CUPRESSINOXYLON JIAYINENSE, A NEW SPECIES OF THE LATE CRETACEOUS FROM HEILONGJIANG PROVINCE, CHINA

by

Wang Ru-feng¹, Wang Yu-fei² & Chen Yong-zhe¹

SUMMARY

Cupressinoxylon jiayinense spec. nov., a new species of silicified coniferous wood, is described from the Late Cretaceous in Jiayin County, Heilongjiang Province, Northeast China. The growth rings are distinct. The transition from earlywood to latewood is gradual. Rays range from 1- to 2-seriate, and are 4–68 cells high. Both horizontal and tangential walls of ray cells are smooth. The cross-field pitting is cupressoid. There are 2 or 3 pits per cross field. Ray tracheids are rarely present. Wood parenchyma is abundant and diffuse. Resin canals are absent. These features indicate affinities with Cupressaceae, specifically with some members of the extant genus *Cupressus*.

Key words: *Cupressinoxylon*, Late Cretaceous, Heilongjiang.

INTRODUCTION

The form genus *Cupressinoxylon* was established by Göppert (1850) to describe the gymnospermous fossil woods that were composed of tracheids and axial wood parenchyma but lack resin canals, including all the fossil woods belonging to Cupressaceae, Taxodiaceae and Podocarpaceae. Gothan (1905) and Kräusel (1949) amended it and established another genus, *Podocarpoxylon* (Gothan 1905) to accommodate the fossil woods belonging to the Podocarpaceae. Although Greguss (1955) suggested that the woods of Cupressaceae could be distinguished from those of the Taxodiaceae by characteristics such as bead-like thickenings on the tangential walls of ray cells, there is no consistency with respect to this or other characteristics that are claimed to distinguish woods of the two families (Steward & Rothwell 1993). Based on their wood structural similarities, both families are more closely related to one another than to any other conifer family. On the basis of this opinion Seward (1919) maintained the form genus *Cupressinoxylon* for all woods showing characteristics of the Taxodiaceae and Cupressaceae (Steward & Rothwell 1993). Nevertheless, many fossil woods clearly related to modern genera of both families have been assigned to *Cupressinoxylon*, *Tetraclinoxylon*, *Chamaecyparioxylon*, *Palaeocallitroxylon*, *Callitroxylon*, *Libocedroxylon*, *Metasequoioxylon*, *Taxodioxylon*, *Sequoioxylon* etc., to show their wood anatomical similarities by several authors (Vaudois & Privé 1971; Du Nai-zheng 1982).

1) College of Life sciences, Shandong University, Jinan 250100, China.

2) Institute of Botany, Chinese Academy of Sciences, Beijing 100093, China.

The silicified woods studied in this paper are assigned to a new species of *Cupressinoxylon* because they closely resemble some species of *Cupressus* in their wood anatomy.

MATERIALS AND METHODS

The present investigation is based on the study of two samples of silicified woods, HLJ-01 in good preservation and HLJ-03 in poor preservation, discovered from the south bank of Heilongjiang River, Taipinglinchang, Jiayin County, Heilongjiang Province, China. The specimens are dated from the Jiayin group, Late Cretaceous (Zhang Zhi-cheng 1983; Li Wei-rong 1986). The Jiayin group contains three Formations named by their localities, the Yongantun Fm., the Taipinglinchang Fm. (overlaid by Yuliangzi Fm.), and the Yuliangzi Fm. where dinosaur skeletons have been excavated (Zhang Zhi-cheng 1983; Li Wei-rong 1986). The strata are well exposed along the riverbank and their sections are simple in structure and relatively continuous. The flora from the Jiayin group consists of *Thallites jiayinensis* Zhang, *Equisetum*? sp., '*Asplenium*' *dicksonianum* Heer, *Arctopteris* sp., *Cladophlebis* sp., *Ginkgo adiantoides* (Unger) Heer, *Taxodium olrikii* (Heer) Brown, *Metasequoia disticha* (Heer) Miki, *Podocarpus* cf. *tsagajanicus* Krassilov, *Pityophyllum* sp., *Cupressinocladus* sp., *Carpolithus* sp., *Macclintockia* cf. *trineris* Heer, *Trochodendroides arctica* (Heer) Berry, *T. smilacifolia* (Newberry) Kryshthovovich, *Platanus densinervis* Zhang, *P. sinensis* Zhang, '*Platanus*' *raynoldsii* Newberry, *Tiliaephyllum* cf. *tsagajanicum* (Krysht. et Baikov) Krassilov, *Pterospermites orientalis* Zhang, *P. heilongjiangensis* Zhang, *Viburnum* cf. *contortum* Lesq., *Nordenskiöldia* cf. *borealis* Heer, *Laurophyllum* sp., *Quereuxia angulata* (Newberry) Kryshthovovich, *Dicotylophyllum* sp. (Zhang Zhi-cheng 1983). The most dominant group of the Jiayin flora are the angiosperms, of which *Trochodendroides* occurred abundantly. The gymnosperms are represented only by Coniferales and one species of Ginkgoales.

