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Cover illustration: The ammonite *Dorsetensia liostraca* Buckman from the Lower Bajocian (Middle Jurassic) Giganteuston Member of Öschingen, Middle Swabian Alb, Germany. For details, see Dietze, V. et al.: The Giganteuston Member of Öschingen (Humphriesianum Zone, Lower Bajocian, Swabian Alb), with comments on the genera *Dorsetensia* Buckman, 1892 and *Nannina* Buckman, 1927, pp. 209–236 in this issue.
Back cover: Atrium of the Munich Palaeontological Museum, view from the main entrance.

Umschlagbild: *Dorsetensia liostraca* Buckman, ein Ammonit aus dem Giganteuston des Unter-Bajociums (Mittlerer Jura) von Öschingen, Mittlere Schwäbische Alb, Deutschland. Für weitere Informationen siehe Dietze, V. et al.: The Giganteuston Member of Öschingen (Humphriesianum Zone, Lower Bajocian, Swabian Alb), with comments on the genera *Dorsetensia* Buckman, 1892 and *Nannina* Buckman, 1927, S. 209–236 in diesem Heft.
Rückseite: Lichthof des paläontologischen Museums München, Blick vom Haupteingang.

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Lower Cretaceous conifer drift wood from Sverdrup Basin, Canadian Arctic Archipelago

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Abstract

A small collection of calcified drift wood from Lower Cretaceous (Valanginium) sediments in the high northern latitude (>70°N) arctic Canada was anatomically examinded. The woods provide evidence of conifer-dominated forests that extended across the northern polar regions during greenhouse periods. Four specimens are assignable to *Protopiceoxylon* Gothan, two to *Dacrydioxylon* Greguss, and one to Coniferophyta indet. This paper documents the first xylem record of a fossil wood from the family Podocarpaceae, morphogenus *Dacrydioxylon*, in the Northern Hemisphere at high latitudes. Modern *Dacrydium* representatives thrive in areas close to the equator or in the Southern Hemisphere. The drift wood sampels were collected in 1974 by Edwin Kemper of Hannover (Germany). A special feature of the Canadian Valanginium sediments are unusual crystal aggregates in dark marine shales, so-called glendonites. These glendonites indicate low water temperatures and special climatic conditions during the polar marin sedimentation.

Key words: Cretaceous drift wood, Canadian Arctic, glendonites, Piceaceae, Podocarpaceae, Sverdrup Basin, wood anatomy

Zusammenfassung

Kalzifizierte Treibhölzer aus der Unteren Kreide (Valanginium) der nördlichen kanadischen Arktis (>70°N) wurden anatomisch untersucht. Zwei Holzfunde von Inseln des Sverdrup Beckens gehören zu *Dacrydioxylon* Greguss, vier zu *Protopiceoxylon* Gothan und einer konnte nicht näher bestimmt werden. Von besonderem Interesse ist der Fund von *Dacrydioxylon* (Podocarpaceae), da er den ersten xylem-anatomischen Nachweis dieser Familie aus Schichten der Unteren Kreide innerhalb hoher Breiten der nördlichen Hemisphäre darstellt. Rezent ist *Dacrydium* (Schuppeneibe) nur äquator-nah und vorwiegend süd-hemisphärisch verbreitet. Aufgesammelt hat die hier vorliegenden Proben bereits 1974 der Geologe Edwin Kemper aus Hannover. Erwähnenswert ist das Vorkommen von eigenartigen fossilen Kristallen, so-genannten Glendoniten, in den Sedimentschichten des Valanginiums. Es sind Calcit-Pseudomorphosen entstanden nach Ikait, der $CaCO_3$-Modifikation bei tiefen Temperaturen. Die Glendonite gelten als Nachweis für spezielle polarmarine Ablagerungsbedingungen und ermöglichen als Paläothermometer Rückschlüsse auf marine Kaltzeit-Klimate.

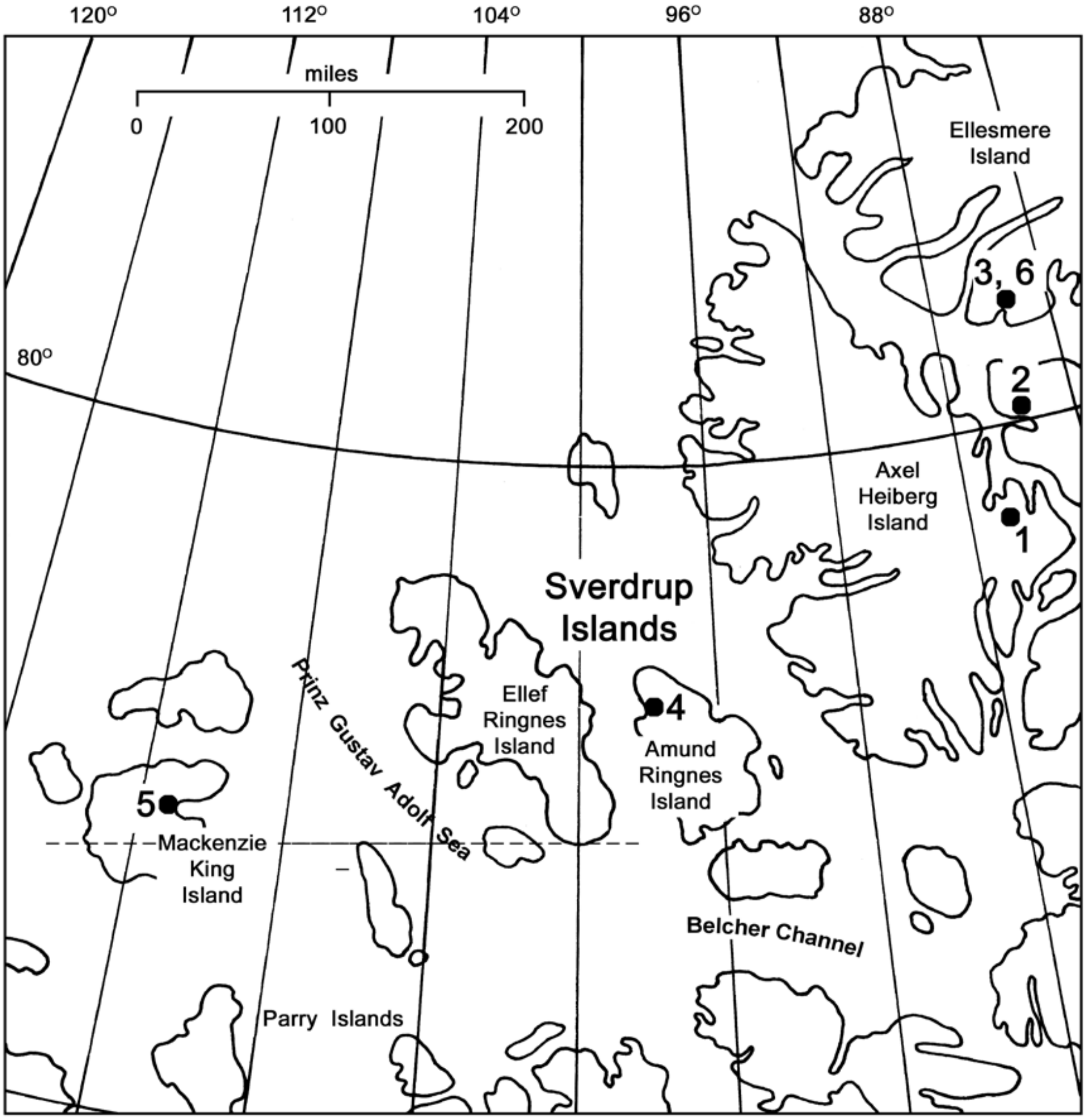
Schlüsselwörter: Arktisches Kanada, Glendonite, Holzanatomie, Piceaceae, Podocarpaceae, Sverdrup Becken, Untere Kreide.

1. Introduction

During the last 10 years, numerous projects have been instituted that aimed at identifying fossil wood and other megafossil plant remains from high latitude (>60°) localities in Alaska, the Canadian Arctic, Spitsbergen, as well as other polar regions (e.g., Harland et al. 2007; Jagels et al. 2001; LePage et al. 2003; Spicer 2003; Wheeler & Arnette 1994).

In the high northern latitudes (>60°), climate during the greenhouse periods of the late Mesozoic and Cenozoic was sufficiently warm for the growth of extensive conifer-dominated forest ecosystem. These forests grew under an unusual light regime composed of long dark winters and summers with continuous sunlight (Chaloner & Creber 1990; Spicer et al. 2002; Skelton 2003). In the Northern Hemisphere there are no modern analogues for these forests. The present tree line does not extend far behind 70° N (Wilmking & Juday 2005). The forests of the Sverdrup Basin (Axel Heiberg and Amund Ringness Islands) appear to have been dominated by the conifers *Cedroxylon* and *Piceoxylon*. More detailed information on Northern Hemisphere Cretaceous (Albian-Aptian) conifer wood anatomy, taxonomy, biodiversity and climatic interpretation can be found in Harland et al. (2007).

