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A MIDDLE EOCENE FOSSIL PLANT ASSEMBLAGE (POWERS CLAY PIT) FROM WESTERN TENNESSEE

David L. Dilcher and Terry A. Lott

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A MIDDLE EOCENE FOSSIL PLANT ASSEMBLAGE (POWERS CLAY PIT) FROM WESTERN TENNESSEE

David L. Dilcher and Terry A. Lott¹

ABSTRACT

Plant megafossils are described, illustrated and discussed from Powers Clay Pit, occurring in the middle Eocene, Claiborne Group of the Mississippi Embayment in western Tennessee. Twenty six species and eight types of plants, and two species of insect larval cases are represented in this study. They include Lauraceae, Annonaceae, Smilacaceae, Platanaceae, Altingiaceae, Myrtaceae, Fabaceae, Fagaceae, Salicaceae, Moraceae, Rhamnaceae, Sapindaceae, Nyssaceae, Theaceae, Apocynaceae, Rubiaceae, Araliaceae, Oleaceae, entire margin morphotype 1-5, tooth margin morphotype 1, reproductive structure morphotype 1, *Folindusia*, and *Terrindusia*. Specimens collected from Powers Pit are compared to those from previous studies from western Tennessee, the Claiborne Group in general, and assessed in terms of extant relationships. The extant relationships of plant megafossils described in this study provide clues to the paleoenvironment of western Tennessee during the middle Eocene. The paleoenvironment may have been subtropical accommodating warm tropical to cool temperate plant species.

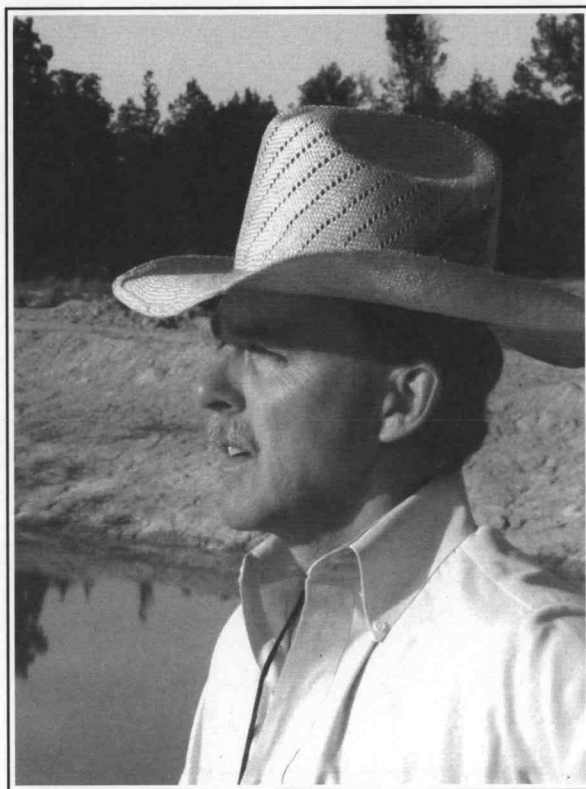
Key words: Eocene, Claiborne Group, Powers Clay Pit, Tennessee, Angiosperms

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IN DEDICATION TO: BRUCE ROGER MOORE



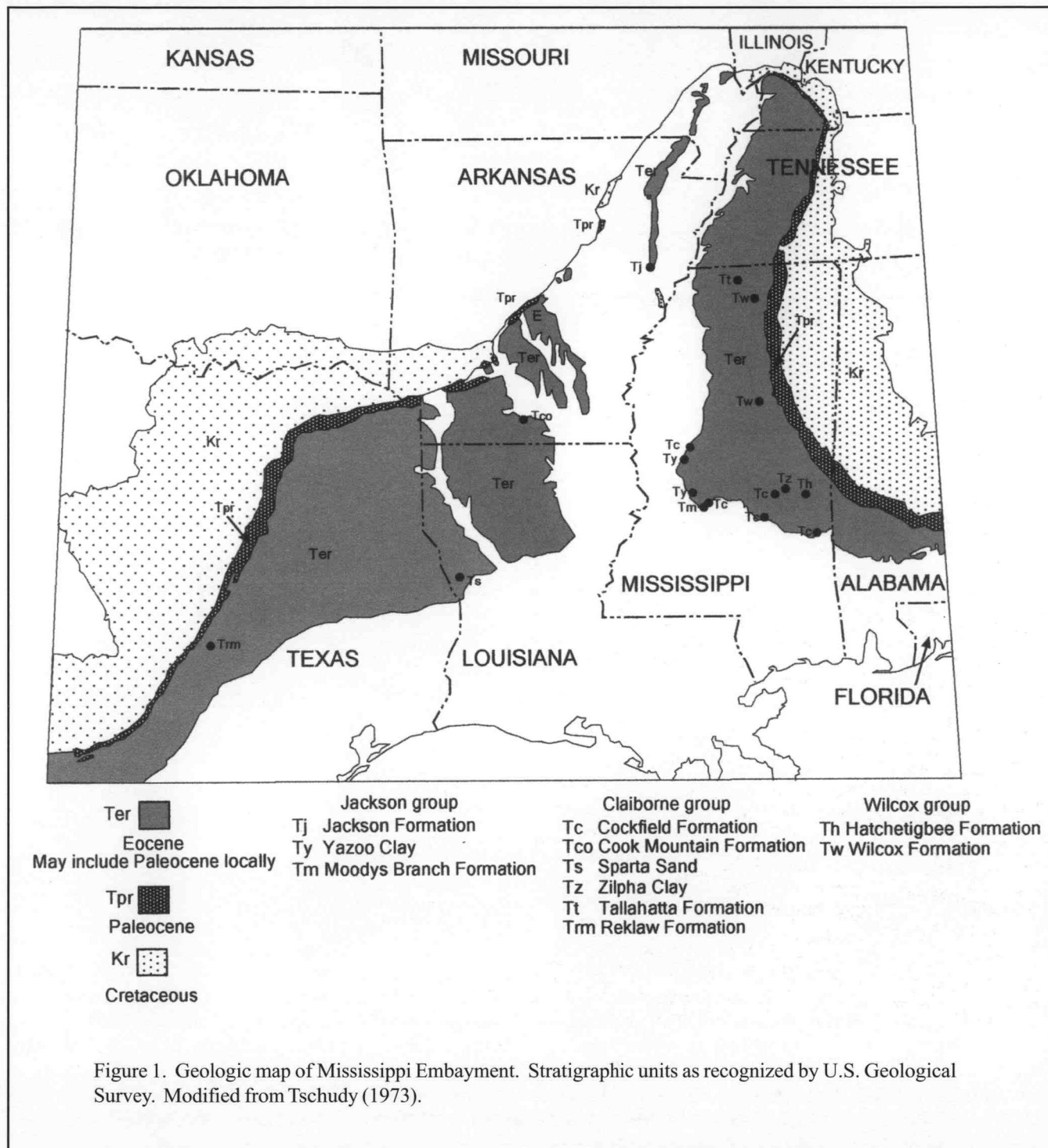
This paper is dedicated to Mr. Bruce Roger Moore, a student of Paleobotany whose interest in the fossil plants of western Tennessee and collections from the Powers Clay Pit helped contribute many fossils to the Paleobotany and Palynology Collection of the Florida Museum of Natural History. His field-work, as part of a team effort, resulted in collections of several of the fossils presented in this paper. His intense passion for collecting and inquiries about the fossil plants and their depositional history encouraged continued study of fossil plants from the middle Eocene of western Tennessee. Roger Moore is a native of western Tennessee and completed a Masters of Science degree from the University of Tennessee in Agronomy. Subsequently, he went into business in western Tennessee. His interest in plants continued, and when Professor Michael Gibson introduced him to the fossils of western Tennessee and he saw how beautifully preserved the plants were, it was like striking a spark under dry kindling. The spark took and flamed into an intense interest in these fossil plants. We are happy to dedicate this paper to him in recognition of his significant contributions of collecting so many fossil plants and making them available for this study and future reports of other fossil localities.

