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A fossil gymnospermous wood from the Miocene of Yunnan, China

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A fossil gymnospermous wood *Taxodioxylon chinense* sp. nov. is described from the Miocene beds of South Yunnan Province, China. This is for the first time that a fossil wood of *Taxodium-Sequoia* type has been found in the Neogene of China.

Key-words—Fossil wood, Gymnosperm, Xylotomy, Miocene (China).

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सारॉंश

चीन में यूनान के मध्यनूतन कल्प से एक अश्मित अनावृतबीजी काष्ठ

नाइ-यंग दु एवं उत्तम प्रकाश

चीन में दक्षिण यूनान प्रॉंत के मध्यनूतन सस्तरों से **टेक्सोडिऑक्सीलॉन चाइनेन्से** नव जाति के नाम से एक अश्मित अनावृतबीजी काष्ठ का वर्णन किया गया है। यह पहला अवसर है कि चीन के पश्चनूतन कल्प में **टेक्सोडियम-सिकोया** सदृश अश्मित काष्ठ प्राप्त हुई है।

THIS detailed anatomical study is based on a fossil wood sent to one of us (N.Z.D.) by Mr Dung-min Liu who collected it from the Miocene Coal Mine of Jingdung County in Yunnan Province of China. Although many palaeobotanical studies have been carried out on the Tertiary flora of Yunnan, this forms the first record of a fossil wood in this flora. Besides, a number of dicotyledonous leaf-impressions and a few gymnospermous fossil leaves comprising *Pinus yunnanensis* Fr. and *Calocedrus lantenoisii* (*Laurent*) comb. nov. are also known from this flora (Anonymous, 1978, pp. 10, 15).

The fossils of Taxodiaceae are known from the Eocene and Palaeocene of China consisting of *Glyptostrobus europaeus* (Brongniart) Heer, *Taxodium tinajorum* Heer, *Metasequoia disticha* (Heer) Miki, *Sequoia chinensis* Endlicher emend. Wang et Li, from the Eocene of Fushun and *Taxodioxylon cryptomerioides* Schönfeld, *Sequoioxylon sequoianum* (Schmal.) Du, *Taiwanioxylon Krasheninnikovii* (Jam.) Khudaiberdyev and *Taxodioxylon* sp. from the Palaeocene of Fushun, although they were reported from North America, Europe and Siberia of USSR from the Late Cretaceous to the Pliocene (Anonymous, 1978, pp. 10-14, Du, 1982). Therefore, the present study records the presence of plants comparable to *Taxodium-Sequoia* in China during the Miocene period.

SYSTEMATIC DESCRIPTION

Family—Taxodiaceae

Genus—*Taxodioxylon* Hartig 1848 emend. Gothan 1905

Taxodioxylon chinense sp. nov.
Pl. 1, figs 1, 3; Pl. 2, figs 5-9

Material—This species is based on a single piece of petrified secondary wood measuring about 10 cm in length and 7 cm in diameter.

Description—Growth rings distinct, demarcated by radially compressed tracheids of the late wood, 840-1260 μm in width, transition from early to late wood more or less abrupt. *Late wood* zones narrow

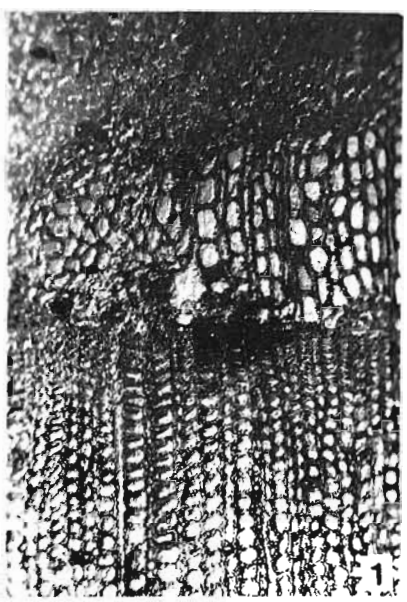
to wide, about 7-18 cells, usually more than 10 cells or 180 μm wide, narrower than early wood (Pl. 1, fig. 1), tracheids thick-walled, walls about 6 μm thick, flattened, squarish to rectangular in cross-section with small lumina, t.d. 24-25 μm, r.d. 18-45 μm. *Early wood* zones about 10-20 cells thick, tracheids thin-walled, walls about 3 μm thick, squarish or rectangular in shape in cross-section with wide lumina, t.d. 36-45 μm, r.d. 45-90 μm (Pl. 2, fig. 5). *Pits* on radial walls of tracheids bordered, 1-3 seriate, usually 2-3 seriate in the early wood tracheids, round, opposite and separate to contiguous, often paired, 27 μm in diameter; pit apertures round, about 9 μm in diameter (Pl. 2, figs 6, 7), tangential walls of tracheids usually smooth, sometimes pitted; pits bordered, round, separated and smaller than on radial walls, about 15 μm in diameter with round apertures. *Bars of Sanio* present (Pl. 2, figs 6, 7). *Xylem rays* uniseriate, 1-16 cells or 39-390 μm high, usually 4-9 cells or 182-260 μm high (Pl. 1, fig. 3); ray cells round, squarish, rectangular or barrel-shaped in tangential section, usually 27 μm in width, 30 μm in vertical height and up to 150 μm in radial length, some of them with dark gummy deposits (Pl. 1, fig. 3); the horizontal and tangential walls of ray cells thin and smooth. *Cross-field* pits taxodioid, 2-5, usually 3 per cross-field, rather large oval in shape, about 14 μm in diameter and commonly in 1-2 horizontal rows; aperture quite big, oval in shape, 12 μm in diameter and arranged horizontally or diagonally (Pl. 2, figs 8, 9). *Axial parenchyma* abundant, diffuse or sometimes in tangential rows (Pl. 2, fig. 5), mainly distributed in early wood; cells squarish or rectangular in cross-section, about 50 μm in diameter and 155 μm in vertical height, often with dark gummy deposits.

