INTRODUCTION

The Cretaceous flora of the Muravyov-Amursky peninsula is widely known due to Kryshtofovich (Kryshtofovich, 1916, 1919; Kryshtofovich and Prynada, 1932) and Krassilov (1967). The Cretaceous deposits of the peninsula are the southern continuation of the Cretaceous deposits of the Razdol'noye Basin and are divided into the Ussuri (Barremian), Lipovtsy (Aptian), and Galenki (Albian) formations and Korkino (Cenomanian) Series (Krassilov, 1967). On the Markovsky peninsula, which is part of the larger Muravyov-Amursky Peninsula, the most complete section of Cretaceous deposits is known in the lower reaches of the Bogataya River in the south; further, it continues to the north along the eastern coast of the Amur Bay. Plant remains were found virtually throughout the section, except for the Korkino Series.

The new species of *Nilssoniocladus* comes from the upper part of the section of the Lipovtsy Formation. This genus was for the first time described by Kimura and Sekido (1975) from the Lower Cretaceous deposits of the Markovsky peninsula near the city of Vladivostok. The finds of such shoots in organic connection with leaves are rare, and new data supplement our knowledge on the diversity, stratigraphic and geographic distribution of the genus *Nilssoniocladus*.

MATERIAL

The material for study is represented by plant imprints collected on the Markovsky Peninsula. Plant imprints originate from locality T.V.-28l, coordinate...
position is 43°15'06.58" N, 132°00'22.74" E (Fig. 1) and concentrated in the upper part of the Lipovtsy Formation section. Earlier, Krassilov (1967) identified in layer no. 18 of this part of section only rare remains of Elatocladus Halle. The investigation of new plant remains allowed us to detect 45 additional taxa.

The collection contains one well-preserved specimen of the new species of Nilssoniocladus, which is represented by imprint and counter-imprint of shoot; phytoleim is not preserved. The collection no. T.V.-28l is kept in the Institute of Biology and Soil Science, Far Eastern Branch, Russian Academy of Sciences (IBSS).

**Fig. 1.** The fossil flora locality in the Sokol Bay, Markovsky Peninsula.

**TAXONOMIC COMPOSITION OF FOSSILS FROM THE SOKOL BAY IN THE MARKOVSKY PENINSULA**

Locality T.V.-28l is situated on the southern coast of the Markovsky Peninsula, southern part of Sokol Bay, and is confined to the upper part of the Lipovtsy Formation section (Fig. 2). Plant remains were found in layers 1, 3–5, and 7.

In layer 1, only remains of conifer Athrotaxopsis expansa Font. emend. Berry and Lycopodites nicanicus Krassil. were found. In layer 3, numerous compressions of Nilssonia nicanica Krassil. were found. In layer 4, abundant imprints of leaves N. densinervis (Font.) Berry and numerous fragments of shoots and cones of Elatides asiatica (Yok.) Krassil., shoots of Taxites brevifolius (Font.) Samyl. and Araucariodendron cf. heterophyllum Krassil., leaves of Pityophyllum ex gr. nordskioldii Heer, and a shoot of Nilsoniocladus anatolii sp. nov., were found. Layer 5 is the most abundant in plant remains. The layer contains numerous imprints of leaves of Nilssonia ex gr. orientalis Heer and Cycadites sulcatus Krysth. et Pryn., shoots and cones of Elatides asiatica and Athrotaxopsis expansa, as well as numerous remains of ferns Osmunda denticulata Samyl., Adiantopteris sewardii (Yabe) Vassilevsk., Arctopteris aff. kolymensis Samyl., Polypodites polyporus Pryn., rare Equisetales (Equisetum sp.), Caytoniales (Sagenopteris variabilis (Velen.) Velen., etc. In layer 7, remains of conifer Athrotaxopsis expansa and lycops Lycopodites nicanicus Krassil. were found.

