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XYLOTOMIC EVIDENCE FOR TWO NEW CONIFERS AND A GINKGO WITHIN THE LATE TRIASSIC CHINLE FORMATION OF PETRIFIED FOREST NATIONAL PARK, ARIZONA, USA

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INTRODUCTION

THE NATURE and extent of woody plant paleobiodiversity existing in the Late Triassic in the vicinity of Petrified Forest National Park (PEFO) can be discovered through comprehensive wood anatomical investigations of the petrified logs in the area. Species assignment on the basis of xylotomic features has uncertainty due to variable cellular phenotypes being expressed in response to changing environmental factors; however, some features of woody elements are genetically determined and thus serve for differentiating among species (Savidge, 2001).

Two of the fossils described here were found within the bounds of PEFO, in the Sonsela Member of the Chinle Formation. The third, from a mudstone facies of the Shinarump Member, Chinle Formation, was uncovered during an excavation not far from the PEFO boundary, near Holbrook, Arizona. Ground thin sections (30 μm) of each stem were prepared and examined by light microscopy. By comparing the observations below with Table 2 in Savidge and Ash (this volume), it emerged that all three trees were different from known species in PEFO, also from one another.

SYSTEMATIC PALEONTOLOGY

Family CHEIROLEPIDIACEAE Hirmer and Hörhammer, 1934.
Genus PROTOCUPRESSINOXYLON Eckhold, 1922.

Type species.–*P. arizonica* sp. nov. by monotypy.

PROTOCUPRESSINOXYLON ARIZONICA new species
Figure 1

Etymology.–*arizonica* to indicate the geographical location of the holotype.

Diagnosis.–Pycnoxylic secondary xylem; cross sectional xylem comprising well-organized radial files of mostly angular tracheids, some rounded with intercellular spaces, scattered thin-walled axial parenchyma, uniseriate rays; in radial section, long spaced or contiguous chains of abietinoid uniseriate, rarely biseriate, bordered pits with circular apertures, oblate pits when contiguous, alternately arranged biseriate pitting infrequent, angular pit outlines rare, ray cells thin-walled with ergastic material, cross-field pits (1-4) cupressoid with steeply inclined openings; in tangential section, rays moderately spaced, uniseriate, rarely partially biseriate, mostly thin-walled homocellular, rarely heterocellular, short, 1-10 circular or oblate, rarely elliptically shaped cells per ray, single-celled rays scarce to absent, bordered pits in 'latewood' elements of same diameter and shape as those in radial walls.

Description.–This holotype was found as an isolated segment, ~30 cm long and ~12 cm in diameter, with small diameter (c. 3 mm) pith and conspicuous rings on its transverse surface.

Occurrence.–Monotype, Crystal Forest, Petrified Forest National Park, locality PFP 117, PEFO 35348 (Holotype).

Horizon.– Rainbow Forest beds, Sonsela Member, Chinle Formation.

Discussion.–Wood of *Protocupressinoxylon arizonica* n. sp. (Figs. 1.1-1.9) is very like that of Upper Jurassic *Protocupressinoxylon purbeckensis* Francis (1983), except that the axial parenchyma indicative of Cupressaceae were not seen in the latter. In cross section, *P. arizonica* n. sp. xylem has circumferential rings, each occurring where a few tiers of radially narrow, thicker walled tracheids form a boundary line contrasting with centrifugally adjoining, radially enlarged, thinner walled tracheids, similar to the latewood – earlywood boundary of extant temperate-zone conifer species. Fully circumferential rings have not previously been confirmed in PEFO fossils, but the presence of circumferential rings is of dubious value as a criterion for distinguishing species because onset of cambial dormancy is unquestionably environmentally controlled. Zones of limited radial width consist of tracheids conspicuous by their variable diameter and loss of normal axial polarity, probably responses to cambial wounding as an uncommon development within this fossil, but no resin canals, traumatic or otherwise, were seen.

Family PROTOPINACEAE Kräusel, 1949.
Genus PROTOPICEOXYLON Gothan, 1907.

Type species.– *Protopiceoxylon novus* n. sp. by monotypy.

PROTOPICEOXYLON NOVUS new species
Figure 2

Etymology.–*novus* for its novel anatomy in relation to known PEFO and Upper Triassic woods.

