LOWER TOARCIAN BLACK SHALES AND PLIENSBACHIAN-TOARCIAN CRISIS OF THE BIOTA OF SIBERIAN PALEOSEAS

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ABSTRACT

Investigations of abundant fossils found in many sections of boundary beds between Pliensbachian and Toarcian time clearly show a differentiation in communities of benthos in the terminal Pliensbachian, a crisis of biota in the beginning early Toarcian, and a new succession of benthos in the Toarcian. The composition of the boundary beds is the same all around the Siberian Platform. Lower Toarcian black shales ("Kiterbyutsk Clay"), which overlap the Pliensbachian, are extraordinarily persistent along strike and are possibly very similar to lower Toarcian shales in Western Europe, the Canadian Arctic, and Northern Alaska. The lithologic composition and geochemical parameters of the lower Toarcian shales are homogeneous throughout Northern Siberia, and the distribution of benthos in the boundary beds is in agreement with them. The great changes take place in communities of macro- and microbenthos; the differentiation of biota in the ecological zones is reduced, the variety of trophical groups is decreased, and, at the beginning of the early Toarcian, opportunist species dominate. The paleogeography of Siberian seas in "Kiterbyutian" time may be in agreement with the second model of bituminous clay accumulation of Hallam (1963; 1975).

INTRODUCTION

Investigations of numerous fossil assemblages found in sections of the Lower and Middle Jurassic in Northern Siberia (Fig.1) show that in the evolution of communities of benthos in Siberian paleoseas, two complex stages in the lateral zonation of benthos are clearly defined: (1) before the early Toarcian crisis of biota and (2) after it.

Lower Toarcian black bituminous clay is the most widespread in lateral extent of the clay sedimentation in the boreal realm. The formation of these clays was caused by the eustatic rise of sea level at the beginning of the early Toarcian (Hallam, 1963; Zakharov et al., 1983; and others). In Northern Russia, Toarcian black shales are known in many sections and wells (Saks, 1976; Shurygin, 1978; and others), including the Kiterbyutian horizon in Middle Siberia, the Togurian horizon in West Siberia, and the lower part of the Suntarskaya Formation in the Vilyuy syneclise and in the Priverkhoyansk. Consequently, the clays nearly surround the entire Siberian Platform. The clays are also known in the Barents Sea and probably are very similar to the lower Toarcian black shales of the North Sea, Western Europe, Canadian Arctic, and Northern Alaska.

DATA AND METHODS

The composition of the Pliensbachian and Toarcian boundary strata is the same for all areas surrounding the Siberian Platform. Lower Toarcian clays (interlaminated black and gray clays with a predominance of the pelitic fraction) overlap upper Pliensbachian siltstones and sandstones.

The stratigraphic range of black shales has been recognized as spanning the lower part of the lower Toarcian (including the lower part of the ammonite zone *Dactylioceras athleticum*). The lithologic composition of the black clays is homogeneous everywhere in Siberia. For example, in sections along the Anabar River, Anabar Bay, and Eastern Taymyr, the maximal content of pelitic fraction (typically for lower part of black shales) varies only by 5 to 6 percent, with a maximum between 91 and 97 percent. These strata are everywhere characterized by a large amount of clay minerals with an unstable lattice and a high content of aluminum in hydrated mica (Kaplan, 1976; Levchuk, 1985; and others).

Moreover, the black shales are constant in thickness from 22 to 25 m over a large area surrounding the Siberian Platform (Shurygin, 1978; and others). Geochemical parameters, such as Li/Ga, B, $Fe_{pyrite}/C_{org.}$, indicate anomalous salinity in the Siberian paleobasin during the early part of clay formation (Fig.2).

The features of the lower Toarcian spore-and-pollen spectrum are interpreted to represent a period of maximum warming (Ilyina,1985). The paleontological and taphonomic characteristics of boundary beds between the Pliensbachian and Toarcian are similar in the sections under consideration.

