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FOSSIL CONIFER WOODS FROM CERRO PICHE GRABEN (TRIASSIC-JURASSIC?) NORTH PATAGONIAN MASSIF, RÍO NEGRO PROVINCE, ARGENTINA

LEÑOS FÓSILES DE CONÍFERAS DEL GRABEN DEL CERRO PICHE (TRIÁSICO-JURÁSICO?) EN LA COMARCA NORDPATAGÓNICA, PROVINCIA DE RÍO NEGRO, ARGENTINA

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THE Cerro Piche Graben appears as a notorious depression in the terrain, with an Eastern-Western orientation and a maximum width of 5 km, at the central region of Río Negro province, north Patagonia, Argentina. It extends for 40 km and is limited to the west by the Queupuniyeo ranges and towards the east by the Bajos Hondos Plateau. The stratigraphic relationships between the sedimentary sequence included in the graben and the surrounding units are still reason for discussion and have led to very different interpretations.

The first observations in this area were made by Corbella (1973), who recognized a tectonic depression bounded by two subparallel faults that generate a block gravitational structure which he denominated Cerro Piche Graben. This author described a sedimentary sequence circumscribed to the depression composed of conglomerates, sandstones, tuffaceous sandstones, tuffs and claystones with plant remains, that overlies the Los Menucos Group (Labudia and Bjerg, 2001) in erosive discordance. Corbella (1973) also mentioned that these outcrops could be correlated with those described near to Los Menucos town, where Triassic flora is well known (Miranda, 1966; Stipanicic *et al*., 1968; Artabe, 1985a, b).

At the western area of the graben Labudia *et al*. (1992) described a 100 m thick sedimentary succession composed of eight fining-upward sequences of fanglomerates, conglomerates, greywackes and mudstones. In these rocks, they found a single specimen of the lycophyte *Pleuromeia* sp., and as a consequence they assigned a Middle-Late Triassic age to these strata, indicating that they coincide to the initial stages of the volcano-sedimentary sequence of Los Menucos Group (Labudia and Bjerg, 2001). New interpretations carried out by Falco *et al*. (2017) have indicated that these deposits correspond to a sedimentation stage later than Los Menucos Group.

The work of Labudia *et al*. (1992) constitutes so far the only contribution about the Cerro Piche paleofloras. Other materials were found by these authors and assigned with doubts to *Pleuromeria* sp., but were not published.

The purposes of the present paper are: 1. to describe for the first time conifer permineralized woods from sedimentary rocks from Cerro Piche Graben, 2. to revise the plant fossils previously studied by other authors, and 3. to provide new information to resolve disagreements about the age of Cerro Piche sedimentary succession.

MATERIALS AND METHODS

Geological context

The fossils were found ca. 70 km north-west of Los Menucos town and 1 km north of Puesto Tono Álvarez locality, in the center of Río Negro province, Argentina (Fig. 1). They are 4 samples corresponding to permineralized trunks and branches of siliceous composition, preserved parallel to the bedding plane, in finely laminated to massive silt-claystones and sandstones. These strata are part of a 550 m thick succession characterized by nine fining-upward cycles composed of conglomerates, sandstones, claystones and tuffs (Fig. 2). According to Falco *et al*. (2017) each of these cycles was deposited by alluvial fans triggered by the reactivation of normal faults that limit the deposits. On the basis of field relations, Falco *et al*. (2017) concluded that this East-West fault affect the sequence of Los Menucos Group, so that the sedimentary rocks bearing the studied fossils are younger than Los Menucos Group and belong to a still unnamed formation.

[Figure 1]

Fossil preparation

Specimens were sectioned following standard procedures. The classic transverse, radial and tangential thin sections were obtained from polished surfaces at the Laboratorio de Cortes of the Museo de La Plata, Argentina. A Leica DM2500 microscope was used to observe the sections with transmitted light. Photographs were taken with a Leica DMC2900 digital camera.

The megascopic and microscopic specimens are deposited at the Collection of the Museo de la Asociación Paleontológica de Bariloche, under the acronym MAPBAR and the numbers 5504 to 5507. The revised materials are deposited in the Collection of the División Paleobotánica of the Museo de La Plata, under the acronym LPPB and the number 12290.

