Universidad Nacional Autónoma de México, Instituto de Geología,
Revista, volumen 10, número 1, 1992, p. 65-70

DICOTYLEDONOUS WOOD FROM THE UPPER CRETACEOUS (MAASTRICHTIAN) OF COAHUILA

Sergio R.S. Cevallos-Ferriz and*
*Reinhard Weber**

ABSTRACT

A silicified wood collected from Maastrichtian sediments of the Olmos Formation, near Agujitas, State of Coahuila, has anatomical characteristics similar to those from the wood of the phyllantoid group (Euphorbiaceae). However, it has some similarity to the wood of Anacardiaceae, Burceraceae, Elaeocarpaceae and Lauraceae.

Resemblance of at least some extant and extinct taxa of these families and the new fossil wood is discussed based on the presence of common features. The fossil wood is characterized by the absence of growth rings, diffuse porosity, solitary and multiple radial pores, simple perforation plates, alternate intervascular pits; thin-walled fibers apparently with septae; 1-4 seriate heterogeneous rays, with one or two erect marginal cells, pits between vessels and ray cells enlarged compared to intervascular pits; diffuse apotracheal and scanty paratracheal parenchyma. Septae in some fibers may be due to the presence of hyphae.

If the secretory function of some cells is confirmed, the wood would be more similar to *Ulminium* Unger (Lauraceae), but if these cells are not secretory the wood from Coahuila would be more similar to *Paraphyllanthoxylon* Bailey (Euphorbiaceae).

Anatomical characters of the wood of this plant reinforce the interpretation of a subtropical or tropical climate with little seasonality during the time of deposition of the Olmos Formation.

Key words: paleobotany, dicotyledonous fossil wood, Cretaceous, Coahuila, Mexico.

RESUMEN

Se describe un ejemplar de madera silicificada recolectado en sedimentos maastrichtianos de la Formación Olmos, cerca de Agujitas, Estado de Coahuila, con afinidad taxonómica con el grupo phyllantoide (Euphorbiaceae), aunque también semejante a la madera de las Anacardiaceae, Burceraceae, Elaeocarpaceae y Lauraceae.

Se discute la similitud que tienen algunos taxa extintos y actuales de estas familias, con base en los caracteres que presenta la madera de la planta fósil. El espécimen se caracteriza por tener anillos de crecimiento indistinguibles, porosidad difusa, poros solitarios y múltiples radiales, placa de perforación simple, punteaduras intervasculares alternas; fibras de pared delgada aparentemente septadas; radios 1-4 seriados, heterogéneos, con una o dos células marginales erectas, las punteaduras entre vaso y parénquima alargadas en comparación con las punteaduras intervasculares; y el parénquima apotraqueal difuso y el paratraqueal escaso. Por su relativa escasez y, en ocasiones, su morfología, los septos en las fibras recuerdan hifas en corte transversal.

Algunas células marginales de los radios y otras asociadas con las fibras y radios pudieran representar células secretoras. Si se confirma la función secretora de estas células, la madera sería más parecida a *Ulminium* Unger (Lauraceae); de no ser así, la madera de Coahuila tendría mayor afinidad con *Paraphyllanthoxylon* Bailey (Euphorbiaceae).

Los caracteres anatómicos de la madera de esta planta refuerzan la interpretación de un clima subtropical o tropical con poco señalamiento de las estaciones durante el tiempo de depósito de la Formación Olmos.

Palabras clave: paleobotánica, madera fósil dicotiledónea, Cretácico, Coahuila, México.

INTRODUCTION

In Mexico, the paleontological study of flowering plants has been mostly restricted to palynological analyses. Angiosperm megafossils are also known, but these have been seldom studied with detail. Fossil woods from Mexico have been known since the past century and sometimes they were donated to public collections along with other types of fossils (Maldonado-Koerdell, 1950). Nevertheless, these woods have been scarcely studied and they have been treated as curiosities.

*Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria, Delegación Coyoacán, 04510 D.F.