The peel method (Zhu Wei-qing 1983) was used in making transverse, radial, and tangential sections of the silicified woods which were preserved at the Department of Paleobotany, Chinese Academy of Sciences, Beijing. The photomicrographs were taken with Olympus photomicrographic equipment. Wood sections of extant conifers for comparative studies were provided by the Institute of Wood Industry, Chinese Academy of Forestry.

SYSTEMATIC DESCRIPTION

Class: CONIFEROPSIDA

Order: **Coniferales**

Family: Cupressaceae

Cupressinoxylon (Göppert) Gothan (1905)

Cupressinoxylon jiayinense, spec. nov.

Holotype: HLJ-01

Repository: Department of Paleobotany, Institute of Botany, Chinese Academy of Sciences, Beijing, China

Type locality: Jiayin County, Heilongjiang Province, China

Stratigraphic horizon: Late Cretaceous

Etymology: From Jiayin County

Diagnosis:

The wood consists of tracheids, axial wood parenchyma and rays. The growth rings are distinct, the transition from earlywood to latewood is gradual. Rays are 1- or 2-seriate, and 4–68 cells high. Both horizontal and tangential walls of ray cells are smooth. The cross-field pitting is cupressoid, 2 or 3 pits per field. Wood parenchyma is abundant. Resin canals are absent.

Description:

Tracheids — The growth rings are distinct. The transition from earlywood to latewood tracheids is gradual (Fig. 1). Tracheids of earlywood are squarish to rectangular with round angles in transverse view. The diameter of tracheids is 17–63 μm in tangential direction, and 34–69 μm in radial direction. Bordered pits on the radial walls of tracheids are circular, 1- or 2-seriate. Uniseriate pits are separate, sometimes slightly contiguous. Biseriate pits are opposite (Fig. 4). The pit pores are round or elliptical with a diameter of 4–6 μm . Crassulae are distinctly present (Fig. 4). Latewood zones are 5–20 cells wide, and usually consist of more than 12 layers of thick-walled cells. The average tracheid diameter is 21 μm in radial direction, and 28 μm in tangential direction. Bordered pits with round apertures on the radial walls are uniseriate. The tangential walls of latewood tracheids are also pitted, but the number of pits is fewer than those on radial walls (Fig. 7).

Wood parenchyma — Axial wood parenchyma is abundant and strands are usually scattered in transverse section (diffuse). They appear to be about the same size as the tracheids, but are more nearly square. The parenchyma cells are about 25 μm in diameter and 155 μm tall and sometimes contain dark gummy deposits. Their terminal walls are unpitted (Fig. 5).

Wood rays — Prominent, usually uniseriate, sometimes biseriate in part, 4–68 cells high (Fig. 6). Both horizontal and tangential walls of ray cells are smooth (Fig. 2). Radially ray cells are about 75 μm long and 16 μm high, each ray cell spans 3–5 tracheids. Cross-field pits are predominantly cupressoid, but occasionally taxodioid. In each cross field, there are 2 or 3 pits in a line; the pits are elliptical and oriented obliquely, with the long radius of about 6 μm and the short radius of 3 μm (Fig. 3). Ray tracheids are rarely present. Their inner walls are smooth.

