A PRELIMINARY STUDY OF EOCENE WOODS FROM WEST TENNESSEE

LOIS CARNEY BOUSMAN

July 15, 1965

To the Graduate Council:

I am submitting a thesis written by Lois Carney Bousman entitled " A Preliminary Study of Some Eocene Woods from West Tennessee". I recommend that it be accepted for eight quarter hours credit in partial fulfillment of the requirements for the degree Master of Arts, with a major in Biology.

Floyd L. Brown
Major Professor

We have read this thesis and recommend its acceptance:

Harold S. Pryor

Haskell C. Phillips

Accepted for the Council:

I G Woodward
Dean of the Graduate School

A PRELIMINARY STUDY OF EOCENE WOODS

FROM WEST TENNESSEE

An Abstract of a Thesis

Presented to

The Graduate Council of

Austin Peay State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

---

by

Lois Carney Bousman

July 1965

ABSTRACT

In this preliminary study of Eocene woods from West Tennessee a survey of the literature revealed a wide assortment of fossils available for systematic study. Fossil preservation forms consist of compressions, impressions and lignitic remains. Lignitic wood was collected from a clay deposit located in the Mississippi embayment and processed in order to determine if anatomical structures were adequate for description.

A series of sections was made from each of seven specimens, which were examined and described individually and comparatively. With one exception anatomical structures were adequate for descriptive purposes. Based on structural similarity, revealed by a comparative examination, the specimens could be placed into one of two groups, both dicotyledonous.

The results indicated that in most of the woods examined, adequate anatomical structures were present to justify a systematic study, which can lead to identification. Accurate plant identification normally requires a study of the flower, fruit, leaves, and wood. It is possible that a particular representative has never been described or is extinct.

A PRELIMINARY STUDY OF EOCENE WOODS

FROM WEST TENNESSEE

A Thesis

Presented to

The Graduate Council of

Austin Peay State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

by

Lois Carney Bousman

July 1965

ACKNOWLEDGEMENT

The gratitude of the author is expressed to those who have read and made constructive criticisms and contributions to all or parts of this thesis, my patient director Mr. Floyd L. Brown, Dr. Haskell Phillips, Dr. Harold Pryor, Mr. David Snyder, Dr. William Ellis and Mr. Ben Stone. Gratitude is also expressed for the facilities made available for this study and freedom to select and pursue my interests.

I gratefully acknowledge the encouragement and interest expressed by my fellow students.

Without the contributions of patience, understanding, and themselves, made by my family, Carlton, Ellyn, Walker, Mary, my mother and father, this thesis would not have been completed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Identification and systematic assignment of fossil woods depend on a knowledge of extant woody dicotyledons (Tippo, 1945) and other taxa of arborescent habits. Since Eocene floras are interpreted as being represented currently at the family level, it is possible to compare Eocene wood with extant wood. Anatomical characters are of diagnostic value in establishing taxon identity (Solereder, 1908; Jeffery, 1917; Record, 1934; Tippo, 1946; Bailey, 1951, 1957; Jane, 1956, 1963; Metcalfe-Chalk, 1957; Esau, 1960; Carlquist, 1961; Davis-Heywood, 1963). These endomorphological studies should supplement exomorphological studies and inherently have no special merit to place them on a higher plane than any other approach to plant taxonomy.

Sound systematic taxonomic studies are based on quantitative and qualitative interpretation, classification, and identification. A variety of wood identification procedures is available; the procedure is selected to meet a specific need.

The objectives of this study are directly related to identification, and consist of the following: (1) establishing perspective in the field of paleobotany, and reviewing some of the paleobotanical literature related to Eocene flora of West Tennessee, (2) determining if the wood remnants are suitable for an anatomical study and if so, to develop methods for such a study, and (3) describing and photomicrographing available diagnostic characteristics.

Objective one necessitates an understanding of the following unique problem: organically unattached structures have been assigned generic and specific names, often based entirely on exomorphological criteria, resulting in the possible assignment of an individual to several genera and theoretically several families. Researchers are interdependent, and the results and methods of each must be fully understood in order to interpret individual problems. Some problems are the process involved in matrix formation, methods of processing material, and methods of recording data.

Numerous specimens have been collected and reported from West Tennessee sedimentary clay deposits, including leaf impressions and cuticles, pollen, fruit, seeds, and lignitic wood. Lesquereux (1859) did the first notable work on this flora; Berry (1916, 1922, 1924, 1930, 1945) worked with a variety of plant materials, especially leaf impressions; Brown (1944) studied lignitic material and leaf impressions; Dilcher investigated Ocotea leaf cuticles (1963) and fungi (1964); Eyde and Barghoorn (1963) identified some lignitic material and leaf impressions in their distributional study of Nyssaceae, and Floyd L. Brown, Austin Peay State College, is currently studying leaf, fruit, and seed anatomy. Until the present study, no thorough investigation of the fossil wood from these deposits had been made.

Objective two is discussed in detail later.

Objective three involves a recognition of some basic problems encountered by systematic wood anatomists. Occasionally plants which are not closely related develop similar habits or structural features, presumably as a response related to ecological conditions. Some similar diagnostic characters have arisen independently in unrelated families, and often, diagnostic characters of value in one family are not of equivalent value in another family. Other variations in anatomical structure occur relative to position in the individual, within a given population, and from population to population (Jane, 1956; Metcalfe-Chalk, 1957; Davis-Heywood, 1963). Timber does not assume adult characteristics in the early life of the bole and branches and caution is necessary in making judgments (Jane, 1963).

Anatomical characters of the vessel, parenchyma, rays, fibres, storied structure, growth rings, and intercellular canals are considered by Metcalfe-Chalk to have the greatest descriptive value in identification. Therefore, in this study the wood was examined microscopically for these characters and photomicrographed. The descriptions, slides, and photomicrographs are deposited with the paleobotanical collection at Austin Peay State College, Clarksville, Tennessee. The descriptions include terminology used in wood anatomy as endorsed by the Committee of Nomenclature, International Glossary (1933, 1957) with modifications by Kribs (1935), Chalk (1937), Bailey and Howard (1941).

CHAPTER II

LITERATURE SURVEY

One of the first American systematic lignitic wood studies was done by F. A. Knowlton (1889) who microscopically examined wood collected from Tertiary clays of Arkansas. Jeffery and Chrysler (1907) used these descriptions for comparative studies of lignitic wood from Brandon, Vermont.

The wood examined by Jeffery and Chrysler had been sent to them by G. H. Perkins. Perkins (1907) described Brandon lignite as usually not resembling coal but as being more like compact, partly decayed wood, and exhibiting variety in structure, appearance, and density. He interpreted the wood as substantially the same in structure and appearance as the "Fibrous Lignite" from Restadt, Eisleben. He also examined South African lignitic wood which had well-preserved grain.

Lesquereux (1859) made the first significant West Tennessee fossil flora descriptions. He described leaf impressions, which had been collected from Fayette County, Tennessee clay deposits by State Geologist J. M. Safford. Safford reproduced and illustrated Lesquereux's publication and in 1888 R. H. Loughridge, a geologist, reproduced and illustrated Safford's work.

In 1909 Wilber Berry undertook his first study of this flora, apparently motivated by a collection from Fayette County, Tennessee, made by L. C. Glenn. From 1910 through 1913 Berry worked throughout the embayment province; his collection sites in West Tennessee are listed in Appendix A.

Berry published a prodigious quantity of fossil flora taxonomic literature. His taxonomic determinations were derived from his interpretation of past climatic conditions and his identifications were based principally on pictorial comparison. Appendix B is Berry's gymnospermous and dicotyledonous flora of Henry County, Tennessee, modified to include interpretations made by later investigators. This floral list is based on samples of floral organs, fruits, seeds, and leaves. Preservation forms are impressions and lignitic material.

Near Puryear, Tennessee (Henry County), Berry (1916) described a collecting site as the "Most remarkable leaf-bearing clay that I have ever seen at any geologic horizon." The woods described in this study were collected in this area.

Careful examination of Berry's work (1916, 1922, 1924, 1930, 1945) has not revealed a description of any wood he collected and studied in Tennessee. In 1916 he described Reynosia praeuntia leaves collected in Puryear, Tennessee and Marshall County, Mississippi. Included is the statement that R. praeuntia wood resembles extant R. septentrionales Urban, but further investigation revealed that the wood reference was from the Claiborne series of Texas and no description, by Berry, has been located. The same year he revised some of Lesquereux's work (Appendix C).

During the 1920's R. L. Collins and J. K. Roberts, geologists studying Tennessee clay, collected what Berry (1930) described as fruits, seeds, calices, flowers, and bracts. Apparently Berry became aware that he had described an overmultiplication of species for in 1930 he wrote, "Although this description (1916) might be much improved in the light of subsequent discoveries, the result would scarcely warrant the time and space necessary for its proper consideration." Berry pronounced his 1930 publication a valedictory on the subject. This pronouncement did not prove to be true for in 1941 he did some work in Kentucky and in 1945 responded to Roland Brown's criticism of his interpretations.

George Whitlatch (1940) reported a number of pieces of petrified wood in Lafayette County and lignitic wood in Benton, Decatur, and Weakley counties, Tennessee. A brief description of the collecting sites is given below.

Benton County

0.9 mile north of Halladay; matrix, a six-foot stratum of black, sandy lignitic clay

Decatur County

matrix, 15-25 foot thickness of dark-gray highly carbonaceous clay, thinly laminated with gray sand

Weakley County

matrix grayish-brown, also a lignite matrix, hard and brittle, black and semi-lustrous

Roland Brown (1944) collected from Mill Creek, Hardeman County, Tennessee, a site at which Berry had worked. After comparing Diospyros asper calices (Berry 1930) with four-parted burs of Fagus Brown assigned the specimens to Fagus aspera. Associated with probable burs of Fagus were leaves of Dryophyllum tennesseensis (Berry, 1930). Brown recognized the leaves as probable Fagaceae, but sufficiently different to justify caution before assigning them to Fagus. Abundant leaves have been found at other localities, but not associated with the burs of Fagus (Brown, 1944). In 1937 Brown collected at Grand Junction and Somerville, Tennessee. This is the area in which Berry (1930) had reported compound leaves of Hicoria crescentia. His report was based on the resemblance of a fragmentary specimen described by Knowlton. Brown interpreted the specimens described by Berry as Hicoria crescentia and Euonymous splendens to be consonant with the interpretation of Staphylea, although no bladdery pods had at that time been found in Tennessee collections. Brown found no authentic fossil record of Salix, Quercus (except Dryophyllum), Celtis, or Platanus (of the P. occidentalis type).

Floyd (1957) states that lignite is found in relative abundance in Upper Createaceous and Eocene sediments of West Tennessee. Some lignites consist of woody fragments and have the texture of the original plant material from which they were formed.

