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On Some Petrified Plants from the Cretaceous of Choshi, Chiba Prefecture VI*

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Described are seven species including four new to science: *Matoniostipes mesozoica* gen. et sp. nov., *Taxaceoxylon japonomesozoicum* sp. nov., *Planoxylon tylosissimum* sp. nov., and *Protocedroxylon pseudo-araucarioides* sp. nov. New to Japan is *Cupressinoxylon sachalinense* which was formerly discovered in Saghalien. Anatomy of secondary wood and pith is elucidated in *Cycadeoidella japonica* which has had little attention except for leaf base armors in the material from Hokkaido. *Araucarioxylon hujinamiense* is new to the locality.

This paper contains the description of the following seven species: 25.** *Matoniostipes mesozoica* gen. et sp. nov.; 26. *Cycadeoidella japonica* Ogura; 27. *Araucarioxylon hujinamiense* Ogura; 28. *Cupressinoxylon sachalinense* Shimakura; 29. *Taxaceoxylon japonomesozoicum* sp. nov.; 30. *Planoxylon tylosissimum* sp. nov.; 31. *Protocedroxylon pseudo-araucarioides* sp. nov.

25. ***Matoniostipes mesozoica*** gen. et sp. nov.

Materials: Specimen No. 71028-a is a black rod, 2.6 cm in length and 4.5 mm and 2.0 mm in long and short diameters respectively. It is elliptical or rather like a flattened semicircle in cross section; namely it has dorsiventrality. There is a node at a point one-third of the distance from the bottom of the specimen. This would be a pinna scar on the stipe. The node divides the upper part of the rod which is more flattened in cross section from the less flattened lower part. The surface of the specimen is covered by a carbonized thin layer which presumably should be the relict of epidermis and outer hypodermal tissues, but it is so fragile that any means of identification would be impossible. Specimen No. 71028-b is similar to 71028-a, though smaller: 1.4 cm long and 4.0 mm and 1.5 mm in long and short diameters respectively.

Description: Fern rachis or petiole with dorsiventrality, semicircular in shape in cross section. Outline more or less concave at ventral and convex at dorsal, showing a weakly curved arc in cross section. Vascular bundle is arranged in U-shape in cross section, open to adaxial side, and undulates 20–22 times showing alternate

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constrictions and swellings. Both ends of the U-shaped vascular bundle involute deeply. Epidermis can not be observed. Hypodermal tissue consists of several layers of thick-walled cells, 8–12 μm in diameter. Outer fundamental tissue consists of large parenchymatous cells, 28–45 μm in diameter, which become smaller as they near the vascular bundle. Pericycle cells, more or less thick-walled, are 15–35 μm in diameter. Each wavy convex part of xylem consists of 10–15 tracheids which are ovoid or coccon-shaped in cross section, 38–75 μm and 55–140 μm in short and long diameters respectively. Fundamental tissue within the vascular bundle consists of sclerenchymatous cells surrounded by a thin layer of parenchymatous cells.

Affinity: As mentioned above, the present specimen has a wavy vascular bundle which is U-shaped in cross section and open to adaxial side. Moreover, its hypodermis and the core of the vascular system are sclerenchymatous. These are the characters specific to the stipes of matoniaceous ferns. Though we have much information on fossil records of matoniaceous ferns, it always concerns the compression of frond or pinnae. It is well known that the Matoniaceae, restricted now to the East Indies, had a wide range in the past, especially in the Mesozoic era. Several genera are common to the Mesozoic: *Matonidium*, *Laccopteris*, *Phlebopteris*, *Nathorstia* and *Matoniophyllum*. These are the form genera of the fronds lacking petioles. Their internal structures have not yet been described. Therefore I should like to establish a new form genus, *Matoniostipes*, for the petrified petioles of the ferns belonging to the Matoniaceae, despite its resemblance to *Matonia pectinata* in having 20–22-fold undulation of the vascular bundle.

Matoniostipes gen. nov.

Petrified stipes of the ferns belonging to the Matoniaceae. Small rod showing dorsiventrality; depressed semicircular in shape in cross section. Wavy vascular bundle is U-shaped in arrangement in cross section, open to ventral side, and much involuting terminally. Outer layer of the hypodermis and the tissue inside the vascular system are sclerenchymatous.

26. ***Cycadeoidella japonica*** Ogura in Journ. Fac. Sci. Imp. Univ. Tokyo, Sec. III **2** (5): 392 (1930).

Materials: The present specimen, No. 70006, is a piece of a twig or a small trunk, 8 cm long and 3.5 cm and 1.5 cm in long and short diameters respectively. Its outer layer, armor, and outer parts of cortex are lost, but its inner layer of cortex, phloem, xylem, and a part of pith are well preserved.

This species was described by Ogura (1930), based on a small shoot from the Upper Cretaceous of Yubari, Hokkaido, the so-called Hakobuchi formation that can be analogized with the uppermost of Senonian. Though well-preserved externally, his specimen retained little of the internal structures. Ogura described mainly the shape and arrangement of armors without much regard to woody elements and pith.