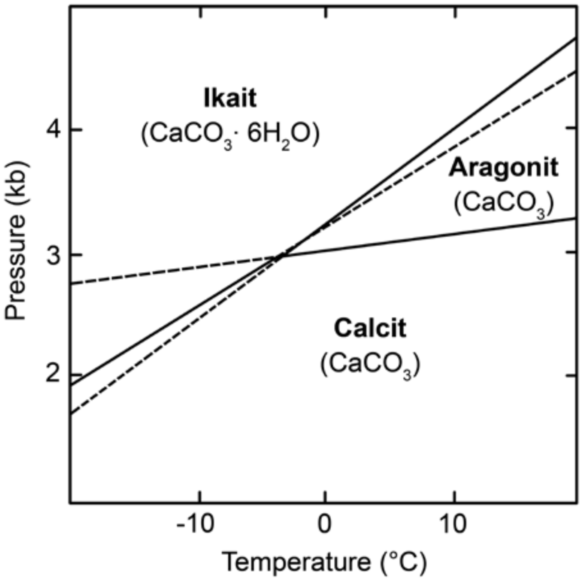
Olaf Sverdrup (1850–1930) from Norway was the first scientist to study the geology of the Canadian



Textfigure 1: Sample localities of conifer driftwood in the Sverdrup Basin, Canadian Arctic Archipelo, carbonized wood collected by Edwin Kemper, June 1974. **1** Axel Heiberg Island, 7 km southwest of Buchaman Lake. – *Coniferoxylon* indet. **2** Ellesmere Island, Reptile Creek near Eureka meteorological Station. – *Protopiceoxylon.* **3a** Ellesmere Island, Blackwelder Mountains north of Greely Fjord. – *Protopiceoxylon*. **3b** Ellesmere Island, Blackwelder Mountains north of Greely Fjord. – *Dacrydioxylon*. **4** Amund Ringnes Island, NW-part of the Island. – *Protopiceoxylon*. **5** Mackenzie King Island, northern part of the Island. – *Dacrydioxylon*. **6** Ellesmere Island, Blackwelder Mountains north of Greely. – *Protopiceoxylon*.

Arctic (Sverdrup 1903). The wood samples described in this paper were collected at six different localities in the Sverdrup Basin (Textfig. 1) by Edwin Kemper, Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, Germany, during a geological research expedition in 1974 under the title of a joint project organized by the Geological Survey of Canada and the Bundesanstalt für Geowissenschaften und Rohstoffe. The object of the field work in 1974 was to take and study geological profiles in the upper part (Berrasian and Valanginian) of the Deer Bay Formation of the Sverdrup Basin. Rock samples, mega-invertebrates, ammonites, and driftwood was collected during this field campaign.

The upper Deer Bay Formation (Valanginian) is characterized by a mass occurrence of driftwood. The abundance of wood remains in Valanginian sediments in arctic Canada stands in sharp contrast to the usual scarcity of wood remains in comparable strata of Early Createceous age in central Europe. Kemper (1987) suggested that the unusual mass accumulation of driftwood in the upper Deer Bay Formation may be due to decreased biological destruction in cold-water conditions. The wood samples are the remains of trees that lived relatively close to the coastline. Pieces of wood were washed into the water and subsequently preserved by calcite mineralization within black mudstones under deep marine conditions.



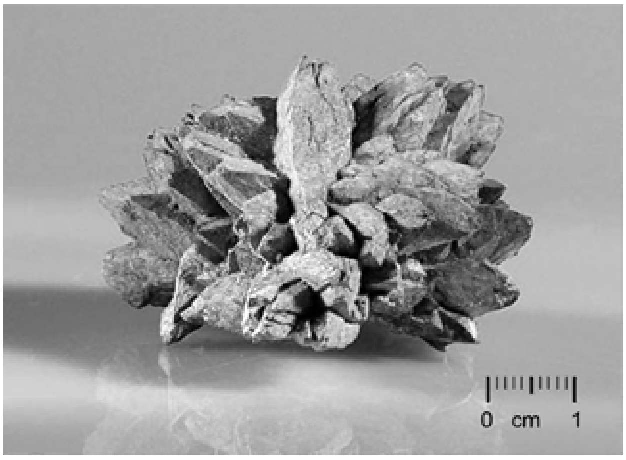
Textfigure 2: Stability relations of the various forms of calcium carbonate. – Aragonit (rhombical), Calcit (hexagonal/trigonal), Ikait (monoclin). The mineral Ikait, a hydrated $CaCO_3$, crystallizes to form stellate aggregates at around 0 °C. – Revised after Kemper (1987: fig. 3).

A distinct specific indicator for climatic analysis of the upper Deer Bay Formation in the Sverdrup Basin is the abundant occurrence of so-called glendonites. The dark, marin, cold water clays of the upper Deer Bay Formation contains numerous layers characterized by large quantities of glendonites (Kemper 1987; Kemper & Schmitz 1981). Glendonites are pseudomorphs, calcite replacements of the mineral Ikaite, a low temperature/high pressure form of hydrated $CaCO_3$ (Textfigs 2, 3). Glendonites are predominantly star shaped, stellate aggregates, and range in size from walnut to fist dimensions. Their occurrence is restricted to marine shales and mudstones, and they can be used as geological thermometers, as indicators of a polar depositional environment in connection with the fossil biotope conditions of the drift wood.

2. Material and Methods

The Deer Bay Formation of the Sverdrup Basin in high arctic Canada is assigned to the Cretaceous stage Valanginian. Absolute age estimates for the Valanginian stage vary from 136,5–132,0 to 140,2–133,9 Ma, according to Skelton (2003) and the International Stratigraphic Chart (2008).

A total of seven wood specimens were processed and examined. Four of these specimens come from Ellesmere Island, the others from Amund Ringnes Island, Axel Heiberg Island, and Mackenzie King Island (Textfig. 1). The specimens were nocked off in the field from calcified stems with a diameter of about 10–15 cm (Kemper 1987: Taf. 5, Figs 1–3). Several specimens in transverse section show coniferous xylem tissue with distinct growth ring boundaries already at low magnification (Kemper 1987: Taf. 5, Figs 4a–5c). The standard sections (transverse, radial longitudinal, tangential longitudinal) were prepared in 1975 at the Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover. In total, 56 thin sections are available that are kept in the collection of the BGR under accession numbers BGR Ma 13134–BGR Ma 13189.



Textfigure 3: Glendonite aggregate, Original Kr379, from Sverdrup Basin, Lower Cretaceous. – Courtesy of the Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover; image: A. Weitze.

The thin sections were examined under transmitted light stereo and compound microscopes. Images were captured with a Zeiss Ultraphot analog camera, digitally remastered and processed using Adobe Photoshop 7,0. The geological age and preservation of wood-anatomical features does not allow for more than identification to morphogenus level. In addition, differences in the anatomical structure of mature stem, root or branch wood between fossil and modern samples must be considered. No attempt was therefore made to identify the specimens to the level of fossil species. We follow here the considerations in the study of Cretaceous wood from Spitsbergen and the Canadian Arctic Archipelago (Harland et al. 2007).

The samples are described and identified using the “IAWA List of microscopic features for softwood identification” (Richter et al. 2004) and other standard descriptions and identification keys (e.g., Philips 1941; Kräusel 1949; Greguss 1955; Medlyn & Tidwell 1979; Barefoot & Hankins 1982). The fossils were compared with wood samples of modern trees kept in the thin section collection of the Xylothec, Wood Research Institute, Technical University Munich.

A special problem regarding the taxonomic nomenclature concerns the name *Dacrydioxylon.* In 1967, Pál Greguss proposed several new generic names for homoxylous woods that subsequently became houshold names and are still widely used in paleobotany today. A recent critical review of Greguss' work (Philippe et al. 1999) based on re-examination of the original material and protologues, however, concluded that several of the genus names (including *Dacrydioxylon* Greguss, 1967: 66) are in fact not valid because type species are not designated. Nevertheless, we here use the widely accepted name *Dacrydioxylon*.

3. Xylotomical investigation

3.1 *Protopiceoxylon*

Coniferales
Family: Pinaceae Lindley, 1836
Organ genus: *Protopiceoxylon* Gothan, 1907
Type species: *Protopiceoxylon extinctum* Gothan, 1907

Protopiceoxylon sp.

Locality 2 (Pl. 1, Figs 1–3; Pl. 4, Figs 1–4): Ellesmere Island, Reptile Creek, near Eureka metereological station. Edwin Kemper collection No. 2 (Textfig. 1).

Material: Eight thin sections, BGR Ma 13146–13153; 5 x TS, 1 x TSL, 2 x RSL; sectional area, min. (1,0 x 3,1), max. (2,1 x 2,6) cm^2.

Locality 3 (Pl. 2, Figs 1–4; Pl. 3, Figs 1–4): Ellesmere Island, Blackwelder Mountains north of Greely Fjord. Edwin Kemper collection No. 3 (Textfig. 1).

Material: Seven thin sections, BGR Ma 13154 –13160; 4 x TS, 1 x TSL, 1 x RSL; sectional area, min. (0,6 x 0,8), max.(2,1 x 3,2) cm^2.

Locality 4: Amund Ringnes Island, NW-part of the Island. Edwin Kemper collection No. 4 (Textfig. 1).

Material: Five thin sections, BGR Ma 13166 – 13170; 2 x Q, 1 x T, 3 x R; sectional area, min. (1,3 x 0,8), max. (2,5 x 3) cm^2.

Locality 6 (Pl. 1, Fig. 4): Ellesmere Island, Blackwelder Mountains, north of Greely Fjord. Edwin Kemper collection No. 6 (Textfig. 1).

Material: Seven thin sections, BGR Ma 13183 –13189; 2 x Q, 3 x T, 2 x R; sectional area, min. (1,1 x 0,9), max. (1,8 x 1,9) cm^2.