From the Tertiary of Papantla, State of Veracruz, a poorly preserved wood (Müller-Stoll and Mädel, 1967) was identified as *Hura americana* Unger (Leguminosae; Unger, 1845, 1857). According to the International Code of Botanical Nomenclature, this species corresponds to a *Nomen nudum.* The first work that reports a well preserved wood is that of Felix and Nathorst (1899) regarding fossil plants from a locality near Tlacolula, Oaxaca. In it, Felix described Tertiary material identified as *Mimosoxylon tenax* (Felix) Müller-Stoll and Mädel, *Palmoxylon cellulosum* Knowlton and *Palmoxylon* cf. *P. stellatum* Unger. Felix (*in* Felix and Nathorst, *op. cit.*) also mentioned the presence of an unidentified coniferous twig from the Neocomian (Lower Cretaceous). Prakash and Boureau (1968) pointed out that Stenzell (1904) identified *Palmoxylon cellulosum, P. angiorhiza, P. astro-verum, P. astron-radicatum* and *P. tenue* from Cretaceous sediments. However, they do not mention the exact localities where these plant organs were collected. Later, Wieland (1914) reported *Araucarioxylon mexicanum* Wieland from the west side of the cerro El Lucero, Oaxaca, in Rhaetic-Liassic sediments. *Araucarioxylon* Kraus has been collected in the Mal Paso Formation (Upper Cretaceous) from the Huetamo, State of Michoacán, area (Pantoja-Alor, 1959). Recently, Weber (1972, 1975) mentioned the presence of abundant wood in the Olmos Formation. He identified most of the samples as gymnosperms (v. gr. *Dadoxylon/Araucarioxylon)*, and noted the presence of *Palmoxylon* Schenk among other angiosperm vegetative axes to which the sample described here belongs. From Upper Cretaceous sediments of Sonora, a wood with anatomical pattern similar to that of the Burceraceae was described by Cevallos-Ferriz (1983).

THE OLMOS FORMATION

The wood described here was collected by Weber in 1970, during one of his visits to the Olmos Formation in the State of Coahuila. This stratigraphic unit was first described by Stephenson (1927). In El Cedral section, it reaches a thickness of 380 m (Robeck *et al.*, 1956). It is composed of continental and transitional sediments representing a delta (Martínez-Hernández *et al.*, 1980).

The Maastrichtian age of the Olmos Formation was first established through observations based on physical geology. Later, observations on planktonic foraminiferal assemblages (*Rosita fornicata/stuartiformis* biozone, *Rugotruncana subcircumnodifer* subzone and *Globotruncana contusa/stuartiformis* biozone, *Globotruncana gansseri* subzone) confirmed this age (Pessagno, 1969), and were used to propose that the San Miguel and Escondido Formations, that overlie and underlie respectively the Olmos Formation, corresponded to the Navarro Group. Zaitzeff and Cross (1970) reaffirmed the Maastrichtian age for these sediments by studying dinoflagellates and acritarcs of the Navarro Group. Recently, a palynological study of the Piedras Negras, Coahuila; Colombia, Nuevo León; and San Ignacio and Miguel Alemán, Tamaulipas, areas confirmed this age for the Olmos Formation (Martínez-Hernández *et al., op. cit.*).

Three horizons with fossil wood are known from the Olmos Formation (Weber, 1972). The lowest is referred as "horizonte con madera silicificada A" and is located in Zone 1 of Robeck and coworkers (1956). The second unit with wood, called "horizonte con madera silicificada B", is located in Zone 2 of Robeck and coworkers (*op. cit.*). The third horizon with fossil wood was not observed by Weber (1972), but its presence was noticed by Delgado (*in* Weber, 1972) at the top of the Olmos Formation. It has been referred as "horizonte con madera silicificada C".

MATERIAL AND METHOD

The wood sample was collected on the road that goes from Sabinas to Nueva Rosita, State of Coahuila, near the town of Agujitas [Figure 1] (Locality 7 of Weber, 1972) in strata of the "horizonte con madera silicificada A". The sample was prepared using the thin-section technique and it was observed and photographed with a model No. 1 Zeiss photomicroscope. For the identification of the wood, besides a large literature revision and comparison to woods from extant plants deposited in the Instituto Nacional de Investigaciones Forestales y Agropecuarias (INIFAP), Mexico, and in the National Xilotheca in the Instituto de Biología, UNAM, the Guess Program and NCSU data base

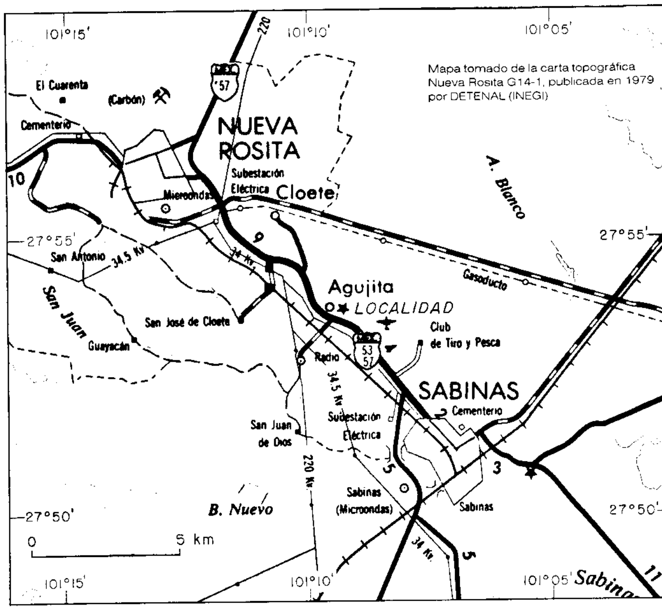


Figure 1.- Location map of the sample locality.