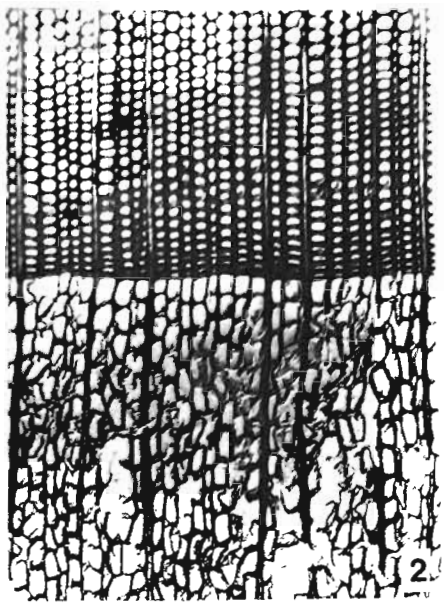
Affinities—The important anatomical characters of the fossil wood are—distinct growth rings, 1-3 seriate bordered pits, uniseriate xylem rays, taxodioid cross-field pits and abundant axial parenchyma. All these features indicate that the present fossil belongs to conifers. Among the conifers it can easily be separated from the families Araucariaceae, Taxaceae and Cephalotaxaceae in the absence of alternate, hexagonal pits and the spiral thickenings on the walls of the tracheids. The absence of resin ducts and the pinoid or abitinean pitting excludes Pinaceae or Abietineae. In Podocarpaceae, the cross-field pits are large, simple or slightly bordered and the growth rings are generally not sharp. Besides, the cross-field pits are also vertically oblique in Podocarpaceae. Cupressaceae and Taxodiaceae show very close xylotomical features with the present fossil wood. However, Cupressaceae can be distinguished by the presence of cupressoid cross-field pits, almost exclusively uniseriate, rarely biseriate pits in the radial walls of the tracheids and generally short xylem rays (Greguss, 1955; Phillips, 1941). Thus it is only with the family Taxodiaceae that the fossil wood shows a close similarity specially with *Taxodium* and *Sequoia* (Greguss, 1955; Jane, 1956).

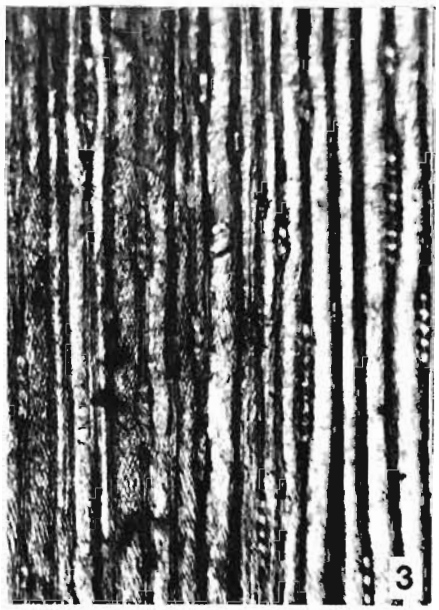
As neither traumatic resin canals nor partly biseriate xylem rays are seen in the present fossil wood, it can not belong to the genus *Sequoia*. However, the present fossil wood shows close similarity with *Taxodium distichum* in most of anatomical features, except the shape of the cross-field pits which somewhat approximates that of *Sequoia sempervirens* (Brown & Panshin, 1940, p. 347, fig. 105). Probably, the fossil is an intermediate between these two genera.