Description: Secondary xylem with homoxylous structure of coniferous wood without primary xylem or bark. The ground tissue is partly disarranged. The anatomical details are well-preserved, best in specimens from localities (2) and (3). Growth ring boundaries visible already with the naked eye, boundaries conspicuous and distinct, in most rings transition from earlywood to latewood gradual, ring boundaries not evenly spaced, earlywood portion 20–50% in locality 2 (TS 13147, TS 13149–TS 13151), compression wood in locality 2 (TS 13147), earlywood portion up to 80% in locality 4 (TS 13166, TS 13169), number of thick-walled layers in the latewood varies between 4 and 25 cells. The amount of increment, mean value of 116 growth rings, varies between 0,5 and 2 mm (Tab. 3). Axial parenchyma uncertain if commonly present. Tracheids in radial rows, 2–5–(8) rows between two rays, outline form of tracheids in transverse section squarish to polygonal, not rounded when in good preservation (Pl. 1, Fig. 4; Pl. 2, Figs 1, 3–4); measurement in earlywood, e.g., radial 42 µm, tangential 39 µm, flattened tracheids in the uttermost latewood, e.g., radial 10 µm, tangential 35 µm. Tracheids distinctly rounded and separated from one another (TS 13149) in decayed tissue (Pl. 1, Fig. 3).Tracheid pitting of the radial walls usually biseriate, partly araucaroid (RSL 13188), short parts uniseriate; individual pits with circular outline, if crowded they show a tendency toward alternate arrangement with polygonal outlines (Pl. 3, Fig. 1; Pl. 4, Figs 2–4), diameter of circular pits 16 µm, pori rounded to oval, approximately 4 µm in diameter. Crossfield pittting common in poor preservation, 2–4–(5), 3 pits in horizontal row (RLS 13153), type piceoid, several of the crossfield pits likely cuppressoid (RLS 13153), pits rounded or oval in shape, diameter 3–4 µm (Pl. 3, Fig. 2). Ray cells uniseriate, in tangential section (1–2)–8–15–(31) cells high, usually 20–840 µm (Pl. 3, Figs 3–4). Horizontal walls of some of the ray parenchyma cells smooth (RLS 13153), others likely nodular. Axial intercellular canals, resin ducts, conspicuous, isolated or groups within ground tissue, traumatic axial canals in distinct tangential rows (TS 13149, TS 13156, TS 13183, TS 13184), maximum up to 18 canals, (Pl. 1, Figs 1–4; Pl. 2, Figs 1–3). The diameter, measured in transverse section, varies between (40)–60–165 µm, epithelial cells thick-walled (Pl. 1, Figs 2, 3), epithelial and subdividing cells of axial intercellular canals in radial section 20–40 µm, and 30–73 µm long in axial direction (RSL 13148).

Identification and Comments: Characteristics of these wood samples from 4 different sites includes (a) the exclusive occurrence of vertically formed resin ducts, (b) relatively large diameters of the bordered pits on the radial walls of tracheids, and (c) the piceoid (abietinoid) pitting of the rays. This combination of anatomical features shows a strong similarity with that seen in the morphogenus *Protopiceoxylon* Gothan, 1907, which is a taxon used for Mesozoic conifer wood. The fossil record of *Protopiceoxylon* has been surveyed and revised repeatedly and by various authors, including Gothan (1910), Medlyn & Tidwell (1979), Ding (2000), and Harland et al. (2007). In a critical review with emphasis on North American all species of *Protopiceoxylon* are compared as to their xylotomy and distribution in geological time (Medlyn & Tidwell 1979). In addition, specimens of *Protopiceoxylon* from Spitsbergen, Ellesmere and Axel Heiberg Islands, and from the Canadian Arctic

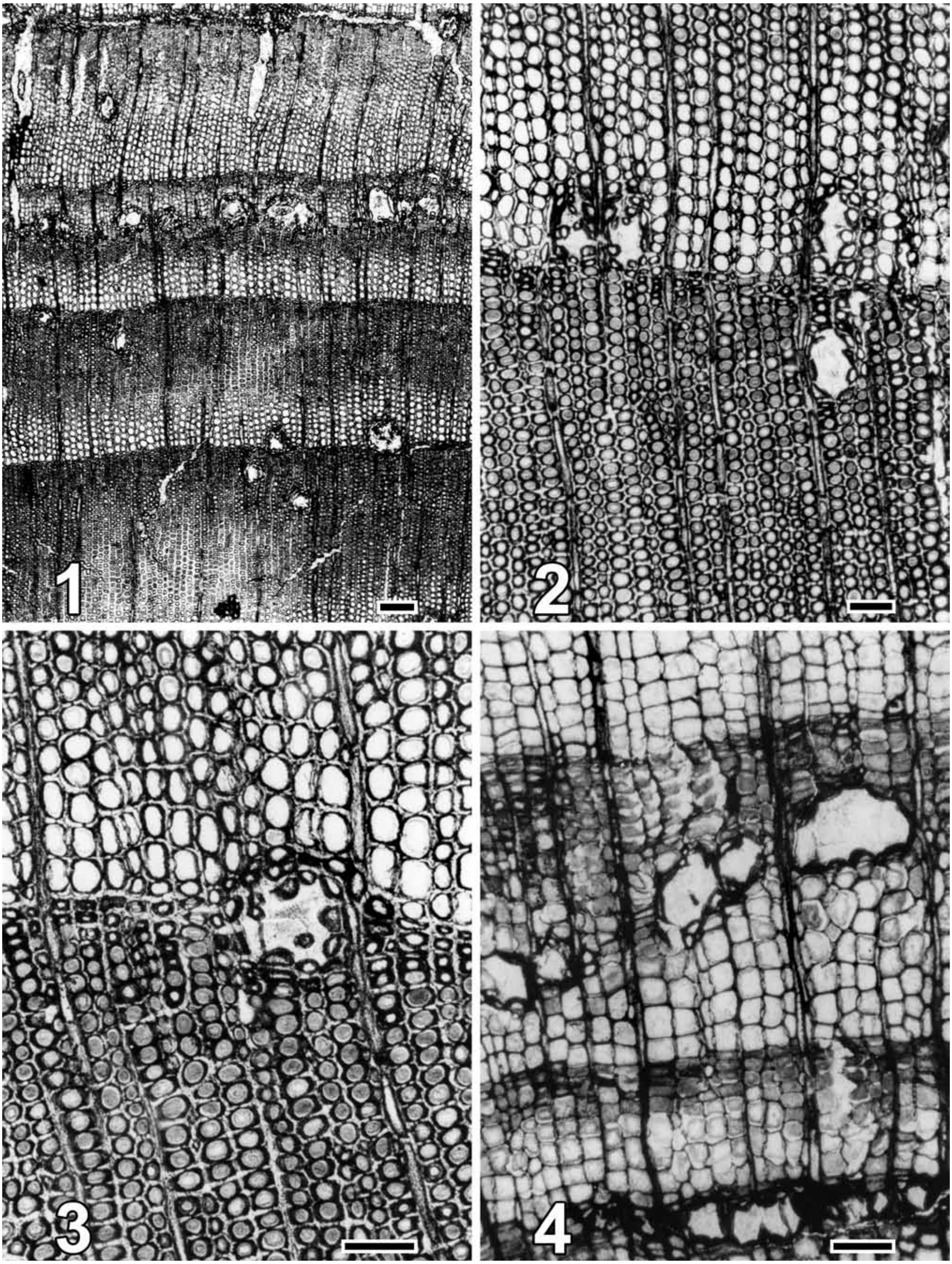


Plate 1: *Protopiceoxylon* sp. from the Lower Cretaceous of Canadian Arctic, Ellesmere Island. – E. Kemper collection No. in parantheses. **(1)** Reptile Creek, BGR Ma 13149 (2); Cross section. Growth rings with relatively straight boundaries and vertical resin ducts. **(2)** Reptile Creek, BGR Ma 13149 (2); Cross section. Growth ring boundaries distinct, vertical resin ducts in early- and latewood. **(3)** Reptile Creek BGR Ma 13149 (2); Cross section. Epithelial cells in vertical resin duct thick-walled. **(4)** Blackwelder mountains, BGR Ma 13186 (6); Cross section. Two growth rings with 7–18 tracheids in radial direction, wood tissue well preserved. Bars = 300 µm (Fig. 1), 100 µm (Figs 2–4).