Taxa found in the fossil assemblages of the upper part of the upper Pliensbachian include ammonites, abundant detrital scavengers (*Taimyrodon, Malletia*),

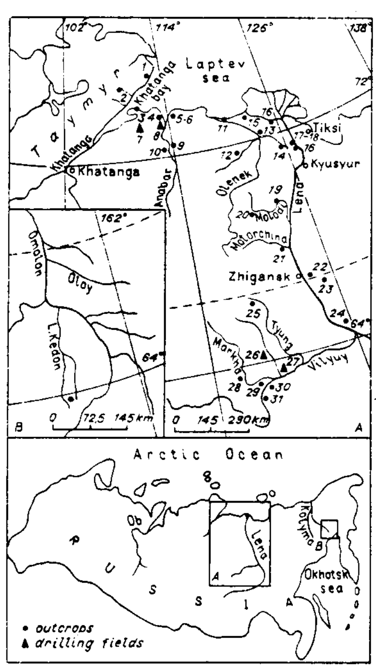


Fig.1. Locations of Lower and Middle Jurassic marine deposits in the Asian part of Russia (A--Northern Siberia, B--Northeast Russia). 1,2, Eastern Taymyr; 3, Yuryung-Tumus Peninsula; 4-6, Anabar Bay; 7, Wells in the Suolama area; 8, Wells in the Vostochnaya area; 9, 10, Anabar River; 11, Cape Tumul; 12-14, Olenek River basin; 15, 16, Lena River delta; 17-21, Eastern Priverkhoyansk; 22-24, Western Priverkhoyansk; 25-31, Vilyuy syneclise.

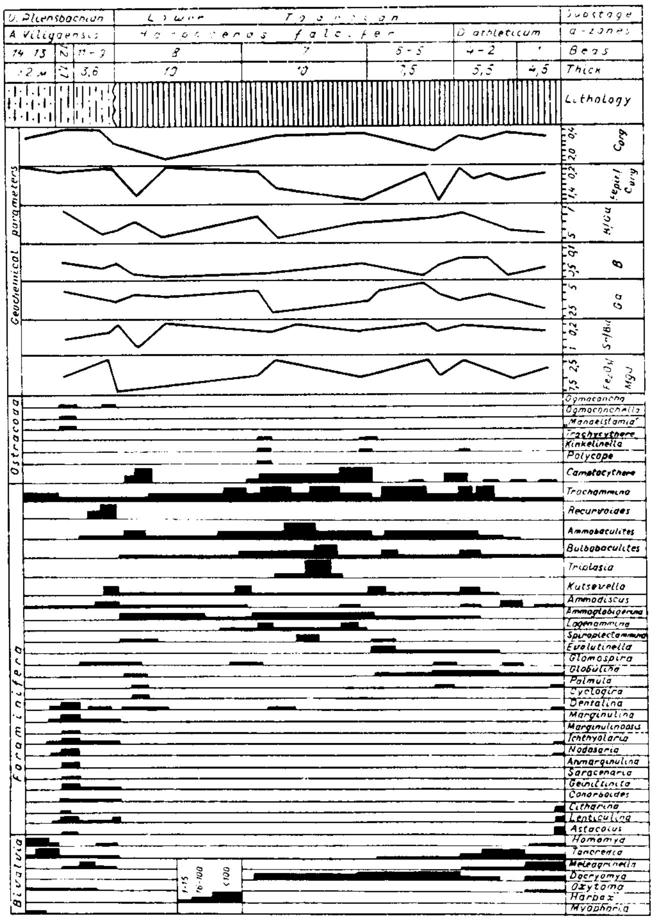


Fig.2. **The distribution of benthic and geochemical parameters in the boundary beds between the Pliensbachian and Toarcian of the eastern Taymyr section. For lithologic symbols see Fig.6.**

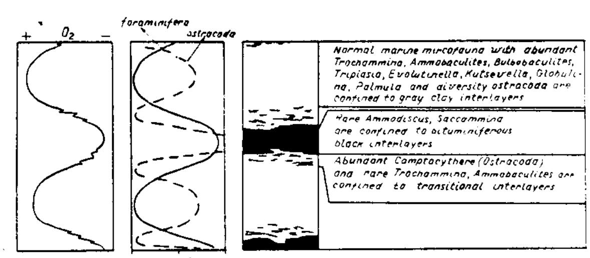


Fig.3. The distribution of microbenthos (concurrent replacement?) and microlamination of the Toarcian black shales in Northern Siberia.

high-level suspension feeders (*Meleagrinella, Kolymonectes, Anradulonectites*, etc.), low-level suspension feeders (*Tancredia, Myophoria, Pleuromya, Homomya*, etc.), and abundant and diverse foraminifera (Shurygin, 1979; Nikitenko, 1991; and others).