INTRODUCTION

There are numerous clay deposits in western Tennessee, many which contain abundant plant fossils. These clay deposits are of middle Eocene age and occur as isolated clay lenses of the Claiborne Group deposited during the Mississippi Embayment of southeastern North America. These numerous clay lenses are distributed in the ancient coastal plains sediments of the northeastern part of the Mississippi Embayment (Fig. 1). There

are many localities in this region (Fig. 2) and each locality yielded hundreds to thousands, even tens of thousands, of plant fossil remains. This report is the first publication in what we expect to become a series of papers detailing the floras of each locality. Reasons for breaking this very large flora of middle Eocene plant-rich deposits into discreet units are elaborated upon in the discussion of this paper.

The fossil plants in the present report were col



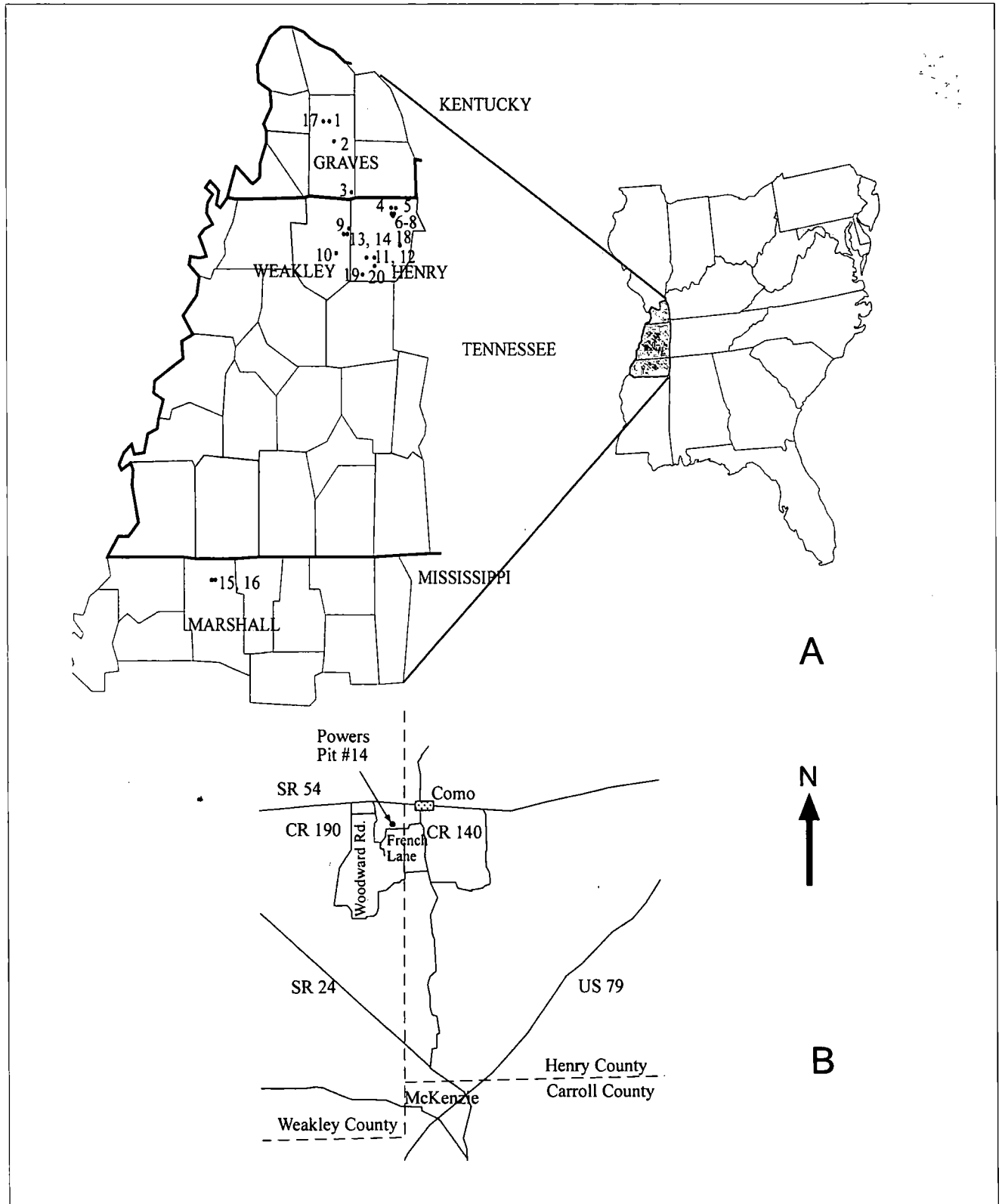


Figure 2. A, Localities of clay pits in Kentucky, Tennessee, and Mississippi, Eastern United States. 1, Lamkin (UF15815). 2, South-40 (UF15824). 3, Bell City (UF15803). 4, New Puryear (UF15819). 5, Puryear (UF15820). 6, Martin (UF15809). 7, Foundry Hill (UF15810). 8, Buchanan (UF15806). 9, Warman (UF15826). 10, Gleason (UF15811). 11, Miller (UF15817). 12, Lawrence (UF15816). 13, Willbank 1 & 2 (UF18884, UF18927). 14, Powers (UF18810). 15, Bovay (UF15737). 16, Bolden (UF15738). 17, Old Hickory (UF15742). 18, Richies Black (UF15828). 19, New Lawrence (UF15818). 20, New Haynes (Rancho, UF15921). B, Locality of Powers Pit (#14), Weakley County, Tennessee.



Figure 3. Powers Pit. A, Northeast corner. B, East side of pit. Photographed by Hongshan Wang.