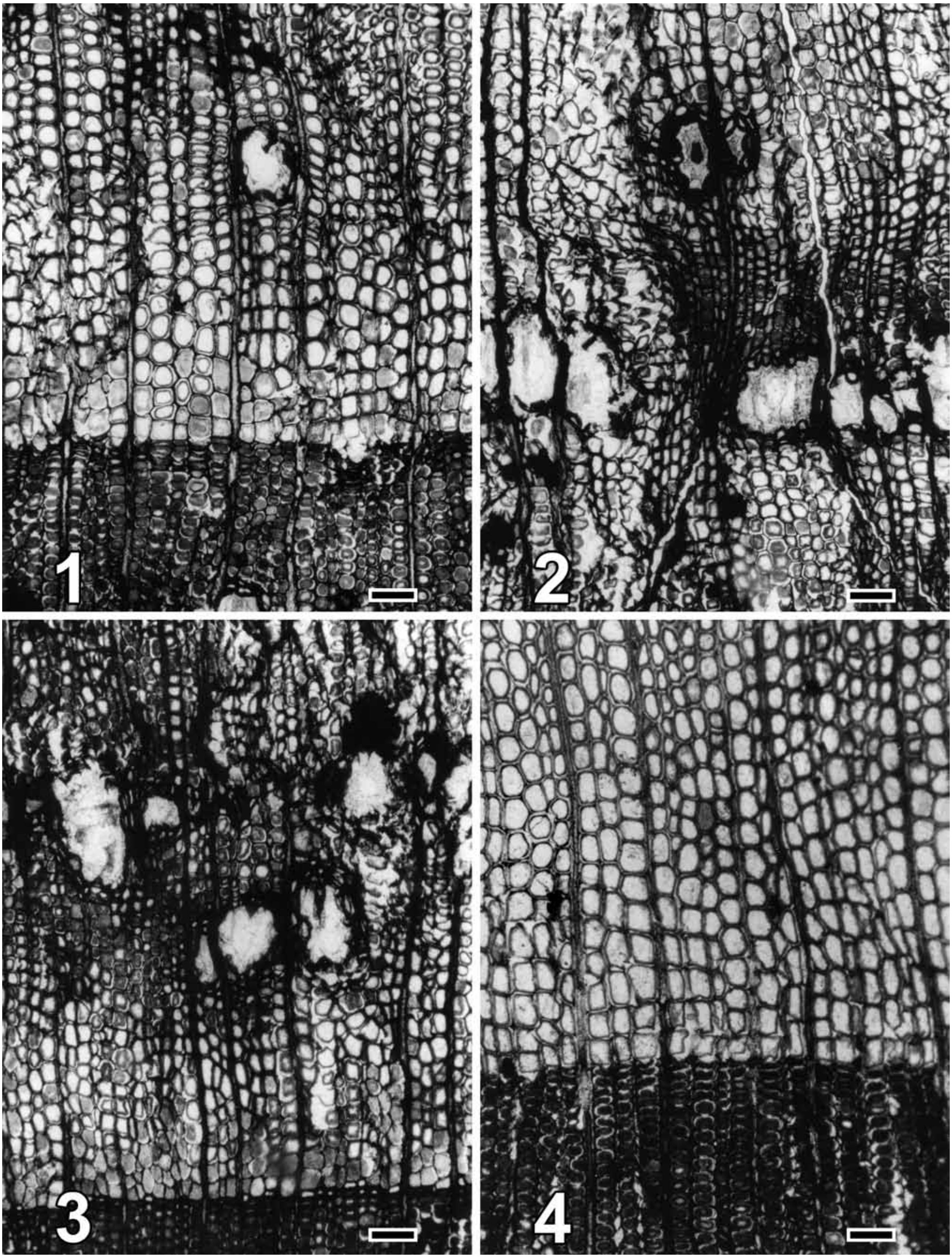


Plate 2: *Protopiceoxylon* sp. from the Lower Cretaceous of Canadian Arctic, Ellesmere Island. – E. Kemper collection No. in parantheses. **(1)** Blackwelder mountains, BGR Ma 13156 (3a); Cross section. Growth ring boundary distinct, 2 axial resin ducts. **(2)** Blackwelder mountains, BGR Ma 13156 (3a); Cross section. Growth ring boundary undistinct, tissue with axial resin ducts anormal distorted. **(3)** Blackwelder mountains, BGR Ma 13156 (3a); Cross section. Growth ring boundary distinct, several axial resin ducts visible in early wood. **(4)** Blackwelder mountains, BGR Ma 13157 (3a); Cross section. Growth ring with abrupt structural change at boundary, including a change in tracheid wall thicknes and tracheid radial diameter. Bars = 100 µm (Figs 1–4).

Table 1: Comparison of features from wood collected by Edwin Kemper (1974) with anatomical data of nine validly identified *Protopiceoxylon* species (Medlyn & Tidwell 1979: tab. 1). The anatomical features of the woods collected by Edwin Kemper range within the documentated xylem variation of *Protopiceoxylon*. A more detailed anatomical comparison with other species of *Protopiceoxylon* has been published by Ding (2000: tab. 1).

Feature	**Medlyn & Tidwell 1979 (nine species compared)**	**E. Kemper collection, this study, Pls 1–4**
Growth rings	Boundaries distinct, transition earlywood to latewood gradual by 7 species, false rings present (?)	Boundaries distinct, transition early to latewod commonly gradual, false rings present (?)
Axial parenchyma	Absent, sparce, in small quantities, present terminally, associated with resin canals	Absent, but uncertain if present in sparce quantities
Tracheid pitting	Radial walls: 1–2, 2–3, biseriate, opposite, araucarioid, form round, contiguous, flattened	Radial pitting most biseriate, in parts uniseriate, alternate, round, araucarioid, flattened when crowded
Crossfield pitting	Pits 1–3, 1–4, 2–4, 4–5, piceoid, abietoid, small bordered piceoid pits with extended apertures	Pits piceoid, 2–4(5), round or oval
Rays	Rays uniseriate, partly biseriate, 1–15, 1–18, 1–25, 1–35, 1–50 cells high	Rays uniseriate, (1–2)–8–15–(31) cells high
Axial resin canals	Resin canals only vertical, normally formed, one species with traumatic rows	Resin canals only axial, in ground tissue, on ring boundaries, local in (traumatic) tangential rows

have recently been described in detail by Harland et al. (2007). This latter study gives also a critical review of the genus *Protopiceoxylon*, a reference as to its ancestry, but also addresses problems of taxonomic nomenclature in connection with the occurrence of anatomical features. It is therefore unnecessary to repeat all these subjects here. The anatomical features seen in the wood samples from the Kemper collection indisputably range within the documented xylem variation of *Protopiceoxylon* (see Tab. 1). The extremely small increments in mm of 232 growth rings have been measured (Tabs 2, 3). *Protopiceoxylon* belongs to the ubiquitos group of extinct conifers commonly referred to as “transitional conifers” (Medlyn & Tidwell 1979). These trees existed from the Middle Jurassic to Middle Cretaceous. The drift wood samples described in this paper are Early Cretaceous in age, and therefore the precise affinities with modern taxa based on xylem structure remain elusive. The conifer-dominated forests during the greenhouse periods, especially the individual taxa, may have had different ecological tolerance in the Cretaceous.

3.2 *Dacrydioxylon*

Coniferales
Family: Podocarpaceae Endlicher, 1847
Subfamily: Podocarpoideae Farjon, 1998
Morphogenus: *Dacrydioxylon* Greguss, 1967

Type species: *Dacrydioxylon estherae* Greguss, 1967 (not validly published according to Philippe et. al. 1999).

Dacrydioxylon sp.

Locality 3 (Pl. 5, Figs 1–4; Pl. 6, Figs 1–4; Pl. 7, Figs 3–4): Ellesmere Island, Blackwelder Mountains north of Greely Fjord. Edwin Kemper collection No. 3 (Textfig. 1).

Material: Five thin sections, BGR Ma 1361 – 13165; 3 x TS, 1 x TLS, 1 x RLS; sectional area min (1,2 x 0,6), max (1,8 x 1,9) cm^2.

Locality 5 (Pl. 7, Figs 1–2): Mackenzie King Island, northern part of the Island. Edwin Kemper collection No. 5 (Textfig. 1).

Material: Twelve thin slides, BGR Ma 13171 – 13182; 3 x TS, 4 x TSL, 5 x RSL; sectional area min (0,9 x 1,8), max (2,5 x 2,8) cm^2.

Descritpion: Secondary xylem of coniferous wood with homoxylous structure without primary xylem or bark, ground tissue partly disarranged (Pl. 5, Fig. 4). Preferable for anatomical study is the wood from Ellesmere Island, locality 3. Growth rings visible to the naked eye, boundaries distinct, delineated by a small band of darker latewood, boundaries more or less irregularly undulating (Pl. 5, Figs 1–4), commonly 2–4–(7) layers of radial flattened latewood tracheids. The number of existing growth rings varies from 11 to >60, the rate of preserved growth ring increments varies between 0,25–1,8 mm mean value (Tab. 3). A small rest of pith tissue occurs in connection with 25 growth rings (TS 13161). Axial parenchyma present, diffuse scattered and difficult to find, sparce or absent in individual growth increments. Transverse end walls in tangential section smooth (TSL 13163). Tracheids in radial rows, (1)–3–7–(14) between two rays, earlywood tracheids in tranversal section, e.g., radial 45 µm, tangential 23 µm (TS 13161), tracheid pitting (Pl. 6, Figs 1–4) in radial walls present, exclusively uniseriate, pits rounded in shape, in loose arrangement without mutual connection, distance 3–5 µm, common distances of up to 35 µm, diameter of

Table 2: Increment in mm of 116 growth rings from drift wood *Protopiceoxylon*. Localities: Ellesmere Island (2, 3, 4) and Amund Ringnes Island (6).

Locality	Slide-No.	Rings	min	max	mean
2	1347	24	0,5	1,8	0,9
2	1349	22	0,5	1,9	1,0
2	1351	12	0,9	2,4	1,8
3	1356	14	0,9	3,1	1,9
3	1357	8	0,2	1,2	0,7
3	1358	3	1,5	2,2	1,8
3	1360	2	1,8	2,0	1,9
4	1369	15	0,5	2,9	1,9
6	1383	6	1,4	2,7	2,0
6	1386	10	0,2	1,2	0,5

Table 3: Increments in mm of 126 growth rings from driftwood samples *Dacrydioxylon*, Podocarpaceae . Localities: Ellesmere Island (3), Mackenzie King Island (5).

Locality	Slide No.	Rings	min	max	mean
3	13161	25	0,2	1,0	0,5
3	13162	12	0,1	0,6	0,4
3	13165	11	0,2	1,1	0,5
5	13171	18	0,6	3,1	1,8
5	13173	>60	0,2	0,7	0,3

the uniseriate tracheid pits 15–20 µm, pori oval, 3–6 µm in diameter. Crossfield pits conspiceous, fenestriform, with one large simple pit, exception 2 pits, pit form rounded or square-oval, diameter in the earlywood 17:21 µm, in latewood 7:15 µm. Ray cells low, uniseriate, size in tangential section (1)–2–5–(9) cells (Pl. 7, Figs 3–4). Ray high in tangential section, e.g., 1–2 cells (15–32 µm), 3–9 cells (4–144 µm), individual ray cells, vertical 15 –16 µm, tangential 7–8 µm. Ray tracheids smooth (Pl. 6, Figs 2–4). Resin ducts absent (Pl. 5, Figs 1–4).

