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Alveolophora khursevichiae sp. nov. from the Miocene sediments of Khanka Lake (Far East)

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With 24 figures and 1 table

Abstract: The new species *Alveolophora khursevichiae* Usoltseva, Pushkar & Likhacheva is described from Middle Miocene deposits of the Novokachalinskaya Formation on the Western coast of Khanka Lake (Far East). This species resembles *A. bifaria* and *A. russica* by complex areolae rows, but differs from these species by other features.

Key words: *Alveolophora khursevichiae*, Khanka Lake, Miocene sediments, double areolae rows, ribs, rimoportulae.

Introduction

Lake Khanka is located on the border of Primorye (Russian Far East) and China. Rock strata of the Novokachalinskaya Formation crop out in coastal cliffs of the western shore of Lake Khanka. According to paleontological data, the age of this Formation corresponds **to the Middle Miocene** (Pavlyutkin et al. 2004). Diatoms of this Formation were studied from 1952 (Jouse 1952) into the 1970's (Moisseeva 1971), and into the 21st Century (Pavlyutkin et al. 2004). *Alveolophora jouseana* Moiseeva and *Alveolophora areolata* Moiseeva were identified among *Alveolophora* Moisseeva & Nevretdinova (Likhacheva et al. 2009) in this formation.

We found out a new fossil species of *Alveolophora* in the Novokachalinskaya Formation, which is described here based on observations made with light and scanning electron microscopy.

Materials and methods

Sediment samples from the Novokachalinskaya Formation were used in this study. The outcrop was on the Western coast of Lake Khanka, between Turiy Rog and Novokachalinsk settlements (Fig. 1). Three types of rock were prevalent in Novokachalinskaya Suite: pebbles, sandstone and fossil tuff-aleurolites and tuff-diatomite. The layers of the section dip approximately 2 degrees to the south and southeast, forming retrogressive depositions on carboniferous sediments of the upper Oligocene and overlapping with Upper Pliocene clay. The thickness of the sediments is 206 m.

The samples were collected in 2010 and 2011 from natural rock outcrops with a height of up to 10 m along the coast of Lake Khanka, between the creek-valley Vtoraya Rechka and Cape Beloglinyany (Fig. 1). These outcrops consisted of tuff-aleurolites and tuff-diatomites of yellowish color. Structurally they were related to the Novokachalinskaya Formation (**upper part**

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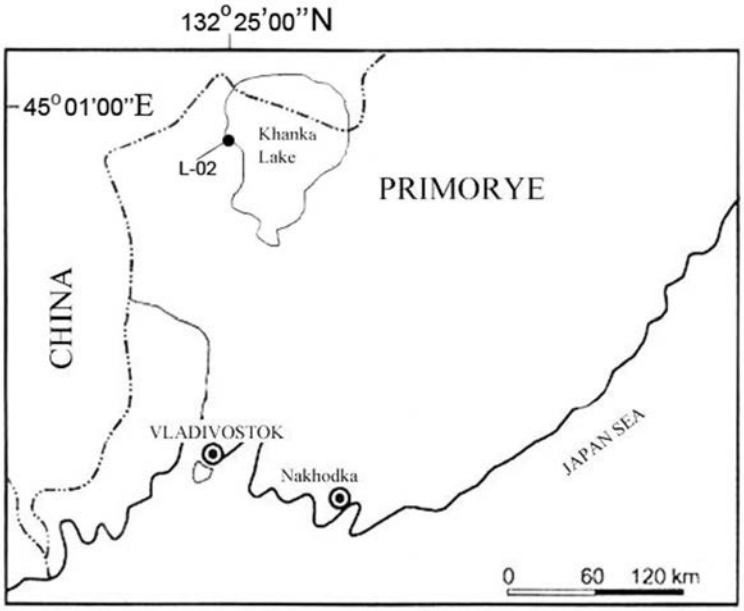


Fig. 1. Map showing the position of the sampling site L-02, on the west coast of Lake Khanka in Primorye, Russian Far East.

of the Middle Miocene). In all samples, a rather rich and well-preserved diatom flora was found. The valves of *Alveolophora khursevichiae* were observed in the sample designated L-02 (Fig. 1).

