Ust–Chaselskaya 210, Sigovoe Formation	2660–2669 (3.8)	*Amoeboceras* (*Amoebites*) ex gr. *kitchini*	*Amoebites* cf. *mesezhnikovi*	Vyachkileva et al., 1990, pl. 49, fig. 8
Ust–Chaselskaya 210, Sigovoe Formation	2660–2669 (4.6)	*Rasenia* (*Rasenia*) sp.	*Prorasenia* sp.	Vyachkileva et al., 1990, pl. 53, fig. 6
Ust–Chaselskaya 210, Sigovoe Formation	2660–2669 (4.7)	*Rasenia* (*Rasenia*) cf.*repentina*	*Rasenia* cf. *optima*	Vyachkileva et al., 1990, pl. 53, fig. 3
Ust–Chaselskaya 210, Sigovoe Formation	2660–2669 (5.3)	*Amoeboceras* (*Amoebites*) ex gr. *kitchini*	*Amoebites* cf. *subkitchini*	Vyachkileva et al., 1990, pl. 52, fig. 3
Ust–Chaselskaya 210, Sigovoe Formation (?)	2752–2760 (1.4)		*Plasmatites zieteni*	**Pl. I, fig. 9**
Kharampurskaya 303, Kharampur Formation (?)	2950–2954 (1.65)	*Craspedites* sp.indet.	*Aulacostephanoides* ? sp.	Vyachkileva et al., 1990, pl. 64, fig. 4
Kharampurskaya 303, Kharampur Formation	3000–3009 (2.0)	*Amoeboceras* (*Amoebites*) *kitchini*	*Amoebites subkitchini*	Vyachkileva et al., 1990, pl. 49, fig. 4
Kharampurskaya 303, Kharampur Formation	3000–3009 (2.5)	*Amoeboceras* (*Amoebites*) sp. indet.	*Amoebites subkitchini*	Vyachkileva et al., 1990, pl. 51, fig. 4
Kharampurskaya 310, Kharampur Formation	2890–2905 (5.7)	*Rasenia* (? *Zonovia*) sp.	*Zenostephanus* (*Xenostephanoides*) sp.	Vyachkileva et al., 1990, pl. 53, fig. 7
Kharasaveiiskaya 48, Kharampur Formation (equivalent)	3120–3135 (2.6)	*Amoeboceras* (*Amoebites*) cf. *pul-chrum*	*Hoplocardioceras elegans*	Vyachkileva et al., 1990, pl. 50, fig. 14
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (4.1)	*Amoeboceras* (*Amoebites*) *pulchrum*	*Hoplocardioceras elegans*	Vyachkileva et al., 1990, pl. 50, fig. 15

Table 1. (Contd.)

Borehole, Formation	Depth, m	Original identification	New identification	Source
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (5.6)	*Amoeboceras* sp. indet.	*Hoplocardioceras* sp.	Vyachkileva et al., 1990, pl. 52, fig. 9
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (6.1)	*Amoeboceras* (*Amoebites*) sp. indet.	*Hoplocardioceras* cf. elegans	Vyachkileva et al., 1990, pl. 51, fig. 3
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (6.4)	*Amoeboceras* (*Amoebites*) sp. indet.	*Hoplocardioceras* sp.	Vyachkileva et al., 1990, pl. 51, fig. 2
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (9.3)	*Amoeboceras* sp. indet.	*Euprionoceras* sp.	Vyachkileva et al., 1990, pl. 52, fig. 10
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (9.3)	*Amoeboceras* sp. indet.	*Euprionoceras norvegicum*	Vyachkileva et al., 1990, pl. 52, fig. 12
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (9.3)	Aulacostephaninae gen. et sp. indet. (?*Rasenia*, ?Zonovia, ?*Aulacostephanus*)	*Zenostephanus* (*Xenostephanoides*) sp.	Vyachkileva et al., 1990, pl. 54, fig. 7
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (10.4)	*Amoeboceras* sp. indet.	*Amoebites* sp.	Vyachkileva et al., 1990, pl. 52, fig. 11
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (10.4)	Aulacostephaninae gen. et sp. indet. (?*Rasenia*, ?*Zonovia*, ?*Aulacostephanus*)	*Zonovia* sp.	Vyachkileva et al., 1990, pl. 54, fig. 11
Kharasaveiiskaya 48, Georgievka Formation (equivalent)	3120–3135 (12.65)	Aulacostephaninae gen. et sp. indet. (?*Rasenia*, ?*Zonovia*, ?*Aulacostephanus*)	*Zenostephanus* (*Z.*) cf. *sachsi*	Vyachkileva et al., 1990, pl. 54, fig. 8
Kholmistaya 667	2907–2922 (14.15)		*Pictonia* (*Pictonia*) sp. cf. *baylei*	*Co. Yu. V. Braduchan*
Kholmistaya 667	2974–2987 (3.3)		*Pictonia* (*Pictonia*) sp.	*Co. Yu. V. Braduchan*
Kholmistaya 695	2871–2884 (5.3)		*Pictonia* (*Pictonia*) cf. *baylei*	*Co. Yu. V. Braduchan*
Kholmistaya 695	2871–2884 (5.7)		*Amoebites bayi*	**Pl. I, fig. 5**
Shushminskaya 10683	2013–2029 (3.2)		*Pictonia* aff. *normandiana* sensu Birkelund et Callomon	**Pl. I, fig. 3**
Yamantylinskaya 925	3442	*Amoebites subkitchini*	*Amoebites subkitchini*	Alifirov et al., 2016, fig. 2.9

