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Fossil wood from Allan Hills and Litell Rocks, Victoria Land, Antarctica

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With 22 text-figures and 1 table

Abstract

Permineralized wood from Allan Hills (Allan Nunatak), South Victoria Land, Antarctica, is anatomically described as *Araucarioxylon allanii* (KRÄUSEL) MAHESHWARI (1972). Only secondary wood is preserved without pith, primary xylem or cortex. Crushed growth rings and wood distortion are obvious the result of mechanical compaction during diagenesis. So far, only two publications are known about fossil wood specimens, collected at Allan Hills (KRÄUSEL 1962, MAHESHWARI 1972).

A fossil wood from Litell Rocks, Rennick Glacier, North Victoria Land, collected during the Antarctic summer 1982/83, is insufficiently preserved in its anatomical structure.

Kurzfassung

Mineralisierte Holzreste aus Allan Hills (Allan Nunatak), Süd Victoria Land, Antarktis, werden xylem-anatomisch anhand von Dünnschliffen als *Araucarioxylon allanii* (KRÄUSEL) MAHESHWARI (1972) bestimmt. Die Publikationen von KRÄUSEL (1962) und MAHESHWARI (1972) waren bisher die einzigen anatomischen Untersuchungen an fossilen Holzfunden aus dem Gebiet von Allan Hills.

Ein mineralisiertes Holz, gefunden im antarktischen Sommer 1982/83 in Litell Rocks, Rennick Gletscher, Nord Victoria Land, ist für eine nähere Bestimmung anatomisch unzureichend erhalten.

Contents

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1. Introduction

Only 2 % of the Antarctic continent´s bedrock is not covered by ice and thus accessible to surface examination (TINGEY 1991a, b).

Several fossil plant remains were collected by the German Antarctic North Victoria Land Expedition, GANOVEX IV, during Antarctic summer 1984/85 (TESSENSOHN & MÄDLER 1987). The plants are preserved as impressions in black shales (e.g. Equisetaceae/*Neocalamites* sp., Glossopteridales/*Glossopteris* sp., *Liquifolium* sp., Corystospermaceae/*Dicroidium odontopteroides*).

The Transantarctic Mountains form the oldest part of mobile West Antarctica, which borders the old Precambrian shield of East Antarctica at its Pacific edge (TESSENSOHN et al., 1981). The metamorphosed basement rocks of the Transantarctic Mountains are overlain by generally flat lying, non-marine cover rocks, predominantly sediments of the Beacon Supergroup. In South Victoria Land the Beacon Supergroup is subdivided in (a) a lower part of plant and fish-bearing Uppper Devonian sediments, (b) a central part of plant-bearing Permian sediments, (c) an upper part of plant-bearing Triassic sediments (TESSENSOHN & MÄDLER 1987). Late in the Permian, sedimentation in Victoria Land appears to have become geographically isolated from the Central Transantarctic Mountains (TINGEY 1991 b).

In North Victoria Land (fossil wood site of Litell Rocks) lithostratigraphic units are difficult to correlate because of the lack of a complete vertical section (COLLINSON 1989). The primary means of correlating sedimentary rock sequences in Antarctica of Late Paleozoic to Early Mesozoic age are predominantly fossil plants. More data on geological problems of Victoria Land (e.g. Allan Hills) are compiled in numerous papers (e.g. CRADDOCK 1982, FUDALI & SCHUTT 1984, GRAHAM & ANNEXSTAD 1989, SCHULTZ & ANNEXSTADT 1984).

The mineralized wood samples, collected during Antarctic summer 1984/85 at Allan Hills, South Victoria Land, are probably of Permian age.

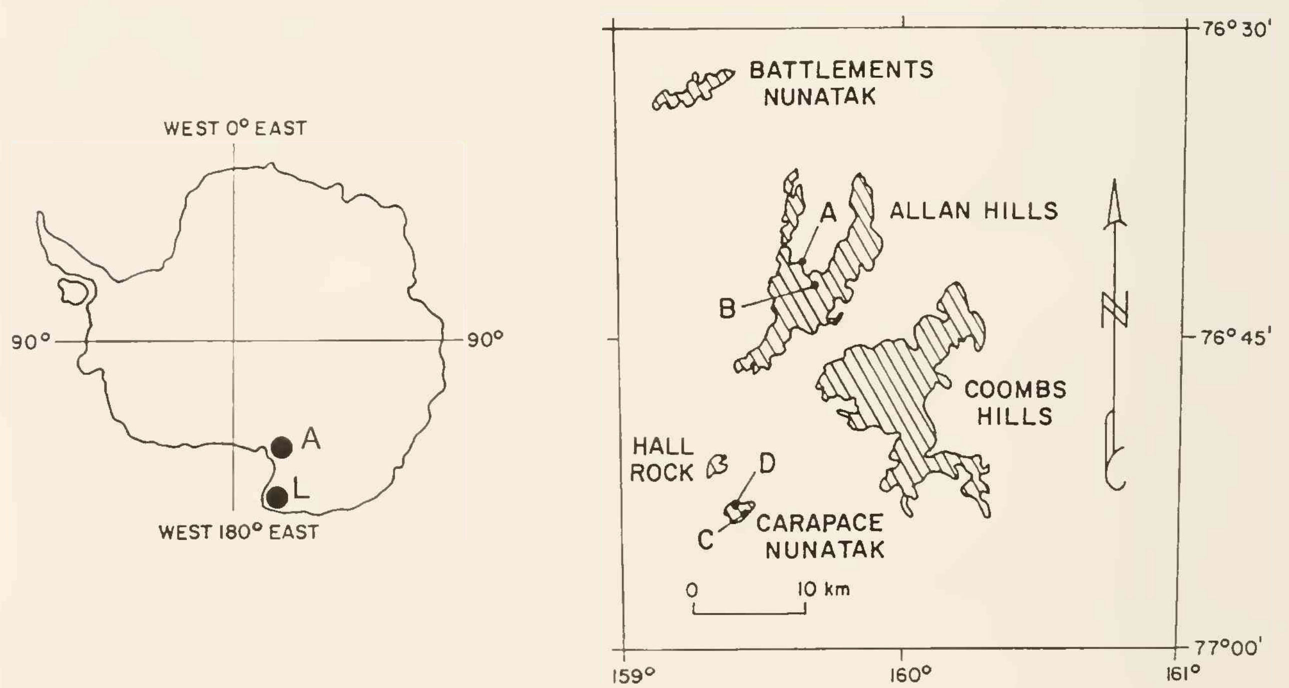

Fig. 1. Two fossil wood sites, (A) Allan Hills and (L) Litell Rocks, Victoria Land, Antarctica. Right: Nunatac Allan Hills and adjacent area. A-D of inset map are basalt localities. – After HULL, SUTTER & BORNS 1982.

The fossil wood remains from Litell Rocks (Rennick Glacier) were collected by the German Antarctic North Victoria Land Expedition GANOVEX III, during Anatarctic summer 1982/83, geological age Permo-Triassic Beacon Supergroup.

The thin-section slides from the wood remains of Allan Hills and Litell Rocks described below are deposited in the Bavarian State Collection, Munich.

2. Mineralized wood from Allan Hills

The post-Beacon Supergroup stratigraphy is relatively simple (HALL, SUTTER & BORNS, 1982). The lowest part of the sequence is exposed at Allan Hills (Allan Nunatak), South Victoria Land, Antarctica. An erosion surface with minimum relief of 50 m is cut into Beacon rocks at least as young as Permian. This surface is overlain in post-Beacon erosional valleys by