(Wheeler *et al.*, 1986; LaPasha and Wheeler, 1987) were used. Statistical data are based on 25 measurements for each characteristic. Terminology employ follows the suggestions made by a committee of the International Association of Wood Anatomists (Wheeler *et al.*, 1989). The fossil material is housed in the Museo de Paleontología of the Instituto de Geología, UNAM (IGUNAM).

SYSTEMATIC DESCRIPTION

Growth rings are indistinct and the wood is diffuse porous (Plate 1, figure 1). Vessels are solitary (54%) or in radial multiples of two (37%), three (7%) and four (2%). Vessel density varies between nine and 12 vessel elements per square millimeter (mean is 10). Vessel elements are approximately 150 μm long (Plate 1, figure 3). The mean tangential diameter is 68 μm (range 29–128 μm), while their mean radial diameter is 185 μm (range 71–343 μm). Vessel element end walls are oblique to almost horizontal with wide borders (Plate 1, figures 5–7). Intervascular pits are rhomboidal, and crowded alternate (Plate 1, figures 6–8). Thin-walled tyloses are present in vessel elements (Plate 1, figure 4).

Thin-walled rectangular cells surrounding the vessel elements correspond to the scanty vasicentric parenchyma (Plate 1, figure 9). Other parenchyma strands representing diffuse apotracheal parenchyma up to three cells wide and six cells high are sporadically seen among the fibers (Plate 1, figure 9).

Rays are one to four cells wide and composed in their main body of radially elongated cells (Plate 1, figure 2). Square or erect marginal cells are organized into one or two rows (Plate 2, figure 15). In some rays the marginal cells have a slightly globose "flame-like" morphology, suggesting that they may have functioned as idioblasts (Plate 1, figure 16). Multiseriate rays height ranges from 420 to 214 μm (mean of 379 μm). A cell with a "drop" of viscous material is present in the multiseriate region of some rays. Poorly preserved structures with fusiform morphology, less than six cells high, and apparently one cell wide, may represent scarce, low, uniseriate rays (Plate 1, figures 10, 12). There are 9–12 rays per millimeter (mean of 11). Vessel element to ray and axial parenchyma pits are slightly elongated in radial direction when compared to the circular to oval intervascular pits.

Between two rays, there are up to nine (10) thin-walled fibers (Plate 1, figure 2) with an oval to angular outline in transverse section. Fiber radial diameter is 14 μm (range 9–17 μm) while their mean tangential diameter is 18 μm (range 13–21 μm). Libriform fibers seem to be septate (Plate 1, figures 11, 13). Preservation does not allow to establish the nature of these presumable partitions in most fibers (Plate 1, figure 13). When structures similar to septae are present in the examined thin sections, they are located in small areas. Possible idioblasts composed of a single thin-walled cell are occasionally associated with the fibers (Plate 1, figure 14).

DISCUSSION

The anatomy of the wood described in this paper has a generalized structural pattern, making its identification with an extant taxon difficult. Its combination of characters is found in more than a single genus or family. Taxonomically, important characters in the wood from Coahuila are: solitary and radial multiple vessels, simple perforation plates, alternate intervascular pits, tyloses in vessel elements; (one) two-four seriate heterocellular rays, that are less than 1 millimeter high; elongate ray to vessel element pits; scanty vasicentric and diffuse apotracheal parenchyma; possible septate fibers and possible idioblasts. All or most of these characters can be found in at least some taxa of Anacardiaceae, Burceraceae, Elaeocarpaceae, Euphorbiaceae, and Lauraceae (Wheeler *et al.*, 1986; LaPasha and Wheeler, 1987).

Fungi in the fossil wood are not abundant, but some hyphae and fungal spores corroborate their presence and may be responsible for the septate appearance of some fibers. Among the families to which the Coahuila wood could be related, species either with or without septate fibers are well known.