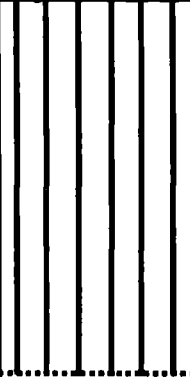

WHITLATCH (surface)		SCHNEIDER AND BLANKENSHIP (subsurface)		STEARNS AND ARMSTRONG (subsurface)		HARDEMAN ET AL. (surface)		PARKS (surface)		PARKS AND CARMICHAEL		SERIES				
1940		1950		1955		1966		1975		1990						
JACKSON FORMATION		JACKSON (?) FORMATION		JACKSON AND CLAIBORNE GROUPS		JACKSON (?) FORMATION				JACKSON FM. — ? —		EOCENE				
WILCOX GROUP	GRENADA FM.	CLAIBORNE GROUP				CLAIBORNE AND WILCOX FMS.				COCKFIELD FM. — ? —						
	HOLLY SPRINGS FM.									COOK MOUNTAIN FM. — ? —						
	ACKERMAN (?) FM.	WILCOX GROUP		WILCOX GROUP		WILCOX FM.				MEMPHIS SAND						
MIDWAY GROUP	PORTERS CREEK CLAY	MIDWAY GROUP	PORTERS CREEK CLAY	MIDWAY GROUP	PORTERS CREEK CLAY	MIDWAY GROUP	PORTERS CREEK CLAY	MIDWAY GROUP	PORTERS CREEK CLAY	WILCOX GROUP		PALEOCENE				
	CLAYTON FM. 		CLAYTON FM.		CLAYTON FM.		CLAYTON FM.		CLAYTON FM.	CLAYTON FM.	— ? — MIDWAY GROUP					
UPPER CRETACEOUS																

Figure 4. Stratigraphic chart of western Tennessee. Modified from Parks (1975) and Parks and Carmichael (1990).

lected at Powers Clay Pit in Weakley County, Tennessee (Figs. 2, 3). This clay pit was selected because we have accumulated, during the past 5 years, a collection of over 400 specimens consisting mainly of leaves, fruits, and seeds through the efforts of B. Roger Moore, the authors, and numerous colleagues who have visited the

site. The well preserved fossil leaves, flowers, fruits, seeds, and insect larval cases occur as compressions/impressions, casts, and carbonized organic material. Many of the fossils collected in Powers Clay Pit can be related to the extant families Lauraceae, Fabaceae, Fagaceae, Theaceae, and Araliaceae, with less abun-