Descriptions were made following standardized terminology of Boureau (1956), Fahn (1990), IAWA Committee (Richter et al. 2004), Philippe and Bamford (2008), and Greguss' wood anatomy atlas (1955). The dimensions of anatomical elements were obtained with 30 measurements in each case. In the description, first the minimum value is mentioned, and second, the maximum value. The average value is cited, between round brackets. Taxonomic determination follows the key proposed by Philippe and Bamford (2008) for mesozoic homoxylic woods.

[Figure 2]

SYSTEMATIC PALEONTOLOGY

Order PINALES Gorozhankin 1904 (=Coniferales)

Genus ***Cupressinoxylon*** Göppert 1850

Type species. *Cupressinoxylon gothanii* Kräusel 1920; Miocene, Poland.

***Cupressinoxylon* sp.** (Fig. 3)

Studied material. MAPBAR-5504, 5505, 5506, 5507.

Description. The studied axes are 5–23 cm in diameter, and correspond to fossil trunks and branches, with preserved pith and xylem (Fig. 3.1). In smaller specimens, the pith is compressed, measuring 1 x 2 mm in diameter (Fig. 3.2), and consists of parenchyma cells, 13–24 (18.2) μm in diameter, and some sclerenchyma cells, 31–48 (39) μm in diameter (Fig. 3.3). Adjacent to the pith, primary xylem strands are identified, in which the protoxylem was not differentiated from the metaxylem (Fig. 3.3). The secondary xylem is homoxylic and pycnoxylic, with indistinct growth rings (Fig. 3.4). Some radially flattened cells with thick walls are present, but it cannot be determined if they form a latewood band of false or true growth rings. Secondary xylem tracheids are quadrangular to rectangular in cross-section (Fig. 3.4). The radial diameter is 15–37 (24.7) μm, and the tangential diameter is 15–30 (20.8) μm. The thickness of the double wall between two adjacent tracheids is 6.8–10.6 (9) μm in radial section and 6.2–9.9 (7.7) μm in tangential section. The mean number of tracheids that separate the rays is six, with a range of 3–12 rows of tracheids.

Tracheids show uniseriate bordered pits on radial walls. Pits are rounded, with circular apertures provided with a conspicuous torus, and, for the most part, with a spaced arrangement, in some cases (less than 10%) with a contiguous organization (Figs. 3.5–7). This pattern belongs to abietinean type of radial pitting *sensu* Philippe and Bamford (2008). Tracheid wall pits are 7–14 (10.2) μm in diameter. Tangential tracheid wall pitting is rare.

Cross-fields have 2 to 8 (mainly 4) bordered pits with oval outline, very small, 2x4–4x8 (2.9x4.6) μm in diameter, placed in two or three spaced rows (Figs. 3.5, 7, 8). Individual pits are of cupressoid type *sensu* IAWA Committee (Richter *et al*., 2004). Pit aperture is horizontal or oblique, and is narrower than the border. Pit arrangement is of cupressoid type cross-field *sensu* IAWA Committee (Richter *et al*., 2004).

Secondary xylem rays are homocellular, uniseriate, and short with rectilinear trajectory, are 54.1–195.6 (111.9) μm and 1– 10 (mode 2; mean 4) cells high (Figs. 3.9, 10). They are composed of rectangular procumbent parenchyma cells with smooth walls. These cells are 15-38 μm in height (23.8 μm) and 12-24 μm wide (18.5).

Several axial cells show transverse walls which, because of the state of preservation, could not be established if they are axial parenchyma cells or septate tracheids (Fig. 3.6). Ray tracheids are absent.

Branch traces were observed, formed by axial tracheids and curved rays, acquiring a spiral or circular pattern (Fig. 3.11).