as *H.* cf. *elegans* (Spath). This specimen is similar to the coarsely ribbed *H. elegans* (Spath) from Spitsbergen (Birkenmajer and Wierzbowski, 1991, text-fig. 10) and resembles some specimens transitional from *H. decipiens* (Spath) to *H. elegans* (Spath) found in the Middle Volga region.

It is possible that equivalents of the terminal Taimyrensis Zone of the Boreal Kimmeridgian can include the single depicted specimen of *Nannocardioceras* known from the central regions of Western Siberia (*N.* cf. *krausei* (Salf.): Vyachkileva et al., 1990, pl. 52, fig. 13, Borehole Tagrinskaya 59).

SYSTEMATIC PALEONTOLOGY

SUPERFAMILY STEPHANOCERATOIDEA NEUMAYR, 1875

FAMILY CARDIOCERATIDAE SIEMIRADZKI, 1891

SUBFAMILY CARDIOCERATINAE SIEMIRADZKI, 1891

Genus *Amoeboceras* Hyatt, 1900

***Amoeboceras (?) klimovae* Rogov, sp. nov. [M]**

Cardioceras aff. *kostromense*: *Stratigrafiya*..., 1957, pl. 20, fig. 4.

Cardioceras cf. *kostromense*: Klimova, 1961, p. 16, pl. 1, fig. 4.

Amoeboceras cf. *kostromense*: Vyachkileva et al., 1990, p. 101, pl. 48, fig. 7.

Amoeboceras (Prionodoceras) ravni: Mesezhnikov, 1967, p. 116, pl. 1, fig. 1; *Stratigrafiya*..., 1976, pl. 13, fig. 5; The *Jurassic Ammonite Zones*..., 1988, pl. 9, fig. 14.

Amoeboceras (Prionodoceras) cf. *ravni*: Meledina et al., 1979, pl. 2, fig. 7.

Amoeboceras (Prionodoceras) aff. *superstes*: Ershova, 1983, pl. 5, fig. 8.

Amoeboceras schulginae: Wierzbowski and Smelror, 1993, pl. 1, fig. 6; Schweigert, 1995, text-figs. 1a–1c, ?1d, 1e; Schweigert and Callomon, 1997, p. 6, pl. 2, fig. 1; pl. 5, fig. 2 (cf.); Schweigert, 2000, pl. 1, fig. 10.

Amoeboceras aff. *schulginae*: Matyja et al., 2006, p. 401, figs. 6k–6n.

E t y m o l o g y. In honor of I.G. Klimova, who was the first to identify representatives of this species in Western Siberia (see the list of synonyms).

H o l o t y p e. Specimen VNIGRI 20/686, collection of M.S. Mesezhnikov (= *Amoeboceras ravni* in Mesezhnikov, 1967, pl. 1, fig. 1); Levaya Boyarka River, outcrops 21–22, lower Kimmeridgian, Bauhini Zone, klimovae Biohorizon.

D e s c r i p t i o n. The shells are semi-involute and small (5–6 cm). The umbilicus is moderately narrow. The whorl cross section is subrectangular owing to the well-developed umbilical and ventrolateral tubercles. The umbilical wall is steep. The ribs are subrectiradiate, less commonly slightly prorsiradiate, or (on the terminal body chamber (TBC)) forming a rursiradiate curvature. They begin from the elongated umbilical tubercles. Another row of tubercles is present in the mid-flank. The secondary ribs are weakly connected to these tubercles and gradually become more prominent toward the ventrolateral shoulder where they form the third (ventrolateral) row of tubercles. On the venter, the ribs are sharply reduced in strength. They are usually separated from the keel by a prominent furrow. The keel possesses small serrations, three to four times greater in number than the secondary ribs. The suture is unknown.

