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FLORA OF THE LOWER CRETACEOUS CEDAR MOUNTAIN FORMATION OF UTAH AND COLORADO. PART III: ICACINOXYLON PITTIIENSE N. SP.¹

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ABSTRACT

Ikacinoxylon pittiiense, a new species of angiospermous wood from the Lower Cretaceous Cedar Mountain Formation of Utah is described and compared with similar fossil and modern woods. It is distinguished from other species of *Ikacinoxylon* by its thick-walled fiber-tracheids with their walls making up at least 50% of the total diameter of the cells, conspicuous bordered pits with obliquely crossing extended apertures on both the tangential and radial walls of its fiber-tracheids, scalariform perforation plates with as few as four or greater than 30 bars, transitional opposite to scalariform pitting on its vessel walls, thick-walled ray cells, and distinct sheath or border cells in its rays. *Ikacinoxylon pittiiense* is the first species of this genus to be reported from Cretaceous sediments. This wood is of special interest because very few angiosperm woods have been reported from lower Cretaceous strata.

SPECIMENS assignable to *Ikacinoxylon* of the Icacinaceae are among the well-preserved petrified dicotyledonous woods collected from the Cedar Mountain Formation east of Ferron, Utah (Thayn, Tidwell and Stokes, 1983). This formation lies between the Lower Cretaceous Dakota Sandstone and the Upper Jurassic Morrison Formation. A palynomorph assemblage from the upper part of the Cedar Mountain Formation studied by Tschudy, Tschudy and Craig (1984) date this horizon as Late Albian. These fossil woods from the Cedar Mountain Formation are found associated with cycadeoids, *Tempskya* and various conifer woods (Stokes, 1952; Tidwell, Thayn and Roth, 1976; Thayn and Tidwell, 1984). All living members of the Icacinaceae are tropical, Southern Hemispheric forms. This paper is, therefore, the first report of an icacinaceous species from North America.

Ikacinoxylon, with its type species *I. citronelloides*, was proposed by Shilkina (1956). Since 1956, however, many other icacinaceous species all from Tertiary sediments in Europe, have been described by Shilkina (1958), Rakosi (1960), and Greguss (1969). Greguss (1969) noted 25 taxa of *Ikacinoxylon*, but only eight were assigned species names. The only other genus of fossil wood assigned to the Icacinaceae is *Citronella*. Its type species, *C. mucronata*, which is still living, was first reported as a fossil by Shilkina (1958).

Specimens, from which *Ikacinoxylon pittiiense* is described, consist of several pieces of silicified secondary wood, the largest of which is 10 cm long and 5 cm wide. The wood is extremely well preserved showing considerable structural detail. This fossil wood was studied from thin sections. Technical terms used in the descriptions are from the "Glossary of terms used in describing wood anatomy" (I.A.W.A., 1957).

SYSTEMATICS SECTION

Family Icacinaceae

Genus *Ikacinoxylon* Shilkina, 1956

Ikacinoxylon pittiiense sp. nov. (Fig. 1-10)

Diagnosis—Growth rings are lacking.

Vessels: Diffuse porous, approximately 24/mm², generally solitary, with some in radial rows (pore multiples) of 2-3 cells long, small vessels occasionally in tangential pairs, vessel outline irregular, radially elongate, individual vessels ranging in size from 85 μ m to 195 μ m in radial diameter, vessel element length 69-970 μ m (avg. 680 μ m); 90 μ m tangential diameter, perforations scalariform with 4 to 30 bars; thin walled tyloses abundant, vessel walls 5-8 μ m thick, tangential intervacular pitting of scalariform (transversely elongate) to opposite slightly bordered pits with large apertures (size variable depending upon the diameter of the vessel), pits widely spaced (non-contiguous); vessel to fiber-tracheid pitting, small (3-5 μ m) opposite pits with narrow slit-like apertures, vessel to ray pitting, small (3-

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5 μm) elliptic to circular, 1–18 slightly bordered pits per crossover field.

Axial parenchyma: Abundant, thin walled, filled with dark substances, apotracheal diffuse or apotracheal in radial rows, up to 40 μm in radial diameter and up to 100 μm high.

