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SOME EOCENE DICOTYLEDONOUS WOODS FROM EDEN VALLEY, WYOMING

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by

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SOME EOCENE DICOTYLEDONOUS WOODS FROM EDEN VALLEY, WYOMING

Introduction

The present study is concerned with the description and identification of approximately one hundred silicified wood specimens. All were originally collected by Mr. Sharpe Osmundson of Council Bluffs, Iowa and subsequently secured by Mrs. Elizabeth Dalve of Cincinnati who kindly presented the material to the Paleobotanical Laboratory of the Botany Department of the University of Cincinnati for diagnosis.

The specimens were picked up on the surface on private property known as Hays' Ranch, being reached by state route 28, about 16 miles east of Farson, Wyoming. Physiographically, the site lies within the Eden Valley, a moderate-sized structural basin drained by a few small streams which are tributary to the Green River.

The geologic strata of the region have been described as flat-lying and consisting of interbedded sandstone, shale, and siltstone. The highest concentration of fossil wood occurs within the sandstone which crops out as low ledges. Even though the specimens were picked up on the surface, it is probable that they were preserved *in situ* and their appearance is the result of weathering in place and not the result of transport from other localities.

The Wyoming Geologic Map of 1925 indicates that the surface rocks of this locality belong to the Green River Formation or possibly the upper Wasatch Formation, thus making the age of the forest upper Lower Eocene.

Thin sections were made by the standard methods. First, transverse sections were made of all the specimens. These were then grouped according to similarities and differences and the best preserved woods of each group were further sectioned to secure the three standard sections (transverse, tangential, and radial) required in the study of modern woods. Among the specimens included in this study, twelve different species of dicotyledons were found.

In describing the specimens, the outline suggested by Record and Chattaway (1939) was followed. It soon became evident that because of the varying states of preservation of the fossils, many of the characteristics applied to modern woods were not applicable to these fossils. The difficulties encountered are as follows:

1. Practically all the specimens showed vessel fillings which suggested tyloses, these being particularly evident in longitudinal sections. They may be true tyloses or they may be due to mineral infiltration during fossilization.
2. In many cases it was impossible to determine accurately the thickness of the walls of the various elements of the xylem. The apparent wall may represent the actual wall of the living wood

or it may have been subsequently thickened by mineralization. This made it difficult to distinguish between fibers and parenchyma in cross sections and thus, a very important diagnostic character - the arrangement of parenchyma - was lost.

3. In most cases no difficulty was found in determining the type of intervascular pitting, but in most cases it was impossible to determine whether the fiber pitting was simple or bordered, or even to observe the pitting at all. In just a few cases was the ray to vessel pitting observed.

4. In no case were vestured pits observed. Since they are so difficult to observe in modern woods, it is quite possible that they could be overlooked in the fossils or had not been preserved at all.

5. Many of the cells of the fossils are of the storage-type and contain dark contents, but it is impossible to determine the original content, if any existed.

6. Fiber length was often impossible to determine due to the difficulty in securing good thin sections and due to the state of preservation.

Despite these difficulties, two approaches were employed with varying degrees of success. First, by a comparison of the material with descriptions in the standard references of Metcalfe and Chalk (1950) and Record and Hess (1943), family after family was eliminated. When similarities existed, comparisons among the genera were made. Finally, the material was compared with various modern species of these genera. In the second approach to identification, the fossil record, particularly the compression material, of comparable age and locality was examined. Modern representatives of many of these were then compared with the specimens. In several cases this latter method was successful. All of the keys to modern woods are difficult to use because of the weaknesses in description mentioned above. Furthermore, most keys are prone to use such characteristics as color, odor, or taste, all of which, of course, cannot be applied to fossil woods. At all times it was necessary to keep in mind that most of the fossil specimens were twigs or possibly rootlets and that most modern descriptions are based on mature wood. Size of elements then becomes an important consideration. Finally, it may be mentioned that due to the youthfulness of the specimens, many were found that had well-preserved tissues in addition to the secondary xylem, such as pith, phloem, and periderm. These tissues were of very little help in identification.

The arrangement of the orders and families is according to Engler's Syllabus der Pflanzenfamilien, 11th edition, 1936.

Acknowledgments

The writer is indebted to Dr. J. H. Hoskins for suggesting the problem and for continual help and encouragement; to Dr. Margaret Fulford for her suggestions in designating the type specimens; and especially to Dr. H. R. Muegel for help in all problems relating to wood anatomy, identification and naming of the specimens, and in translations.

It would have been impossible to complete this study without the aid of slides and specimens from the Yale Collection so kindly selected and sent by Miss Mary Record of that university. Miss Jeannette Kryn of the University of Michigan was of assistance in the identification of the anacardiaceous material. For aid and suggestions in the preparation of the photographs, the author is indebted to Mrs. Maxine Abbott of the University of Cincinnati and to Mr. H. L. Jeter of the USPHS.

Description of Species

Angiospermae

Dicotyledonae

Myricales

Myricaceae

Myrica L.

35 modern species of shrubs and small trees in temperate and tropical regions of the world.

Vessels small,[1] usually exclusively solitary; perforation plates exclusively scalariform or scalariform and simple; intervascular pitting alternate to scalariform; pits to parenchyma round. Fibers with distinctly bordered pits. Parenchyma abundant, diffuse, paratracheal, and sometimes metatracheal or terminal. Rays heterogeneous, uniseriate or up to 8 cells wide and not very high; oil cells sometimes present.

Myrica scalariformis Kruse, sp. nov.

Secondary xylem:

Growth rings: indistinct; possibly as many as 10 in the specimen (diameter of specimen 29 mm., center very eccentric).

Vessels: typically diffuse porous; pores virtually all solitary, occasionally in multiples of two, evenly distributed, more or less circular, average diameter 70 mu.; average vessel member length 600 mu.; 40 to 60 pores per square mm.;

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[1] This and the following descriptions of modern genera are based on Metcalfe and Chalk (1950), Record and Hess (1943), and various papers in Tropical Woods.

thick-walled, large tyloses apparently present in some vessels: perforation plates scalariform, frequently reticulated, long, up to 35 or 40 bars; bars about as wide as the spaces plates very steeply inclined from the horizontal: intervascular pitting opposite in 4 or 5 vertical rows; borders circular, about 5 mu. in diameter; inner apertures included, lenticular, about half as long as diameter of border, with tendency to horizontal orientation; apertures of pit-pairs apparently not crossed: vessel to ray pitting fine, opposite, half bordered, borders on vessel side essentially circular, about 3.5 mu. in diameter; inner apertures lenticular, oriented horizontally, nearly as long as diameter of border; 12 to 15 pits per cross-field.

Wood parenchyma: fairly abundant, in long strands, arrangement not determinable, but probably diffuse or a few strands in groups.

Rays: strikingly heterogeneous, bi- or triseriate, mostly the former, with uniseriate margins of 1 to occasionally 5 cells; height 140 to 430 mu. (3 to 20 cells, averaging 15), width less than 35 mu.; marginal cells square or slightly upright, cells in interior of ray mostly procumbent with occasional tiers of square or upright cells interspersed between the procumbent tiers; occasional low uniseriate rays of upright cells; most of the multiseriate rays with large, storage-type cells which are either procumbent, square, or upright and which occupy the entire width of the ray.

Fibers: moderately thick-walled (4.4 mu.); diameter variable, 8 to 18 mu., length 280 to 550 mu.; ends somewhat rounded; pits distinctly bordered, in one or occasionally two vertical rows; borders circular, about 5 mu. in diameter; inner apertures slit-like, included, extending nearly to the border, orientation nearly vertical; apertures of pit-pairs crossed as a small angle.

Pith:

Very small; character of cells not determined. (The possibility remains that a pith is absent and that this specimen may be a root.)

Other tissues:

Absent in specimen.

Type specimen and slides: No. B-3302.[2]

Discussion:

Lesquereux in his Green River Flora (1883) lists 20 species of Myrica based on compression material and Berry in

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[2] These and the following numbers refer to the collection numbers of specimens in the Paleobotanical Collection of the University of Cincinnati.

his work on the Wilcox Flora (1916) lists two species of leaf compressions of the same genus. Comparing the specimen with a prepared slide of the mature wood of Myrica cerifera, a Linnaean species, a striking similarity was noted, particularly in the pore arrangement and the rays as viewed in tangential section. Some minor differences, however, were noted as follows:

1. The rays in the fossil are mostly biseriate, but occasionally triseriate, while in M. cerifera the reverse is the case.
2. Storage-type cells (oil cells) are absent in M. cerifera, but are present in the fossil.
3. The intervascular pitting is scalariform in M. cerifera, but opposite in the fossil.

It is evident that this specimen is not M. cerifera, but it will be noted that in every case in which there is a difference, the fossil wood deviates in no way from the general generic description given above. The very distinct scalariform perforations of the vessels as seen in radial section (Fib. 3) suggested the specific epithet.

Fossil and modern range of the genus:[3]

Compression of leaves, flowers, and seeds of Myrica are abundant in the fossil record throughout every period from the Cretaceous to the present; in fact, more fossil species have been described than there are modern species. For

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[3] In this and the following discussions of the fossil record, particular emphasis is placed on Lesquereux's Green River Flora and Berrys's Wilcox Flora because of their completeness and approximately same age as the woods under discussion.

North America alone, Knowlton (1919) lists 63 valid species and to this La Motte (1944) adds 24 additional species or varieties. Lesquereux (1883) described two species from the Dakota Group of Cretaceous age from Kansas. In his original work on the Green River Flora, Lesquereux (op. cit.) lists 20 species, 11 of which are described in detail. Brown (1934), however, referred 6 of Lesquereux's species to other genera. Berry (1916) in his original work on the Wilcox flora, described two species and to this he later added one more (1930a). In Europe, the genus is represented from the Oligocene to the present. The only other genus in the family Myricaceae (Comptonia L'Her.) is much less frequently found in the fossil record; the earliest record in North America is from the lower Miocene, one species being described by Berry (1929) from the Latah Formation. As far as the author could ascertain, the fossil wood of Myrica has not previously been described.

The geographic distribution of the genus as a fossil is quite extensive in North America. It extends from Massachusetts southward along the Atlantic coast to Florida, thence westward as a very wide band the southern limit of which is the Gulf of Mexico and the southern boundary of the United States to the west coast. The northern limit in the United States passes through Maryland, Kentucky, Nebraska, Wyoming, to the Pacific in Oregon. Northward it has been found in a wide band passing through British Columbia and Saskatchewan, the

Northwest Territory on into Alaska.

At present the genus is found throughout the temperate and tropical regions of both the Eastern and Western Hemispheres. In North America the northern limit extends as a line from Labrador to Minnesota, into Saskatchewan.

Ranales

Magnoliaceae

Talauma Juss.

50 modern species of trees and shrubs of general occurrence throughout the tropics, with the exception of Africa.

Pores 10 to 40 per square mm.;[4] solitary or in radial lines; moderate sized to rather large; vessel members very long; perforations scalariform, bars very few to fairly numerous. Parenchyma in terminal lines. Rays rarely without oil cells.

Talauma multiperforata Kruse, sp. nov.

Secondary xylem:

Growth rings: fairly distinct; five in specimen, 1 to 2 mm. wide. (Diameter of specimen about 16 mm.)

Vessels: diffuse porous to semi-ring porous; pores solitary and in radial multiples of 2 to 4, essentially circular except for flattening along line of contact

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[4] This description is based on McLaughlin (1933).

between pores of multiples, 56 to 126 mu. in diameter, averaging 96 mu., 30 to 40 per square mm.; vessel member length 350 to 500 mu.; tyloses not observed: perforations scalariform with many narrow bars to occasionally simple; plates inclined about 45 degrees toward rays: intervascular pitting scalariform to occasionally opposite; pits about 8 mu. apart: vessel to ray pitting not observed.

Wood parenchyma: not observable in the specimen.

Rays: heterogeneous, bi- or triseriate with 1 to 4 rows of marginal cells which are large and greatly elongated vertically; cells of uniseriate parts of multiseriate rays in the interior of the ray are similar to the marginals; other cells of rays square or slightly procumbent; uniseriates rare and entirely of upright cells; height 8 to 42 cells, maximum 1.5 mm.; maximum width 63 mu.; about 10 rays per mm. as measured on the tangential surface: rounded storage-type cells, which resemble oil cells, common.

Fibers: fairly thick-walled (3.5 mu.), but lumina large; average diameter 21 mu.; average length 750 mu.; pitting not observable.

Pith:

Center of specimen not preserved, but if a pith existed, it was very small.

Other tissues:

Absent in specimen.

Type specimen and slides: No. B-3283.

Discussion:

Considering pore distribution and size, ray characteristics, perforations in vessels, and intervascular pitting, two families are known which include these characteristics in a manner similar to that exhibited by the specimen. These families are the Magnoliaceae and the Olacaceae, the only significant difference between them being in the arrangement of the wood parenchyma. No parenchyma was observed in the fossil. However, after examination of prepared slides of several species of many genera of both families, it was felt that the specimen should be placed in the Magnoliaceae. Examination of three species of Talauma (T. minor Urb., T. sambuensis Pitt., and T. gloriensis Pitt.) indicate two marked similarities with the specimen. First, the vessel members are unusually long in both the fossil and in the modern species (up to 0.5 mm.); second, all have prominent oil cells in the rays. Furthermore, it was found in T. gloriensis, that the wood fibers have very thin walls and are indistinguishable from parenchyma as seen in transverse section. This could account for the apparent absence of parenchyma in the specimen. The longitudinal sections of the fossil are not large enough to include an entire growth ring and thus it is quite possible that terminal parenchyma could be completely overlooked.

Not only is the affinity definitely with the Magnoliaceae, but the specimen may be considered as a species of the genus Talauma with a fair degree of confidence, although not a modern species. The rather numerous bars in the perforation plates of the vessels suggested the specific name.

Fossil and modern range of the genus:

As far as it could be ascertained, Talauma has not been previously recognized in the fossil record, either as petrified wood or as compressions. The Magnoliaceae, however, is extensively represented as compressions from the Cretaceous to the present throughout the Northern Hemisphere, Magnolia L. and Liriodendron L. accounting for practically all occurrences. The only authentic fossil wood specimen of the family was described by Hofmann (1952) from the Oligocene of Austria and given a new generic name - Magnolioxylon because of its close resemblance to Magnolia. As compressions the family has many representatives, only a few of which will be mentioned. Lesquereux (1883) described 6 species of Magnolia and 8 species Liriodendron from the Cretaceous Dakota group of Kansas, Nebraska, Minnesota, and Colorado. Berry (1916) in his original work on the Wilcox flora described 2 species of

Magnolia and in his revision (1930a) adds a new variety to one of his previously described species. Dorf (1942) lists 5 species of *Magnolia* from the Medicine Bow Formation of southern Wyoming and northeastern Colorado. From the Shantung Province of China, Hu and Chaney (1940) describe one species of the same genus of Miocene age.

The present range of *Talauma* is throughout the tropics of the world with the exception of Africa. It does not reach as far north as the United States.

Rhoeadales

Capparidaceae

Forchhammerioxylon scleroticum Kruse, gen. et sp. nov.

Secondary xylem:

Growth rings: three, clearly marked by tangential bands of conjuctive parenchyma. (Diameter of specimen in which structure was preserved only 5 mm.)

Vessels: typically diffuse porous; pores all solitary and in no definite arrangement, all more or less of the same size, mostly oval with longer axis radial, averaging 31 by 42 mu.; about 75 pores per squære mm.; vessel member length variable 96 to 184 mu.; tyloses apparently absent: perforations not observed distinctly, but apparently simple; end walls inclined from a small angle to about 45 degrees from the horizontal: no pitting observable.

Wood parenchyma: conjunctive, terminal, averaging 5 or 6 cells in width, fusing with larger rays, thus dividing wood into individual bundles and giving a clover-leaf pattern; cells similar in all respects to those of the rays as seen in transverse section: parenchyma also paratracheal and diffuse, both types in long strands.

Rays: fusiform and considerably twisted as seen in tangential section; extremely variable in width and height, from uniseriate to 10 cells in width and from 3 to more than 40 cells in height; all cells somewhat elongated vertically as seen on the tangential surface; about 8 rays per mm. as measured on the tangential surface.