David Dilcher (1963) made a cuticular analysis of some leaves collected from Eocene clays at Puryear, Tennessee. Basing his work on both an extant reference collection and a fossil collection, Dilcher concluded that the leaves described by Berry as Oreodaphne obtusifolia were Ocotea obtusifolia [Berry] LaMotte [1952]. In 1964 Dilcher described leaves collected from the Spinks Clay Company pit near Henry, Tennessee, as similar to the extant genera *Sapindus* and *Chrysobalanus*. Fossil *Sapindus* resembles *S. marginatus* and *Chrysobalanus* sp. resembles extant *C. icaco* both of which occur in Florida and the West Indies. At this time Dilcher also did an extensive study of epiphyllous fungi.

Eyde and Barghoorn (1963) worked with leaf impressions and lignitic material. They assigned *Nyssa curta* and *N. wilcoxiana* (Berry, 1930) to *N. complanta* and pointed out that most nyssaceous leaves may be found in genera of Annonaceae, Moraceae, Juglandaceae, Fagaceae, Magnoliaceae, Lauraceae, Sapindacae, Ebenaceae and Apocynaceae.

CHAPTER III

GEOLOGY

West Tennessee is part of the Mississippi embayment which dominates the central portion of the northern Gulf Coastal province and extends into parts of Illinois, Missouri, Kentucky, Arkansas, Mississippi, Alabama, east Texas, Louisiana, and Tennessee (Fig. 1). Overall embayment form is an asymmetrical syncline, plunging gulfward, with modifications near the center in the form of the Jackson and Monroe uplifts. A downwarp forms the great embayment of Cretaceous, Tertiary (Murray, 1960) and Quarternary (Whitlatch, 1940) rocks in the southern portion of the coastal geosyncline.

The stratigraphy of West Tennessee is characterized by Upper Cretaceous, Paleocene, and Eocene deposition beds. These beds are divided into five units, based on electric logs: (1) Top of the Paleozoic rocks; (2) Top of the Cretaceous system; (3) Paleocene; (4) Lower Eocene; (5) Middle and Upper Eocene. Based on samples and electrical log characteristics, three depositional types of sediments have been differentiated: (1) back-beach clay and sand; (2) shallow-water near-shore sand; (3) deeper-water clay and shale (Stearns and Armstrong, 1955, 1958).

The Cretaceous system and Eocene series are predominantly sedimentary plastic clay. The purity of the clay and the condition of the leaves it contains indicate that deposition took place during lagoonal conditions. The diameters of the deposits range from a few yards to many acres and the depths range from a foot up to 80 feet. Sluggish streams probably transported the sediment from a low-lying, nearly featureless plane into lakes, swamps, and shallow seas. The resulting lenticular bedded deposits frequently are interbedded with thin sand layers and carbonaceous clay. The fossil woods described in this study were collected from a matrix of Eocene plastic, sedimentary, ball clay. Plastic sedimentary clay is commercially classified as ball, wad, or sagger clay. These are trade names based on use. Ball clay particles range from fine-grained to colloidal and represent the substance remaining longest in suspension. Variable amounts of lignitic matter are usually present and the beds are commonly overlain by beds of lignite. Color ranges from light gray through pale pink to blue, brown, or black (Whitlatch, 1940).

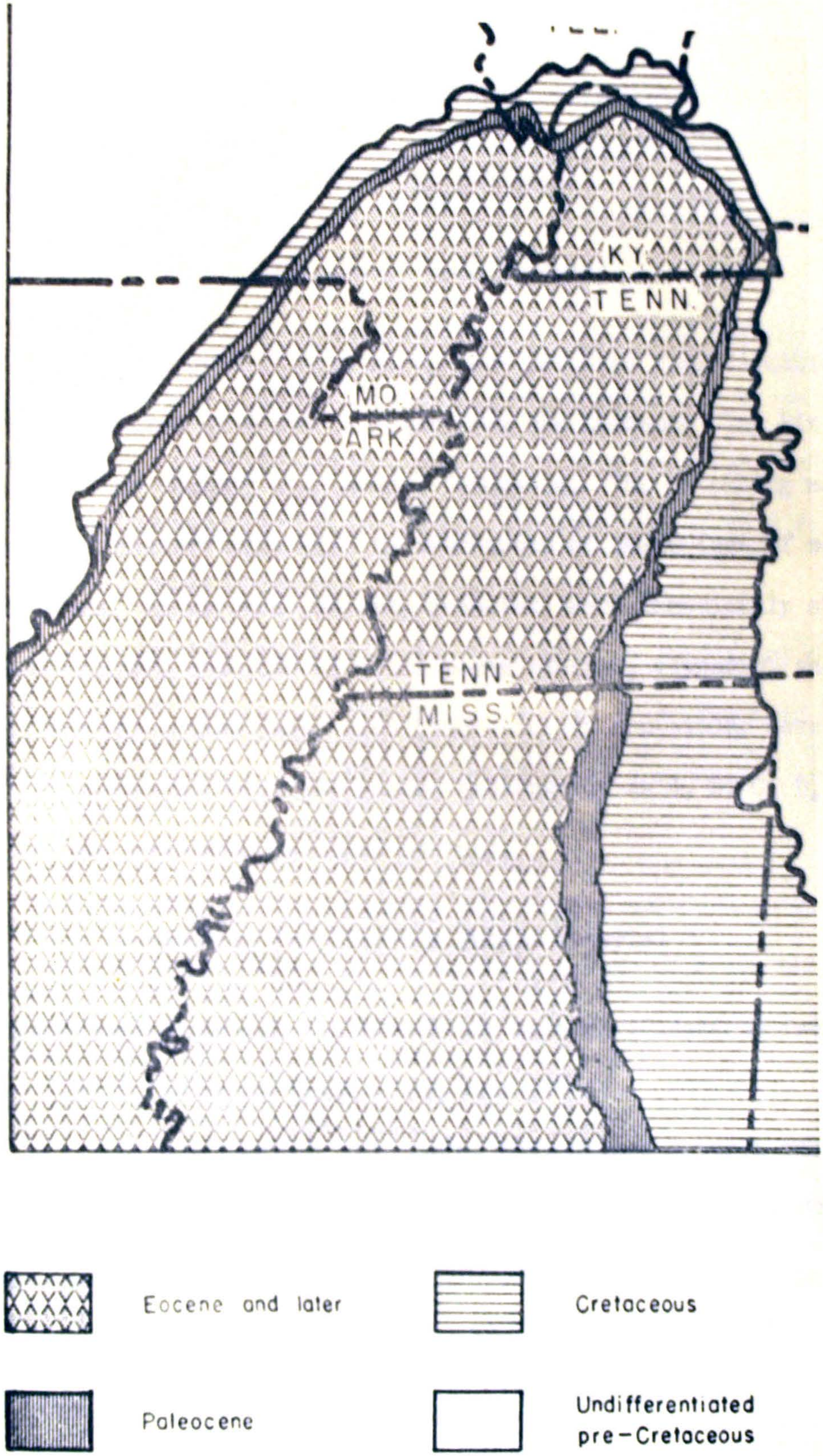

Figure 1. Generalized areal geology of the upper Mississippi Embayment.

Figure 1

CHAPTER IV

METHODS AND MATERIALS

The Fossil Wood Material

The slides used in this study were prepared from lignitic material collected by Floyd L. Brown from the Lawrence Clay Pit of the Spinks Clay Company near Henry, Tennessee. The entombing matrix was gray sedimentary clay with an overburden of 20-30 feet of soil. The specimens, which were randomly selected, were immediately stored in a preservative solution of equal parts ethanol, glycerin, and water. Six collection jars, each theoretically containing several different specimens, were designated arbitrarily as A, B, C, D, E, and F and the specimens assigned numbers.

Procedures for Studying Fossil Material

The procedures used in this study were modifications from Jeffery (1917), Johansen (1940), and Sass (1951).

1. With the aid of a dissecting microscope, several one cubic centimeter blocks of wood were dissected from each specimen. Cuts were made as closely as possible on the tangential, transverse, and radial planes. The blocking material was periodically treated with preservative solution to prevent rapid desiccation.

2. The blocks were placed in polyethylene containers, covered immediately with an equal parts solution of 48% hydrofluoric acid and

deionized water, sealed, and allowed to stand at room temperature for a maximum of 24 hours. This step, the function of which was to dissolve minerals, especially silicates, which are detrimental to sectioning, was done under a hood.

3. The hydrofluoric acid solution was decanted and the blocks flushed thoroughly for 30 minutes with running water and allowed to soak in water for 8-24 hours. Remnants of the acid are damaging to both the equipment and the sections; the presence of acid can be determined by litmus paper.

4. Dehydration was accomplished by using a graded series of alcohol (Table I), the blocks remaining in each grade for four hours. The alcohol was decanted rapidly in order to avoid excessive contact with the air.

5. The dehydrant was removed and the specimens were then covered with approximately four times their volume of a solvent (Cellosolve, ethylene-glycol-monoethyl ether) for the infiltration material. The blocks remained in this solution for 24 hours.

6. Parloidion, a nitrocellulose compound, was a successful infiltration agent for most of the blocks. The blocks were taken through a 0.5%, 1.5%, 2%, 4%, 6%, 8%, and 10% series of Parloidion solutions. The first concentration was added, the bottles corked, placed in a press, and put into a 3505 Labline vented oven in which a temperature of 70 degrees centigrade was maintained. The bottles were removed, cooled, uncorked, and the solution removed. The blocks were

TABLE I. Dehydration Series for Fossil Blocks

	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Approximate % Alcohol	50	70	85	95	100
Distilled Water	50	30	15		
95% Ethanol	40	50	50	45	
Tertiary Butyl	10	20	35	55	75
100% Ethanol					25

immediately covered with the next higher concentration, resealed, and the interval in the oven, under pressure repeated for each higher concentration. Treatment in the last solution, 10%, was repeated and the viscosity of the solution was then increased by adding a dry chip of Parloidion daily. This process was terminated when the viscosity was great enough to form a continuous matrix of 0.5 centimeter at room temperature.

7. The nitrocellulose embedded blocks were transferred to individual specimen bottles and covered by a hardening agent, chloroform, for 24 hours. This process was carried out under a hood.

8. The chloroform was decanted and the blocks were covered with an equal parts solution of ethanol, glycerin, and distilled water. This solution will maintain the embedded blocks indefinitely, although alcohol must be added periodically (Johansen, 1940).

9. Immediately prior to sectioning, the Parloidion matrix was removed completely and the blocks were reembedded in softened Paraplast. Paraplast blocks were cast in heavy-duty aluminum foil boats. The paraplast blocks were then softened in hot Paraplast, placed on a hot microtome disc and the specimen block pressed into sectioning position. Liquid Paraplast was maintained in a metal container placed in a hot water bath. By repeatedly pressing the Paraplast with a hot scapel and rapidly dipping the disc and block into the liquid Paraplast, the degree of adherence was adequate for sectioning, when cooling was done at room temperature. Sectioning should be done promptly and continually.