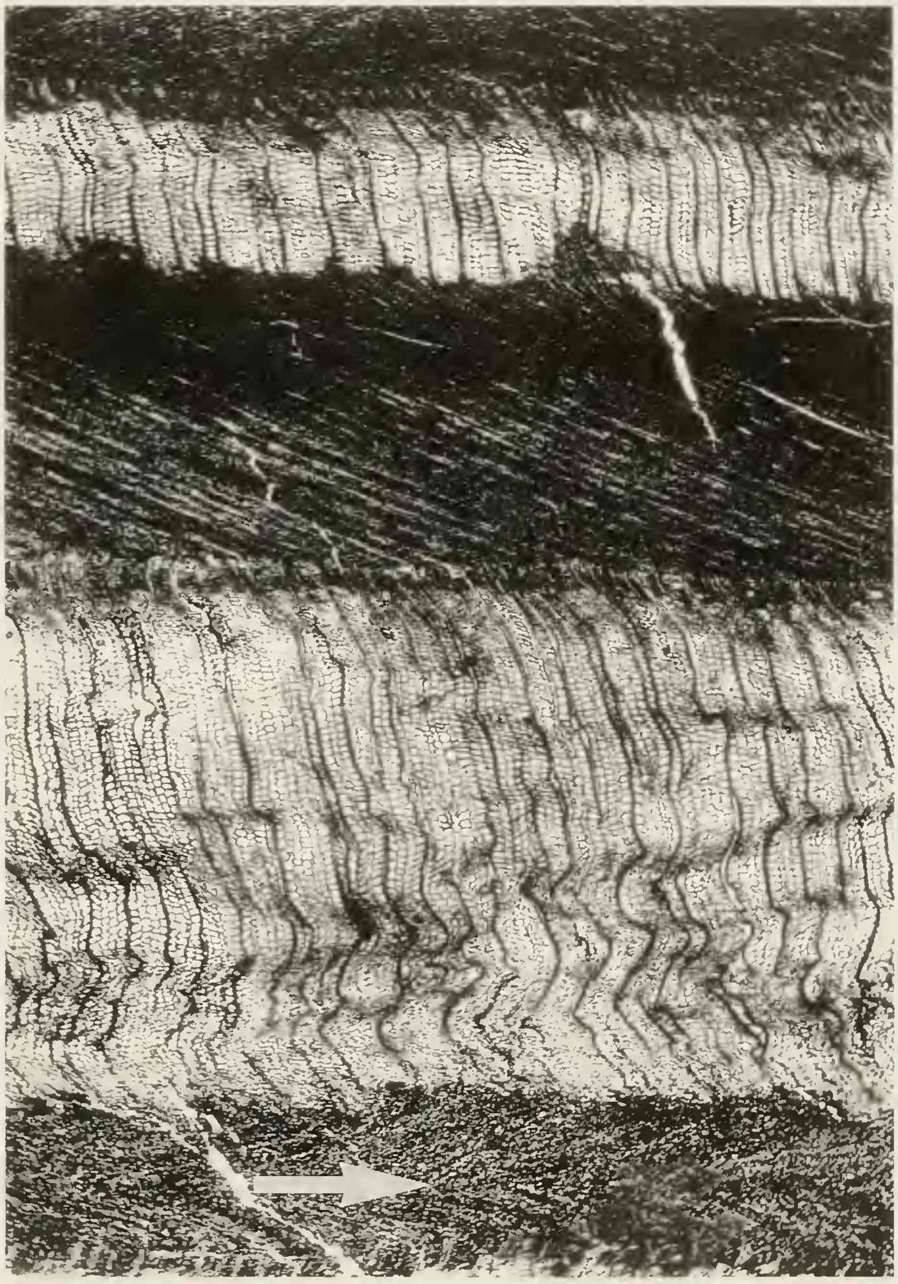

Fig. 2. Transverse section showing distorted rays and regions where the wood appears in a zig-zag pattern (arrow) due to compression of tracheids. x 25.

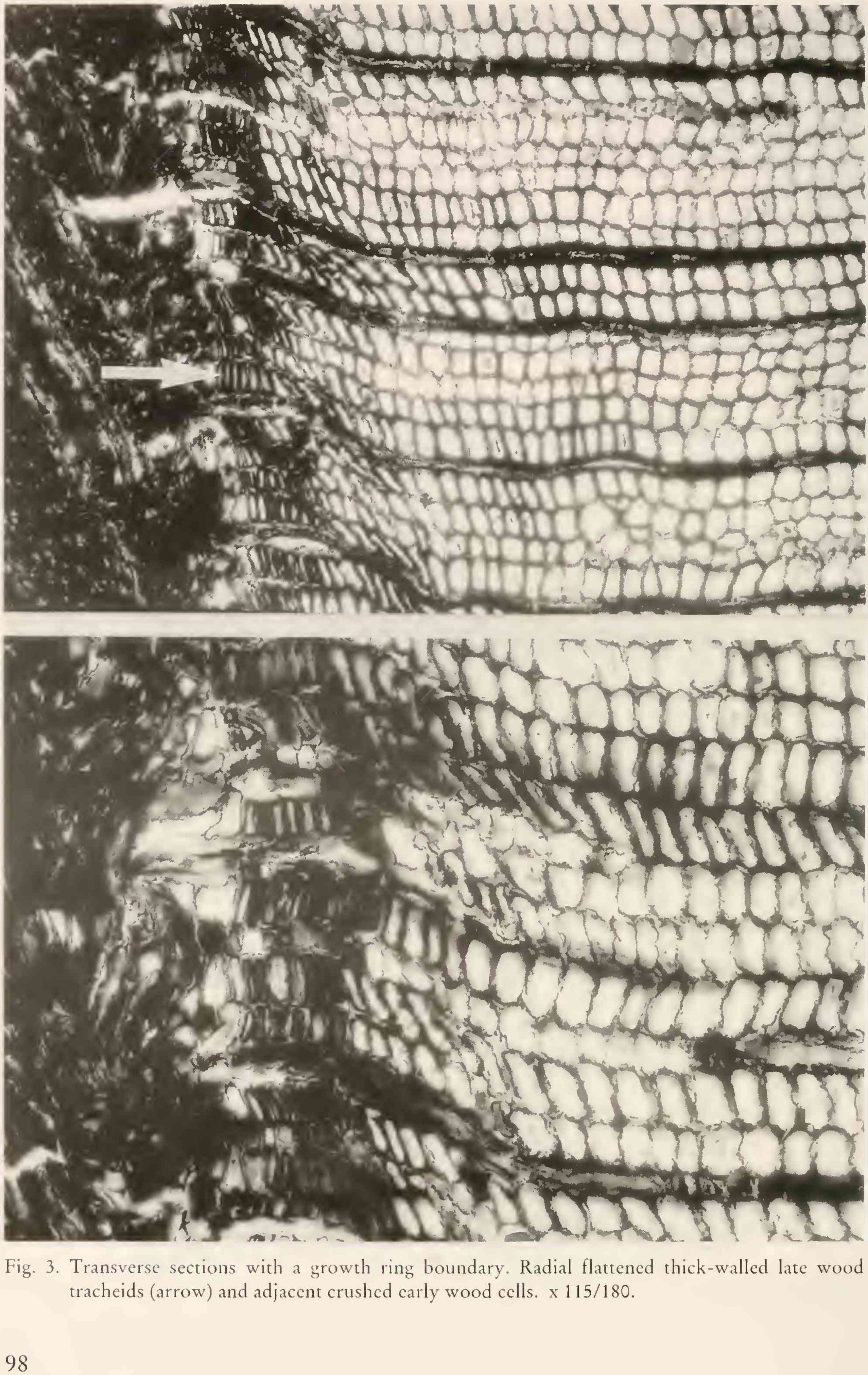

Fig. 3. Transverse sections with a growth ring boundary. Radial flattened thick-walled late wood tracheids (arrow) and adjacent crushed early wood cells. x 115/180.

sandstone and conglomerate. Extrusive and intrusive basalt and dolorite are common at Allan Hills. Igneous activity younger than the Beacon Sandstone (Triassic and older) is recorded in the Allan Hills-Carapace Nunatak area. Radiometric ages, K-Ar whole-rock data, obtained from basalt flows in the Allan Hills-Carapace Nunatak area: apparent age 185-152 (m.y.).

Fossil plants and invertebrates from the Allan and Carapace Nunataks have been described or discussed by PLUMSTEAD (1962), KRÄUSEL (1962), TOWNROW (1967) and others.

2.1 Anatomical description

Genus *Araucarioxylon* KRAUS 1870

Araucarioxylon allanii (KRÄUSEL) WAHESHWARI 1972

1962 *Dadoxylon allani* KRÄUSEL, in PLUMSTEAD, Trans-Antarctic Expedition 1955–1958, Sci. Rept., Geol., no. 9, p. 138, pl. 27, figs. 16–21, pl. 28, figs. 23-25.

Holotype: – Specimen 690/3

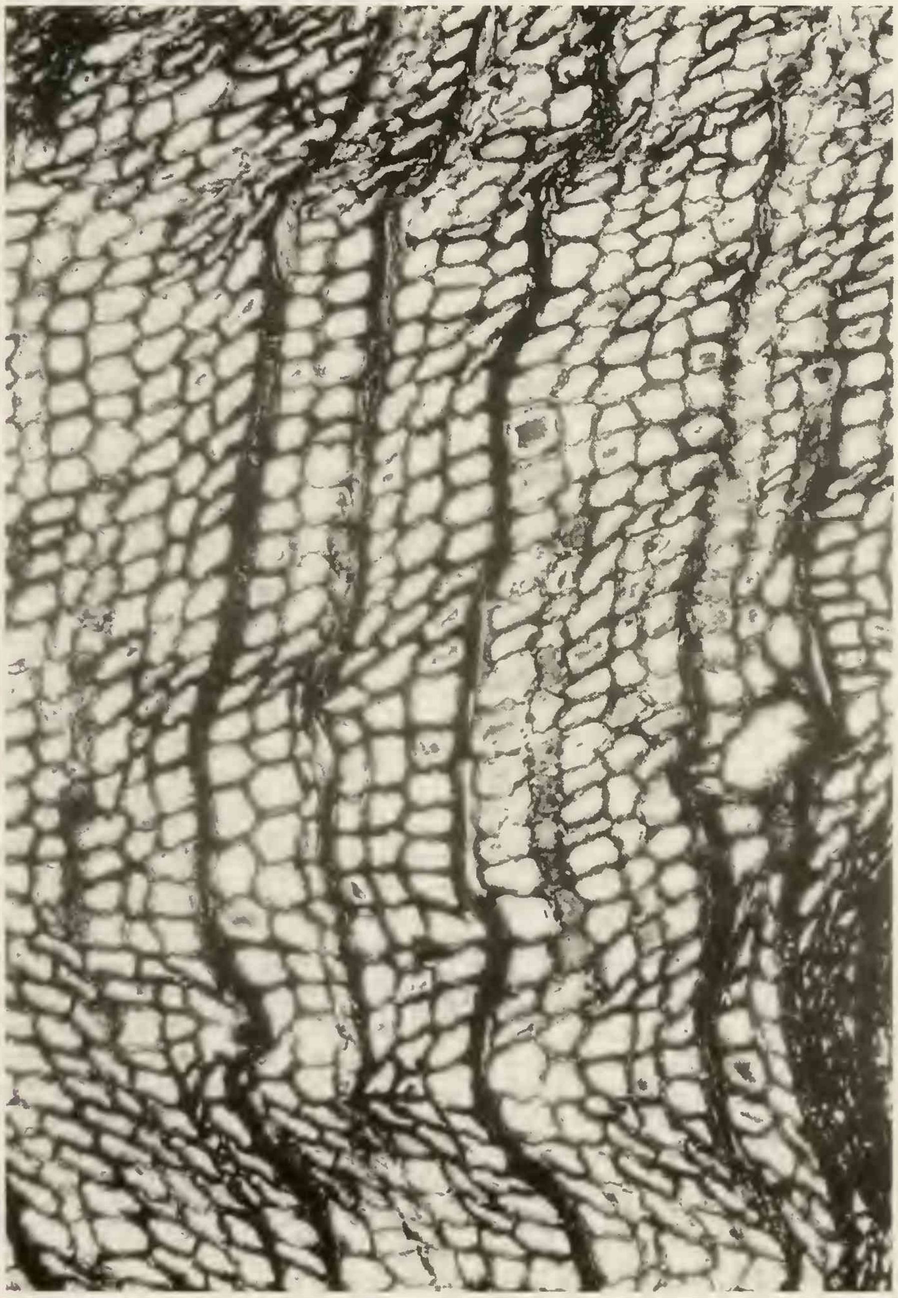

Fig. 4. Transverse section showing some crushed cells, distorted rays and radial rows of tracheids. x 115.