Lower Toarcian fossil assemblages are depauperate. Cephalopoda are very rare or absent. Only the upper part of these beds is characterized by the appearance of belemnites (*Passaloteuthis, Catateuthis*, and others). Monotypical accumulation of opportunist species (*Dacryomya*) is usual for macrobenthos. *Tancredia, Meleagrinella, Modiolus*, and others appear only in the upper part of these beds (Shurygin, 1986; and others).

The distribution of microbenthos is very peculiar in lower Toarcian strata. Abundant monospecies accumulations of the ostracode *Camptocythere* are typical for the boundary portions of thin (1- to 3-mm-thick), organic-rich black clay interbeds. In gray clays that alternate with black interbeds, accumulations of diverse foraminifera have been found (Fig.3). Eurytropic *Ammodiscus* and *Saccammina* have been found in the black clay interbeds.

RESULTS AND DISCUSSION

Analysis of the stratigraphic distribution of macro- and microbenthos taxa indicates the absence of carry-over between benthic communities from the terminal Pliensbachian to the beginning of the early Toarcian. In fact, a new suite of species appears at this boundary in the Siberian paleoseas. The *Dactylioceras tenuicostatum* phase was a critical time (Fig.4).

Pliensbachian benthic assemblages were retained in small quantities and with low diversity (crisis of biota) in Siberian early Toarcian sections of the *Tiltoniceras propinquum* ammonite zone (Siberian analog to *Dactylioceras tenuicostatum*) (Fig.2). Full renewal of assemblages took place in the beginning of the

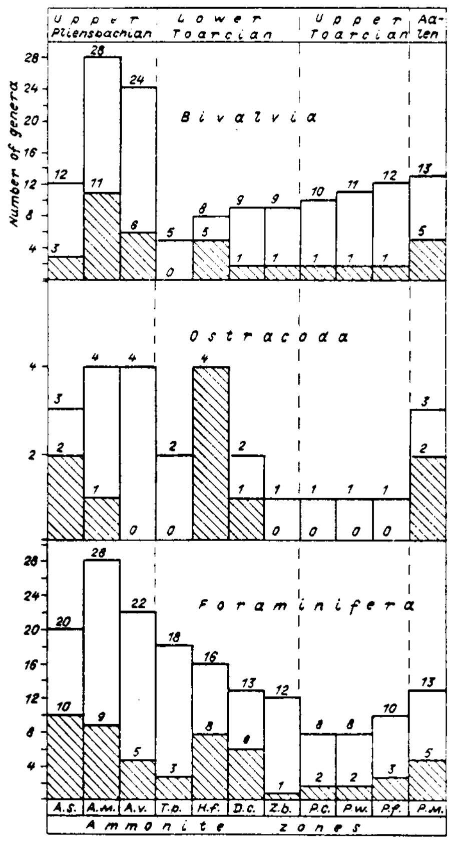


Fig.4. Taxonomical structure of the Pliensbachian-Toarcian crisis of the biota of the Siberian seas. Shaded--number of genuses which appeared. Ammonite zonations: A.s., *Amaltheus stokesi*; A.m., *A. margaritatus*; A.v., *A. viligaensis*; T.p., *Titoniceras propinquum*; H.f., *Harpoceras falcifer*; D.c., *Dacrylioceras commune*; Z.b., *Zugodactylites braunianus*; P.c., *Pseudolioceras compactile*; P.w., *P. wurttenbergeri*; P.f., *P. falcodiscus*; P.m., *P. mclintocki*.

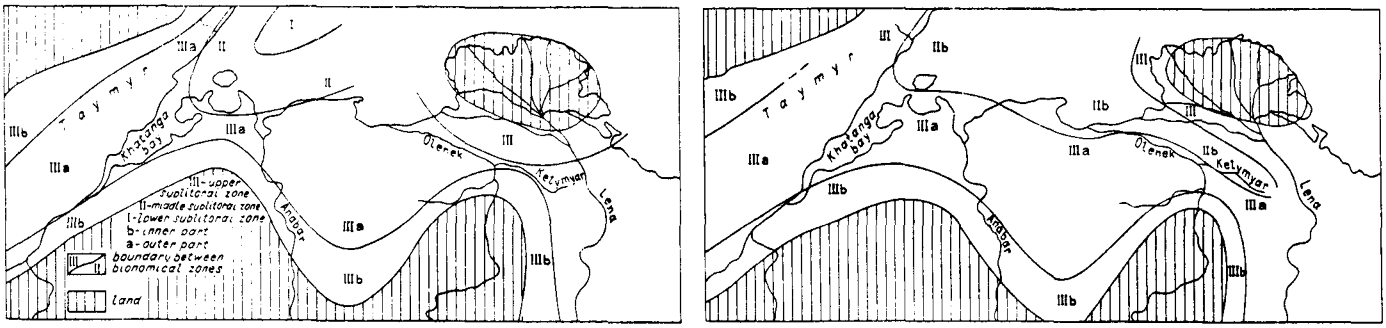


Fig.5. The Siberian marine basin in the late Pliensbachian (left) and early Toarcian (right) and the distribution of ecological zones.