10. Sectioning was done with an Ogawa Seiki 1942 chrome, hand operated microtome, with an 80 millimeter knife. The knife was set at an angle of 45 degrees or less. When possible, 3 blocks were orientated for 3 different planar sections for each specimen. The knife was continually flooded and cleaned with xylene, applied with a small brush. Sections were carefully removed with a clean brush, placed on a slide, and mounted with Harleco Synthetic Resin, covered, and held under pressure by clothes pins.

11. The slides were cataloged by collection jar letter and specimen number.

CHAPTER V

RESULTS

Description Procedures

In this study specimens 1, 2, 3, 4, 5, 16, and 19 were examined macroscopically, microscopically, and photomicrographed. Macroscopically the specimens varied in friability, lamination, and degree of infiltration. The wood breaks readily into small, irregular fragments which appear destitute of structure in their transverse fracture. But when split along some lines, notably in the direction of the rays, structure can usually be macroscopically observed. Microscopically the specimens varied in the planes available for study. Photomicrographs were made by using a Unitron photomicroscope to which a 35 millimeter Exakta camera was adapted. Kodak Tri-X film was used.

The sections were examined microscopically for characteristics interpreted by Metcalfe and Chalk (1957) as having the greatest identification value.

Vessels

Vessels were examined from the following aspects: distribution, pattern, frequency as seen in transverse sections, type of perforation, intervascular pitting, pitting between vessels and wood-or ray-parenchyma cells, and the occurrence of spiral thickening.

Parenchyma

When studying parenchyma a basic distinction depends on distribution as seen in transverse section. Distinction is drawn between apotracheal types, in which the distribution is fundamentally independent of the vessels, and paratracheal types, in which the distribution is determined as dependent on the vessels. The three main types of apotracheal parenchyma are terminal, diffuse and metatracheal. Paratracheal types are vasicentric, aliform, and confluent.

Wood Rays

The most widely used character of wood rays is width, either in cell diameter or number of cells. Two other useful characters are homogeneous and heterogeneous ray types.

Fibres

Fibres are usually distinguished as either libriform fibres, with simple pits, or fibre-tracheids with bordered pits. The most important characters of fibres are the pitting and presence or absence of septa.

Storied Structure

Storied structure is a character which describes the arrangement of cells or tissues in horizontal series as seen in tangential section. The term is applied to particular tissue or in a general sense.

Growth Rings

Growth rings indicate cambial activity and the development of tissues.

Intercellular Canals

Intercellular canals, both vertical and radial types, are of great diagnostic value.

Descriptions

Specimen 1 was selected from collection jar A. It was very dense, friable, and sectioned most easily on the radial plane and least easily on the tangential plane.

VESSELS: Figures 2, 4, 5, 6

Transverse section: vessels compressed and distorted (Fig. 3)

Tangential section: portions of the elements scattered and diffuse (Fig. 3)

Radial section: remnants of vessel elements were present; scalariform walls (Figs. 4, 5); oblique element association and wood parenchyma pitting present (Fig. 3); distribution of the vessels was solitary and diffuse; no tyloses were observed

PARENCHYMA: Figures 2, 3, 6, 7, 8, 9

Transverse section: wood parenchyma association was not definable; ray members were homogeneous; one ray type contained erect components, the other ray type contained procumbent components; rays were separated by narrow fibre layers (Fig. 2)

Tangential section: uniseriate rays, size varying from ray to ray (Fig. 3)

Radial section: one ray type storied, erect, opposite components containing homogeneous material (Fig. 7); interconnective canals were observed (Fig. 7); the other ray type contains procumbent, storied, alternate components, which contained heterogeneous cellular material (Figs. 6, 7, 8); some wood parenchyma strands were observed (Fig. 9)

Good fibre definition was not possible, due to the state of preservation.

PLATE II

Fig. 2. Transverse section of specimen 1, general field 200X

Fig. 3. Tangential section of specimen 1, light areas indicate vessel element distribution, rays, and vertical fibres 100X

Fig. 4. Radial section of specimen 1, scalariform vessel walls 800X

Fig. 5. Radial section of specimen 1, scalariform walls, oblique element association and wood parenchyma 400X

PLATE II

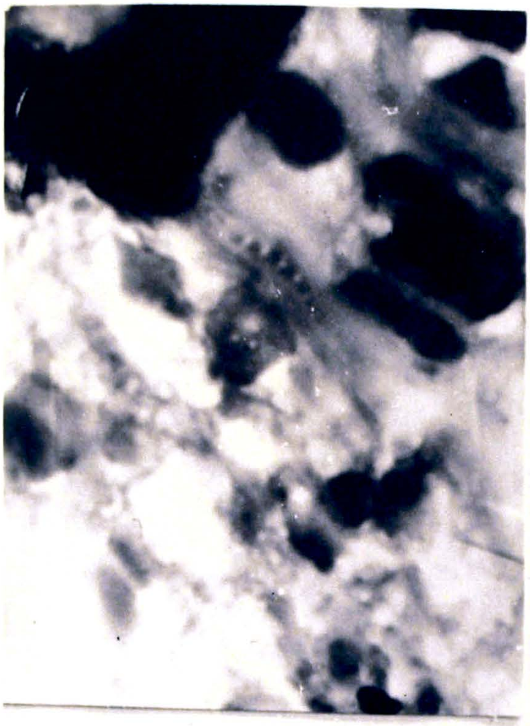

Figure 2

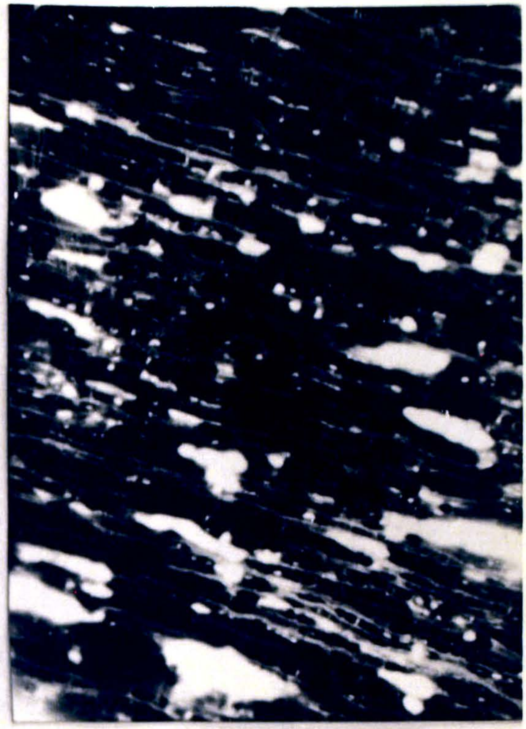

Figure 3

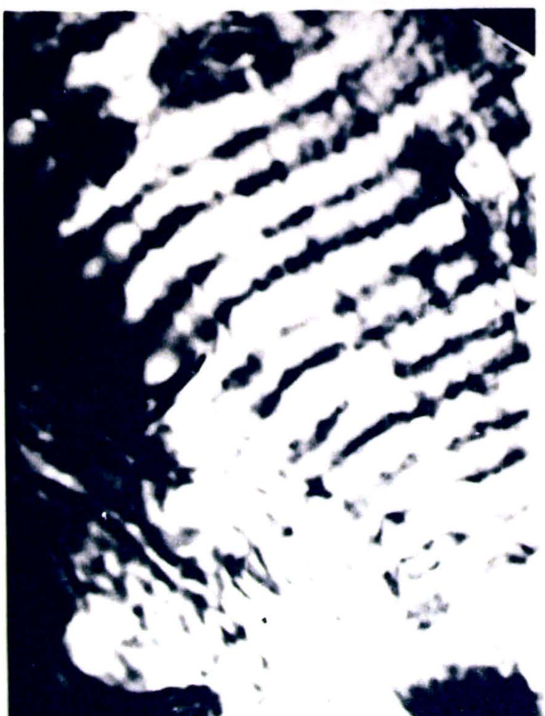

Figure 4

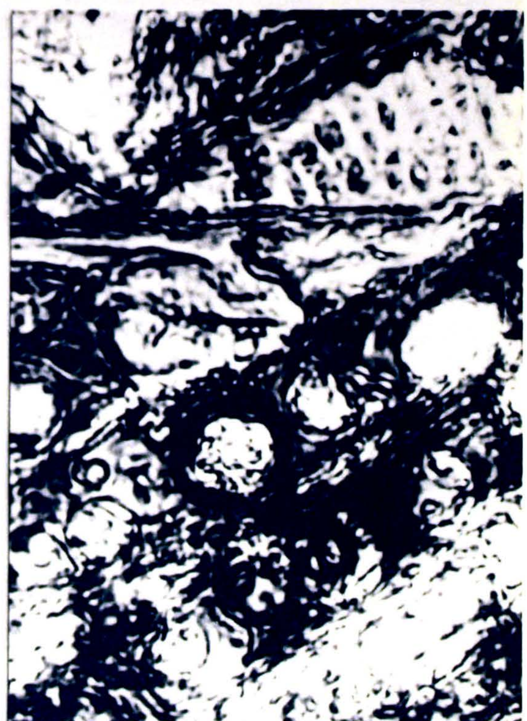

Figure 5

PLATE III

Fig. 6. Radial section of specimen 1, ray types, fibres 150X

Fig. 7. Radial section of specimen 1, ray components interconnective strands 400X

Fig. 8. Radial section of specimen 1, procumbent ray components, intercellular walls, fibres 325X

Fig. 9. Radial section of specimen 1, vessel remnant (lower left) and adjacent wood parenchyma strand 325X

PLATE III

Figure 6

Figure 7

Figure 8

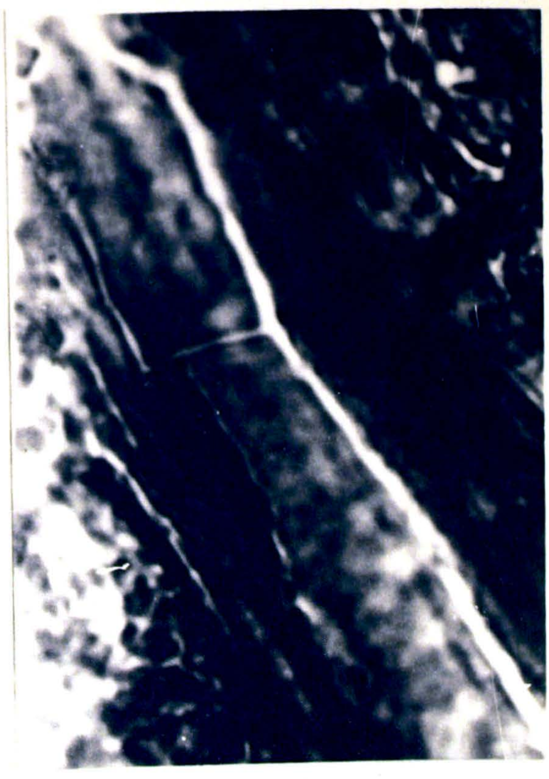

Figure 9

Specimen 2 was selected from collection jar B.

