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Boreal Middle Jurassic-Early Cretaceous Radiolaria of Okhotsk Coast of Kamchatka

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Middle Jurassic radiolarians have been discovered in red jaspers from the lowest tectonic slab of the Omgon Range. This is the first find of reliable Jurassic radiolarians on Kamchatka. All the species, among which there are 5 new endemics, are described in detail. The Middle Jurassic radiolarian assemblage is characterized by a small diversity and a sharp predominance of nassellarians, which account for more than 90%. The genera *Stichocapsa, Parvicingula, Archaeodictyomitra* and *Xitus* are dominant. The Omgon Range (Sea of Okhotsk coast, Western Kamchatka) was formed by intensively deformed tectonic slabs, some of which are made up of volcanogenic-siliceous rocks, and some of turbidite terrigenous rocks. All these formations were not earlier considered more ancient than the Early Cretaceous. Late Jurassic-Early Cretaceous radiolarian assemblages were found in volcanogenic-siliceous rocks of the upper (third from the bottom) tectonic slab, associated with pillow basalts. Their age has been confirmed by finds of buchias. A description of Tithonian-Valanginian radiolarians also is given.

INTRODUCTION

Earlier the most ancient finds of radiolarians on Kamchatka were dated as Cretaceous.

Virtually all the sites of Cretaceous radiolarians have been concentrated along the shores of the Bering Sea (Eastern Kamchatka) or in Middle Kamchatka. Only individual finds of Early Cretaceous and Late Cretaceous radiolarians are known in Western Kamchatka.

This article gives a description of Middle Jurassic (hypothetically Bajocian-Callovian) and Late Jurassic - Early Cretaceous radiolarians from the Sea of Okhotsk shores of Western Kamchatka.

POSITION IN SECTION OF MIDDLE JURASSIC-EARLY CRETACEOUS RADIOLARIAN ASSOCIATIONS OF WESTERN KAMCHATKA AND STRATIGRAPHIC RELATIONSHIPS

We have already cited new data on the geological structure and age of geological formations of the Omgon Range (Fig. 1): a sector of territory along the shores of the Sea of Okhotsk, including the basin of the Moroshechnaya River - Cape Omgon (Western Kamchatka) was already dealt with by us earlier in [2, 3].

The Omgon Range consists of highly deformed formations of the volcanogenic-siliceous complex and a complex of terrigenous turbidites [2]. The volcanogenic-siliceous complex was earlier assigned to the Kingiveemskaya suite, whose age was regarded as Early Cretaceous [9]. These complexes form a series of slices which dip to the southeast.

The volcanogenic-siliceous complex consists of three spatially separated tectonic slabs {Fig. 2): northern (structurally lower), central (middle) and southern (lower). Each slab, in turn, is disrupted by a series of upthrow faults and thrusts, also dipping to the southeast.

The northern slab is made up of lavas and clastolavas of pillow and massive basalts with lenses and interlayers of flints and jaspers. The visible thickness is 15 m. Numerous individual tectonic outcrops of basalts and gabbro occur here. A Middle Jurassic association of radiolarians was extracted here on the western slope of Mount Promezhutochnaya in the zone of a beach from jasper siliceous rocks (sample 604.2, Fig. 2), lying amidst the pillow basalts: *Archicapsa* sp. cf. *A. pachyderma* (Tan Sin Hok), *Archicapsa* sp. A., *Archicapsa* sp. B., *Dictyomitrella (?)* sp. A, *Parvicingula* sp. B Carter, *Xitus* sp. A, *Xitus* sp. B, including a number of new species, among which the following have already been described: *A. curta* Vish., *Archaeodictyomitra elliptica Vish.,Stichocapsa globosa Vish.,Xitus primitivus* Vish. [40]. All the forms are rather well preserved. Virtually all the species evidently belong to the Boreal province (Canada, Koryakia, Alaska). There is no other fauna in these layers. Taking into account that most of the species are represented by new forms, we will examine the time framework of existence of the known species. *Parvicingula* sp. B Carter was described from the Lower Bajocian formation on Graham Island in the Queen Charlotte Islands archipelago [16]. *Archicapsa* sp. cf. A.*pachyderma* is known in several radiolarian associations of the world whose age is no younger than the Middle Jurassic. The forms *Archicapsa* sp. A resemble representatives of the Bagotidae family, described from North America and characteristic of the Early-Middle Jurassic. In addition, similar forms, as well as the new species which we described in [40] (*Archaeodictyomitra elliptica, Sticocapsa globosa, Xitus primitivus*), occur widely in the Bajocian of the Rarytkin Range in Koryakia (sample 596/3 [11]). Thus, the age of the complex most likely is Middle Jurassic.

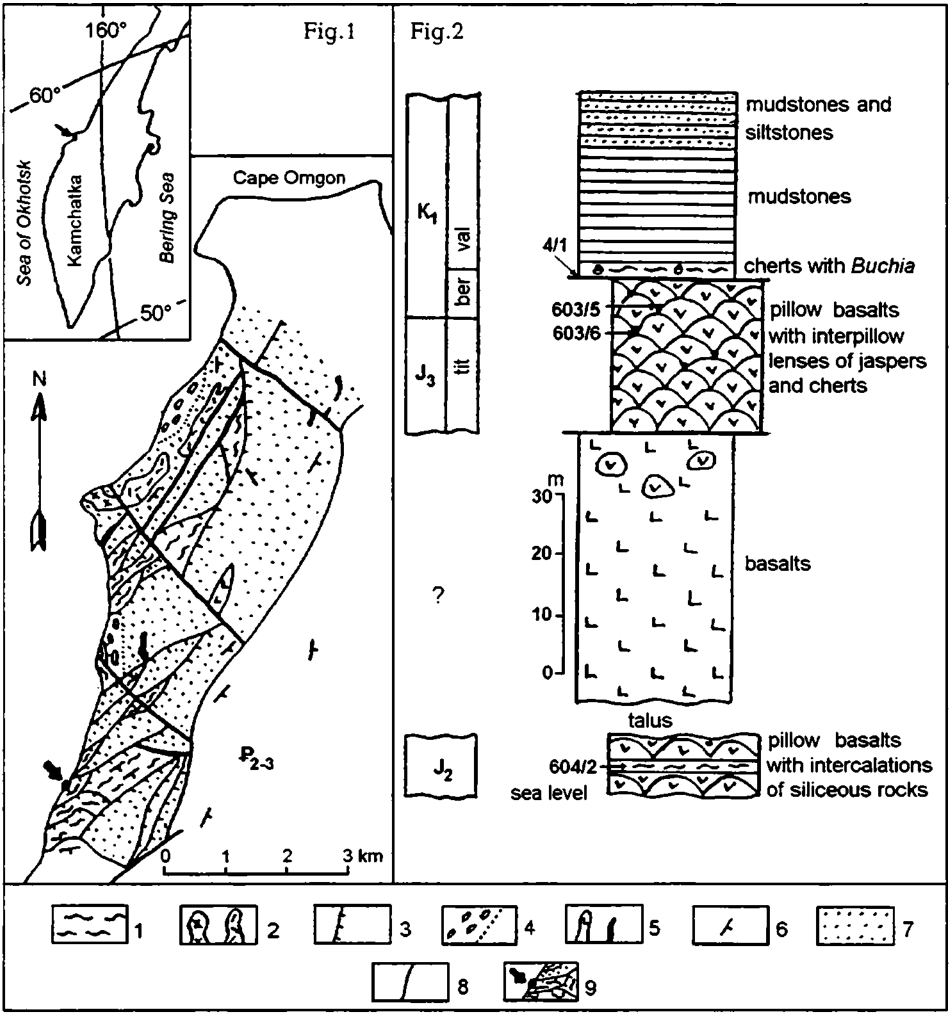

Fig. 1 Schematic geological map of Omgon Range.

1 — volcanogenic-siliceous complex, 2 — diorite and dacite intrusions, 3 — thrusts and steeply dipping faults, 4 — olistostromic horizon, 5 — diabases and dacite dikes, 6 — dip direction, 7 — terrigenous turbidite complex, 8 — stratigraphic contact, 9 — location of section shown in Fig. 2.

Fig. 2 Schematic section of Mount Promezhutochnaya exposure.

Amygdaloidal basalts and porphyrites with lenses of flints and jaspers (5-15 m), mudstones, siliceous limestones, psammitic tuffs of basic composition or hyaloclastites participate in the structure of the central plate. The apparent thickness is 30 m.