T y p e l o c a l i t y: Coal beds of Allan Nunatak I, South Victoria Land, near the head of the Mackay Glacier, NW of Tent Peak, 76°, 43´ S, 159°, 45´ E, Ross Sea area, Antarctica; estimated age: Permo-Carboniferous; collectors: B. Gunn and E. Warren.

1972 *Araucarioxylon allanii* (Krausel) comb. nov., Waheshwari, Palaeontographica, B, **138**, p. 23, pl. 3, figs. 1-3, pl. 4, figs. 1-5, text-fig. 9.

M a t e r i a l: Five specimens; four specimens come from the vicinity of the type locality Allan Nunatak I.

M i n u t e a n a t o m y

G r o w t h r i n g s present, about 12 growth rings crushed (Fig. 2), only two growth rings, 1,8 and 3 mm wide, are distinctly preserved; approximately 8 - 12 thick-walled and radially flattened latewood tracheids versus thin-walled early wood tracheids (Fig. 3). In some sections examined, the early wood tissue or many individual wood cells are crushed and partly

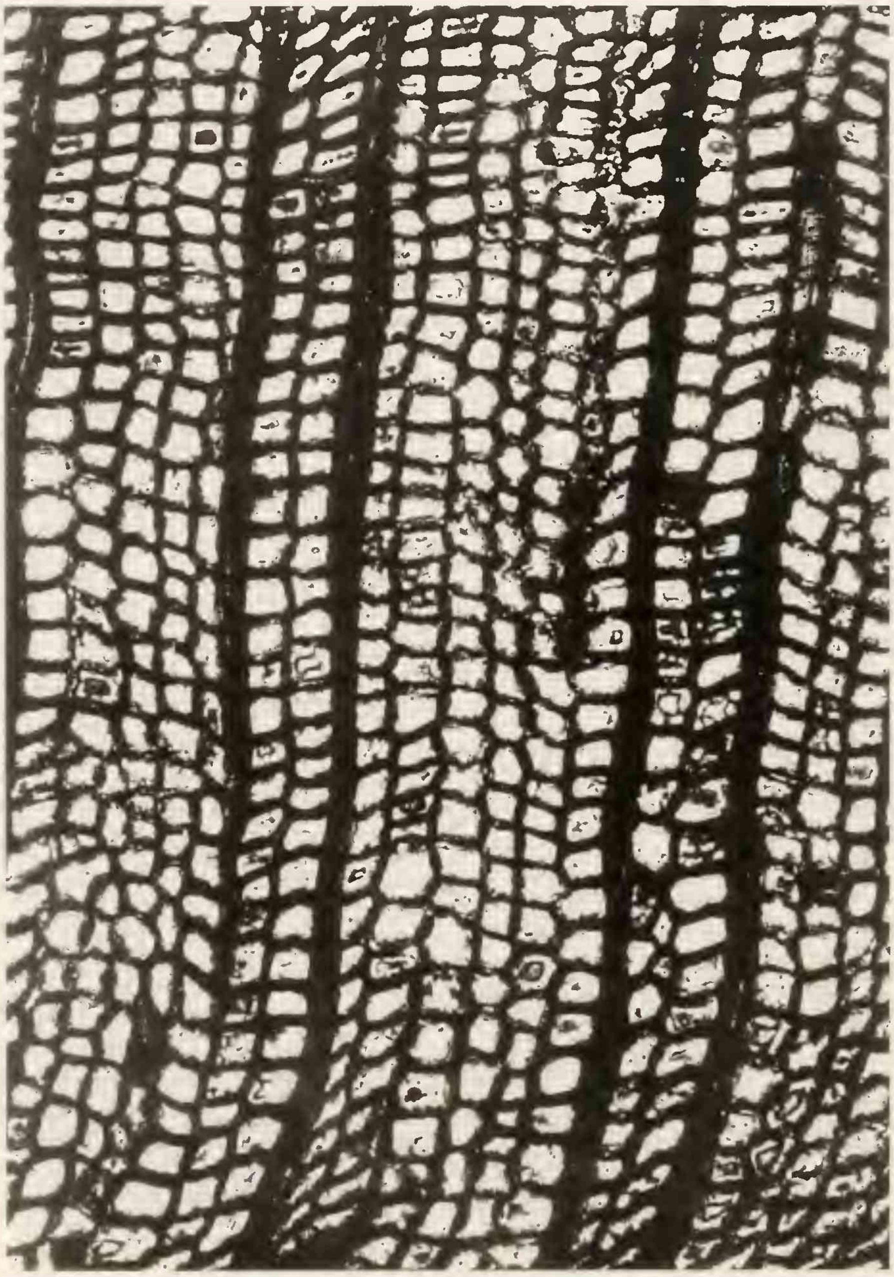

Fig. 5. Transverse section showing square-rectangular and polygonal tracheids. x 125.

extensively distorted. There are regions where the wood appears in a zig-zag pattern due to compression of the tracheids (Fig. 2). In some regions tissue is so extensive distorted that it is impossible to identify the cell walls (Fig. 2, 3).

T r a c h e i d s in cross section (Fig. 4, 5, 6) are square-rectangular or polygonal, (22-37µm) x (17-50 µm) in diameter, radial flattened late wood tracheids e.g. 11 x 38 µm (Fig. 3); approximately (tang.) 52 x (rad.) 78 tracheids per square millimetre; (1) - 2 - 5- (6 - 9) tracheid rows between two rays, 120 accounts (cross section): 1 (10), 2 (20), 3 (32), 4 (23), 5 (16), 6 (10), 7 (6), 8 (2), 9 (1); tracheid walls 5 - 6 µm thick. The tracheidal walls have decayed to a great extent, but the bordered pits are partly preserved in transverse section (Fig. 6). The length of the tracheids is difficult to mesure due to poor preservation.

A x i a l p a r e n c h y m a is not present.

R a y s are homocellular, uniseriate, partly bi- and triseriate (Fig. 7-11), rays (2)-16-21-(33) cells high and (60-836 µm, mean 210-436 µm) in height. In tangential section, the ray