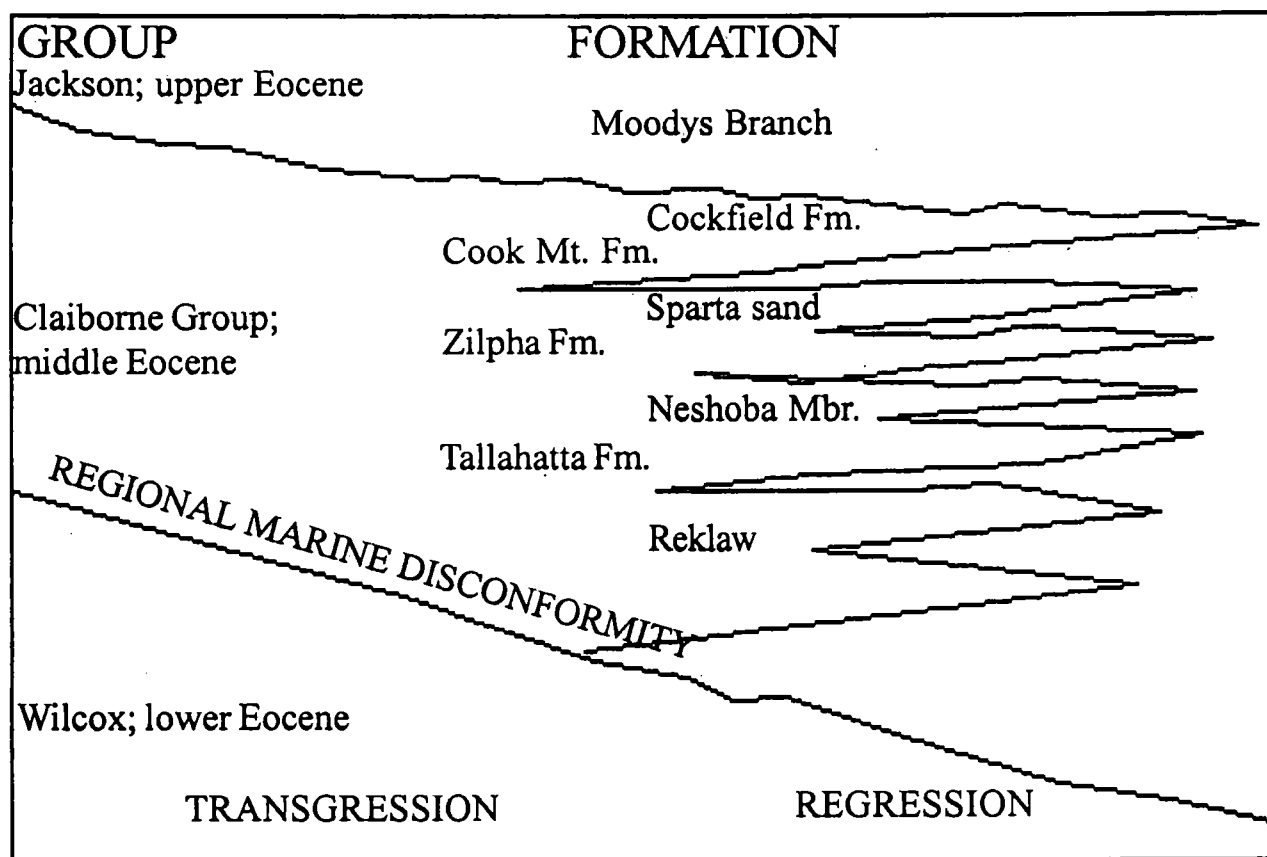


Figure 5. Transgression-regression schematic. From Potter and Dilcher 1980.

dant fossils related to Annonaceae, Moraceae, Rhamnaceae, Smilacaceae, and Myrtaceae. A few rare specimens are related to Platanaceae, Altingiaceae, Salicaceae, Sapindaceae, Nyssaceae, Apocynaceae, Rubiaceae, and Oleaceae. There are also some caddisfly cases associated with the plant fossils.

E.W. Berry (1916, 1930, 1941) originally considered the plant fossils from numerous localities extending from Texas, Arkansas, western Tennessee, western Kentucky, Mississippi and Alabama to be of lower Eocene, belonging to the Wilcox Formation. Later, the age of this flora was clearly shown based on palynological correlations to belong to the middle Eocene Claiborne Group (Elsik & Dilcher 1974; Frederiksen 1988). As well as the age, the depositional settings of these plant-rich clay deposits has been revised over the last 60 years. These revisions will be discussed in the material and methods section of this report.

Since the original reports of the Eocene floras from southeastern North America (Berry 1916, 1930, 1941), methods for the study of fossil plant remains have been revised, and the philosophy of reporting on specific fossil plants and floras has undergone extensive modification (Hickey 1973; Dilcher 1974; LAWG 1999; Dilcher

2000a). The entire concept of presenting huge fossil floras that demand only brief comparisons with living plant genera are now understood to be filled with identification errors. As Dilcher (1974) mentioned, Berry's identifications for the Eocene floras of southeastern North America were about 60% incorrect or held some margin of systematic errors and thus Berry's conclusions are often not supported. With this in mind, the flora presented here is done so with tentative assignments to extant genera and more certain assignments to extant families as in Dilcher (2001). This is logical because many extant families can be recognized and validated by Eocene times, but fewer extant genera can be validated by that time. The use of leaf morphotypes (Johnson 1989; Ellis et al. 2003; Barclay et al. 2003) is a practical way to proceed in paleobotanical studies of fossil leaves for which a modern generic affinity is uncertain. Several angiosperm leaf morphotypes are presented in this study.

This report represents the first attempt in over 75 years of presenting an entire known fossil flora based upon megafossil evidence, from the Eocene sediments of southeastern North America. It is limited to a single locality, represents a change in age, presents new ideas

in the deposition of the flora, and a new philosophy in our approach to this floristic study from previous floras of this region by Berry (1916, 1930). The more recent research of these fossil plants, limited to studies of specific taxa or specific families, is indicated below.

PREVIOUS PALEOBOTANICAL INVESTIGATIONS

There is a long and rich history of investigations of plant megafossils collected in western Tennessee and Kentucky, starting in the mid 1800's (Lesquereux 1859, 1869; Owen 1860; Safford 1869; Berry 1914, 1916, 1922, 1924, 1930, 1937, 1941). Brown (1939, 1940, 1944, 1946, 1960) provided limited taxonomic revisions of some of the fossil material previously published by Berry. Subsequently, systematic revisions and additions to the Claiborne megafossil flora can be found in Dilcher (1963, 1969, 1971, 2000b), Dilcher & McQuade (1967), Dilcher & Mehrotra (1969), Dilcher & Dolph (1970), Dilcher et al. (1974, 2001), Crepet et al. (1974, 1975, 1980), Dolph (1975), Crepet & Dilcher (1977), Dilcher & Daghljan (1977), Crepet (1978), Roth & Dilcher (1979), Crepet & Daghljan (1980, 1982), Jones & Dilcher (1980, 1988), Potter & Dilcher (1980), Weiss (1980), Roth (1981), Zavada & Crepet (1981), Jones (1984), Dilcher & Manchester (1986, 1988), Jones et al. (1988), Taylor (1988), Grote & Dilcher (1989, 1992), Sun (1989), Herendeen & Dilcher (1990a,b,c, 1991), Herendeen et al. (1990), Call & Dilcher (1992), Herendeen (1992), Moore (2001), & Moore et al. (2003). Palynological reports from western Tennessee can be found in McLaughlin (1957), Tschudy (1973), Elsik & Dilcher (1974), Potter (1976), & Taylor (1987, 1989) while dispersed cuticle of one locality was presented by Kovach & Dilcher (1984). These publications since 1963 represent work on individual taxa or limited families common in the Eocene floras of western Tennessee. The reason for this systematic rather than floristic emphasis is given in the discussion of this paper.