A Tithonian-Berriassian assemblage of radiolarians, including *Archaespongoprunum* sp., *Praeconocaryomma* sp. cf. P. *magnimamma* (Rust), *Holocryptocanium barbui* Dumitrica, *Xitus* sp. C, *Coneta* cf. *hsui* Pessagno, *Ristola* sp., *Parvicingula* sp., *Archaeodictyomitra* sp., was isolated from the red jaspers (samples 603/5, 6 — taken 60 m to the north of sample 604/2) forming an interpillow filling amidst the basalts (Fig. 2). The species *Coneta* cf. hsui Pessagno (Table 1, Figs. 6-9) exhibits a similarity to the species *Ristola hsui* Pessagno, for the first time described from the Lower Tithonian of the Coastal Ranges in California [33], but later as *Ristola* sp. aff. R. *boesii* (Parona) from the Lower-Middle Valanginian buchian zone of *Buchia pacifica* [34]. In addition, we found a similar species earlier in Koryakia in one sample jointly with the Berriasian-Early Valanginian *Buchia* sp. cf. *Buchia inflata* (Toula) and *Buchia keyserlingi* Lahusen var. *sibirica* Sokolov [6, 7]. The species *Holocryptocanium barbui* Dumitrica occurs widely in the Lower Cretaceous of both Pacifica and Tethys [1, 6, 13, 14, 42]. The lower limit of existence of this species is the Early Berriasian [13, 14]. The species *Praeconocaryomma magnimamma* Pessagno is a typical Kimmeridgian-Tithonian form [33-35]. Accordingly, the assemblage which we examined most likely existed in the Tithonian-Berriasian.

The southern slab is made up of pillow basalts, intercalated with calcareous jaspers and flints. This section is crowned by a thick band ranging from mudstones to agglomerat tuffs. The apparent thickness is 30-50 m.

The Late Berriasian-Valanginian *Buchia inflata* (Toula) were discovered in a horizon (with a thickness 1 m) of siliceous mudstones at the bottom lying directly on basalts (Fig. 2). The following radiolarians were determined directly above the horizon with buchias in a sample of siliceous jasperlike limestone (sample 4/1) taken by A. B. Tsukernik: *Pantanellium lanceola* (Parona), *Parvicingula khabakovi* (Zhamoida), *Pseudodictyomitra cosmoconica* (Foreman), *Ristola* sp. cf. *Ristola cretacea* (Baumgartner), *R. boesii* (Parona), *Thanarla pulchra* (Squinabol), *Mirifusis* sp. Virtually all the species enumerated above belong to the Tethys province and have a Berriasian-Hauterivian interval of occurrence, with the exception of the species *Parvicingula khabakovi*, which is a typically Boreal form with an interval of occurrence Kimmeridgian-Valanginian. The age of this assemblage most likely is therefore Berriasian-Valanginian.

The contact between the volcanogenic-siliceous and terrigenous turbidite complex is tectonic. The total apparent thickness of the entire volcanogenic-siliceous complex is about 80 m.

Locally the deposits of the terrigenous complex cover a volcanogenic-siliceous complex with an angular unconformity, at the base forming a detrital horizon which probably has an olistostromic nature. The olistoliths are made up of rocks of both complexes and are enclosed in a tectonized siltstone-mudstone matrix.

Radiolarians of Berriasian-Valanginian age were noted earlier in the volcanogenic-siliceous complex [9]. The following were determined in the complex: *Pantanellum corriganensis* Pessagno, *P. (?) berriassianum* Baumgartner, *Tricolocapsa cuvierri* Rust, *Hemicryptocapsa ornata* (Zhamoida), *Cryptamphorella* ex gr. *conara* (Foreman), *Diacanthocapsa? parva* (Tan), *Siphocampe rostrata* Chabakov, *S.?* ex gr. *alexandrae* Chabakov, *Parvicingula khabakovi* (Zhamoida), *Archaeodictyomitra apiarium* (Rust), *Ristola altissima* (Rust), *R. boesti* (Parona). The representative assemblages of spores and pollens discovered in the terrigenous complex, together with the macrofauna, characterize the age of the lower and upper parts of the complex as Aptian-Albian and Maastrichtian, respectively (data from V. K. Sorokina, Petropavlovsk-Kamchatskiy).

Thus, Middle-Late Jurassic radiolarians were discovered for the first time in the territory of Western Kamchatka along the shores of the Sea of Okhotsk. Particular mention must be made of the uniqueness of the Middle Jurassic radiolarian assemblage, which has no analogues among those known in the literature. Fig. 3 shows the location of finds of Jurassic radiolarians in Western Kamchatka.

RELATIONSHIP BETWEEN RADIOLARIANS AND CLIMATE

Middle Jurassic radiolarians still remain a poorly studied group among these microorganisms. Until recently there has not been a single publication on the evolution of Jurassic Boreal radiolarians in either the Russian or in the foreign literature,whereas several fundamental monographs have been devoted to the Mesozoic radiolarians of the Tethys and their evolution [13, 14, 18, 31, 36, 37].A.Popovskiy, who discovered several species with abipolar occurrence, was the first to indicate the existence of cold- and warm-water species. Later W.Riedel established that there are endemic, bipolar and cosmopolitan species among the radiolarians. It was demonstrated that tropical species do not enter the waters of the Antarctic region and that the Antarctic convergence zone serves as a boundary between antarctic and subantarctic faunas [12].

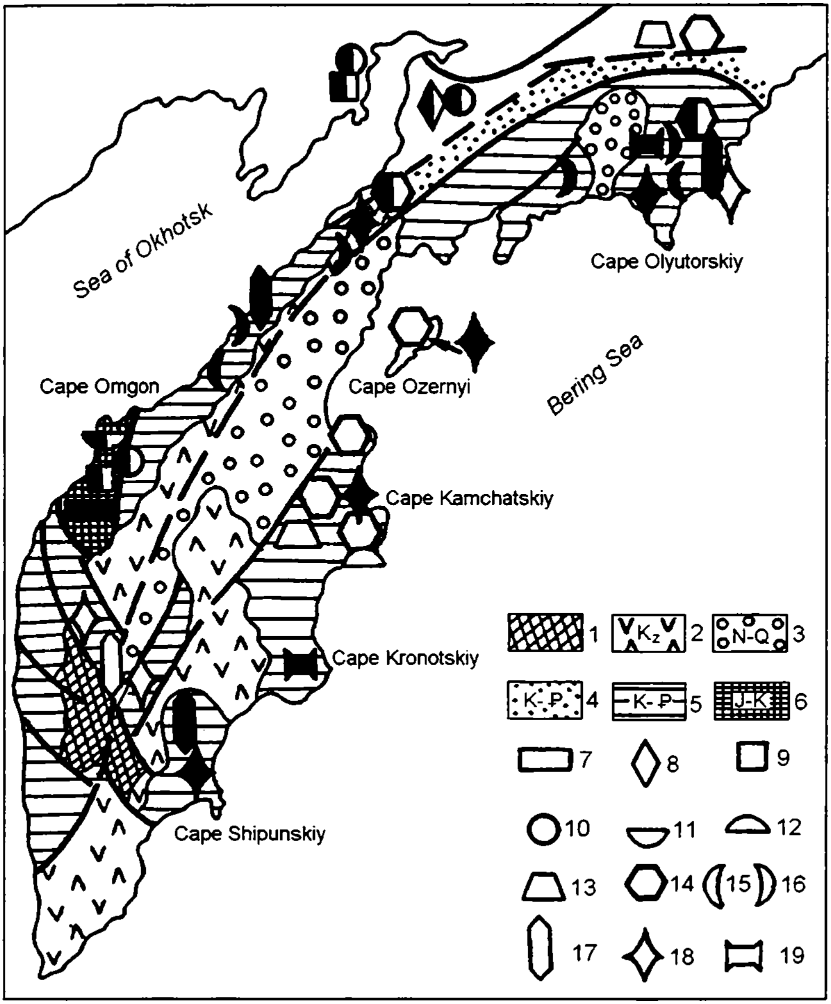

Fig. 3 Places of finds of radiolarians on Kamchatka.

