Paleontological Journal, Vol. 35, No. 4, 2001, pp. 442–446. Translated from Paleontologicheskii Zhurnal, No. 4, 2001, pp. 106–109.

First Finds of the Genus *Oswaldheeria* (Miroviaceae, Pinopsida) in the Lower Cretaceous of Northern Asia

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Received March 7, 2000

Abstract—Material on the genus *Oswaldheeria* (Miroviaceae, Pinopsida) from the Mesozoic of Russia is presented for the first time. A new species, *Oswaldheeria orientalis*, is described, and a new composition of *Oswaldheeria neosibirica* is proposed.

INTRODUCTION

The family Miroviaceae was introduced by Bose and Manum (1990) for Mesozoic conifers that have a leaf epidermis structure similar to the modern genus *Sciadopitys* Siebold et Zuss. The specific feature of Miroviaceae leaves is the single stomatal zone situated on the lower leaf surface. The family includes five genera distinguished by both morphological and epidermal characters. One of these genera, *Oswaldheeria* M.N. Bose et Manum, is characterized by linear or lanceolate leaves tapering towards the leaf base and by stomata situated on the lower leaf surface and arranged in a single stomatal zone that is not embedded into a groove. The authors of the genus described four species, *O. hallei* M.N. Bose et Manum (the type species), *O. arctica* M.N. Bose et Manum, *O. scotica* M.N. Bose et Manum, and *O. macrophylla* (Florin) M.N. Bose et Manum (Bose and Manum, 1990; Manum *et al.*, 1991). Later, A.V. Hvalj (1997) transferred *Sciadopitys latiuscula* Kiritchk. (Kiritchkova, 1985) to *O. latiuscula* (Kiritchk.) Hvalj. and *Mirovia sibirica* (Samyl.) M.N. Bose et Manum (Bose and Manum, 1990) to *O. samylinae* (Sveshnik.) Hvalj.

The material under study is fossil leaves from the Lower Cretaceous of the Lena Coal Basin (the Markha, Tyung, Kenkeme, and Beridzhan rivers of eastern Siberia).

A detailed epidermal study of the specimens, including the holotype from the Lower Cretaceous of the Markha River Basin, revealed that *O. latiuscula* leaves described by A.I. Kiritchkova (1985) as *Sciadopitys latiuscula* are identical to the leaves of *O. macrophylla* from the Middle Jurassic of northern Norway. The species *Sciadopitys macrophylla* was described by Florin (1922) and transferred to *O. macrophylla* by Bose and Manum (1990). Therefore, the specific epithet *O. latiuscula* is a junior synonym of *O. macrophylla* (Pl. 11, figs. 12–14).

The species *Sciadopitys sibirica* Samyl. was described from the Lower Cretaceous of the Kenkeme River, but no holotype was designated (Samylina, 1963). I.N. Sveshnikova revised the species composition of the genus *Sciadopitys* and introduced a new genus, *Sciadopityoides* Sveshnik. (Sveshnikova, 1981). She described a new species, *Sciadopityoides samylinae* Sveshnik., based on the material of V.A. Samylina. Later, this species was transferred first to *Mirovia sibirica* (Bose and Manum, 1990) and, finally, to *Oswaldheeria samylinae* (Hvalj, 1997). This species is also known from the Lower Cretaceous of the Tyung River Basin (named *Sciadopitys sibirica* Kiritchkova, 1985, pl. 72, figs. 1–6, without description).

Leaves, identical in their epidermal structure to the leaves of *O. hallei* from the Lower Cretaceous of the Canadian Arctic, western Greenland, and Spitsbergen, were found in the Lower Cretaceous of the Beridzhan River. This find considerably extends our knowledge about the distribution of this species.

Our study confirms the occurrence of *Oswaldheeria* in the Early Cretaceous of Siberia, the Russian Far East, and the Arctic.

The revision of the available material and epidermal study of the leaves from the Lower Cretaceous of the southern Primorye described as *Sciadopitys* sp. (Samylina, 1961) and later questionably transferred to the genus *Oswaldheeria* (Hvalj, 1997) permit the reliable assignment of these leaves to the genus *Oswaldheeria*, and the description of a new species, *O. orientalis* sp. nov. The locality under discussion is the southernmost occurrence of the genus *Oswaldheeria*.