Identification: *Dacrydium* Sol. ex A. B. Lambert, 1807, is one of currently 18 extant genera recognized in the conifer family Podocarpaceae. With regard to xylem anatomy, the Podocarpaceae exhibit great heterogeneity. The 21 species of *Dacrydium*, subfamily Podocapoideae, are equally well differentiated from each other (Phillips 1941). Comparisons were made with reference collections of recent wood samples of Podocarpaceae deposited in the Xylothek, Institute of Wood Research, Munich, i.e. with *Dacrydium araucarioides*, *D. balansae*, *D. beccarii* (HM 4200), *D. colensoi* (HM 4416), *D. cupressious* (9 different numbers), *D. elatum* (HM 841, 15425), *D. gibbsiae* (HM X-4322), *D. quillauminii* (HM X-1541), *D. lycopodioides* (HM 4295), *D. nausoriense* (HM 4260), *D. nidulum* (HM 4261), *D. pectinatum* (HM 15278), and *D. spec*. (HM 2938). The combination of features most closely corresponding to that seen in the fossil is that of *D. colensoi* (HM 416). Special wood anatomical features of *Dacrydium* include the conspicuously large cross-field pits and the lack of axial and tangential resin ducts (Pl. 6, Figs 1–4; Pl. 7, Figs 3–4). Increments in mm of 126 growth rings are exceptionally small (Tab. 3). Xylem identification of permineralized wood of the genus *Dacrydium* is, according to our knowledge, to date limited to only three *Dacrydioxylon* specimens from Cenozoic sites in central Europe, i.e. Hungary and Germany (Tab. 4).

Podocarpoxylon dacrydioides Cui from the Lower Cretaceous of Inner Mongolia, China (Cui 1995), is remarkably similar to wood of the genus *Dacrydium*. However, the number of pits per field is lower, and the pits in *P. dacrydioides* are not normally “window-like”, i.e. occupying nearly the entire cross-field (Cui 1995: “occasionally one”). Determinations of the number of pits per cross-field in early wood tracheids should be based on at least 25 counts, according to the IAWA Committee recommendations. We have counted as many cross-fields as possible (>250), most of which have only a single large pit. According to the IAWA Committee (2004: 51) the cross-field pitting is highly significant for the identification of conifereous wood. Furthermore, one of the important features of *Podocarpoxylon* are small cross-field pits with slit-like apertures or predominantly small pinoid pores. Therefore we hold the opinion that our fossil is closer to *Dacrydioxylon* than *Podocarpoxylon*, and consequently have assigned our fossil to the morphogenus *Dacrydioxylon*.

Comments: The genus *Dacrydium* appears to exhibit a relatively wide ecological amplitude throughout geological times (Taylor et al. 2009: 843). It is therefore reasonable to assume that *Dacrydium* in the Early Cretaceous grew under different climatic conditions than reperesenatives of that genus today. The present-day genus *Dacrydium* has a fairly wide distribution, with 21 species (all trees of montane and subalpine tropical forests) in the Malay Archipelago, New Caledonia, New Zealand, Tasmania, and southern Chile (Textfig. 4). They often indicate infertile soils or other conditions unfavourable to angiosperms (Farjon 1998). The Podocarpaceae is the second largest extant conifer family. They are today restricted mainly to the Southern Hemisphere, further to Central America and Mexico (e.g., Mill 2003). Megafossil evidence and scattered Nothern Hemisphere reports of pollen, however, suggest that in the past a few taxa, including *Dacrydium*, have been more cosmopolitan in distribution (e.g., Reinink-Smith & Leopold 2005; Taylor et al. 2009: 843). In the Southern Hemisphere, the genus is evidenced since the Triassic (Fontes & Dutra 2010). Nevertheless, records from high latitudes in the Northern Hemisphere have been absent to date. As a result, we do not have a satifying explanation as to why fossil wood specimens assignable to the morphogenus *Dacrydioxylon* occur in high latitude regions of Arctic Canada.

3.3 *Coniferoxylon* indet.

Locality 1 (Pl. 8, Figs 1–3): Axel Heiberg Island, 7 km SW of Buchanan Lake; Edwin Kemper collection No. 1 (Textfig. 1).

Material: Twelve thin sections: BGR Ma 13134 –13145; 6 x TS, 4 x TSL, 2 x RSL; sectional area: min (1,3 x 0,8), max (2,5 x 3) cm^2.

Description: Secondary xylem of coniferous wood with homoxyleous structure without primary xylem or bark. The anatomical preservation is poor. Growth ring boundaries are distinct, transition from earlywood to latewood in the same growth ring is conspicuous, growth ring width very small (Tab 5). Tracheid cell tissue decayed, partly distorted. Rays in poor preservation, mostly low, up to 11 cells (TSL13140). Resin ducts present, axial intercellular canals in distinct tangential bands on the growth ring boundaries (TS 13134, TS 13139, TS 13145), seldom in the tracheid ground tissue (TS 13138). The epithelial cells appear to be thick-walled.

Table 5: Increments in mm of 65 growth rings from *Coniferoxylon* indet. Locality: Axel Heiberg Island (1).

Locality	Slide No	Rings	min	max	mean
1	13134	12	1,6	2,6	2,0
1	13135	8	1,6	2,5	2,1
1	13137	11	1,4	2,6	1,9
1	13138	13	1.3	2,6	1,8
1	13139	16	1,8	1,9	1,9
1	13145	5	1,1	2,3	1,8

4. Summarizing remarks

The fossil wood morphogenus *Dacrydioxylon* Greguss, 1967, Podocarpaceae, is recorded here for the first time from two different Islands in the

Table 4: Record of mineralisized wood samples of *Dacrydioxylon*, Podocarpaceae. – Localities: (a) Ellesmere Island, (b) Mackenzie King Island.

Dacrydioxylon	**Country**	**Geological age**	**References**
D. esthereae	Hungary	Lower Oligocene	Greguss 1967
D. tanadi-kubaskanum	Hungary	Lower Oligocene	Greguss 1967
D. makroporosum	Germany	Upper Miocene	Selmeier 1985
Dacrydioxylon (a)	Canadian Arctic	Lower Cretaceous	Selmeier & Grosser
Dacrydioxylon (b)	Canadian Arctic	Lower Cretaceous	Selmeier & Grosser