OBJECTIVES

This study is an attempt to document the megafossil flora (with minor faunal elements included) of one specific clay pit in western Tennessee, by presenting each type of megafossil plant found that is now in the Paleobotany and Palynology Collection of the Florida Museum of Natural History. Leaf morphotypes are presented and morphological descriptions of each taxon are correlated with modern genera when some similarities are noticed. As taxa can be related to a specific extant family, extant genus, and extinct fossil plant morphotypes, the overall floral composition of this fossil locality can be compared with floras of modern ecosystems and

known fossil floras. The use of such comparisons in the understanding of the paleoenvironment, paleoclimate, stasis and change in floristic composition through time will be presented in the discussion. As floras from other localities are published, we expect that the plant species composition of this locality will be used to compare and contrast with species lists from other middle Eocene fossil plant localities. A leaf morphology key is provided for preliminary field identification for this one locality (Table 3). This will allow the leaf morphotypes presented here to be used in field studies of plant fossil diversity, overall species richness and abundance.

MATERIALS AND METHODS

The plant megafossils and insect larval cases presented in this report were collected mostly in July 2000, May 2001 and April 2002 from the Powers Clay Pit, Weakley County, Tennessee, 36° 16.94 N, 88° 31.78 W, in sediments belonging to the middle Eocene, Claiborne Group. Specimens were also collected from a commercial shed with piles of clay mined from Powers Clay Pit, at the headquarters of H. C. Spinks Clay Company in July 2002. Terminology for leaf description follows Hickey (1973), Radford et al. (1974), Dilcher (1974) and LAWG (1999). The systematic classification used follows APG II (2003). The fossil material is numbered with the University of Florida acronym (UF) followed by the locality number (18810 for Powers Clay Pit), then the individual specimen number (e.g. UF18810-34381). Modern leaves cited for comparison are numbered as the University of Florida Modern Reference Leaf Collection followed by the specimen number (e.g. UF5437). Herbarium specimens of modern leaves were examined at the University of Florida Herbarium (FLAS). Some specimens are figured but not described such as Entire Margin Morphotype 3 (UF18810-34450) and Entire Margin Morphotype 4 (UF18810-34449).

Changing concepts of stratigraphic nomenclature for the Claiborne Group in western Tennessee since the 1940's are illustrated in Figure 4. The clay lenses in the upper Claiborne Group were considered to represent near-marine paleoenvironments because of the possible coastal elements, such as sabal palms in the fossil floras (Berry 1916, 1930), sedimentary environment types (Stearns 1957), and the presence of hystrichospheres and dinoflagellates (Parks 1975). Dilcher (1974) suggested that the clay lens of some of the plant-rich clay pits represented oxbow lake deposits. Dolph (1975) also envisioned back-swamp paleoenvironments on ancient floodplains while Potter (1976) also suggested abandoned river channels. Potter & Dilcher (1980) presented numerous detailed outlines of several clay pits with some

Table 1. Systematic list of the flora and fauna with exemplary specimens. * Indicates an extinct fossil genus or unknown modern genera similar to this fossil.

	Order	Family	Species
Magnoliids	Lurales	Luraceae	<i>Ocotea</i> sp.
	Magnoliales	Annonaceae	<i>Duguetia</i> sp.
Monocots	Liliales	Smilacaceae	<i>Smilax</i> sp. 1 & 2
			Undetermined Monocot* sp.
Eudicots	Proteales	Platanaceae	<i>Platanus</i> * sp.
Core Eudicots	Saxifragales	Altingiaceae	<i>Liquidambar</i> sp.
Rosids	Myrtales	Myrtaceae	<i>Myrcia</i> sp.
Eurosids I	Fabales	Fabaceae	<i>Cladrastis</i> -like sp.
			<i>Ormosia</i> -like sp. 1 & 2
			<i>Swartzia</i> sp.
			<i>Berryophyllum</i> * <i>tenuifolia</i> (Berry) Jones et Dilcher
			<i>Berryophyllum</i> * sp.
	Malpighiales	Salicaceae	<i>Knightiophyllum</i> * <i>wilcoxianum</i> Berry
			<i>Populus</i> sp.
			<i>Pseudolmedia</i> sp.
			<i>Ficus</i> -like sp.
			<i>Berhamniphyllum</i> * <i>claibornense</i> Jones et Dilcher
Eurosids II	Sapindales	Sapindaceae	<i>Berhamniphyllum</i> * sp.
			<i>Cupanites</i> sp.
			<i>Nyssa eolignitica</i> * Berry
Asterids	Ericales	Theaceae	<i>Ternstroemites</i> * sp.
			<i>cf. Gordonia</i> sp.
			<i>Apocynophyllum</i> * sp.
Euasterids I	Gentianales	Apocynaceae	<i>cf. Paleorubiaceophyllum</i> * sp.
		Rubiaceae	<i>cf. Paleorubiaceophyllum</i> * sp.
Euasterids II	Apiales	Araliaceae	<i>Dendropanax eocenensis</i> Dilcher et Dolph
	Lamiales	Oleaceae	Oleaceae leaf morphotype
Incertae sedis			Entire margin morphotype 1*
			Entire margin morphotype 2*
			Entire margin morphotype 3*
			Entire margin morphotype 4*
			Entire margin morphotype 5*
			Tooth margin morphotype 1*
Insect cases			Reproductive structure morphotype 1*
			<i>Folindusia</i> sp.
			<i>Terrindusia</i> sp.