Rays: Three to four per tangential mm, heterogeneous with both uniseriate and multiseriate present, uniseriate rays comprised of vertical cells only, multiseriate rays from 2–12 cells wide (maximum width of 370 μm), and up to 36 cells in height and over 4 mm high; comprised of both vertical and procumbent cells, vertical ray cells are rectangular in outline and occur as border cells (1–5) or in 1–2 rows of marginal cells along the margins of the rays, the procumbent cells make up the body of the rays, radial ray cell walls with scattered minute (3 μm) simple pits.

Fiber-tracheids: Round to irregular in outline, 40- μm diameter; tangential and radial walls with uni- or biseriate rows of evenly spaced 3–5- μm bordered pits with obliquely crossing apertures, walls approximately 8 μm thick and occupy up to 50% or more of the total diameter of the fiber-tracheids.

Repository: Brigham Young University, 2191 (Holotype).

Locality: 9 miles (5.6 km) east of Ferron, Utah (U.S. Geol. Surv. map: Desert Lake Quadrangle, NE $\frac{1}{4}$, SW $\frac{1}{4}$, Sec. 23, T20S, R8E).

Horizon: Cedar Mountain Formation

Age: Lower Cretaceous (probably Albian)

Etymology: The species designation, "*pittense*" is given to bring attention to the distinct bordered pits on the walls of the fiber-tracheids.

DISCUSSION—The Icacinaceae is a tropical family of trees, shrubs, woody vines, and rare herbs (Benson, 1957). This family of 60 genera was divided by Engler (1893) into subfamilies and tribes partly on the basis of their anatomy. His classification was subsequently reviewed by Bailey and Howard (1941a–d). Engler's classification established three subfamilies, the Icacinoidae, Lophopyxidoideae, and the Cardiopterygoideae. A total of three genera were

assigned to the latter two subfamilies, and there is a question as to their true icacinaceous affinities (Bailey and Howard, 1941a). The subfamily Icacinoidae was divided by Engler (1893) into four tribes, the Icachineae, Iodeae, Sarcostigmateae, and Phytocreneae. The Icachineae is a tribe of trees, shrubs, or climbers which has members in all three of the anatomically distinct groups of the Icacinoidae (Bailey and Howard, 1941b). These groups consist of one with exclusively scalariform perforation plates, one with both scalariform and simple perforations, and one with exclusively simple perforations. The other three tribes of the Icacinoidae are climbers with only simple perforations in their vessels. *Icacinoxylon pittense* is most similar to members of the Icachineae in the anatomical group having exclusively scalariform perforation plates.

Metcalf and Chalk (1950) reviewed the major anatomical features of the Icacinaceae. In this family the vessels are small in cross section, usually less than 100- μm mean tangential diameter and sometimes less than 50 μm . The vessels in those species with exclusively scalariform perforations are mostly solitary in arrangement with only an occasional pore multiple or pair. The intervacular pitting is circular and opposite or transitional between scalariform and opposite, and vessel to ray pitting is similar to that on the rest of the vessel wall. The scalariform perforation plates have numerous thin bars, as many as 50 in some genera, and the perforations are reticulate in *Calatola* and *Pennantia*. The average vessel element length in those forms with only scalariform perforation plates is 147 μm . Tyloses are present in two modern genera, *Cantleya* and *Emmotum*.

The amount and distribution of wood parenchyma in taxa of the Icacinaceae is highly variable. Typically, there is abundant apotracheal parenchyma arranged in numerous short lines, although in a few genera it is found in definite bands or is vasicentric. Multiseriate rays are distinctly heterogeneous and of the Kribs' (1935) Heterogeneous Type I. They are variable in width and height, ranging from 3 or 4

Fig. 1–6. 1. Transverse section illustrating the broad rays, solitary vessels and lack of growth rings. $\times 33$. 2. Transverse section of a vessel among thick walled fiber-tracheids with distinct pits. $\times 495$. 3. Tangential section illustrating heterocellular multiseriate ray. Note that the ray cells are thick walled. Pitting on fiber-tracheids (A), dark axial parenchyma cells (B) and tyloses (C) are also present. $\times 215$. 4. Transverse section showing heterocellular multiseriate rays, a uniseriate ray, and apotracheal diffuse as well as scanty paratracheal parenchyma. $\times 200$. 5. Radial section of the heterocellular ray, scalariform perforation plates, tyloses in the vessels, and elongate vertical parenchyma cells. $\times 40$. 6. Radial section. Pitting present on the fiber-tracheids and an elongate scalariform perforation plate with many thin bars. $\times 495$.