1 — metamorphic rocks, 2 — volcanic rocks, 3 — terrigenous rocks, 4 — Ukelayatskiy flysch, 5 — siliceous-terrigenous rocks, 6 — Middle-Jurassic-Lower Cretaceous rocks, 7-19 — radiolarian assemblages: 7 — Middle Bajocian-Early Bathonian, 8 — Middle Bathonian-Early Callovian, 9 — Middle Callovian-Middle Tithonian, 10 — Late Tithonian-Early Berriasian, 11 — Middle Berriasian-Middle Valanginian, 12 — Late Valanginian-Hauterivian, 13 — Barremian-Aptian, 14 — Albian-Turonian, 15 — Coniacian-Early Santonian, 16 — Late Santonian-Early Campanian, 17 — Middle Campanian, 18 — Late Campanian-Early Maastrichtian, 19 — Late Maastrichtian-Early Paleocene. The filled symbols denote a Boreal character of the assemblages, unfilled symbols — Tethyan character, half-filled — mixed).

In the Pacific Ocean S. B. Kruglikova [10] established that tropical species do not go northward beyond the northern boundary of the zones of mixing of waters (approximately 40° N). However, the latitudinal zonality may be distorted due to currents carrying colder or warmer waters.

PALEOLATITUDINAL MODEL OF DISTRIBUTION OF RADIOLARIANS

In the example of study of the Late Jurassic radiolarian associations of California E. Pessagno et al. [35] proposed a model of distribution of Jurassic radiolarians by provinces. In the Tethyan realm (from 30°N to 30°S) they define three provinces from north to south: Northern, Central and Southern Tethys. They define the Central Tethyan province on the basis of a great diversity of pantanellids and an absence of the genus *Parvicingula*, whereas the Northern and Southern Tethyan provinces are characterized by a moderate presence of different *Parvicingula* species with an abundance of pantanellids. The boundaries of the Central province are drawn along latitudes 22° N and S. The Boreal realm (to the north of 30°N) is characterized on the graph by a minimum of pantanellids with a sharp increase in Parvicingulidae. The realm is divided into two provinces: South Boreal, where a few pantanellids are still present, and North Boreal (beyond 50°N), where they are absent.

The existence of the Australian Province is regarded as a mirror reflection of the Boreal province. However, data by Kiessling [24] and Scasso [24], based radiolarians from the high latitudes of the southern hemisphere, contradict this model. They feel that the Jurassic Tethyan radiolarian fauna extends to 39°S and the pantanellids constitute up to 50% in the Boreal radiolarian associations forming at 60°S. All this enabled Kiessling and Scasso [24] to propose a modified curve for the distribution of radiolarians in the high latitudes of the southern hemisphere, where the boundary between the Tethyan and Australian realms ran along 39°S, and between the North Boreal and South Boreal provinces along 45°. W. Kiessling attributes the asymmetry of his model to different temperature conditions during the Jurassic in Northern and Southern Paleo-Pacifica.

OVERVIEW OF LOCATIONS OF JURASSIC BOREAL RADIOLARIAN ASSOCIATIONS

Jurassic Boreal radiolarians, in addition to California (27 new genera and 135 new species, a total of more than 450 species [14]), Argentina (13 species, among which there are 2 new genera) and Antarctica [24], are known in the Eurasian Northern Hemisphere (Moscow region [15]; Timan-Pechora depression [27], [38]; northern part of Siberian Platform [5]; Koryakia [8]; basins of the Anyui and Kolyma Rivers, Koryakskoe Plateau and Western Kamchatka [6, 7]).

Already in the 1930's I. Khudyaev [22] and A. Chabakov [17] described 76 species of radiolarians from thin sections for the Tithonian-Valanginian of the Vyatka-Kama region. Among these 76, 63 were new and only 13 had been encountered earlier in the Mediterranean. The species proposed by I. Khudyaev [22] for the most part are classified as nassellarians (among these 28 are new). A. Chabakov [17] discriminated another 20 new species. G. Kozlova [27] confirmed the validity of a considerable part of these species and proposed another 12 new species. It is very important to note that a high percentage of these species are endemics.

Even by studying the radiolarians in thin sections, A. Chabakov noted that the general appearance of the fauna differed sharply from the compared Western European data with respect to: 1) smoothness of the shells, that is, there was an almost complete absence of radial apophyses and complexly structured spicules; 2) a predominance of turretlike forms (in the list of species and in the percentage makeup of the main mass of specimens). The nassellarians described in detail in Norway and on Spitsbergen are represented for the most part by the genus *Parvicingula*. In contrast to the shallow-water sections of England and arctic Russia, where there is a sharp predominance of multisphere spongy spheroidal and discoidal forms, here there is a sharp dominance of turretlike radiolarians [4, 19].

Such a considerable number of cyrtoidal forms made it possible to postulate the possibility of the existence in the Late Jurassic of a stable zone of paleoupwelling that extended parallel to the Urals fold structure, along which there may be a southward migration of Boreal radiolarian faunas, as has been recorded in Jurassic sections of Ulyanovsk Region [39].

The first find of Oxford-Valanginian radiolarians [5] in the north of Middle Siberia(on the PaksaPeninsulain coastal precipices of the Seaof Laptevs) is unique and is of great scientific interest. The Oxford-Valanginian radiolarians of the Gulf of Anabar exhibit a similarity to the Kimmeridgian-Ryazan association of the North Sea and they also are close to the Norwegian associations of the same age. The importance of finding Jurassic-Cretaceous radiolarians is that this broadens our knowledge concerning Boreal fauna of the Russian Middle Mesozoic and may serve as a key to the interpretation of the paleoclimatic conditions of radiolarian associations from the terranes of the northwestern Pacific Ocean margin.

Already in the 1960's A. I. Zhamoida [12] described the species *Parvicingula khabakovi* (Zhamoida), indicating a range of its occurrence from the Koryakskoe Plateau to Sakhalin. Later this species was encountered in Siberia, on the Pechora and in North America. It is not impossible that the range of occurrence of this species or species similar to it, being dominant or component parts of the radiolarian associations, also possibly marks a trace of the ancient Pacific Ocean paleocurrent or paleocurrents of the upwelling type.

The Middle Jurassic radiolarians of the Omgon Range of Western Kamchatka (Sea of Okhotsk coast) also can be assigned to the high-latitude region. These fauna are characterized by a sharply impoverished composition in comparison with tropical fauna of the same age, archaic in appearance due to the absence of forms with a complex morphology and with presence of high-latitude endemics, having abipolar distribution.A detailed study of the morphology of the skeletons of radiolarians has shown that most of the species from the Jurassic of Western Kamchatka are of a smaller size and are more compact in form, but the diverse projections and long thin needles, so characteristic for tropical complexes, here are massive, poorly developed or totally absent. Some morphological changes also are observed in the nature of the shell wall. The high-latitude shells of the Mediterranean species *Praeconocaryomma magnimamma* are massive, thick-walled and usually without needles. Species of the genus *Archicapsa* have a compact form and a dense spongy wall. Due to a change in the form of the skeleton (more broadened in the low-latitude species and drawn out in relatively high-latitude species) the nature of the shell ribbing changes. In tropical species it is seemingly distended, large-ribbed, with large pores, but in the temperate and high latitudes — well-proportioned, thin-ribbed, striated and small-pored, and therefore the very same number of ribs falls in a different length of the shell circumference. In the assemblage there is a sharp dominance of three genera: *Parvicingula, Stichocapsa* and *Xitus*. The genera *Archaeodictyomitra* and *Archicapsa* are of subordinate importance. Spumellarians are present only as individuals. Nassellarians make up more than 90% of the entire assemblage of radiolarians.

Thus, our preliminary study of the Jurassic radiolarian associations isolated from rocks from the Northern Boreal province of Russia by chemical processing [4, 38, 39] indicated that their distribution also differs substantially from that proposed in the model published by Pessagno et al. [35], constructed in the example of North America. In Northern Europe, in contrast to North America, in Jurassic radiolarian associations a high percentage is accounted for by pantanellids (up to 50% in the Kimmeridgian of the Moscow syneclise; 10-25% in the Vyatka-Kama basin, 5% in the Timan-Pechora province) and discoid spongy forms, not characteristic for California. In the Jurassic of the

Pacific Ocean framing of Russia there are radiolarian assemblages made up 75% or more of nassellarians, amongst which there is a sharp predominance of parvicingulids, and there are more diverse associations in which the parvicingulids and pantanellids are present in equal numbers [6]. In the Early Cretaceous complexes of Sakhalin pantanellids sometimes make up to more than 75%. It must be noted that in the Jurassic assemblages of Western Kamchatka pantanellids were not encountered at all, whereas in Eastern Kamchatka and in Japan they occur widely [30, 41]. The world distribution of Jurassic radiolarian assemblages, in which parvicingulids have been described, is represented in Fig. 4.

All the material set forth above forces us in this stage of the research to desist from the use of the Pessagno curve in an analysis of the Boreal radiolarian associations of the Russian Mesozoic.