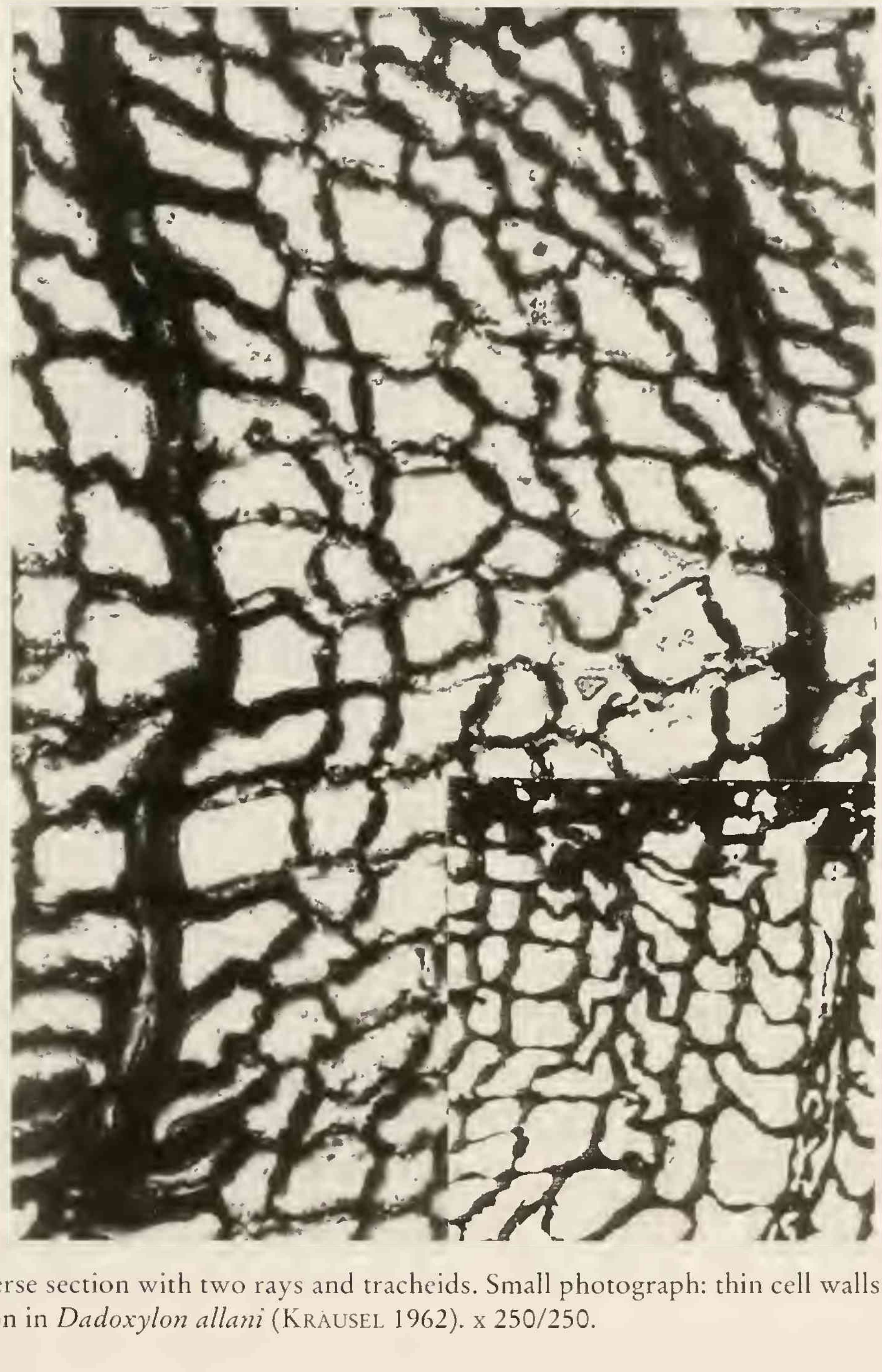

Fig. 6. Transverse section with two rays and tracheids. Small photograph: thin cell walls due to decomposition in *Dadoxylon allani* (Kräusel 1962). x 250/250.

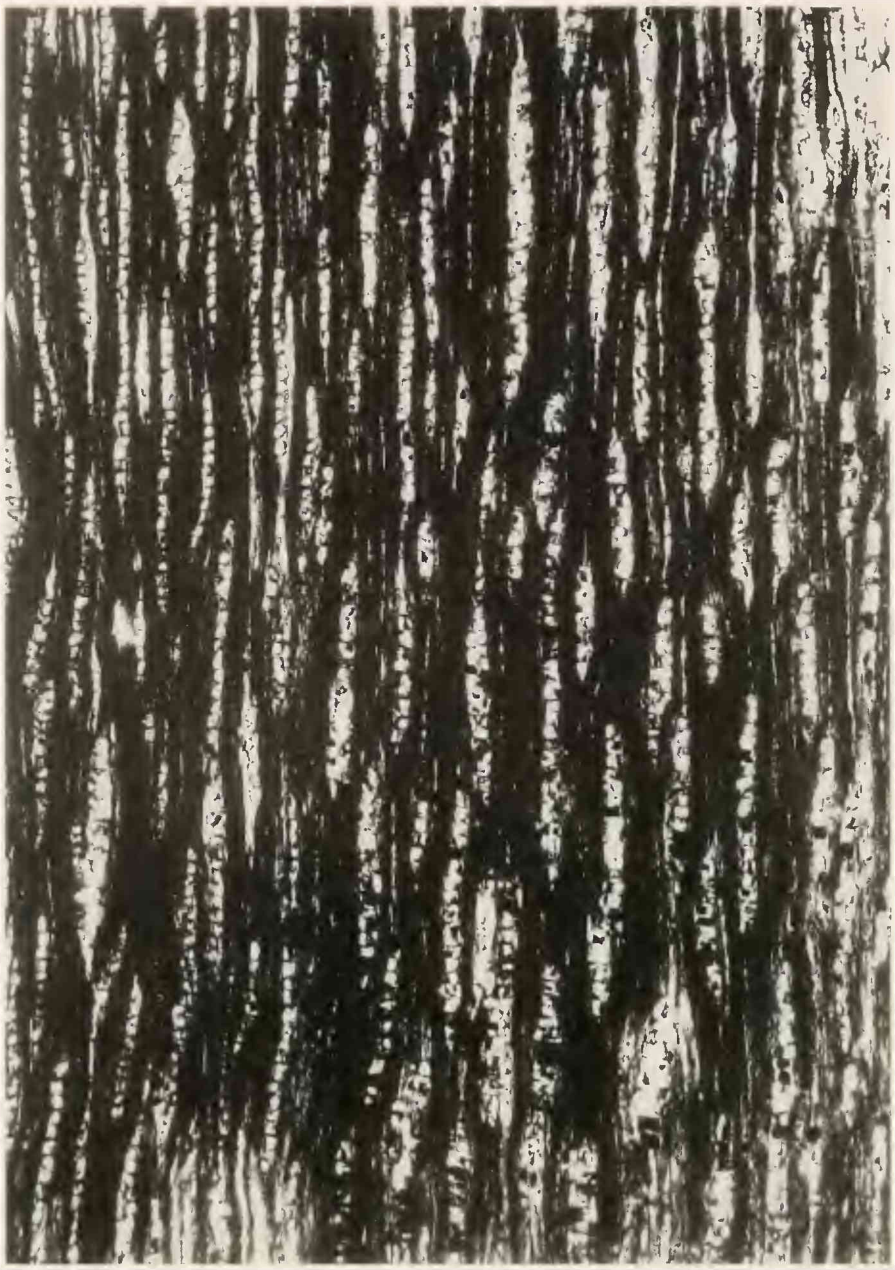

Fig. 7. Tangential longitudinal section through the secondary xylem showing homocellular rays. x 55

parenchyma cells are ovale, usually higher than broad, cells in the center of the ray are partly barrel-shaped, end cells of the rays (tangential view) are often triangular with rounded corners, e.g. 48 µm high and 36 µm broad (Fig. 10, 11). In radial section the homocellular nature of the rays is obvious. Cells appear rectangular in outline (Fig. 14). Rays 12 - 14 - (16) per mm, determined from tangential section.

P i t s on the radial walls of the tracheids are bordered, separate or contiguous, 1 - 2 - (3) seriate (Fig. 12); a radial wall (30 µm wide) with small, circular, uniseriate and separated bordered pits (e.g. 7,5 µm in diameter); multiseriate bordered pits are predominantly alternate and hexagonal (about 10 µm in diamter), partly opposite (Fig. 13), apertures of the bordered pits approximately 3,5 µm. The inner apertures are partly elliptical, but this is probably an artifact caused by distortion of circular apertures when the xylem was compacted. There are no pits on the tangential walls of the tracheids.

C r o s s - f i e l d p i t s are subcircular to oval in shape, in twenty different cross-fields are 2 - 3 - (4 - 6) pits preserved, pits about 5 - 6 µm in diameter. All cross-field pits appear to be simple (Fig. 14).

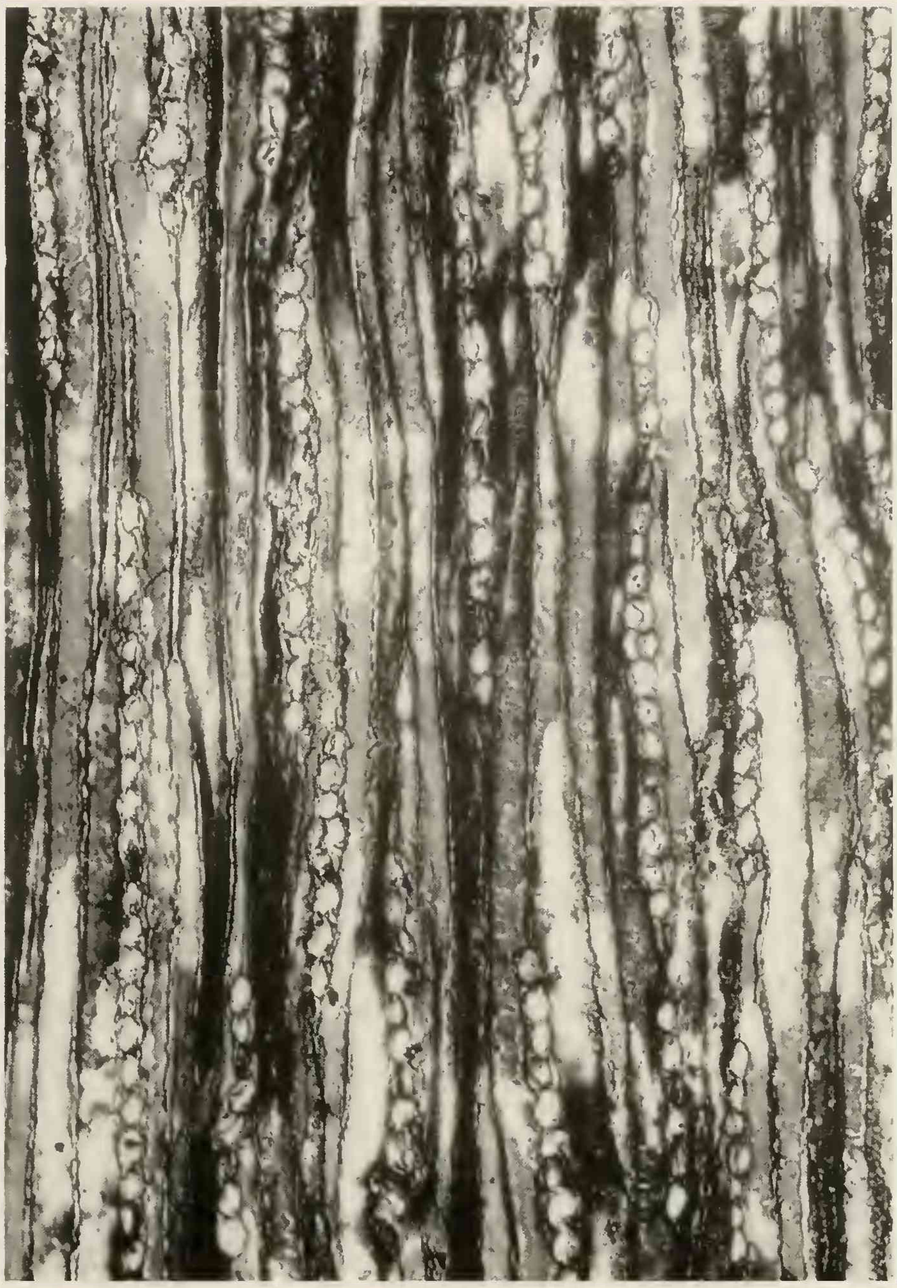

Fig. 8. Tangential longitudinal section with homocellular predominantly uniseriate rays. x 115.