Fig. 7-10. 7. Radial section illustrating transitional scalariform to opposite (arrow) pitting on the vessel wall. $\times 990$. 8. Radial section of a tapered scalariform perforation plate with sinuous reticulated bars. $\times 495$. 9. Tangential section showing the overall size and distribution of rays. $\times 35$. 10. Tangential section of the dark axial parenchyma and fiber-tracheids with distinct extended aperture bordered pits (arrow). $\times 495$.

cells, up to 10 or more cells wide and from 1 to over 4 mm high. Commonly, both uniseriate and multiseriate rays are present. Where multiseriate rays are narrow or uniseriate rays are scarce, the multiseriate rays may dissect to produce "aggregate" rays. The uniseriate rays are often numerous and consist of high, upright cells. Fiber-tracheids in species with exclusively scalariform plates have been reported to have large conspicuous borders. The walls of the fibers are also generally very thick, which leaves only a small lumen.

Icacinoxylon pittense compares with the above listed characters of Icacinaceae in having similar vessel element size, arrangement, and pitting. The vessels are small, with the largest

being less than $100\ \mu\text{m}$ in tangential diameter. The vessel elements have exclusively scalariform perforation plates; or at least if simple perforations are present, they are obscured by tyloses. The presence of tyloses is also in agreement with at least two modern genera in the family. Vessels are usually solitary with occasional chains or tangential pairs. Pitting on both the tangential and radial vessel walls is opposite and transitional opposite scalariform, and the vessel to parenchyma pits are similar to those on the rest of the wall. The number of bars in the scalariform perforation plates ranges from 4 to 30. This characteristic is not in complete agreement with the Icacinaceae since modern members of the family typically

have more than four bars in a plate. However, some of the perforation plate borders are reticulate, which agrees with two modern members of the family. The vessel element length is smaller in the fossil than in the corresponding living types, averaging only 680 μm long, while the smallest average vessel element length of recent genera with exclusively scalariform plates is 950 μm (Bailey and Howard, 1941b). The wood parenchyma in *Icacinoxylon pitttense* is apotracheal diffuse, scanty paratracheal, or arranged in radial lines. The presence of uniseriate rays and Kribs' (1935) Heterogeneous Type I multiseriate rays of up to 12 cells wide and as high as 4.0 mm or more, also agrees with the Icacinaceae. The fiber-tracheids of *I. pitttense* have conspicuous bordered pits and thick walls, two more characteristics in common with the Icacinaceae.

None of the living members of the genera of Icacinaceae completely match *Icacinoxylon pitttense*, but the characteristics found in this species can be observed in various genera of the family. In cross section *I. pitttense* most closely resembles *Citronella smythii* with its broad multiseriate rays, thick walled fiber-tracheids and solitary vessels. The vessel wall pitting is similar to *Urandra ammu*, which has transitional opposite to scalariform pits. The elongate scalariform-reticulate perforation plates of *I. pitttense* are similar to those of *Dendrobangia boliviana*. The tangential aspect of the wood in *I. pitttense* is similar to the tangential section of *Gonocaryum calleryanum* as it has large multiseriate rays. Although it cannot be conclusively demonstrated that *I. pitttense* is directly related to the modern Icacinaceae, the fossil fits best into the genus *Icacinoxylon*.

Of the fossil icacinaceous species discussed by Greguss (1969), *Citronella mucronata* D. Don, *Icacinoxylon citronelloides* Shilkina (1956), and *I. hortobagyii* Greguss (1969) appear the most similar to *Icacinoxylon pitttense*.

Fossil wood of *Citronella mucronata* is apparently the same as that of the living plant and is, therefore, not given the "oxylon" designation. It has scalariform perforation plates but the bars are thicker and fewer in number than those in *Icacinoxylon pitttense*. The rays of *C. mucronata* vary from 6 to 8 cells wide, as opposed to the up to 12-cell-wide rays of *I. pitttense*. The vessels in *C. mucronata* have spiral thickenings and pits with vertically oriented slit-like apertures, both of which are absent in *I. pitttense*.