Fibers: thick-walled (4 mu.) with small lumen, average width 8.8 mu., length not determined, many septate, considerably twisted as seen in tangential surface; pitting not observable: irregular groups of about 12 very thick-walled cells, which apparently are stone cells, are found in the conjunctive tissue immediately on the outside of each phloem area.

Included phloem: concentric type, in irregular patches averaging 100 mu. in diameter, near end of each growth ring; usually two areas are found in each bundle formed by the conjunctive tissue and the larger rays; phloem cells completely disintegrated.

Pith:

Absent (this specimen could possibly be a root).

Other tissues:

Absent in specimen.

Type specimen and slides: No. B-3272.

Discussion:

It must be mentioned that this is a very small specimen (only 5 mm. in diameter) and that only two thin sections could be prepared (transverse and tangential); however, the preservation of cellular detail is good and the description is fairly complete. The extensive work by Chalk and Chattaway (1937) on modern woods with included phloem was used in the identification of this fossil. It appears that the affinity is definitely with the Capparidaceae, being closely akin to the genus Forchhammeria Liebm.

Chalk and Chattaway describe Forchhammeria as follows:

"Successive bundles of xylem and phloem, repeating the structure of the young stem, separated by tangential bands of conjunctive parenchyma and by large interfascicular rays."

"Vessels: Pores very small, solitary; evenly distributed. Vessel members short; perforations simple; pits to parenchyma small, alternate. Rays: Interfascicular predominant, very wide and high; cells variable in size and shape, square to erect, rarely procumbent. Fascicular narrow and low, rare. Parenchyma: Conjunctive in tangential bands, separating the xylem and phloem bundles; cells irregular, square or erect, sometimes hexagonal. Metatracheal in short tangential uniseriate lines; cells usually 2 per strand. Wood fibers: with moderately thick walls; pits numerous, with small but distinct borders."

The specimen was compared with *F. longifolia* Standl. and it was found that the overall pattern found by the phloem areas and conjunctive parenchyma is strikingly similar. The minute anatomy, however, showed several important differences listed below.

1. No stone cells are found in the conjunctive parenchyma of *F. longifolia* although they are quite evident in the fossil. Stone cells are found, however, in *Cadaba* Forsk. and *Maerua* Forsk., other members of the same family.
2. The metatracheal parenchyma strands consist of more than two cells in the fossil.
3. Fibers are septate in the fossil but not in the modern wood.

It appears that these differences are too significant to place the specimen in the genus *Forchhammeria* even though there is probably a close affinity. The other genera

(Cadaba and Maerua) mentioned in connection with stone cells are characterized by a marked radial arrangement of the pores. A new genus, Forchhammerioxylon, is suggested to show its relationship; its specific name suggests the occurrence of stone cells in the conjunctive parenchyma.

Fossil and modern range of the genus:

Examination of the literature failed to reveal references to Forchhammeria; in fact, the representation of the Capparidaceae in the fossil record is very scanty. The only record of a wood specimen belonging to the family is Capparidoxylon geinitzi Schenk (1883) from the Oligocene of Egypt, which is referred to the genus Capparis (Tourn.) L. by the author, but there are no members of this genus which have included phloem. A few references to the family were found in the compression floras of the United States. Berry (1916) describes one species of Capparis from the Wilcox and later in his revision (1930) adds a new variety of the same species. From the Jackson flora, Berry (1924) describes a seed compression named by him, Capparidocarpus.

Forchhammeria is now confined to the Americas north of the equator, the West Indies and from California to Guatemala and Salvador.

Geraniales

Rutaceae

Amyridoxylon ordinatum Kruse, gen. et sp. nov.

Secondary xylem:

<u>Growth rings</u>: indistinct; probably three in the type specimen. (Diameter of preserved part of specimen about 25 mm., embedded in thick silicified, colorless matrix.)

<u>Vessels</u>: Typically diffuse porous; pores at beginning of growth ring, solitary or in multiples of 2 to 5 cells with a tendency toward a tangential arrangement; later pores solitary or more commonly in long radial chains of up to 30 cells; occasionally in tangential multiples of 2 to 10 cells which probably all belong to the same vessel due to shift in direction; pores circular or slightly flattened radially, averaging 28 mu. in diameter, numerous, several hundred per square mm., possibly over 500; vessel member length averaging 115 mu.; tyloses not observed: perforations simple (occasional "elbows" due to tangential shift in direction of members of same vessel give the appearance in certain parts of the tangential section that the end walls are imperforate); plates inclined at a small angle from the horizontal: intervascular pitting alternate, very fine, about 2 mu. in diameter; borders circular; inner apertures included, lenticular, extending nearly to the border, with a tendency to horizontal orientation: vessel to ray pitting not observed: vessel members in horizontal seriation

with the rays.

Wood parenchyma: diffuse, very scarce, in short strands of 2 or 3 cells.

Rays: heterogeneous, uniseriate or occasionally biseriate in part, mostly of procumbent cells with occasional interspersed or marginal tiers of square cells; height mostly 7 or 8 cells or 110 mu., which corresponds to one horizontal seriation or tier; fused rays of 2 to 4 tiers of up to 30 cells occasionally found; average width 8 mu.; about 20 rays per mm. as measured on the tangential surface.

Fibers: thin-walled (1.6 mu.), short, averaging 160 mu. in length with a tendency for horizontal seriation with the rays and vessel members; occasionally septate; diameter 7 mu.; length not determined: pitting bordered; borders long oval with longer axis 4 mu.; apertures slit-like, included, and oriented vertically.

Storied structure: vessel members and rays clearly storied as viewed in tangential section; fibers less definitely so; about 175 tiers per inch.

Pith:

Small, circular, of large, moderately thick-walled parenchyma.

Other tissues:

Absent in specimen.

Type specimen and slides: No. B-3288. Other material examined: specimen and slides: No. B-3275.

Discussion:

On the basis of minute anatomy, it was not difficult to arrive at two families which included all the characteristics of the specimen. These are the Zygophyllaceae and the Rutaceae. The significant differences between these families are as follows:

Zygophyllaceae	Rutaceae
1. Pores often very irregularly arranged; radially arranged in Bulnesia.	1. Pores mostly in short, sometimes long, radial multiples.
2. Fibers never septate.	2. Fibers septate in a few species.
3. Elements storied in all species.	3. Elements sometimes storied in Esenbeckia.

It will be noted that the Zygophyllaceae are chiefly characterized by exhibiting storied structure in all cases, while a radial arrangement of the pores characterizes the Rutaceae. It was felt that the arrangement of the pores is of more diagnostic value than storied structure, thus the specimen was placed in the Rutaceae. To further substantiate the decision, the presence of septate fibers in the specimen and some species of the Rutaceae, but never in the Zygophyllaceae, offered additional evidence for a correct diagnosis. Also, storied structure has been reported in the family, in the genus Esenbeckia H., B. et K. Although radially arranged pores are found in Bulnesia A. Gray of the Zygophyllaceae, examination of several species of this genus indicated no similarity whatever with the fossil.

Within the Rutaceae, Amyris L. appears to be most closely related to the specimen. Five modern species of this genus were compared with the fossil and a marked similarity was found in pore arrangement and rays as seen in tangential section between all the modern woods and the ancient wood. However, storied structure is absent in all these modern species.

With a considerable degree of confidence, this specimen is placed in the Rutaceae, but the presence of storied structure precluded its being placed in the genus Amyris. The suggested genus Amyridoxylon indicated the other close similarities. The storied structure is indicated in the specific epithet.

Fossil and modern range of the genus:

No reference was found in the literature of either fossil wood or compressions of Amyris, which is similar in many respects to this new genus. Other members of the Rutaceae, however, are well represented and will be discussed in connection with the following wood.

Amyris is now confined to the New World: from southern Florida and Texas, southward through Central America to northern South America.

<u>Fagara monophylloides</u> Kruse, sp. nov.

Secondary xylem.

<u>Growth rings</u>: obscured by color banding, but at least 4 indistinct rings. (Specimen elliptical, 11 by 16 mm.)

<u>Vessels</u>: typically diffuse porous; pores solitary and in radial chains or multiples of 2 to 7 cells; majority of pores average 42 mu. in diameter; occasional pores, usually in chains, average 21 mu. in diameter; all gradations between extremes found; pores essentially circular except for radial flattening along line of contact in the multiples, more than 200 per square mm.; thick-walled tyloses abundant; vessel member length not determined due to obscuring effect of tyloses: perforations simple; plates inclined about 45 degrees from the horizontal: intervascular pitting alternate, fine, border outline elliptical, longer axis 3.5 mu.; inner apertures included, lenticular, and oriented essentially horizontally: vessel to ray pitting fine, simple or very narrowly half-bordered, outline elliptical with longer axis averaging 4 mu., but with considerable variation in size; tendency for horizontal orientation; about 10 pits per cross-field.

<u>Wood parenchyma</u>: paratracheal, fairly abundant, in strands of 3 or 4 cells which are 5 or more times as long as wide; end cells of strands tapering and with tips rounded: pits to vessels apparently half-bordered;

border outline long elliptical with longer axis varying from 4 to 6.5 mu.; apertures on vessel side of pit-pair lenticular to slit-like, included, and horizontally oriented: parenchyma also diffuse in long vertical multiseriate strands of large, irregularly shaped cells, all with dark content, very suggestive of pith flecks.

Rays: heterogeneous, uniseriate or very rarely biseriate in part; marginal cells usually upright, occasional tier or tiers of upright or square cells in interior of rays; the rest of the cells procumbent: height of rays 5 to 22 cells, averaging 10, maximum 840 mu.; maximum width 13 mu.; about 18 rays per mm. as measured on the tangential surface.

Fibers: rather thick-walled (3.2 mu.), lumen small; diameter 8 mu.; length not determined; pitting not observable.

Pith:

Rather large (3 mm. in diameter), more or less circular, of isodiametric parenchyma cells without intercellular spaces.

Other tissues:

Absent in specimen.

Type specimen and slides: No. B-3279.

Discussion:

This specimen definitely belongs in the Rutaceae. Examination of the fossil record of members of this family suggested the genus Fagara L. Comparing the specimen with a prepared slide of Fagara monophylla Lam., the similarity was astounding in every detail. Even the macroscopic appearance of the specimen is strikingly similar to a small branch of this species.

The specific epithet of the specimen is suggestive of the extremely close relationship to the modern species of Fagara mentioned above. It was deemed advisable not to use this species name since it is frequently impossible to differentiate species of a given genus by wood anatomy alone.

Fossil and modern range of the genus:

Fagara is well represented in the fossil record in the United States, but apparently it is confined entirely to the Eocene. The geographic range of the compressions is widely scattered, due, no doubt, to the limits of the genus itself. Linnaeus and Engler recognize Fagara as a genus distinct from Zanthoxylum, while many other authors group both genera under under Zanthoxylum. The latter genus also is widely known in the fossil condition. Those identified as belonging to Fagara L. have been collected from Florida, Kentucky, Tennessee, Mississippi, Texas, Colorado, Wyoming, and California. It has also been found in the West Indies and Mexico. Berry (1916) describes 3 species from the Wilcox flora, all of which are substantiated in his revision (1930). The same author (1924) describes 2 species from the Claiborne flora and 4 from the Jackson flora. Later one species was identified by Berry (1930b) from the Wind River Basin of Wyoming which is of Green River age. It has not been described from the Green River flora itself. One species has been identified by Berry (1938) from Argentina.

The fossil wood of Fagara has not previously been reported but there are several known members of the family Rutaceae. Several species of Evodioxylon Chiarugi have been described; one by Hofmann (1952) from the upper Oligocene of Austria, and another by Boureau (1950) from the Oligocene of Libya.

The living members of the genus are pantropical in distribution. In the United States, it is only found in southern Florida.

Root of Fagara monophylloides Kruse, sp. nov.

Secondary xylem:

Growth rings: obscured by color banding, but at least 7 more or less distinct rings present; the last two clearly defined. (Specimen considerably flattened, 43 by 22 mm.)

Vessels: typically diffuse porous; pores solitary and in radial chains or multiples of 2 to 9, averaging

7 cells; chains of large and small cells intermixed; diameter of pores variable, 56 mu. down to 21 mu., with majority at either extreme, but with all gradations; larger pores essentially circular, smaller pores, when in multiples, radially flattened; thick-walled tyloses abundant in all vessels; about 150 pores per square mm., larger pores slightly more numerous at beginning of growth ring; vessel member length averaging 150 mu.: intervascular pitting alternate, fine, border outline slightly elliptical with longer axis 4 mu.; inner apertures included, lenticular, and oriented essentially horizontally: vessel to ray pitting fine, simple or very narrowly half-bordered; outline elliptical with considerable variation in size, average longer axis 3.2 mu.; no orientation; 8 or 9 pit pairs per cross-field.

Wood parenchyma: paratrachial, fairly abundant, cells greatly elongated vertically, in strands of 5 to 7 cells, end cells of strands tapering with tips rounded: pits to vessels apparently half-bordered; what appears to be border outline lenticular with longest axis varying from 4 to 8 mu.; inner apertures on vessel side included, lenticular, and oriented horizontally.

Rays: heterogeneous, uniseriate, marginal cells usually upright; occasional tier or tiers of square or upright cells in interior of rays; rest of cells procumbent: height of rays 5 to 14, averaging 8 cells, maximum 300 mu.; maximum width 14.5 mu.; about 12 rays per mm. as measured on the tangential surface.

Fibers: fairly thin-walled (1.5 mu.), diameter 8 mu.; pitting not observable.

Pith:

Absent, though center is preserved.

Other tissues:

Absent in specimen.

Specimen and slides: No. B-2864.

Discussion:

In spite of minor differences in size of various elements, there appears to be no doubt that this specimen belongs with the stem described above. The thin walls in the wood fibers of the root, as compared with the stem, is to be expected on the basis of the comparative anatomy of these two organs. It will be noted that the pith is quite large in the stem, while in this specimen, it is entirely absent. Unfortunately, the primary xylem was not preserved, thus it is impossible to determine the position of the protoxylem.

Fagara biseriata Kruse, sp. nov.

Secondary xylem:

Growth rings: fairly distinct, 5 present in specimen. (Diameter of specimen 36 mm.)

Vessels: diffuse porous with slight tendency to diminution in size of pores during growth period; pores solitary and in radial chains of 2 to 8 or 9 cells; diameter of pores extremely variable, 77 mu. in early wood, 50 mu. in late wood, many small pores only 8 mu.; majority at the extremes but all gradations are found; pores circular or slightly elongated radially, walls fairly thick (3.5 mu.), 60 to 100 per square mm.; thin-walled tyloses abundant in the larger vessels; members of larger vessels averaging 260 mu. in length, smaller vessels up to 370 mu. with long tails extending considerable distance beyond perforation: perforations simple; plates nearly horizontal with a wide rim in the largest vessels and a gradual transition to very steeply inclined in the smallest vessels: intervascular pitting alternate, very fine, crowded but not touching; pit borders of larger vessels elliptical, 3.6 by 2.4 mu., of the smaller circular, 3.2 mu. in diameter; apertures slit-like, included, and nearly as long as the border; orientation horizontal in the larger vessels, nearly vertical in the smallest, all gradations in intermediate-sized vessels: Vessel to ray pitting not observed.

Wood parenchyma: paratracheal, very sparse, occasional strands of 4 or 5 cells adjoining a few of the vessels.

Rays: heterogeneous, mostly biseriate with uniseriate margins of 1 to 3 cells and occasional single cells in interior of rays; rarely triseriate in part; marginals square or slightly upright, interior cells procumbent; occasional low uniseriate rays: all cells fairly thick-walled (2 mu.): height 6 to 33 cells, averaging 20, maximum 560 mu.; maximum width 27 mu.; about 16 rays per mm. as measured on the tangential surface.

Fibers: moderately thick-walled (3 mu.), 8 mu. in diameter and 450 mu. in length: pitting not observed.

Pith:

Small, circular, of large parenchyma cells all with dark content.

Primary xylem:

Narrow band preserved; protoxylem not distinguishable.