In locality T.V.-28l, the remains of Athrotaxopsis expansa are the most numerous among conifers, Cycadites sulcatus, among Bennettites, Nilssonia densinervis and N. ex gr. orientalis, among cycads, Osmunda denticulata and Onychiopsis psilotoides (St. et W.) Ward, among ferns. In addition, the following plant remains were found here: Marchantites yabei Krysh., Lycopodites nicanicus, Equisetum sp., Egonocormus cretaeum Deng, Osmunda cretacea Samyl., Ruffordia goeppeerti (Dunk.) Sew., Gleichenites porzilii Sew., G. zippei (Corda) Sew., Coniopteris burejensis (Zal.) Sew., Adiantopteris swardii, A. yuasensis (Oishi) Krassil., Asplenium samalinae Krassil., Haussmannia sp., Polypodites polyporus, Arctopteris aff. kolymensis, Arctopteris sp. 1, Lobifolia novopokrovskii (Pryn.) Rasskaz. et E. Lebedev, Cladophlebis ex gr. denticulata (Brongn.) Font., C. opposita Pryn., Sagenopteris variabilis, Sagenopteris sp., Clonozamites sp., Pterophyllium burejense Pryn., P. manchurense (Oishi) Krassil., Pseudocycas sp., Nilssonia nicanica, Nilsoniocladus anatolii sp. nov., Podozamites ex gr. lanceolatus.
These plant-bearing strata are dated as Aptian (Krassilov, 1967); spores and pollen were not found here. In carbonate interlayers in the upper part of the section (Fig. 2, layer 5), solitary ill-preserved radiolarians were found and studied in thin sections. According to O.L. Smirnova’s personal communication (Pacific Oceanological Institute, FED RAS), the radiolarians are represented predominately by the globular *Spumellaria* Haeckel, and also three- and multi-segmented forms of *Nassellaria* Haeckel. Unidentified on the specific level *Stichocapsa* Haeckel, and representatives of *Tricyrtida* Haeckel were also recognized. The carbonate layer in the middle part of the Lipovtsy Formation section contains, along with *Spumellaria*, representatives of *Nassellaria*, which were identified as *Stichocapsidae* and *Williriedallidae*. The presence of remains of radiolarians, stenohaline microorganisms, points to the marine sedimentation environment. All this suggests that the Lipovtsy Formation was formed under coastal marine conditions and that the coal-bearing deposits of the Formation should be assigned to the paralic type.

The description of the new species of *Nilssonioclados* is given below.

**SYSTEMATIC PALEOBOTANY**

Order CYCADALES DUMORTIER, 1829

Family Nilssoniaceae kimura et Sekido, 1975

Genus *Nilssonioclados* Kimura et Sekido

*Nilssonioclados anatolii* Voynets, sp. nov.

Plate 35, figs. 1, 2

**Etymology.** From the name Anatoly, in honor of A.F. Lysyuk, geologist of the Primorsky Exploring and Surveying Expedition.

**Holotype.** IBSS, no. TV.-28l/1; imprint and counter-imprint of shoot; Southern Primorye, Markovsky Peninsula, Sokol Bay; upper part of Lipovtsy Formation, Aptian (Pl. 35, fig. 1; Fig. 3).

**Diagnosis.** Fragment of stem. Leaves attached to its distal part. Stem approximately 6–7 mm wide, 50 mm long, with transverse ridges formed of leaf elliptic-rhomboidal scars, 0.3–0.9 mm high, up to 3 mm wide, large rhomboidal leaf scars, up to 3 mm in diameter, and round small scars, 1 mm in diameter. Leaves simple, oblanceolate, petiolate. The basal parts of leaf blades wedge-shaped.

**Description** (Fig. 3). There are single specimen, preserved as imprint and counter-imprint of the upper part of shoot fragment. The shoot fragment is unbranched, 6–8 mm wide and about 50 mm long. The stem with four transverse ridges. First transverse ridge is situated 9 mm below apical part of the stem, second is 18 mm below the first, third is 9 mm below second, and fourth is 15 mm below the third. Leaf

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**Explanation of Plate 35**

Figs. 1 and 2. *Nilssonioclados anatolii* sp. nov.: (1) holotype IBSS, no. 28/1 TV.-28l; (2) specimen IBSS, no. 28/1 TV.-28l, shoot fragment.