D i m e n s i o n s i n millimeters and ratios:[2]

Specimen no.	Dm	UW	WW	WH	Rp	Rs	Rr
SGM 489-416	43	13.3	–	13.1	9	~16	1.77
VNIGRI 20/686	50	14.8	16.5	20	11	16	1.45
SMNS 9716	40.5	15	12	14	12	19	1.58
SMNS 9716	40	12	9	13	11	15	1.36

O c c u r r e n c e. Lower Kimmeridgian, Bauhini Zone, klimovae Biohorizon of Scotland, Spitsbergen, shelf of the Barents Sea, Franz Josef Land, northern regions of Central Siberia, southern Germany, and Western Siberia.

C o m p a r i s o n. This species is close to *?A. schulginae* Mesezhn. in the general type of ribbing (presence of three rows of tubercles and relatively coarse and widely spaced ribs with low ribbing ratio), but differing from it in being approximately half its size and in the absence of the weakening of ribs on the TBC. It is similar to the poorly studied species *A. ravni* Spath, which remains known only from two specimens of the type series. It is possible that the holotype depicted by Spath can in fact belong to the genus *Cardioceras*, because as was indicated by Sykes and Callomon (1979), the type locality (Shendwick, Eastern Scotland) does not expose beds younger than the middle Oxfordian Tenuiserratum Zone. Nevertheless, if *A. ravni* is assigned to the genus *Amoeboceras* from the upper Oxfordian, then in fact the only character resembling *A. (?) klimovae* is the presence of three rows of tubercles (this is the only distinguishing character of this species indicated by Spath). At the same time, the more strongly involute coiling, the significantly less densely spaced ribs in the internal whorls, and the absence of modification of ornamentation on the TBC readily distinguish *A. (?) klimovae* sp. nov. from *A. ravni*.

V a r i a b i l i t y. In general representatives of the species from different regions are morphologically similar in the type of ornamentation, shape, and size of the shell. At the same time, the density of the ribbing varies (from 9 to 12 primary ribs per half whorl), as well as their shape: the ribs can be subradiate or slightly bent. The primary ribs first slightly bend toward the aperture, and the secondary ribs form a falcate, directed backward (Matyja et al., 2006, text-figs. 6m–6n). The character of the keel region of the shell is also highly variable: the keel can be separated from the ribs by a relatively deep and well-developed

[2] Dm—shell diameter; UW—umbilicus width; WW—whorl width; WH—whorl height; Rp—number of primary ribs per half whorl; Rs—number of secondary ribs per half whorl; Rr—ribbing ratio, calculated as Rs/Rp.

furrow or by a smooth band, or in some cases, the ribs continue onto the keel.

R e m a r k s. The species *A. (?) schulginae* Mesezhn. and *A. (?) klimovae* sp. nov. are assigned to *Amoeboceras* tentatively. Their coarse ribbing with three rows of tubercles is not typical of *Amoeboceras*, although the weakening of the ribbing on the TBC in *A. (?) schulginae* Mesezhn. is similar to the weakening of ribbing observed in late *Amoeboceras*, whereas three rows of tubercles (even weakly developed) are sometimes present in *Amoeboceras* from the Rosenkrantzi Zone (Matyja et al., 2006, text-fig. 6b). The interpretation of the dimorphism in this species is not entirely clear. These are typical macroconchs, but their unequivocal correlation with the microconchs is not certain. These species are always found in association with *Plasmatites*, and the range of their variation includes characters typical of *Plasmatites* (ribs continuing onto the keel and the curvature of the ribs), suggesting that these are possible macroconchs of *Plasmatites*. At the same time, *Plasmatites* are found in association with large evolute macroconchs (such as *Euprionoceras* sp. in Schweigert, 2000, pl. 1, fig. 11), which are even more similar to *Plasmatites*.

M a t e r i a l. See the synonymy list.

Genus *Plasmatites* Buckman, 1925

T y p e s p e c i e s: *Plasmatites crenulatus* Buckman, 1925; British Geological Survey, GSM30523,[3] collection of S.S. Buckman, 1902, Bowood Park, Wiltshire, England. Buckman originally assigned this specimen to the *plastum hemera* (currently the middle Oxfordian), which contains the type species of the genus *Plasmatoceras* (Buckman, 1925, pl. 616). In this region, both Oxfordian and lower Kimmeridgian beds are exposed, and in the opinion of J.K. Wright (pers. comm.), *Plasmatites crenulatus* comes from the basal part of the Kimmeridgian. It is considered (Matyja et al., 2006) that *P. crenulatus* Buckm. is a junior synonym of *P. praebauhini* (Salfeld, 1915). Salfeld's species is based on two syntypes: one from the Oxfordian clay in Galievo (near Moscow) (Salfeld, 1915, pl. 17, fig. 6) and the other from the Kimmeridgian of Norfolk (Salfeld, 1915, pl. 17, fig. 5); and neither specimen shows the transition of the ribs onto the keel, although in the shell shape and ribbing the English syntype resembles *P. crenulatus* Buckm. The English specimen was later selected as the lectotype (Sykes and Callomon, 1979), but at present this specimen is represented by a poorly preserved whorl fragment,[4] which cannot be used to compare Buckman's and Saldfeld's species.