D i a g n o s i s : Growth rings present; tracheids in transverse section square-rectangular or polygonal, mostly 2 - 5 tracheid rows between two rays; axial parenchyma absent; bordered pits on radial walls separate or contiguous, 1-2-(3)seriate, partly opposite; rays homocellular, 1-2-(3)seriate, 2-33 cells high, 12-16 per mm; cross-field pits simple, number 2-6.

C o l l e c t i o n l o c a l i t y : Allan Hills, South Victoria Land, German Antarctic Expedition 1984; five fossil wood specimens handed over (1987) from Prof. Dr. F. SCHULTZ, Max-Planck-Institute for Chemistry (Otto-Hahn-Institute), Mainz, Germany (Personal letter from 23. 02. 1987). No further details are available.

E s t i m a t e d a g e : Permo-Carboniferous, Beacon Supergroup.

M a t e r i a l : Five dark specimens and 12 thin-section slides with Inventar-No. BSP 1997 I 11.

2.2 Affinities

Only secondary xylem is preserved, wood tissue homoxylous, pycnoxylic; pith, primary xylem, phloem or cortex unknown; apparently wood from decorticated trunks or branches.

The present specimen from Allan Hills agrees remarkably well with the wood remains from the coal beds of Allan Nunatak (KRÄUSEL 1962; MAHESHWARI 1972). The anatomical characters seem to fall within the known range of variation of secondary wood tissue (Tab. 1). Structural features of the specimen (BSP 1997 I 11) indicate that its closest approach among the fossil woods is with the wood-type of *Araucarioxylon*, especially with *Araucarioxylon allanii* (KRÄUSEL) MAHESHWARI (1972).

The fossil wood under consideration has (crushed) growth rings (CREBER 1972), square-rectangular or polygonal tracheids in cross section, mostly 2-5 tracheid rows between two rays, 1-2-(3)seriate rays, bordered pits on the radial walls and simple cross-field pits. It is obvious that the wood distortion (crushed growth rings) is the result of mechanical compaction during

Fig. 9. Tangential longitudinal section with partly biseriate rays. x 125.

diagenesis. Crushed and compressed bands of cells have been reported on other fossil Antarctic woods (e.g. KRÄUSEL 1962, MAHESHWARI 1972, DEL FUEYO et al. 1995, Fig. 4). Fungal hyphae, common within tracheids in Lower Cretaceous conifer wood of Antarctica (JEFFERSON 1987, Fig. 12) are absent in the wood from Allan Hills.

The anatomical features between the specimen (BSP 1997 I 11) and the holotype *Dadoxylon allani* 1962 (specimen 690/3) are n e a r l y i d e n t i c a l . Square-rectangular tracheids in transverse section (Fig. 6), 1-2seriate rays in tangential section (Fig. 11) and especially the shape of simple cross-field pits (Fig. 14) can be compared side by side photographically (KRÄUSEL 1962/specimen BSP 1997 I 11).

All cross-field pits, partly poorely preserved, appear to be simple (Fig. 14). The most fundamental difference between simple and bodered pits is that in the bordered pit the secondary wall arches over the pit cavity (ESAU 1953; GOTHAN 1905; MARGUERIER 1977). In specimen (BSP 1997 I 11) no such overarching can be observed in the cross-field pits. Cross-field is a term of convenience for the 'box-shaped area' (Fig. 14), deliminated by the intersecting walls of a longitudinal tracheid and a ray parenchyma (WHEELER & BAAS 1994).

Fig. 10. Tangential longitudinal section showing uniseriate rays and a ray with a triseriate section. x 180.

Fig. 11. Tangential longitudinal section with a single biseriate ray. Small photograph: a single ray from *Dadoxylon allani* (KRÄUSEL 1962). x 250/250.

According to TRUSWELL (1991) the genus *Araucarioxylon* may represent glossopterid trunks, a common component of Antarctic Permian assemblages (*Glossopteris*-dominated vegetation). During the last decades, there has been a steady flow of papers on the paleobotany of Antarctica and India (BOSE et al. 1989; STEWART & ROTHWELL 1993). Megafossil assemblages range in age from Lower Permian to Lower Cretaceous. Triassic remains were reported from Allan Nunatak by RIGBY & SCHOPF (1967) and TOWNROW (1967). The first Permian plant fossils from Allan Nunatak, now Allan Hills, are obvious the above mentioned wood remains (KRÄUSEL 1962; MAHESHWARI 1972). Paleoenvironmental indicators and ecology of Permian/Triassic woods and petrified forests from the Transantarctic Mountains have been investigated (CUNEO et. al. 1991; JEFFERSON & TAYLOR 1983).

Wood of the genus *Araucarioxylon* has been of littel use in evolutionary interpretation since it is similar to that of cordaites, in particular the genus *Dadoxylon* (STOCKEY 1982: 150). Wood assigned to the genus *Araucarioxylon* is reported from the Lower Carboniferous to the

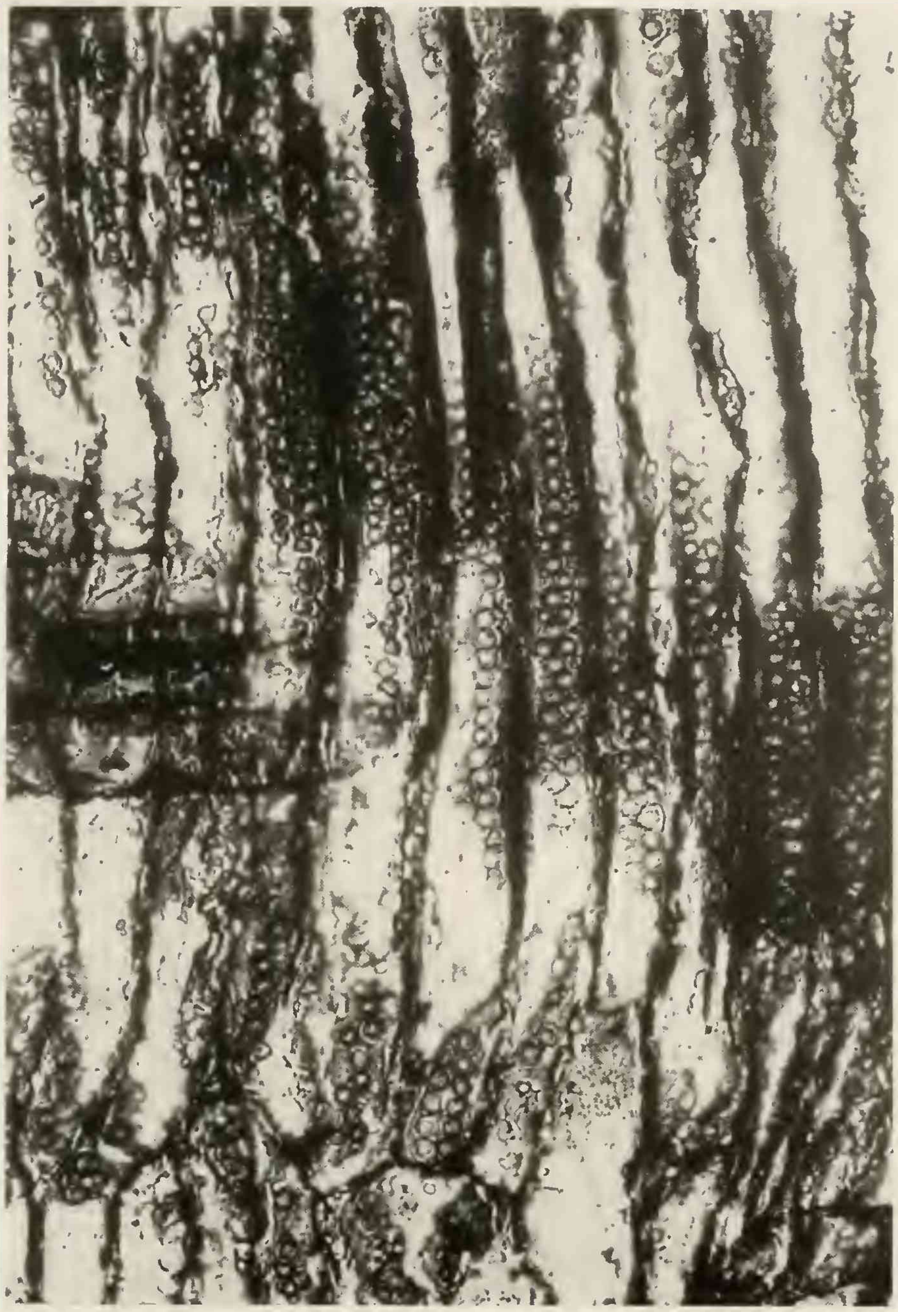

Fig. 12. Radial longitudinal section showing radial walls with bordered pits. x 250.