SUMMARY

The described type of Middle-Late Jurassic radiolarian associations is characterized by a predominance of Parvicingulidae, which are a characteristic component element of Boreal associations (Fig. 4).

Work on study of evolution of radiolarians of the Boreal Mesozoic for the time being is in its initial stage. At the present time, as was demonstrated,

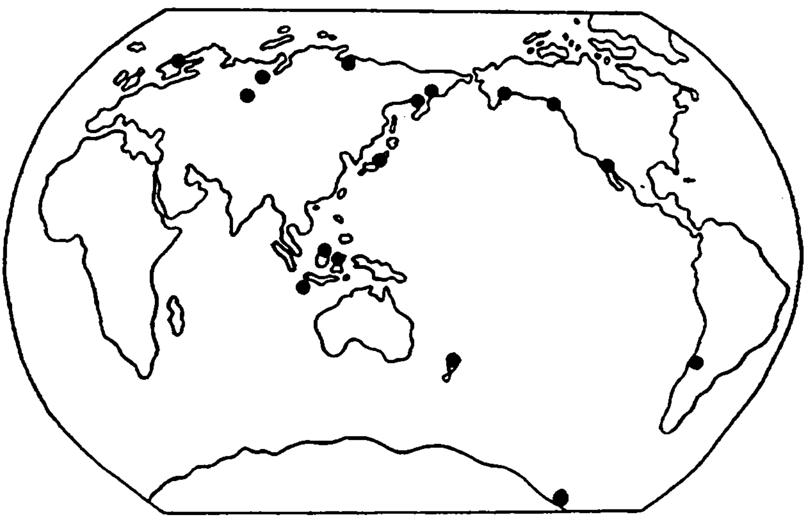

Fig. 4 World distribution of finds of genus *Parvicingula*.

such fauna has been discovered and in part described only in individual regions and for individual stratigraphic intervals in Antarctica, Canada, America and Russia (Northeast Russia, Pechora Basin, Moscow syneclise and Volga region).

In order to proceed to an analysis of the evolution, paleoecology and paleobiogeography of Boreal radiolarian associations of the Jurassic, it is necessary to carry out descriptive work both on the basis of an inadequately studied stratigraphic interval (Lower-Middle Jurassic) and for regions where Jurassic radiolarians have not been studied (Pacific Ocean margin of Russia) or have been inadequately described (Arctic Siberia, eastern slope of the Polar Urals, Volga region, Caspian syneclise and its margins). Precisely for this reason, this article gives a detailed description of the Jurassic radiolarians of Kamchatka from the collection stored at the Lithosphere Institute, Russian Academy of Sciences.

In contrast to the radiolarian associations of the same age in Northern Siberia, the northeastern part of the Russian plate and Norway, the Middle to Late Jurassic and Early Cretaceous radiolarian associations of the Okhotsk coast of Western Kamchatka were studied using a scanning electron microscope and are illustrated in 7 phototables.

The novelty of the research results which we have presented in this article is that they represent new data on the Mesozoic Boreal radiolarian associations in the north and northeast of Russia, which makes it possible to compare them with the same-age associations of the East European and Siberian Platforms and other regions of Northeast Russia. An analysis of all the factual material for the territory of Russia will make it possible in the future to correct the Pessagno and Kiessling-Scasso curves, constructed during the course of the preceding research carried out on the basis of data for California and Antarctica, and also will make it possible to propose a new original model of development of the Mesozoic Boreal fauna of the Eurasian North.

APPRECIATIONS

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DESCRIPTION OF RADIOLARIANS

Superorder POLYCYSTINA Ehrenberg, 1838, emend. Riedel, 1967
Order SPUMMELARIINA Ehrenberg, 1875
Superfamily SPONGODISCACEA Haeckel, 1882, emend. Pessagno. 1971, 1973
Family SONGURIDAE Haeckel, 1887
Subfamily ARCHAEOSPONGOPRUNINAE Pessagno, 1973
Genus *Archaeospongoprunum* Pessagno, 1973
***Archaespongoprunum* sp.**
Plate 6, Figure 1; Plate 7, Figure 1

D e s c r i p t i o n . Substeric spongy shell having two polar needles.The form of the needles is trihedral; at the distal end the needle is slightly twisted with the twist beginning 2/3 of the distance from the end of the needle. The place of attachment of the needle to the spongy sphere is evidently somewhat dissolved.

O c c u r r e n c e . Tithonian-Berriasian. Okhotsk coast of Kamchatka.

Family PRAECONOCARYOMMIDAE Pessagno, 1976
Genus *Praeconocaryomma* Pessagno, 1976
***Praeconocaryomma* sp. cf. *P. magnimamma* (Rust)**
Plate 6, Figure 2; Plate 7, Figure 2

Acanthosphaera magnimamma Rust — Rust, 1898, p. 12, pl. 4, f. 1. [36]

Praeconocaryomma magnimamma (Rust) — Pessagno, 1977, p. 77, pl. 5, f. 14-16, pl. 6, f. 1; Vishnevskaya et al., 1996, pl. 1, f. 2.

D e s c r i p t i o n . Spherical shell over whose entire surface there are subconical projections to which needles possibly were attached, There are 8-10 such xytoid projections or nodosae, sometimes called mammilae.

O c c u r r e n c e . Late Kimmeridgian-Early Tithonian in Mediterranean Sea region, California; Tithonian-Berriassian of Omgonk Range of Okhotsk coast of Kamchatka.

Order NASSELLARIINA Ehrenberg, 1875
Superfamily CYRTOIDEA Haeckel, 1862,
Subsuperfamily EUCYRTIDILAE Ehrenberg, 1857
Family ARCHAEODICTYOMITRIDAE Pessagno, 1976
Genus *Archaeodictyomitra* Pessagno, 1976
***Archaeodictyomitra curta* Vishnevskaya**
Plate 2, Figs 4-5; Plate 7, Figure 11

Name from Latin: *curta* - short.

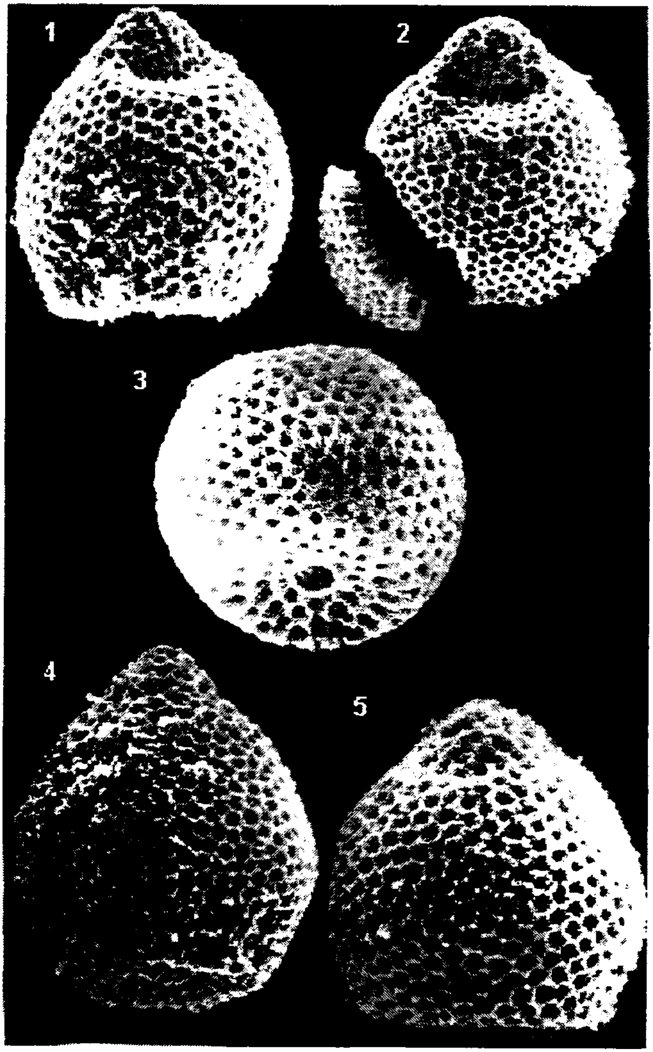
H o l o t y p e — 604/2-11-97, pl. 1, f. 14; pl.4, f. 1; paratypes 604/2-11-60, pl. 1, f. 15; 604/2-6V-16, pl. 1, f. 16; 596/3-6V-49, pl. 2, f. 4; 596/3-6V-61, pl. 2, f. 5.