D i a g n o s i s. The shells are small (up to 4 cm in diameter, but usually less), semievolute, with a subrectangular cross section of the shell. The cross section of the whorls and ornamentation in most populations are highly variable (e.g., Birkelund and Callomon, 1985, pl. 9, figs. 8–13; Schweigert and Callomon, 1997, pl. 1; text-figs. 2a–2m). The cross section of adult shells varies from low subrectangular with whorls twice as wide as high (Schweigert and Callomon, 1997, pl. 1, fig. 9) to highly oval with the height considerably exceeding the width (Salfeld, 1915, pl. 17, fig. 6). The ribs are mainly simple and biplicate. The density of ribbing, the inclination of the ribs, their differentiation, prominence of ribs and tubercles, and the transition of the ribs onto the keel are highly variable. For example, the number of primary ribs per half whorl in *P. bauhini* (Opp.) within one sample varies from 10 to 26, and the number of secondary ribs varies from 17 to 40 (Schweigert and Callomon, 1997, p. 6). The degree of differentiation of the ribbing varies from similarly developed primary and secondary ribs, with no tubercles at the bifurcation point, to coarse primary ribs, terminating with a node and separated from the secondary ribs by a smooth band (Schweigert and Callomon, 1997, pl. 1). The furcation of the ribs usually occurs in the mid-flank or slightly above. Sometimes the secondary ribs can also bifurcate (usually near the keel). The ribs can be almost rectiradiate (Schweigert and Callomon, 1997, pl. 1, fig. 10) and can be sharply bent toward the aperture on the TBC (Schweigert and Callomon, 1997, pl. 1, figs. 24–26), but most commonly the ribs are weakly falcate. *Plasmatites*, in contrast to all younger and older cardioceratid species, has ribs connected to the serrations of the keel, which is very distinct. However, in *P. bauhini* (Opp.), the secondary ribs can become tubercles separated from the keel by a smooth band (this variation of the ribbing is most characteristic of morphotypes with a wide whorl cross section). In other species, the secondary ribs are not connected to the keel (in most specimens of *P. tuberculatoalternans* (Nik.)), and the least ornamented species of the genus, *P. zieteni* (Rouill.), often completely lacks secondary ribs, although in most specimens such ribs are present to a variable extent, and the well-preserved specimens have ribs sometimes connected to the serrations of the keel. The appearance of ribs and a keel in the shell is also recorded at considerably different shell diameters; especially late, the ribbing can appear in *P. zieteni* (Rouill.). The suture is weakly dissected (Buckman, 1925, pl. 618); its ontogeny is not studied.

S p e c i e s c o m p o s i t i o n. *P. bauhini* (Opp.), *P. crenulatus* (Buckman) (= *P. quadratolineatus* (Salf.)), *P. lineatus* (Quenst.), ?*P. mossolovoense* (Sason.), *P. piecarum* (Malin.), *P. praebauhini* (Salf.), ?*P. rasoumowskii* (Rouillier), *P. tuberculatoalternans* (Nik.) (= *P. transversum* (Quenst.)), *P. zieteni* (Rouill.) (= *P. gerassimovi* (Kalach. et Mesezhn.)).

O c c u r r e n c e. Lower Kimmeridgian, Bauhini Zone and its equivalents. Mass occurrences of *Plasmatites* are characteristic in the first place for Subboreal regions (England, Scotland, European Russia,

[3] The photographs and the 3D model can be found at http://www.3d-fossils.ac.uk/fossilType.cfm?typSampleId=579419.

[4] GSM26054, http://www.3d-fossils.ac.uk/fossilType.cfm?typSampleId=582690.