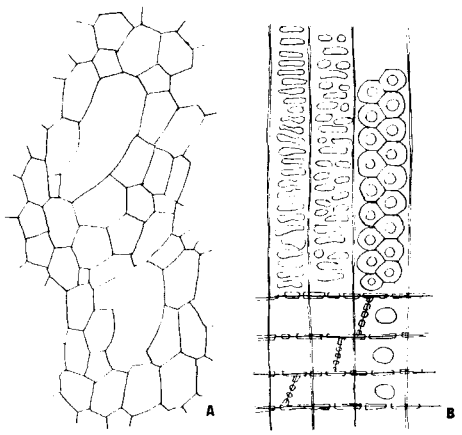

Fig. 1. *Cycadeoidella japonica* Ogura. A: cross section of mucilaginous sacs in pith. Mucilaginous sacs are not surrounded by epithelial cells; B: radial section of Wood. A cross field is sculptured by single large pit.

Description: Manoxylic wood without resin or mucilaginous canals or sacs; consisting of tracheids, many rays and wood parenchyma and displaying secondary wood 4 mm in thickness. Annual rings entirely absent. Tracheids regularly arranged in radial rows, elongated radially and rectangular in cross section, 30–50 μm and 30–60 μm in tangential and radial diameters respectively. Bordered pits on radial walls typically araucarian, arranged contiguously and alternately in 1–3 rows, circular or hexagonal in shape and 10–20 μm in diameter, with pit apertures of 5 μm in diameter. Scalariform pits appear in the younger part of secondary wood. Rays abundant, always parenchymatous, usually uniseriate, 1–32 cells, mostly 6–9 cells high, separated by 1–9 (average 5.3) rows of tracheids. Ray cells are pitted on all walls. Pits on horizontal walls simple, 7–10 μm in diameter, and arranged sparsely in one irregular row. A single large pit present in a cross field, circular or ovoid in shape and 12–18 μm in diameter. In tangential section, ray cells are circular, about 20 μm in diameter, or ovoid or rectangular, 16–25 μm and 35–45 μm in horizontal and vertical length respectively. Primary wood is erroded; its fine structure can not be observed. Cortex, composed of thin-walled cells, contains mucilaginous sacs, which have no epithelia. Leaf traces in cortex show no girdling, i.e., they are not cycadean but cycadeoidean in type. Pith consists of parenchymatous cells like those of cortex, also containing mucilaginous sacs, which are elliptical in outline in vertical as well as cross sections, 40–90 μm and 90–160 μm in short and long diameters respectively, not surrounded by epithelia. Phloem is normally coniferous, traversed by phloem rays. Sieve cells decreased in width and cells of medullary rays increase in size toward the cortical parenchyma as in *Cycas*.

Affinity: In general characters of wood, the present species much resembles *Bucklandia choshiensis* which was reported from the same locality (Nishida, 1970). But it differs from the latter in having a single large pit in a cross field instead of several. Moreover the lack of epithelium in mucilaginous sacs should distinguish it from *Bucklandia* in which the mucilaginous canals are surrounded by epithelial cells in the pith

and cortex. Ogura (1930) could not describe the wood anatomy of this species in his original work, but fortunately he left a brief comment on the pith in which he recognized a few mucilaginous sacs. As I examined the type specimen of Ogura, I confirmed that there is no difference in the shape and structure of the sacs between his type specimen and mine. This is the one and only diagnostic character by which we strictly distinguish the present species from *Bucklandia choshiensis*. Though the second on record, the finding of the present specimen reveals the wood anatomy which has been left obscure.

27. ***Araucarioxylon hujinamiense*** Ogura in Journ. Fac. Sci. Univ. Tokyo, Sect. III **7** (10): 504 (1960).

Materials: Specimens are the pieces of the secondary wood, 3–4 cm long and 0.5–2.0 cm and 1.0–2.0 cm in short and long diameters respectively, and well-preserved.

They can be identified with *A. hujinajiense* in wood anatomy described by Ogura (1960) in having numerous tyloses in tracheids, often biseriate rays reaching 45 cells high, and a single large ovoid pit in a cross field. This species was first discovered from the Upper Cretaceous of Fujinami, Arita-gun, Wakayama Prefecture. Choshi (Lower Cretaceous) is the second locality of this species in Japan.

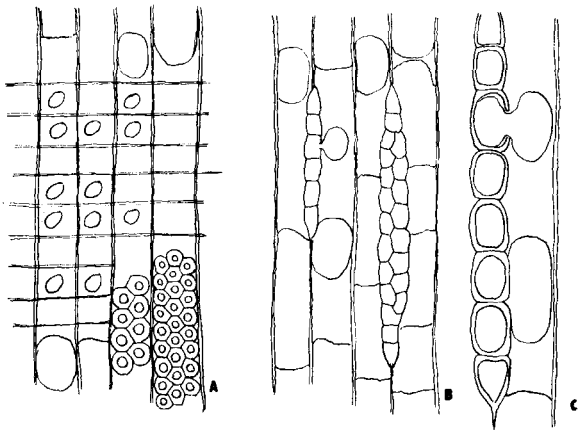

Fig. 2. *Araucarioxylon hujinamiense* Ogura. Radial (A) and tangential (B, C) sections. Numerous septa in tracheids and single large pit in a cross field are diagnostic characters of this species.

28. ***Cupressinoxylon sachalinense*** Shimakura in Sci. Rep. Tohoku Imp. Univ. 2nd Ser. **19** (1): 50 (1937).

Materials: Specimen, No. 71010, is a piece of the secondary wood, 3.5 cm long and 2.3 cm and 1.8 cm in long and short diameters respectively, and poorly preserved.