Eothanarla (?) sp. — Vishnevskaya, et al., 1991, pl. 4, f. 10.

Archaeodictyomitra curta Vishnevskaya — Vishnevskaya et al., 1996, pl. 1, f. 14-16, pl. 4, f. 1.

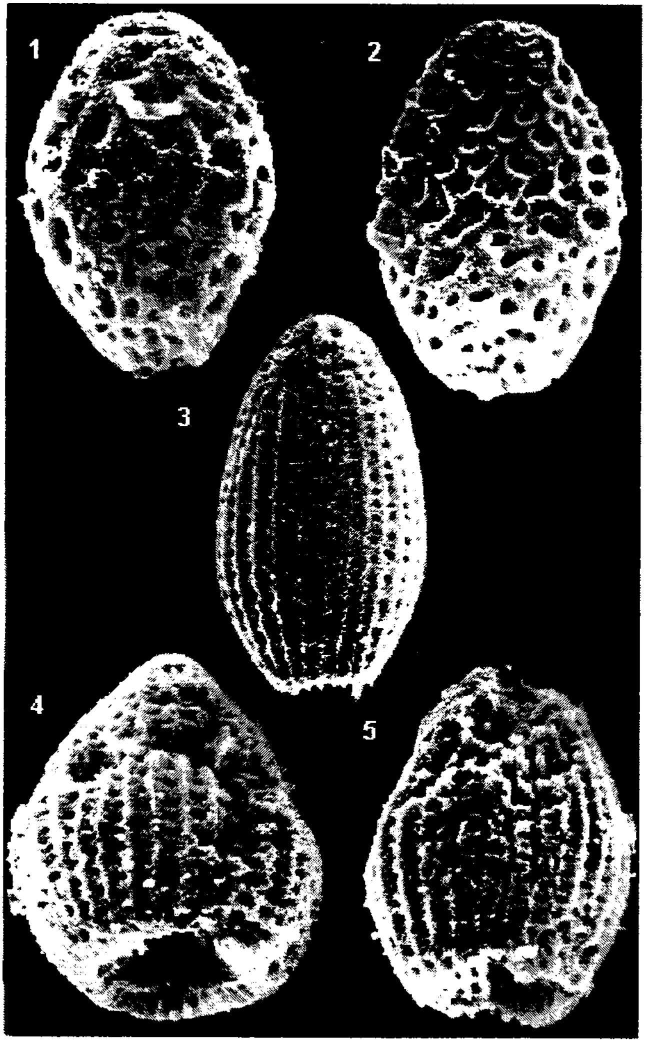
D e s c r i p t i o n . Multisegment barrel-shaped shell with thickening in middle part, narrowing in distal part and sharpening in initial part. In the central, most broadened part there are up to 28-30 longitudinal ribs (costae); in the initial part of the shell the ribs frequently converge, but toward the terminal part the number of ribs increases. The pores are rounded or slightly drawn out along the width of the shell and their size and positioning are not consistent. In the proximal part of the shell there is a depression resembling an aperture in the form of a sutural (?) pore.

Plate 1



1-5 - *Stichocapsa globosa* Vishnevskaya, 1 — sample 596-3, ×130; 2-5 — sample 604-2, 2 — ×110, 3 — ×190, 4 — ×190, 5 — ×230.

Plate 2



1 - *Archicapsa* sp. cf. *A. pachyderma* (Tan Sin Hok), ×170; 2 - *Archicapsa* sp. A., × 120; 3 - *Archaeodictyomitra elliptica* Vishnevskaya, × 170; 4-5 - *Archaeodictyomitra curta* Vishnevskaya, × 170.

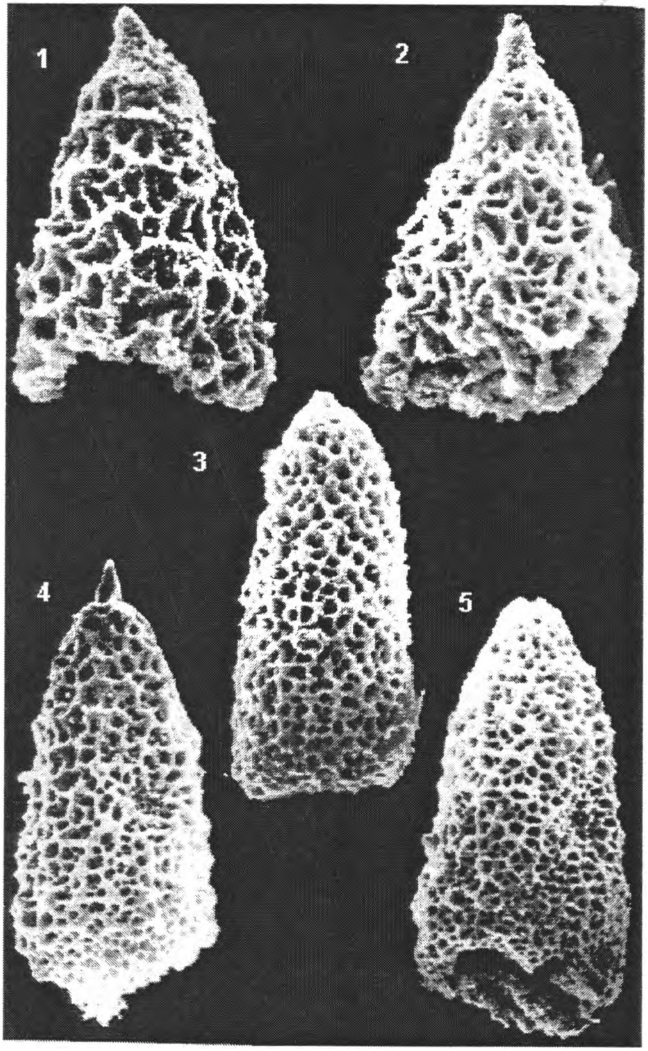
1-5 — sample 604-2.

Comparison. *Archaeodictyomitra curta* Vishnevskaya differs from *Mita* sp. A Carter ([16], p. 49, pl. 17, f.9) in having pores of a lesser size and the presence of a depression resembling the "window" described in Bagotidae (Pessagno et Whalen, 1982), which probably could perform the function of a sutural pore or something like it.

Size (μm). Holotype + 6 paratypes:

	Holotype	Mean	Maximum	Minimum
Length of shell	220	225	292	175
Width of shell	135	175	210	135

Plate 3



1-2 - *Xitus* sp. A.,× 170; 3-5 - *Xitus primitivus* Vishnevskaya, ×100, ×100, ×120.

1-5 — sample 604-2.

L o c a t i o n : 604/2, see text and Figure 2. Location 596/3 — Rarytkin Range [6, 11].

O c c u r r e n c e . Bajocian-Bathonian of Koryakia [6, 11], Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka.

Archaeodictyomitra elliptica **Vishnevskaya**

Plate 2, Figure 3; Plate 7, Figure 12

N a m e : from the English elliptic.

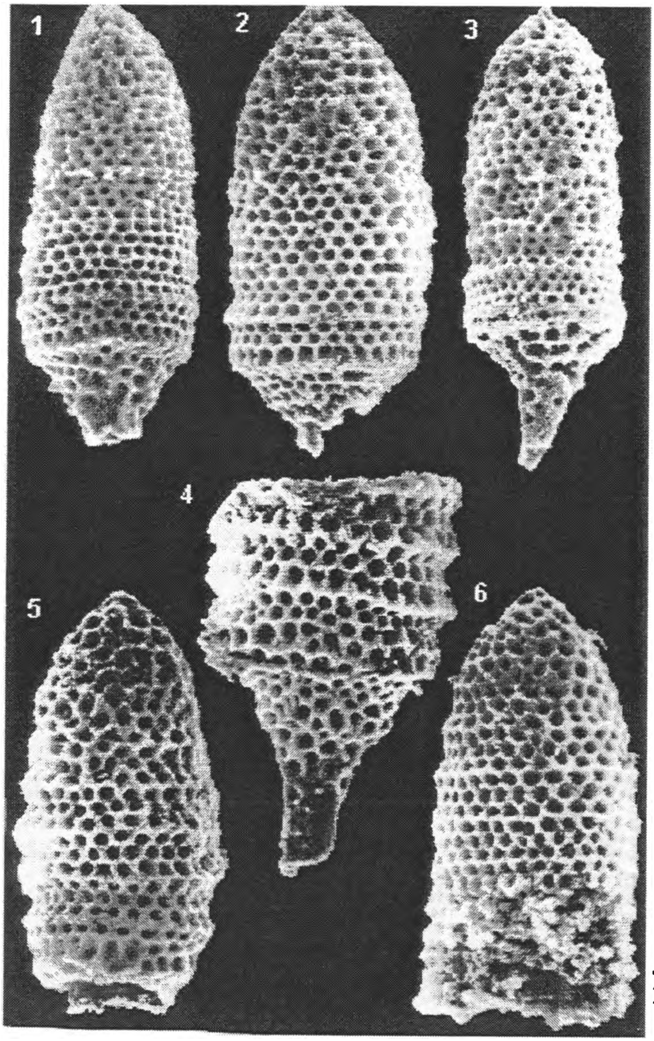
H o l o t y p e — 604/2-II-71, pl. 2, f. 3.