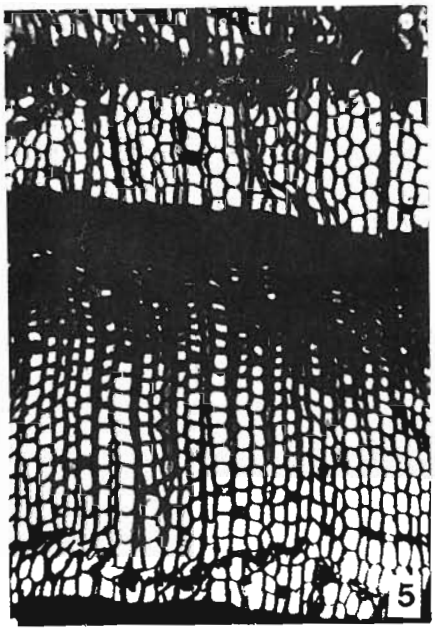
PLATE 1 →

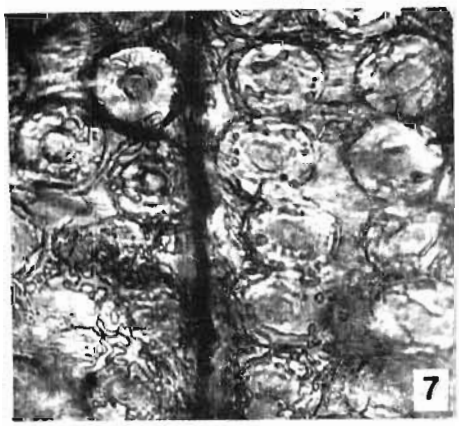
1. *Taxodioxylon chinense* sp. nov.—Cross section showing distinct growth rings and early and late wood zones. × 90; Slide no. YJ-1/1.
2. *Taxodium distichum* (L.) Rich.—Cross section of the modern wood showing similar growth rings and the tracheids as in the fossil wood. × 90. Slide no. BSIP W180.
3. *Taxodioxylon chinense* sp. nov.—Tangential longitudinal section showing distribution of xylem rays. × 130; Slide no. YJ-1/3.
4. *Taxodium distichum* (L.) Rich.—Tangential longitudinal section of the modern wood showing similar structure of xylem rays as in the fossil wood. × 130; Slide no. BSIP W180.
5. *Taxodioxylon chinense* sp. nov.—Another cross section showing the tracheids and axial parenchyma. × 90; Slide no. YJ-1/1
6. *Taxodioxylon chinense* sp. nov.—Radial longitudinal section showing 1-3 seriate bordered pits in radial walls of tracheids. × 210; Slide no. YJ-1/2.
7. *Taxodioxylon chinense* sp. nov.—Radial longitudinal section magnified to show the details of 2-3 seriate bordered pits of tracheids and the Bars of Sanio. × 1225; Slide no. YJ-1/2.
8. *Taxodioxylon chinense* sp. nov.—Radial longitudinal section magnified to show the cross-field pitting. × 1225; Slide no. YJ-1/2.
9. *Taxodioxylon chinense* sp. nov.—Another radial longitudinal section magnified to show the cross-field pitting. × 1225; Slide no. YJ-1/2.