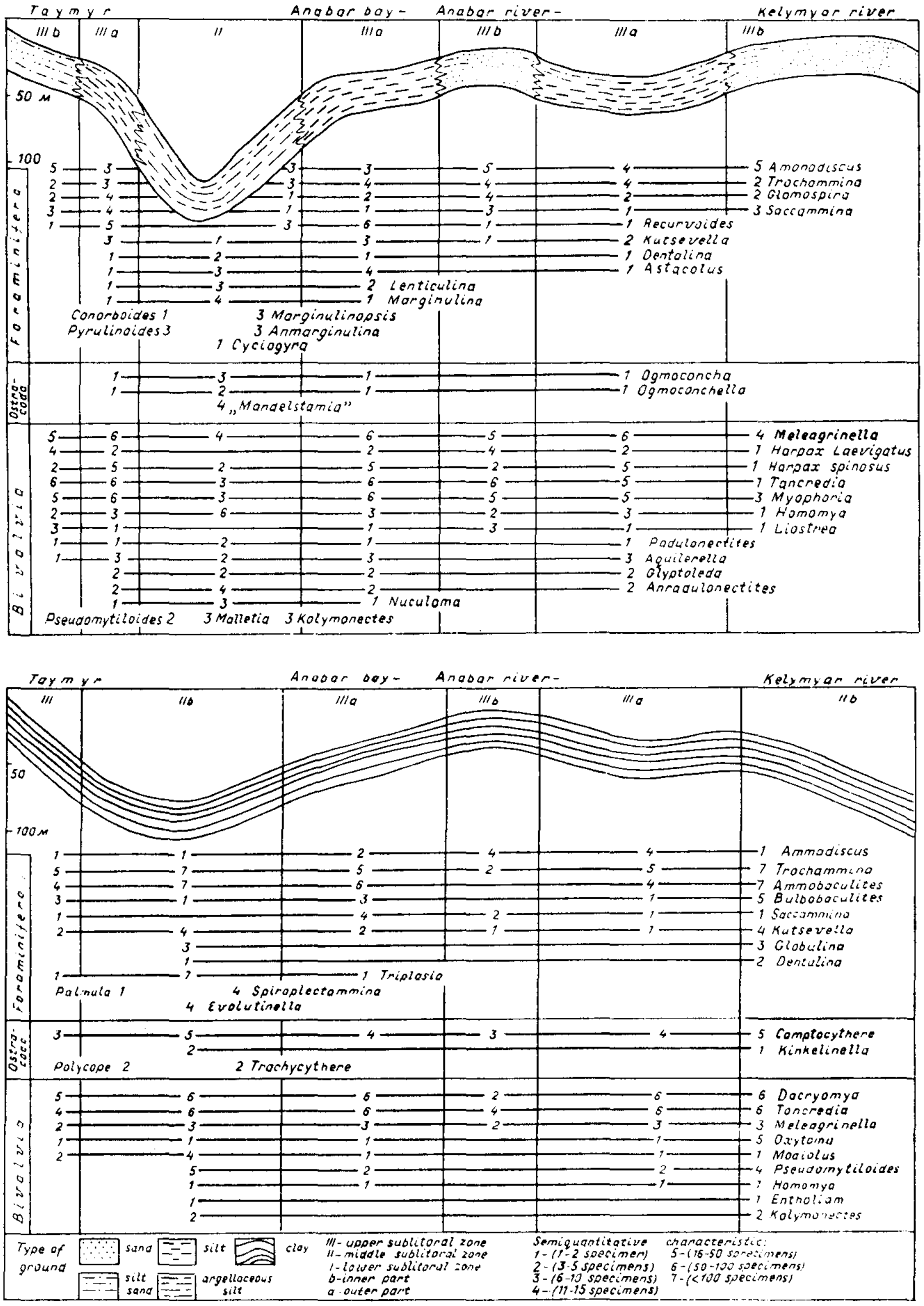


Fig.6. Bathymetric profile and lateral zonation of benthos of the Khatanga-Lena paleobasin (see Fig. 5) in the terminal Pliensbachian (above) and the beginning of the early Toarcian (below).