The first discovery of this species was made in the Upper Cretaceous of Kawakami Coal-mine, Toyohara, Southern Saghalien. Fine structures of wood can not be observed precisely, but certain important characteristics can be found adequate for specific identification: rays 1–20 cells high, uni-, bi- and triseriate; very small pits, 1–3 in number, in a cross field. New to Japan.

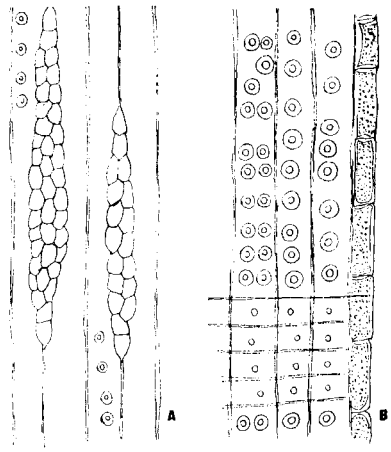

Fig. 3. *Cupressinoxylon sachalinense* Shimakura. Tangential (A) and radial (B) sections. Bi- and triseriate rays and small single pit in a cross field are specific features of this species.

29. ***Taxaceoxylon japonomesozoicum*** sp. nov.

Materials: The specimen No. 70004 is a well-preserved piece of the secondary wood, 3.0 cm long and 1.5 cm and 0.8 cm in long and short diameters respectively.

Description: Wood consists only of tracheids and rays, devoid of wood parenchyma. Growth rings not visible. No resin canals are present. Tracheids arranged regularly in radial rows, 18–30 μm and 16–25 μm in radial and tangential diameters respectively. Bordered pits on radial walls of tracheids circular, 11–13 μm in diameter, mostly arranged separately in one row, with circular pit apertures 5 μm in diameter. Rims of Sanio not visible. Bordered pits on tangential walls often present, small in size and sparsely distributed in one row. Tracheids often have tertiary spiral thickenings of the walls. These are single spirals solitarily running with a pitch of 7–15 μm, sometimes 20 μm. Ray cells oblong or rectangular in tangential section, 18–25 μm and 9–14 μm in vertical height and horizontal width respectively, entirely parenchymatous and pitted only on the radial walls. One or rarely two half-bordered pits in a cross field, circular or ovoid, 5–7.5 μm in long diameter, and if two, vertically arranged.

Affinity: The present specimen bears tertiary spiral thickenings on walls of tracheids. It lacks ray tracheids and resin canals in wood tissues, and therefore undoubtedly it represents a taxaceous wood. We have only a little information on Mesozoic taxaceous wood and, at least in Japan and adjacent Far East, nothing about such a wood has ever been reported. *Torreyoxylon boureaui* Greguss (1967) from the Lower Cretceous of Hungary has paired or triplet spiral thickenings running down the tracheidal walls. This is a torreyan feature rather than taxoid. Hence the present specimen seems to belong to *Taxaceoxylon*, as its spiral thickenings do not make pairs nor triplets. Bhardwaj (1952) described *Taxoxylon rajmahalense* from the Jurassic of Rajmahal Hills in India, but afterwards Kräusel and Jain (1964) reexamined their findings from the same locality and renamed it *Taxaceoxylon rajmahalense* (as to the reason for not using the traditional name *Taxoxylon* but adopting *Taxaceoxylon*,

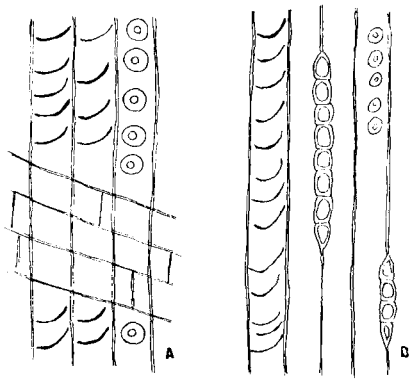

Fig. 4. *Taxaceoxylon japonomesozoicum* sp. nov. Tangential (A) and radial (B) sections, showing tertiary spiral thickenings.

refer to Kräusel and Jain 1964). The spirals in tracheids of *T. rajmahalense* run in pairs. Hence it ought to belong to *Torreyoxylon* Greguss (1967) in the strictest sense. As the present specimen shows spirals which do not run in pairs nor by three but solitarily, it should be classed under *Taxaceoxylon*. The generic nomenclature for fossil taxoid wood has become considerably complicated. Kräusel and Jain (1964) designate *Taxoxylon torreyanum* Shimakura (1936) from the Pleistocene of Kanagawa Prefecture, Japan, as a type species of *Taxaceoxylon*. As represented by its specific epithet, *Taxaceoxylon torreyanum* has spiral thickenings which run in pairs like those of living *Torreya nucifera* (Shimakura, 1936). It also ought to belong to *Torreyoxylon* in the strictest sense. Thus the generic names for fossil wood relating to the living *Taxus* ought to be revised. The present species might be the sole instance of the Mesozoic wood with close affinity for the living *Taxus*. It much resembles *Taxus canadensis* in general anatomy: height of rays, pits in a cross field and inclination and pitch of spirals.

30. ***Planoxylon tylosissimum*** sp. nov.

Materials: Specimens No. 71039-a, b and c and No. 71050 are pieces of the secondary wood, 2–6 cm long and 0.5–1.5 cm and 1.2–2.0 cm in short and long diameters respectively. Specimen No. 71050 is the best-preserved among them.