Archaeodictyomitra elliptica Vishnevskaya— Vishnevskayaet et. al., 1996, pl.2, f.3-5.

D e s c r i p t i o n . Elliptic shell with subspherical cephalis; it has from 20 to 22 rows of longitudinal ribs (costae), becoming gradually narrowing toward the distal part of the shell. The pores are small of approximately equal size, having a circular form, situated between longitudinal ribs, but the positioning of the horizontal rows is not always consistent. Depression absent.

C o m p a r i s o n . It differs from *Archeodictyomitra curta* Vishnevskaya in having aregular elliptic form, smaller size of pores, their more regular circular form and

Plate 4



1-6 - *Parvicingula omgoniensis* Vishnevskaya,1 - ×110, 2,4-6 -× 120, 3 - × 80.
1-6 — sample 604-2.

more rigorous positioning, as well as an absence of an aperture in the proximal part of the shell; it differs from *Mita* sp. A Carter ([16], p. 49, pl. 17, f. 9) in having a lesser size of the pores and a different form of its. It differs from other species of this genus in having a more archaic nature of pore distribution.

S i z e (μm). Holotype + 6 paratypes:

	Holotype	Mean	Maximum	Minimum
Length of shell	352	340	420	270
Width of shell	210	210	240	150

L o c a t i o n . 604/2, see text and Figure 2.

O c c u r r e n c e . Bajocian-Bathonian [6, 11], Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka.

Archaeodictyomitra sp.

Plate 5, Figure 3; Plate 7, Figure 9

O c c u r r e n c e . Tithonian-Berriasian. Okhotsk coast of Kamchatka.

Family EUCYRTIDIIDAE Ehrenberg, 1847

Genus _Dictyomitrella_ Haeckel, 1887

Dictyomitrella (?) sp. A

Plate 7, Figure 20

D e s c r i p t i o n .Multisegment shell, differing only in the presence of perforated pores which are rigorously positioned on both the longitudinal and transverse ribs, which sharply distinguishes this form from many others due to such an archaic nature of the pores.

O c c u r r e n c e . Middle Jurassic. Okhotsk coast of Kamchatka.

Dictyomitrella (?) sp. B.

Plate 6, Figure 3; Plate 7, Figure 4.

C o m p a r i s o n . It differs from *Dictyomitrella (?)* sp. A in having a form of the costae closer to dictyomitrids.

O c c u r r e n c e . Middle Jurassic, Okhotsk coast of Kamchatka.

Family STICHOCAPSIDA Haeckel, 1881

Subfamily STICHOCAPSINAE Haeckel, 1881

Genus _Stichocapsa_ Haeckel, 1881

Stichocapsa globosa Vishnevskaya

Plate 1, Figs 1-5; Plate 7, Figs 17-19

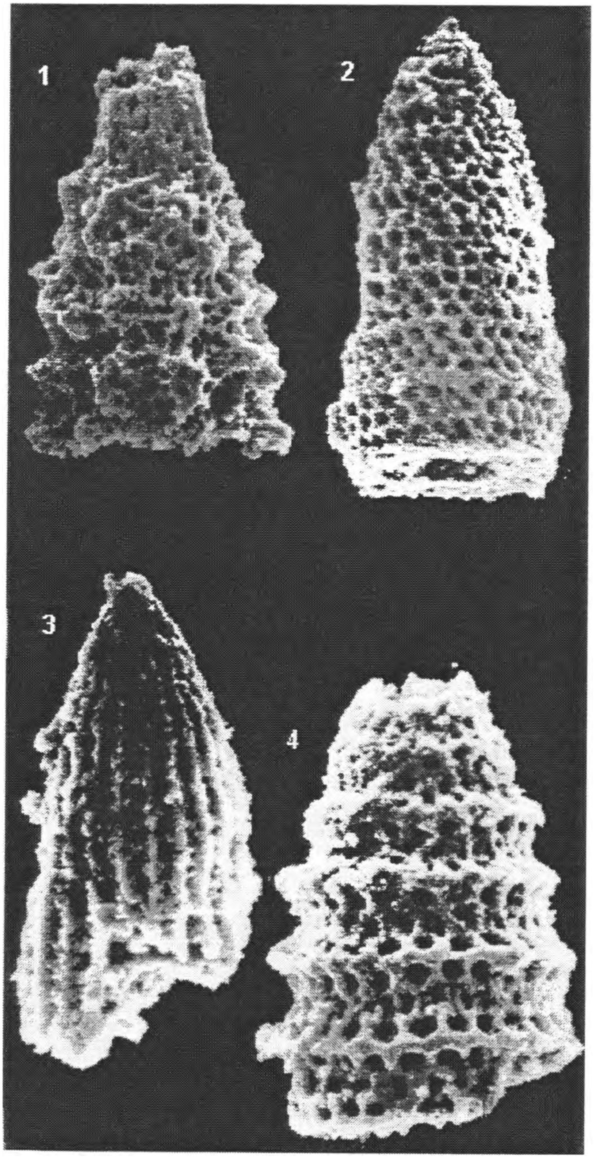
N a m e : from the Latin globosa — spherical.

H o l o t y p e — 604/2-II-66, pl. 1, f. 1, 3, pl. 7, f. 18-19; paratypes 604/2. pl. 2, f. 2, 4-5; pl. 7, f. 17.

Stichocapsa globosa Vishnevskaya - Vishnevskaya et al., 1996, pl. 2, f. 12-18; pl. 4, f. 4; pl. 5, f. 1-19.

D e s c r i p t i o n . Four-segment shell with subspherical domed cephalothorax and with spherical distal end; it has a dense hexagonal cellular structure. On the semicircumference of the shell in the most expanded part there are 18-20 pores. The pores are of a small circular form of approximately equal size and are situated in hexagonal frameworks. Between the thorax and abdomen there is a depression filled

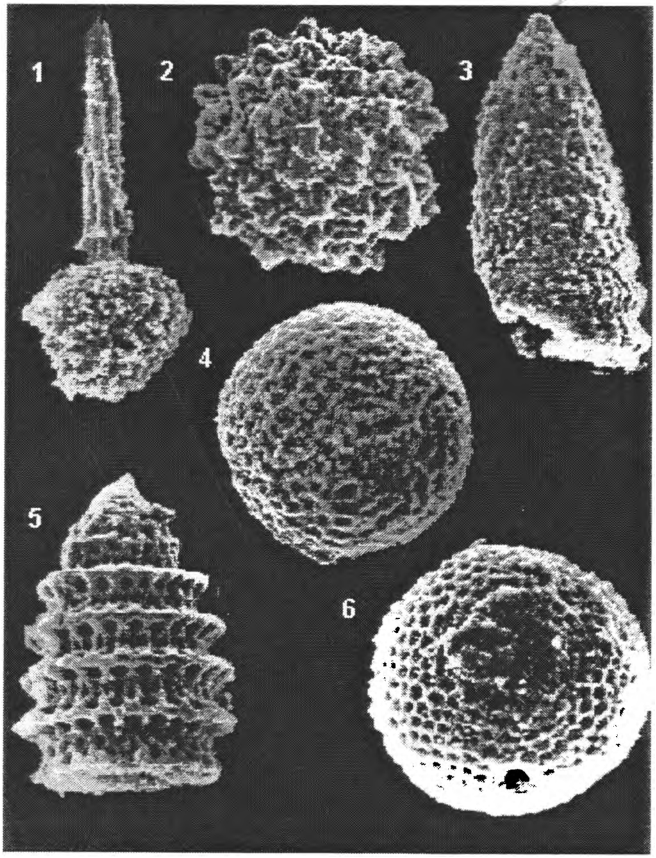
Plate 5



1 - *Xitus* sp. C, × 135; 2 - *Parvicingula* sp. A, × 135; 3 - *Archaeodictyomitra* sp., × 255; 4 - *Coneta* cf. *hsui* Pessagno, × 225.