[Figure 3]

Generic assignment and specific comparisons. The genus *Cupressinoxylon* Göppert 1850 was created for fossil trunks which preserved bark, pith and secondary xylem. However, according to Philippe and Bamford (2008), the taxon can also be used for isolated fossil woods. From the protologue provided by Göppert (1850), the wood of *Cupressinoxylon* can be characterized as a secondary xylem with distinct growth-rings with usually narrow latewood; tracheid radial pits round and uniseriate, also biseriate or tri-or quadriseriate, opposite, also sometimes on tangential walls; axial parenchyma; homocellular rays, low and uniseriate composed of pitted parenchyma cells; cupressoid cross-field and usually ordered in rows and columns (Bamford *et al*., 2002; Philippe and Bamford, 2008). However, the genus has been applied in a broader sense, in this way several species included in *Cupressinoxylon* do not adjust to the original diagnosis, for example *C. kotaense* Rajanikanth and Sukh-Dev 1989, *C. mochaense* Nishida 1984 and *C. gondwanensis* Kumarasamy and Jeyasingh 2004 do not present axial parenchyma ; *C. zamunerae* Bodnar, Ruiz, Artabe, Morel and Ganuza 2015 exhibits heterocellular rays; and

C. artabeae Ruiz, Brea, Raigemborn and Matheos 2017, *C. hallei* Kräusel 1924 (see Brea *et al*., 2016) and *C. jiayinense* Ru-feng, Yu-fei, W. and Yong-zhe 1996 possess high wood rays (up to 27 cells, up to 21 cells and up to 68 cells respectively). Accordingly, present-day workers use *Cupressinosxylon* for fossil woods with tracheid pits with an abietinean pattern and cupressoid cross-fields (Phillippe and Bamford, 2008), characterization into which the Cerro Piche fossil woods fit. The regular preservation of the studied samples prevents the assignment at species level, since two diagnostic characters (i.e. growth rings and axial parenchyma) are not clear. However, due to the presence of several cupressoid pits in the cross fields (2-8 pits per field), the Cerro Piche woods are similar to *C. hallei* (2-6 pits; Cretaceous-Eocene, Argentina and Antarctica) and *C. mochaense* (3-6 pits; Eocene, Chile).

Systematic affiliation. The genus *Cupressinoxylon* has been related to the Family Cupressaceae *sensu lato* in general (Bodnar *et al*., 2015), or linked particularly to Cupressaceae *sensu stricto* (Brea *et al*., 2016), due to the presence of abietinoid tracheid pitting, axial parenchyma and cupressoid cross fields, and the absence of normal resin canals and helical thickenings.

Undetermined conifer wood (Fig. 4)

Studied material. LPPB 12290.

Description. The specimen consists of a permineralized axis of 3 cm in diameter, with a deficient state of preservation. It presents homoxylic and pycnoxylic secondary xylem (Fig. 2.1). In the radial section, some tracheids pits are distinguished, which are bordered, uniseriate and contiguous (Fig. 2.2).

***Comments*.** This sample was collected and determined by Labudía *et al*. (1992), but was not included in their publication. In the collection label, it was assigned to the genus *Pleuromeia* (Lycophyta, Pleuromeiales) with doubts. However, and although its preservation is not optimal, the recognizable anatomical characteristics allow to discard the correspondence to Pleuromeiales. The arborescent lycophytes have a secondary xylem of limited thickness and have tracheids with scalariform thickenings, which differentiate them from the examined material. Therefore, the studied material corresponds to a conifer wood.

[Figure 4]

DISCUSSION

Previous works correlate the Cerro Piche sedimentary sequence with Los Menucos Group and suggest a Middle to Late Triassic age, based on the finding of *Pleuromeia* sp. (Labudia *et al*., 1992; Labudia and Bjerg, 2001), a taxon circumscribed to that period. Recently, Coturel (com. pers.), in her review on the Pleuromeiales of Argentina, reinterpreted the specimens studied by Labudia *et al*. (1992) (LPPB 12288, 12289) as coniferous branches. When they are analyzed in detail, the structures described as leaf bases by Labudia *et al*. (1992, pl. 1) show a more irregular and much more spaced pattern than the typical arrangement of Pleuromeiales. Actually, the permineralized woods analysed here exhibit scars on their external surface, probably corresponding to branch scars, which are very similar to the structures present in the samples studied by Labudia *et al*. (1992, pl. 1). As a consequence of these interpretations, the Triassic age adjudicated to the Cerro Piche sedimentary sequence is at least debatable.