Description: Growth rings not visible. Woods consist of tracheids and rays. Neither wood parenchyma nor resin canal present. Tracheids rectangular in shape in cross section, often more or less elongated radially or tangentially, 46–58 μm and 43–67 μm in radial and tangential diameters respectively. Bordered pits on radial walls arranged contiguously and alternately in 2–3 rows, circular and somewhat flattened, 15–20 μm in diameter; typically araucarian type of pittings. Bordered pits on tangential walls also araucarian in arrangement; though sparsely pitted. Many of tracheids occluded with numerous tyloses and have some septa which seems to originate in tyloses (see below). Rays always parenchymatous, usually uniseriate, and rarely biseriate in part, 3–29, usually 7–16, cells high; 140 μm (3 cells high) — 1150 μm (29 cells high) in height, and run at intervals of 1–8, 3.8 average, rows of

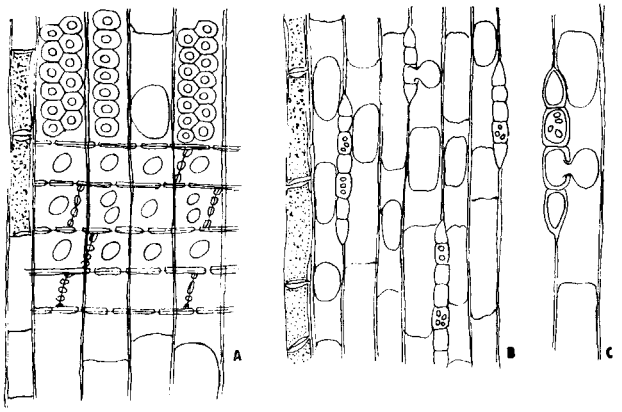

Fig. 5. *Planoxylon tylosissimum* sp. nov. Radial (A) and tangential (B, C) sections. Many septa originating in tyloses are exhibited in B and C.

tracheids. Ray cells vertically elongated ovoid, or vertically elongated rectangular in shape in tangential section, 22–30 μm and 38–46 μm in horizontal and vertical width respectively. Tangential and horizontal walls of ray cells pitted by small simple pits; abietineous pitting present on ray cells. One or two large pits present in a cross field, broad oblong or ovoid in shape and 20–29 μm in long diameter.

Affinity: Exhibiting typically araucarian and abietineous pittings on their wood elements, the present specimens seem to belong to the Protopinaceae. Moreover the presence of a single or two large pits in a cross field would be an important diagnostic characteristic of *Planoxylon* (Stopes, 1916). *P. Hectori* from the Cretaceous of New Zealand and *P. pseudo-Hectori* from the same locality as that of the present specimen almost always exhibit uniseriate rays which are usually 3–9 and 3–6 cells high in the respective species. These two species are sculptured by 1–2 pits, which are, if two, arranged in a vertical row in a cross field. The present species has horizontally arranged pits in a cross field. *P. Lindleii* from the Upper Lias in England has resin canals which the present specimens do not have. *P. choshiense* from the same locality as that of the present specimens mostly resembles the present specimen in having biseriate rays and horizontally arranged two pits in a cross field, but differs from the latter in having more numerous biseriate rays and sometimes triseriate rays. Thus the present specimens are distinguished from any species of *Planoxylon* described so far, as it has such very characteristic features as being devoid of wood parenchyma and possessing numerous tyloses. *P. Inaii* from the Upper Cretaceous of Saghalien, which has several small pits in a cross field, would not belong to *Planoxylon* but to *Cedroxylon**. Watari (1960) confirmed in *Xenoxylon latiporosum* that the septa in tracheids originate in tyloses which are derived from ray cells. The present specimens also show that tyloses would be derived from ray cells and turn to septa in tracheids (Fig. 10, C, D).

* ***Cedroxylon Inaii*** (Shimakura) comb. nov. *Planoxylon Inaii* Shimakura in Sci. Rep. Tohoku Imp. Univ. 2nd Ser. 19 (1): 11 (1937).

31. ***Protocedroxylon pseudo-araucarioides*** sp. nov.

Materials: The specimens, No. 71056-a, b and c, are pieces of the secondary wood, 4–7 cm long and 1.0–2.0 cm and 0.5–1.2 cm in long and short diameters respectively, and well-preserved.

Description: Growth rings not visible. Woods consist of tracheids and rays, and devoid of wood parenchyma and resin canals. Tracheids rectangular or more or less radially or tangentially elongated rectangular in shape in cross section, 24–36 μm and 27–40 μm in tangential and radial diameters respectively. Tracheids often occluded with resinous brown substances and frequently have several septa which seem to have originated in tyloses. Bordered pits on radial walls araucarioid; contiguously and alternately arranged in 1–3 rows; circular or somewhat flattened, 15–20 μm in diameter. Bordered pits on tangential walls also present, though sparsely. Rays always parenchymatous, mostly uniseriate, rarely biseriate in part, 2–22, usually 5–15 cells high, or 80 μm (2 cells high) –800 μm (22 cells high) in height, and run at intervals of 1–9, 4.0 average, of tracheids. Ray cells vertically elongated ovoid or rectangular in shape in tangential section, and variable in size, 20–27 μm and 34–75 μm in horizontal width and vertical length respectively. Abietineous pittings on ray cells present, i.e., tangential and horizontal walls pitted by small simple pits. A single large or 3–6 small pits present in a cross field, broad oblong or ovoid in shape and 7–10 μm in long diameter.