Although several fossil woods have been described as having similar anatomical pattern to the families with which the Coahuila material best compares, there are significant differences among them and the new material from the Olmos Formation. Presence of resin canals, gum ducts or laticifers, two sizes of rays, number or marginal cells in rays, numerous uniseriate rays, and/or type of axial parenchyma are characters that help to distinguish among most of these taxa (*cf.* Metcalfe and Chalk, 1950; Mädel, 1962; Manchester, 1977; Richter, 1981). There are, however, two Cretaceous fossil woods with anatomical structure most similar to the Coahuila material: *Paraphyllanthoxylon* Bailey (Euphorbiaceae) and *Ulminium* Unger (Lauraceae).

Although in Cretaceous woods related to Lauraceae, as in the Coahuila wood and some extant species of this family, presence of secretory cells has not been demonstrated categorically, in the fossil material of this age some cells with globose morphology may have had this function (Page, 1981). It is preferable not to include the wood of the Olmos Formation in *Ulminium* until the presence of secretory cells is positively demonstrated.

Within Euphorbiaceae the wood of Coahuila is closer to section Glochidion of the Phyllanthoideae type (Metcalfe and Chalk, 1950). Among the fossil genera based on wood samples with Euphorbiaceae affinity, *Paraphyllanthoxylon* (similar to *Bridelia* and *Phyllanthus*) and *Securinegoxylon* Mädel (similar to *Securinega*) are included in this section (Mädel, 1962).

The anatomical structure of the Coahuila wood is similar to the original description of *Paraphyllanthoxylon* by Bailey (1924). However, *Paraphyllanthoxylon* is characterized by two sizes of rays that are higher than 1 mm and septated fibers (Bailey, 1924; Thayn *et al.*, 1983). In contrast, the wood from Coahuila has shorter and one sized rays, and the nature of the partitions is dubious.

Among the Cretaceous woods included in *Paraphyllanthoxylon* two distinct anatomical patterns based on ray structure can be distinguished (Wheeler *et al.*, 1987). *P. arizonense* Bailey and *P. illinoisense* Wheeler and coworkers have uniseriate and multiseriate heterocellular rays with long uniseriate margins that may fuse with other rays to create multiseriate and uniseriate zones. These characteristics, as well as other features of the genus, suggest that these two are similar to Euphorbiaceae, although they share some similarity to Flacourtiaceae and Violaceae (Wheeler *et al.*, 1987). *Paraphyllanthoxylon capense* Mädel could be included in this group.

A second group of species *P. idahoense* Spackman, *P. alabamense* Cahoon and *P. utahense* Thayn and coworkers have scarce uniseriate rays and only one or two rows of upright to square marginal cells in multiseriate rays (Spackman, 1948; Cahoon, 1972; Thayn *et al.*, 1983). This ray structure is more similar to Anacardiaceae, Burceraceae and Lauraceae than to Euphorbiaceae (Wheeler *et al.*, 1987), and is also closer to the wood from Coahuila. This second group of *Paraphyllanthoxylon* species is synonymized to *Phyllanthinium* by Prakash and coworkers (1986).