Other tissues:

Absent in specimen.

Type specimen and slides: No. B-2819.

Discussion:

The microscopic examination of a transverse section of this specimen showed a decided similarity to the species of Fagara previously described. The pore arrangement is identical and both show a large variation in size of the vessels. This specimen, it will be noted, exhibits two types of intervascular pitting while Fagara monophylloides shows only one type; however, pitting was observable in only the largest vessels of the previously described species and thus unknown in the smaller vessels. The only significant difference is in the width of the rays - almost entirely uniseriate in F. monophylloides, mostly biseriate in this specimen. Slight differences in the various elements are to be expected, since this fossil is larger than the former species.

The biseriate character of the rays suggested the specific name.

Simarubaceae[5]

Suriana L.

S. maritima L., the only species in the genus, is a shrub or small tree of infrequent occurrence along the seacoast throughout the tropics.

Pores small to minute, rather numerous, solitary and, more often in multiples of 2 to 8; perforations simple; intervascular pitting very fine. Rays uniserate or locally biseriate; mostly only a few cells high,

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5 Record and Hess (1943) place Suriana in a separate family, the Surianaceae, Metcalfe and Chalk (1950), however, feel that on the basis of wood structure, there is no need to separate it from the Simarubaceae.

but occasionally vertically fused; decidedly heterogeneous, nearly all of the cells being square or upright; gum abundant; pits to vessels very small. Parenchyma narrowly vasicentric and diffuse. Fibers rather thick-walled; pits very small, simple or indistinctly bordered. Ripple marks present; all elements storied, though fused rays may occupy 2 to 5 tiers.

Suriana inordinata Kruse, sp. nov.

Secondary xylem:

Growth rings: very indistinct or possibly absent. (Diameter of specimen 20 mm.)

Vessels: typically diffuse porous; pores solitary and in chains or radial multiples of 2 to 11 or 12 cells, very rarely in small clusters, all more or less of same size, averaging 35 mu. in diameter; solitary pores slightly elongated radially, those in chains radially flattened along line of contact; about 140 pores per square mm.; average length of vessel members 175 mu.; tyloses apparently absent: perforations simple with a wide rim; plates inclined about 45 degrees from the horizontal: intervascular pitting alternate, rather crowded, very fine, about 3 mu. in diameter, outline circular or slightly elongated horizontally; about 12 pits per cross-field.

Wood parenchyma: very sparingly paratracheal, in short strands.

Rays: heterogeneous, entirely uniseriate; most of cells square, occasional tiers of slightly upright or slightly procumbent cells; cell walls thickened in corners as seen in radial section, making lumen appear circular: height 3 to 13 cells, averaging 6 or 7 cells, 70 to 300 mu.; maximum width 15 mu.; about 20 rays per mm. as measured on the tangential surface.

Fibers: fairly thin-walled (2 mu.), average diameter 7 mu., length approximately 230 mu.: pitting not observed.

Pith:

Relatively small, roughly circular, of rounded, large (35 mu. in diameter) parenchyma cells which are more or less disconnected.

Primary xylem:

A few cells remaining next to pith; protoxylem not distinguishable.

Vascular cambium:

Cambial zone only one cell in width.

Phloem:

About one half of very thick-walled fibers and one half of sieve tubes with a tendency for the two tissues to alternate in concentric, but discontinuous bands.

Other tissues:

Absent in specimen.

Type specimen and slides: No. B-2868. Other material examined: specimen and slides, No. B-2809.

Discussion:

Wood of *Suriana maritima* L. was compared with the fossil. The radial sections were remarkably similar, i.e., both showed a preponderance of square cells in the rays with walls thickened in the corners. Other sections showed a few differences as follows:

1. Ripple marks are indistinctly defined in the modern wood, but definitely absent in the specimen.
2. Wood fiber walls are thinner in the specimen than they are in the modern wood.

Ripple marks are not of much diagnostic value, especially when all other characteristics fit very closely. Perhaps, they are the result of environment and would thus, not be present consistently throughout even such a small group as a species. Fiber wall thickness can vary considerably within a genus.

The specific epithet suggests the lack of storied structure which is present in the only modern species of *Suriana*.

Fossil and modern range of the genus:

As far as it could be ascertained, *Suriana* has not previously been reported from the fossil record either as wood or as a compression. The Simarubaceae, however, have a few representatives, the most important of which is Ailanthus Desf. Compressions of this genus have been found from the Eocene and Miocene of western North America and from the Oligocene and Miocene of Europe. Hu and Chaney (1940) describe one species from the Miocene of China. Berry (1916) describes a species of Simaruba DC. from the Wilcox flora and later in his revision (1930) sets up a new genus Simarubites under which he describes one species.

Platen (1908) describes two species of fossil wood belonging to this family from the Tertiary of Nevada County, California, both of which he assigns to a new genus, Simarubinium. In both cases the diagnosis is brief and illustrations are lacking.

At the present, Suriana is pantropical in distribution, usually occurring along sea coasts. In the United States, one species is found in southern Florida.

Euphorbiaceae

Heveoxylon microporosum Kruse, gen. et sp. nov.

Secondary xylem:

Growth rings: very indistinct or possibly absent. (Diameter of specimen 31 mm.)

Vessels: typically diffuse porous; pores solitary and in radial multiples of 2 to 9 cells, rarely in small clusters, extremely variable in size from

100 mu. down to 20 mu. in diameter (smaller pores are probably elongated tips of vessel members); solitary pores circular, those in multiples flattened along line of contact, 30 to nearly 100 per square mm. with considerable variation in different parts of the section; moderately thick-walled tyloses abundant; vessel member length variable 265 to 575 mu.: perforations simple; plates steeply inclined from the horizontal: intervascular pitting alternate, fine, detail not preserved: vessel to ray pitting fine, simple or very narrowly half-bordered; outline circular to occasionally elliptical; circular pits average 6 mu. in diameter, elliptical pits 5.6 by 12 mu. with longer axis horizontal; 6 to 10 pits per cross-field, appearing sieve-like.

Wood parenchyma: sparingly paratracheal, in long vertical strands, cells considerably elongated vertically; also metatracheal, in irregular multiseriate bands.

Rays: strikingly heterogeneous; all rays both uniseriate and biseriate, with alternation from one-celled to two-celled condition as many as 9 times in a given ray; marginal cells very long-pointed as seen in tangential section; uniseriate parts of rays and margins of rays of large upright or square cells, biseriate parts of small procumbent cells which are greatly elongated radially and greatly flattened vertically; many of larger cells rounded as seen in radial section: height of rays 10 to over 40 cells, averaging 15 to 20, some over 1 mm. high, mostly less; maximum width 27 mu. About 10 rays per mm. as measured on the tangential surface.

Fibers: fairly thick-walled (3.5 to 4.0 mm.); average diameter 16 mu.; length not determined: pitting not observed.

Pith:

Relatively large (3 mm. in diameter), pentagonal, center of round to hexagonal cells all with dark content; rest of pith mostly of elongated cells as seen in transverse section; no intercellular spaces.

Phloem:

In numerous concentric, but interrupted bands, alternating with periderm; sieve tubes greatly elongated vertically and considerably twisted; sieve plates not observed; parenchyma in diffuse strands, very sparse; phloem rays less heterogeneous than xylem rays.

Periderm:

In numerous concentric, interrupted bands, alternating with phloem; cellular detail not preserved: numerous vertical ducts, circular to somewhat tangentially elongated, averaging 90 mu. in diameter.

Other tissues:

Absent in specimen.

Type specimen and slides: No. B-2791.

Discussion:

Slides of several modern species of Hevea Aubl. all show one prominent feature in common with the fossil - extreme heterogeneity of the rays with a marked alternation from a uniseriate to a biseriate condition as viewed on the tangential surface. Furthermore, one species - H. microphylla Ule - not only shows this type of ray but has all other characteristics in common with the fossil except the size of the pores. The pores are larger in the modern wood, but this is to be expected since the modern slide is from mature wood, while the slide of the fossil was made from a very young stem.

On the basis of Record's (1938) description of the wood of Hevea, it is difficult to justify the inclusion of this specimen in this genus because of the following significant differences:

Generic description	Fossil
1. Pores mostly large.	1. Pores medium-sized (less than 100 mu.)
2. Rays less than 30 cells high.	2. Rays sometimes over 40 cells high.
3. Intervascular pitting rather large.	3. Intervascular pitting fine.
4. Wood parenchyma abundant, reticulare and in irregular narrow bands.	4. Wood parenchyma sparingly paratracheal, also metatracheal in irregular bands.

Generic description	Fossil
5. Wood fibers with thin walls.	5. Wood fibers with fairly thick walls.

In spite of these differences, the fossil is remarkably similar to H. microphylla. Perhaps, this species was not examined when the generic description was prepared or it should be reexamined for the possible inclusion in another genus. Nevertheless, it is with considerable confidence that this specimen is placed in the Euphorbiaceae and the subfamily Crotonoideae on the basis of ray characteristics alone. Unfortunately, it was impossible to compare other tissues, such as pith, phloem, and periderm.

The generic name suggests the affinity to the one species of Hevea - H. microphylla - and the specific name refers to the small pores of the specimen in comparison with the genus in general.

Fossil and modern range of the genus:

No fossil reference to the genus Hevea was found in the literature from either North or South America; in fact, the record of the family Euphorbiaceae is very scanty. Most of the fossil occurrences in North America are from the upper Cretaceous and Eocene with the family practically unreported, particularly in the western part of the continent, after the Eocene. No member of the family has previously been reported from the Green River flora. Berry (1916),however, from the Wilcox flora, describes two species of Drypetes Vahl, two species of _Crotonophyllum_ Velen., and one species of _Euphorbiophyllum_ Ettingshausen. Later (1930) he adds one species of _Manihot_ Adamson.

Felix (1887) describes from the Tertiary of Columbia the only fossil wood that could be found that is directly referable to the Euphorbiaceae. The new generic and specific name given by him is _Euphorbioxylon speciosum_.

Considering the similarity in leaf form and structure of _Hevea_ and _Ficus_ L., and the many reports of the latter genus in the compression floras, it appears quite possible that at least some of the fossil plants referred to _Ficus_ might belong to _Hevea_.

Hevea is now confined to northern South America, ranging from the Amazon Basin northward to Venezuela and the Guianas.

Sapindales

Anacardiaceae

Schinoxylon actinoporosum Kruse, gen. et sp. nov.

Secondary xylem:

Growth rings: inner rings indistinct; outer rings fairly clearly marked. (diameter of specimen 28 mm.)

Vessels: diffuse porous, but with a tendency for the larger pores to be more numerous at beginning of growth ring, at least in the later rings; vessels of two kinds: (a) vessels of all sizes with members averaging about 100 mu. in length and with essentially horizontal end walls (they frequently show a tangential shift in the vertical alignment of the vessel members, in which case the laterally connected members have long and somewhat rounded tails extending beyond the perforations); (b) very small tracheid-like vessels with members averaging over 300 mu. in length and with very long steeply inclined end walls (at least three simple perforations were observed in the radial section, indicating that these cells are vessels and not tracheids); larger pores mostly solitary, sometimes in radial multiples of 2 to 4 cells; medium sized and smaller pores occasionally solitary, but mostly in radial chains or multiples of up to 25 cells; rarely clusters are found of all sizes; pores quite variable in size from 70 mu. down to 15 mu., essentially circular except for flattening along line of contact when in multiples, about 100 per square mm.: moderately thick-walled tyloses abundant in the larger vessels: fine, but distinct, spiral thickenings on the vessels of type (a): perforations simple: intervascular pitting of vessels of type (a) alternate, fine, border outline circular or slightly oval, diameter 4 mu., inner apertures slit-like, included and without definite orientation; of type (b) alternate, fine, border outline circular, diameter 5 mu., inner aperture slit-like, included, and oriented half way between vertical and horizontal, outer aperture very small, circular. Vessel to ray pitting fine, simple, circular to elliptical, 4 to 5 mu. in longest dimensions; about 8 pits per cross-field.

Wood parenchyma: apparently absent.

Rays: heterogeneous; uniseriate entirely or uniseriate and biseriate in part; marginal cells upright in radial section and long pointed in tangential section; interspersed tiers of upright or square cells in interior of only the high cells; other cells procumbent: height of rays 7 to 20 cells, averaging 13, 100 to 330 mu.; maximum width 20 mu.: about 15 rays per mm. as measured on the tangential surface.

Fibers: rather thin-walled; average diameter 8 mu.; length not determined; pitting not observed.

Gum ducts: radial, numerous, elongated vertically, variable in size from 30 by 75 mu. to 90 by 280 mu.; rays containing ducts considerably enlarged.

Pith:

Small, circular or somewhat oval, of nearly round parenchyma cells without intercellular spaces.

Bark:

Cellular detail lacking, but it (probably periderm) contains numerous oval, tangentially elongated vertical ducts, averaging about 40 by 80 mu.

Other tissues: absent or indiscernible.

Type specimen and slides: No. B-2818. Other material examined: specimen and slides, No. B-2822.

Discussion:

After this and the following specimen were tentatively assigned to the Anacardiaceae, the material was sent to Miss Jeannette Kryn of the University of Michigan for confirmation. In a personal communication, Miss Kryn lists the following as the most characteristic features of the family:

"(1) Large to moderately large, solitary pores or multiples of two or three.

(2) Large intervascular pit pairs.

(3) Very large, horizontally elongated or gash-like, half-bordered vessel to ray pit pairs."

It is the feeling of Miss Kryn and the author that size of the elements can be discounted on the grounds that the specimens are very young stems in comparison with the mature wood of the modern material. The presence of horizontally elongated or gash-like ray to vessel pit pairs in the fossils substantiated the diagnosis that the material was correctly placed in the Anacardiaceae, especially since radial gum ducts are so prominent in the rays.

It was suggested by Miss Kryn that this specimen is similar in all respects to Schinus L. except for the arrangement of the pores as seen in transverse section; in Schinus they form an ulmiform pattern, while here they are definitely radially arranged. Since the specimen differs from Schinus in only this one characteristic and it surely belongs to the Anacardiaceae, although not exactly matching a modern genus, its affinity is suggested by the generic name. The specific epithet indicates the radial arrangement of the pores in contrast to the modern species of Schinus.

Fossil and modern range of the genus:

Schinus, which is very similar to the specimen under consideration, has not been reported in the fossil condition from North America. The only reference seen was by Berry (1938) of one species from the Tertiary of Argentina. The Anacardiaceae, however, is well represented as compressions from the upper Cretaceous to the present throughout the world. The most abundant representattives belong to the genera Rhus L, Pistacia L., and the form genus Anacardites Saporta. A few of the reported occurrences of members of the family are as follows:

1. Lesquereux (1883) from the Green River flora, 8 species of Rhus.
2. Brown (1934) from the Green River flora, one species of Anacardites.
3. Berry (1916) from Wilcox flora, one species of Heterocalyx Saporta, one species of Metopium P. Browne, and 7 species of Anacardites. Metopium, however, was removed from the list in his revision of 1930.

4. Dorf (1942) from the Medicine Bow Formation, one species of Pistacia.
5. Hu and Chaney (1940), from the Miocene of Shantung Province, China, one species of Pistacia and one of Rhus.

Only two genera of anacardiaceous fossil woods have been previously described:

1. Anacardioxylon Felix (1882)
   - A. spondiaeformis Felix (1882 from the Tertiary of Antigua.
   - A. uniradiatum Felix (1894) from the Eocene of
   - A. magniporosum Platen (1908) from the Tertiary of California.
2. Rhoidium Unger (1850)
   One species was originally described by Unger from the Tertiary of Hungary; later, two more species were described by other authors; one from the Cretaceous of Russia and the other from the Tertiary of the Philippines.

Although one species of Schinus is cultivated in southern California, the genus is now native to South America, the Hawaian Islands, and St. Helena.

Edenoxylon parviareolatum Kruse, gen. et sp. nov.

Secondary xylem:

Growth rings: apparently absent, although 3 concentric color rings are present. (Diameter of specimen 37 mm.)