VESSELS: Figures 10, 11, 12, 13, 14, 15, 16, 17

Transverse section: radial pore multiples (Fig. 16), diameters of the pores variable; lumens contain tyloses or heterogeneous inclusions (Fig. 10)

Tangential section: distribution and lack of good longitudinal definition indicate distortion; no vessel element was observed in its entirety; remnants of vessel walls were best observed by careful examination of longitudinal cracks; a vessel containing a heterogeneous mass, and adjacent wood parenchyma strands was observed (Fig. 12); vessels were observed best in dense sections; tyloses were observed (Fig. 13)

Radial sections: vessel distribution diffuse (Fig. 15); tyloses; elements joined at oblique angles (Fig. 10), the angle variable when sectioned through the lumen (Fig. 15); truncate orientation of the elements in radial view (Fig. 16); intervascular interconnective apertures (Fig. 17)

PARENCHYMA: Figures 10, 12, 13, 14

Transverse section: (Fig. 10) wood Parenchyma was not distinguished; rays are separated by narrow bands of homogeneous tracheary material

Tangential section: rays indicate a storied orientation (Fig. 12, 13), rays separated by narrow bands of undefined tracheary material; uniseriate and possibly a few multiseriate homogeneous rays (Fig. 14); component cell size varies from ray to ray

Due to some indication of truncation, tracheary material was interpreted as tracheids. No growth rings or intercellular ducts were observed; however, a tangential view indicates possible horizontal canals.

PLATE IV

Fig. 10. Transverse section of specimen 2, pore multiples, tyloses 150X

Fig. 11. Transverse section of specimen 2, general field 50X

Fig. 12. Tangential section of specimen 2, vessel and adjacent wood parenchyma strands, rays 100X

Fig. 13. Tangential section of specimen 2, tylose, homogeneous uniseriate rays 200X

PLATE IV

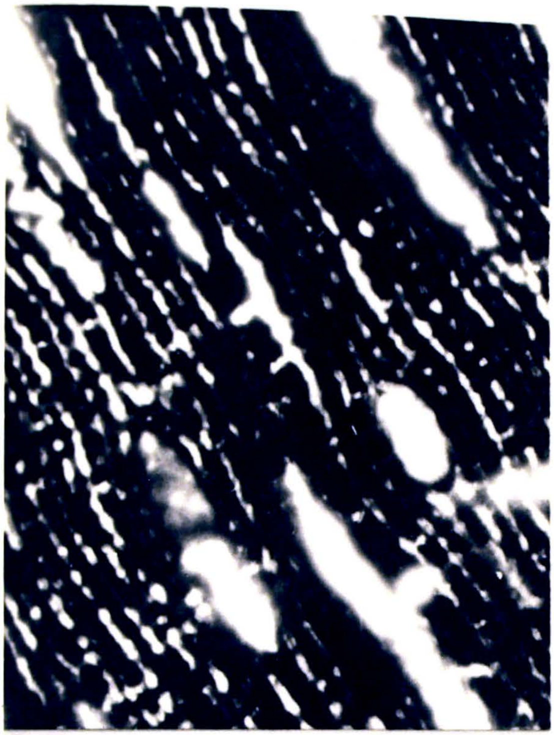

Figure 10

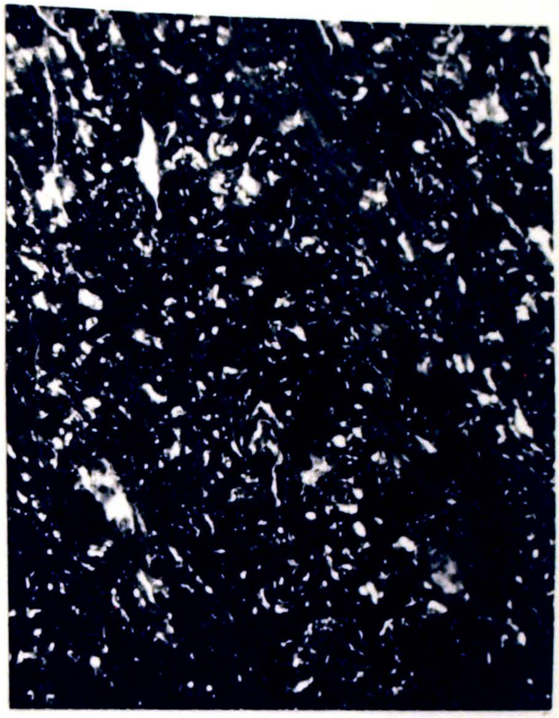

Figure 11

Figure 12

Figure 13

PLATE V

Fig. 14. Tangential section of specimen 2, general field, uniseriate homogeneous rays, possible multiseriate rays 100X

Fig. 15. Radial section of specimen 2, vessel distribution, oblique end walls, tyloses 100X

Fig. 16. Radial section of specimen 2, intervascular interconnective apertures 800X

Fig. 17. Radial section of specimen 2, intervascular interconnective apertures 400X

PLATE V

Figure 14

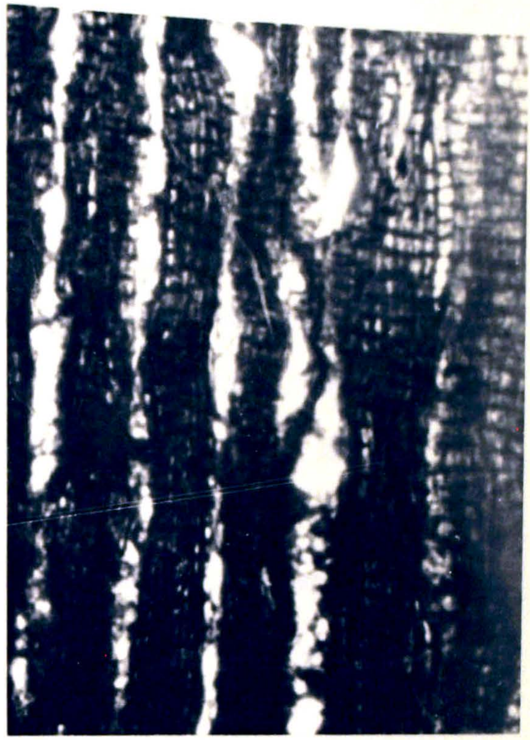

Figure 15

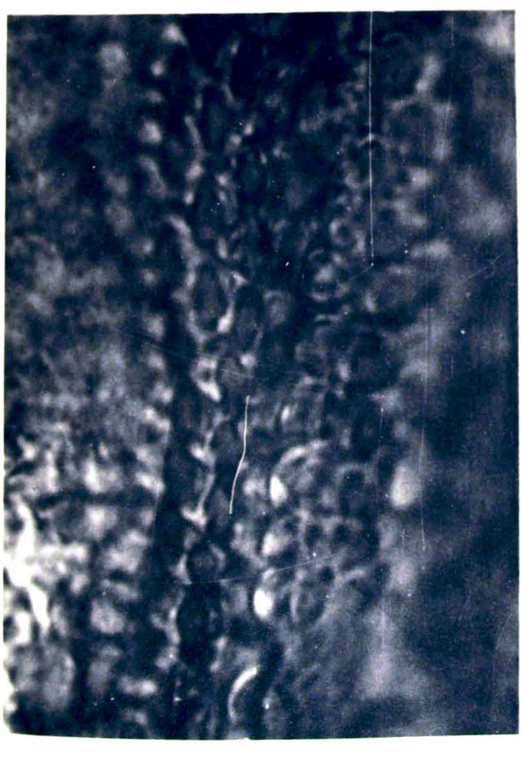

Figure 16

Figure 17

Specimen 3 was selected from collection jar C. It was a dense mass of friable material, sectioning most easily on the radial plane. No tangential sections were obtained.

VESSELS: Figures 18, 19, 20, 21

Transverse section: radial pore multiples; multiple components varied in size; some vessels were collapsed, others greatly distorted (Figs. 18, 19); diffuse distribution

Radial section: diffuse vessel distribution; tyloses or heterogeneous masses (Figs. 19, 20); elements join at an oblique angle

PARENCHYMA: Figures 18, 19, 20

Transverse section: wood parenchyma was not distinguished; parenchymatous rays are separated by narrow bands of homogeneous, undefinable tracheary material

Radial sections: rays indicate a storied alternating orientation, apparently separated by narrow bands of undefined, vertical tracheary material (Figs. 18, 19, 20)

FIBRES: Figures 18, 19, 20

Fibres were grouped in a homogeneous mass, lacking definition

PLATE VI

Fig. 18. Transverse section of specimen 3, pore multiple 300X

Fig. 19. Transverse section of specimen 3, diffuse vessel distribution, pore multiples 150X

Fig. 20. Radial section of specimen 3, vessel distribution 200X

Fig. 21. Radial section of specimen 3, vessel distribution, heterogeneous intracellular mass 150X (lower left)

PLATE VI

Figure 18

Figure 19

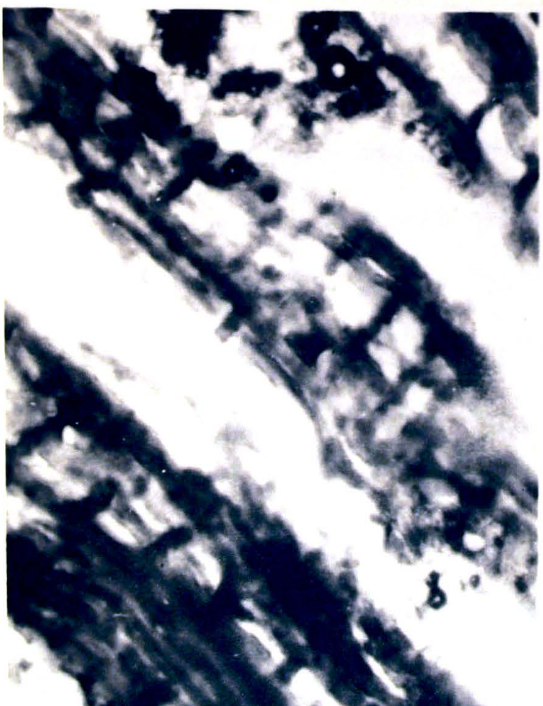

Figure 20

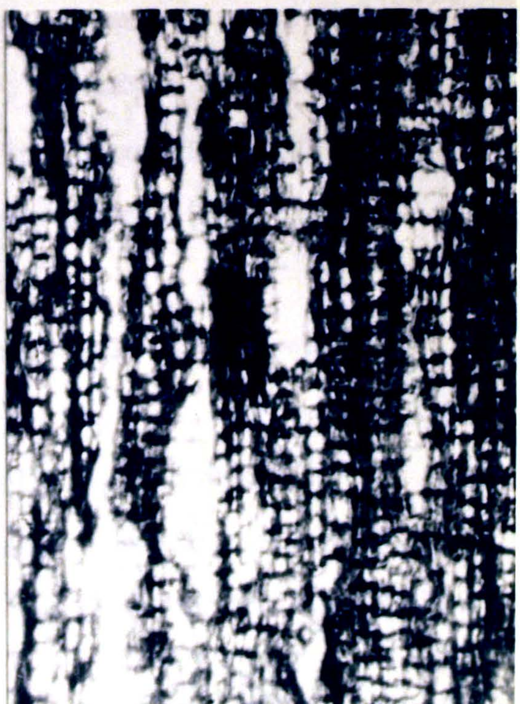

Figure 21

Specimen 4 was selected from collecting jar D. It laminated easily on the radial plane.