1-2 — sample 603-5; 3-4 — sample 603-6.

Plate 6



1 -*Archaeospongoprunum* sp., × 100; 2 - *Praecono-caryomma* sp. cf. P. *magnimamma* (Rust), × 100; 3 - *Dictyomitrella* (?) sp. B, × 160; 4 - *Holocryptocanium* sp. cf. *H. barbui* Dumitrica, × 160; 5 - *Coneta* cf. *hsui* Pessagno, × 140; 6 - *Holocryptocanium barbui* Dumitrica, × 160.

1-3 — sample 603-5; 4-6 — sample 603-6.

with the same or somewhat smaller pores. The apertura is small and circular, seemingly impressed into the shell, bordered by a low rim.

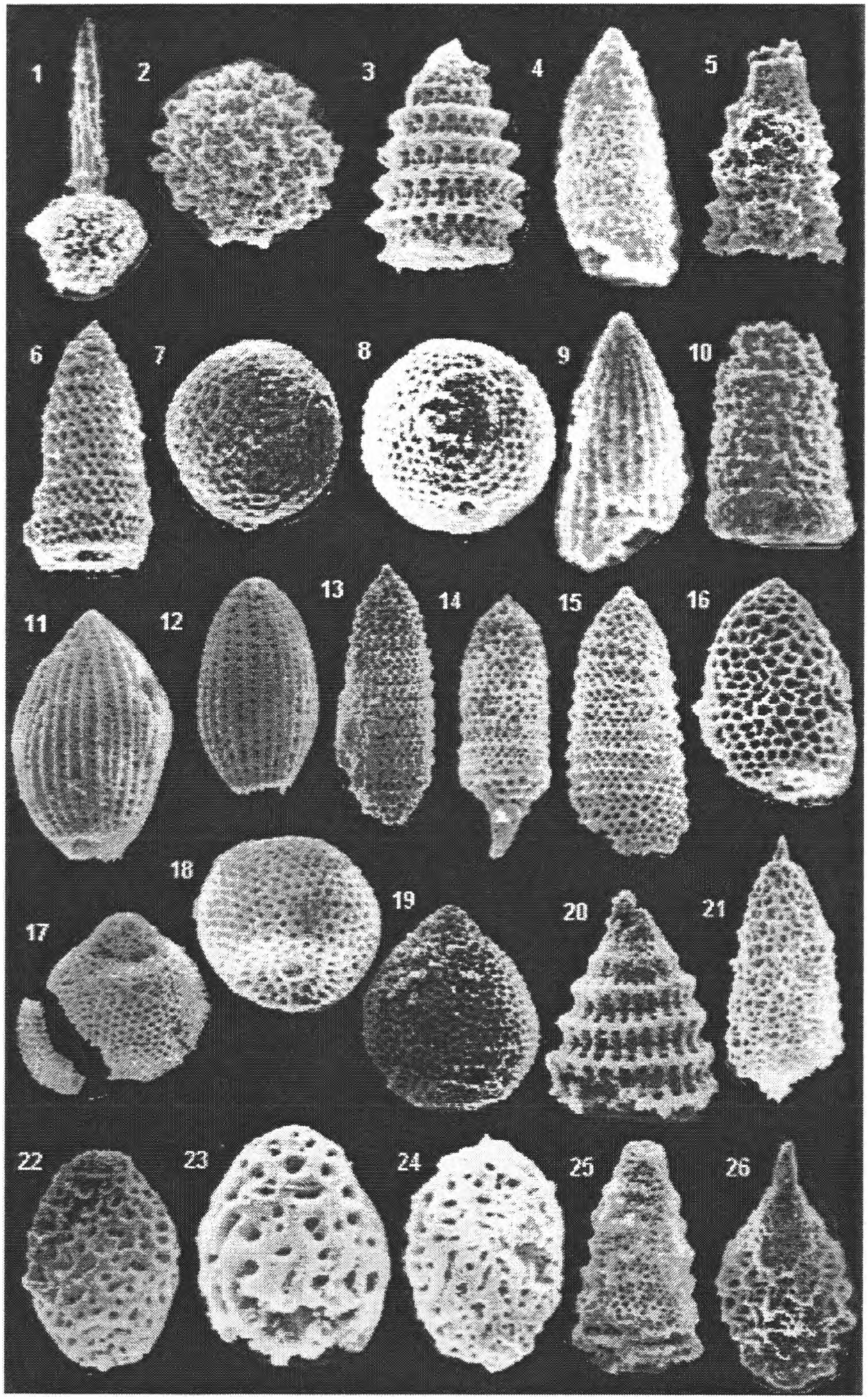
C o m p a r i s o n . *Stichocapsa globosa* is close to *S. robusta* Matsuoka ([30], p. 146, pl. 1, f. 6-13, pl. 2, f.. 7-12) and *S. convexa* Yao [41], but differs from them in having a subspherical shape of the shell and apertura.

S i z e (μm). Holotype + 6 paratypes:

	Holotype	Mean	Maximum	Minimum
Length of shell	180	190	210	165
Width of shell	165	190	210	165
Height of cephalothorax	38	35	40	27
Apertura diameter	25	27	30	25
Diameter of depression	120	115	107	127

L o c a t i o n : 604/2, see text and Figure 2.

Plate 7



Occurrence. Bajocian-Bathonian of Koryakia [6, 11], Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka.

Family PARVICINGULIDAE Pessagno, 1977
Genus *Parvicingula* Pessagno, 1977a
***Parvicingula omgoniensis* Vishnevskaya**
Plate 4, Figs 1-6; Plate 7, Figure 14

Name: from geographical place name Omgon.

Holotype — 604/2-11-90, pl. 4, f. 3, pl. 7, f. 14; paratypes pl. 4, f. 1, 2, 4-6.

Parvicingula omgoniensis Vishnevskaya - Vishnevskaya et al., 1996, pl. 2, f. 6-11; pl. 4, f.2.

Description. Multisegment shell (from 7 to 12, if the distal mouth tube is preserved), cylindrical-elliptical with subspherical cephalis; has from 13 to 15 pores in a transverse row on semicircumference of shell, gradually narrows toward distal part of shell. The pores are small with a circular form, are approximately equal in size, and are arranged in a chessboard pattern. The interrib sectors have 3-4 rows of hexagonal pores and the waist rings are poorly expressed.

The shell wall is two-layered, where the lower layer has a primitive cellular structure, whereas the upper layer has a slightly xytoidal structure. Beak absent.

Comparison. *Parvicingula omgoniensis* differs from *Parvicingula bluefordae* Hull and from *Parvicingula gracila* Hull [21] with respect to the form of the shell and the absence of a beak; it differs from *Parvicingula blowi* Pessagno [34] in having a lesser number of segments and poorly expressed constrictions between them; it differs from *Parvicingula garda* Hull [21] due to the absence of trapezoidal segments; *Parvicingula omgoniensis* is closer to *Parvicingula corralensis* Hull [21], but differs in the absence of a beak and a thicker two-layer wall.

Size (μm). Holotype + 6 paratypes;

	Holotype	Mean	Maximum	Minimum
Length of shell	390	405	430	370
Width of shell	160	200	205	195

Location. 604/2, see text and Figure 2.

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1 - *Archaeospongoprunum* sp., × 81; 2 - *Praeconocaryomma* sp. cf. P. *magnimamma* (Rust), × 81; 3 - *Coneta* cf. *hsui* Pessagno, × 117; 4 - *Dictyomitrella* (?) sp. *B*, × 135; 5 - *Xitus* sp. C, × 81; 6 - *Parvicingula* sp. A, × 81; 7 - *Holocryptocanium* sp. cf. *H. barbui* Dumitrica, × 135; 8 - *Holocryptocanium barbui* Dumitrica, × 126; 9 - *Archaeodictyomitra* sp., × 153; 10 -*Xitus* sp. D, × 90; 11 - *Archaeodictyomitra curta* Vishnevskaya, × 117; 12 - *Archaeodictyomitra elliptica* Vishnevskaya, × 112.5; 13,15 - *Parvicingula* sp.B, Carter, × 63, × 54; 14 - *Parvicingula omgoniensis* Vishnevskaya, × 63; 16 - *Canutus* sp, × 90; 17-19 - *Stichocapsa globosa* Vishnevskaya, × 81, × 117, ×117; 20 - *Dictyomitrella* (?) sp. A., × 108; 21 - *Xitus primitivus* Vishnevskaya, × 67.5; 22-24 - *Archicapsa* sp. *A*, × 81, × 117, × 81; 25 - *Xitus* sp. B, × 63; 26 - *Xitus* sp. A, × 63.

