TRIASSIC WOOD FROM THE GORDON VALLEY, CENTRAL TRANSANTARCTIC MOUNTAINS, ANTARCTICA

by

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SUMMARY

Wood from an *in situ* permineralized forest from the Middle Triassic of Gordon Valley (Queen Alexandra Range, central Transantarctic Mountains) in Antarctica is described as a new taxon. Approximately 100 trunks in growth position are present at the site; they range from 13–61 cm in diameter and suggest that some of the trees were up to 20 m tall. Pits in the radial walls of the tracheids are of the abietinean type. Rays are uniseriate and 1–9 cells high; cross fields include one to two pits that appear to be simple. Axial parenchyma is absent. Pith and cortex are not preserved. The Antarctic wood is compared with existing fossil wood types from Antarctica and other parts of Gondwana. Although the fossil wood shares a number of characteristics with the Podocarpaceae, it differs from any existing genera and is described as a new taxon, *Jeffersonioxylon gordonense*.

Key words: Petrified forest, anatomy, Triassic, Antarctica, Podocarpaceae, wood, gymnosperms.

INTRODUCTION

Petrified gymnosperm woods from the southern hemisphere are common in strata ranging from the late Paleozoic to the Tertiary. Numerous taxa have been described from Triassic rocks in all parts of Gondwana, including India (e.g., Sahni 1931), South Africa (e.g., Kräusel 1949; Giraud & Hankel 1986), Argentina (e.g., Bonetti 1966), New Caledonia (e.g, Lanteaume 1950; Salard 1968), Madagascar (e.g., Loubière 1938), Australia (e.g., Shirley 1898; Burges 1935), and New Zealand (Stopes 1916).

Historical collections of fossil wood represented some of the earliest evidence of past life in Antarctica. Specimens were collected on expeditions as early as the turn of the century (e.g., Sharman & Newton 1894, 1898; Gothan 1908). Mesozoic wood has been reported from both the continent (e.g., Grindley et al. 1964; Barrett et al. 1986; Tessensohn and Mädler 1987) and the peninsula region (e.g., Halle 1912; Douglas

1923). Many of these papers, however, are geological reports that only mention the occurrence of petrified wood samples and do not include detailed anatomical or systematic descriptions. Gordon (1930) described *Dadoxylon (Araucarioxylon)* from South Georgia (Antarctic peninsula region) and Seward (1914) detailed *Antarcticoxylon priestleyi* from the Priestley Glacier area (northern Victoria Land). However, neither of these specimens can be accurately dated. Gordon's specimen was collected on a beach and was assigned to either the upper Paleozoic or lower Mesozoic. Although Walton (1925) later included *A. priestleyi* in the Triassic genus *Rhexoxylon*, Seward's material was collected from a moraine and the exact age is therefore uncertain. It may have originated in Triassic, Jurassic, or even Permian rocks (Skinner & Ricker 1968). There are several examples of Cretaceous gymnospermous wood (e.g., Jefferson & MacDonald 1981; Torres & Lemoigne 1989; Chapman & Smellie 1992; Francis & Coffin 1992; Philippe et al. 1993), including wood with growth rings that have provided paleoclimate information (Francis 1986). Jurassic wood from Antarctica, although relatively rare, has been reported (Jefferson et al. 1983; Tasch & Gafford 1984).

Although *in situ* petrified forests, in which the trees are fossilized in growth position, are rare in the southern hemisphere, a few have been reported. Conwentz (1885) described a forest of Oligocene age from Patagonia that consisted of several different wood types (*Cupressinoxylon, Glyptostroboxylon,* and *Araucarioxylon*). The Cerro Cuadrado petrified forest of Patagonia (Jurassic) is perhaps the best known *in situ* fossil forest in Gondwana. The wood of these massive trees was believed to have araucarian, or perhaps taxodiaceous affinities (Wieland 1935; Calder 1953), but Stockey's work on ovulate cones from the same deposit suggested taxodiaceous and pinaceous affinities for *Pararaucaria* (Stockey 1977). Recently, Cúneo (1991) provided an ecological analysis of the Patagonian forests. Halle (1912) noted a podocarp-type fossil forest in the Falkland Islands (Islas Malvinas), which was later examined by Birnie and Roberts (1986) and determined to be Tertiary in age.