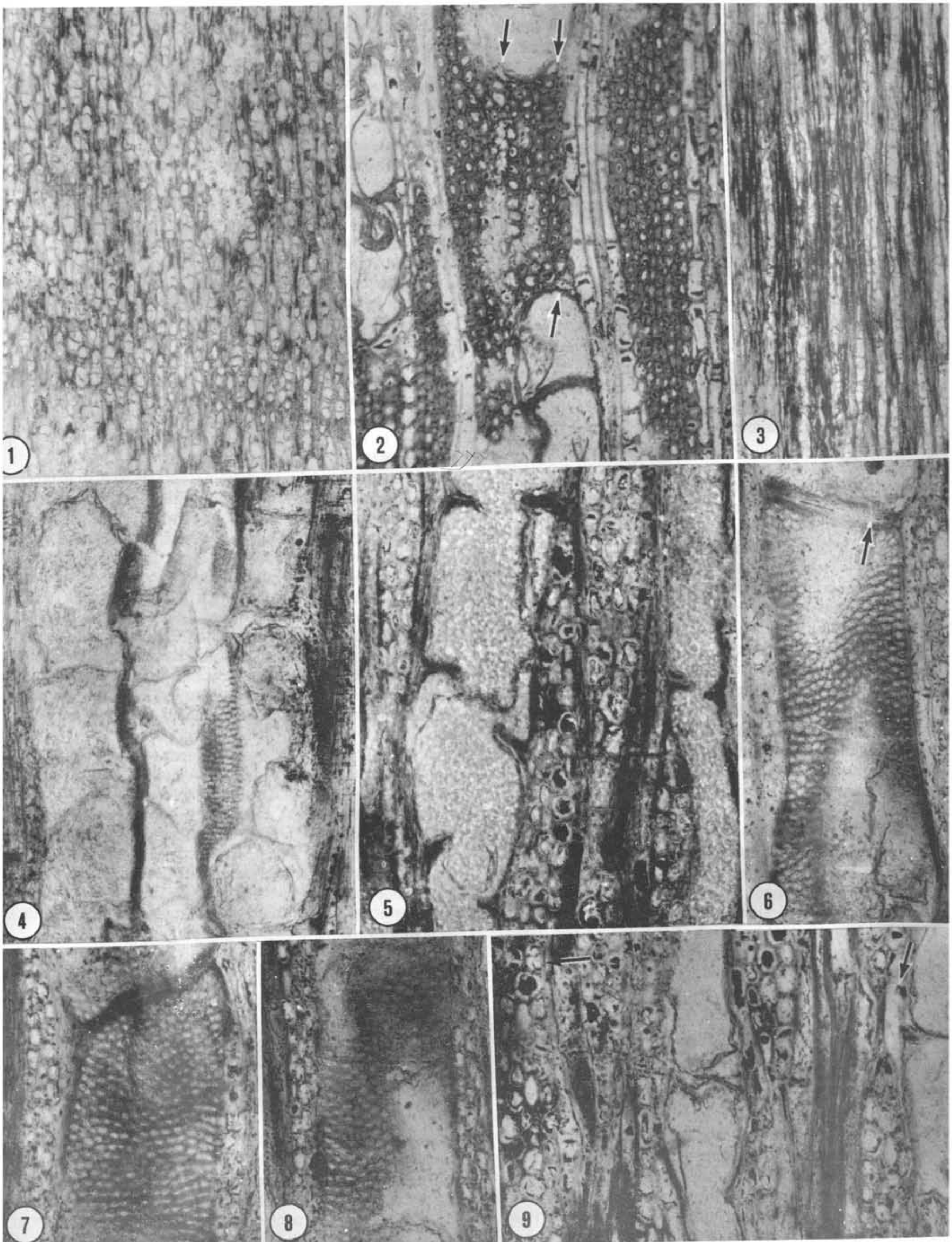
The affinity of the wood from Coahuila with an extant taxon is not possible. It is clear, however, that the wood of the Olmos Formation has anatomical structure of the phyllantoid type. Woods with similar structure are accommodated in the genera *Paraphyllanthoxylon* and *Ulminium.* Woods from other localities, presenting a similar anatomical pattern, are thought to be most similar to Euphorbiaceae and Lauraceae. If the parenchyma cells with viscous contents and/or the globose cells in the ray margins are confirmed to be secretory cells, the Coahuila wood would represent an *Ulminium*. However, if these cells are not secretory, the wood of the Olmos Formation would represent a *Paraphyllanthoxylon* with short rays and few marginal cells. It is necessary to find new wood samples of the same type in order to decide the true nature of these cells.

The parataxonomic system proposed by Page (1979, 1980, 1981) for Cretaceous woods from California offers an alternative option to put the Coahuila wood into structural context. In this system of classification, the wood of the Olmos Formation fits better in group XIA. This is characterized by having vessels, simple perforation plate, alternate intervascular pits and vasicentric axial parenchyma. Included in this group are woods with anatomical pattern similar to that of Lauraceae, Sapindaceae, Combretaceae, Leguminosae, Menispermaceae, and Lardizabalaceae, among others (Page, 1981).

PALEOECOLOGY

The environment in which the plants of the Olmos Formation developed has been described as deltaic-fluvial and swampy (Martínez-Hernández *et al.*, 1980). Macrofossil plant evidence suggests a subtropical/tropical climate (Weber, 1972, 1975). Draw paleoecological conclusions based on a single wood type is rather speculative. However, the absence of growth rings in the wood of Coahuila suggests that the plant that produced the wood of Coahuila grew in an area with small climatic oscillations through the year. Other characters found in the wood of the Olmos Formation, like vessel diameter, their apparent short length, and the tendency to form multiple radial vessels, are generalized ones, but one would be expected (not restricted) to be present in the wood of some plants in a tropical area.