cross sections of their shapes, and the lithology of the clay lenses. They concluded that they conformed to clay plugs typical of oxbow lakes in an ancient middle Eocene river systems, or braided stream distributary migrating across their flood plains. Taking into account multiple overlapping clay lenses surrounded by cross-bedded sands with frequent clay rip-up, noted in two clay pits, Moore et al. (2003) suggested clay plugs of oxbow lakes in a braided river system in the ancient flood plain. Regional and local pollen data (Engelhardt 1964; Tschudy 1973; Elsik 1974; Elsik & Dilcher 1974; Potter 1976), and repeated marine transgression/regressions in southwestern Tennessee (Stearns 1957; Murray 1961) (Fig. 5) indicate that the clay lenses are correlated with the mainly nonmarine (Fisher 1964; Frederiksen 1988) Cockfield Formation of the Claiborne Group (Potter & Dilcher 1980).

SYSTEMATIC COMPOSITION

The taxa we have recognized are listed in Table I and organized according to the APG system of classification.

SYSTEMATIC PALEONTOLOGY

Laurales

Lauraceae

Ocotea sp.

(Fig. 12, C-E, G)

Description.—Majority of leaves incomplete, lamina linear to narrowly elliptic, symmetrical, ~ 8.5–14.7 cm long by 0.9–3.1 cm wide, length/width ratio 4.7:1 – 9.4:1; apex angle acute, with cuneate flanks; base angle acute, with cuneate to slightly concave flanks. Margin entire and thickened or with a marginal vein. Petiole stout, ~ 1.2 cm long, widening gradually towards lamina. Venation pinnate; secondary venation weak brochidodromous with 6–9 pairs, angle of divergence 20–40°. One pair of acrodromous basal to suprabasal secondary veins extending 1/3 – 1/2 distance of leaf length. Tertiary veins reticulate, with a continuous row of tertiary looping along the marginal side of the upturned secondary veins.

Discussion.—The general venation patterns are similar to those found in the families Lauraceae and Monimiaceae, although in Monimiaceae the orientation of tertiary veins in the upper 1/3 of the leaf is toward the midvein (Klucking 1987). Within Lauraceae, the number of secondary vein pairs, acrodromous venation, and tertiary looping are similar to *Oreodaphne pseudoquianensis* Berry (*Ocotea pseudoquianensis* [Berry] LaMotte), *O. obtusifolia* Berry (*Ocotea obtusifolia* [Berry] LaMotte; Berry 1916; Dilcher 1963),

and *Ocotea* species of Klucking (1987). In specimen 34410a, the shape, and suprabasal acrodromous venation is similar to *O. quianensis* Aublet (Klucking 1987). The venation matches the course of the acrodromous venation, such as one vein extends 1.5x further than the other. In specimen 34409, the venation pattern is close to *O. fasciculata* (Nees.) Mez. (Klucking 1987). *Ocotea* pollen is also recorded from the upper Claiborne of Alabama (Gray 1960). The isolated leaves of Lauraceae are well placed within the family based upon venation and form, however they are notoriously difficult to place within a genus and one can do little more than picture match unless some unique features of venation and cuticle are present. In this leaf the strong paired basal veins provide a distinct character that can be identified from pit to pit and also holds close similarities to a leaf from the middle Eocene Messel pit in Germany (Sturm 1971). The leaves from Messel are generally similar to those illustrated by Dilcher (1963) from other clay pits, including the nature of the cuticle but with the exception of the abundance and placement of the trichome bases along the anticlinal cell walls. In the future, cuticle preparations of the fossils discussed here from Powers Pit may also have similarities in the nature of the cuticle. The leaves illustrated in Fig. 12 C and G may represent one species while the specimen illustrated in Fig. 12 D, E is certainly a different species. Cuticular features will be important to distinguish them.

Material examined.—UF18810-34381, 34385a, 34409, 34410a, 34411.

Magnoliales

Annonaceae

Duguetia sp.

(Fig. 10, D, E; Fig. 14, C; Fig. 16, A)

Description.—Leaf incomplete, lamina elliptic, symmetrical, ~10–17 cm long by 4.2–9 cm wide, length/width ratio 1.9:1 – 2.4:1; apex missing; base obtuse; margin entire. Venation pinnate; secondary venation brochidodromous, ~14 pairs of secondary veins, angle of divergence 50–80°, secondary veins mostly alternate, with basal venation sigmoidal, and mid to upper venation arching slightly or straight, from the midvein to near the margin then arching sharply upward joining superadjacent vein. Up to two strong intersecondary veins in each intercosta, sometimes flanked by weaker and shorter intersecondary veins. Tertiary veins percurrent to lineate, sometimes forked and at right angles to secondary veins. Excostal veins uniseriate to biseriate, close to margin. Ultimate venation open.