On the other hand, the conifer fossil woods described are assignable to *Cupressinoxylon*, a genus whose distribution extends to both hemispheres, in Middle

Triassic to Miocene rocks (Philippe *et al*., 2004; Bodnar *et al*., 2015), consequently it would not provide conclusive data about the age of these strata.

CONCLUSIONS

From this study, it is concluded that the paleoflora preserved on the sedimentary succession of Cerro Piche Graben is, until now, constituted exclusively by conifers. In particular, the finding of conifers assigned to *Cupressinoxylon* suggests that a younger age, for example Jurassic, cannot be discarded for these strata.

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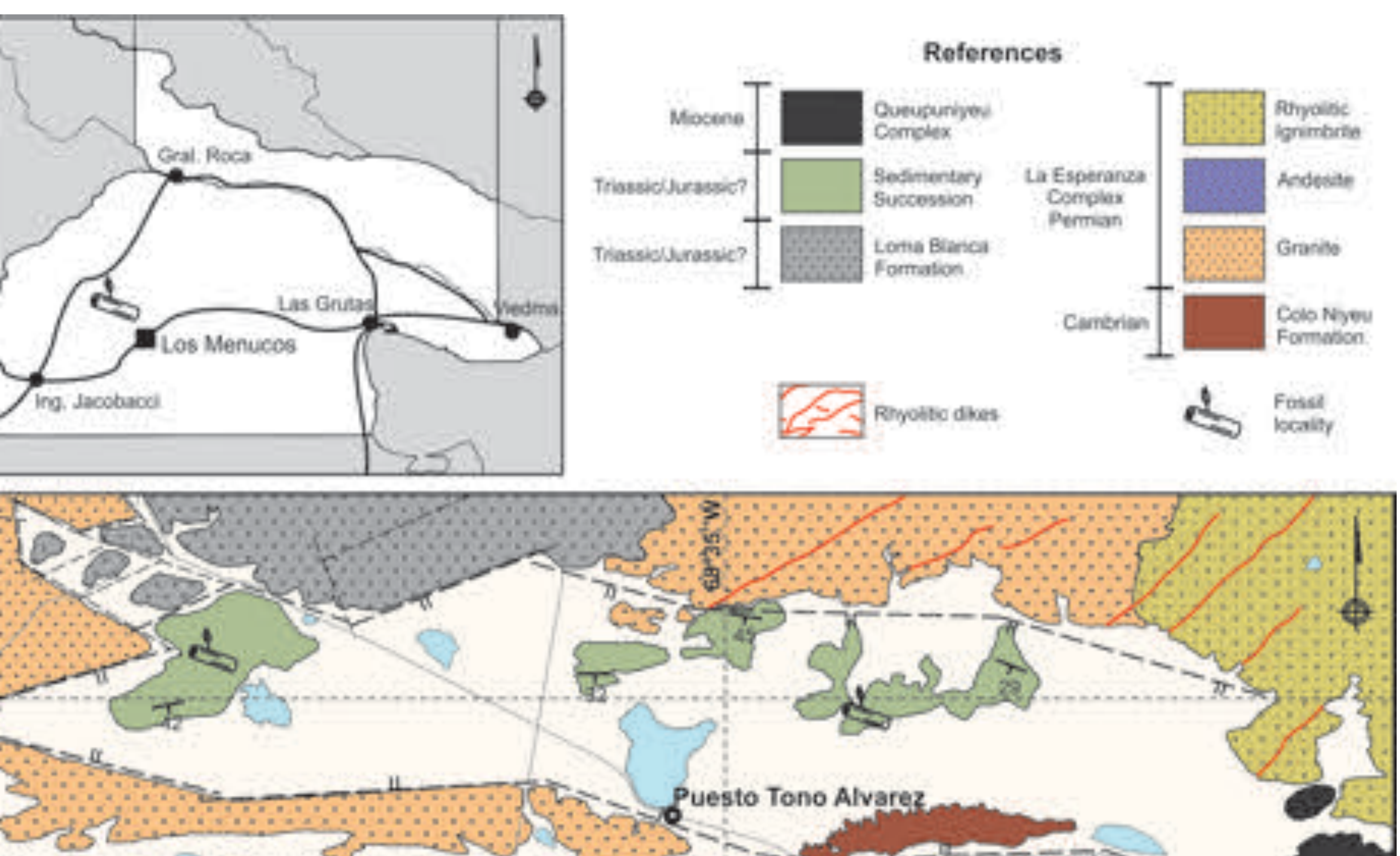
FIGURE CAPTIONS

Figure 1. 1, Location map of the fossil locality; **2,** Geologic framework of the western area of Cerro Piche Graben (modified from Cucchi *et al*., 1999).