Harpoceras falcifer ammonite zone. A new stage of succession of benthic communities is recorded by this event. A similar picture emerges from the study of the structural evolution of benthos lateral zonation in Siberian paleoseas.

Analysis of numerous fossil assemblages of synchronous multifacies strata and an application of the Golovkinskiy-Walter rule (Golovkinskiy, 1868; Walter, 1893; Wheeler and Beesley, 1948; and others) make it possible to reconstruct the lateral zonation of benthic faunas as a succession of bottom communities on the slope of the sedimentary basin (Zakharov and Shurygin, 1984; and others). Benthic communities in Siberian paleoseas were most abundant and diverse at the end of the Pliensbachian. Paleogeographic differentiation of the benthos was recognized in paleobasins and in ecological zones at this time (Fig.5). Lateral variations with 5 to 6 zones are typical for late Pliensbachian paleoseas. After a crisis in the bottom biota in the beginning of the Toarcian, a new stage of formation of climax communities in the lateral zonation of benthos is clearly recorded starting with the *Harpoceras falcifer* phase. During the course of the crisis, differentiation of benthos in ecological zones reduced lateral variations to 2 to 3 zones and there was a decrease in diversity of life forms in individual zones of the lateral zonation, a simplification of trophical structure (Fig.6).

There was essentially a full renewal of biotic communities at the end of the *tenuicostatum* phase and in the beginning of the *falcifer* phase. Ecological peculiarities of benthos resulted in the predominance of opportunist species in benthic communities after the crisis of biota. Based on the type and number of benthic communities, lateral distribution of facies, and geochemical parameters (Kaplan, 1976), it is apparent that shallow waters occupied large areas of the Siberian paleoseas at this time (Fig.5). There was a likely coastal buffer of swampy plains which suppressed the delivery of coarse-grained material to the sedimentary basin.

Chemical weathering processes were most intensely active in this area during the Early Jurassic. There are no coarse-grained facies of nearshore zones in coastal sections (East Taymyr, Anabar River sections, etc.) in the lower part of the Toarcian. Under conditions of a warm climate and extensive shallow waters, the distribution of benthos was controlled by anomalies in the salinity and gas regimes.

The paleogeography of Siberian seas in Kiterbyutian time possibly corresponds to the second model of Hallam (1975) (Fig.6, bottom) for bituminous clay accumulation. The presence of alternating thin interbeds of black shales, enriched by organic materials and containing an accumulation of ostracoda with pronounced pore canal systems, with layers of gray clay characterized by a wide diversity of foraminifera, supports this interpretation (Fig.3). This peculiar structure of Toarcian black shales can be observed everywhere among Siberian sections. The alternating structure may be attributed to alternating periods of stagnant water and relatively well aerated bottom water, as well as to periodic increases in the delivery of organic material to the basin.

The specific assemblages of microfauna alternate with each other according to these conditions. Short descriptions of characteristic species of microfauna from the black shales (see pl.1, Figs.1-18) and overlapping Toarcian deposits (see pl.1, Figs.19-25) are given below.

SYSTEMATICS

Order Foraminiferida Eichwald, 1830
Suborder Textulariina Delage and Herouard, 1896
Superfamily Ammodiscacea Reuss, 1862
Ammodiscus glumaceus Gerke and Sossipatrova, 1961
Pl. 1, Fig. 18.

Ammodiscus glumaceus: Gerke, 1961, p. 128, pl. 12, Figs. 1-6; pl. 13, Fig. 15; Sapyanik and Sokolov, 1991, pl. 10, Fig. 11.
Distribution: Toarcian-Aalenian in Siberia, Toarcian in Northeast Russia, Aalenian in Europe.

Superfamily Lituolacea de Blainville, 1827
Ammobaculites lobus Gerke and Sossipatrova, 1961
Pl. 1, Fig. 10.

Ammobaculites lobus: Gerke, 1961, p. 139, pl. 16, Figs. 4-7.
Ammobaculites fontinensis (Terquem): Tappan, 1955, p. 45, pl. 2, Fig. 6; Riegraf, 1985, p. 97, pl. 6, Fig. 10; Nagy and Johansen, 1991, p. 20, pl. 2, Figs. 13-16.
Distribution: lower Toarcian in Siberia, Northeast Russia, Alaska, and Europe.