Fig. 3. Isolated petiolate leaf, specimen IBSS, no. 28/7 TV.-28l.

Southern Primorye, Markovsky Peninsula, Sokol Bay; upper part of the Lipovtsy Formation section, Aptian. Scale bar is 10 mm for Figs. 1 and 3 and 5 mm for Fig. 2.
A NEW SPECIES OF *NILSSONIOCLADUS* KIMURA ET SEKIDO
scars, arranged in tight spiral, are distinctly viewed on the stem. In the outer annual rings zones, they are elliptic-rhomboidal, small, 0.3–0.9 mm high and up to three mm wide, corresponding to cataphylls (Fig. 3). In the internodes, leaf scars are larger (up to 3 mm in diameter), rhomboidal, corresponding to normally developed leaves. Thin transverse folds are often formed below the leaf scars. Small (up to 1 mm) rounded lenticle-like structures are distributed on the stem surface irregularly.

Leaves are simple, oblanceolate, petiolate, attached to the shoot apex (Pl. 35, fig. 1). Maximal leaf width (up to 38 mm) falls on the middle part of a leaf and gradually decreases towards its base; complete length of leaves is unknown. Petioles are up to 20–25 mm long and 2–3 mm wide. Rachis is about 1.8 mm thick and round. Leaf blades are entire, some of them with slightly sinuous margins. The bases of leaf blades are wedge-shaped; the shape of leaf apices is unknown. Veins in leaf blades are thin, simple, parallel, straight, and slightly curved upward near leaf margins. Venation density is 15–19 veins per 5 mm. 

Comparison. The new species differs from N. nipponensis (Kimura and Sekido, 1975) in the simple non-segmented leaves, presence of annual/seasonal growth rings on the stem, cataphyll scars, longitudinal grooves, and lenticle-like structures.

The studied species differs from N. alaskensis (Spicer and Herman, 1996) in the presence of two types of leaf scars: large rhomboidal scars of normal leaves and small elliptic-rhomboidal scars of cataphylls. In addition, N. alaskensis possess large round scarls of lateral shoots and segmented leaves, assigned to another morphotype.

The Primorsky species differs from N. chukotensis (Spicer and Herman, 1996) in the presence of outer annual rings on stem and scars of cataphylls. In the new species, unlike N. chukotensis, leaves are simple, non-segmented, sitting on longer petioles.

The studied species differs from N. tairae (Takimoto et al., 1997) in the non-segmented leaves, which are sitting on petioles of larger size (up to 25 mm), by larger leaf scars and presence of annual/seasonal growth rings in its stem.

In N. japonicus (Takimoto et al., 1997), relative to Primorsky species, leaves are segmented, sitting on long (55 mm) petioles. The Japanese species is characterized by shoots of two types: long shoots (up to 8 cm) with ill-preserved ornamentation on their surface and short shoots with rhomboidal leaf scars.

The Maastrichtian species from Northern Dakota, assigned to Nilssonio cladus (Peppe et al., 2007), in fact must be assigned to Nilssonia (the American material is presented by only dispersed leaves, whereas the genus Nilssonio cladus was established on shoots with leaves of Nilssonia-type, attached to their apical parts).

Remarks. Following Spicer and Herman (1996), I regard transverse ridges as annual/seasonal annual growth boundary of stem (outer annual rings).

Fragments of dispersed leaves are found near the shoot (Pl. 35, fig. 1), which I assigned to the new species on the basis of their venation character. In the same layer one isolated leaf was found (Pl. 35, fig. 3). The leaf is petiolate; its blade has wedge-shaped base, sinuate-concave apex, and dense venation pattern. On their whole morphology, these leaves are similar to leaves, attached to the shoot.

Material. One shoot fragment, Lower Cretaceous, Lipovtsy Formation, Markovsky Peninsula, Southern Primorye; collection IBSS no. 28, specimen TV.-281/1.

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REFERENCES