Icacinoxylon citronelloides has smaller, more numerous and more angular vessels than *I. pitttense*. It also has thinner walled ray cells

and fiber-tracheids and smaller, less distinct, sheath cells in the rays than does *I. pitttense*.

The outline of the rays, the type of perforation plates, and the pitting of *Icacinoxylon hortobagyii* are close to the corresponding features of *I. pitttense*. It differs from *I. pitttense* by having more concentrated and clustered vessels, less distinct sheath cells in the rays, and more radially elongate procumbent ray cells.

Other species of *Icacinoxylon* reported by Greguss (1969) differ from *Icacinoxylon pitttense* in such characteristics as fiber-tracheid wall thickness, size and arrangement of ray cells, vessel concentration and pitting.

Many other families have species with wood structure similar to the Icacinaceae. Among these are the Fagaceae, Platanaceae, Magnoliaceae, Dilleniaceae, Ericaceae, and Theaceae. The Fagaceae is similar to the Icacinaceae in that fagaceous species have diffuse porous wood, solitary vessels, uniseriate as well as multiseriate rays and a much smaller ray cell size. However, the former family differs from *I. pitttense* by having mostly simple perforations, typical fusiform uniseriate rays with procumbent rather than vertical cells and closely spaced intervacular pits. Multiseriate rays of the members of Fagaceae are homocellular or slightly heterocellular rather than exclusively heterocellular as in *I. pitttense*.

Anatomically, the wood of the Platanaceae is very close to Icacinaceae. The wood of these two families differs in that the wood in species of Platanaceae has fewer than 20 bars in the perforation plates, few or no uniseriate rays, and has homocellular rather than heterocellular multiseriate rays. Since *I. pitttense* has heterocellular rays and perforation plates with up to 30 or more bars, it cannot be placed in the Platanaceae.

The wood in some members of the Magnoliaceae is also similar to that of the Icacinaceae but differs by having only a few widely spaced bars in the perforation plates, a maximum width of seven cells in the rays, and terminal rather than diffuse or vasicentric axial parenchyma (Metcalf and Chalk, 1950).

The description of the Dilleniaceae given by Metcalfe and Chalk (1950) nearly parallels their description of the Icacinaceae. *Icacinoxylon pitttense* is placed in the latter family because it lacks simple perforation plates and 4 to 10 rows of upright cells in the margins of the rays which occur in members of the Dilleniaceae.

The Theaceae is similar to the Dilleniaceae and hence, the Icacinaceae. The Theaceae differs from the Icacinaceae and thus, *Icacinoxylon pitttense*, by having more numerous ves-

sels, somewhat smaller rays, and striations on the vessel walls.

Oxydendrum of the Ericaceae is similar to *Icacinoxylon pitttense* but has slightly narrower rays, some simple perforation plates, and lacks tyloses (Panshin, DeZeeuw and Brown, 1964).

Page (1968) amended the genus *Plataninium* Unger 1842 emd. Vater 1884, to include fossil woods which resemble some members of the Platanaceae, Eupteleaceae, Fagaceae, and Icacinaceae, but whose familial affinities cannot be definitely determined. *Icacinoxylon pitttense* shows many of the diagnostic characters of the genus *Plataninium* but it has heterocellular rays and radially aligned axial parenchyma in contrast to the homocellular rays and tangentially aligned wood parenchyma characteristic of *Plataninium*.

According to Young (1960), the Cedar Mountain Formation was deposited on flood plains inland from the sea. This concept is supported by the presence of channel fills at the Ferron site. *Icacinoxylon pitttense* and *Paraphyllanthoxylon utahense* (Thayn et al., 1983) may have grown along these streams, but more likely their wood was carried from higher ground to their depositional site. Specimens of these species are not abundant in the Cedar Mountain Formation and none have been found in growth position. In either case, the environmental conditions under which they grew, especially temperature and moisture availability, seems to have been relatively uniform since there is very little variation in vessel size throughout the individual specimens. The lack of growth rings suggests that the trees grew under tropical to subtropical conditions. The fact that most of the families related to these woods are mainly tropical in their present distribution adds substance to this postulation.

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