Diagnosis.–Pycnoxylic secondary xylem; in cross section, radial files of angular tracheids and uniseriate rays, also scattered small-diameter vertical resin ducts, no resinous tracheids or

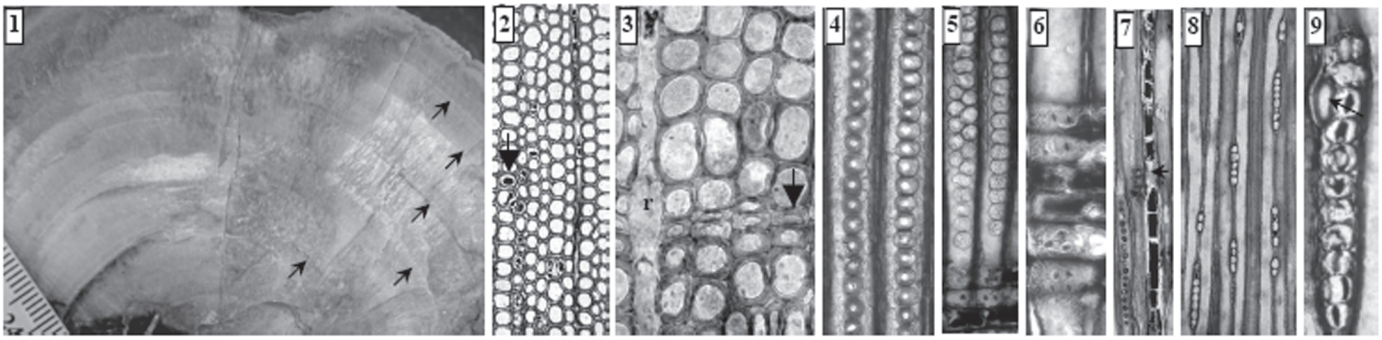

Figure *1*. *Protocupressinoxylon arizonica* n. sp. in transverse (1-3), radial (4-7) and tangential (8, 9) sections. *1*. Overview of rings (arrowed), mm scale; *2*. Axial parenchyma (one arrowed); *3*. Ring boundary (arrow) and a ray (r); *4*. Contiguous oblate bordered pits; *5*. Partially biseriate, alternating, abietinoid bordered pits; *6*. Cupressoid cross-field pits; *7*. Axial parenchyma (one arrowed); *8*. Spaced, short homo-cellular rays, oblate, thin-walled cells; *9*. A rarely seen hetero-cellular, partially biseriate ray with a secondary-walled ray cell (arrowed).

axial parenchyma; in radial section, uniseriate contiguous or non-contiguous chains of abietinoid bordered pits, oblate when contiguous, circular apertures, homo- and hetero-cellular rays, thin-walled ray parenchyma with ergastic contents, cross-field pits (1-4) cupressoid with steeply inclined openings, bordered pits in secondary-walled ray cells; in tangential section, bordered pits infrequent, same diameter /shape as in radial walls, short rays often one-celled, distant, no horizontal resin canals.

Description.–This holotype was found as a partially buried trunk with exposed roots and ~0.6 m dia. root collar.

Occurrence.–Monotype, Blue Mesa, Petrified Forest National Park, locality PFP 118, PEFO 35349 (Holotype).

Horizon.– Flattops One bed, Sonsela Member, Chinle Formation.

Discussion.–Features of *Protopiceoxylon novus* n. sp. wood are shown in Figures 2.1 to 2.9. The presence of hetero-cellular rays with ray tracheids and of weakly developed longitudinal resin canals indicates Pinaceae affinity.

Family GINKGOACEAE Engler, 1897.

Type species.– *G. hewardii* n. gen et n. sp. by monotypy

GINKGOXYLPROPINQUUS HEWARDII new genus and species
Figure 3

Etymology.–*Ginkgoxylpropinquus*, indicating the fossil wood's similarity to wood of *Ginkgo biloba* L.; *hewardii*, recognizing the person who discovered the fossil and made it available for research.