Affinity: Above-mentioned structures show somewhat conclusively that the present specimens have combined araucarian-abietineous characteristics; they would belong to *Protocedroxylon* (as for discussion about this treatment, see the previous work on *Protocedroxylon japonicum*, Nishida, 1967, p. 491). The present specimens represent an intermediate form of *P. japonicum* from the Cretaceous of Choshi, Japan and *P. araucarioides* from the Cretaceous of Liao-tung Peninsula, China. It resembles *P.*

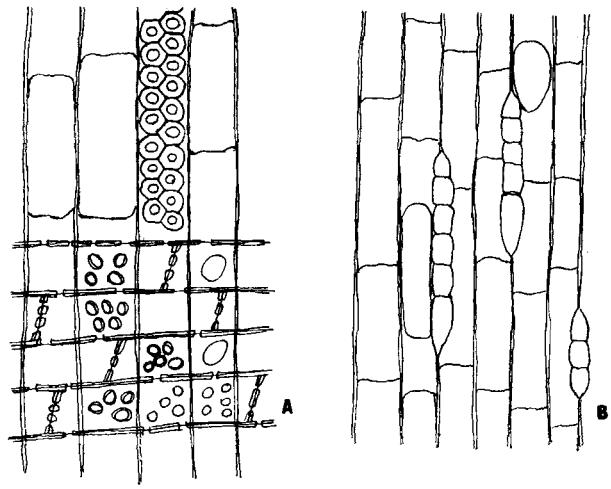

Fig. 6. *Protocedroxylon pseudo-araucarioides* sp. nov. Radial (A) and tangential (B) sections. Numerous septa in tracheids and several pits in a cross field are diagnostic features of this species.

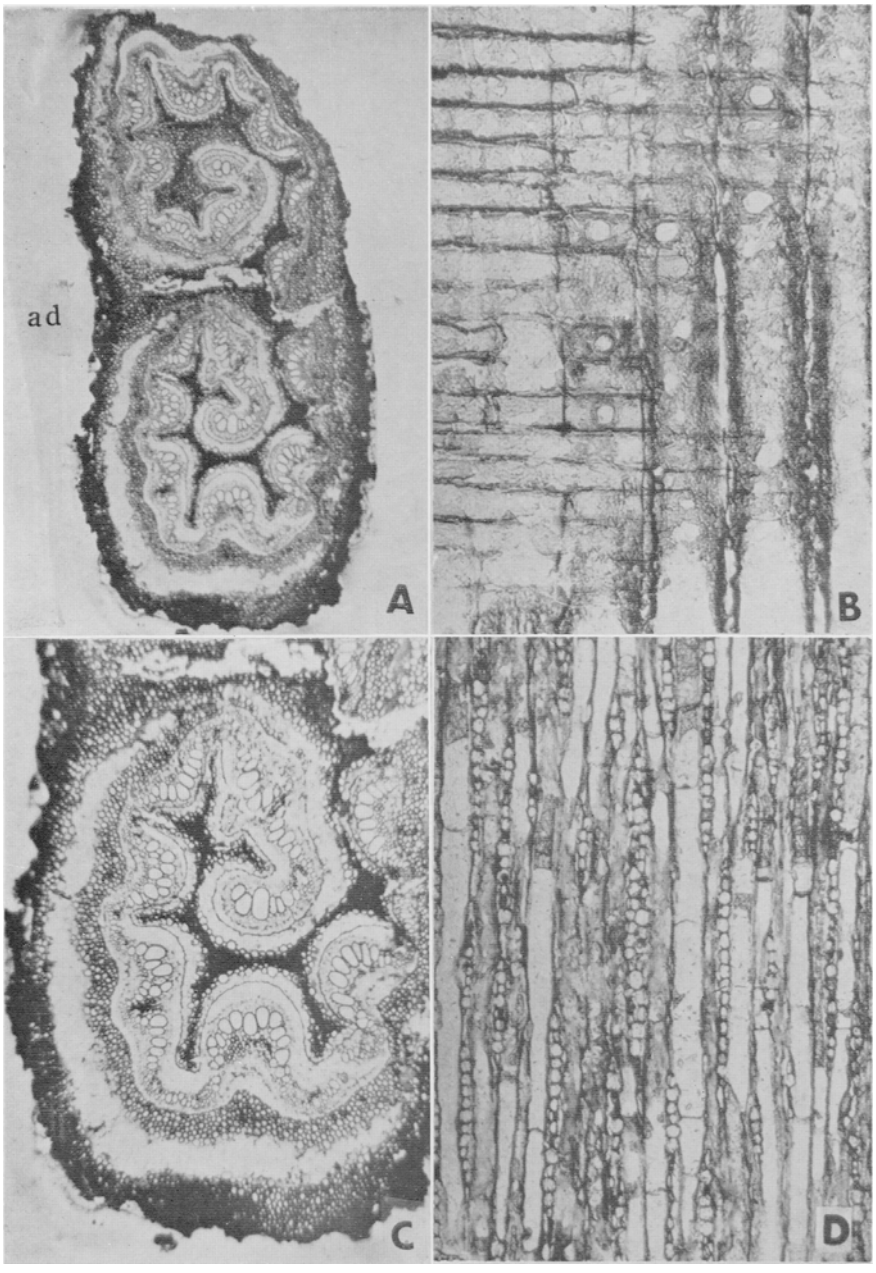

Fig. 7. *Matoniostipes mesozoica* sp. nov. (A, C) and *Araucarioxylon hujinamiense* Ogura (B, D). A, C: cross sections; B, D: radial and tangential sections respectively; ad: adaxial side.