P. bauhini, *P. crenulatus*, *P. zieteni*, *P. praebauhini*), where they dominate across the zone. In the Submediterranean sections (Switzerland, southern Germany, Central Poland), *Plasmatites* (*P. bauhini*, *P. piecarum*, *P. praebauhini*) are also numerous, but their occurrences are usually found in several thin horizons. A record of *P. zieteni* in the Bimammatum Zone and Subzone of Switzerland (Gygi, 2000, pl. 10, fig. 2) is worth mentioning. In the Arctic (Eastern Greenland—*P.* cf. *zieteni*; Spitsbergen—*P.* cf. *bauhini*; Franz Josef Land, Western and Central Siberia—*P.* cf. *bauhini*, *P. praebauhini*, *P. zieteni*), occurrences of *Plasmatites* are relatively few, but the reasons for this are still uncertain (possibly a sampling bias, or local geology, or true infrequency of this genus at high latitudes. No occurrences of *Plasmatites* are known to the east of Nordvik.

Comparison. Shells of *Plasmatites* are similar in shape, size, and ornamentation to some upper Oxfordian *Amoeboceras*, from which they differ primarily in the continuation of secondary ribs onto the keel or development tubercles instead of such ribs, and also in the frequent presence of ribs inclined toward the phragmocone on the TBC. *Plasmatites* are likewise distinguished from the earliest *Amoebites* (*A. bayi* (Birk. et Call.)), which in the shell shape, ribbing, and variability are similar to *Plasmatites*, but have a keel separated from the ribs by a smooth band. Some of the later species of *Amoebites* have ribs continuing onto the keel (Mesezhnikov and Romm, 1973).

Remarks. *Plasmatites* is a typical microconch genus. Mass occurrences of microconchs of *Plasmatites* in the basal Kimmeridgian and the almost complete absence of macroconchs readily agree with the interpretation of dimporphs given by Matyja (1986) as representatives of seasonal breeding cohorts (Wierzbowski and Rogov, 2013). At the same time, it is possible that dimorphs in these ammonites were weakly differentiated in size. The species *?P. mossolovoense* (Sason.) is assigned to the genus *Plasmatites* provisionally. Although this species found in the "upper part of the upper Oxfordian" resembles *P. zieteni* (Rouill.) and was compared by Sasonov (1957, pp. 143–144) to *P. zieteni*, it is also very similar to some cardioceratids from the upper part of the middle Oxfordian, and it is possible that its stratigraphic placement could be erroneous.

Plasmatites zieteni (Rouillier, 1849)

Plate I, figs. 1, 2, 9, 11–16, 18

Ammonites sp.: Rouillier, 1846, pl. A, figs. 8a, 8b; Rouillier and Vosinsky, 1848, p. 264.

Ammonites zieteni: Rouillier and Vosinsky, 1849, p. 368.

Ammonites zieteni var. *angiolinus*: Czapski, 1849, p. 616, pl. 7.

Amaltheus zieteni: Nikitin, 1878, c. 151, pl. 2, fig. 19 (suture).

Cardioceras zieteni: Nikitin, 1916, p. 10, pl. 1, figs. 10–13; *Atlas*..., 1949, pl. 49, figs. 3–4.

Amoeboceras bauhini: Sykes and Callomon, 1979, pl. 121, figs. 4, 5.

Amoeboceras (Prionodoceras) aff. *marstonensis*: *Middle and Upper Oxfordian*..., 1989, pl. 22, figs. 4a–4c.

Amoeboceras (Amoeboceras) gerassimovi: *Middle and Upper Oxfordian*..., 1989, p. 85, pl. 26, figs. 3–8.

Amoeboceras ovale: Gygi, 2000, p. 79, pl. 10, fig. 2.

Amoeboceras (Plasmatites) bauhini: Głowniak et al., 2010, pl. 4, figs. 9–11.

Amoeboceras (Plasmatites/Amoebites) sp. juv.: Alifirov et al., 2016, text-fig. 2.7.

Amoeboceras (Plasmatites) gerassimovi: Alifirov et al., 2016, text-fig. 2.8.

Amoeboceras (*Plasmatites*) *zieteni*: Wierzbowski et al., 2016, Fig. 5.7–8.

Non *Ammonites zieteni*: Potiez and Michaud, 1838, p. 20 (= *Ludwigia* ex gr. *murchisonae* (J. Sow.)).

Non *Ammonites zieteni*: Oppel, 1856, p. 165 (= *Coeloderoceras zieteni* (Opp.)).

Non *Ammonites striatus zieteni*: Quenstedt, 1883–1885, p. 222, pl. 28, figs. 1–4 (= *Liparoceras zieteni* Trueman, 1919).

Non *Cardioceras zieteni*: Ilovaisky, 1903, p. 271, pl. 11, figs. 3–4; Malinowska, 1958, pp. 789, 792, 795; Malinowska, 1968, p. 122 (= *Cardioceras (Miticardioceras)* ex gr. *tenuiserratum* (Opp.)).

Non *Cawtoniceras zieteni*: *Geology of Poland*..., 1988, pl. 24 (= *Cardioceras (Miticardioceras)* ex gr. *tenuiserratum* (Opp.)).