The preparation of samples for LM and SEM was performed as described previously (Glezer et al. 1974) with modifications of the authors. Sediment samples were treated with 30% hydrogen peroxide at 75°C for 1 h and rinsed three times with distilled water. Further, samples were processed by heavy liquid cadmium in triple volume with specific gravity 2.6 and centrifuged for 10 min. Then, the surfaced light fraction with diatoms was drained, diluted and the distillate washed from the heavy liquid by centrifugation. Some cleaned diatom material was air-dried on coverslips and mounted onto glass slides with Naphrax. Observations were made with a Axiovert 200 ZEISS LM equipped with a Pixera Penguin 600CL camera. For SEM observations, the material was then placed on aluminum stub, dried, coated with gold under vacuum in an SDC 004 (BALZERS) sputter coater, and examined with a Quanta 200 SEM.

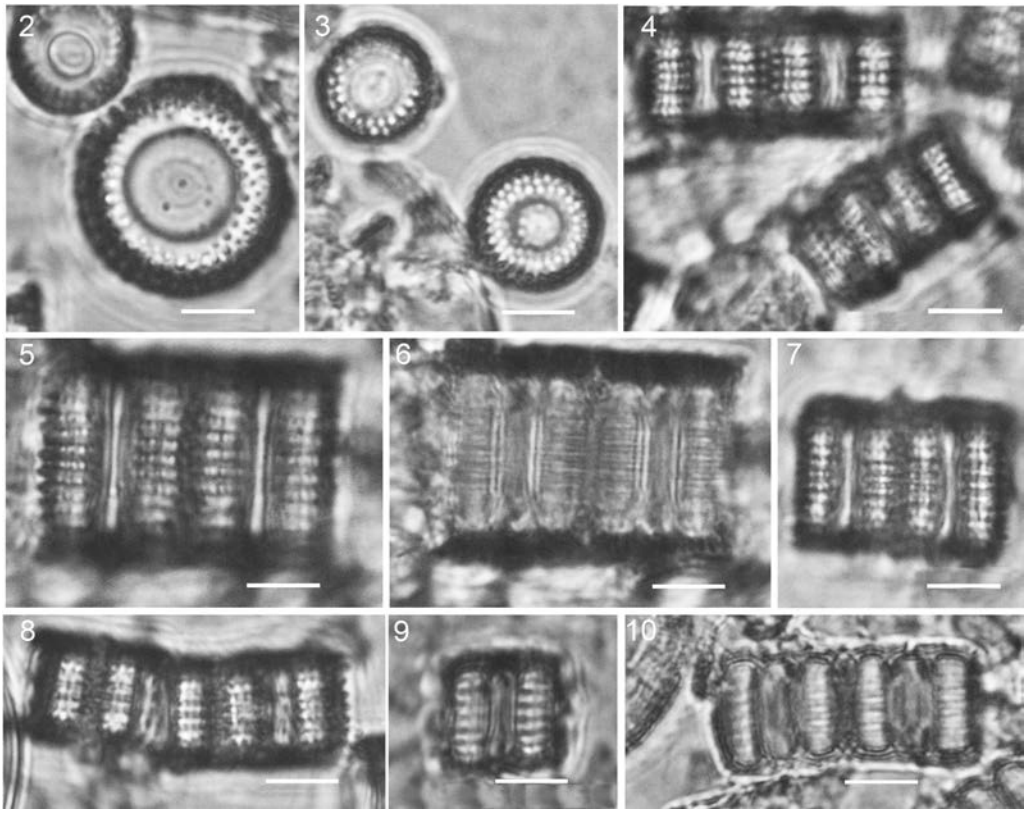
Results

***Alveolophora khursevichiae* sp. nov. Usoltseva, Pushkar & Likhacheva (Figs 2–28)**

Description

LM: Frustules in valve view are round (Figs 2, 3), 6.6–17.0 µm in diameter. The Ringleiste (R) has a circular opening and may be narrow or occluded about half of its total width (Figs 2, 3). Areolae on the valve face are variable in their arrangement, they may be isolated, as a ring near the margin (Fig. 2) or located over the entire surface (Fig. 3). All frustules are short cylinders, straight (Figs 4–10), 2.2–5.0 µm in height.

SEM: Valve face with granules all over the surface or at the periphery (Fig. 11–13). Frustules short, cylindrical (Figs 14–17), united by linking spines that are rectangular with rounded edges



Figs 2–10. LM. *Alveolophora khursevichiae* sp. nov. from the Novokachalinskaya formation, Primorye, Russian Far East. Figs 2, 3. External valve face view. Figs 4–10. External valve view of filaments. Scale bar: 5 μm.