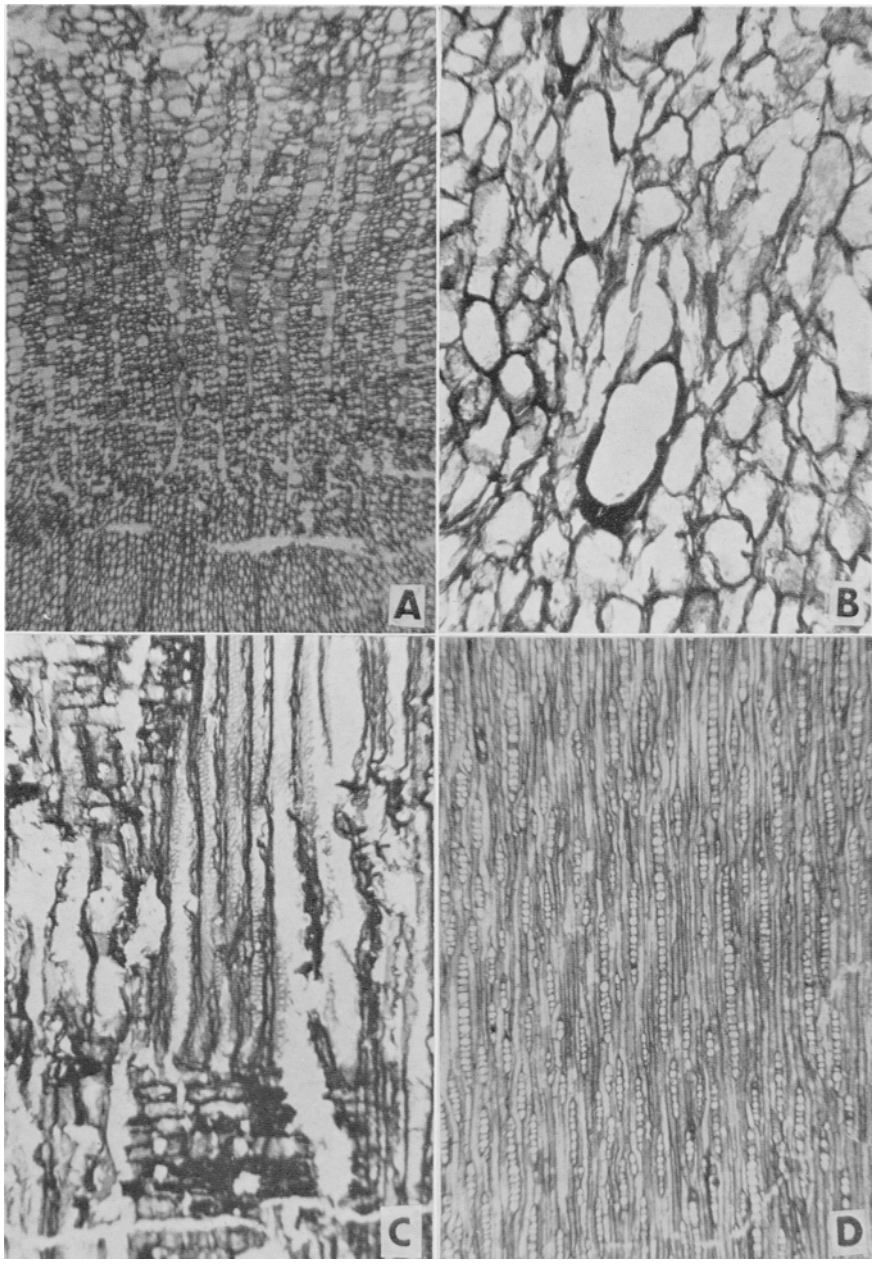

Fig. 8. *Cycadeoidella japonica* Ogura. A: cross section showing wood (below) and phloem (above); B: cross section of pith inculding mucilaginous sacs without epithelial cell; C, D: radial and tangential sections of wood respectively.