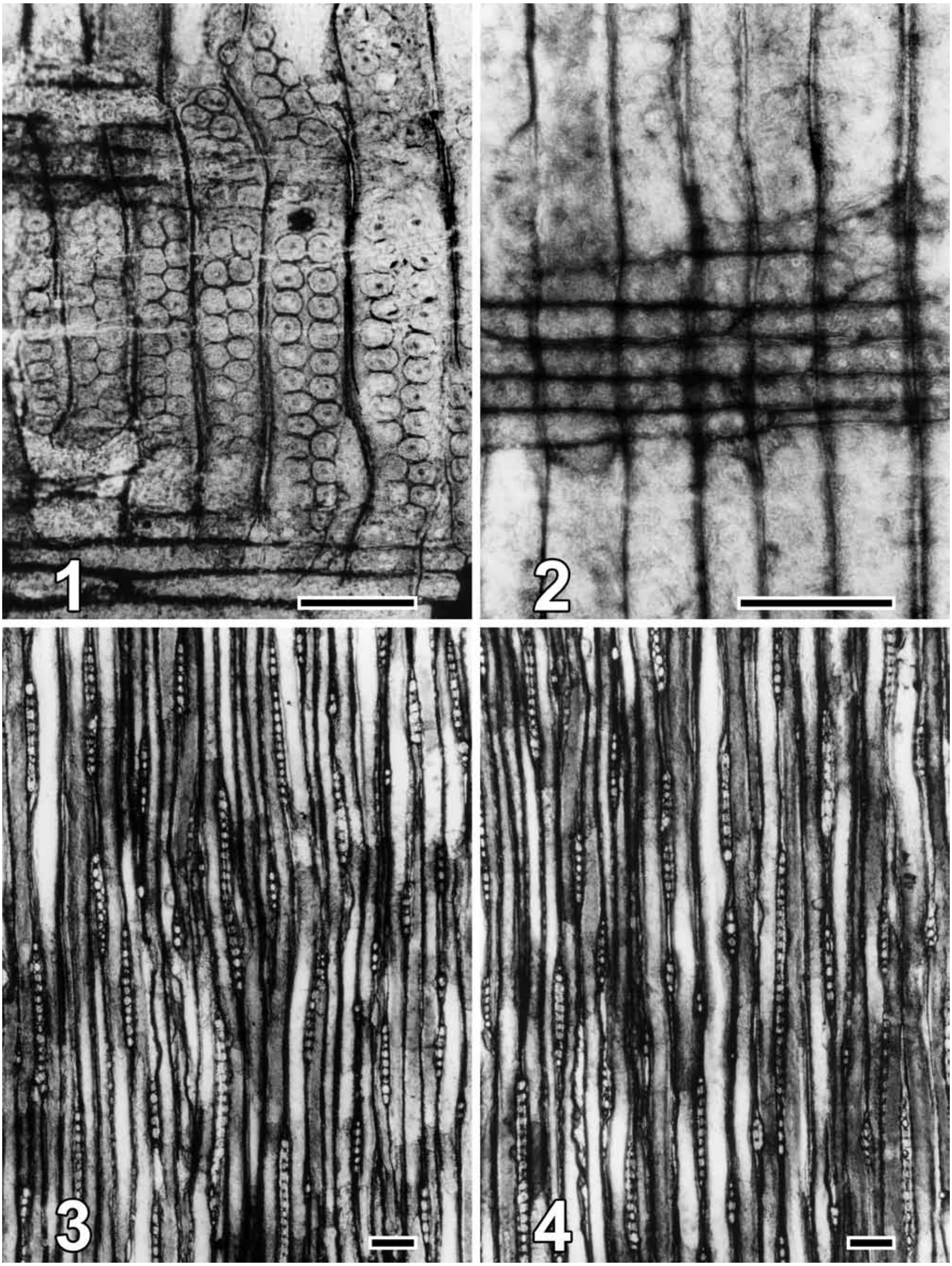


Plate 3: *Protopiceoxylon* sp. from the Lower Cretaceous of Canadian Arctic, Ellesmere Island. – E. Kemper collection No. in parantheses. **(1)** Blackwelder Mountains, BGR Ma 13159 (3a); Radial section. Tracheid pitting two-seriate, opposite and alternate. **(2)** Blackwelder Mountains, BGR Ma 13159 (3a); Radial section. Cross field pitting piceoid. **(3)** Blackwelder Mountains, BGR Ma 13154 (3a); Tangential section. Rays uniseriate, average height 2–17 cells. **(4)** Blackwelder Mountains, BGR Ma 13154 (3a); Tangential section. Rays uniseriate, partly biseriate, average height 2–32 cells. Bars = 100 µm (Figs 1–4).

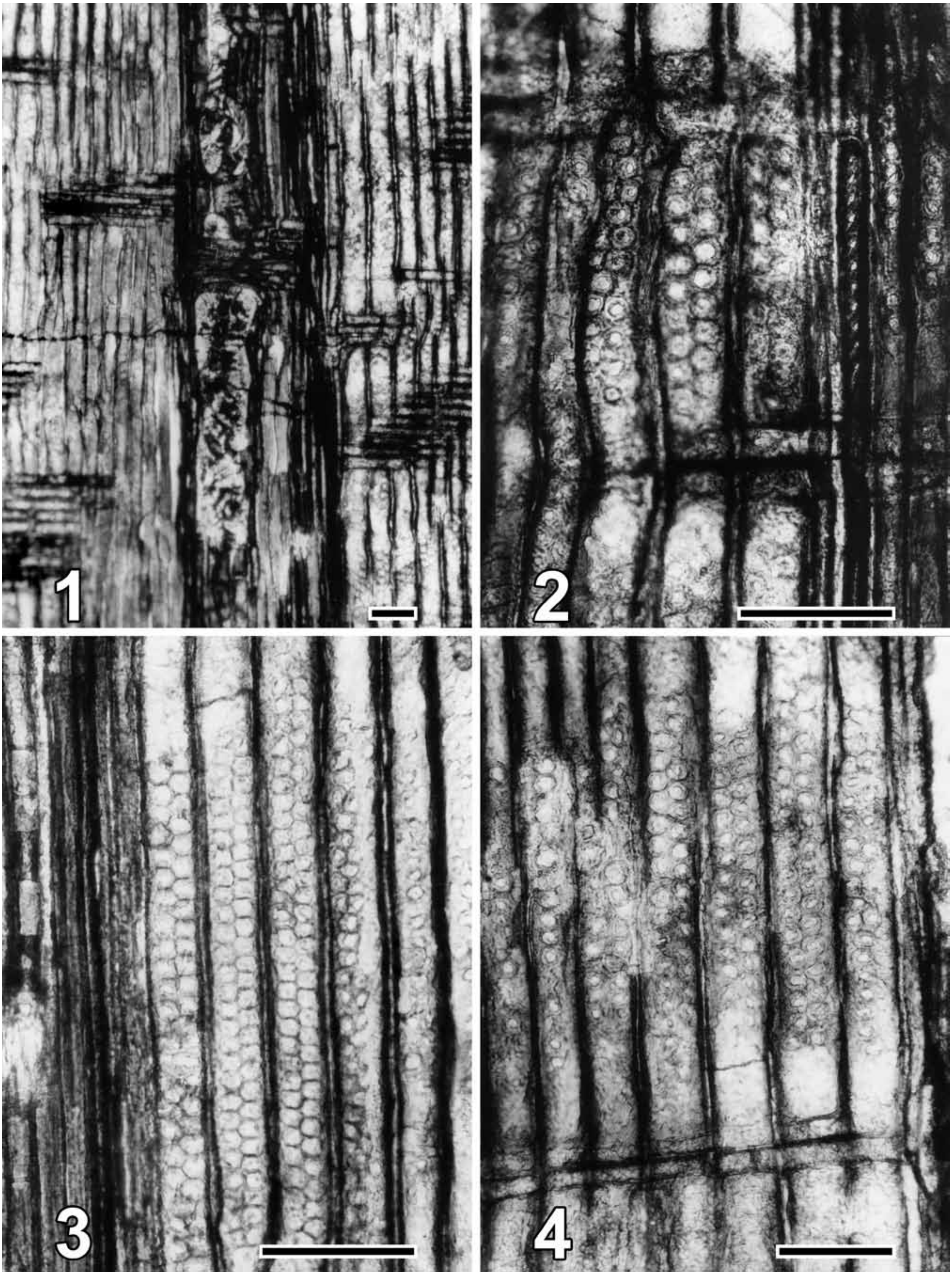


Plate 4: *Protopiceoxylon* sp. from the Lower Cretaceous of Canadian Arctic, Ellesmere Island. – E. Kemper collection No. in parantheses. **(1)** Reptile Creek, BGR Ma 13153 (2); Radial section. Part of vertical resin duct in late wood. **(2)** Reptile Creek, BGR Ma 13153 (2); Radial section. Pitting biseriate, arrangement alternate. **(3)** Reptile Creek, BGR Ma 13153 (2); Radial section. Pitting predominantly biseriate, arrangement alternate. **(4)** Reptile Creek, BGR Ma 13153 (2); Radial section. Pitting biseriate, partly uniseriate. Bars = 100 µm (Figs 1–4).

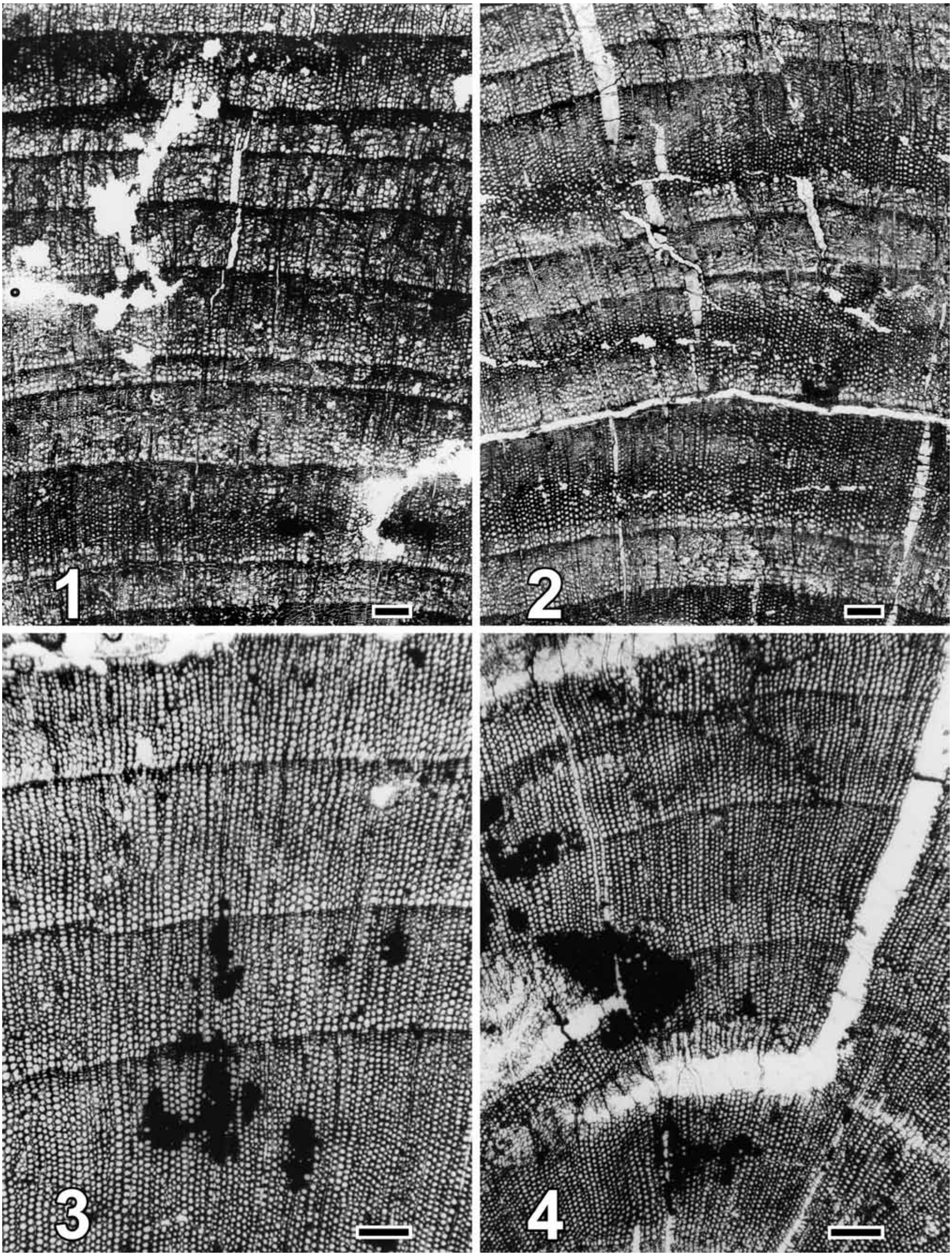


Plate 5: *Dacrydioxylon* sp. from the Lower Cretaceous of Canadian Arctic,Ellesmere Island. – E. Kemper collection No. in parantheses. **(1)** Blackwelder Mountains, BGR Ma 13165 (3b); Cross section. Growth ring boundaries distinct with wide and narrow rings. **(2)** Blackwelder Mountains, BGR Ma 13161 (3b); Cross section. Wood tissue slowly dislocated before permineralisation. **(3)** Blackwelder Mountains, BGR Ma 13161 (3b); Cross section. Growth ring boundaries distinct, transition from early- to latewood gradual. **(4)** Blackwelder Mountains, BGR Ma 13161 (3b); Cross section. Transition from early- to latewood gradual, tissue partly separated by fissure. Bars = 300 µm (Figs 1–4).