Tertiary. Fossil woods occur (a) in the form of secondary wood fragments, (b) in form of trunk fragments with preserved pith, primary and secondary xylem. Classification of Palaeozoic pycnoxyl woods, identified only on features of secondary wood structure, suggested by LEPEKHINA (LEPEKHINA & YATSENKO-KHMERLEVSKY 1966; LEPEKHINA 1972: 53): (1) *Araucarioxylon* KRAUS, (2) *Prototaxoxylon* KRÄUSEL & DOLIANITI, (3) *Baieroxylon* GREGUSS, (4) *Protophyllocladoxylon* KRÄUSEL, (5) *Platyspiroxylon* GREGUSS. To those five taxa about 20 additional wood-types have been classified (LEPEKHINA 1972:54). According to DEL FUEYO et al. (1995: 119) these artificial systems do nothing to improve our understanding of plant groups through time.

Table 1. Anatomical comparison of fossil wood from Allan Hills, Antarctica.

Species & Reference	Age & Locality	Stem diameter (cm)	Rays width / height (# of cells)	Axial paren-chyma
Dadoxylon allani KRAUSEL 1962	Permo-Carboniferous Allan Nunatak I	?	mostly uniseriate (1-12)	absent
Araucarioxylon allanii WAHESHWARI 1972	Permian, vicinity of Allan Nunatak I	?	uni-/biseriate (1–27)	absent
Araucarioxylon allanii 1997	? Permo-Carboniferous Allan Hills	?	uni-/bi -(tri)-seriate (1–33)	absent

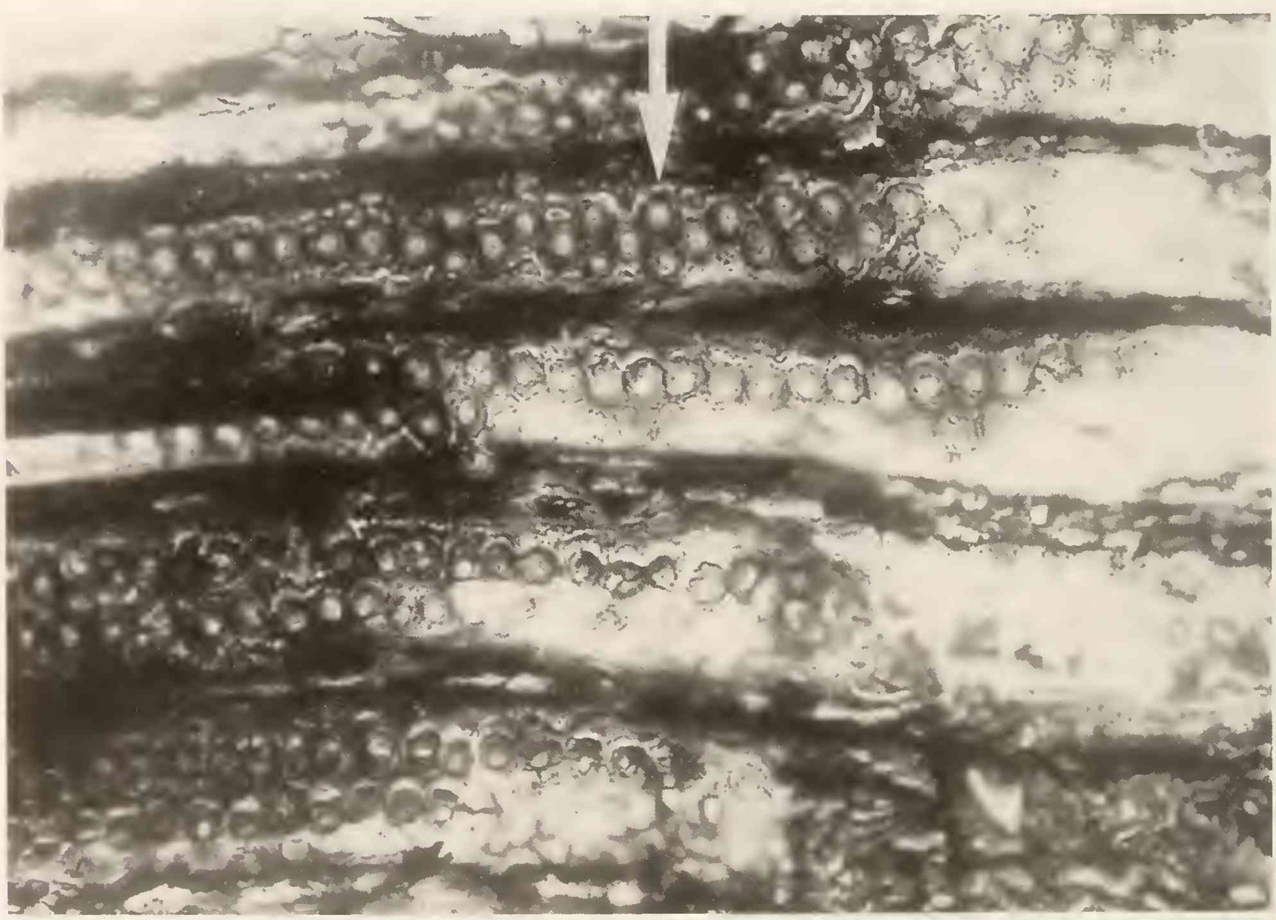

Fig. 13. Radial longitudinal section showing radial walls (a) with single rows of bordered pits, (b) with alternate or opposite (arrow) arrangement. x 250.

(Table 1 continued)

Tracheids in cross section			Bordered pits on radial walls			Cross-field pits			
shape	wall thick (µm)	diam. (µm)	shape	arrangement	diam. (µm)	no./ field	shape	diam. (µm)	inner aperture
square-rectan-gular	?	?	roundish-hexagonal	uni-/bi-/tri-, seriate, iso-lated, alternate	?	1-6-(8)	roundish-oval	?	simple
square-rectan-gular	?	?	circular, hexagonal	separate, contiguous, alternate, subopposite	?	2-6-(12)	subcir-cular to oval	?	simple
square-rectan-gular	5-6	max. 37x50	circular, hexagonal	separate, contiguous, alternate, opposite	7-10	2-6	subcir-cular to oval	5-6	simple

3. Mineralized wood from Litell Rocks

Litell Rocks is an ice-free area within the huge Rennick Glacier covering approximately 50 km^2 (Duphorn 1981). Litell Rocks, the largest nunatak in the Rennick Glacier, is situated midway between the Bowers Mountains to the east and the northern edge of the Morozumi Range to the west (Fig. 15). The Rennick Glacier surface near Litell Rocks lies between 200 and 400 m above sea level. Litell Rocks is a nunatak landscape of selective glacial erosion and drumlinization. More details and results of physiographical and glacio-geological research have been obtained during GANOVEX 1979/80 (Duphorn 1981).

3.1 Anatomical description

In all of the dark thin slides studied, only secondary xylem is preserved without pith, primary xylem or cortex.

Tracheids in transverse section are generally in an extremly poor state of preservation, partly square-rectangular, probably 2-9 tracheid rows between two rays (Fig. 16). The tracheid walls have decayed to a great extent (Fig. 17). Rays and tracheids in tangential view distorted (Fig. 18). Radial walls of the tracheids with bordered pits, uni- and biseriate, occasionally opposite (Fig. 19, 20), circular bordered pits e.g. about 11 µm in diameter (Fig. 21). Cross-field pits minute (? artefact), number 6-7, probably 2 µm in diameter (Fig. 22). This wood is so badly preserved, that no further details can be recognized. A closer definition is therefore impossible.

Collection locality: Litell Rocks, about 162° E, 71° 25´ S; pebble (debris) of the Rennick Glacier, North Victoria Land, Antarctica, German GANOVEX III - Expedition, Antarctic summer 1982/83; collector: S. Ulitzka, Mineralogical Institute, University Würzburg, Germany.

Estimated age: Permo-Triassic, Beacon Supergroup.