Figure 2. Schematic log of the studied sedimentary succession, located north of Tono Alvarez stall.

Figure 3. 1–11, *Cupressinoxylon* sp., **MAPBAR**-5505; **1,** polished surface of the permineralized axis; **2,** pith in cross-section; **3,** detail of a sclerenchyma cell of the pith (left arrow) and the primary xylem (rigth arrow); **4,** cross-section of the secondary xylem tracheids; **5,** uniseriate and spaced tracheid radial pits; **6,** lateral view of the bordered pits and the torus (arrow); on the left there is an axial cell with transverse walls; **7–8,** view of the cupresoid cross fields; **9–10,** tangential sections, showing the uniseriate rays; **11,** spiral pattern, formed in a branch trace. Scale bar: **1**= 1 cm; **2**= 500 µm; **3**= 50 µm; **4, 9, 10**= 100 µm; **5, 6**= 30 µm; **7**= 15 µm; **8, 11**= 20 µm.

Figure 4. 1–2, Undetermined conifer wood, **LPPB** 12290; **1,** cross section of the secondary xylem; **2,** detail of bordered and uniseriate pits of the tracheids. Scale bar: **1**= 120 µm; **2**= 50 µm



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Los Menucos
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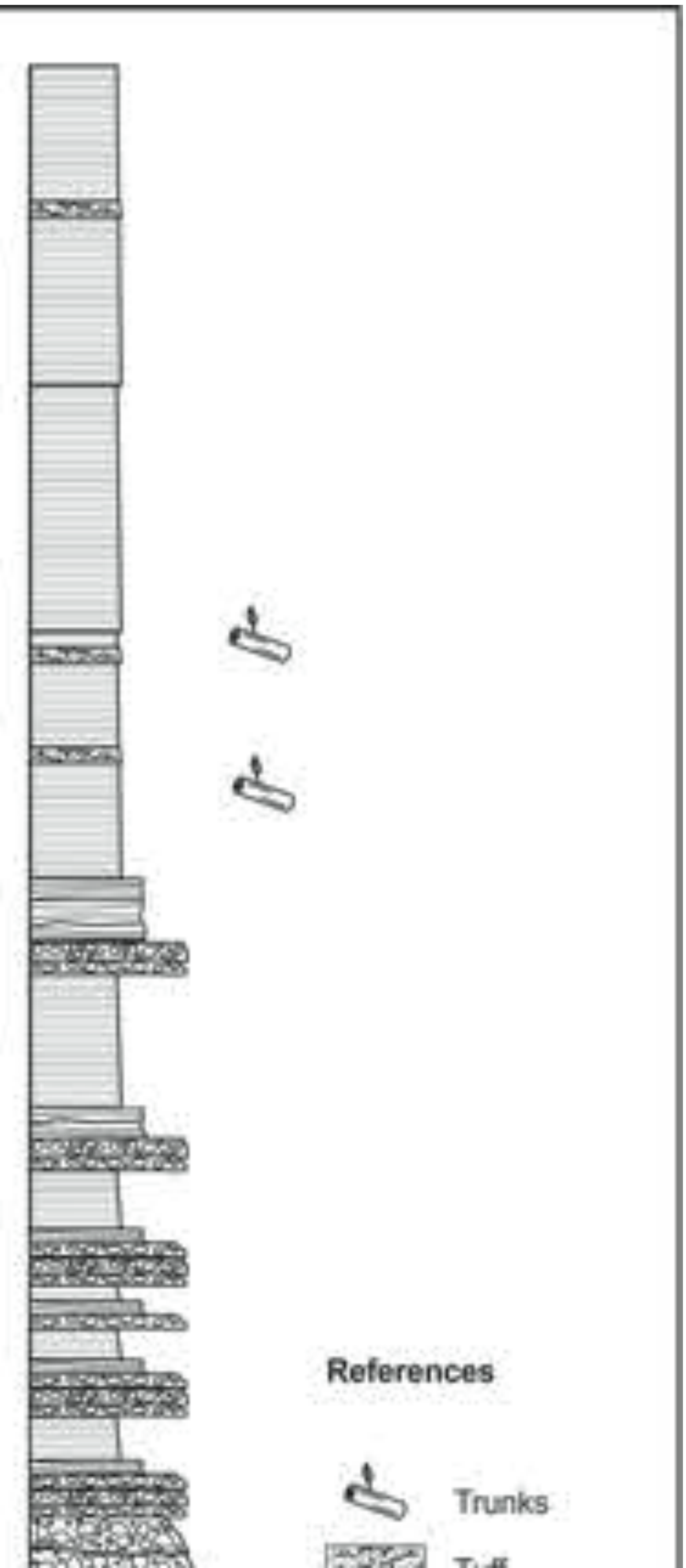
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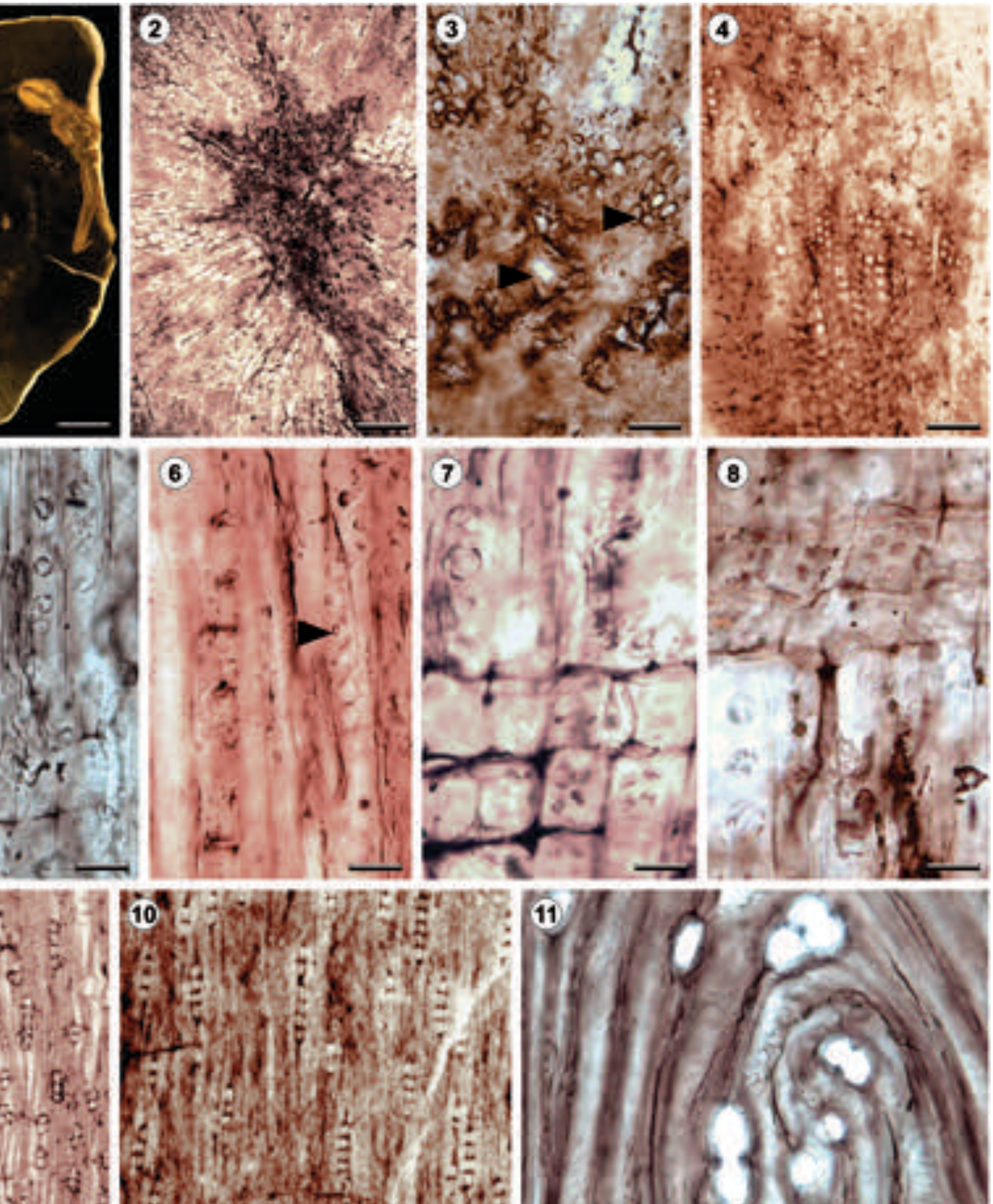