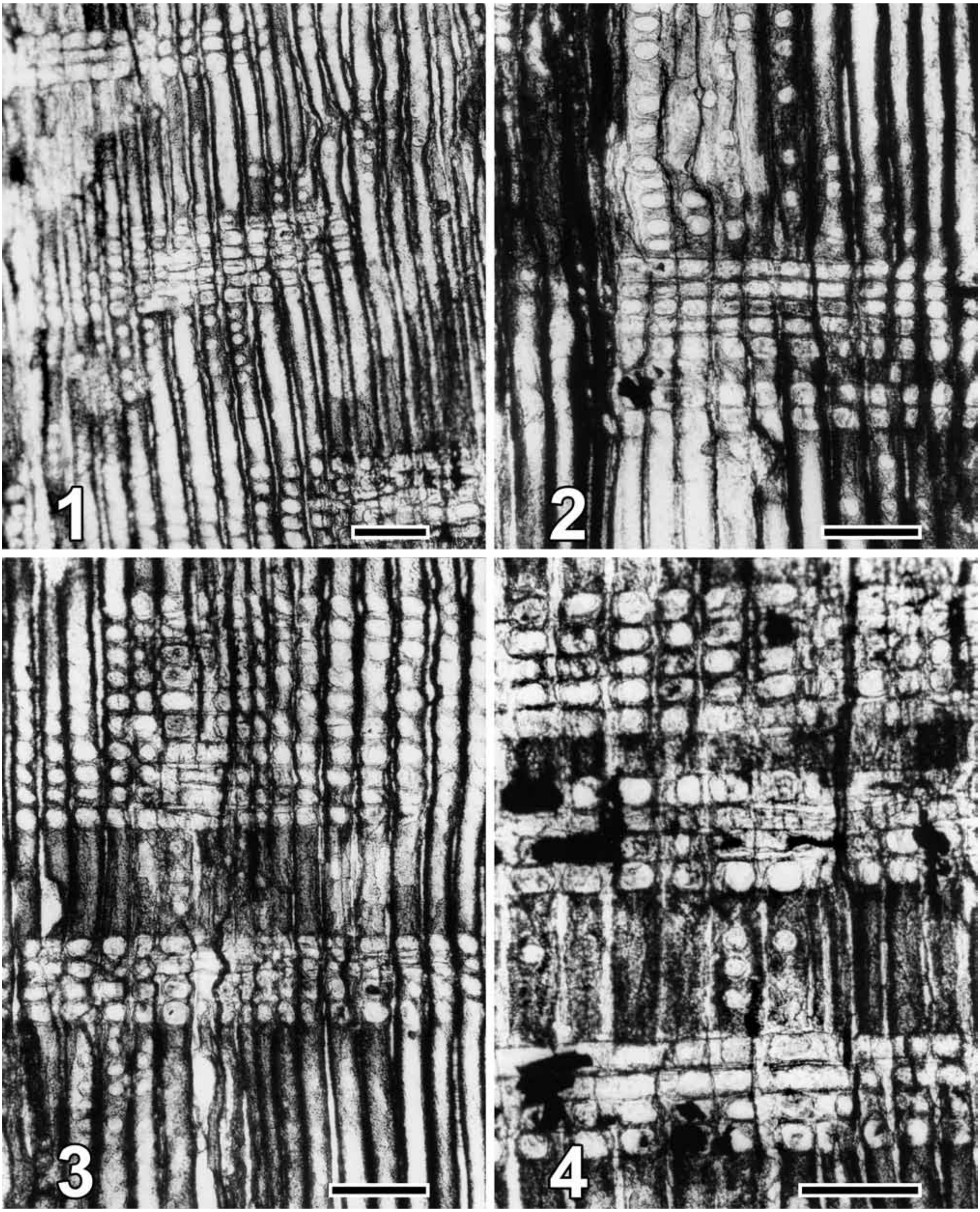


Plate 6: *Dacrydioxylon* sp. from the Lower Cretaceous of Canadian Arctic, Ellesmere Island. – E. Kemper collection No. in parantheses. **(1)** Blackwelder Mountains, BGR Ma 13164 (3b); Radial section. Tracheid pitting uniseriate, partly visible. **(2)** Blackwelder Mountains, BGR Ma 13164 (3b); Radial section. Tracheid pitting uniseriate, bordered pits mostly isolated in vertical direction. **(3)** Blackwelder Mountains, BGR Ma 13164 (3b); Radial section. Crossfield pitting fenestriform ("window-like"). **(4)** Blackwelder Mountains, BGR Ma 13164 (3b); Radial section. Crossfield pitting distinctly "window-like" with one large apparently simple square or rectangular pit. Bars = 100 µm (Figs 1–4).

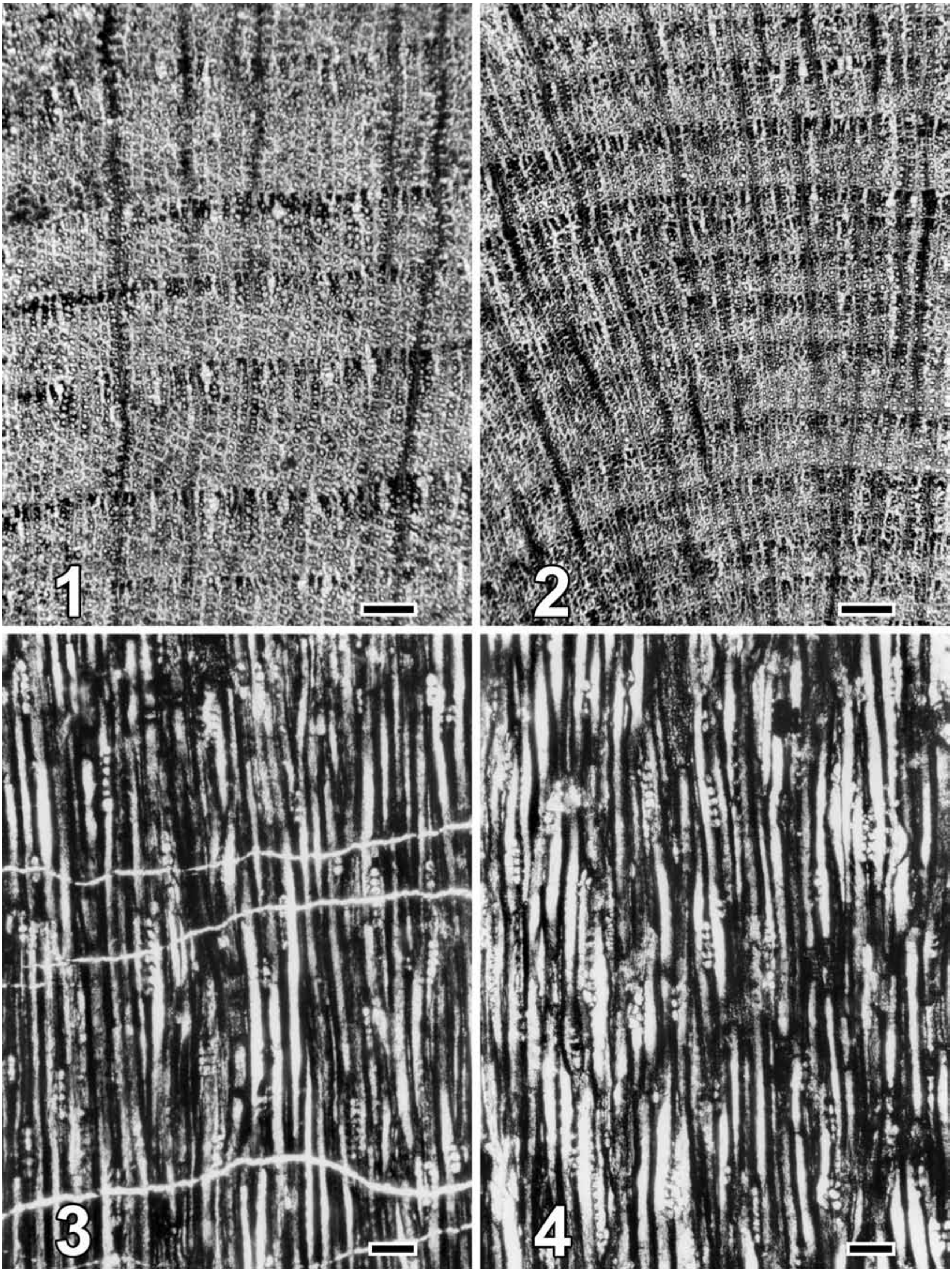


Plate 7: *Dacrydioxylon* sp. from the Lower Cretaceous of Canadian Arctic, Mackenzie King Island. – E. Kemper collection No. in parantheses. **(1)** Mackenzie King, BGR Ma 13173 (5); Cross section. Seven growth ring boundaries recognizable. **(2)** Mackenzie King, BGR Ma 13173 (5); Cross section. Growth ring boundaries with fiftheen narrow rings. **(3)** Blackwelder Mountains, BGR Ma 13163 (3b); Tangential section. Rays only up to 7 cells high. **(4)** Blackwelder Mountains, BGR Ma 13163 (3b); Tangential section. Rays only up to 9 cells high, uniseriate. Bars = 300 µm (Figs 1, 2), 100 µm (Figs 3, 4).