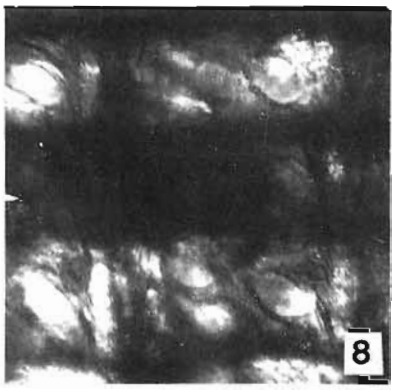












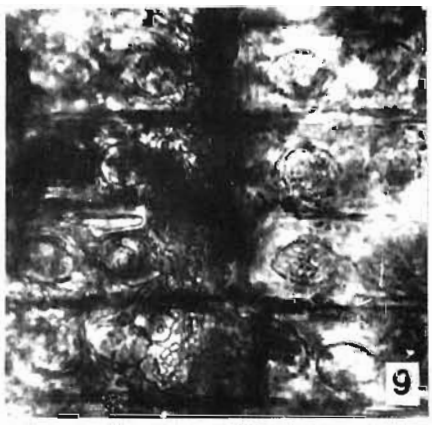


PLATE 1

The genus *Taxodioxylon* was established by Hartig in 1848 for describing the fossil woods of Taxodiaceae (Seward, 1919). A large number of species of *Taxodioxylon* have so far been described from the Cretaceous and Tertiary formations throughout the world. These have been enumerated and classified by Kräusel (1919, 1949) and Prakash (1968, 1972). Since then, a number of species have been added to *Taxodioxylon*. Besides, some other taxodiaceous fossil woods have also been recorded, viz., *Glyptostroboxylon tenerum* (Kraus) Conwentz (Kostyniuk, 1967) from the Tertiary of Turow, south-west Poland, *Metasequoioxylon hungaricum* Greguss 1967, *Sequoioxylon* cf. *S. germanicum* Greguss 1967, *Sequoioxylon medullare* Greguss 1967, and *Sequoioxylon podocarpoides* Greguss 1967—all from the Tertiary of Hungary and *Sequoioxylon sequoianum* (Schmal.) Du 1982 as well as *Taiwanioxylon krasheninnikovii* (Jam.) Khudaiberdyev (Du, 1982) from the Palaeocene of Fushun, China. Amongst those reported from China are: *Taxodioxylon cryptomerioides* (Schonfeld) Du 1982, *Sequoioxylon sequoianum* (Schmal.) Du 1982 and *Taiwanioxylon krasheninnikovii* (Jam.) Khudaiberdyev (Du, 1982) which apparently bear affinities with the woods of *Cryptomeria, Sequoia* and *Taiwania* respectively and differ from the present fossil in having 1-2 seriate usually uniseriate bordered pits in radial walls of the tracheids and 1-4, usually 2 cross-field pits in *Taxodioxylon cryptomerioides*, very narrow late wood zones (usually 1-2 cells thick) and very high xylem rays (1-40 cells high) in *Sequoioxylon sequoianum*, and cupressoid cross-field pits in *Taiwanioxylon krasheninnikovii*.

A detailed comparison with other fossil woods of *Taxodioxylon* indicates that the present fossil is also different from all of them in some features such as number, shape and size of cross-field pits on the radial wall, height of xylem rays, etc. Hence, it is being named here as a new species *Taxodioxylon chinense* sp. nov., the specific name indicates its occurrence in the Miocene sediments of China.

Although a number of fossil species which may belong to the genus *Taxodium* have been reported from all over the world, there are only three living representatives in this genus, i.e., *Taxodium ascendens* Brongniart, *T. distichum* (L.) Rich. and *T. mucronatum* Ten., while the genus *Sequoia* is represented only by one species, *Sequoia sempervirens* Endlicher (Willis, 1973, pp. 1060, 1132). *Taxodium distichum* and *Sequoia sempervirens* are both very large trees and now-a-days they grow in North America only. But during the Cretaceous and Tertiary times they were widely distributed throughout the Northern Hemisphere (Florin, 1963, pp. 209-212). According to Florin's study on the distribution of conifer genera in time and space, the genera *Sequoia* and *Taxodium* probably disappeared from the Europe-Asian continent by the end of the Pliocene period (Florin, 1963, p. 210). However, so far no fossils showing affinities with these genera are known from the Neogene deposits of China, although a few fossil leaf and woods resembling *Taxodium* and *Sequoia* were found from the Eocene and Palaeocene formations of this region (Anonymous, 1978, pp. 11, 13; Du, 1982). So the present finding adds some more evidence about the occurrence and distribution of the genera *Taxodium* and *Sequoia* in China during the Neogene.

SPECIFIC DIAGNOSIS

Taxodioxylon chinense sp. nov.

Growth rings distinct. *Late wood* about 7-18(10) cells thick; tracheids thick-walled, walls about 6 μm thick, flattened, squarish to rectangular in shape with small lumina, t.d. 24-25 μm, r.d. 18-45 μm. *Early wood* usually several times wider than the late wood; *tracheids* squarish or rectangular in shape with wide lumina, t.d. 36-45 μm, r.d. 45-90 μm. *Pits* on the radial walls of tracheids 1-3 seriate, bordered usually 2-3 in the early wood, round, opposite and separate to contiguous, often paired, 27 μm in diameter; apertures round, about 9 μm in diameter; tangential walls usually smooth, pits round, separated and smaller than in radial walls, about 15 μm in diameter with round apertures. *Bars of Sanio* present. *Xylem rays* uniseriate, 1-16 cells or 39-390 μm high; ray cells round, squarish, rectangular or barrel-shaped in tangential section, usually 27 μm in width and 30 μm in vertical height, up to 150 μm in radial length; the horizontal and tangential walls of ray cells thin and smooth. *Cross-field pits* taxodioid, 2-5 usually 3 per cross-field, rather large, oval in shape, about 14 μm in diameter and commonly in 1-2 horizontal rows; pit apertures quite big, oval in shape, 12 μm in diameter and arranged diagonally. *Axial parenchyma* abundant, diffuse and in tangential rows, mainly distributed in the early wood and resiniferous; parenchyma cells squarish or rectangular in cross-section, about 50 μm in diameter. *Resin canals* absent.

Holotype—Palaeobotany Department Herbarium Specimen no. YJ-1, Botanical Institute, Academia Sinica, China.

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