Resin canals — Both horizontal and vertical resin canals are absent.

COMPARISONS WITH OTHER CONIFEROUS FOSSIL WOODS

The wood structure of the new species is characterized by abundant axial wood parenchyma, smooth-walled ray cells with cupressoid cross-field pits and absence of resin canals. These characteristics completely coincide with the generic features of *Cupressinoxylon* as described by Gothan (1905). In the genus Knowlton (1919) listed 27 species of *Cupress(in)oxylon* from North America, Kräusel (1919) recorded over 170 species, which were variously referred to *Cupressinoxylon*, *Cupressoxydon* and *Cupressus*. In many cases the generic names, *Cupressinoxylon* and *Cupressoxydon*, have been used synonymously in describing the same species. Many of these taxa were not determined as to species. Even some of the determinations were based on poorly preserved or scanty material. Therefore, it was not surprising that the identifications cannot be authenticated (Lutz 1930). Kräusel (1919) limited the number of forms which may be referred with reasonable certainty to *Cupressinoxylon* to 17 species. Stopes (1915) listed 4 species from Lower Greensand, Isle of Wight. Vaudois and Privé (1971) summarized the main work about *Cupressinoxylon* and finally enumerated 44 species which had been named scientifically. Compared with these species, HLJ-01 is closely related to four of these species but the discrepancy between them is also distinct (Table 1).

1. *Cupressinoxylon cupressoides* Kräusel (1919). According to the description given by Lutz (1930), it differs from HLJ-01 chiefly in that its parenchyma cells occur in tangential bands of 2 or 3 cells thick. And the pits on the tangential walls of the tracheids are numerous. Its rays are usually low, the highest only had 23 cells (Lutz 1930).
2. *Cupressinoxylon vectense* Barber (1898). The main differences with HLJ-01 are: In *C. vectense*, the number of pits per cross field is usually 1, but 2 or 3 in HLJ-01. In *C. vectense*, the rays are only 1–12 cells high but they are 4–68 cells high in HLJ-01. Furthermore, in *C. vectense* the horizontal walls of ray cells are thin, but thick in HLJ-01 (Barber 1898; Seward 1919; Shimakura 1936).
3. *Cupressinoxylon megeeci* Knowlton (1889) seems to be similar to HLJ-01 in some respects. The chief differences from HLJ-01 are as follows: 1) The simple pits in cross field. 2) Its wider rays (1–3-seriate). 3) Bordered pits on the radial walls of tracheids are 2- or 3-seriate (Stopes 1915; Seward 1919).
4. *Cupressinoxylon koettilitzi* Seward (1919) differs from HLJ-01 in its alternate bordered pits on the radial walls of tracheids. Elsewhere, the simple cross-field pits and low rays (1–25 cells high) also indicate their incompatible characteristics (Seward 1919).

Fig. 1–7. *Cupressinoxylon jiaiyinense*. – 1: Transverse section, showing the distinct growth rings and transition from earlywood to latewood. – 2: Radial section, showing the walls of ray cells. – 3: Radial section, showing cross-field pitting. – 4: Radial section, showing the pits on radial walls of earlywood tracheids. – 5: Radial section, showing axial wood parenchyma cells. – 6: Tangential section, showing distribution of xylem rays. – 7: Tangential section, showing the pits on tangential walls of latewood tracheids. – Bar equals 90 µm in Fig. 1; 15 µm in Fig. 2; 18 µm in Fig. 3; 30 µm in Fig. 4; 25 µm in Fig. 5; 80 µm in Fig. 6; 80 µm in Fig. 7.

Table 1. The differences between *Cupressinoxylon jiayinense* and closely related species of the same genus. * = main difference.