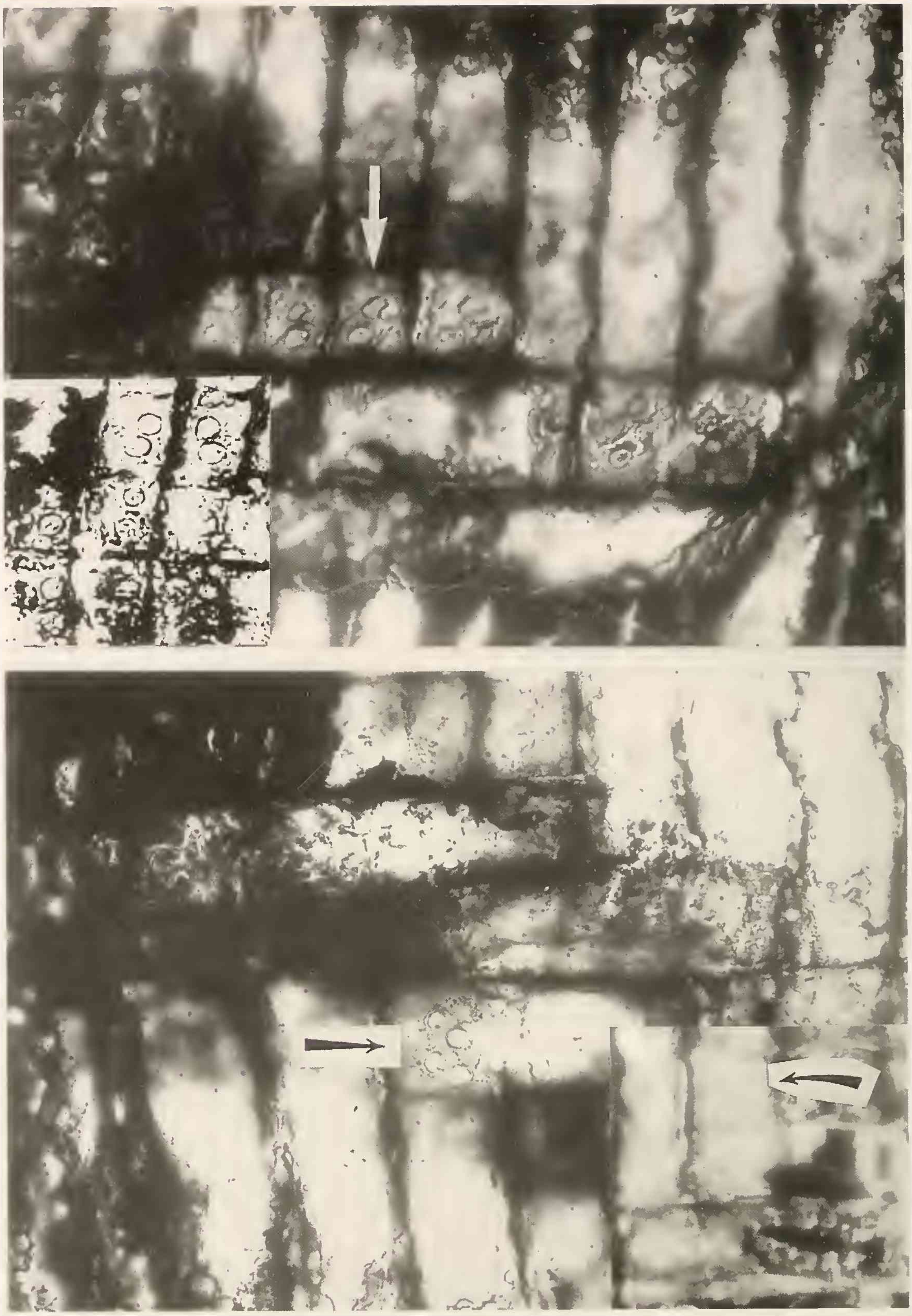

Fig. 14. Radial longitudinal section with simple cross-field pits. A b o v e : 2 simple pits (arrow); small photograph, *Araucarioxylon allanii* (MAHESHWARI 1972). x 520/500. B e l o w : 4 - 6 simple cross-field pits (2 arrows). x 520/400.

Fig. 15. Locality map of North Victoria Land showing the main distribution of glaciers and areas with bare rocks. Fossil wood site of Litell Rocks is a ice-free area within the huge Rennick Glacier (arrow) - After DUPHORN 1984.

Fig. 16. Transverse section showing badly preserved secondary xylem with ? rays and tracheids. x 55.

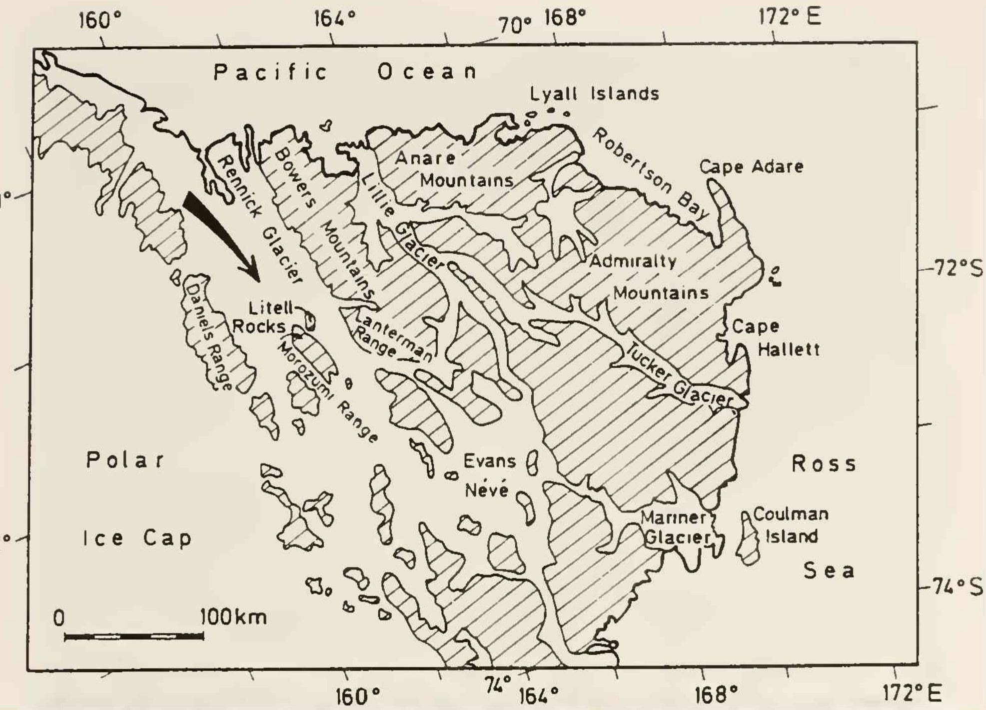
160°
164°
70°
168°
172° E
Pacific Ocean
Lyall Islands
Robertson Bay
Cape Adare
Anare Mountains
Rennick Glacier
Bowers Mountains
Lillie Glacier
Admiralty Mountains
70°
-72°S
Litell Rocks
Daniels Range
Lanterman Range
Morozumi Range
Cape Hallett
Tucker Glacier
Polar
Ice Cap
Evans Névé
Ross
Sea
Mariner Glacier
Coulman Island
72°
-74°S
0
100km
160°
74°
164°
168°
172° E