Diagnosis.–Pycnoxylic secondary xylem; in cross section, oft-disorganized tracheid radial files, tracheids of varied tangential diameter, axial parenchyma; in radial section, ray cells long, swollen, uniformly thin-walled with ergastic contents, cross-field pits (1-3) cupressoid with openings inclined c. 60°, long uniseriate chains of abietinoid bordered pits separated by weak crassulae, occasionally biseriate chains of non-araucoid pits arranged alternately sometimes oppositely; in tangential section, high frequency uniseriate rays to 16 cells in height, single-celled rays common, 1-2 biseriate cells rarely within uniseriate rays, cells upright of variable width.

Description.–Before excavation, a trunk >20 m in length and ~1 m root collar diameter with attached roots.

Occurrence.–Single specimen, discovered during an exca-

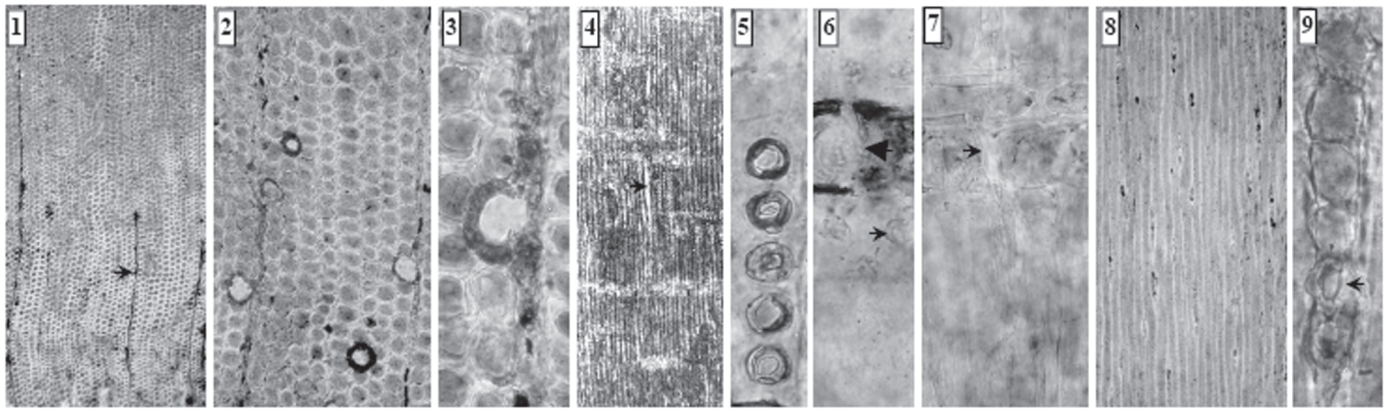

Figure *2*. *Protopiceoxylon novus* n. sp. in transverse (1-3), radial (4-7) and tangential (8, 9) section. *1*. Overview of tracheids and uniseriate rays (one arrowed) with ergastic material; *2*, *3*. Sporadically distributed, small-diameter vertical resin canals border the rays; *4*. Rays and part of a resin canal (arrow) in radial view; *5*. Non-contiguous abietinoid bordered pits, generally circular apertures; *6*. An hetero-cellular ray with cupressoid cross-field pitting (small arrow) in a thin-walled cell, and a neighbouring thicker-walled cell with a remnant of a bordered pit (large arrow); *7*. Ray cells with thick walls (one arrowed); *8*. Distantly spaced, generally short, uniseriate hetero-cellular rays; *9*. A hetero-cellular ray showing one ray cell with thickened walls (arrow).