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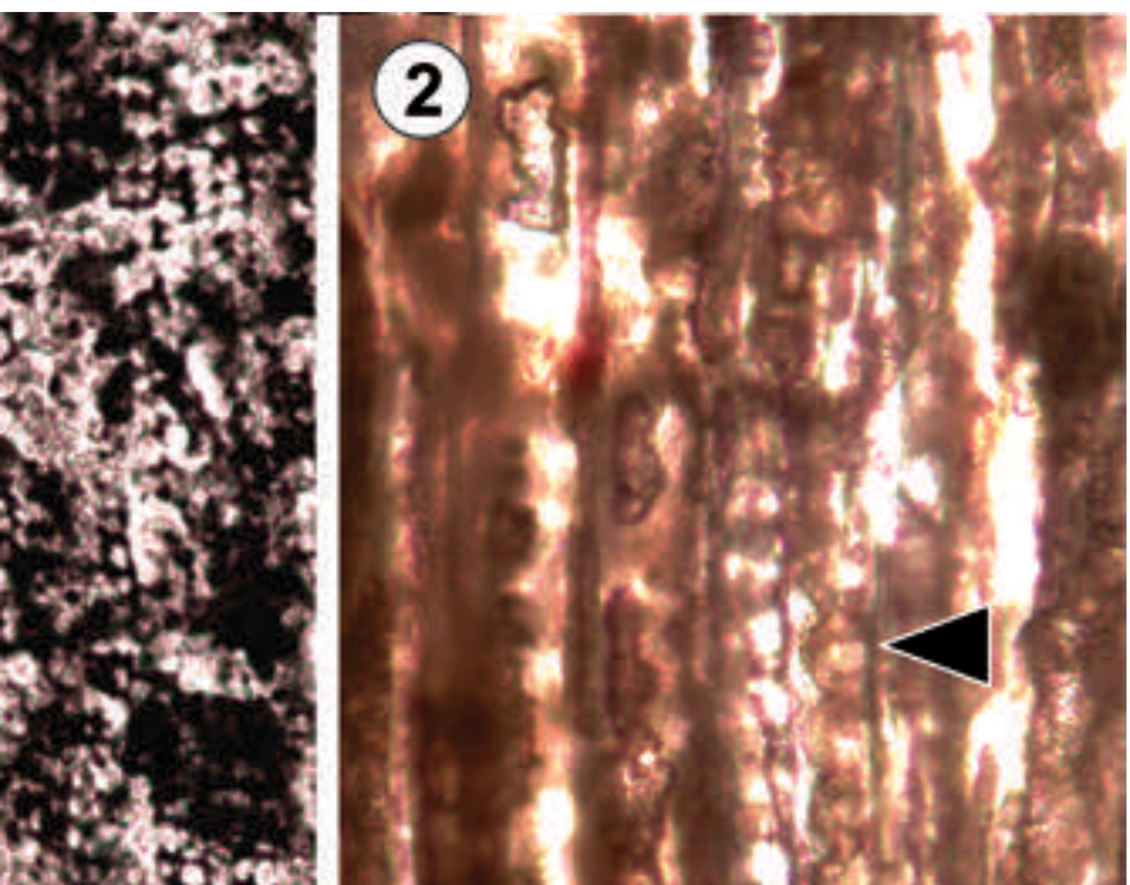
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