Antarctica also has a few records of *in situ* petrified forests. Perhaps the best known are the Lower Cretaceous forests on Alexander Island (Jefferson 1982). In the central Transantarctic Mountains a small Permian forest was described from Mt. Achernar (Taylor et al. 1992; Cúneo et al. 1993). Perhaps the largest in terms of numbers of *in situ* individuals is a Triassic site in the Gordon Valley, where there are approximately one hundred trees in growth position (Cúneo et al. 1991). Sedimentological data suggest that this forest grew on the levees of a braided stream system. Based on the spacing of the individuals, diameter of the trees, and number of annual rings (maximum of 86 rings), this forest is interpreted as being mature (Taylor et al. 1991). The sediments in which the trees are rooted contain abundant specimens of the common Triassic leaf type *Dicroidium* (Corystospermales = Mesozoic seed ferns). However, features of the wood are more typically coniferous (pycnoxylic with few rays) than pteridospermous (manoxylic with many wide rays). Since the Gordon Valley trunks do not appear similar to any other wood types described to date, we have placed them in a new genus. The intent of this paper is to describe the wood from this site and to compare it with other fossil and, where possible, extant woods.
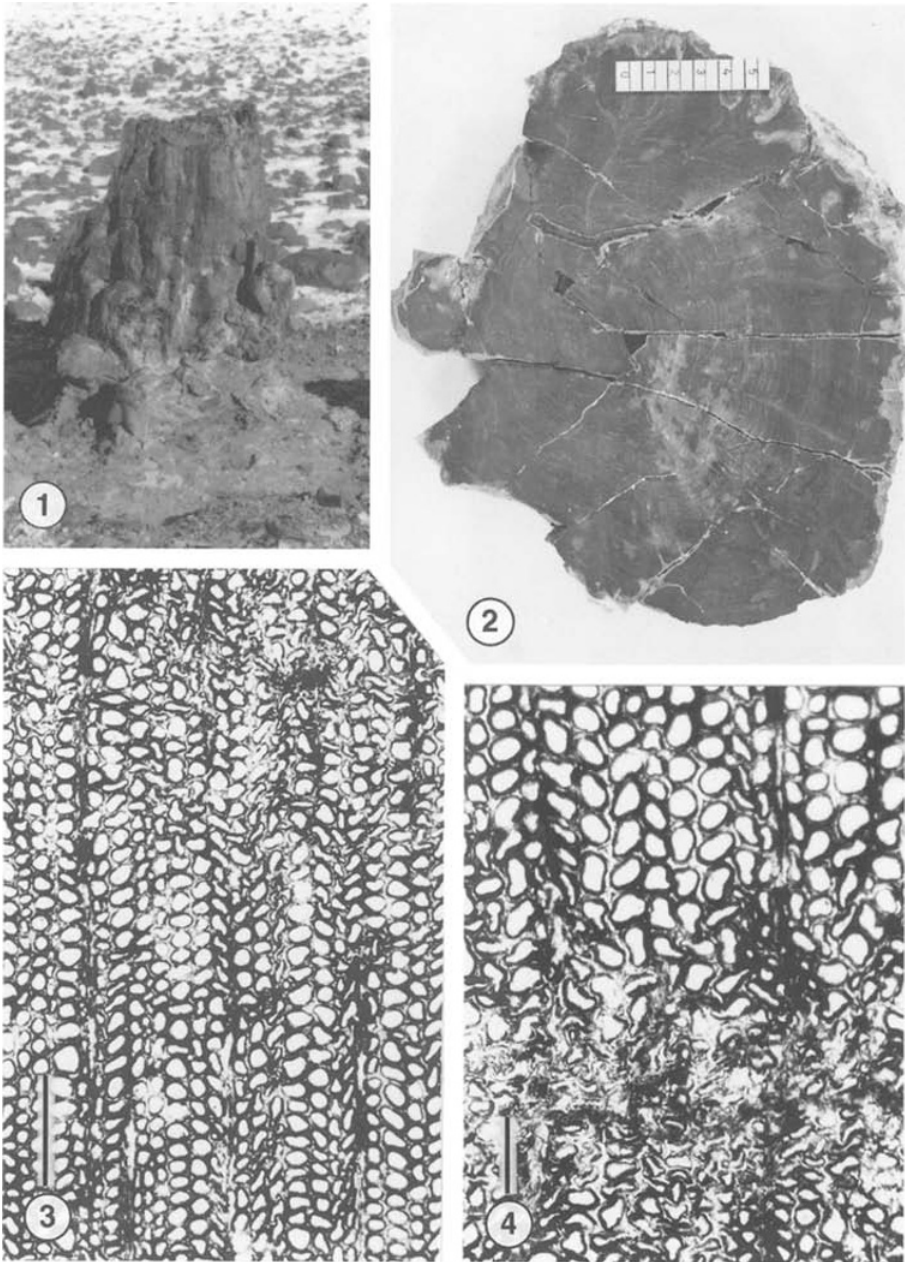
Fig. 1–4. *Jeffersonioxylon gordonense*. – 1: *In situ* tree from the Gordon Valley site. Trunk is approximately 0.5 meters tall. – 2: Transverse section of *in situ* tree showing several growth rings. Specimen No. 11,469 A; scale bar = 5 cm. – 3: Transverse section showing uniseriate rays and distribution of tracheids. Specimen No. 11,471 Aß; scale bar = 200 μm. – 4: Transverse section showing false growth ring with zone of crushed cells. Specimen No. 11,471 Aß; scale bar = 100 μm.