Species Characters	<i>C. jiayinense</i>	<i>C. cupressoides</i>	<i>C. vectense</i>	<i>C. megeci</i>	<i>C. koettitzii</i>	<i>C. fujeni</i>	<i>C. hanshanense</i>
Arrangement of bordered pits on radial walls of tracheids	1-2-seriate, opposite	1-2-seriate, opposite	uniseriate, seldom biseriate, alternate*	2-3-seriate, opposite	1-2-seriate, opposite, seldom alternate*	uniseriate, seldom biseriate, opposite*	uniseriate*
Bordered pits on tangential walls of latewood tracheids	present	numerous*	present	present	present	present	absent*
Distribution of axial wood parenchyma	scattered	in tangential zone bands*	scattered, seldom in zone bands	scattered	absent*	scattered	scattered
Width of rays	1-2-seriate	uniseriate, seldom biseriate	uniseriate, seldom biseriate	1-2-seriate	exclusively uniseriate*	uniseriate, seldom biseriate	uniseriate, seldom biseriate
Height of rays	4-68 cells	1-23 cells*	1-16 cells*	2-49 cells	1-25 cells*	1-12 cells*	1-12 cells*
Pits in the cross field	cupressoid, 2-3 pits per field	cupressoid, 2 pits per field	cupressoid, usually 1 pit per field*	simple pits, 1-2 pits per field*	cupressoid, 2-4 pits per field	simple? cupressoid? 1-4 pits per field*	3-7 pits per field*
Wood ray tracheids	present	absent*	absent*	absent*	absent*	absent*	absent*

In China, two other specimens of *Cupressinoxylon*, *C. hanshanense* Zhang et Cao (Zhang Shan-zhen & Cao Zheng-yao 1986) and *C. fujeni* Mathews et Ho (Sze 1963) were also reported. In *C. hanshanense*, the bordered pits on the radial walls of tracheids are slightly separate and arranged in one line. Bordered pits on the tangential walls of tracheids are absent. Rays are uniseriate, 1–12, usually 4–6 cells high. There are usually 3 or 4 pits per cross field, occasionally 6 or 7 (Zhang Shan-zhen & Cao Zheng-yao 1986). So there is much discrepancy between *C. hanshanense* and HLJ-01. In *C. fujeni*, the rays are very low (1–12 cells high). The cross-field pits are simple, and the central part of ray cells is swollen. Sze suggested that these characteristics show its affinities to Araucariaceae (Sze 1963).

The detailed comparison with other fossil woods of *Cupressinoxylon* indicates that the specimen HLJ-01 is different from all of them in some features such as the number and the size of cross-field pits, the height of rays, etc. Hence, it is named here as *C. jiayinense* *spec. nov.* The specific name derives from its occurrence in Jiayin County of China.

AFFINITIES WITH EXTANT CONIFERS

The wood structure of *Cupressinoxylon jiayinense* is similar to that of three extant genera of Cupressaceae, viz. *Cupressus*, *Chamaecyparis* and *Biota*. However, there are wood anatomical differences between them. In *Chamaecyparis* the growth rings are rather narrow and the cross walls of axial parenchyma cells have nodular thickenings, while in *C. jiayinense* the growth rings are much wider. There are no nodular thickenings on the cross walls of axial parenchyma cells. In *Biota*, the wood rays are low (1–6 cells high) and the horizontal walls of ray cells are usually pitted. In *Cupressus*, the horizontal walls of ray cells are rather thin and the pits on the radial walls of earlywood tracheids are usually uniseriate, while in *C. jiayinense* the horizontal walls of ray cells are thick and the pits on the radial walls of earlywood tracheids are 1- or 2-seriate. It is obvious that the wood structural differences between *C. jiayinense* and *Cupressus* are much smaller than those between *C. jiayinense* and the other genera of the Cupressaceae. *Cupressinoxylon jiayinense* and *Cupressus* possess many common characters in wood structure, including wide growth rings, gradual transition from earlywood to latewood, higher wood rays with cupressoid cross-field pitting, and ray tracheids. Therefore, *Cupressinoxylon jiayinense* might be regarded as an individual member of Cupressaceae, which has a close relationship with *Cupressus*.