1, 2, 4-6 — sample 603-5; 3, 7-9 — sample 603-6; 10-26 — sample 604-2.

O c c u r r e n c e . Bajocian-Bathonian [6. 11], Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka.

Parvicingula sp. A
Plate 5, Figure 2; Plate 7, Figure 6

D e s c r i p t i o n . Subconical shell, somewhat narrowed in central part. Annular girdle and ribs are expressed poorly; there are three rows of pores between the ribs. Beak absent. Similar forms not found for comparison.

O c c u r r e n c e . Tithonian-Berriasian. Okhotsk coast of Kamchatka.

Parvicingula sp. B. Carter
Plate 7, Figs 13, 15

Parvicingula sp. B - Carter et al., 1988, p. 56, pl. 18, f. 3, 4.

C o m p a r i s o n . *Parvicingula* sp. B Carter exhibits a similarity to *P. blowi* Pessagno ([35], p. 85, pl. 8, f. 11-14), but differs from the latter in having more regular pores and their positioning and less clearly expressed annular girdles. *Parvicingula* sp. B Carter differs from *Parvicingula corralensis* Hull [21] with respect to form and structure and the positioning of pores, as well as the absence of distinct annular girdles.

O c c u r r e n c e . Early Bajocian of Canada [16]. Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka

Genus _Coneta_ Blome and Hull, 1995
Coneta cf. _hsui_ (Pessagno)
Plate 5, Figure 4; Plate 6, Figure 5; Plate 7, Figure 3

Ristola sp. aff. *R. boesii* (Parona) - Pessagno, 1977, p.48, pl.8, f. 5; Pessagno et al., 1984, p. 29, pl. 3, f. 16, 18, 23.

Ristola hsui (Pessagno) - Pessagno et al., 1984, p.29, pl.4, f.2-3.

Parvicingula hsui Pessagno, 1977, p.85, pl.8, f.15-16; pl.9, f. 1-5.

Parvicingula boesii (Parona) – O'Dogherty, 1994, p.111, pl.8, f.16.

Coneta hsui (Pessagno) Hull, 1995, p.16, pl.1, f.6, 10, 18, 22; pl.6, f.10.

D e s c r i p t i o n . This form is similar to both *Ristola* sp.aff.*R. boesii* (Parona) and to *R. hsui* (Pessagno), but differs from them in having a lesser number of segments and a different structure of the pores, which seemingly are connected from three rows into a single row, flattened in width and seemingly drawn out in height in the intervals between the protruding ribs. Precisely this feature enabled us to assign this species to R. *hsui.*

O c c u r r e n c e . Middle Valanginian of California; Tithonian-Berriasian of Okhotsk coast of Kamchatka.

Superfamily PLAGIACANTHOIDAE Hertwig, 1879, emend. Petrushevskaya, 1971
Family PLAGIACANTHOIDAE Hertwig, 1879, emend. Petrushevskaya, 1971
Genus *Archicapsa (Parona), 1890*
***Archicapsa* sp. cf. *A. pachyderna* (Tan Sin Hok)**
Plate 2, Figure 1

Comparison. This form is similar to *Archicapsa pachyderma* Tan Sin Hok ([20], f. 9-44; [26], pl. 1, f. 8), A. sp. (Kido, 1982, pl. 5, f. 12), A. sp. A ([32], pl. 1, f. 17; [29], pl. 1, f. 9, 22, 23; [42], pl. 3, f. 3), but is twice as large.

Occurrence. Middle Jurassic of Japan, Omgon Range of Okhotsk coast of Kamchatka.

***Archicapsa* sp. A**
Plate 2, Figure 2; Plate 7, Figs 22-24

Comparison. Form close to *Gongylothorax* (?) spp. - Kishio, 1982, pl. 8, f. 21 [25], but differs in having a spongy structure of the shell wall.

Occurrence. End of Early-beginning of Middle Jurassic of Japan, Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka.

Family CANUTIDAE Pessagno and Whalen, 1982
Genus *Canutus* Pessagno and Whalen
***Canutus* sp. A**
Plate 7, Figure 16

Comparison. Differs from all known species in having a broader shell with small pore frameworks of irregular shape.

Occurrence. Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka.

Family WILLIRIEDELLIDAE Dumitrica, 1970
Genus *Holocryptocanium* Dumitrica, 1970
***Holocryptocanium barbui* Dumitrica**
Plate 6, Figure 6; Plate 7, Figure 8

Holocryptocanium barbui Dumitrica, 1970, p. 76, pl. 17, f. 105-108 a, b, pl. 21, f. 136; Pessagno, 1977, p. 40, pl. 6, f. 18; Schaaf, 1981, p. 435, pl. 2, f. 1 a, b, pl. 10, f. 6 a, b; Yao, 1984, pl. 5, f. 1; Baumgartner, 1984, pl. 4, f. 14; Basov & Vishnevskaya, 1991, pl. XIV, f. 1-7.

Holocryptocanium barbui japonicum Dumitrica - Nakaseko & Nishimura, 1981, p. 154, pl. 3, f. 5a, b, 6, 7,a, b, pl. 14, f. 8.

Occurrence. Tithonian-Cenomanian of Tethys, Aptian-Cenomanian of Paleo-Pacifica, Tithonian-Berriasian of Okhotsk coast of Kamchatka.

Holocryptocanium sp. cf. _H. barbui_ Dumitrica
Plate 6, Figure 4; Plate 7, Figure 7

C o m p a r i s o n . Form similar to *Holocryptocanium* sp. — Matson & Pessagno, 1979, f. 2 N, O [28], but due to the clear character of the rounded pores and the presence of pore frameworks has been assigned to *Holocrytocanium barbui*, from which it differs only in having a smaller apertura.

O c c u r r e n c e . Hauterivian-Barremian of Puerto Rico,Tithonian-Berriasian of Okhotsk coast of Kamchatka.

Family XITIDAE Pessagno, 1977 [34]
Genus _Xitus_ Pessagno, 1977 [34]
Xitus primitivus Vishnevskaya
Plate 3, Figs 3-5; Plate 7, Figure 21

N a m e : from the English word primitive.

H o l o t y p e - 604/2-11-61, pl. 3, f. 4, paratypes 604/2-11-64, pl. 3, f. 3; 596/3.6V-53, pl. 3, f.5.

Xitus primitivus Vishnevskaya, 1996, pl. 3, f. 1-6; pl. 4, f. 3.

D e s c r i p t i o n .Multisegment shell (from 7 to 9-10 segments), elliptic-conical with subspherical cephalis; shell wall two-layered; the lower layer has small pores of a circular shape, approximately equal in size, upper layer — xytoidal in structure, but the pores are not always consistently arranged, the positioning is frequently random. In the middle part of the shell it is possible to observe a depression or the absence of the upper layer, as a result of which a clearly visible depression (45-55 μm) is formed. A short (50-60 μm) beak is frequently preserved.

C o m p a r i s o n . It differs from all known species die to a random xytoidal structure of the wall and presence of an aperture in the central part of the shell.

S i z e (μm). Holotype + 6 paratypes.

	Holotype	Mean	Maximum	Minimum
Length of shell	430	465	540	390
Width of shell	240	250	280	220

L o c a t i o n : 604/2, see text and Figure 2.

O c c u r r e n c e . Bajocian-Bathonian of Koryakia [6, 11], Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka.

Xitus sp. A
Plate 3, Figs 1-2; Plate 7, Figure 26

C o m p a r i s o n .Principal difference — presence of massive beak.

O c c u r r e n c e . Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka.

Xitus sp. B
Plate 7, Figure 25

C o m p a r i s o n . Differs from other species in having pores of a lesser size and of a different form.

O c c u r r e n c e . Middle Jurassic of Omgon Range of Okhotsk coast of Kamchatka.

Xitus sp. C

Plate 5, Figure 1; Plate 7, Figure 5

C o m p a r i s o n . The principal distinguishing feature is the presence of a very broad cephalis, equal in width to three noduses.

O c c u r r e n c e . Tithonian-Berriasian of Omgon Range of Okhotsk coast of Kamchatka.

Xitus sp. D

Plate 7, Figure 10

C o m p a r i s o n . It differs from other species of this genus in having a more archaic nature of pore distribution.

O c c u r r e n c e . Tithonian-Berriasian of Omgon Range of Okhotsk coast of Kamchatka.

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