The anatomy of the wood of the Olmos Formation, therefore, can be correlated with the previous paleoecological obser-



MAASTRICHTIAN FOSSIL

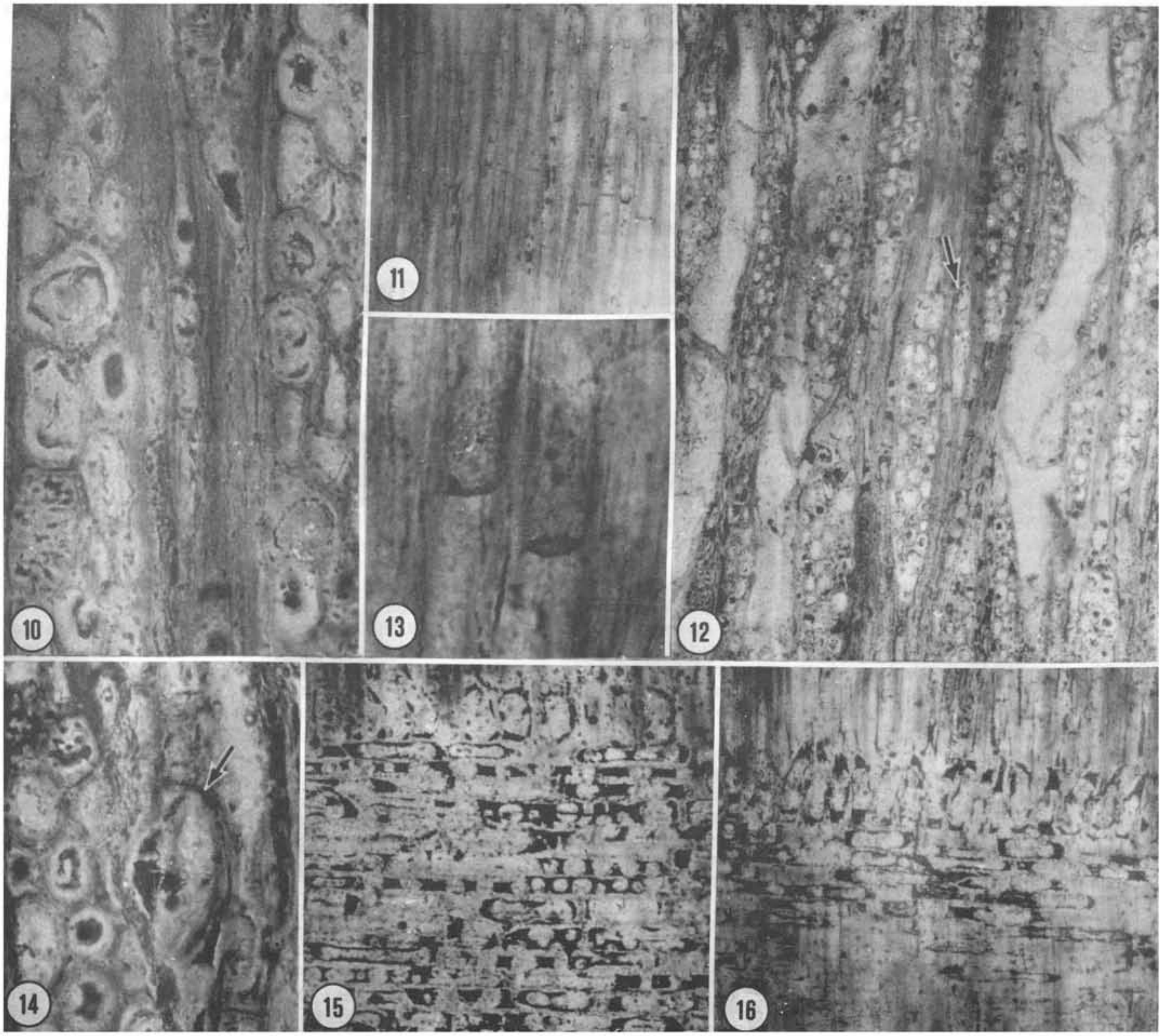


Plate 1.- Maastrichtian fossil wood from Coahuila; figure 1—transverse section showing diffuse porosity, LPb No. 50, x19; figure 2—transverse section showing thin walled-fibers and some parenchyma cells associated with vessels elements (arrows), LPb No. 50, x109; figure 3—tangential section showing ray size and distribution, LPb No. 55, x29; figure 4—radial section showing vessel elements with thin-walled tyloses, LPb No. 58, x277; figure 5—tangential section showing vessel elements with simple perforation plate, LPb No. 55, x138; figure 6—tangential section showing a vessel element with alternate and opposite intervascular pits and simple perforation plate, LPb No. 55, x196; figure 7—tangential section showing vessel elements with alternate and opposite intervascular pits, LPb No. 55, x196; figure 8—tangential section showing a vessel element with alternate intervascular pits, LPb No. 55, x196; figure 9—tangential section showing parenchyma cells associated with vessel elements (arrows), LPb No. 55, x87; figure 10—tangential section showing possible uniseriate ray, LPb No. 55, x616; figure 11—tangential section showing thin-walled fibers with possible septa (arrows), LPb No. 55, x95; figure 12—tangential section showing parenchyma cells not associated with vessel elements (arrows), LPb No. 55, x80; figure 13—tangential section showing the dubious nature of some septa (vs. hifae), LPb. No. 55, x683; figure 14—tangential section of a globose cell that may represent an idioblast, LPb No. 55, x615; figure 15—radial section of a ray showing erect marginal cells, LPb No. 58, x285; figure 16—radial section of a ray showing "flame"-like marginal cells that may represent secretory cells, LPb No. 58, x285.