ACKNOWLEDGEMENTS

We are very grateful to Prof. Cheng-sen Li for his help in the fossil wood collection and discussion of the manuscript. We express our gratitude to Prof. Wei-qing Zhu for his experienced counsel on the peel method and Prof. Jia-ju Yang from the Institute of Wood Industry, Chinese Academy of Forestry, who provided extant conifer wood sections for comparative study. Thanks are due to Dr. Jin-zhong Cui, Dr. Jin-xing Lin and Prof. Ming-yu Xu for their many helpful suggestions about the paper. This work was supported by grants from the National Natural Science Foundation of China No. 39300007 and No. 38321001, SFPPAS No. 9218 and partly from the Young Scientists Lab of Plant Origin and Environmental Changes.

REFERENCES

- Barber, C.A. 1898. *Cupressinoxylon vectense*, a fossil Conifer from the Lower Greensand of the Isle of Wight. *Ann. Bot.* 12: 329–361.
- Du Nai-zheng. 1982. The preliminary research on fossil woods from the Palaeocene of Fushun Coal Mine of Liaoning Province, China. *Contributions of Research from the Botanical Institute, Acad. Sin.* 3: 63–68. (In Chinese with English Abstract.)
- Göppert, H.R. 1850. *Monographie der fossilen Coniferen*. Hollandsche Maatsch. Wetensch. Natuurk. Verh. 6: 196.
- Gothan, W. 1905. *Zur Anatomie lebender und fossiler Gymnospermen-Hölzer*. Abh. Kön. Preuss. Geol. Land., Berlin 44: 1–108.
- Greguss, P. 1955. Identification of living Gymnosperms on the basis of xylotomy. *Akademiai Kiado, Budapest*.
- Knowlton, F.H. 1919. *A Catalog of the Mesozoic and Cenozoic plants of North America*. U. S. Geol. Surv. Bull. 696.
- Kräusel, R. 1919. Die fossilen Koniferen-Hölzer. *Palaeontographica*, Abt. B, 62: 185–275.
- Kräusel, R. 1949. Die fossilen Koniferen-Hölzer. II. Kritische Untersuchungen zur Diagnostik lebender und fossiler Koniferen-Hölzer. *Palaeontographica*, Abt. B, 89: 81–203.
- Li Wei-rong. 1986. Late Cretaceous Strata in the Jiayin area, Heilongjiang Province. *Regional Geology of China No.1*: 28–36. Geological Publishing House, Beijing. (In Chinese with English Abstract.)
- Lutz, H.J. 1930. A new species of *Cupressinoxylon* (Göppert) Gothan from the Jurassic of South Dakota. *Bot. Gaz.* 66: 92–107.
- Seward, A.C. 1919. *Fossil Plants IV*. Cambridge University Press, London.
- Shimakura, M. 1936. Studies on fossil woods from Japan and adjacent lands, *contr. I. Sci. Rep. Tohoku Imp. Univ., Sec. Ser. (Geol.)*. 18: 267–310.
- Steward, W.N & G.W. Rothwell. 1993. *Palaeobotany and the evolution of plants*. Cambridge University Press, London.
- Stopes, M.C. 1915. *Catalogue of Mesozoic plants in the British Museum – The Cretaceous flora, part II*. Longman, London.
- Sze H.G. 1963. *Fossil plants of China 2, Mesozoic plants of China*. Science Press, Beijing. (In Chinese.)
- Vaudois, N. & C. Privé. 1971. Revision des bois fossiles de Cupressaceae. *Palaeontographica*, Abt. B, 134: 61–86.
- Zhang Shan-zhen & Cao Zheng-yao. 1986. On the occurrence of *Cupressinoxylon* from the Jurassic of Anhui. *Acta Palaeobot. Palynol. Sinica* 1: 23–30. (In Chinese with English Abstract.)
- Zhang Zhi-cheng. 1983. The Upper Cretaceous fossil plant from Jiayin region, Northern Heilongjiang. *Professional Papers of Stratigraphy and Paleontology* 11: 111–132. (In Chinese with English Abstract.)
- Zhu Wei-qing. 1983. Studies on the peel method of palaeobotany. *Chinese Bull. Bot.* 1: 51–53. (In Chinese.)