Triplasia kingakensis Loeblich and Tappan, 1952
Pl. 1, Figs. 6, 7.

Triplasia kingakensis: Tappan, 1955, p. 46, pl. 13, Figs. 4-11.
Flabellammina sp.: Wall, 1983, pl. 1, Fig. 9-13.
Distribution: Lower part lower Toarcian in Alaska, Canada, and Siberia.

Kutsevella barrowensis (Tappan, 1951)
Pl. 1, Fig. 17.

Haplophragmoides? barrowensis: Tappan, 1955, p. 42, pl. 2, Figs. 1-5.
"*Haplophragmoides*" *barrowensis* Tappan: Wall, 1983, p. 268, pl. 1, Figs. 1, 2, 33, 34.
Distribution: Upper part upper Pliensbachian - lower Toarcian Alaska, Canada, Northeast Russia, and Siberia.

Bulbobaculites strigosus (Gerke and Sossipatrova, 1961)
Pl. 1, Figs. 8, 9.

Ammobaculites strigosus: Gerke, 1961, p. 141, pl. 16, Figs. 8-12.
Ammobaculites sp. 4925: Poulton et al., 1982, p. 60, pl. 4, Fig. 9.
Bulbobaculites oviloculus: Nagy and Johansen, 1991, p. 22, pl. 3, Figs. 8-13.
Distribution: Toarcian in Siberia, Northeast Russia, Canada, and North Sea.

Superfamily Trochamminacea Schwager, 1877
Trochammina kisselmani Sapyanik and Sokolov, 1991
Pl. 1, Figs. 15, 16.

Trochammina topagorukensis Tappan: Riegraf, 1985, p. 99, pl. 6, Figs. 19, 20, 22-24.
Trochammina sablei Tappan: Riegraf, 1985, p. 99, pl. 6, Fig. 21.
Trochammina kisselmani: Sapyanik, 1991, p. 109, Fig. 4; Sapyanik and Sokolov, 1991, pl. 10, Fig. 10.
Distribution: Toarcian in Siberia, Northeast Russia, and Europe.

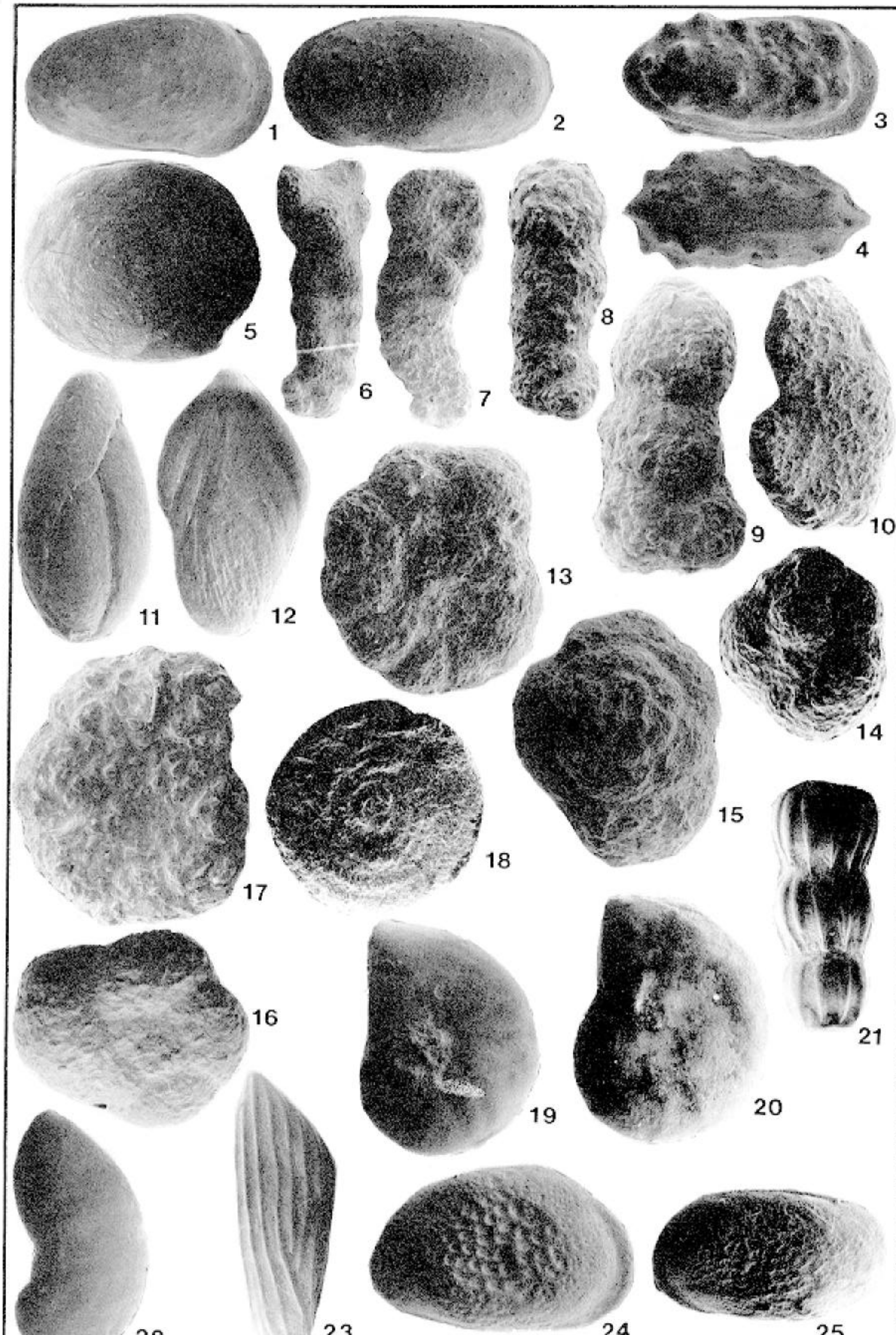
Suborder Lagenina Delage and Herouard, 1896
Superfamily Nodosariacea Ehrenberg, 1838
Nodosaria pulhra (Franke, 1936)
Pl. 1, Fig. 21.