MATERIALS AND METHODS

All of the trunks are silicified and preserved in growth position (Fig. 1); in a few specimens it is possible to observe the transition region between the stem and subaerial portions. The site of the forest is a levee deposit in the Gordon Valley (84° 11' 10" S, 164° 54' 28" E), Beardmore Glacier region, central Transantarctic Mountains (Barrett & Elliot 1973). Stratigraphically, the site is within the Fremouw Formation, which is regarded as Early-Middle Triassic (Barrett et al. 1986).

Cellulose acetate peels of transverse, radial and tangential sections of the main trunks (specimen nos. 11469, 11470, 11471, 11473, 11517, 11618) were prepared by etching the specimens in 49% hydrofluoric acid for intervals of 10, 20, 30, 60 and 120 seconds. Varying the etching time was necessary because of the differential preservation within the trunks. A few thin peels were stained with safranin in an attempt to enhance contrast. Peels were mounted on standard microscope slides with Coverbond mounting medium. Slides and peels are deposited in the Paleobotanical Collections of the Ohio State University under the following acquisition numbers: 15,190–15,240.

SYSTEMATICS

FAMILY PODOCARPACEAE ?

Jeffersonioxylon Del Fueyo, Taylor, Taylor et Cúneo, *nov. gen.*

Generic diagnosis: Coniferous wood with tracheids polygonal in cross section and fusiform longitudinally; pitting on radial walls uniseriate or biseriate, bordered; pits round with inner aperture elliptical or round; cross-field pitting: 1 or 2 circular to oval pits per field; rays uniseriate and homocellular, 1–9 cells high; axial parenchyma absent.

Jeffersonioxylon gordonense Del Fueyo, Taylor, Taylor et Cúneo, *nov. spec.*

Specific diagnosis: Trunks up to 60 cm in diameter with well-developed secondary xylem; tracheids approximately 40 μm in diameter and greater than 1200 μm long; wall 5 μm thick with bordered pits on radial walls in a single row or two opposite rows, pits separated, circular, 10 μm in diameter with elliptical to rounded inner aperture; tangential pits generally absent; cross-field pits one or two, circular (5 μm) to ovate (5 × 3 μm), and horizontal to obliquely positioned; rays homocellular, uniseriate and 1–9 cells high (3 or 4 most common), rays separated by 2–19 rows of tracheids, parenchyma of rays with thin, unpitted walls (2.5 μm thick); vertical walls straight to oblique in radial section; ray cells 25 μm high by 20 μm wide in tangential section and up to 116 μm long in radial view.

Holotype: Specimen 11471 A, B. — *Paratypes:* Specimens 11469 A, B; 11470 A–C; 11473; 11517 A–D; 11618.

Collection locality: Upper Gordon Valley, central Transantarctic Mountains, Antarctica (84° 11' 10" S, 164° 54' 28" E).

Stratigraphic position: Upper part of the Fremouw Formation, Beacon Supergroup, Middle Triassic.

Etymology: The generic name *Jeffersonioxylon* is given in honor of the late Timothy Jefferson, who pioneered the study of Antarctic fossil woods and their importance in understanding paleoclimate; the specific name *gordonense* refers to the Gordon Valley collecting site.

Description

In all of the trunks studied, only secondary xylem was preserved; the trunks were apparently decorticated during preservation and pith/primary xylem was not preserved. Mean trunk diameter is approximately 25 cm (range = 20–60 cm).

In almost all the sections examined, the individual wood cells are crushed and in some cases extensively distorted (Fig. 4). For example, in Specimen 11,517 there are regions where the wood appears in a zig-zag pattern due to compression of the tracheids. Transverse sections of the trunks exhibit growth rings (Fig. 5), although due to poor preservation, many of these are easier to discern at low magnification (Fig. 2). In addition, extensive crushing of some tracheids gives the appearance, at low magnification, of false rings. Growth rings range from a few tenths of a millimeter up to about 7 millimeters in width. Individual tracheids are tangentially flattened, or compressed so that the cells are sinuous in transverse section. In some regions tissue distortion is so extensive that it is impossible to identify cell walls (Fig. 4). It is probable that the wood distortion is the result of mechanical compaction during diagenesis, perhaps in response to the trees being inundated by muds that subsequently shifted and compacted the trunks. Crushed and compressed bands of cells have been reported in other fossil woods, including those from Antarctica (Kräusel 1962; Maheshwari 1963, 1972).