Detailed study of the leaves from the Lower Cretaceous deposits of Faddeevskii Island (the New Siberian Islands in the arctic region), which were described earlier as *Sciadopitys neosibiricus* Abramova (1985), revealed characters sufficient for the referral of these leaves to the genus *Oswaldheeria*. These characters are the constricted leaf base and the single stomatal zone, which is not in a groove, on the lower leaf surface. Thus, Faddeevskii Island is the easternmost known locality of the genus.

Different sclerotization of the cells of the stomatal zone and other epidermal cells, a feature considered to

Geographic occurrence of the genus *Oswaldheeria* in the Mesozoic

System series / Geographic region	Jurassic		Cretaceous
	Middle	Upper	Lower
Canadian Arctic			*O. arctica* *O. hallei*
Western Greenland			*O. hallei*
Scotland		*O. scotica*	
Northern Norway	*O. macrophylla*		
Spitsbergen			*O. arctica* *O. hallei*
Eastern Siberia			*O. hallei* *O. macrophylla* *O. samylinae*
New Siberian Islands			*O. neosibirica*
Southern Primorye			*O. orientalis*

be diagnostic at the generic level (Bose and Manum, 1990), is not always consistent. Thus, weaker sclerotization of the ordinary cells of the stomatal zone in comparison with other epidermal cells, weaker sclerotization of all of the lower epidermal cells in comparison with the cells of the upper surface, and, finally, sclerotization of all of the epidermal cells are observed in the leaves of many species, e.g., *O. macrophylla, O. scotica*, and *O. orientalis*. Consequently, this feature may be considered as diagnostic only at the species level. The presence of several rows of elongated cells, with a cuticular ridge along the stomatal zone, is specific for the majority of the species of *Oswaldheeria*. Transverse sections demonstrate that the stomatal zone is not sunken in a groove (Pl. 11, fig. 13), and the cuticular ridges further increase sclerotization of the margins of the stomatal zone.

The wide occurrence of the genus *Oswaldheeria* from the Middle Jurassic to the Lower Cretaceous in the Canadian Arctic, Greenland, northern Europe and northern Asia is established (table).

MATERIAL

Collection no. 835 of fossil plants from the Lower Cretaceous deposits of the Markha, Tyung, and Beridzhan rivers (the Lena Coal Basin) that is housed in the Museum of Oil Geology and Paleontology of All-Russia Research Institute of Oil and Geological Prospecting (VNIGRI) (St. Petersburg) was donated by A.I. Kiritchkova. Collection no. 12356 of fossil plants from the Lower Cretaceous of Faddeevskii Island is housed in the TsNIGR (Central Institute of Oil and Geological Exploration) Museum (St. Petersburg). Collection no. 501 of fossil plants from the Lower Cretaceous of the Kenkeme River (the Lena Coal Basin), as well as collection no. 506 of fossil plants from the Lower Cretaceous of the southern Primorye are housed in the ~~Paleontological~~ PaleoBotanical Laboratory of the Botanical Institute, Russian Academy of Sciences (BIN) (St. Petersburg).

The terminology proposed by Samylina (1972) and Bose and Manum (1990) has been used for the description of leaf epidermal structure.

The photographs of leaf impression and cuticular slides were made in the Paleontological Laboratory of BIN. Microphotographs were taken with a JSM–35c scanning electron microscope.

Data on the genus *Oswaldheeria* from the Mesozoic deposits of Russia are given for the first time.

SYSTEMATIC PALEONTOLOGY

Family Miroviaceae M.N. Bose et Manum, 1990

Genus *Oswaldheeria* M.N. Bose et Manum, 1990

Species composition.

1. *O. arctica* M.N. Bose et Manum, 1990.

2. *O. hallei* M.N. Bose et Manum, 1990; Hvalj, 1997.—*Sciadopitytes hallei* Florin, 1922.—*Sciadopityoides (?) hallei* (Florin) Sveshnik., 1981; Manum, 1987.

3. *O. macrophylla* (Florin) M.N. Bose et Manum, 1990; Manum *et al.*, 1991; Hvalj, 1997.—*Sciadopitytes macrophylla* Florin, 1922.—*Sciadopityoides macrophylla* (Florin) Sveshnik., 1981. *Sciadopitys macrophylla* (Florin) Manum, 1987.—*Sciadopitys latiuscula* Kiritchk., 1985.—*O. latiuscula* (Kiritchk.) Hvalj, 1997.

4. *O. neosibirica* (L.N. Abramova) Nosova, comb. nov.—*Sciadopitys neosibiricus* L.N. Abramova, 1985.—*"Sciadopitys" neosibirica* L.N. Abramova, Hvalj, 1997.