Synonymy: see Riegraf, 1985.
Distribution: Toarcian in Europe and Siberia.

Lenticulina multa Schleifer, 1961
Pl. 1, Figs. 19, 20.

Lenticulina (*Lenticulina*) *multa* Schleifer: Gerke, 1961, pl. 105, Figs. 1, 2; pl. 106, Fig. 3; Sapyanik, 1991, p. 111, Fig. 6; Sapyanik and Sokolov, 1991, pl. 11, Fig. 6.
Lenticulina (*Lenticulina*) *externa* Schleifer: Gerke, 1961, pl. 106, Figs. 1, 2; Sapyanik, 1991, p. 107, Fig. 2; Sapyanik and Sokolov, 1991, pl. 11, Fig. 7.
Lenticulina (*Lenticulina*?) *adversa* Schleifer: Gerke, 1961, pl. 104, Fig. 6; pl. 105, Fig. 3.
Lenticulina (*Lenticulina*?) ex gr. *mironovi* (Dain): Gerke, 1961, pl. 104, Figs. 1-3.
Lenticulina praemulta: Sapyanik, 1991, p. 111, Figs. 6a, b.
Lenticulina sp. 1: Nagy and Johansen, 1991, p. 26, pl. 5, Fig. 30;

Plate 1. Locality for Figs. 1-18: Eastern Taymyr, lower Toarcian, ammonite zones *Harpoceras falcifer* and lower part of *Dactylioceras athleticum* ("Kiterbyutsk" clays). 1, 2. *Camptocythere mandelstami* Gerke and Lev: 1, female carapace, Z1048/1, x47; 2, male carapace, Z1048/3, x40. 3, 4. *Trachycythere verrucosa* Triebel and Klinger: 3, Z1048/16, x56; 4, Z1048/17, x50. 5. *Polycope pelta* Fisher, Z1048/98, x200. 6, 7. *Triplasia kingakensis* Tappan: 6, Z1048/57, x40; 7, flabellamminolike specimen, Z1048/59, x43. 8, 9. *Bulbobaculites strigosus* (Gerke and Sossip.), megalospheric specimens: 8, Z1050/20, x88; 9, Z1050/21, x200. 10. *Ammobaculites lobus* Gerke and Sossip., Z1050/22, x83. 11. *Globulina sibirica* Kisselman, Z1050/23, x166. 12. *Palmula tenuistriata* (Franke), Z1050/24, x50. 13. *Evolutinella* sp., Z1050/25, x144. 14. *Ammoglobigerina canningensis* (Tappan), Z1050/26, x133. 15, 16. *Trochammina kisselmani* Sapyanik and Sokolov: 15, microspheric specimen, Z1048/81, x145; 16, megalospheric specimen, Z1048/80, x89. 17. *Kutsevella barrowensis* (Tappan), Z1050/27, x83. 18. *Ammodiscus glumaceus* (Gerke and Sossip.), Z1050/28, x88. Locality for Figs. 19-25: Eastern Taymyr, Toarcian, ammonite zone *Dactylioceras athleticum* - ammonite zone *Pseudolioceras compactile*. 19, 20. *Lenticulina multa* Schleifer: 19, microspheric specimen, Z1048/109, x56; 20, megalospheric specimen, Z1048/110, x72. 21. *Nodosaria pulhra* (Franke), Z1050/30, x65. 22. *Astacolus praefoliaceus* (Gerke), Z1048/112, x83. 23. *Citharina* sp., Z1050/31, x68. 24, 25. *Camptocythere occalata* Gerke and Lev: 24, female carapace, Z1048/5, x47; 25, male carapace, Z1050/32, x50.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pl. 7, Fig. 7.
Distribution: Upper part lower Toarcian - lower Aalenian in Siberia and Northeast Russia, and upper Toarcian in North Sea.