vations of this geologic unit. This wood also documents the presence of an arboreal stratum that grew around the aquatic systems identified based on macro and microfossils (Martínez-Hernández *et al.*, 1980; Weber, 1972, 1975). As the study of other woods and macrofossils of the Olmos Formation continues, the taxonomic affinity of the new wood will be better understood and a more complete idea of the plants that formed part of this community will be reached.

ACKNOWLEDGMENTS

Authors express their thanks to Dr. Theodore Delevoryas, University of Texas, for an invitation to his laboratory where this study began. Recognition is due to Dr. Edouard Boureau and Dr. Catharine Privé, University P. and M. Curie, Dr. Virginia Page, Stanford University, and Dr. Elisabeth A. Wheeler, University of North Carolina, for their comments to the identification of the wood. Valuable comments by Dr. Elisabeth A. Wheeler and an unknown reviewer significantly improved this paper.

BIBLIOGRAPHICAL REFERENCES

Bailey, I.W., 1924, The problem of identifying the wood of Cretaceous and later dicotyledons—*Paraphyllanthoxylon arizonense*: Annals of Botany, v. 38, p. 439–452.

Cahoon, E.J., 1972, *Paraphyllanthoxylon alabamense*—a new species of fossil dicotyledonous wood: American Journal of Botany, v. 59, p. 5–11.

Cevallos-Ferriz, S.R.S., 1983, Descripción de una madera de angiosperma cretácica de Cananea, Sonora, México—los xilitos en el estudio de los angiopermopsida: Universidad Nacional Autónoma de México, Anales del Instituto de Biología, v. 54, p. 97–112.

Felix, Johannes, and Narthorst, A., 1899, Versteinerungen aus dem mexikanishen Staat Oaxaca, *in* Felix, Johannes, and Lenk, Hans, eds., Beiträge zur Geologie und Paläontologie der Republik Mexiko: Stuttgart, Schweizerbart, part 2, p. 46-51.

LaPasha, C.A., and Wheeler, E.A., 1987, A microcomputer based system for computer-aided wood identification: IAWA Bulletin 8, new series, p. 347–354.

Mädel, Erika, 1962, Ergebnisse der Forschungsreise Richard Kräusel's 1954 nach Süd-und Südwest Afrika, 1, 8—die Fossilen Euphorbiaceen-Hölzer mit besonderer Berücksichtigung neuer Funde aus der Oberkreide Süd-Afrikas: Senckenbergiana Lethaea, v. 43, p. 283–321.

Maldonado-Koerdell, Manuel, 1950, Los estudios paleobotánicos en México, con un catálogo sistemático de sus plantas fósiles (excepto Tallophyta y Bryophyta): Universidad Nacional Autónoma de México, Instituto de Geología, Boletín 55, 72 p.

Manchester, S.R., 1977, Wood of *Tapirira* (Anacardiaceae) from the Paleogene Clarno Formation of Oregon: Review of Paleobotany and Palynology, v. 23, p. 119-127.

Martínez-Hernández, Enrique; Almeida-Leñero, Lucía; Reyes-Salas, Margarita; y Betancourt-Aguilar, Yolanda, 1980, Estudio palinológico para la determinación de ambientes en la cuenca Fuentes-Río Escondido (Cretácico Superior), región de Piedras Negras, Coahuila: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 4, p. 167-185.

Metcalfe, C.R., and Chalk, L., 1950, Anatomy of the dicotyledons: Oxford, Clarendon Press, 2 t., 1500 p.

Müller-Stoll, W.R., and Mädel, Erika, 1967, Die Fossilen Leguminosen-Hölzer—eine Revision der mit Leguminosen verglichenen fossilen Hölzer und Beschreibungen älter und neuer Arten: Palaeontographica, Abteilung B, Paläophytologie, v. 119, p. 95–174.