Legends of Figures 5–15:

Fig. 5–9. *Jeffersonioxylon gordonense.* – 5: Transverse section showing growth ring. Arrow indicates region of probable latewood. Specimen No. 11,469 Bß; scale bar = 100 µm. – 6: Transverse section showing distribution of tracheids and rays. Specimen No. 11,471 Aß; scale bar = 100 µm. – 7: Detail showing thick secondary wall of tracheids. Upper arrow indicates region where middle lamella is preserved; lower arrow designates a pit. Specimen No. 11,471 Aß; scale bar = 25 µm. – 8: Tangential section of uniseriate ray seven cells high. Note contents in several of the parenchyma cells. Specimen No. 11,471 A; scale bar = 50 µm. – 9: Tangential section showing bordered pits of two tracheids. Specimen No. 11,471 A; scale bar = 50 µm.

Fig. 10–15. *Jeffersonioxylon gordonense.* – 10: Radial section showing ray (arrow). Note uniseriate pits of tracheids. Specimen No. 11,471 Bß; scale bar = 100 µm. – 11: Radial section of ray. Note thin, oblique end walls and dark contents. Specimen No. 11,471 Ba; scale bar = 50 µm. – 12: Radial section showing two possible cross-field pits (arrows), each with a single aperture. Specimen No. 11,471 Ba; scale bar = 25 µm. – 13: Tracheid showing a single row of bordered pits. Specimen No. 11,471 Ba; scale bar = 50 µm. – 14: Tracheid with two rows of opposite pits. Specimen No. 11,471 Ba; scale bar = 25 µm. – 15: Ray cell with three cross-field pits (arrows). Specimen No. 11,471 Ba; scale bar = 25 µm.
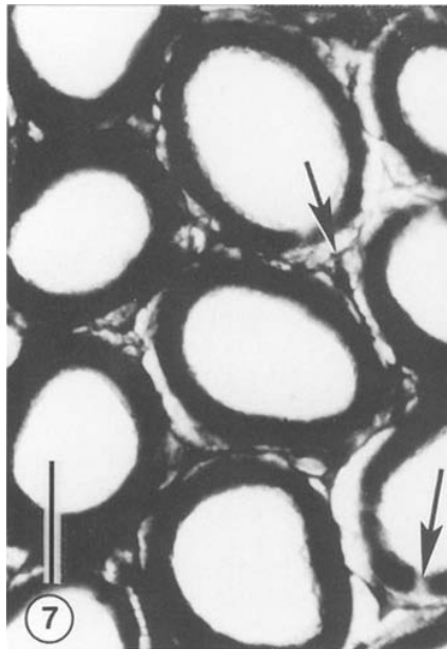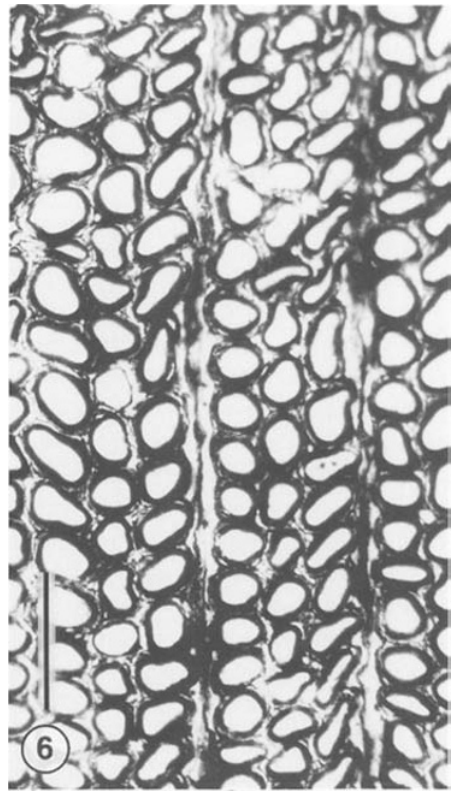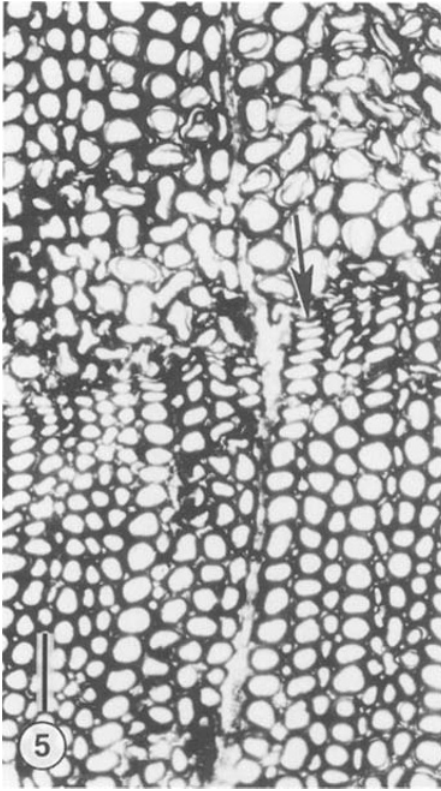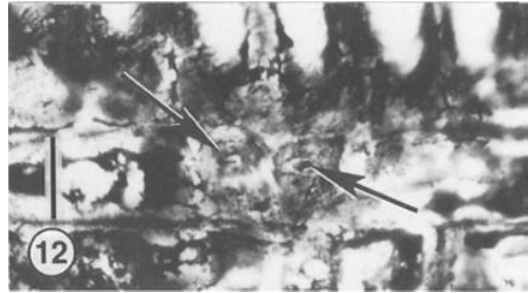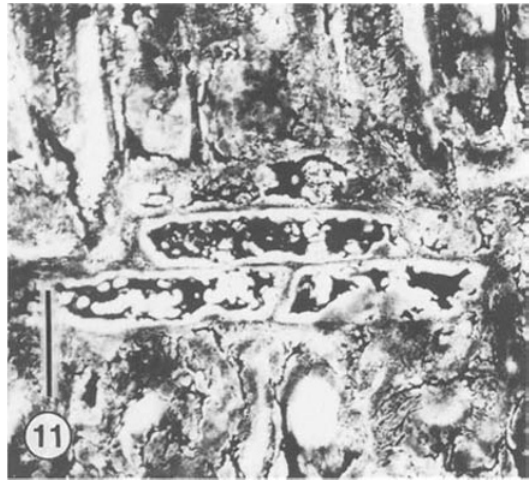
In areas where there is little crushing the rays are separated by 2–19 rows of tracheids, with an average separation of 7 rows (Fig. 3). Tracheids are polygonal in transverse section (Fig. 6) and average 40 μm in diameter; the wall is about 5 μm thick. In Figure 7 the tracheid walls are separated from the middle lamella giving an elliptical shape to the tracheid. Axial parenchyma is not present.