Vessels: typically diffuse porous; pores solitary and in radial chains of 2 or 3 cells, occasionally in chains of up to 9 cells made up of small pores, essentially circular, majority averaging 50 mu. in diameter, a few in the longer chains 20 to 35 mu. in diameter, about 100 per square mm.; fairly thick-walled tyloses abundant; vessel members variable in length from 100 to 300 mu.: perforations simple; plates nearly horizontal to an inclination of about 45 degrees from the horizontal: intervascular pitting alternate, fine, border outline lenticular, 4 mu. in longest axis; inner apertures included, lenticular to slit-like, and extending almost to border outline; orientation horizontal: vessel to ray pitting fine to medium, simple, varying from round, about 4 mu. in diameter to long oval with longer axis about 8 mu.; occasionally pits are close enough to each other to give a reticulate pattern; no orientation of any pit-pairs.

Wood parenchyma: apparently absent.

Rays: heterogeneous; mostly uniseriate, rarely biseriate in part; in most cases marginal tier of cells are upright with occasional interspersed tiers of square or upright cells in interior of larger rays; rest of cells procumbent: height of rays 2 or 3 up to 20 cells (70 to 450 mu.), averaging about 13 cells; maximum width 13 mu.: about 20 rays per mm. as measured on the tangential surface.

Fibers: fairly thin-walled (2.4 mu.); average diameter 10 mu.; length not determined but in excess of 0.5 mm. with long tapering ends; many septate with very thin nearly horizontal septa: pitting not observed.

Gum ducts: radial gum ducts fairly numerous within fusiform rays which become bi- or triseriate at top and bottom of duct with a single row of cells laterally; larger ducts 140 by 70 mu., smaller 63 by 28 mu.: epithelial cells not preserved.

Pith:

Relatively large, somewhat distorted by compression, but probably circular, of large, essentially hexagonal parenchyma, without intercellular spaces; more than half of cells filled with dark substance.

Phloem:

Consists of 4 or 5 narrow concentric bands separated by periderm (?); "living phloem" (closest to wood) very narrow: phloem bands themselves banded by concentric rings of dark cells, which are probably parenchyma cells, since they have the same appearance as the ray parenchyma: companion cells and fibers not observed.

Periderm:

Existence not definitely ascertained, but it possibly appears as narrow concentric rings alternating with phloem tissue (rhytidome structure?); region contains numerous circular or slightly oval vertical ducts averaging 12 mu. in diameter: cellular detail too poorly preserved for further description.

Other tissues:

Absent or not discernible.

Type specimen and slides: No. B-3280.

Discussion:

This specimen of a young stem and a root of the same thing were also examined by Miss Kryn and it was her conviction that they belonged to the Anacardiaceae, in spite of the fact that they could not be placed in any modern genus. It will be noted that two characteristic features of the family are present: (1) horizontally elongated or gash-like vessel to ray pitting, and (2) radial gum ducts in the rays. It is, without too much confidence, that this specimen is placed in the Anacardiaceae. A new genus name is proposed indicating the locality of occurrence - Eden Valley. The specific name is suggestive of the small intervascular pits which are not characteristic of the family as a whole.

Root of <u>Edenoxylon parviareolatum</u> Kruse

Secondary xylem:

<u>Growth rings</u>: very indistinct; possibly three in specimen. (Diameter of specimen 17 mm.)

<u>Vessels</u>: typically diffuse porous; pores solitary and in radial chains or multiples of 2 to 6 cells, occasionally in chains of up to 10 cells made up of very small pores, essentially circular except for flattening along line of contact, majority averaging about 65 mu. in diameter, a few in the longer chains about 20 mu. in diameter, 75 to 100 per square mm.; thick-walled tyloses in a few vessels; vessel members variable in length from 100 to 335 mu.: Perforations simple; plates nearly horizontal to an inclination of about 45 degrees from the horizontal: intervascular pitting alternate, fine, border outline elliptical, 4 mu. along longer axis; inner apertures included, lenticular to slit-like and extending almost to border; orientation horizontal: vessel to ray pitting not well preserved, but apparently similar to that of the stem; i.e., pits simple or possibly with a very narrow border on the vessel side of the pit-pairs.

<u>Wood parenchyma</u>: sparingly paratracheal, in long strands of cells which are 2 to 3 times as long as wide (in tangential section) and rather large, width

about 18 mu.; ends of strands somewhat pointed: pitting to vessels rather coarse and apparently half-bordered; outline greatly elongated horizontally and frequently nearly as long as the width of the parenchyma cell in tangential section.

Rays: heterogeneous; mostly uniseriate, rarely biseriate in part; in most cases marginal tiers of cells are upright with frequent interspersed tiers of square or upright cells in interior of larger rays; rest of cells procument, but not greatly elongated radially: height of rays 2 up to 15 cells (100 to 630 mu.), averaging 10 cells; maximum width 16 mu. About 16 rays per mm. as measured on the tangential surface.

Fibers: thin-walled (1.5 mu.); average diameter 10 mu.; length not determined; many septate with thin, nearly horizontal septa: pitting not observed.

Gum ducts: radial gum ducts very infrequent (only one observed) within fusiform ray, oval, vertically elongated, 65 by 32 mu.: epithelial cells not preserved.

Pith:

Absent

Phloem:

Phloem tissue quite broad and consisting almost entirely of vertically elongated sieve tubes which vary considerably in length; sieve plates not observed; rays cells mostly square or upright as viewed in radial section: region contains numerous, oval, tangentially elongated, vertical ducts arranged in 5 concentric bands with a tendency for the size to increase centrifically, the smaller averaging 70 by 120 mu., the larger roughly 100 by 280 mu.

Vascular cambium:

Region broken in specimen, but the zone is at least 4 cells in width; cells as seen in longitudinal sections 3 to 5 times as long as wide and with horizontal end walls.

Other tissues:

Absent or not discernible.

Specimen and slides: No. B-3278.

Discussion:

Under low magnification, there appears to be no difference between this specimen and the stem previously described except for the absence of a pith in this case. Under higher magnification, minor differences were noted as follows: (1) almost all elements are slightly smaller in the stem, and (2) wood parenchyma is absent in the stem while it is sparingly paratracheal in the root. These differences are to be expected on the basis of the comparative anatomy of these two organs. After all considerations, it is felt that these two specimens definitely belong to the same species of plant.

Contortae

Apocynaceae

<u>Aspidospermoxylon uniseriatum</u> Kruse, gen. et sp. nov.

Secondary xylem:

<u>Growth rings</u>: absent. (Specimen very irregular in outline, about 26 mm. in diameter.)

<u>Vessels</u>: typically diffuse porous; pores mostly solitary, occasionally in multiples of two, no definite arrangement, oval with longer axis radial, somewhat variable in size but mostly 84 to 140 mu. in diameter, number variable in different parts of specimen from 40 to 60 per square mm.; thin-walled tyloses in some vessels; vessel members 240 to 370 mu. in length: perforations simple; plates transverse or slightly oblique: intervascular pitting alternate, very small (4 mu.); apertures included, indistinct, but apparently slit-like and with horizontal orientation: ray to vessel pitting not observed: vessels as seen in longitudinal sections occupy more than 50 per cent of field.

<u>Wood parenchyma</u>: fairly abundant, paratracheal, in long strands of 9 or more cells. (Wound parenchyma also present.)

<u>Rays</u>: heterogeneous; mostly uniseriate, occasionally biseriate in part; cells in interior of rays mostly procumbent, but with occasional tiers of square or

slightly upright cells; marginals square or slightly upright; cells fairly thick-walled (2 mu.), many of the larger with a dark content: height variable 4 to 26 cells or 35 to 430 mu.; width averaging 17 mu.: about 12 rays per mm. as measured on the tangential surface.

Fibers: fairly thin-walled (2 mu.); average diameter 18 mu.; average length 300 mu. Pits bordered, very small, 4 mu. in diameter.

Gum ducts: radial, widely scattered, within fusiform rays, oval with longer axis vertical, about 150 by 60 mu. in tangential section.

Pith:

If present, not preserved.

Phloem:

Of sieve tubes and concentric bands of fibers; occasional oval, tangentially elongated, vertical ducts 55 by 70 mu.

Cortex:

Of parenchyma cells with scattered strands of fibers; oval, vertical, and tangentially elongated ducts 70 by 90 mu.

Other tissues:

Absent or not discernible.

Type specimen and slides: No. B-2866.

Discussion:

Poor preservation of this specimen made diagnosis difficult; however, the presence of radial gum ducts, uniseriate rays, and very fine intervascular pitting eliminated many families, reducing the possibilities to seven. Many modern representatives of these families were examined and it was found that the Apocynaceae gave the best fit in all characteristics. An outstanding feature of this specimen is the large area covered by the vessels as seen in both longitudinal sections. Only the genus Aspidosperma Mart. et Zucc. showed this character to any degree, being particularly evident in A. cruentum Woodson.

It is felt that the specimen belongs to the Apocynaceae, but does not fit any modern genus sufficiently close to be included in any of them. The similarity to Aspidosperma is suggested in the genus name and the species name indicates the uniseriate condition of rays of the fossil which was not found in any samples of modern species.

Fossil and modern range of the genus:

Only one reference was found of the occurrence of Aspidosperma in the fossil condition - one species of a compression described by Hollick (1924) from Porto Rico. Furthermore, no descriptions of fossil woods were found that could be referred to the Apocynaceae. There are, however, a few members of the family which have been reported from the

New World as follows:

1. Berry (1916) from the Wilcox flora, 5 species of Apocynophyllum Unger and one species of Echitonium Unger. In his revision of the flora Berry (1930) describes 6 species and 1 variety of Apocynophyllum, 4 species and 1 variety being new.
2. Berry (1924) from the Claiborne describes 2 species of Apocyno phyllum and from the Jackson, 2 more of the same genus.
3. Brown (1934) in his revision of the Green River flora refers a species originally assigned by Knowlton (1923) to Salix to the genus Apocynophyllum.
4. Brown (1929) from the Green River flora describes a species of his new genus Apocynospermum.
5. Berry (1938) from the Tertiary of Argentina describes one species each of Allamanda L., Plumiera L., Echites L., and Landolphia Pal. Beauv.

Aspidosperma is now native to tropical America with the highest concentration of species in Brazil. Its range does not extend into the United States.

Incertae Sedis

Unknown Dicotyledon

Secondary xylem:

Growth rings: absent. (This specimen shows wounding in the early stages of growth with a subsequent development of a considerable amount of parenchyma; diameter of specimen 12 mm.)

Vessels: typically diffuse porous; pores in definite radial alignment, mostly in chains or multiples of 2 to 4 cells, occasionally up to 10 cells, a few pores solitary, mostly about 100 mu. in diameter, those in long multiples sometimes only 35 mu. in diameter, circular or slightly elongated radially, about 38 per square mm.: tyloses abundant; average vessel member length 370 mu.: perforations scalariform with up to 16 bars; plates inclined about 45 degrees from the horizontal: intervascular pitting scalariform to occasionally reticulate; bars narrow, about 8 mu. apart, and about one fifth as wide as the spaces between them: vessel to ray pitting not observed.

Wood parenchyma: paratracheal, abundant, in long vertical strands; pitting simple, elliptical, about 5 by 8 mu. with longer axis horizontal.

Rays: heterogeneous; most cells procumbent but not greatly elongated radially, some square, a few slightly upright, size extremely variable in all types; all cells somewhat elongated vertically as seen on the tangential surface: width 3 to 5 cells, mostly 5, averaging 56 mu.; extremely high, in excess of 700 or 800 cells or more than 8.5 mm. which is the length of the slide: about 5 rays per mm. as measured on the tangential surface.

Fibers: moderately thick-walled (4 mu.); average diameter 15 mu.; length not determined: pitting not observed.

Pith:

Slightly oval, about 1 mm. in diameter; cellular detail not preserved.

Primary xylem:

Narrow band containing spiral elements and parenchyma of two kinds: (1) strands of vertically elongated cells, and (2) multiseriate strands of essentially isodiametric cells, all with dark content (wound parenchyma?): position of protoxylem not determined.

Phloem:

Rather wide zone, about 50% of which is made up of numerous, large, roughly circular (as seen in transverse section) areas of very thick-walled sclerenchyma which are arranged in three concentric bands: the inner two circles of sclerenchyma bundles consist of a central core of relatively short (175 mu.) fiber-like cells surrounded by a sheath of large, irregularly shaped, but essentially isodiametric cells, the entire forming long vertical cylinders: the outer zone of sclerenchyma bundles (possibly in periderm) are made up entirely of essentially isodiametric cells forming more or less spherical groups: detail of sieve tubes not discernible.

Other tissues:

Absent or not discernible.

Specimen and slides: No. B-2814.

Discussion:

It may seem peculiar that this specimen which is fairly well preserved and exhibits several outstanding characteristics, such as scalariform perforations, scalariform intervascular pitting, extremely high rays, and prominent sclerotic bundles in the secondary phloem, could not be placed in at least a single family. On the basis of wood anatomy alone it could be placed with equal confidence in 16 families. Examination of the available literature pertaining to these families and many more failed to show anything similar to the sclerotic bundles so evident in the specimen. Many slides of modern woods were used for comparison, but none were found which had very high rays, let alone the phloem bundles.

Until more information is available on stem structure, it is deemed advisable not to attempt a name for this specimen.

Summary

This study is concerned with the description and identification of a number of silicified dicotyledonous woods from the Green River Formation (upper Lower Eocene) of the Eden Valley in southwestern Wyoming. Twelve specimens are described, eleven of which are identified. All of the species and six of the genera are new. The following is a systematic list of the species:

MYRICALES

Myricaceae

Myrica scalariformis Kruse, sp. nov.

RANALES

Magnoliaceae

Talauma multiperforata Kruse, sp. nov.

RHOEADALES

Capparidaceae

Forchhammerioxylon scleroticum Kruse, gen. et sp. nov.

GERANIALES

Rutaceae

Amyridoxylon ordinatum Kruse, gen. et sp. nov.

Fagara monophylloides Kruse, sp. nov.

F. biseriata Kruse, sp. nov.

Simarubaceae (Surianaceae)

Suriana inordinata Kruse, sp. nov.

Euphorbiaceae

Heveoxylon microporosum Kruse, gen. et sp. nov.

SAPINDALES

Anacardiaceae

Schinoxylon actinoporosum Kruse, gen. et sp. nov.

Edenoxylon parviareolatum Kruse, gen. et sp. nov.

CONTORTAE

Apocynaceae

Aspidospermoxylon uniseriatum Kruse, gen. et sp. nov.

Incertae sedis

Unknown dicotyledon.

Since the inception of this study many additional wood specimens from Eden Valley have been added to the Paleobotanical Collection of the University of Cincinnati. The majority appear to be dicotyledons, but the collection contains at least four species of monocotyledons which are probably referable to the genus *Palmoxylon* Schenk. In addition there are about a dozen specimens of fern petioles which have previously been identified as *Eorhachis lomarioides* Arnold. Gymnosperms are entirely lacking. Until more specimens are identified, paleoecological considerations await later papers.