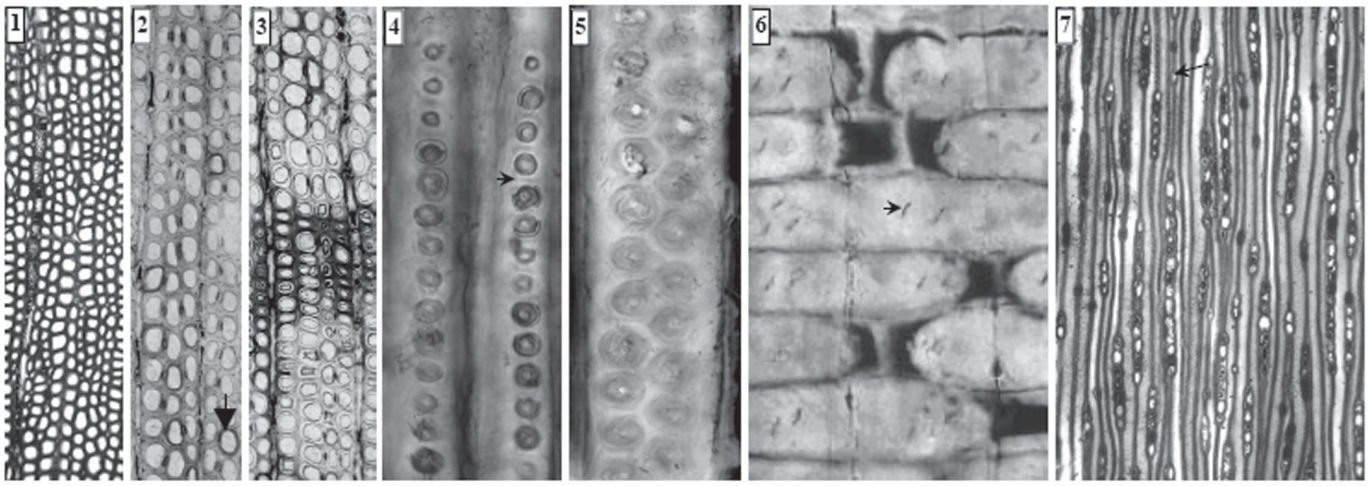

Figure *3*. *Ginkgoxylpropinquus hewardii* n. gen. n. sp. in transverse (1-3), radial (4-6) and tangential (7) sections. *1*. Overview of generally disorganized xylem; *2*. Non-inflated axial parenchyma (one arrowed); *3*. The darker radially compressed cells are evidence for a growth interruption; *4*. Uniseriate chains of abietinoid bordered pits, possibly separated by crassulae (arrow); *5*. Biseriate chains of abietinoid bordered pits; *6*. Cupressoid cross-field pits with steeply inclined apertures (one arrowed) in greatly swollen ray cells with ergastic material polarized to their ends; *7*. Closely spaced uniseriate rays among undulating tracheids; single-celled rays (arrow) are common.

vation south of Navajo Boulevard within the city limits of Holbrook, Arizona, PEFO 34356 (Holotype).

Horizon.– Shinarump Member, Chinle Formation.

Discussion.–Features of *G. hewardii* n. gen. n. sp. wood are shown in Figures 3.1 to 3.7. Tracheids of varied diameter, disorganized radial files, abundant unicellular rays, swollen ray cells, and cupressoid cross-field pitting support assignment of this tree to Ginkgoaceae. Besides *Ginkgo*, Ginkgoaceae form genera include *Arctobaiera*, *Baiera*, *Baieroxylon*, *Czekanowskia*, *Eretmophyllum*, *Ginkgoidium*, *Ginkgoites*, *Ginkgomyeloxylon*, *Ginkgophyllum*, *Ginkgophyton*, *Ginkgophytoxylon*, *Ginkgoxylon*, *Nehvizdya*, *Proto-ginkgoxylon*, *Sphenobaiera*, *Windwardia* and additional putative genera such as *Pecínovicladus* (Scott et al., 1962; Philippe, 1995; Falcon-Lang, 2004). Reliable differentiation among species and genera is complicated by the fact that phenotypic features of *Ginkgo biloba* L. can be highly variable within individual trees. Compared with Lower Permian *Ginkgophytoxylon lucasii* Tidwell et. Munzing (1995) of New Mexico, *G. hewardii* n. gen. n. sp. is distinct by lacking biseriate rays and long chains of biseriate pits, and in having generally short rays and 1-3 cross field pits. *G. hewardii* n. gen. n. sp. wood evidently has axial parenchyma but, if so, they are not conspicuously inflated. Calcium oxalate crystals were not seen in *G. hewardii* n. gen. n. sp., but under conditions of acidic silicification they would dissolve. It could not be determined if growth interruptions in outer trunk wood of *G. hewardii* n. gen. n. sp. were fully circumferential. Augmenting this report, two ginkgophyte leaves have been found in PEFO (S. R. Ash, pers. com.).

CONCLUSIONS

Anatomical features found in the three investigated fossils indicate that, during Late Triassic times in this region, conifers and ginkgophytes having abietinoid wood co-existed with trees having araucoid secondary xylem.

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