Rays are uniseriate and from 1–9 cells high (Fig. 8). In tangential section, cells in the center of the ray are barrel-shaped, while those at the top and bottom are triangular with rounded corners. Each of the ray parenchyma cells is 25 μm high and approximately 20 μm wide. There are no pits on the tangential or transverse walls. In radial section the homocellular nature of the rays is obvious. Cells appear rectangular in outline and are up to 116 μm long (Fig. 11). The majority (62%) of the tangential walls show some degree of obliqueness. Many of the ray cells contain dark materials that tend to obscure wall features.

The length of the tracheids in *Jeffersonioxylon* is difficult to measure due to poor preservation, but some extend for more than 1200 μm. Individual elements are fusiform in outline, but some have slightly rounded ends (Fig. 10). Pits are confined to the radial walls and in most tracheids are uniseriate (Fig. 13), although in a few elements two rows are present and these appear to be oppositely arranged (Fig. 14). Pits are solitary and usually located toward the end of each cell. They are circular and approximately 10 μm in diameter. The inner aperture is typically elliptical, but this is probably an artifact caused by distortion of circular apertures when the xylem was compacted. In tangential section, the bordered nature of the pits can be seen more clearly (Fig. 9). Cross-field pits in *Jeffersonioxylon* are difficult to characterize due to poor preservation. One or two pits per cross field are most common (Fig. 12), but a few sections contain 3 per cross field (Fig. 15). Cross-field pits are circular to oval and range from 3–5 μm in diameter. All appear to be simple; however, preservation of these features is very poor.

DISCUSSION

The literature on Paleozoic and Mesozoic fossil gymnosperm wood is extensive and many species and genera have been established based on isolated specimens of secondary xylem. In Table 1, we have summarized selected species of Mesozoic gymnosperm woods from Gondwana, especially Antarctica. We have included those for which there is a reasonable amount of anatomical information available and in which overall preservation is relatively good, but have excluded types with centripetally developed wood (e.g., Kräusel 1956a, 1956b, 1962). Although *Jeffersonioxylon gordonense* is presently known only from features of the secondary xylem, we have included a few genera in Table 1 for which information is known about both primary and secondary tissues.

In contrast to the pith and primary tissues, the secondary xylem of many Paleozoic and Mesozoic gymnosperms, especially coniferous wood (e.g., *Dadoxylon*-type), is uniform and simply organized. Thus, there are relatively few meaningful characters