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Fig. 1. Myrica scalariformis Kruse.
Transverse section. (x 120)

Fig. 2. Myrica scalariformis Kruse.
Tangental section. (x 120)

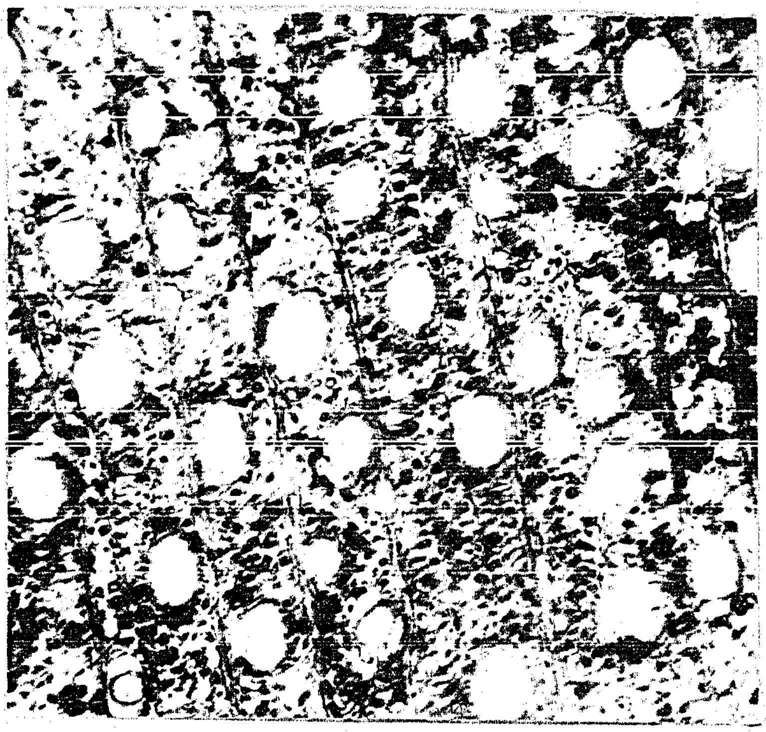

Fig. 1

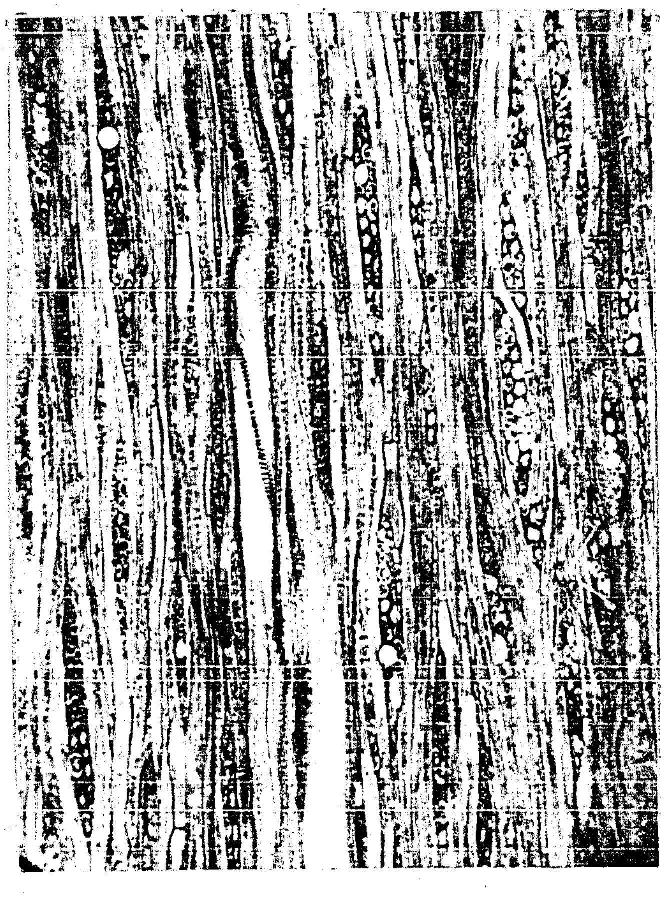

Fig. 2

Fig. 3. Myrica scalariformis Kruse.
Radial section. (x 120)

Fig. 4. Talauma multiperforata Kruse.
Transverse section. (x 120)

Fig. 3

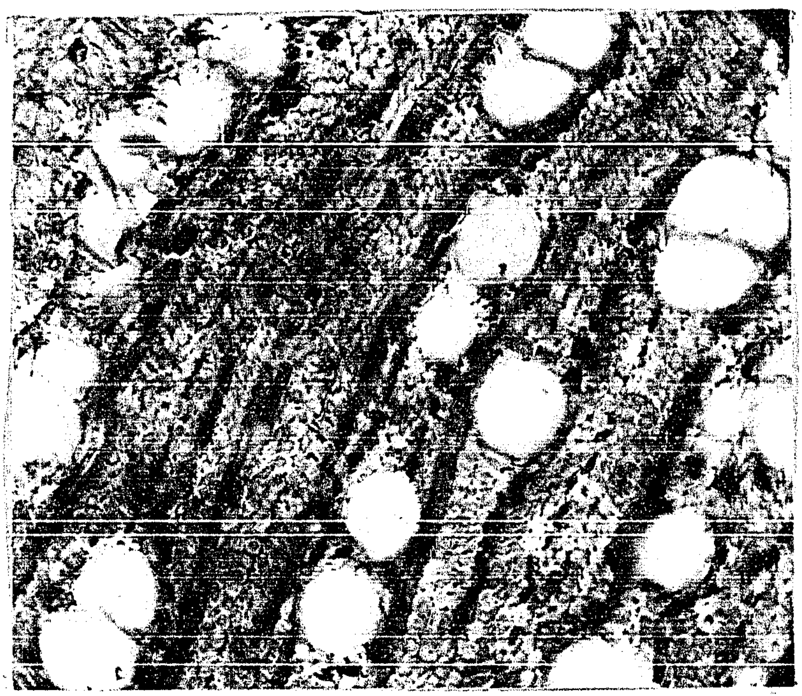

Fig. 4

Fig. 5. *Talauma multiperforata* Kruse.
Tangential section. (x 120)

Fig. 6. *Talauma multiperforata* Kruse
Radial section. (x 120)

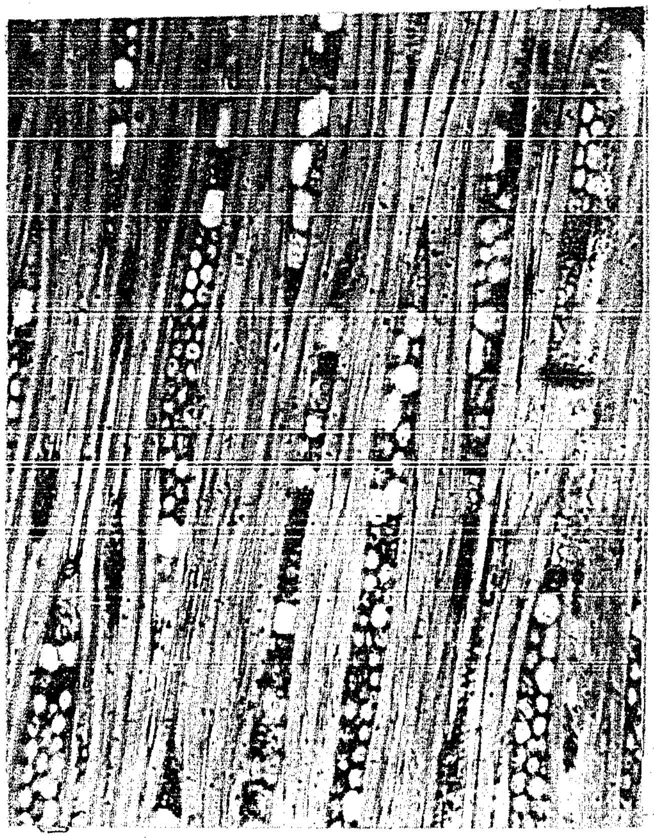

Fig. 5

Fig. 6

Fig. 7. Forchhammerioxylon scleroticum Kruse.
Transverse section. (x 48)

Fig. 8. Forchhammerioxylon scleroticum Kruse.
Tangential section. (x 48)

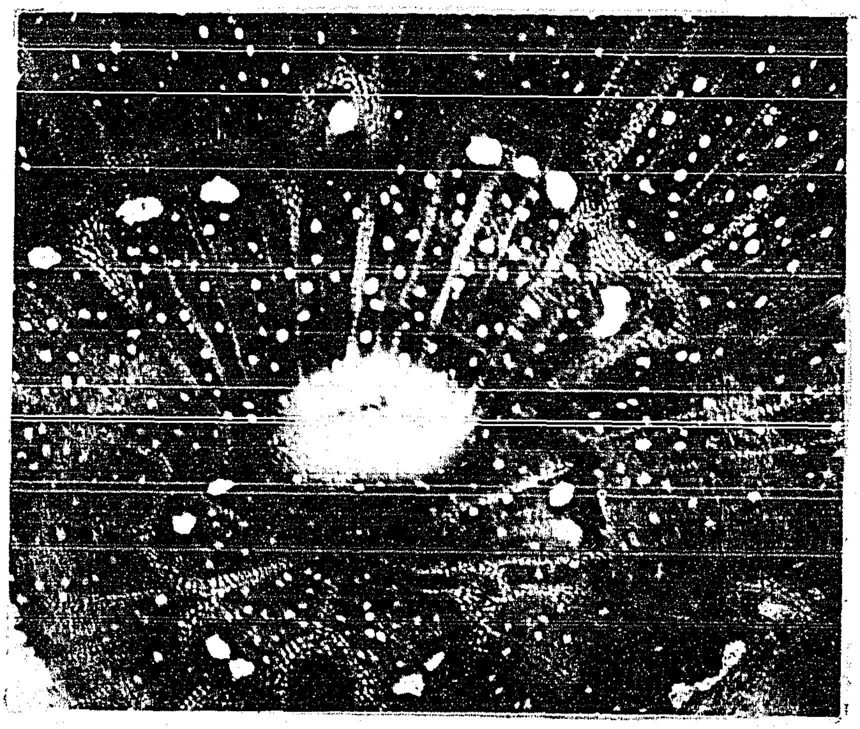

Fig. 7

Fig. 8

Fig. 9. _Amyridoxylon ordinatum_ Kruse.
Transverse section. (x 120)

Fig. 10. _Amyridoxylon ordinatum_ Kruse.
Tangential section. (x 120)

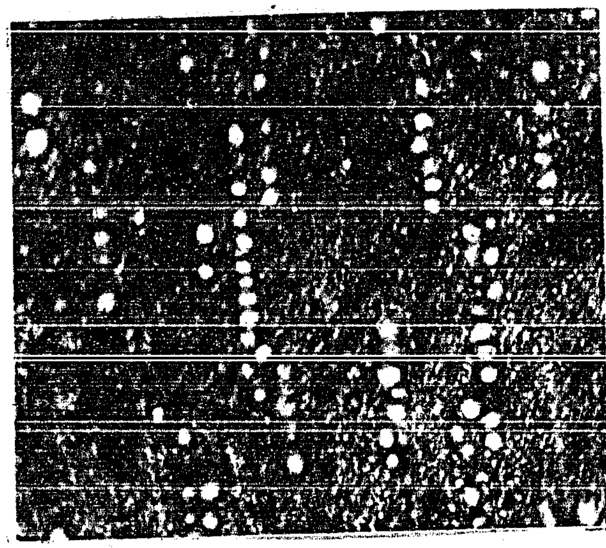

Fig. 9

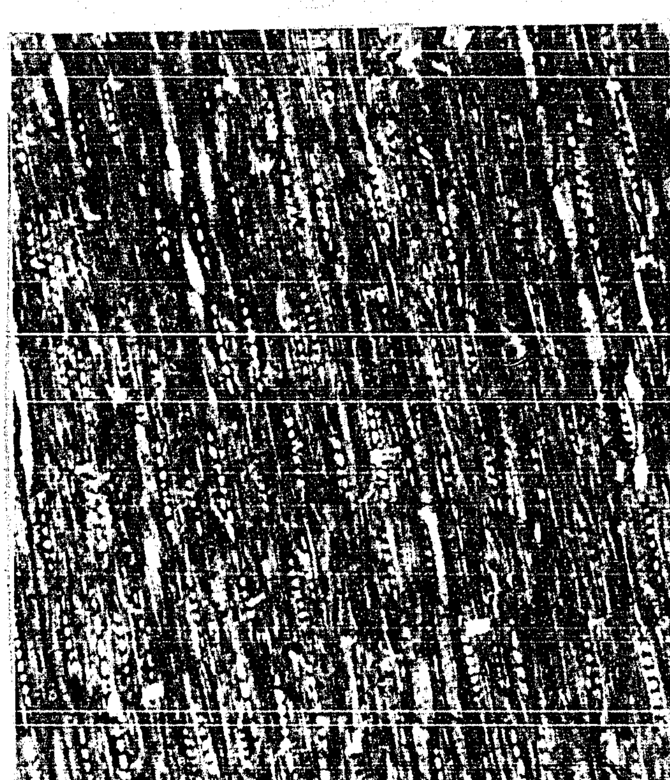

Fig. 10

Fig. 11. Amyridoxylon ordinatum Kruse.
Radial section (x 120)

Fig. 12. Fagara monophylloides Kruse.
Transverse section (x 120)

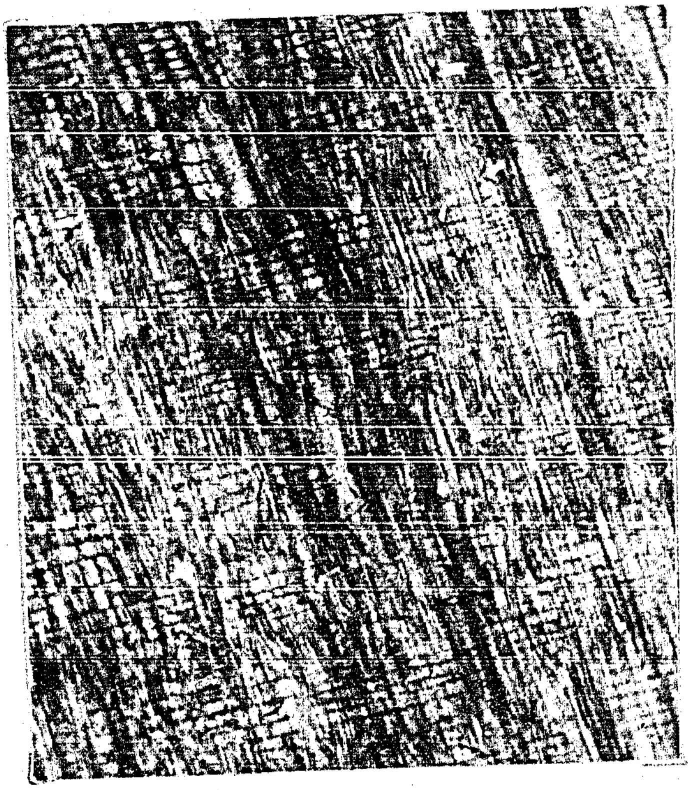

Fig. 11

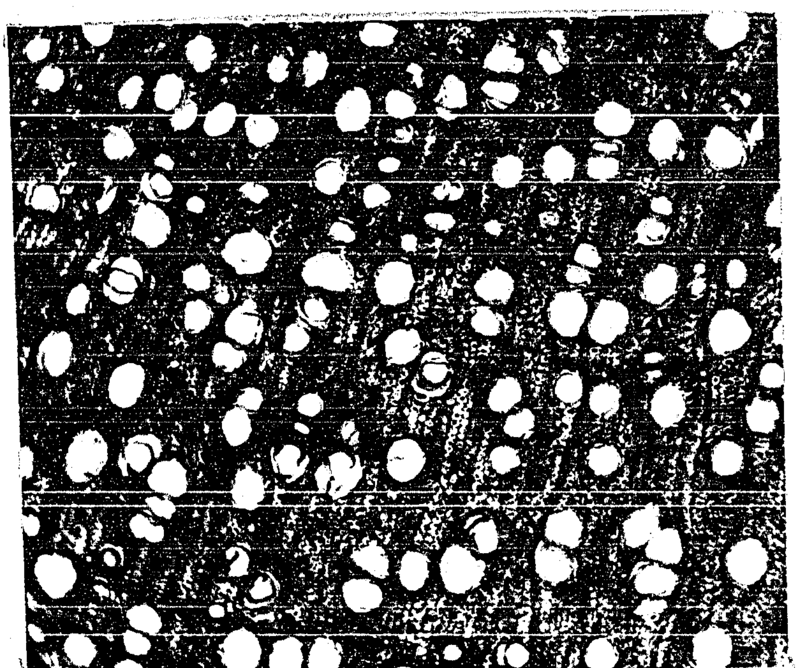

Fig. 12

Fig. 13. *Fagara monophylloides* Kruse.
Tangential section. (x 120)

Fig. 14. *Fagara monophylloides* Kruse.
Radial section. (x 120)