Fig. 15

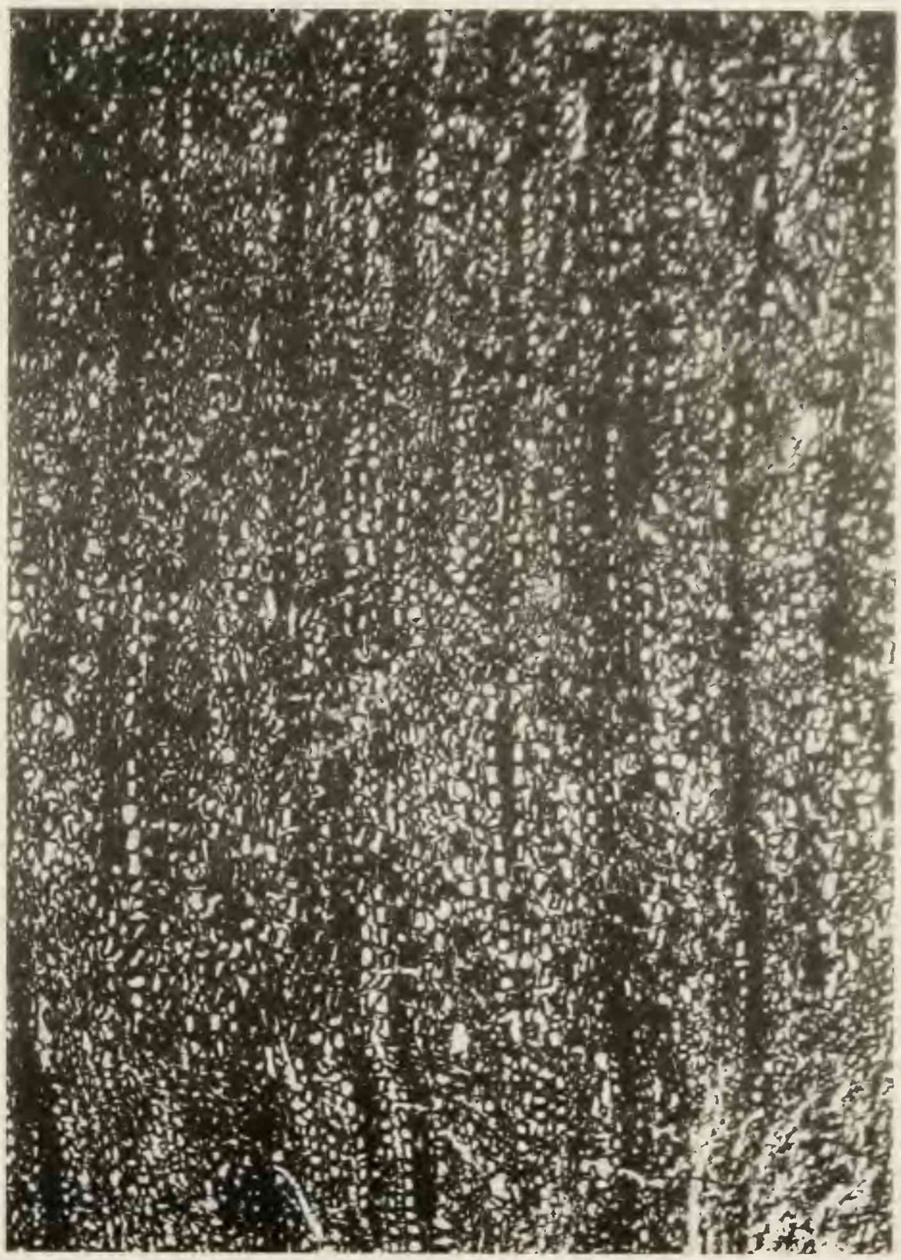

Fig. 16

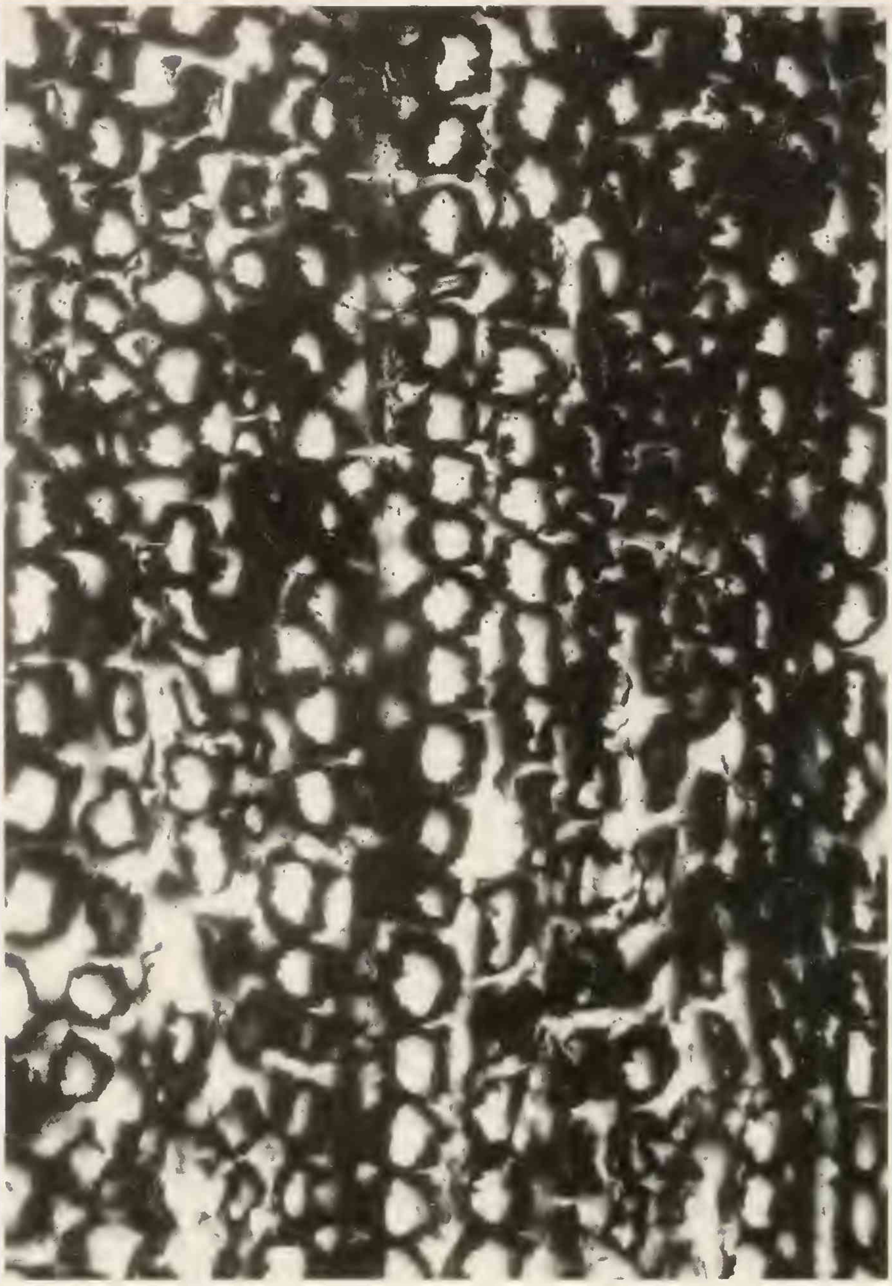

Fig. 17. Transverse section showing distribution of tracheids with thick secondary wall. x 250.

M a t e r i a l : One dark specimen and 13 thin-section slides with Inventar-No. BSP 1997 I 10; fossil wood with red weathering crust, desert varnish (lacqua) of the cold desert.

4. Fossil wood from Antarctic and Gondwana

Petrified gymnosperm woods from the southern hemisphere are common in strata ranging from the late Palaeozoic to the Tertiary. Numerous taxa have been described since (1898) from all parts of Gondwana: Antarctica, Argentina, Australia, India, New Caledonia, New Zealand, Madagascar, South Africa (Del Fueyo et al. 1995).

Stockey (1989) has given a valuable survey about the coniferalean remains from Antarctica and Gondwana, excluding ginkgophytes. According to Stockey the study of fossil plants and the conifers in particular is in its infancy. Among the extant conifer families, Araucariaceae and Podocarpaceae are dominant in Gondwana. Wood from an *in situ* permineralized forest from

Fig. 18. Tangential longitudinal section showing distorted rays. x 125.

the Middle Triassic of Gordon Valley (Transantarctic Mountains) has been described as *Jeffersonioxylon gordonense* (Del Fueyo et al., 1995). Including *J. gordonense* seventeen select conifer woods from Gondwana have been compared anatomically (rays, axial parenchyma, tracheids, intertracheary pits, cross-field pits), see table 1, p. 120 - 121 (Del Fueyo et al. 1995).

'Antarctic Paleobiology' (Taylor, T. N. & Taylor E. L. 1989) provides a valuable comprehensive overview of the paleobotany (palynology) in Antarctica and examines the interrelationships of Antarctic floras to those of other Gondwana continents. An extensive annotated bibliography rounds off the presentation. The reference list contains 374 entries.

Fig. 19. Radial longitudinal section with bordered pits on radial walls. x 125.

5. Acknowledgements

I am indebted to Prof. Dr. L. Schultz (Mainz) and K.-P. Kelber (Würzburg) for handing over the plant fossils for anatomical study and for all accompanying informations. Thanks are due to H. Mertel (thin-section slides) and R. R. Rosin, Institute for Wood Research (film procession, prints), both Munich.

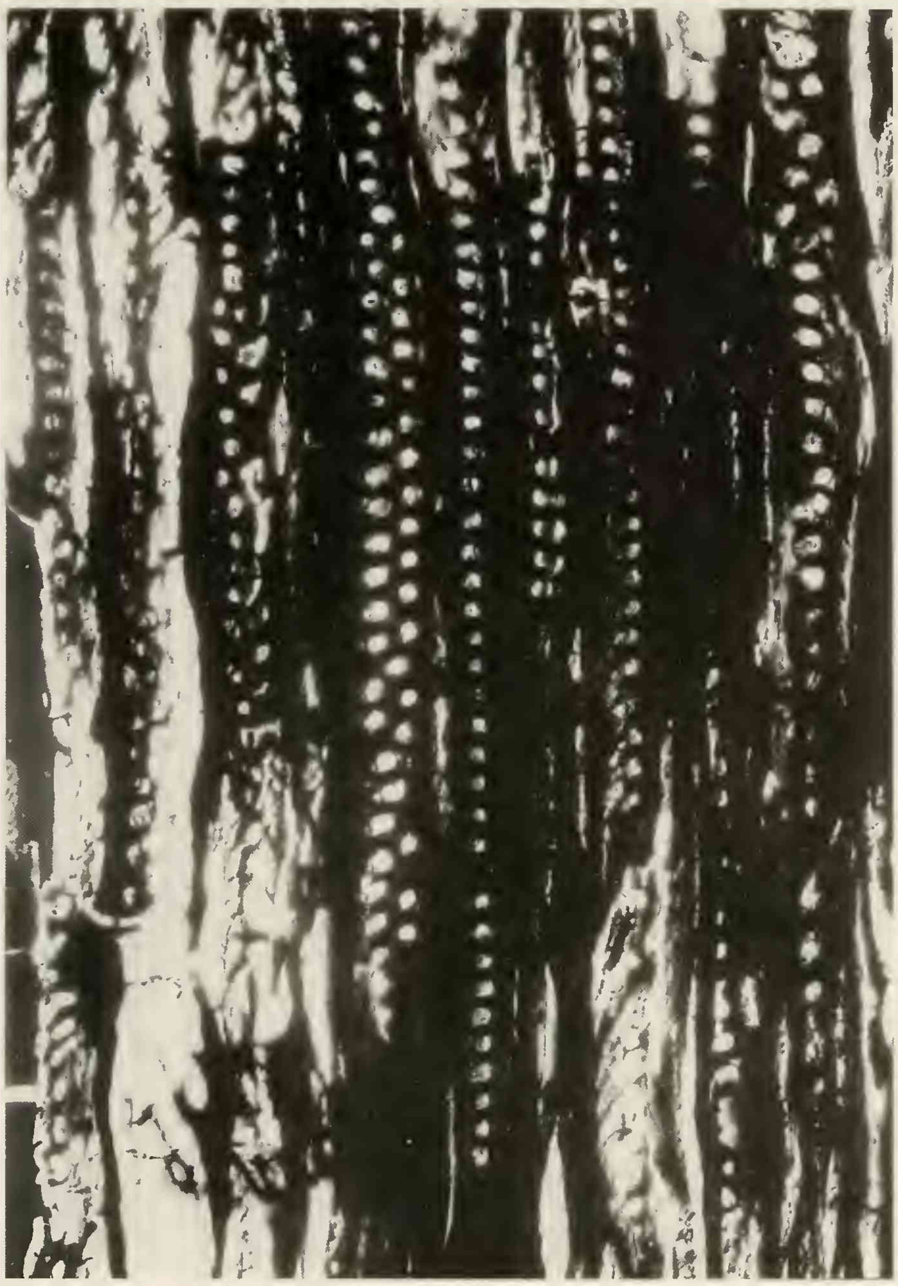

Fig. 20. Radial longitudinal section showing radial walls with uni- and biseriate rows of borderd pits. x 250.

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Fig. 21. Radial longitudinal section showing a radial wall with circular bordered pits. x 520.

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Fig. 22. Radial longitudinal section with 7 minute cross-field pits (arrow). x 520.

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