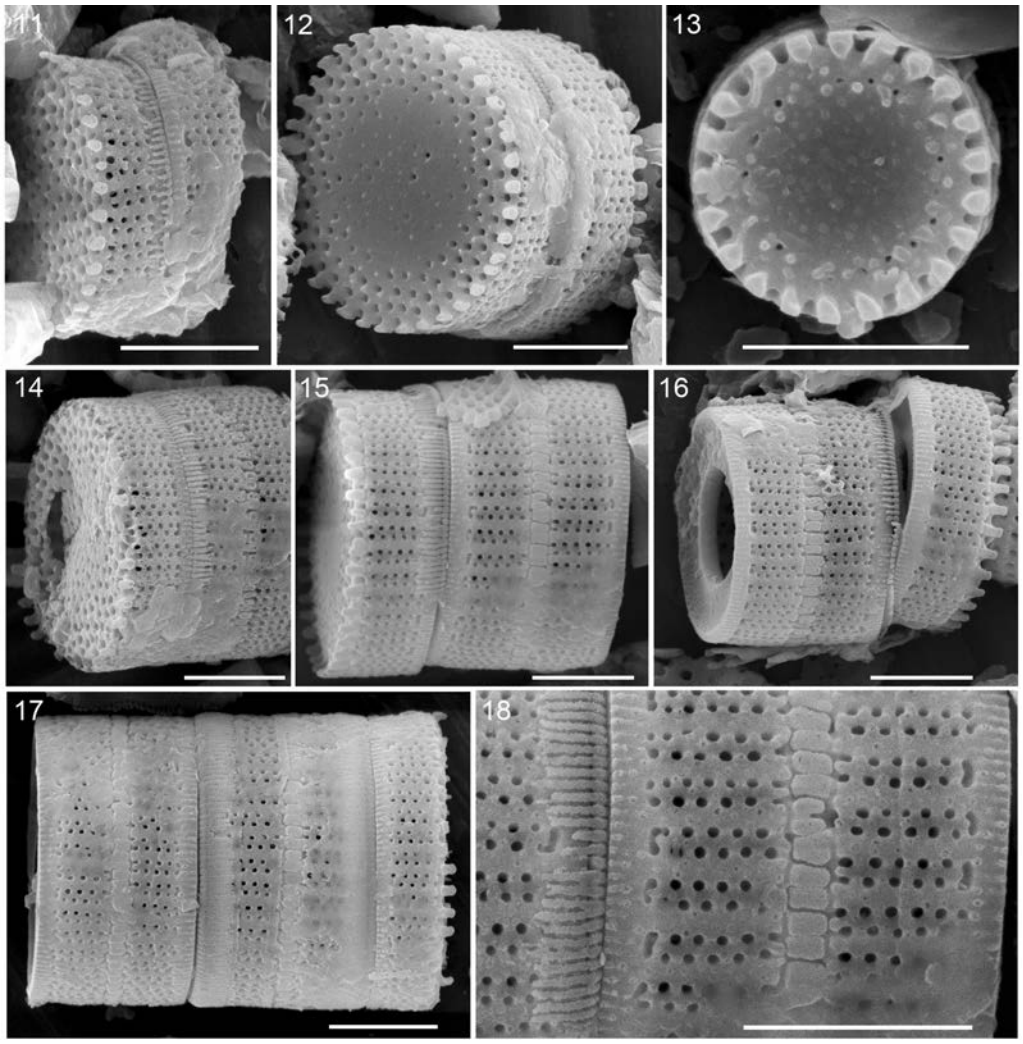
(Figs 15–18). Separation spines slightly pointed (Figs 19, 20). Areolae on the mantle are situated in straight double rows (Figs 14–18), 10 double rows in 10 μm (20 rows in 10 μm); 4–6 areolae in each row (20 in 10 μm within a row). The collar is narrow (0.6 μm) with small ribs (Figs 15–18). Areolae are round (Figs 14–18), 0.15 μm in diameter (Fig. 18). External openings of rimoportulae are positioned between the areolae of the first row forming a wide areola (Fig. 18). Ringleiste is deep, rarely narrow (Figs 19, 20, 22–24). Sometimes it is possible to observe wide valves with a narrow ringleiste (Fig. 21). Rimoportulae are sessile, located on the ringleiste, next to septa (Figs 20, 22–24). Alveolae with longitudinal (10–12 in 10 μm) ribs (costae) on the internal surface of the valve mantle (Figs 20–24). Sometimes small pointed spines are visible outside of the valve face.