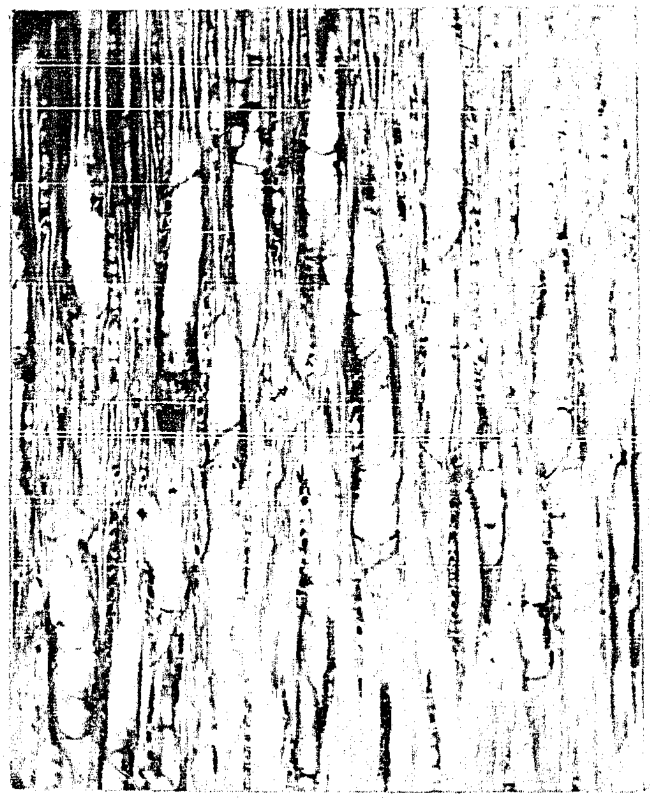

Fig. 13

Fig. 14

Fig. 15. _Fagara_ _monophylloides_ Kruse. Root. _Transverse section._ (x 120)

Fig. 16. _Fagara_ _monophylloides_ Kruse. Root. _Tangential section._ (x 120)

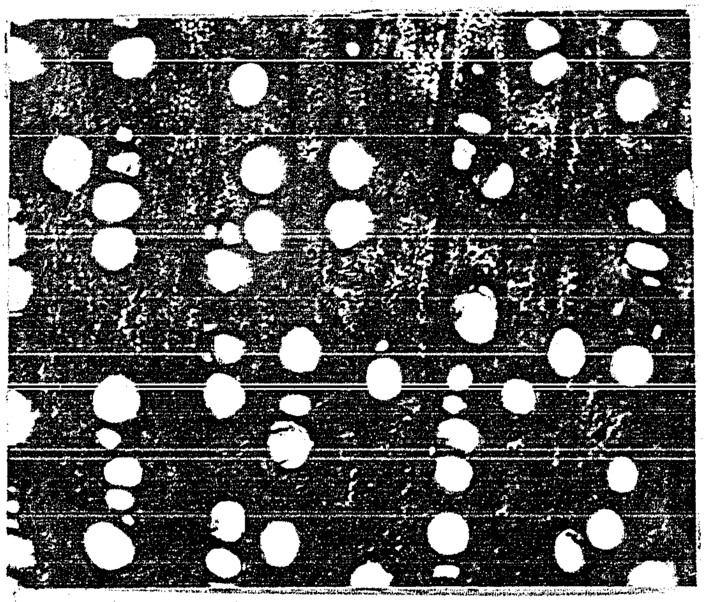

Fig. 15

Fig. 16

Fig. 17. Fagara monophylloides Kruse. Root.
Radial section. (x 120)

Fig. 18. Fagara biseriata Kruse.
Transverse section. (x 120)

Fig. 17

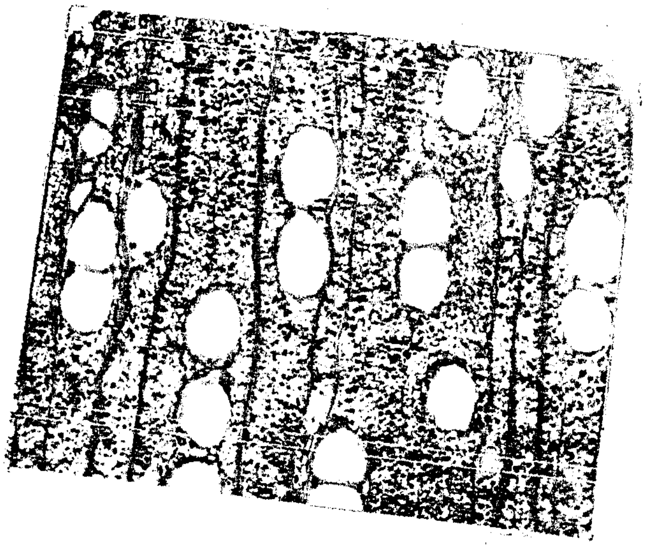

Fig. 18

Fig. 19. _Fagara biseriata_ Kruse.
Tangential section (x 120)

Fig. 20. _Fagara biseriata_ Kruse.
Radial section. (x 120)

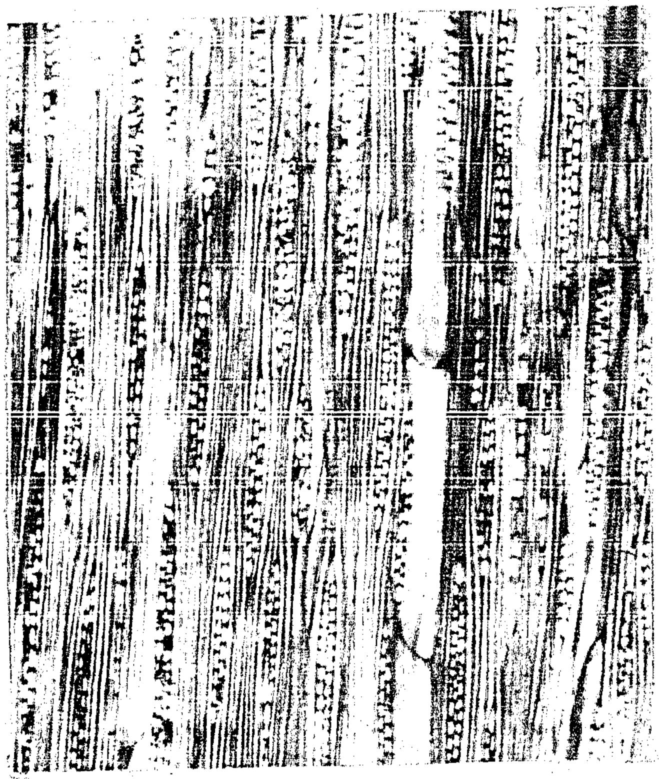

Fig. 19

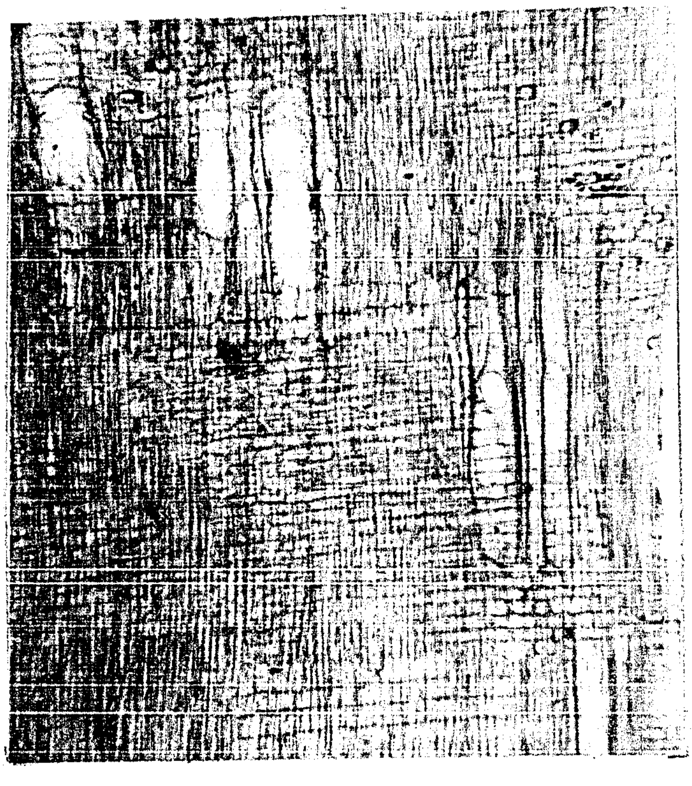

Fig. 20

Fig. 21. Fagara biseriata Kruse.
Tangential section showing intervascular pitting.
(x 370)

Fig. 22. Suriana inordinata Kruse.
Transverse section. (x 120)

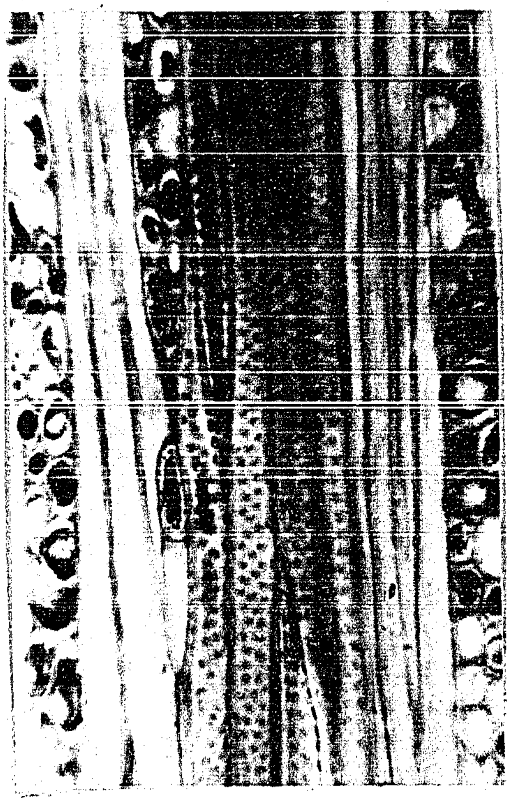

Fig. 21

Fig. 22

Fig. 23. <u>Suriana inordinata</u> Kruse.
<u>Tangential section.</u> (x 120)

Fig. 24. <u>Suriana inordinata</u> Kruse.
<u>Radial section.</u> (x 120)

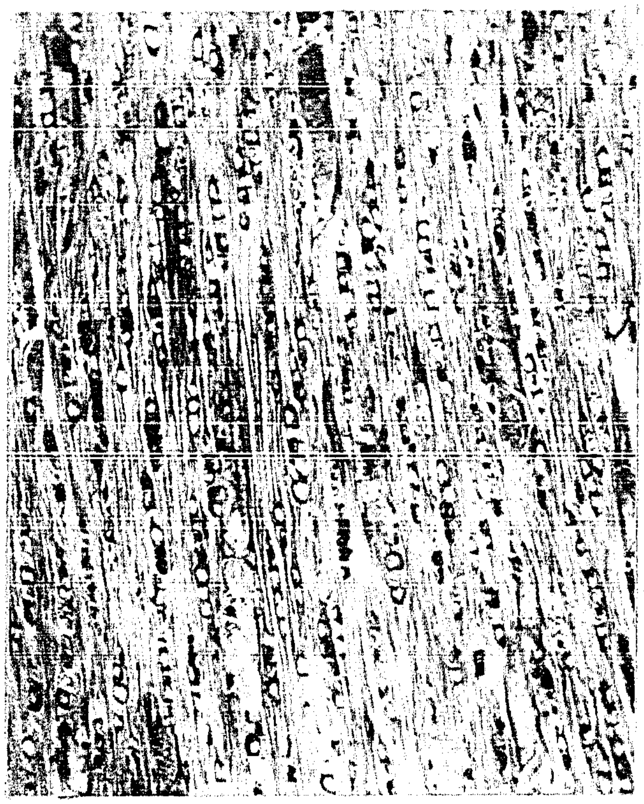

Fig. 23

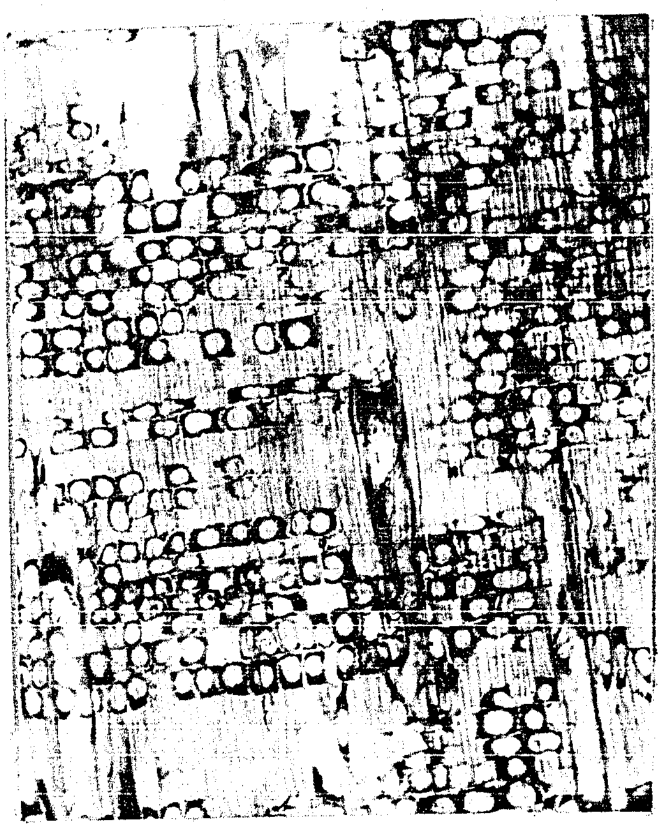

Fig. 24

Fig. 25. _Hevea microporosa_ Kruse.
Transverse section. (x 120)

Fig. 26. _Hevea microporosa_ Kruse.
Tangential section. (x 120)

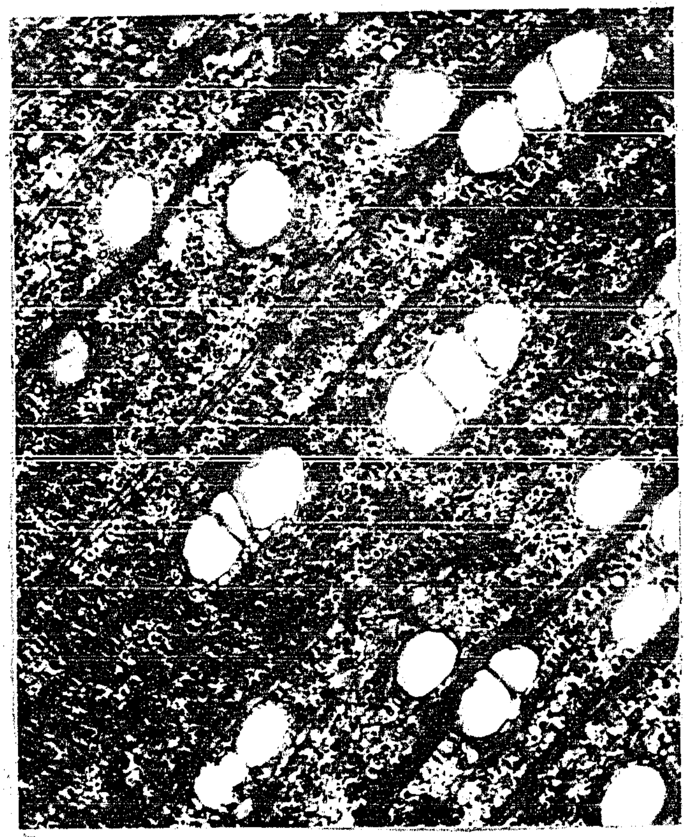

Fig. 25

Fig. 26

Fig. 27. _Hevea microporosa_ Kruse.
Radial section. (x 120)

Fig. 28. _Hevea microporosa_ Kruse.
Transverse section of bark showing
vertical ducts. (x 48)