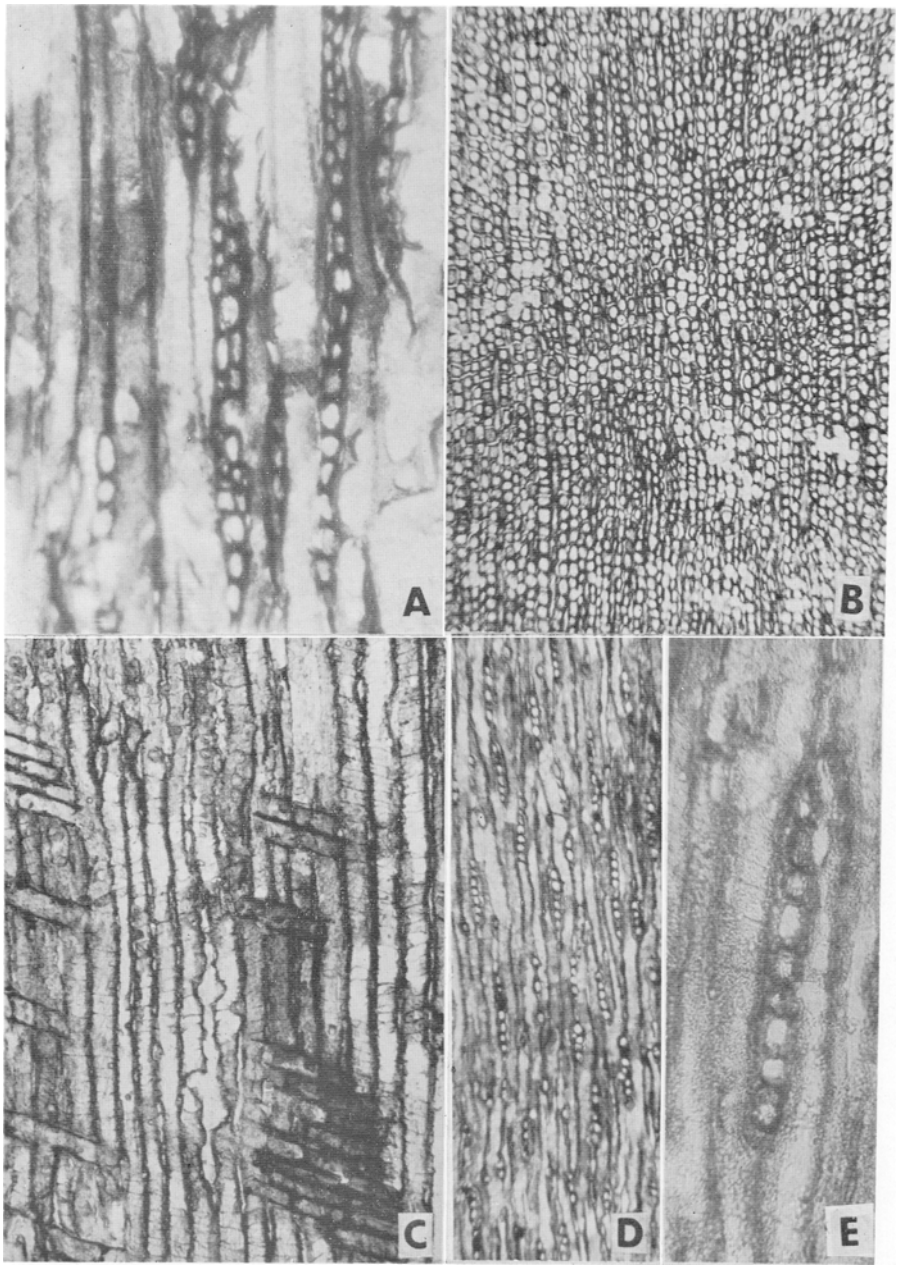

Fig. 9. A: tangential section of *Cupressinoxylon sachalinense* Shimakura, showing biseriate rays; B-E: *Taxaceoxylon japonomesozoicum* sp. nov. Cross (B), radial (C) and tangential (D, E) sections. Tertiary spiral thickenings are seen in C, E.