Holotype: Slide № L–02 deposited at Limnological Institute of SB RAS, Irkutsk, Russia.

Isotype: Circled specimen on slide ANSP GC 36358 (Academy of Natural Sciences, Philadelphia).

Type locality: Novokachalinskaya Formation, second half of Middle Miocene, Lake Khanka, Russian Far East.

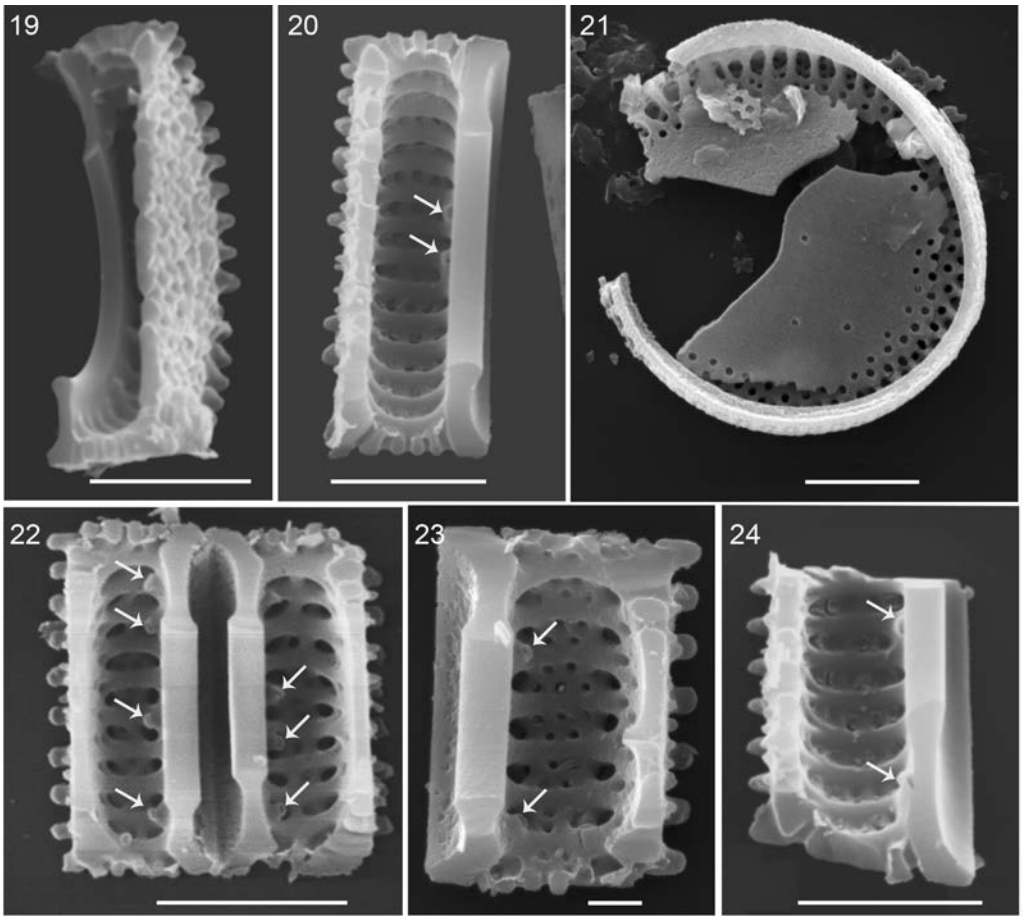
Etymology: The species is dedicated to Galina Khursevich, in recognition of her impact on the study of fossil diatoms of Russia.



Figs 11–18. SEM. *Alveolophora khursevichiae* sp. nov. Figs 11–14. External view of valve face showing areolae position. Figs 14–18. External valve view showing areolar rows and separating spines. Scale bar: 5 µm.