5. *O. orientalis* Nosova, sp. nov.—*Sciadopitys* sp. Samylina, 1961.—*Oswaldheeria* (?) sp. Hvalj, 1997.

6. *O. samylinae* (Sveshnik.) Hvalj, 1997.—*Sciadopitys sibirica* Samyl., 1963.—*Sciadopityoides samylinae* Sveshnik., 1981.—*Sciadopityoides sibirica* (Samyl.) Manum, 1987.—*Arctopitys sibirica* (Samyl.) M.N. Bose et Manum, 1990.—*Mirovia sibirica* (Samyl.) M.N. Bose et Manum, 1990.

Explanation of Plate 11

Figs. 1–6. *Oswaldheeria orientalis* Nosova sp. nov., holotype BIN, no. 506/79a: (1) a leaf fragment, ×1; (2) unfolded cuticular membrane, ×63; (3) stoma, inside view, SEM, ×430; (4) stoma, ×480; (5) part of the stomatal zone, ×160; and (6) upper leaf surface, ×160.

Figs. 7–11. *Oswaldheeria neosibirica* Nosova comb. nov., specimen TsNIGR, no. 12356/3: (7) lower leaf surface with the stomatal zone, ×63; (8) upper leaf surface, ×63; (9) upper leaf surface, ×160; (10) part of the stomatal zone, ×160; and (11) stomata, × 480.

Figs. 12–14. *Oswaldheeria macrophylla* (Florin) M.N. Bose et Manum, specimen VNIGRI, no. 835/56n: (12) leaf fragment, ×2; (13) transverse leaf section, ×22; and (14) stoma, inside view, SEM, ×500.

7. *O. scotica* M.N. Bose et Manum, 1990; Hvalj, 1997.—*Sciadopitytes scotica* Florin, 1922.—*Sciadopityoides scotica* (Florin) Sveshnik., 1981.

***Oswaldheeria orientalis* Nosova, sp. nov.**

Plate 11, figs. 1–6

Sciadopitys sp.: Samylina, 1961, p. 642, pl. 6, figs. 4–6.

Oswaldheeria (?) sp.: Hvalj, 1997, p. 100.

Etymology. From Latin *orientalis* (eastern).

Holotype. BIN, no. 506/79a; southern Primorye, village of Lipovtsy, Suifunsk Coal Basin, borehole 3, depth 166–168 m; Early Cretaceous.

Diagnosis. Leaves linear, more than 10 mm long, 1.5–2.0 mm wide, apex obtuse. Cells of upper epidermis short and broad, rectangular and polygonal, rarely elongated. Anticlinal walls thick, straight; periclinal wall smooth. Lower epidermis has a distinct median stomatal zone about 1/2 width of leaf. Cells of lower epidermis outside stomatal zone similar to those of upper epidermis. Cells (5–7 rows) along stomatal zone elongated, each with a cuticular ridge. In some parts of the leaf, cuticle stomatal zone slightly thinner than over the rest of lamina. Ordinary cells within stomatal zone short or elongated, rectangular or polygonal, usually with a cuticular ridge. Stomata typically longitudinally oriented, rarely oblique. Subsidiary cells 5–7. Guard cell wing-like, well sclerotized.

Description. Leaves are linear, more than 10 mm long and 1.5–2.0 mm wide with an obtuse apex. There is a matte middle band on the lower leaf surface corresponding to the stomatal zone. Veins are not visible. The upper epidermis consists of short, rarely elongated tetragonal or polygonal cells with rounded angles. The anticlinal walls of the cells are thick and straight, and the periclinal wall is even. The cells lack trichomes.

The lower epidermis consists of the central stomatal zone occupying about 1/2 of the leaf width, and two marginal zones without stomata; the cells of the marginal zones are identical to the cells of the upper epidermis. There are five to seven rows of elongated cells with cuticular ridges along the stomatal zone. In certain regions, the ordinary cells of the stomatal zone are slightly weaker sclerotized than other cells of the lower and upper surfaces. The ordinary cells of the stomatal zone may be short or elongated and tetragonal or polygonal with rounded angles. The majority of these cells have narrow cuticular ridges. The stomatal zone includes a single band with 14–16 stomata located along the width of the zone. The stomata are oriented longitudinally, sometimes obliquely. They do not form long rows. There are five to seven subsidiary cells. Guard cells are wing-shaped and strongly sclerotized.