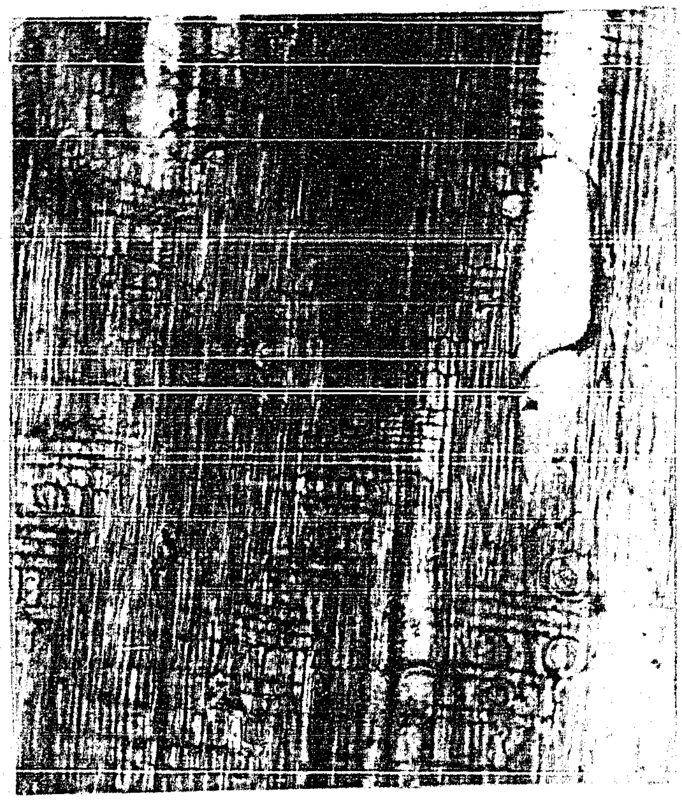

Fig. 27

Fig. 28

Fig. 29. Hevea microporosa Kruse.
Transverse section of pith. (x 30)

Fig. 30. Schinoxylon actinoporosum Kruse.
Transverse section. (x 120)

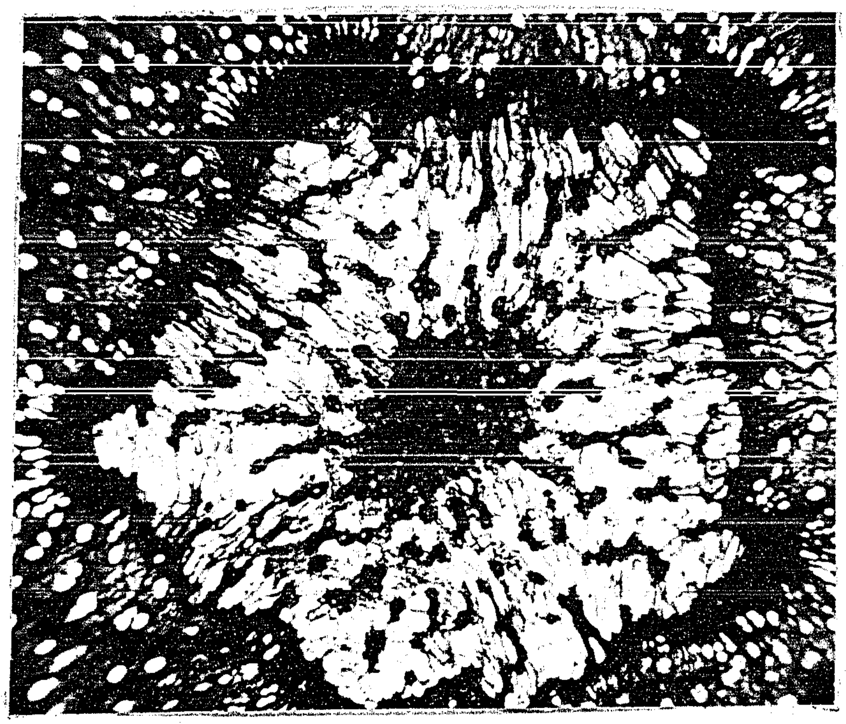

Fig. 29

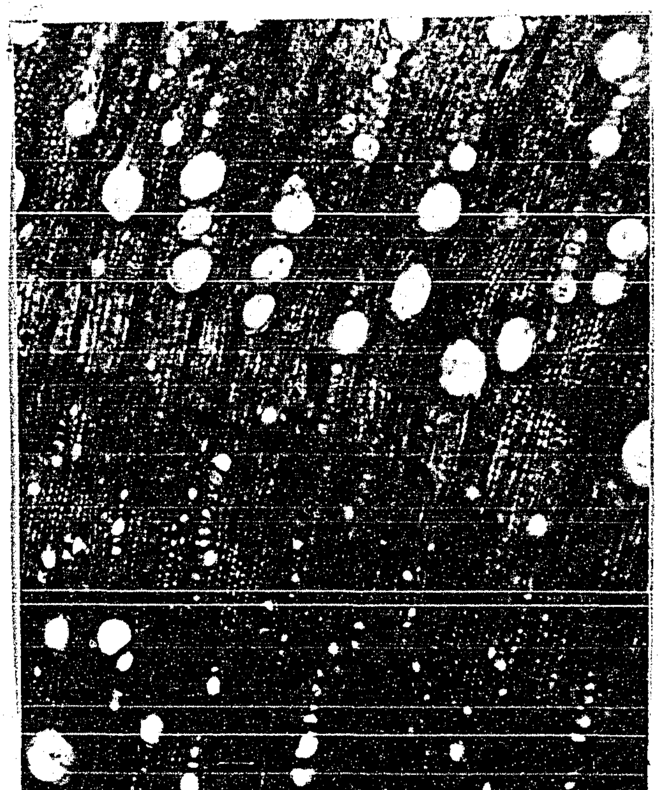

Fig. 30

Fig. 31. _Schinoxylon actinoporosum_ Kruse. Tangential section showing radial gum ducts. (x 120)

Fig. 32. _Schinoxylon actinoporosum_ Kruse. Radial section. (x 120)

Fig. 31

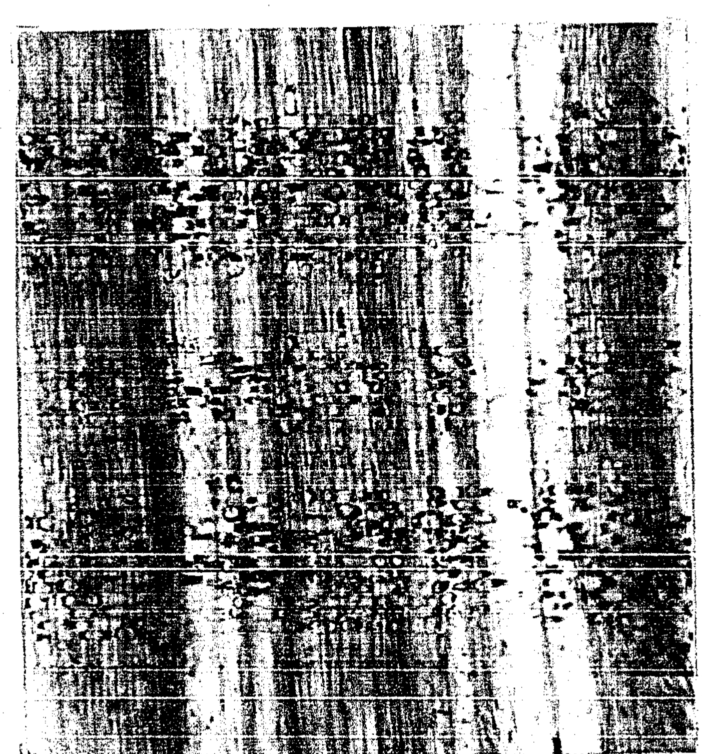

Fig. 32

Fig. 33. Schinoxylon actinoporosum Kruse.
Transverse section of bark showing vertical ducts. (x 120)

Fig. 34. Edenoxylon parviareolatum Kruse.
Transverse section. (x 7)

Fig. 33

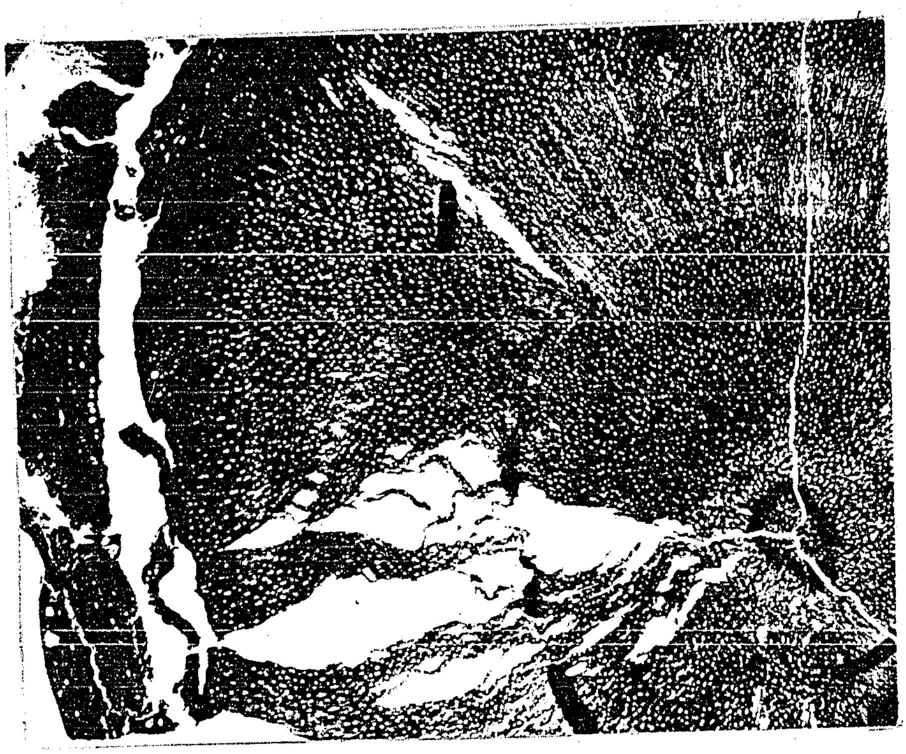

Fig. 34

Fig. 35. _Edenoxylon parviareolatum_ Kruse.
Transverse section. (x 120)

Fig. 36. _Edenoxylon parviareolatum_ Kruse.
Tangential section. (x 120)

Fig. 37. _Edenoxylon parviareolatum_ Kruse.
Radial section. (x 120)

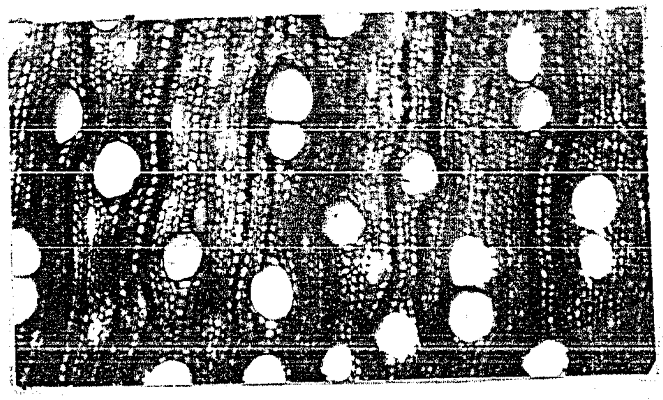

Fig. 35

Fig. 36

Fig. 37

Fig. 38. Eden oxylon parviareolatum Kruse.
Transverse section showing vertical
ducts in periderm. (x 120)

Fig. 39. Edenoxylon parviareolatum Kruse.
Transverse section of bark and
wood. Root. (x 48)

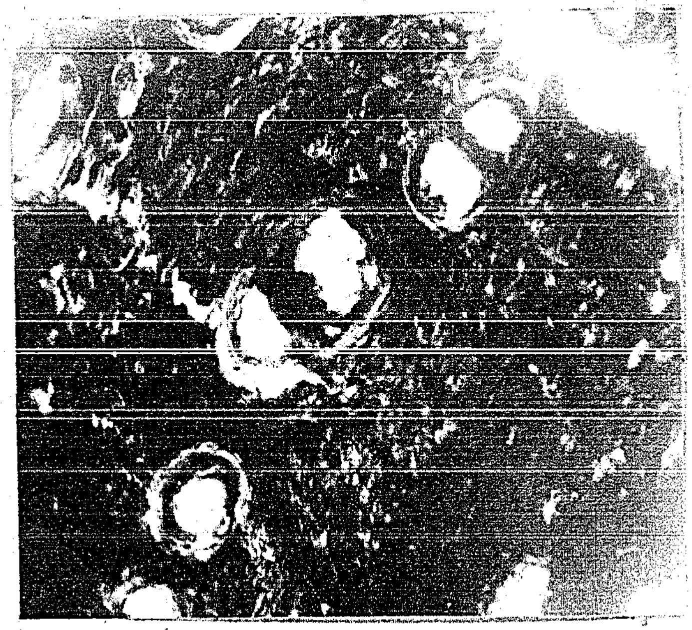

Fig. 38

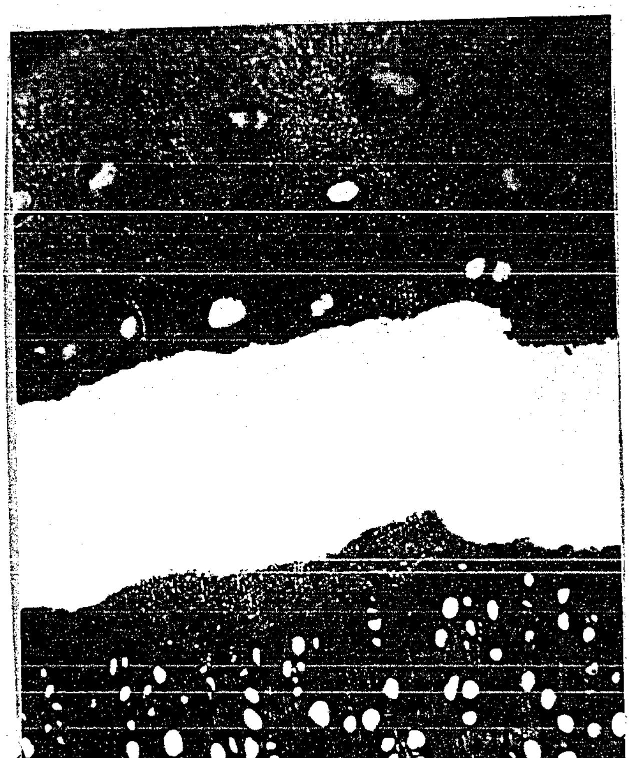

Fig. 39

Fig. 40. *Edenoxylon parviareolatum* Kruse.
Root. Tangential section. (x 120)

Fig. 41. *Edenoxylon parviareolatum* Kruse.
Root. Radial section. (x 120)

Fig. 40

Fig. 41

Fig. 42. Aspidospermoxylon uniseriatum Kruse.
Transverse section. (x 120)

Fig. 43. Aspidospermoxylon uniseriatum Kruse.
Tangential section. (x 120)

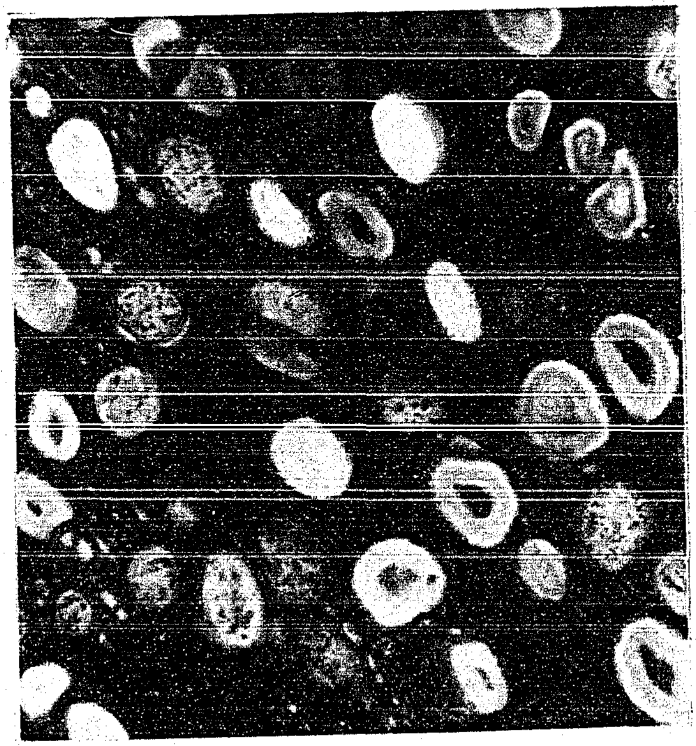

Fig. 42

Fig. 43

Fig. 44. _Aspidospermoxylon uniseriatum_ Kruse.
Tangential section showing radial gum ducts.
(x 120)