VESSELS: Figures 23, 24, 25, 26, 27

Transverse section: very distorted; vessels compressed (Figs. 23, 24, 25)

Radial section: remnants of vessel elements present (Figs. 26, 27); scalariform walls (Fig. 27)

PARENCHYMA: Figures 23, 24, 28, 29, 30

Transverse section: wood parenchyma lacks good definition; ray parenchyma scattered and very distorted (Figs. 23, 24)

Radial section: procumbent, alternating, storied ray with heterogeneous intracellular inclusions; erect, opposite, storied rays usually contained homogeneous intracellular inclusions (Figs. 28, 29, 30); procumbent cell pitting with fibres was observed and interconnective canals between procumbent cells clearly defined (Figs. 31, 32)

FIBRES: Figures 23, 24, 29, 30, 31, 32

Transverse section: tracheary material was collapsed (Figs. 23, 24)

Radial section: tracheary material had bordered pits (Figs. 29, 30, 31, 32) apparently in continuous layers; careful examination indicated tracheids and tracheid-fibres

PLATE VII

Fig. 22. Transverse section of specimen 4, indicating compression and distortion 50X

Fig. 23. Transverse section of specimen 4, indicating compression and distortion 100X

Fig. 24. Transverse section of specimen 4, indicating structural components and distortion 400X

Fig. 25. Radial section of specimen 4, indicating vessel element remnant, procumbent and erect ray cells 150X

PLATE VII

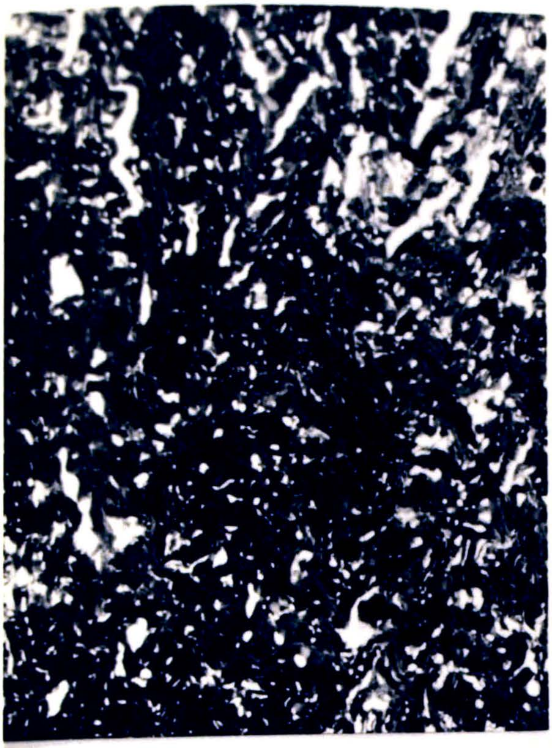

Figure 22

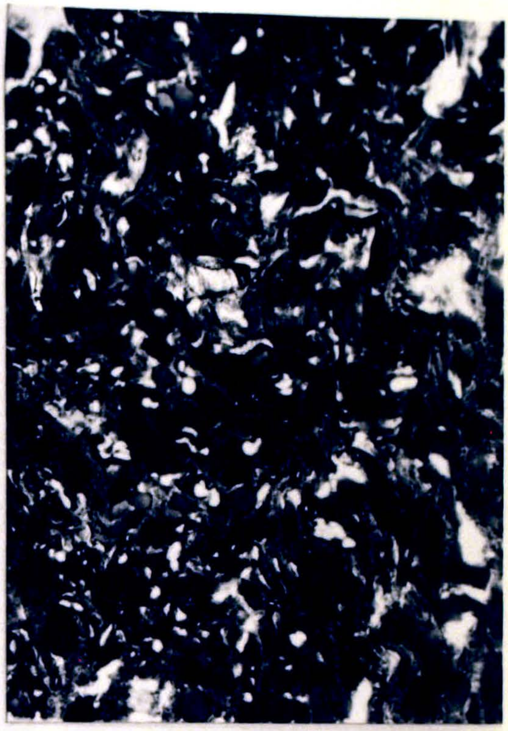

Figure 23

Figure 24

Figure 25

PLATE VIII

Fig. 26. Radial section of specimen 4, scalariform vessel wall 300X

Fig. 27. Radial section of specimen 4, indicating intracellular material of the procumbent and erect cells, storied alternation of the procumbent cells; storied, opposite arrangement of the erect cells, fibres 100X

Fig. 28. Increased magnification of Fig. 28 200X

Fig. 29. Fibre pitting 300X

Figure 26

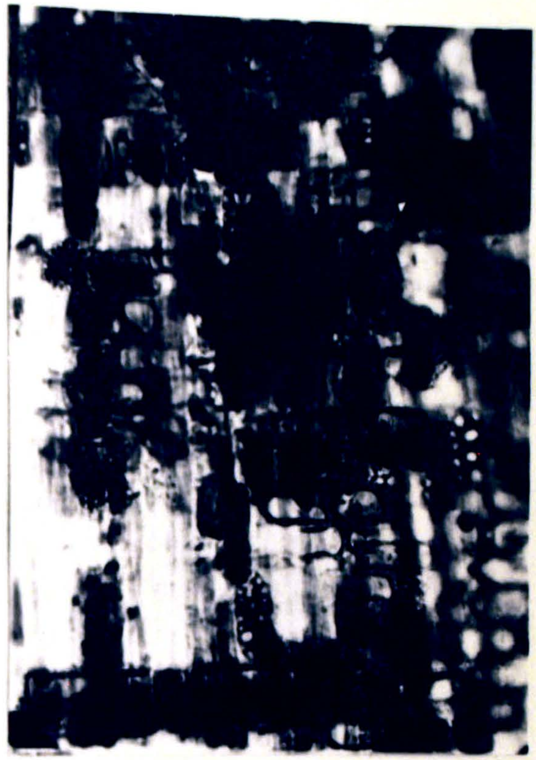

Figure 27

Figure 28

Figure 29

PLATE IX

Fig. 30. Procumbent cells with interconnective canals 300X

Fig. 31. Procumbent cells with interconnective canals and horizontal walls

Figure 30

Figure 31

Specimen 5 was selected from collection jar E. Figure 32 indicates the state of preservation which made an interpretation of structural components impractical.

PLATE X

Fig. 32. Section from specimen 5, indicating the state of preservation

PLATE X

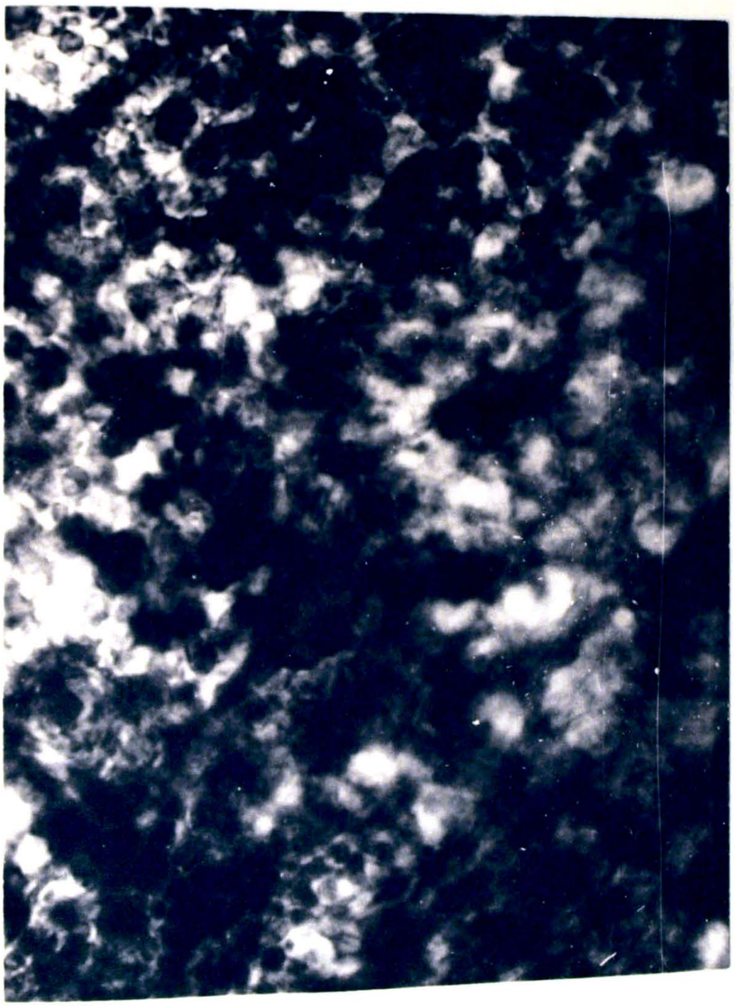

Figure 32

Specimen 16 was selected from collection jar F.