Page, V.M., 1979, Dicotyledonous wood from the Upper Cretaceous of central California: Journal of the Arnold Arboretum, v. 60, p. 323–349.

———1980, Dicotyledonous wood from the Upper Cretaceous of central California, part 2: Journal of the Arnold Arboretum, v. 61, p. 723—748.

———1981, Dicotyledonous wood from the Upper Cretaceous of Central California, part 3: Journal of the Arnold Arboretum, v. 62, p. 437—455.

Pantoja-Alor, Jerjes, 1959, Estudio geológico de reconocimiento de la región de Huetamo, Estado de Michoacán: Consejo de Recursos Naturales no Renovables (México), Boletín 50, 36 p.

Pessagno, E.A., 1969, Upper Cretaceous stratigraphy of the Western Gulf Coast Area of Mexico, Texas and Arkansas: Geological Society of America Memoir 111, 139 p.

Prakash, Utan; Bande, M.D.; and Lalitha, V., 1986, The genus *Phyllanthus* from the Tertiary of India with critical remarks on the nomenclature of fossil woods of Euphorbiaceae: The Palaeobotanist, v. 35, p. 106–114.

Prakash, Utan, and Boreau, Edouard, 1968, Bois fossiles du Palmiers: Mémoires de la Section des Sciences du C.T.H.S, p. 130-146.

Richter, H.G., 1981, Anatomie des sekundären Xylems and der Rinde der Lauraceae: Sonderbände des Natürwissenschaftlichen Vereins in Hamburg, 5, Hamburg, Verlag Paul Parey, 157 p.

Robeck, R.C.; Pesquera-Velázquez, Rubén; and Ulloa-A., Salvador, 1956, Geología y depósitos de carbón en la región de Sabinas, Estado de Coahuila: Congreso Geológico Internacional, 20, México, D.F., 109 p.

Spackman, William, Jr., 1948, A dicotyledonous wood found associated with the Idaho Tempskyas: Annals of the Missouri Botanical Garden, v. 35, p. 107–116.

Stenzel, K.G., 1904, Fossile Palmenhölzer—Palaeontology und Geologie Osterreich-Ungarns und des Orients: Mittelungen der Gesellschaft der Geologie und Paläontologischen, Institut Universitat Wien, v. 16, p. 107-288.

Stephenson, L.W., 1927, Notes on the stratigraphy of the Upper Cretaceous formations of Texas and Arkansas: American Association of Petrologists and Geologists Bulletin, v. 11, p. 1–17.

Thayn, G.F., Tidwell, W.D., and Stokes, W.L., 1983, Flora of the Lower Cretaceous Cedar Mountain Formation of Utah and Colorado; part 1, *Paraphyllanthoxylon utahense*: Great Basin Naturalist, v. 43, p. 394–402.

Unger, F., 1845, Synopsis Plantarum Fossilium: Leipzig, 330 p.

———1857, Beiträge zur näheren Kenntnis des Lethakalkes: Denschr. Akad. Wiss., v. 14, p. 13-38.

Weber, Reinhard, 1972, La vegetación maestrichtiana de la Formación Olmos de Coahuila, México: Boletín de la Sociedad Geológica Mexicana, v. 33, no. 1, p. 5–19.

———1975, *Aachenia knoblachi* n. sp.—an interesting conifer from the Upper Cretaceous Olmos Formation of northeastern Mexico: Palaeontographica, Abteilung B, Paläophytologie, v. 152, p. 76–83.

Wheeler, E.A.; Baas, P.; and Gasson, P.E., eds., 1989, IAWA list of microscopic features for harwood identification: IAWA Bulletin 95, new series, v. 10, p. 219–332.

Wheeler, E.A.; Lee, E.; and Matten, L.C., 1987, Dicotyledonous woods from the Upper Cretaceous of southern Illinois: Botanical Journal of the Linnean Society, v. 95, p. 77-100.

Wheeler, E.A.; Pearson, R.; LaPasha, C.A.; Hatley, W.; and Zack, T., 1986, Computer-aided wood identification—reference manual: North Carolina Agricultural Research Service Bulletin 474, p. 1–160.

Wieland, G. R., 1914, La flora liásica de la Mixteca Alta: Instituto Geológico de México, Boletín 31, 162 p.

Zaitzeff, J.B., and Cross, A.T., 1970, The use of dinoflagellates and acritarchs for zonation and correlation of the Navarro Group (Maastrichtian) of Texas: Geological Society of America Special Paper 127, p. 341–397.

Manuscript received: May 27, 1991.
Corrected manuscript received: September 12, 1991.
Manuscript accepted: September 13, 1991.