Fig. 45. _Aspidospermoxylon uniseriatum_ Kruse.
Radial section. (x 120)

Fig. 44

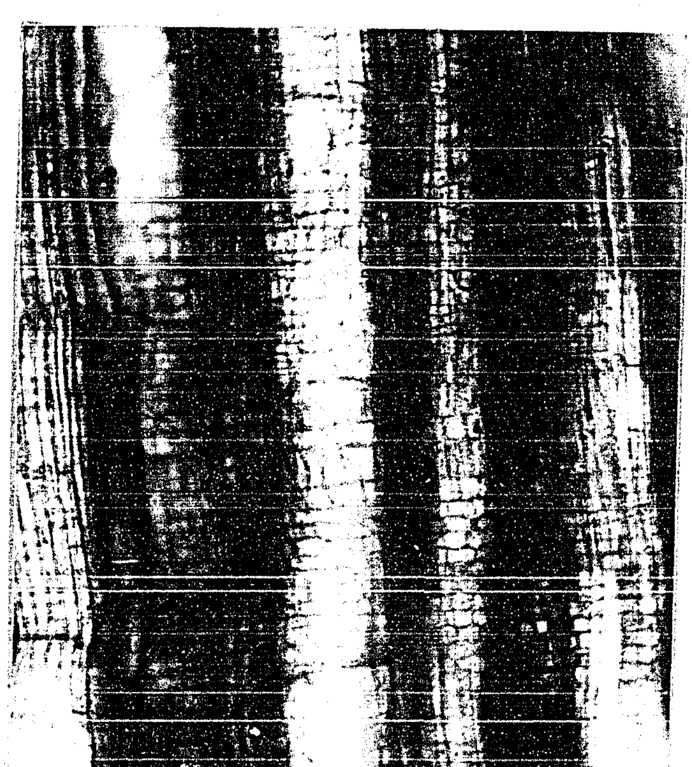

Fig. 45

Fig. 46. Aspidospermoxylon uniseriatum Kruse.
Transverse section of cortex showing
vertical ducts. (x 120)

Fig. 47. Unknown dicotyledon.
Transverse section. (x 7)

Fig. 46

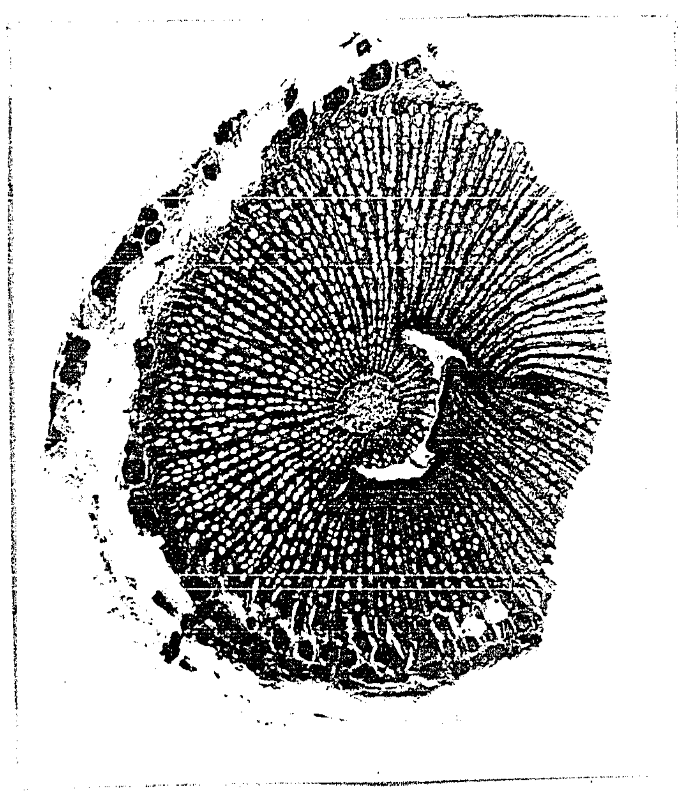

Fig. 47

Fig. 48. Unknown dicotyledon.
Tangential section. (x 120)

Fig. 49. Unknown dicotyledon.
Radial section. (x 120)

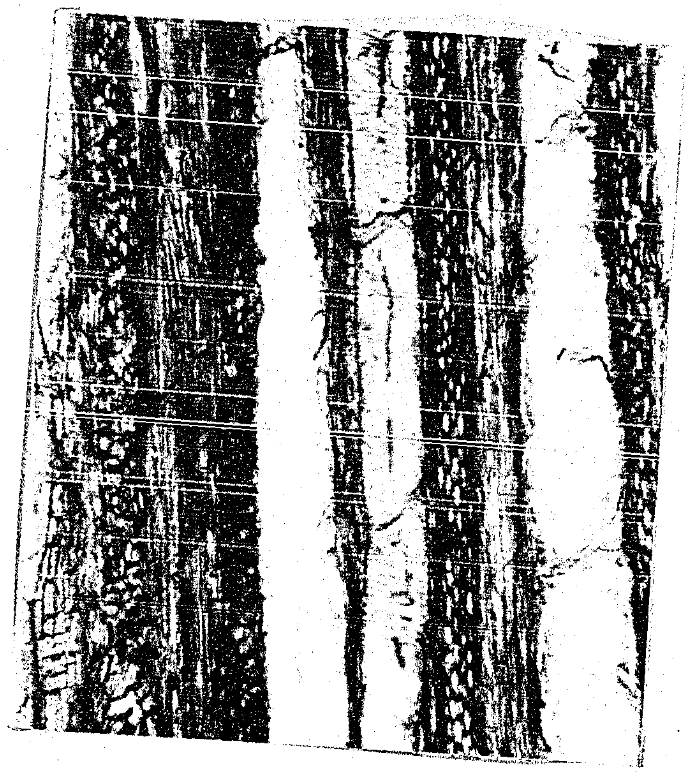

Fig. 48

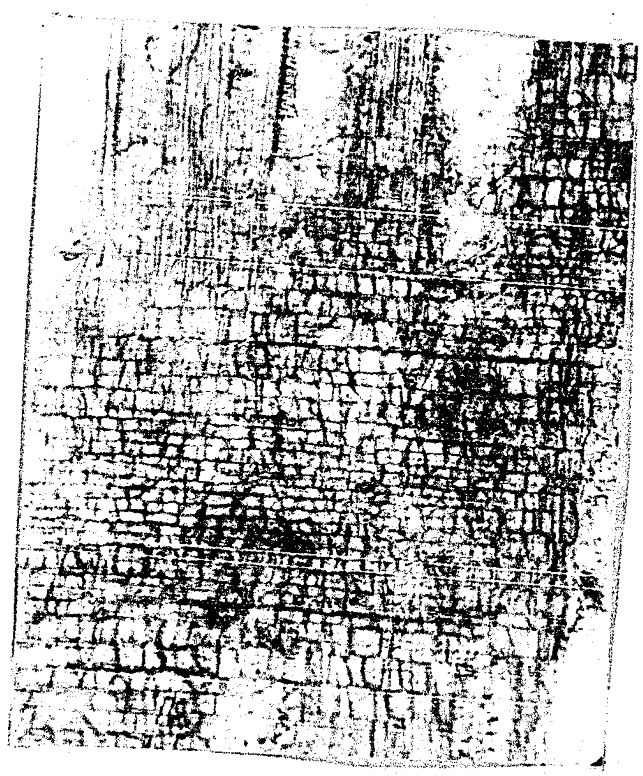

Fig. 49

Fig. 50. Unknown dicotyledon.
Tangential section of phloem showing sclerenchyma. (x 48)

Fig. 51. Unknown dicotyledon.
Transverse section showing sclerenchyma bundles. (x 40)

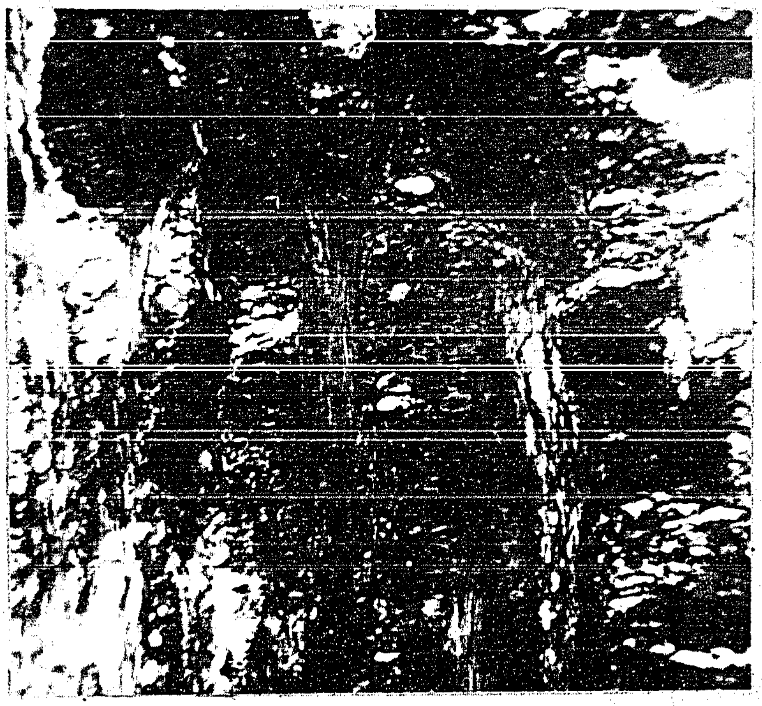

Fig. 50

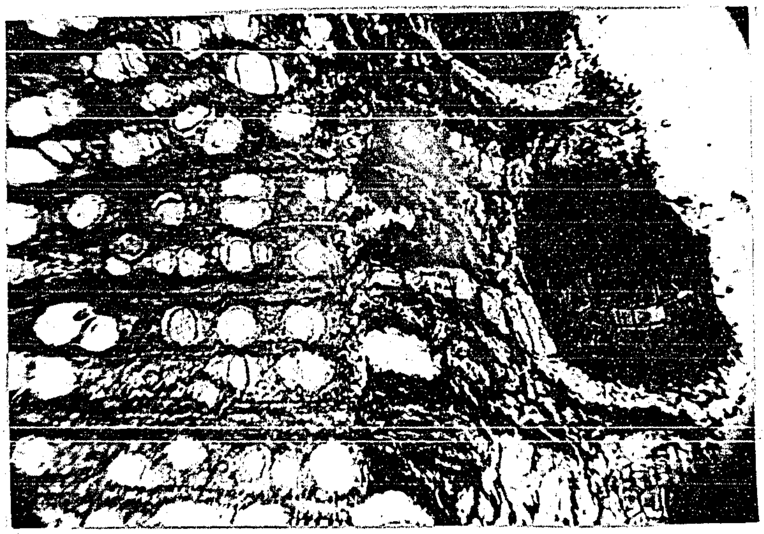

Fig. 51

Fig. 52. *Amyridoxylon ordinatum* Kruse.
Tangential section showing intervascular pitting. (x 500)

Fig. 53. *Fagara monophylloides* Kruse.
Radial section showing intervascular pitting. (x 500)

Fig. 54. *Fagara monophylloides* Kruse.
Radial section showing ray to vessel pitting. (x 500)

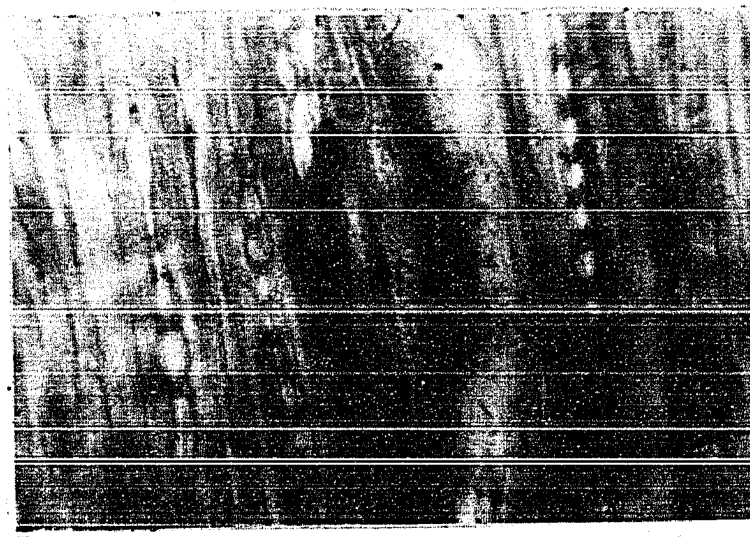

Fig. 52

Fig. 53

Fig. 54

Fig. 55. Fagara monophylloides Kruse. Root.
Tangential section showing intervascular pitting. (x 500)

Fig. 56. Suriana inordinata Kruse.
Tangential section showing intervascular pitting. (x 500)

Fig. 57. Hevea microporosa Kruse.
Radial section showing ray to vessel pitting. (x 500)

Fig. 55

Fig. 56

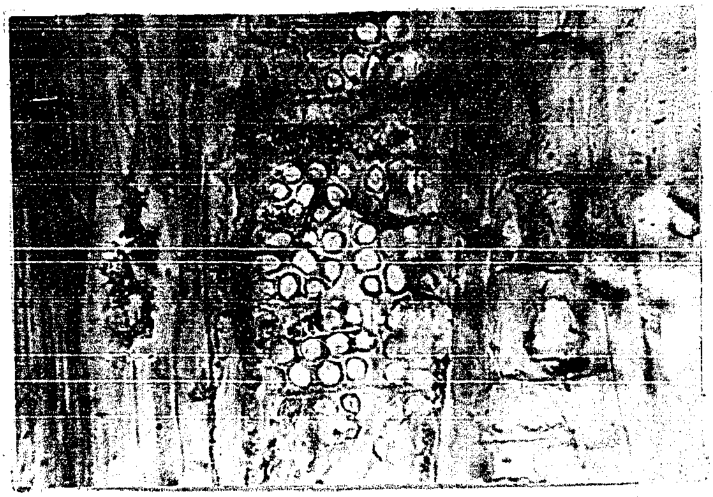

Fig. 57

Fig. 58. Edenoxylon parviareolatum Kruse. Root. Tangential section showing intervascular pitting. (x 500)

Fig. 59. Aspidospermoxylon uniseriatum Kruse. Radial section showing intervascular pitting. (x 500)

Fig. 58

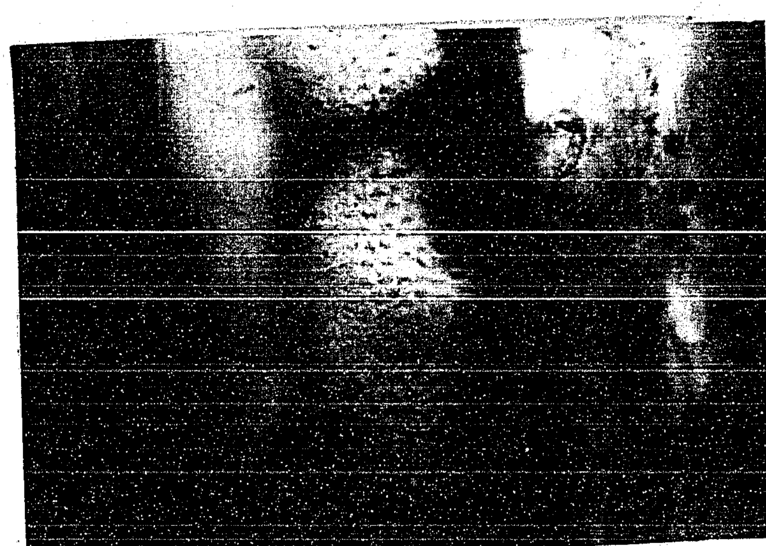

Fig. 59