VESSELS: Figures 33, 34, 35, 36, 38, 40, 41

Transverse section: very distorted and compressed (Figs. 35, 36, 37, 38); tyloses were present (Fig. 38) as well as other intracellular material (Figs. 38, 39, 40)

Tangential section: a few element remnants were observed

Radial section: scalariform walls observed (Fig. 41)

PARENCHYMA: Figures 33, 34, 35, 36, 42, 43, 44

Transverse section: wood parenchyma was not definable; ray parenchyma was very distorted and in a poor state of preservation (Figs. 33, 34, 35, 36)

Tangential section: ray parenchyma in various stages of decomposition; apparently uniseriate and a few multiseriate rays (Figs. 42, 43)

Radial section: alternating, storied, procumbent cells, containing heterogeneous material (Fig. 44); opposite, storied, erect cells containing homogeneous material

FIBRES: Fibres apparently had collapsed; lacked good definition, very close examination indicated bordered pits

PLATE XI

Fig. 33. Transverse section of specimen 16, indicating distortion, compression, and state of preservation 300X

Fig. 34. Transverse section of specimen 16, indicating cellular structure and state of preservation 300X

Fig. 35. Transverse section of specimen 16, indicating cellular structure and state of preservation 300X

Fig. 36. Transverse section of specimen 16, indicating cellular structure and state of preservation 300X

PLATE XI

Figure 33

Figure 34

Figure 35

Figure 36

PLATE XII

Fig. 37. Transverse section of specimen 16, indicating tylose state of a vessel element 400X

Fig. 38. Transverse section of specimen 16, 300X

Fig. 39. Transverse section of specimen 16, indicating variation of vessel element intracellular content 200X

Fig. 40. Transverse section of specimen 16, indicating variation of vessel element intracellular content 300X

PLATE XII

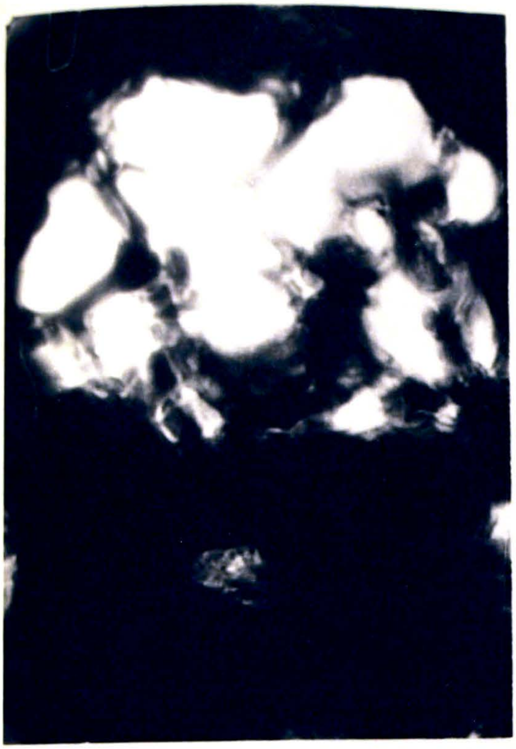

Figure 37

Figure 38

Figure 39

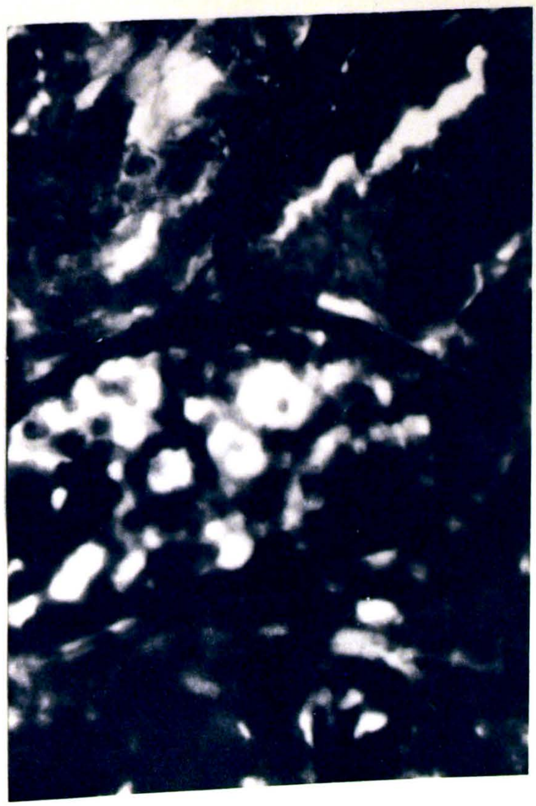

Figure 40

PLATE XIII

Fig. 41. Radial section of specimen 16, indicating scalariform vessel element wall 300X

Fig. 42. Tangential section of specimen 16, indicating state of preservation and uniseriate rays 300X

Fig. 43. Tangential section of specimen 16, indicating state of preservation and multiseriate, storied ray 400X

Fig. 44. Radial section of specimen 16, indicating alternating, storied, procumbent cells containing heterogeneous material

PLATE XIII

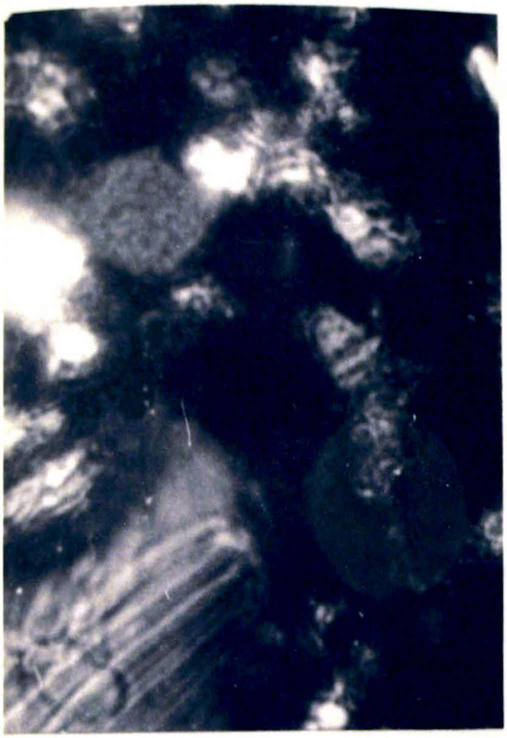

Figure 41

Figure 42

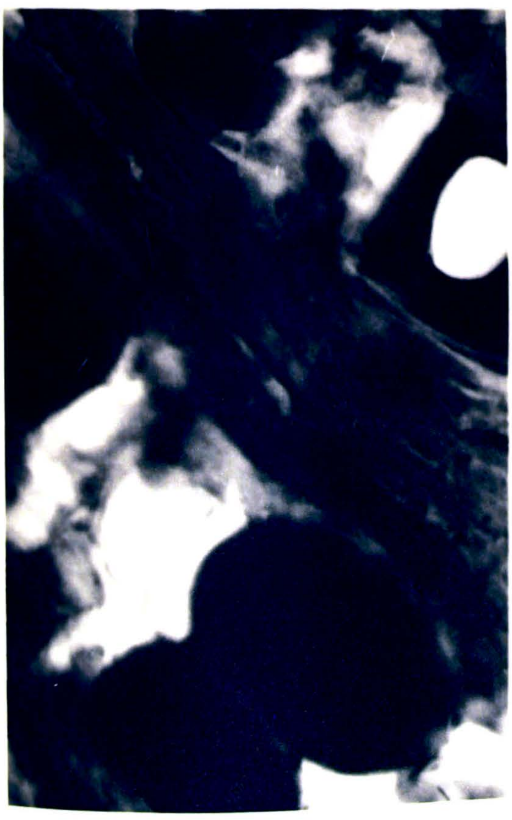

Figure 43

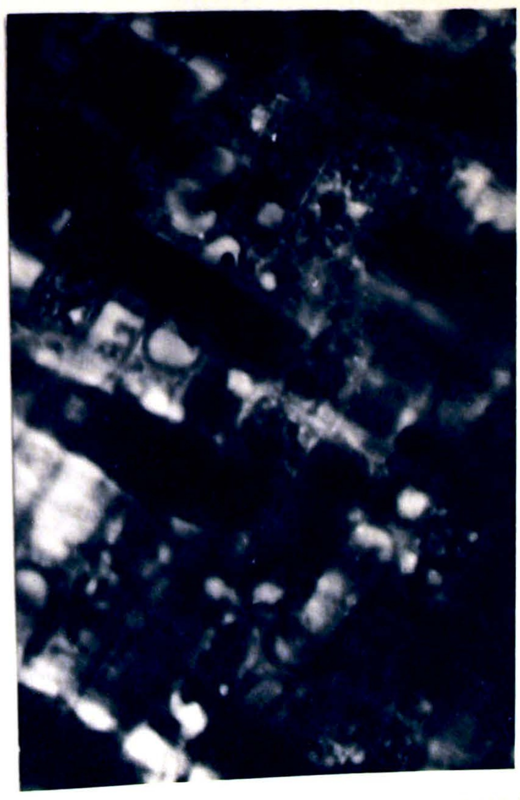

Figure 44

Specimen 19 was selected from collection jar F. This was a particularly interesting specimen, containing hyphal material and associated structures.

VESSELS: Figures 45, 46, 47, 48, 49

Transverse section: distribution diffuse and solitary (Fig. 45); compressed

Tangential section: vessel deterioration, and adjacent wood parenchyma (Figs. 46, 47)

Radial section: scalariform end walls (Fig. 48), and vessel wall remnants (Figs. 47, 49)

PARENCHYMA: Figures 45, 46, 47, 48, 49, 50

Sections: lack of definition, associated with poor state of preservation (Figs. 45, 46, 47, 48, 49)

Indications of hyphal material and fungal activity can be noted in all of the figures, especially Figs. 48, 51, 52, 53

PLATE XIV

Fig. 45. Transverse section of specimen 19, indicating diffuse, solitary vessel distribution and compression 150X

Fig. 46. Tangential section of specimen 19, vessel deterioration and adjacent wood parenchyma 200X

Fig. 47. Tangential section of specimen 19, remnant of vessel wall and wood parenchyma 300X

Fig. 48. Radial section of specimen 19, scalariform vessel wall remnant fungal hyphae 200X

Figure 45

Figure 46

Figure 47

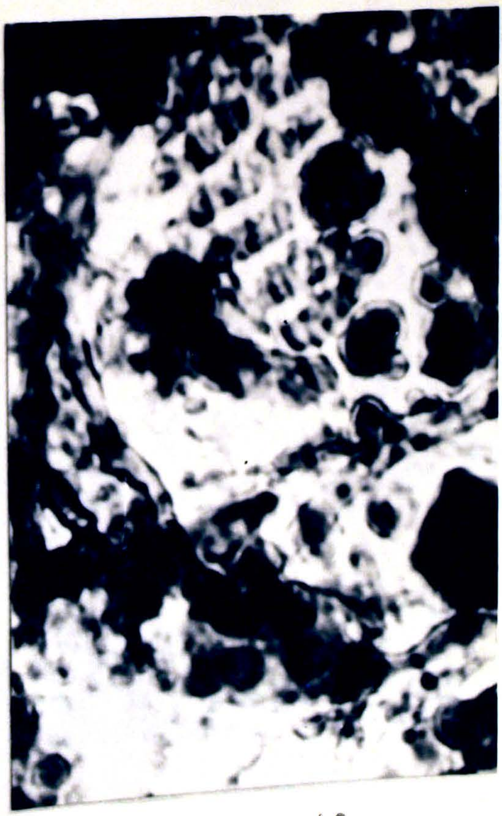

Figure 48

PLATE XV

Fig. 49. Section of specimen 19, fungal hyphae 250X

Fig. 50. Section of specimen 19, fungal hyphae 250X

Fig. 51. Transverse section of specimen 19, poor state of preservation and lack of parenchyma definition 150X

Fig. 52. Radial section of specimen 19, vessel element wall remnant and adjacent deterioration 200X