that can be used to distinguish wood alone. Prasad (1982) noted that a parallel taxonomy exists for many fossil woods – one for those in which pith, primary and secondary xylem are present and one for those in which only secondary xylem is preserved. Lepekhina (1972) attempted to formalize this two-tiered taxonomic system and suggested that there are only 5 formal taxa that can be identified on the basis of secondary xylem alone: *Araucarioxylon* Kraus, *Baieroxylon* Greguss, *Platyspiroxylon* Greguss, *Protophyllocladoxylon* Kräusel, and *Prototaxoxylon* Kräusel & Dolianiti. To these five taxa, Lepekhina (in Lepekhina & Yatsenko-Khmelevsky 1966; Lepekhina 1972) added new names for just the secondary xylem fragments of taxa that had previously been described based on both secondary and primary xylem. Clearly, these artificial systems do nothing to improve our understanding of plant groups through time. Some authors however, such as Creber (1972), have recognized the importance of fossil wood in biostratigraphy and correlation, without contributing to the taxonomic problems outlined above. Others, such as Chapman and Smellie (1992), have chosen to use an artificial system. In this case, the authors described Cretaceous wood from the Antarctic peninsula using the Paleontologic Data-Handling Code system of Hughes (1989), resulting in taxa such as "Coniferwood-Cretaceous-clusteredpits." While this method does provide anatomical detail that can be useful to other investigators, in this case the wood is so well-preserved that it could have been assigned to existing fossil taxa. Thus, when one considers the diversity of this particular flora, it is difficult to understand exactly how many taxa are represented.

Most of the fossil woods that contain a pith and primary xylem are characterized by secondary xylem of the *Dadoxylon*-type. In this form, the tracheids have pits on the radial walls of the so-called araucarian or araucarioid-type, that is, they are multiseriate, alternate, and hexagonal. Together with *Araucarioxylon*, these two taxa are perhaps the most commonly used form genera for fossil wood and their taxonomy has been reviewed and emended several times (e.g., Maheshwari 1972; Giraud 1991; Philippe 1993). Seward (1919) regarded the two taxa as representing the same genus because of the difficulty in distinguishing them. Maheshwari (1972), on the other hand, suggested the taxa could be distinguished by the presence of uniseriate rays in *Araucarioxylon* and biseriate rays in *Dadoxylon*. Both taxa, however, exhibit araucarioid pitting. Since this pitting type does not occur in *Jeffersonioxylon*, the Antarctic wood cannot be assigned to one of these widely ranging form genera. Similarly, *Kykloxylon* Meyer-Berthaud et al., an anatomically preserved stem from the early Middle Triassic of Antarctica, can be eliminated from comparison since it also exhibits araucarian-type pitting (Meyer-Berthaud et al. 1993).

Since *Jeffersonioxylon* and *Antarcticoxylon* Seward both occur in the Beacon Supergroup of Antarctica, it is important to discuss the features of these taxa. The intertracheal pitting in *Antarcticoxylon* consists of a single row of contiguous, slightly flattened pits, although some tracheids show two rows of alternate, polygonal pits (Seward 1914). Based on these features, Seward suggests affinities with the Araucariaceae. In contrast, the pits in *Jeffersonioxylon* generally occur in a single row and are circular; when biseriate, the pits appear opposite. In addition, the tracheid walls of

Table 1. Select conifer woods from Gondwana.

	Species & Reference	Age & Locality (Fm = Formation)	Stem diameter (cm)	Rays: width / height (# of cells)	Axial paren-chyma
1.	*Antarcticoxylon priestleyi* Seward 1914	Upper Triassic Fremouw Fm, Antarctica	7.5	uni-/biseriate (1–24)	absent
2.	*Araucarioxylon floresii* Torres & Lemoigne 1989	Upper Cretaceous Livingston Island, Antarctica	?	uniseriate (2–12)	present
3.	*Cedroxylon neocaledonicum* Salard 1968	Triassic Marais de Mara, Nw Caledonia	?	uni-/biseriate (1–20)	present
4.	*Circoporoxylon amarjolense* Kräusel & Jain 1963	Jurassic Rajmahal Stage, India	1.5	uni-/biseriate (1–15)	absent
5.	*Cupressinoxylon nova-valesiae* Burges 1935	Triassic Hawkesbury Series, Australia	5.5 x 2.8	uniseriate (2–8)	present
6.	*Dadoxylon agathioides* Kräusel & Jain 1963	Jurassic Rajmahal Series, India	3	uni-/biseriate (2–20)	absent
7.	*Kykloxylon fremouwensis* Meyer-Berthaud et al. 1993	Middle Triassic Fremouw Formation Antarctica	1.5	uniseriate (1–10)	absent
8.	*Notophytum krauselii* Meyer-Berthaud & Taylor 1991	Middle Triassic Fremouw Formation Antarctica	0.5–20	uniseriate (1–7)	scanty
9.	*Podocarpoxylon indicum* Bhardwaj 1953	Jurassic Rajmahal Stage, India	3	uniseriate (1–5)	absent
10.	*Podocarpoxylon walkomi* Kräusel 1949	Jurassic Walloon Series Australia	4	uniseriate (5–12)	present
11.	*Protojuniperoxylon ischigualas-tensis* - Bonetti 1966	Triassic Ischigualasto Fm, Argentina	?	uni-/biseriate (1–27)	absent
12.	*Protophyllocladoxylon cort-aderitaensis* - Menéndez 1956	Triassic Cortaderita Beds, Argentina	45	uniseriate (1–15)	absent
13.	*Protopodocarpoxylon aff. guildense* Giraud & Hankel 1986	Jurassic Nandanga Formation, Tanzania	?	uniseriate (1–15)	absent
14.	*Protopodocarpoxylon triassicum* Kräusel 1949	Triassic Hawkesbury Series, Australia	?	uniseriate (3–10)	scanty
15.	*Taxaceoxylon sp.* cf. *rajmahalense* Kräusel & Jain 1963	Jurassic Rajmahal Stage, India	2	uni-/biseriate (1–22)	absent
16.	*Xenoxylon canoasense* Kräusel 1949	Middle Triassic Canoas, Brazil	?	uni-/biseriate (2–7)	?
17.	*Jeffersonioxylon gordonense*	Middle Triassic Fremouw Fm, Antarctica	45	uniseriate (1–9)	absent