Discussion

Alveolophora is an ancient extinct freshwater genus. It existed from the Late Eocene until the end of the Miocene (Kozyrenko et al. 2008). There are ten spesies: *A. antiqua* (Moisseeva) Moisseeva, *A. russica* Usoltseva, Kociolek & Khursevich (= *A. areolata* (Moisseeva) Moisseeva), *A. baicalensis* Khursevich & Fedenya, *A. bifaria* Nevretdinova & Moisseeva, *A. jouseana* (Moisseeva) Moisseeva, *A. tscheremissinovae* Khursevich, *A. robusta* (Khursevich) Usoltseva & Khursevich, *A. bradburyi* Usoltseva, Kociolek & Khursevich, *A. nevadica* Usoltseva, Kociolek & Khursevich and *A. americana* Usoltseva, Kociolek & Khursevich (Usoltseva et al. 2013).



Figs 19–24. SEM. *Alveolophora khursevichiae* sp. nov. Internal view of valve showing ringleiste, costae, and rimoportulae position (arrows). Scale bar: 5 μm (Figs 19–22, 24), 1 μm (Fig. 23).

One of the main diagnostic features of the genus *Alveolophora* is the presence of internal pervalvar costae, separating the alveolae, on the valve mantle (Moisseeva & Nevretdinova 1990). Each two rows of areolae of *A. khursevichiae* alternate with costae.

Among all known species of the genus, only 2 – *A. bifaria* and *A. russica* have complex rows of areolae. These species are also known from the Russian Far East (Moisseeva & Nevretdinova 1990, Khursevich 1994, Kozyrenko et al. 2008). The new species *A. khursevichiae* have a wide range of morphological features, some of them similar with these *Alveolophora* species from other regions of Russian Far East. For example, *A. khursevichiae* resembles *A. bifaria*, which was described from upper Eocene (?) – lower Miocene sediments from Russia (the northern shore of Penzhinskaya Bay, the Shestakovka stratum), by having double rows of areolae. *Alveolophora. khursevichiae* also resembles *A. russica* from Penzhinskaya Bay and Primorye (Oligocene – Middle Miocene) by complex areolae rows. Comparison of other morphological characters of these *Alveolophora* species is presented in Table 1.

Table 1. Morphological characters of *Alveolophora* species based on this paper and references.

Taxon	Location, Age	Valve mantle height	Valve shape and diameter	Pattern of areolar rows on mantle
A. russica Usoltseva, Kociolek & Khursevich	Russia, Penzhinskaya Bay, Oligocene (?) – Early Miocene; Russia, Primorye, Early-Middle Miocene	6–9 µm	round; 10-30 µm	up to 10/10 µm; straight; 3–5 rows of areolae alternate with costae
A. bifaria Nevretdinova & Moisseeva	Russia, Primorye, Late Eocene (?) – Early Miocene	5–16 µm	round; 10–50 µm	10/10 µm; straight; 2 rows of areolae alternate with costae
A. khursevichiae sp. nov. Usoltseva, Pushkar & Likhacheva	Russia, Primorye, Novokachalinskaya Formation, the western shore of Lake Khanka Middle Miocene	2.2–5.0 µm	round; 6.6–17.0 µm	20/10 µm; straight; 2 rows of areolae alternate with costae

The new species differs from other species by small size of the valves, form of linking spines, presence of a deep ringleiste, patterns of areolar rows on the mantle, areolae on valve face and position of the rimoportulae (Table 1).

Alveolophora khursevichiae occurs in the sediments of the Novokachalinskaya formation of the Middle Miocene age, later than the age interval for *A. bifaria*, which might be an ancestral species.

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Pattern of areolae on valve face	Rimoportulae	Pattern of costae and alveolae	Ringleiste	Linking spines	References
randomly scattered; may be lacking; striae may be seen near the margin	not reported	2,5–3 alveolae /10 µm	absent	spathulate-widened	Moisseeva & Nevretdinova 1990
dense or scattered across the central area of valve face, along the margin of the valve face are alveolar striae	short tube, located at the base of alveolae or on their partitions	5 alveolae/ 10 µm, separated by longitudinal and longitudinal and transverse septae	narrow or absent	"Y"-shaped or triangular	Moisseeva & Nevretdinova 1990
scattered over the entire surface; barely forming 1-3 rings near the margin	sessile, located on the Ringleiste next to septae	10 alveolae/10 µm, separated by longitudinal septae	deep, rarely narrow	short, rectangular with rounded edges	This study

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