Comparison. The leaves of the new species are characterized by the absence of papillae on the subsidiary cells. Papillae are also absent on the subsidiary cells of *O. hallei* from the Lower Cretaceous of western Greenland and *O. scotica* from the Upper Jurassic of Scotland (Bose and Manum, 1990). However, these two species differ from *O. orientalis* sp. nov. by the ordinary cells of the lower epidermis without cuticular ridges and by the elongated cells of the upper epidermis.

Material. Numerous leaf fragments from the same locality.

***Oswaldheeria neosibirica* (L.N. Abramova) Nosova, comb. nov.**

Plate 11, figs. 7–11

Sciadopitys neosibiricus: Abramova, 1985, p. 105, pl. 1, figs. 1–5, pl. 2, figs. 1, 4, and 5.

"Sciadopitys" neosibirica: Hvalj, 1997, p. 104.

Holotype. TsNIGR, no. 12356/2, figured by Abramova (1985, pl. I, figs. 2, 4, and 5; pl. II, fig. 5); New Siberian Islands, Faddeevski Island, borehole no. 33, depth 80–81 m, lower part of the Bunginsk Formation, Early Cretaceous.

Diagnosis. Leaves linear, more than 30 mm long, 2.0–4.0 mm wide, tapering towards base; apex acute. Cells of upper epidermis elongated and rectangular. Anticlinal walls straight; periclinal wall with cuticular ridge. Lower epidermis with distinct median stomatal zone, about 1/3–1/2 leaf width. Cells of lower epidermis outside stomatal zone like those of upper epidermis. Cells (3–5 rows) along stomatal zone elongated, rectangular, each with cuticular ridge. Cuticle of stomatal zone thinner than over the rest of lamina. Ordinary cells within stomatal zone short and elongated, rectangular or polygonal, with cuticular ridge. Stomata typically longitudinally orientated, tending to form discontinuous files. Subsidiary cells 4–6. Guard cells oval, sunken, and well sclerotized.

Description. Leaves are linear, more than 30 mm long, and 2.0–4.0 mm wide. The leaf apex is pointed, and the base tapering. A matte middle band is visible on the lower leaf surface and corresponds to the stomatal zone. The upper epidermis is formed by elongated tetragonal cells, occasionally, by shorter cells

with acute angles. The anticlinal walls of cells are straight; the periclinal wall is provided with a cuticular ridge.

The lower epidermis consists of the central stomatal zone (1/3–1/2 of the leaf width) and two marginal zones lacking stomata. The cells of these marginal zones are identical to the cells of the upper epidermis. There are three to five rows of elongated cells with cuticular ridges in the stomatal zone. In certain regions, the ordinary cells of the stomatal zone are considerably weaker sclerotized than other cells of the lower and upper surfaces. The ordinary cells of the stomatal zone may be elongated or short, tetragonal or polygonal; flattened cells occur. All ordinary cells of the stomatal zone bear cuticular ridges. There is a single stomatal band within the stomatal zone containing 10–16 stomata located across the zone. The stomata are oriented longitudinally. They form short rows. There are four to six subsidiary cells. Guard cells are lunate or oval and strongly sclerotized.

Comparison. *O. neosibirica* comb. nov. by the absence of papillae on the subsidiary cells. The same is observed in *O. hallei* from the Lower Cretaceous deposits of western Greenland, *O. scotica* from the Upper Jurassic of Scotland (Bose and Manum, 1990), and *O. orientalis* sp. nov. from the Lower Cretaceous of southern Primorye. *O. hallei* and *O. scotica* differ from *O. neosibirica* by the ordinary cells of the lower epidermis without cuticular ridges. The epidermal structure of the leaves of *O. neosibirica* is most similar to that of *O. orientalis* sp. nov. These species differ from each other in the outline of the guard cells of the stomata; the guard cells of *O. neosibirica* are lunate to narrow oval, and those of *O. orientalis* sp. nov. are wing-shaped. Moreover, the cells of the upper epidermis of *O. neosibirica* are more often elongated with acuminate angles and cuticular ridges, unlike the short cells with rounded angles and without the cuticular ridges of *O. orientalis* sp. nov.

Material. Numerous leaf phytoleims.

ACKNOWLEDGMENTS

I am grateful to A.I. Petrova for taking photographs under the light microscope, to L.A. Kartseva for taking microphotographs under SEM, and to A.I. Kirichkova for providing material and valuable remarks during the preparation of this paper.

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Таблица VI