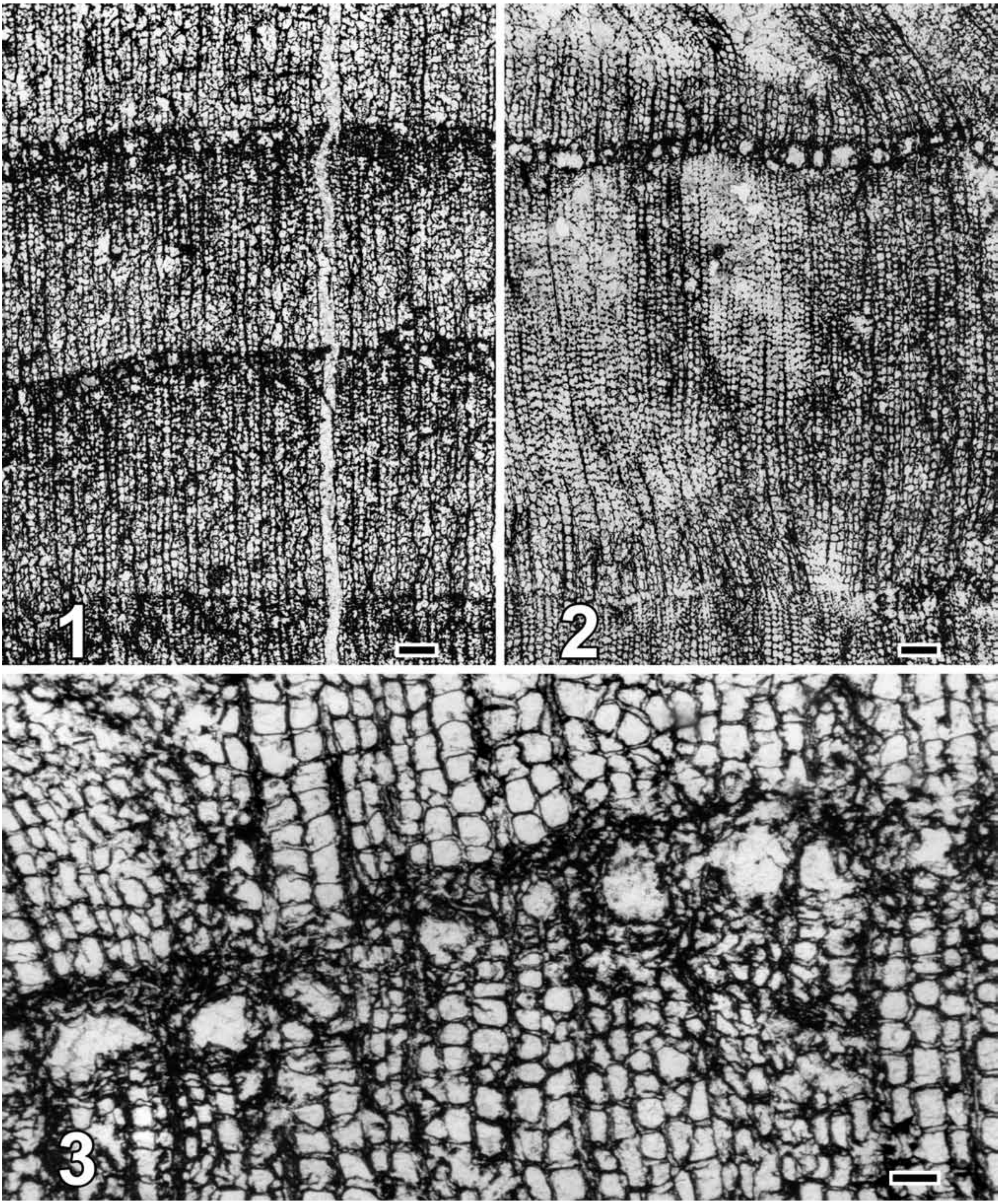
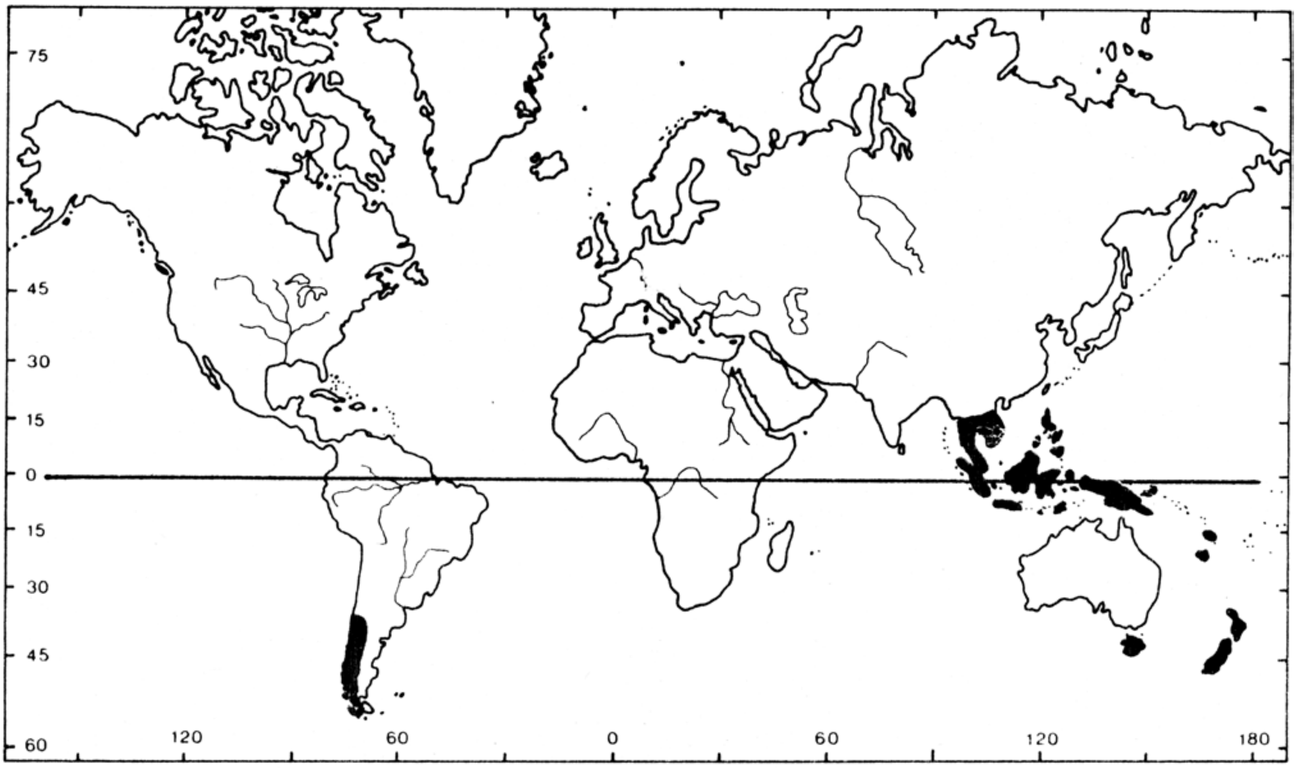


Plate 8: *Coniferoxylon* indet. from the Lower Cretaceous of Canadian Arctic, Axel Heiberg Island. E. Kemper collection No. in parantheses. **(1)** Axel Heiberg Island, BGR Ma 13139 (1); Cross section. Growth ring boundaries distinct, transition from early- to latewood gradual. **(2)** Axel Heiberg Island, BGR Ma 13139 (1); Cross section. One growth ring boundary distinct with row of vertical resin ducts, second growth ring boundary vague. **(3)** Axel Heiberg Island, BGR Ma 13134 (1); Cross section. Vertical resin ducts near growth ring boundary, obviously with thick epithelial cells. Bars = 300 µm (Figs 1, 2), 100 µm (Fig. 3).



Textfigure 4: Present-day geographical distribution (black) of the genus *Dacrydium* Sol. ex G. Forst., 1786.

Northern High Hemisphere polar region. A characteristic wood anatomical feature of *Dacrydioxylon* is the distinct dacrydioid pitting of the cross fields that indisputably identify the fossils as belonging to that genus. All anatomical features correspond with the anatomical structure of the recent genus *Dacrydium*. The present study thus extends the fossil record of *Dacrydium* wood further back in geological time. A credible interpretation of the presence of *Dacrydium* quite far away from the extant geographical distribution is lacking and probably very difficult based on this isolated record. Four mineralizised drift woods belong to the morphogenus *Protopiceoxylon* Gothan, 1907. This fossil genus has been already recorded in Cretaceous (Albian-Aptian) sediments in high northern latitudes (>60°). The wood anatomical analysis of seven driftwood samples from high Arctic Canada suggest that paleodiversity during the various greenhouse periods in these regions was greater than currently documented. We hope that this study will initiate new interest in these paleofloras, and anticipate that further xylotomical studies will provide new interesting details about the paleodistribution of trees in the late Mesozoic high latitude Northern Hemisphere.

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