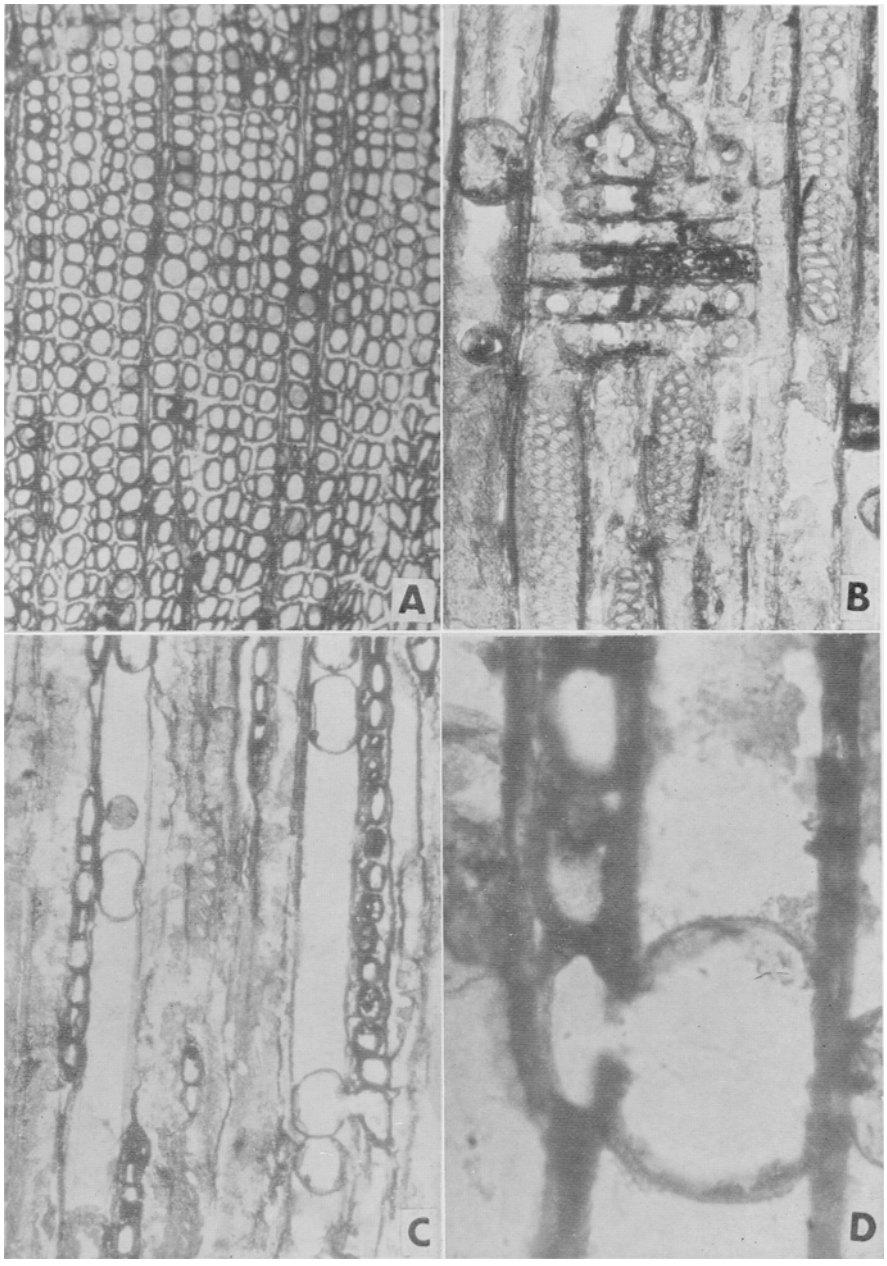

Fig. 10. *Planoxylon tylosissimum* sp. nov. Cross (A), radial (B) and tangential (C, D) sections. Tylosis derived from ray cell is seen in D.

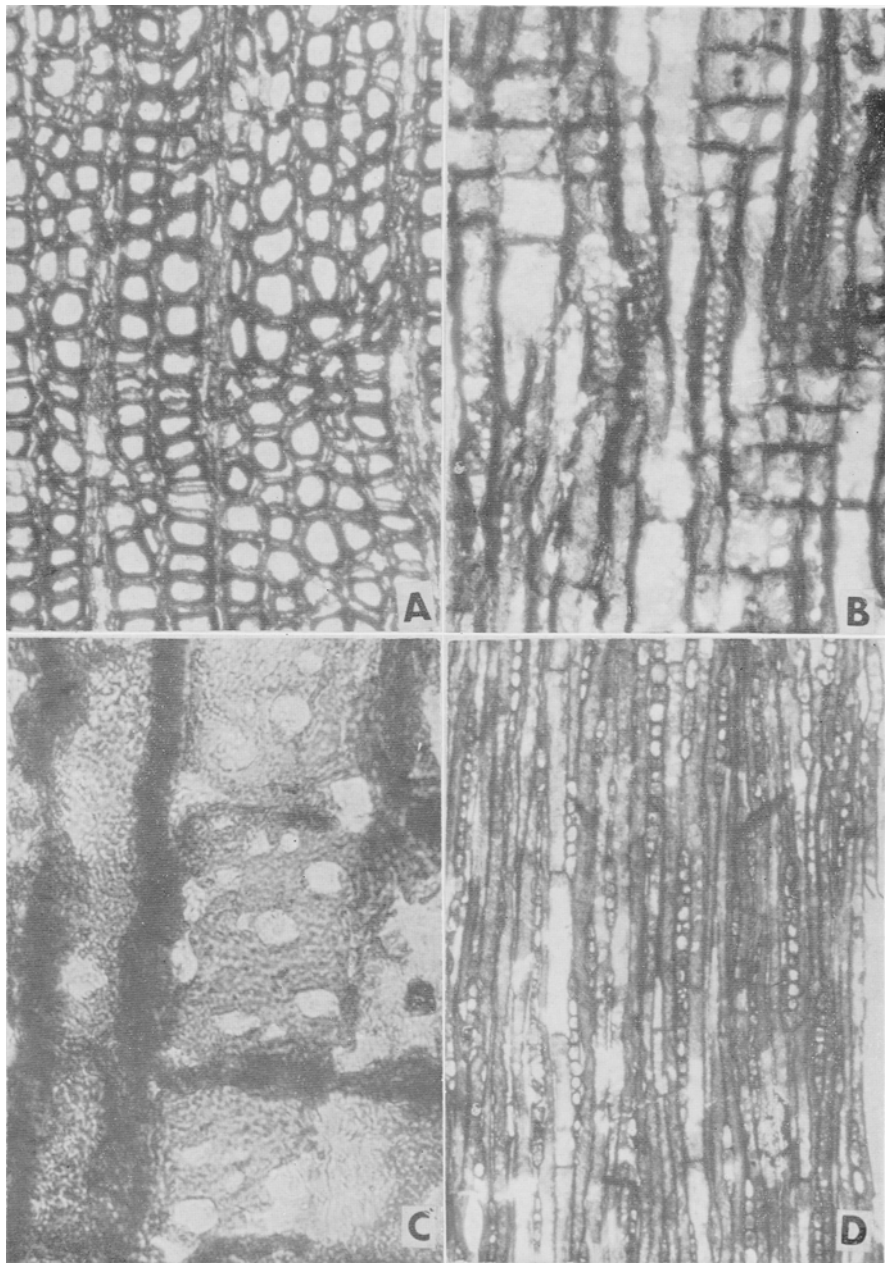

Fig. 11. *Protocedroxylon pseudo-araucarioides* sp. nov. Cross (A), radial (B, C) and tangential (D) sections. Several pits in a cross field are seen in C.

japonicum in having several septa in a tracheid, and having several, up to six, pits in a across field. It differs from the latter in having higher rays, up to 22 cells high instead of 2–4, up to six cells high in the latter. *P. araucarioides* has also higher rays and septa in tracheids, but can be distinguished from the present species in having 1–2 pits in a cross field instead of 1–6. Thus the present specimens would represent a new species relating to *P. araucarioides*.

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