Discussion.—The characters of shape, margin, and narrowly spaced secondary veins are characteristic in

the families Annonaceae and Magnoliaceae. The difference is in the angle of the secondary veins, and ultimate venation. In Magnoliaceae, the secondary veins have moderate angles ($<55^\circ$) and the ultimate venation is closed, while in Annonaceae and the Powers Pit specimens, the secondary veins are high angled ($>55^\circ$) and the ultimate venation is open (Klucking 1986). Specimen UF34418 is similar to *Magnolia leei* Knowlton (Berry 1916, 1922, 1930, 1941) and *Duguetia leei* (Knowlton) Roth et Dilcher (Roth 1981) in the nature of the secondary venation and the percurrent tertiary veins. Specimen UF34407 is similar to *D. argentea* Fries in secondary and excostal venation, and in that the tertiary veins are lineate. Although the genus was identified from other Claiborne clay pits using characters of epidermal anatomy (Roth 1981), the specimens from Powers Pit were not investigated anatomically. The extant species *Duguetia* is distributed in the Neotropics (Roth 1981; Dilcher 2000b).

Material examined.—UF18810-34407, 34418.

Liliales
Smilacaceae
Smilax sp. 1
(Fig. 13, C, D)

Specimen description.—Lamina ovate, symmetrical, ~ 6.5 cm long by 3.6 cm wide; apex missing; base angle obtuse, with concave flanks; margin entire. Petiole missing. Venation basal acrodromous, of three primary veins, two secondary veins basal acrodromous. Tertiary veins mixed opposite, alternate percurrent, tertiary vein angle acute.

Discussion.—The general shape, size, margin, and prominent basal acrodromous venation is similar to Smilacaceae, Rhamnaceae, and Dioscoreaceae. In Rhamnaceae, such as *Ziziphus cinnamomum* Triana & Planch. (Heald 2002), there are three prominent basal acrodromous veins, but they lack the outer less prominent basal acrodromous veins present in Smilacaceae (Conran 1998). In Dioscoreaceae, such as *Dioscorea decipiens* J. D. Hooker (Zhizun & Gilbert 2000) and *D. bulbifera* L. (UF6173), the tertiary venation is distinctly opposite percurrent. The presence of five prominent basal acrodromous veins, and tertiary veins of mixed opposite and alternate percurrent is characteristic of Smilacaceae, and is similar to Berry's *Smilax wilcoxensis* (1930) of the Wilcox Flora, but the basal characters are different from our specimen. Berry's type material is incomplete, but diagramed to show that the secondary veins arise from the midvein independently. This is not the case with *Smilax* sp.1, as a pair of secondary veins arise from the very base of the midvein and then each bifurcates

into the lateral acrodromous veins. If this character is demonstrated to be one of species importance, and if the details of Berry's *S. wilcoxensis* can be determined from other material, then we can ascertain whether these are conspecific. *Smilax* cuticle is known to differ between similar leaves from different localities so that species differences sometimes can be determined only by cuticular anatomy (Sun & Dilcher 1988).

Material examined.—UF18810-34415.

Smilax sp. 2
(Fig. 13, E; Fig. 14, A)

Specimen description.—Lamina ovate-cordate, symmetrical, ~ 8.5 cm long by 6.2 cm basal width; apex missing; base angle obtuse, with cordate flanks; margin entire. Petiole missing. Venation campylodromous, with three primary veins, two secondary veins basal acrodromous. Tertiary venation barely discernable.

Discussion.—The conspicuous characters of *Smilax* sp. 2, such as basal acrodromous venation with a cordate leaf base and entire margin, can be found in Smilacaceae and Dioscoreaceae, although in Dioscoreaceae they can have up to 11 primaries and the tertiary venation is distinctly opposite percurrent (Zhizun & Gilbert 2000; Raz 2002). Although the leaf shape of extant *Smilax bona-nox* L. is highly variable (Godfrey 1988), some forms with a cordate base are similar to our specimen. There are about 300 extant species of *Smilax* worldwide. Many species are common in southeastern North America extending into Mexico and Central America.

Material examined.—UF18810-34435

Undetermined Monocot sp.
(Fig. 19, B)

Specimen description.—Leaf blade fragment, 1.3 cm wide. One strong midvein and one strong parallel marginal vein, otherwise other parallel veins barely discernable. No cross venation evident.

Discussion.—Lack of definitive characters makes further determination of this specimen impossible at this time. If cross veins were preserved, this character might be attributed to the palms. The lack of characters is not due to poor preservation alone, as a palm leaf fragment would normally show parallel secondary veins and the typical cross veins.

Material examined.—UF18810-34400

Proteales
Platanaceae
Platanus sp.
(Fig. 7, A-C)

Specimen description.—Leaf incomplete, palmately lobed, appears to be 3-lobed; apex missing; base angle obtuse, with rounded flanks. Leaf margin occasionally serrate, teeth straight to curved, sinuses rounded. Petiole missing. Venation palinactinodromous; secondary venation camptodromous, angle of divergence 35–40°.

Discussion.—The lobed nature of the leaf is similar to Lauraceae (*Sassafras*), Altingiaceae (*Liquidambar*), and Platanaceae (*Platanus*), although in *Sassafras* and *Liquidambar* the primary venation is suprabasally actinodromous, and in *Liquidambar* the margins are continuously serrate, and with basal lobing (Schwarzwalder 1986). General characters such as lobes, venation, and occasional teeth are similar to *Platanus* sp., although Platanaceae venation is sometimes superbasally actinodromous. The secondary veins are not sufficiently preserved near the margins to determine if they extend into the teeth (“Platanoid”) or not, but the slope does suggest that they curve away from the teeth as in *Platanus kerrii* Gagnep. (Schwarzwalder 1986). This is the first occurrence of a lobed *Platanus* leaf in the Claiborne flora. Pollen of *Platanus* is recorded from the upper Claiborne of the Mississippi Embayment (Frederiksen 1980a, 1988).

Material examined.—UF18810-34439.

Saxifragales
Altingiaceae
Liquidambar sp.
(Fig. 18, D, H)

Specimen description.—Fruit laterally compressed, subglobose, 2 cm diameter. Convolute carbonaceous material with scattered circular impressions of style bases with, or without acute impressions of style tips.