Non *Cardioceras (Miticardioceras?) zieteni*: *Middle and Upper Oxfordian*..., 1989, pp. 8, 9, 32, 38 (= *Cardioceras (Miticardioceras)* ex gr. *tenuiserratum* (Opp.)).

Holotype. The holotype is not designated. The type series comes from Simbirsk (Ulyanovsk) and Shchukino. The ammonites described by Rouillier in 1846 as found "in Simbirsk" (which apparently should mean the Simbirsk Governorate, which then included a large part of Ulyanovsk oblast, part of Samara oblast, Chuvashia, and Mordovia), while the description published in 1849 also mentions occurrences from Mneviki and Shchukino (presently both sites are within Moscow). Since a large part of the collection of K.F. Rouillier was lost in a fire (see Bessudnova and Starodubtseva, 2014), a neotype was selected from the collection of S.V. Nikitin (specimen no. TsNIGR 29/5247, this paper, Plate I, fig. 13), collected in Mnevniki.

Description. The shells are semievolute, small (usually, up to 3 cm in diameter). The whorl cross section varies from rounded to oval, and in different specimens, the height can be either considerably greater than the whorl width, or approximately the same, or slightly less. A low finely serrated keel is present. The subrectiradiate or slightly prorsiradiate primary ribs appear at considerably different shell diameters. The ribs can terminate in small tubercles. The secondary ribs are small, falcate or rursiradiate; their number is 1.5–2.5 times greater than that of the primary ribs. They are usually separated from the primary ribs and keel by smooth bands and rarely continue onto the keel. The secondary ribs can appear on the outer whorls or on the TBC (my collection includes such specimens from the Russian Platform); sometimes they are very weakly developed or absent; in some specimens, they can terminate in tubercles. In some cases, the secondary ribs can bifurcate near the keel.

Dimensions in millimeters and ratios:

Specimen no.	Dm	UW	WW	WH	Rp	Rs	Rr
TsNIGR 28/5247	17.75	6.38	10.3	7.34	8		
TsNIGR 30/5247	24.86	9.27	12.9	10.2	14	26	1.85
TsNIGR 29/5247	20.7	8,54	8.57	7.55	12		
TsNIGR 32/5247	16.7	5.1	6.54	7.33	14		
SGM MK4760	32.3	11.4	–	11.76	15	29	1.93
SGM MK4761	29.7	10.94	–	11.9	19	31	1.63

Occurrence. Lower Kimmeridgian, Bauhini Zone, zieteni Biohorizon and its equivalents in Scotland (?), northern Switzerland, Eastern Greenland, European Russia, Western Siberia, and Khatanga Basin.

Comparison. This species differs from other representatives of the genus *Plasmatites* in the poorly developed secondary ribs and in the relatively late appearance of the ribbing, although both of these characters are highly variable. Apart from that, in most specimens of *P. zieteni*, the keel is separated from the secondary ribs by a smooth band, and the ribs only rarely continue onto the keel. This morphology of the venter is similar to other species from the lower part of the Bauhini Zone, *P. tuberculatoalternans* (Nik.) and *P. piecarum* (Malin.), from which *P. zieteni* (Rouill.) is distinguished by less strongly developed secondary ribs and usually well-developed primary ribs.

Variability. *P. zieteni* (Rouill.), like other species of *Plasmatites*, shows a considerably intraspecific variability. The cross section of the TBC can vary from high-oval with the height considerably exceeding the width to low-oval with the width almost twice the height. The number of primary ribs on the outer whorls in different specimens varies from 9 to 20. The primary ribs appear at significantly different diameters, from 0.3 to 1.5 cm. The secondary ribs can appear relatively early in the ontogeny and can be present only in the TBC or can be altogether absent.

Remarks. *Ammonites zieteni* Rouillier, 1849 is a junior homonym of *Ammonites zieteni* Potiez et Michaud, 1838, but Roullier's species nevertheless can be retained as valid according to Article 23.9.1 of the International Code of Zoological Nomenclature. *Ammonites zieteni* Potiez et Michaud, 1838 was used extremely rarely. It was mentioned by Gosselet (1869), and then Getty (1973) listed this name in a discussion of *Ammonites striatus zieteni* Quenstedt, 1884. At the same time, Roullier's species was consistently mentioned as being valid, but following the paper by Ilovaisky (1903), this name was mainly used for the middle Oxfordian *Cardioceras (Miticardioceras)*, which are similar to *Plasmatites zieteni* (Rouillier) in the weakly developed secondary ribs.