PLATE XV

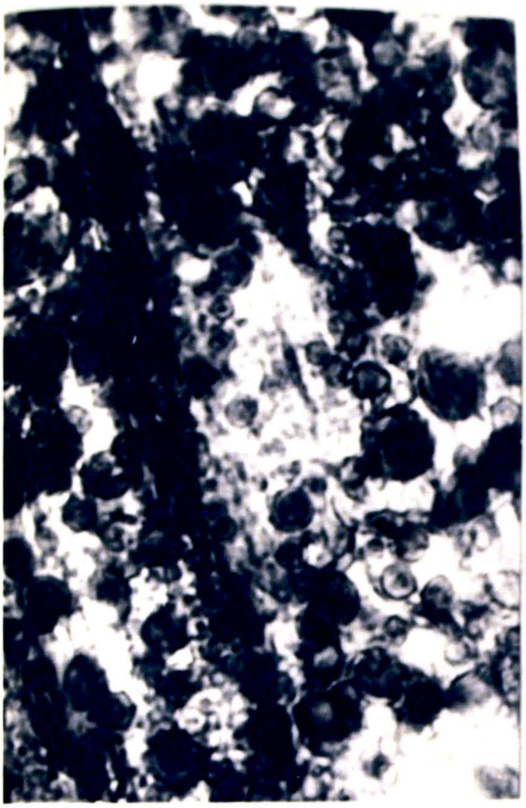
Figure 49

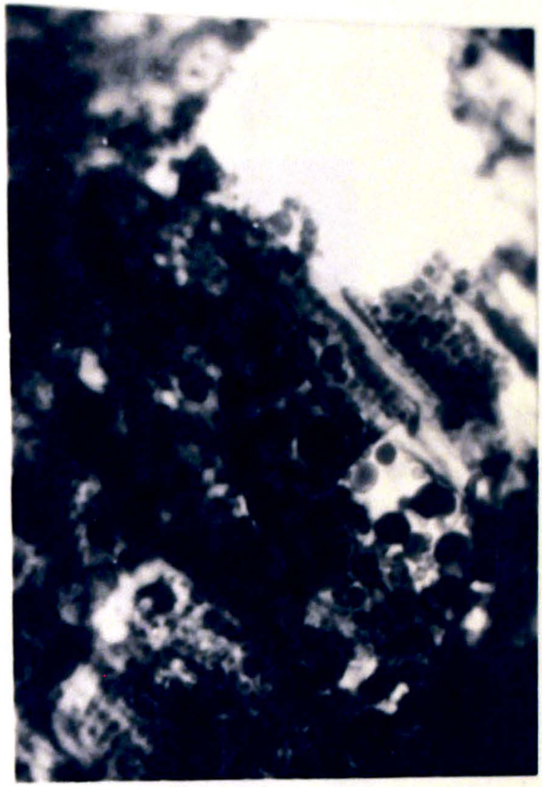
Figure 50


Figure 51


Figure 52

PLATE XVI

Fig. 53. Section of specimen 19, fungal hyphae 250X

PLATE XVI

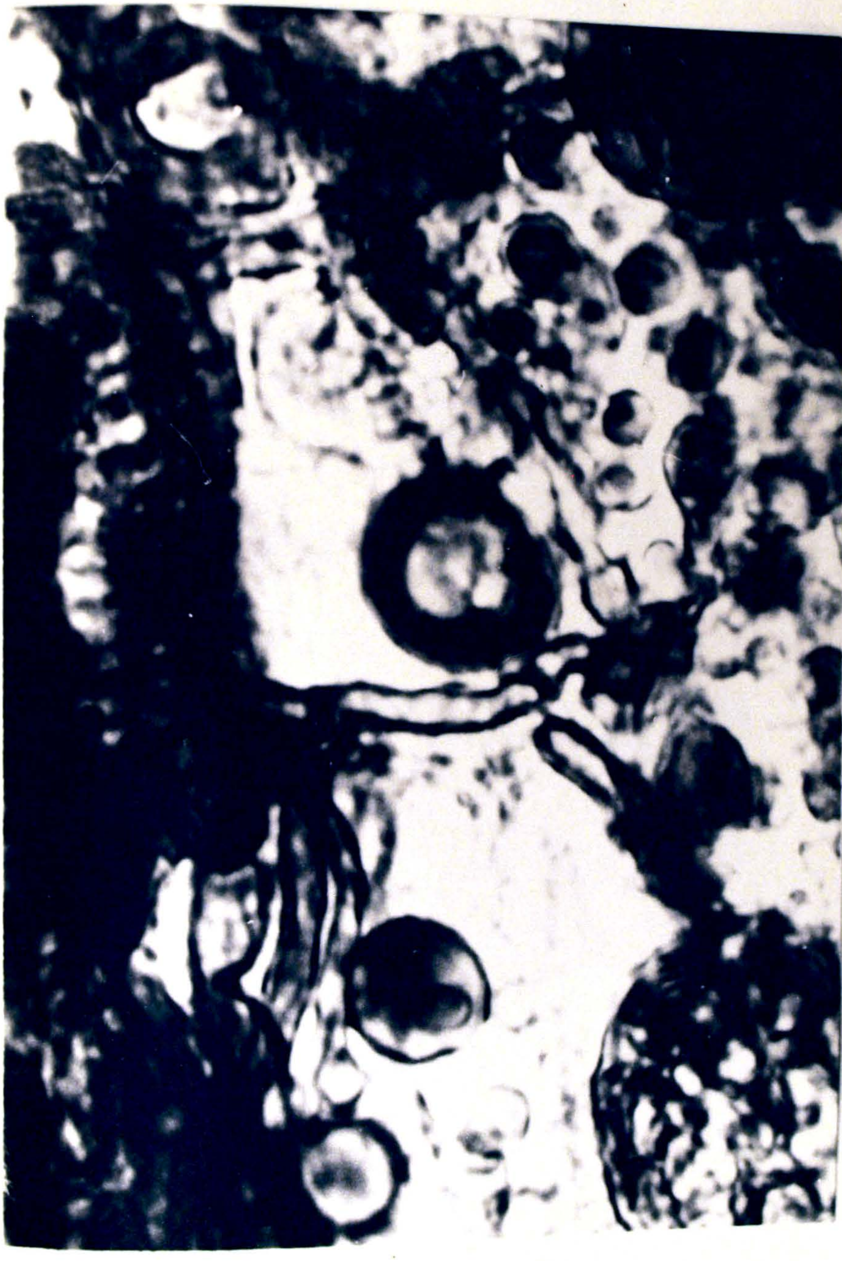

Figure 53

CHAPTER VI

DISCUSSION OF RESULTS

In this study an attempt was made to determine the practicality of a comprehensive study of Eocene fossil woods from West Tennessee. Approximately ten blocks were selected from each specimen in order to have adequate material for sectioning and periodic examination.

Although alcohol dehydration by a graded series, 15%, 18%, 30%, 50%, 70%, 85% and 95% was an adequate process, it proved to be unnecessarily slow. The process summarized in Table I was faster and produced less friable blocks. A comparative examination of the blocks indicated that the higher initial concentration of alcohol was not structurally damaging.

Cellosolve, an infiltrate solvent, was more satisfactory than an equal parts, alcohol-ether solution, due to the following factors: infiltrate dissolving time was reduced; the workable temperature range was greater and the solvent did not have to be handled under a hood.

Parloidion was an adequate infiltrating and matrix agent for most of the blocks. An attempt to soften the Parloidion matrix by increasing the alcohol concentration of the preservation solution was successful, but impractical, as the degree of adherence to the second embedding material, Paraplast, was decreased. The double embedding procedure used was adequate for sectioning.

Each section of a series from each specimen was examined individually and comparatively. No growth rings were observed in any of the transverse sections. Failure to find any evidences of such rings could have been due to distortion or because the growth rings were inherently inconspicuous or generally not evident, such as in some genera of Apocynaceae, in which bands of denser fibres indicate regions of cambial activity (Ingle-Dadswell, 1953).

Specimens 2 and 3 were similar in a number of characteristics. Vessel distribution was diffuse and radial pore multiples were present. Vessel pitting and vessel-ray pitting were uniform, alternate, and vestured. Tyloses, a characteristic which is absent when the size of the vessel-ray pit aperture is less than 10 microns (Chattaway, 1949) were observed. Parenchyma rays were homogeneous or weakly heterogeneous, with a tendency toward two types--uniseriate, erect cells (predominant) and multiseriate rays (less common and indicated). Wood parenchyma was not distinguished in transverse sections, but was indicated by sparsely distributed strands in radial sections.

Specimens 1, 4, and 16 were similar in a number of characteristics. Vessel distribution was diffuse and solitary, pitting was scalariform, and tyloses were observed. Wood parenchyma distribution was not observed. This characteristic is highly correlated in many genera with the presence or absence of septate fibres (Record, 1934;

Jane, 1956; Metcalfe-Chalk, 1957). Septate fibres were not observed in this study.

In transverse section, ray parenchyma was distorted and poorly preserved. Two uniseriate and weakly heterogeneous ray types were observed. One ray type was composed of alternating, storied, procumbent cells; the other, of opposite, storied, erect cells. The fibres apparently had collapsed; and a careful examination indicated bordered pits, although it was not determined whether the fibres were fibre-tracheids or libriform fibres.

The results indicate that adequate structures are available for identification purposes. It is hoped that this study will stimulate further wood studies which will eventually be correlated with data collected from other associated plant materials.

CHAPTER VII

SUMMARY

In this study seven lignitic wood specimens were examined microscopically for diagnostic characteristics. Specimens two and three were apparently similar, as were specimens one, four, and sixteen; specimen nineteen contained fungal hyphae.

The inherent properties of the specimens, which were variable, determined the degree of adequacy of the technique.

The diagnostic characteristics observed in the wood examined indicate the practicality of an extensive study and that additional data are needed to increase reliability and validity before accurate generalities of identification significance can be made.

BIBLIOGRAPHY

BIBLIOGRAPHY

Bailey, I. W., R. A. Howard, 1941. The comparative morphology of Icacinaceae: III. Imperforate tracheary elements and xylem parenchyma. J. Arnold Arbor. 22: 432-442.

______, 1951. The use and abuse of anatomical data in the study of phylogeny and classification. Phytomorphology 1: 67-69.

Berry, E. W., 1916. The lower Eocene floras of southeastern North America. U. S. Geol. Surv. Prof. Paper 91.

______, 1922. Additions to the flora of the Wilcox group. U. S. Geol. Surv. Prof. Paper 131-A.

______, 1924. The Middle and Upper Eocene floras of southeastern North America. U. S. Geol. Surv. Prof. Paper 92.

______, 1930. Revision of the Lower Eocene Wilcox floras of the southeastern states. Geol. Surv. Prof. Paper 156.

______, 1945. The lower Eocene flora of southeastern North America. Jour. of Wash. Aca. of Sci. 35 (3): 87-89.

Brown, R. W., 1944. Temperate species in the Eocene flora of the southeastern United States. Wash. Aca. of Sci. 34 (11): 348-351.

Carlquist, Sherwin, 1962.. Comparative Plant Anatomy. Holt, Rhinehart and Winston. New York.

Chattaway, M. M., 1949. The development of tyloses and secretion of gum in heartwood formation. Aust. J. Sci. Res. B 2 (3): 227-240.

Dilcher, D. L., 1963. Cuticular analysis of Eocene leaves of <u>Ocotea obtusifolia</u>. Am. Jour. Bot. 50: 1-7.