(Table 1 continued)

	Tracheids in cross section			Intertracheary pits			Cross-field pits			
	shape	wall thick (µm)	diam. (µm)	shape	arrangement	diam. (µm)	no./ field	shape	diam. (µm)	inner aperture
1.	?	?	?	circular-polygonal	1 row flattened, 2 alternate	?	?	?	?	?
2.	polygonal	?	18–60	circular-hexagonal	1 row contiguous, 2 alternate	12–21	1–4	circular	10–15	?
3.	polygonal	?	15–60	circular	1 or 2 rows opposite	13–18	2–6	circular-elliptical	3.5–4	elliptical
4.	square-rectangular	? ?	13 x 20 30 x 20	circular-oval	1 row separate, 2 opp.-alternate	13; 16 x 13	1–2 1–2	circular	5–7	simple
5.	polygonal	?	20–30 30–40	circular	1 row separate	?	2–4	?	?	?
6.	polygonal	?	13–25	circular-hexagonal	1 row flattened, 2 alternate	13 x 10 23 x 13	2–8 2–8	circular	10	elliptical
7.	square-polygonal	?	25–70	circular	1 row separate-contiguous, 2 opp.-alternate	8 x 10 10 x 14	3–9	oval-circular	7 x 10 10 x 25	horizontal
8.	square-polygonal	?	50	circular	1 row separate-contiguous, 2 opp.-alternate	8–14	1–4	oval-rectangular	7 x 10–24	horizontal oblique
9.	square-polygonal	?	20–24	circular	1 row	10–12	1	oval	?	elliptical
10.	?	?	?	circular-elliptical	1 row separate-contiguous, 2 opposite	?	2–5	?	?	simple
11.	square	2–7	18–50	circular-hexagonal	1 row contiguous, 2 alternate	15–18	3–6	oval	?	oblique
12.	hexagonal-rectangular	?	33–37 41–43	circular-hexagonal	1 row separate, 2–3 alternate	16	1	circular-oval	23	simple
13.	polygonal	8–14	37–65 56–73	circular	1 row separate, 2 alternate	15–26	2–10	circular-oval	4–8	elliptical
14.	?	?	30	circular	1 row	?	2–6	?	?	?
15.	polygonal	7–10	13 x 30	circular	1 row separate	10	?	?	?	?
16.	?	?	?	circular-elliptical	1 row contiguous, 2 alternate	9–15	1–8	circular	?	simple
17.	polygonal	5	40	circular	1 row separate, 2 opposite	10	1–2 3	circular, elliptical	5 5 x 3	?

Jeffersonioxylon are much thicker than those in *Antarcticoxylon*, but this may be an artifact of preservation. Although Walton (1925) included *A. priestleyi* in *Rhexoxylon*, this assignment is not generally accepted (Archangelsky & Brett 1961). Meyer-Berthaud and Taylor (1991) re-examined Seward's material and also agreed that *Antarcticoxylon* should remain separate from *Rhexoxylon*. They note that although the genus is vaguely defined, the leaf trace emission (Seward's material was crushed) does appear to be similar to that in *Notophytum* Meyer-Berthaud & Taylor (1991).