Genus *Amoebites* Buckman, 1925

Amoebites peregrinator Rogov, sp. nov. [?m]

Plate I, figs. 8, 19, 20

Amoeboceras kitchini: Arkell and Callomon, 1963, pl. 32, fig. 26.
cf. *Amoeboceras* (*Amoebites*) aff. *A. (A.) beaugrandi* (m): Birkelund and Callomon, 1985, pl. 4, figs. 6–8.
cf. *Amoebites* aff. *beaugrandi*: Rogov, 2014, text-fig. 5.6.

Etymology. From the Latin *peregrinator* (traveler), as this species has a wide geographic range.

Holotype. Specimen SGM MK4223. Tarkhanovskaya pristan, Member 4, 5.1 m above the water level; upper Kimmeridgian, Mutabilis Zone, peregrinator Biohorizon.

Description. The shells vary from semievolute to semi-involute and have a small diameter (up to 3–4 cm). The whorl cross section is unknown, as the entire type series is represented by laterally compressed specimens The primary ribs are radial, relatively widely spaced and coarse, both on the terminal body chamber and on the inner whorls. Near the midflank they form a node, and then they become somewhat weaker and either subdivide into two secondary radial ribs or form a primary rib. The secondary ribs strengthen toward the ventrolateral shoulder and may form a node. After the node, the ribs become weaker and completely disappear, although some ribs continue onto the keel. The keel is composed of relatively widely spaced and large serrations, the number of which is approximately 1.5–2 greater than the number of secondary ribs. The suture is unknown.

Dimensions in millimeters and ratios in %:

Specimen no.	Dm	Du	WW	H	Rp	Rs	Rr
SGM MK4223	17.22	5.62	–	7.15	12	22	1.83
Specimen unnumbered, INGG	24.5	9.4	–	9	11	17	1.54

Occurrence. Upper Kimmeridgian, Kitchini Zone, Modestum Subzone (Mutabilis Zone of the Subboreal scale), peregrinator Biohorizon of Scotland, ?Eastern Greenland, Spitsbergen, European Russia, and Western Siberia.

Comparison. This species is similar to *A. spathi* (Schulg.) and *A. bayi* (Birk. et Call.) in shape and size but differs in the considerably more widely spaced primary ribs and in the presence of prominent tubercles at the places of rib bifurcation. Some specimens of *A. bayi* (Birk. et Call.) also have prominent tubercles at the places of rib bifurcation and have subrectiradiate ribs (Birkelund and Callomon, 1985, pl. 1, figs. 4, 6),

Table 2. Correlation of the infrazonal scales of the Kimmeridgian of Western Siberia, Franz Josef Land, Spitsbergen, and northern Central Siberia