______, 1963. Epiphyllous fungi from Eocene deposits in western Tennessee. Dissert. Yale Uni.

Davis, P. A., V. H. Heywood, 1963. Principles of Angiosperm Taxonomy. Oliver and Boyd. London.

Chalk, L., 1937. The phylogenetic value of certain anatomical features of dicotyledonous woods. Ann. Bot. London., N. S. I.: 408-428.

Esau, K., 1960. Anatomy of Seed plants. John Wiley. New York.

Eyde, R. J., E. C. Barghoorn, 1963. Morphological and paleobotanical studies of Nyssaceae, II, the fossil record. J. of Arnold Arbor. XLIV: 329-352.

Floyd, R. J., 1957. Rocks and minerals of Tennessee. Dept. of Consv. Div. of Geol. Inf. Cir. 5.

Ingle, H. D., H. E. Dadswell, 1953. The anatomy of the timbers of the south-west Pacific area. II. Apocynaceae and Annonaceae. Aust. Jour. of Bot. 1: 1-26.

International Association of Wood Anatomist, Committee on Nomenclature, 1933. Glossary of terms used in describing woods. Trop. Woods. 36: 362-370.

International Association of Wood Anatomist, Committee on Nomenclature, 1957. Glossary of terms used in describing woods. Tropical Woods. 107: 1-36.

Jane, F. W., 1956. The Structure of Wood. Macmillan. New York.

______, 1963. Botanical aspects of wood science. Vistas of Botany Vol. II, W. B. Turrill, Ed. Macmillan Co. New York.

Jeffery, E. C., 1917. The Anatomy of Woody Plants. Uni. of Chicago Press. Chicago.

______, M. A., Chrysler, 1907. The lignites of Brandon. Rept. of the Vermont State Geologist, 195-204.

Johansen, D. A., 1940. Plant Microtechnique. McGraw-Hill. New York.

Knowlton, F. H., 1889. Ann. Rept. Geol. Survey Ark. 2: 247-267.

Kribs, D. A., 1936. Salient lines of structural specialization in the wood rays of dicotyledons. Bot. Gax. 96.

Lesquereux, Leo., 1869. Am. Phil. Soc. Trans., new ser., Vol. 13.

Loughridge, R. H., 1888. Report on the geological and economic features of the Jackson's purchase region. Ky. Geol. Surv.

Metcalfe, C. R., L. Chalk, 1957. Anatomy of the Dicotyledons. Vol. I, II. Oxford at the Clarendon Press. London.

Murray, G. E., 1961. Geology of the Atlantic and Gulf Coastal Province of North America. Harper and Bros. New York.

Perkins, G. H., 1907. The lignite or brown coal of Brandon. Rept. of the Vermont State Geologist. 188-201.

Record, S. A., 1934. Identification of the Timbers of Temperate North America. John Wiley. London.

Sass, J. E., 1951. Botanical Technique. Iowa State College Press. Ames.

Solereder, H., 1908. Systematic Anatomy of the Dicotyledons. Clarendon Press. Oxford.

Stearns, R. G., C. A. Armstrong, 1955. Post-Paleozoic stratigraphy of the western Tennessee and adjacent portions of the upper Mississippi Embayment. Tenn. Dept. Cons. Dept. Geol. Rep. of Inv. 2.

______, 1958. Creataceous, Paleocene, and Lower Eocene geologic history of the northern Mississippi Embayment. Tenn. Dept. Cons. Div. of Geol. Rep. of Inv. 6.

Tippo, Oswald, 1946. The role of wood anatomy in phylogeny. The Am. Mid. Nat. 36: 362-370.

Whitlatch, G. L., 1940. The clays of West Tennessee. Tenn. Dept. of Cons. Div. of Geol. Bull. 49.

APPENDIX

APPENDIX A

Berry's Collecting Sites in West Tennessee

Chester County:

16, Taylor farm, Silerton road

Hardeman County:

17, Big Cut at Pine Top; 18, Rogers Spring; 19, gully north of old State Line road; 20, three-fourths mile west of Rogers Spring road; 21, 3 miles south of Saulsbury; 22, Saulsbury; 23, Center Church; 24, $2\frac{1}{2}$ miles northwest of Burnetts Store; 25, 2 miles southeast of Bolivar (Murrell place); 26, half a mile southeast of Walnut Grove Church; 27, Bolivar, west of hospital; 28, Young farm, northwest of Shandy; 29, $2\frac{1}{4}$ miles north of Shandy; 30, Mill Creek; 31, Gin Creek; 32, Teague; 33, north of Clover Creek, 34, 1 mile northeast of Cloverport; 35, Whiteville; 36, Shepherd Price farm; 37, $5\frac{1}{4}$ miles south of Whiteville; 38, Piney Creek, 10 miles east of Bolivar; 39, $1\frac{1}{4}$ miles east of Grand Junction

Fayette County:

40, $1\frac{1}{2}$ miles west of Grand Junction; 41, Baughs Bridge; 42, one-fourth mile northwest of Smyrna Church; 43, Brinkley Place, Fayette Corners; 44, 1 mile west of Laconia; 45, $3\frac{1}{4}$ miles northeast of Somerville; 46, half a mile south of Henley's store; 47, north of Loosahatchie River, 1 mile north of Somerville; 48, Safford-Lesquereux locality; 49, float in Grenada ironstone; 50, 1 1/5 miles south of Somerville; 51, $1\frac{1}{2}$ miles south of Somerville-Whiteville road; 52, 2 9/10 miles southwest of Somerville; 53, $1\frac{1}{2}$ miles northeast of Williston; 54, three-fourths mile northwest of Pattersonville; 55, road west of La Grange; 56, La Grange; 57, gully west of State road, La Grange; 58, Davenport property, La Grange; 59, 1 mile south of Grand Junction; 60, 4 3/4 miles southwest of Williston; 61, 5 miles southwest of Williston

Madison County:

62, Pinson; 63, cut, Gulf, Mobile & Northern Railroad, one-fourth mile south of Mandy; 64, Will Brooks farm, northwest of Mercer; 65, Jim Tomphson farm, northeast of Jackson; 66, 2 miles southeast of Spring Creek; 67, Pope farm, north of

Mercer; 68, one-fourth mile east of Denmark; 69, Jackson-Bolivar road, $5\frac{1}{2}$ miles south of Jackson; 70, Mobile & Ohio Railroad, 4 miles north of Jackson

Gibson County:

71, 4 miles southwest of Trenton; 72, 1 mile west of Milan

Haywood County:

73, Somerville-Brownsville road, 1 mile north of Dancyville

Carroll County:

74, Thompson-Barksdale prospect, 2 miles south of McKenzie; 75, Huckleberry Schoolhouse

Henry County:

76, Foundry Church pit; 77, Whitlock pit; 78, Breedlove pit; 79, Bradley pit; 86, Grable pit; 81, Puryear; 82, Cottage Grove; 83, Atkins pit; 84, Spink pit; 85, Holcomb property, 2 miles south of Paris; 86, 1 mile southeast of New Boston; 87, Grove pit; 88, Cole pit; 89, pits southwest of Crossland

APPENDIX B

Modification of Berry's Gymnospermous and Dicotyledonous Flora of Henry County, Tennessee

BERRY		MODIFICATIONS
Families	Genera	
Pinaceae	*Taxodium*	
	Arthrotaxis	
Juglandaceae	*Engelhardtia*	
Myricaceae	*Myrica*	
Fagaceae	*Dryophyllum*	
Moraceae	*Artocarpoides*	
	Pseudolmedia	
	Ficus	
Protaceae	*Banksia*	
	Proteoides	
	Knightiphyllum	
Polygonaceae	*Coccolobis*	
Nyctacinaceae	*Pisonia*	
Magnoliaceae	*Magnolia*	
Anonaceae (Annonaceae)	*Anona* (*Annona*)	
Capparidaceae	*Capparis*	
Rosaceae	*Chrysobalanus*	
Mimosaceae	*Inga*	
	Pithecolobium	
	Mimosites	
Caesalpiniaceae	*Cassia*	
	Caesalpinia	
	Gleditsiophyllum	

Papilionaceae	Canavalia	
	Dalbergia	
	Leguminosites	
	Sophora	
Rutaceae	Fagara	
	Citrophyllum	
Simarubaceae	Simaruba	
Meliaceae	Carapa	
	Cedrela	
Humiriaceae	Vantanea	
Malpighiaceae	Hiraea	
	Banisteria	
Euphorbiaceae	Crotonophyllum	
Anacardiaceae	Anacardites	
	Metopium	
Illicaceae	Ilex	
Celastraceae	Celastrus	
	Euonymus	Staphylea (Brown, 1945)
	Maytenus	
Sapindaceae	Cupanites	
	Dodonaea	
	Sapindus	
Rhamnaceae	Reynosia	
	Rhamnus	
	Zizyphus	
Tiliaceae	Grewiopsis	
Sterculiaceae	Sterculia	
Bombaceae	Bombacites	
Dilleniaceae	Dillenites	
Ternstroermiaceae	Ternstroemites	
Flacourtiaceae	Bania	

Lauraceae	*Cinnamomum* *Persea* *Oreodaphne* *Mespilodaphne* *Nectandra* *Laurophyllum*	*Ocotea obtusifolia* [Berry] La Motte [1952]
Myrtaceae	*Myrica* *Calyptranthes* *Eugenia*	
Combretaceae	*Laguncularia* *Combretanthites* *Terminalia* *Conocarpus*	
Hydrocaryaceae	*Trapa*	
Melastomataceae	*Melastomites*	
Araliaceae	*Oreopanax* *Schefflera*	
Cornaceae	*Nyssa*	Nyssaceae Nyssa (Eyde and Barghoorn)
Myrsinaceae	*Icacorea*	
Sapotaceae	*Bumelia* *Mimusops* *Sideroxylon*	
Ebenaceae	*Diospyros* (calices)	*Fagus* burs (Brown, 1944)
Oleaceae	*Fraxinus* *Osmanthus*	
Apocynaceae	*Apocynophyllum* *Echitonium*	
Boraginaceae		
Verbenaceae	*Avicennia*	
Rubiaceae	*Psychotria* *Guettarda* *Rubiacites*	

APPENDIX C

Berry's Revision of Lesquereux's West Tennessee Flora

Berry	Lesquereux
Nectandra lancifolia	Laurus caroliniensis (Michaux)
Inga mississippiensis	Prunus caroliniana (Michaux)
Sophora lesquereuxi	Quercus myrtifolia (Willdenow)
(?)	Fagus ferruginea (Michaux)
Dryophyllum tennesseensis	Quercus! crassinervis Urban
Banksia safford	Quercus saffordi (Lesquereux)
Diospyros brachysepala	Andromeda dubia (Lesquereux)
Cassia glenni	A. vaccinifoliae affinis (Lesquereux)
Chrysobalanus inaequalis	Elaeagnus inaequalis (Lesquereux)