Palmula tenuistriata (Franke, 1936)
Pl. 1, Fig. 12.
Synonymy: see Riegraf, 1985.
Distribution: Toarcian in Europe, Siberia, and Caucasus.

Astacolus praefoliaceus (Gerke, 1961)
Pl. 1, Fig. 22.
Lenticulina (Astacolus) praefoliacea: Gerke, 1961, pl. 93, Figs. 6-9.
Astacolus praefoliaceus (Gerke): Sapyanik, 1991, p. 107, Fig. 2; Sapyanik and Sokolov, 1991, pl. 11, Fig. 5.
Distribution: Upper part lower Toarcian - lower Aalenian in Siberia, Barents Sea, and Northeast Russia.

Globulina sibirica Kisselman, 1983
Pl. 1, Fig. 11.
Globulina sibirica: Kisselman, 1983, p. 104, pl. 1, Figs. 1, 2; Sapyanik and Sokolov, 1991, pl. 11, Fig. 8.
Globulina jurensis: Kisselman, 1983, p.104, pl. 1, Fig. 3; Sapyanik and Sokolov, 1991, pl. 10, Fig. 8.
Globulina? sp. 1: Kisselman, 1983, p. 105, pl. 1, Fig. 5.
Eoguttulina? sp.: Wall, 1983, p. 268, pl. 1, Figs. 20, 21.
Distribution: Toarcian in Siberia, Northeast Russia, and Canada.

Subclass Ostracoda Latreille, 1806
Order Podocopida Muller, 1894
Suborder Podocopina Sars, 1866
Superfamily Cytheracea Baird, 1850
Family Progonocytheridae Sylvester-Bradley, 1948
Camptocythere mandelstami Gerke and Lev, 1958
Pl. 1, Figs. 1, 2.
Camptocythere mandelstami var. *mandelstami*: Lev, 1958, p. 42, pl. 5, Fig. 5; pl. 6, Figs. 1-3, 5.
Camptocythere porrecta: Lev, 1958, p. 44, pl. 5, Figs. 1-4.
Distribution: Lower part lower Toarcian in Siberia and Northeast Russia.

Camptocythere occalata Gerke and Lev, 1958
Pl. 1, Figs. 24, 25.
Camptocythere mandelstami var. *occalata*: Lev, 1958, p. 42, pl. 6, Fig. 4.
Camptocythere toarciana: Bate and Coleman, 1975, p. 8, pl. 2, Figs. 1-11; Riegraf, 1985, p. 84, pl. 4, Figs. 5-6.
Camptocythere cf. *toarciana* Malz: Nagy, 1989, pl. 3, Figs. 16-17.
Distribution: Upper part lower Toarcian - upper Toarcian in Siberia, Northeast Russia, and Europe.

Family Trachycytheridae Kozur, 1972
Trachycythere verrucosa Triebel and Klingler, 1959
Pl. 1, Figs. 3, 4.
Synonymy: see Riegraf, 1985.
Distribution: Lower part lower Toarcian in Siberia and Europe.

Order Myodocopida Sars, 1866
Suborder Cladocopina Sars, 1866
Family Polycopidae Sars, 1866
Polycope pelta Fischer, 1961
Pl. 1, Fig. 5.
Synonymy: see Riegraf, 1985.
Distribution: Lower Jurassic in Europe, lower Toarcian in Siberia.

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