When all of the available characters are analyzed, *Jeffersonioxylon* appears most similar to wood included in the form genera erected for podocarpaceous wood types, such as *Podocarpoxylon* Gothan (Triassic-Tertiary), *Mesembrioxylon* Seward (Jurassic-Recent), and *Circoporoxylon* Kräusel. It also exhibits some similarities with *Cupressinoxylon* Göppert (Jurassic-Tertiary) (Table 1). Features in common include the abietinean nature of the pits (a single row of circular, separate pits or two rows of opposite, circular, and separate pits), the presence of low, uniseriate rays with unpitted cell walls, and circular to elliptical, simple cross-field pits that are few in number (Greguss 1955; Vaudois & Privé 1971; Marguerier & Woltz 1977). However, some of the most important features for distinguishing these wood taxa are characters of the cross-field pits, which are very poorly preserved in *Jeffersonioxylon*. For example, Boureau (1956) lists one of the principal differences between *Podocarpoxylon* and *Cupressinoxylon* as the orientation of the inner aperture of the cross-field pits; tending toward horizontal in *Cupressinoxylon* and oblique-vertical in *Podocarpoxylon*. However, this feature is not always constant. In the extant taxon, *Podocarpus minor*, the inner aperture is horizontal, while in extant *Cupressus torulosa* the aperture is vertical (Greguss 1955). Sahni (1931, 1938), in his study on Mesozoic conifer woods from India, mentioned this same problem in the fossil taxa, *Podocarpoxylon* and *Cupressinoxylon*. Overall, the cross-field pitting in *Podocarpoxylon* differs from that in *Jeffersonioxylon* in that the former has circular pits with very narrow, often slit-like apertures (podocarpoid type; Marguerier & Woltz 1977), while the latter has simple circular pits.

Mesembrioxylon and *Cupressinoxylon* differ from *Jeffersonioxylon* in several features. Although *Mesembrioxylon* is poorly defined, Seward (1919) notes the presence of scattered axial parenchyma, while Sahni (1931) states it may be either present or absent. Both authors describe resin canals in wounded portions of the stem, a feature which does not occur in the Antarctic wood. Sahni (1931) cites Gothan (1905) as stating that neither resin canals nor axial parenchyma can be used to distinguish *Mesembrioxylon* from similar genera such as *Cupressinoxylon*. These authors believe the only important character is the nature of the cross-field pits. Like *Cupressinoxylon* (Vaudois & Privé 1971), *Mesembrioxylon* can be distinguished from *Jeffersonioxylon* by the narrow, oblique aperture in the cross-field pits. *Cupressinoxylon* additionally differs from the Antarctic material in the abundance of axial parenchyma usually present in this taxon (Gothan 1905; Vaudois & Privé 1971).

Circoporoxylon Kräusel is another form genus of fossil podocarp wood. This genus was very generally defined as secondary xylem with the anatomical features of a

podocarp, but with circular cross-field pits (Kräusel 1949). One of the new combinations proposed by Kräusel was *Circoporoxylon hortii* Stopes (1915). Stopes' material, from the Lower Greensand of England (Cretaceous), is well-preserved and described as including uni-to multiseriate rays up to 80 cells high. The tracheids include pits on the tangential walls in the latewood. Rays are so numerous that they are often separated by only one row of tracheids. Although the genus is so broadly defined as to include almost all podocarp wood, the well-defined features of *C. hortii* suggest that *Jeffersonioxylon* cannot be allied with this taxon.

The presence of *Notophytum* Meyer-Berthaud & Taylor, also from the Fremouw Formation in the central Transantarctic Mountains, is worth noting since this taxon shares several features with members of the Podocarpaceae (Meyer-Berthaud & Taylor 1991). The genus is based on branching axes preserved in permineralized peat. Both primary and secondary xylem are preserved. The secondary xylem is similar in most respects to that of *Jeffersonioxylon*. However, the size and shape of the cross-field pits are different. *Notophytum* includes 1 to 2 or up to 4 pits per field. They are simple or slightly bordered and measure up to 24 μm in diameter, much larger than those in *Jeffersonioxylon*, which do not exceed 5 μm in diameter.

Considering all the characters available, *Jeffersonioxylon* has its closest affinities with members of the Podocarpaceae. However, in most cases the wood taxa associated with this family are either poorly defined, or *Jeffersonioxylon* does not contain crucial characters that would allow us to place it in an already existing taxon. In addition, because of the poor preservation of *Jeffersonioxylon*, the important characters of the cross-field pits are equivocal. Nevertheless, *Jeffersonioxylon* does provide additional evidence for the widespread distribution of the Podocarpaceae in Antarctica during the Mesozoic (Townrow 1967a, 1967b; Jefferson & MacDonald 1981; Stockey 1989).

There have been attempts to characterize fossil wood types with little attention paid to natural affinities (e.g., Chapman & Smellie 1992). However, we believe that such systems reduce the available information on fossil plants, since they provide no opportunity to investigate the evolutionary and biogeographic distribution of plant clades through time. Although the absence of a complete suite of anatomical characters in some fossil woods such as *Jeffersonioxylon* make assignment within major groups difficult, a detailed analysis of the preserved characters is the only method that can be used to establish character variability within major taxonomic groups. When combined with other sources of information (e. g., reproductive organs, pollen, other specimens that expand the character range) this increased resolution greatly expands the opportunity to more accurately define the distribution of conifer families like the Podocarpaceae in time and space.

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