Western Europe: Substage	Western Europe: Zone	Western Siberia (this paper): Biohorizon	Western Siberia (this paper): Subzone	Western Siberia (this paper): Zone	Western Siberia (Meledina et al., 2014; Alifirov et al., 2016): Zone	Western Siberia (Meledina et al., 2014; Alifirov et al., 2016): Zone	Franz Josef Land (Rogov, 2014; Wierzbowski et al., 2016): Biohorizon	Franz Josef Land: Subzone	Franz Josef Land: Zone	Spitsbergen (Rogov, 2014, modified): Biohorizon	Spitsbergen: Subzone	Spitsbergen: Zone	Northern Central Siberia (Wierzbowski and Rogov, 2013, modified): Biohorizon	Northern Central Siberia: Subzone	Northern Central Siberia: Zone	Substage
Upper Kimmeridgian	Autissiodorensis		*Suboxydiscites taimyrensis* ?		*Aulacostephanus autissiodorensis*	?		?			*Suboxydiscites taimyrensis* ?			*Suboxydiscites taimyrensis*		Upper Kimmeridgian
Upper Kimmeridgian	Eudoxus	*Hoplocardioceras elegans*	*Hoplocardioceras decipiens*		*Aulacostephanus eudoxus*	?	*Hoplocardioceras elegans*; *H. decipiens*	*Hoplocardioceras decipiens*		*Hoplocardioceras elegans*; *H. decipiens*	*Hoplocardioceras decipiens*		*N. anglicum*; *H. elegans*; *H. decipiens*	*Hoplocardioceras decipiens*		Upper Kimmeridgian
Upper Kimmeridgian	Eudoxus	*Euprionoceras sokolovi*; *Euprionoceras norvegicum*	*Euprionoceras sokolovi*		*Aulacostephanus eudoxus*	?	*Euprionoceras sokolovi*	*Euprionoceras sokolovi*		*Euprionoceras sokolovi*; *Euprionoceras norvegicum*	*Euprionoceras sokolovi*		*Euprionoceras sokolovi*	*Euprionoceras sokolovi*		Upper Kimmeridgian
Upper Kimmeridgian	Mutabilis	*Zenostephanus* (*Z.*) *sachsi*; *Amoebites peregrinator*	*Amoebites modestum*	Kitchini	*Aulacostephanus sosvaensis*	*Amoeboceras kitchini*	*Zenostephanus* (*Z.*) *sachsi*	*Amoebites modestum*	Kitchini	*Zenostephanus* (*Z.*) *sachsi*; *Amoebites peregrinator*	*Amoebites modestum*	Kitchini	*Amoebites salfeldi*; *Zenostephanus* (*Z.*) *sachsi*	*Amoebites modestum*	Kitchini	Upper Kimmeridgian
Lower Kimmeridgian	Cymodoce	*Amoebites mesezhnikovi*	*Amoebites subkitchini*	Kitchini	*Rasenia evoluta*	*Amoeboceras kitchini*		*Amoebites subkitchini*	Kitchini	*Amoebites pingueforme*; *Amoebites mesezhnikovi*	*Amoebites subkitchini*	Kitchini	*Amoebites pingueforme*; *Amoebites mesezhnikovi*	*Amoebites subkitchini*	Kitchini	Lower Kimmeridgian
Lower Kimmeridgian	Cymodoce / Baylei	*Amoebites bayi*	*Amoebites bayi*	Kitchini	*Pictonia involuta*	*Amoeboceras kitchini*		?	Kitchini	*Amoebites bayi*	*Amoebites bayi*	Kitchini	*Amoebites bayi*	*Amoebites bayi*	Kitchini	Lower Kimmeridgian
Lower Kimmeridgian	Baylei	*Amoeboceras* (?) *klimovae*; *Plasmatites zieteni*	*Plasmatites bauhini*		?*Amoeboceras* (*Plasmatites*) *bauhini*		*Amoeboceras* (?) *klimovae*	*Plasmatites bauhini*		*Amoeboceras* (?) *klimovae*; *Amoeboceras* (?) *schulginae*	*Plasmatites bauhini*		*Amoeboceras* (?) *klimovae*; *Plasmat. zieteni*; *Amoeboc.* (?) *schulgin.*	*Plasmatites bauhini*		Lower Kimmeridgian

but they are distinguished from *A. peregrinator* sp. nov. by the somewhat more strongly evolute shell and by the coarse and more widely spaced ribbing. The ornamentation of this species resembles that of *A. pingueforme* (Mesezhn.), a species also with relatively widely spaced primary ribs. The species described differs from the latter in the rectiradiate ribs and considerably smaller shell size.

V a r i a b i l i t y. In most regions, the occurrences of this species are not numerous and show only slight variability in the lateral and ventrolateral tubercles, in the density of the primary ribs, and in the density of serrations on the keel. However, while ammonites from Eastern Greenland described by Birkelund and Callomon (1985, see the synonymy list), indeed belong to this species, the Greenland population is dominated by specimens with more densely spaced primary ribs than in other regions, although the Greenland population also includes specimens with relatively widely spaced ribs. Apart from specimens with rectiradiate ribs, the population includes fewer specimens in which the ribs are somewhat prorsiradiate, as well as specimens with very infrequent biplicate ribs.

R e m a r k s. The species is provisionally assigned to microconchs, but so far has not been found with other cardioceratids, and potential macroconchs are as yet unknown. As this is one of the later species of *Amoebites*, it is possible that this is a microform macroconch.

M a t e r i a l. Tarkhanovskaya pristan: SGM MK 4213, 4214 (3.2–3.4 m above the visible base of Member 4), MK 4217, 4223 (3.35 and 5.1 m above the base of Member 4), IPGG unnumbered specimen (three ammonites on one fragment of core) from Borehole Payakhskaya 4, interval 3890–3900 m, lower part.

CONCLUSIONS

The analysis of published data and the results of the examination of ammonite collections assembled in the Kimmeridgian of Western Siberia suggest that the Boreal zonal and infrazonal ammonite cardioceratid scales can be successfully used in this region (Table 2). The proposed scale is better substantiated and is more detailed than the presently used scale based on aulacostephanids. The scale correlates well with the infrazonal successions of the adjacent regions (Franz Josef Land, Spitsbergen, and northern regions of Central Siberia (Table 2). For the first time, the cardioceratid-based subdivision of the upper Kimmeridgian is proposed for Western Siberia. The terminal part of the Kimmeridgian is the least well characterized by ammonites, and the presence of the equivalents of the Taimyrensis Zone can be expected on the basis of a single occurrence of *Nannocardioceras* cf. *krausei* (Salf.).

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