Discussion.—Impressions in the fruit appear similar to *Liquidambar styraciflua* L. before dehiscence of the basal portion of the persistent styles (Godfrey 1988). *Liquidambar* fruit have been recorded from the Claiborne flora but were not described or figured (Berry 1930). Pollen of *Liquidambar* is recorded from the upper Claiborne of Alabama (Gray 1960).

Material examined.—UF18810-34432.

Myrtales
Myrtaceae
Myrcia sp.
(Fig. 10, F-H)

Specimen description.—Leaf incomplete, lamina possibly elliptic, ~ 7 cm long by 3.2 cm wide; apex and base missing; margin entire. Petiole missing. Midvein stout; venation pinnate; secondary veins narrowly spaced, angle of divergence 70–80°, straight from midvein to

intramarginal vein. Some intersecondary veins present, a few admedially branched. Leaf margins with paired intramarginal veins, one running along the margin, the second 1–2 mm inside the leaf margin and slightly scalloped. Tertiary veins sometimes joining secondary veins at acute angles.

Discussion.—The spacing and angle of the secondary veins, along with the intramarginal venation is similar to *Qualea* in Vochysiaceae, and *Calyptanthus*, *Syzygium* and *Myrcia* in Myrtaceae (Klucking 1988). The difference is in the intersecondary veins, in Vochysiaceae they branch toward the margin, while in Myrtaceae some are admedial, branching towards the midvein. Also, in Vochysiaceae, the secondary veins curve toward the margin (Sajo & Rudall 2002). Venation is similar to *Myrcia* and *Syzygium*, but in *Syzygium* the secondary veins are recurved to sigmoidal (Klucking 1988). Leaf size, along with secondary and intramarginal venation is similar to *Calyptanthus eocenica* Berry (Berry 1916), but in *Calyptanthus*, both intramarginal vein pairs run 1–2 mm inside the leaf margin (Klucking 1988). Pollen of Myrtaceae (*Myrtaceidites*) is recorded from the upper Claiborne of Mississippi and Alabama (Gray 1960; Engelhardt 1964; Frederiksen 1980a, 1988).

Material examined.—UF18810-34386.

Fabales
Fabaceae
Cladrastis-like sp.
(Fig. 10, A-C)

Description.—Lamina of leaflet lanceolate, symmetrical to slightly asymmetrical, 6.5–9.5 cm long by 2–2.3 cm wide, length/width ratio 3.3:1 – 4.1:1; apex angle acute; base angle obtuse, with rounded flanks; margin entire. Petiolule 3 mm long, with cross striations. Venation pinnate; secondary venation brochidodromous, 9–10 pairs of secondary veins, angle of divergence 30–60°, secondary veins straight or arching from midvein to near margin then arching up to superadjacent vein. One to two intersecondary veins per intercosta. Midvein deeply impressed. Tertiary veins orthogonal. Excostal venation in 1–2 series.

Discussion.—The size, shape, apex, and venation are similar to *Sapindus* (Sapindaceae) and *Cladrastis* (Fabaceae) but in *Sapindus* the base is cuneate, curved, and asymmetrical (UF335, 340, 343, 345, 352; Herendeen 1992; Yu & Chen 1991). The venation and size of the smaller leaflets are similar to *Gleditsiophyllum eocenicum* Berry (Berry 1916; Herendeen 1992). Extant species of *Cladrastis* have a temperate distribution (Herendeen 1992).

Material examined.—UF18810-34402, 34413a,

34421, 34428.

Ormosia-like sp. 1

(Fig. 11, A-C)

Description.—Lamina of leaflet elliptic, symmetrical, 11 cm long by 4.7-5.6 cm wide; apex angle acute, with acuminate flanks; base angle acute, with convex flanks; margin entire. Petiolule missing. Venation pinnate; secondary venation weak brochidodromous, 6-8 pairs of secondary veins, angle of divergence 40-60°, secondary veins alternate, broadly arching from the midvein to near the margin then arching sharply and directed medially toward midvein joining superadjacent vein. Weak basal secondary veins, and 1-3 weak to strong intersecondary veins per intercosta. Tertiary veins percurrent, straight to slightly sinuous, unbranched to branched, tertiary angle obtuse.

Discussion.—The absence of a petiolule makes the determination to family difficult because the leaflets of legumes frequently have short, wrinkled appearing petiolules. The general shape, size, apex, margin, and venation of these specimens suggest leaflets in the families Fabaceae and Connaraceae. These two families seem very close in the morphological characters of their leaflets, although in Connaraceae the tertiary venation is generally more prominent as in *Connarus fasciculatus* (de Candolle) Planchon (Forero 1983) and *Rourea minor* (Gaertn.) Alston (Jongking 1989). Within Fabaceae, this fossil leaflet morphology and venation are similar to *Swartzia racemosa* Benth. (FLAS 165336) and *Ormosia grandiflora* (Tul.) Rudd although in *S. racemosa* the margins have a few teeth. Further study of the anatomy would help to clarify the generic and species determination of these fossils. At present the leaflets appear most similar to *Ormosia* sp. 1 (Herendeen 1992; Fig. 119) and so are placed in that genus.

Material examined.—UF18810-34404a, 34406.

Ormosia-like sp. 2

(Fig. 7, I, K)

Specimen description.—Leaflet incomplete, lamina narrowly elliptic, symmetrical, ~ 6 cm long by 1.4 cm wide, length/width ratio ~ 4.3:1; apex missing; base angle acute, with slightly convex flanks; margin entire. Petiolule prominently cross-striated, 0.8 mm long by 0.15 mm wide. Venation pinnate; secondary venation brochidodromous, angle of divergence 30-40°, secondary veins alternate, extending straight from midvein to margin or curving abruptly upward near the margin. One pair of weak acute basal secondary veins, and 1-2 intersecondary veins per intercosta. Tertiary veins percurrent. Quaternary veins random and reticulate.

Discussion.—Leaflet petiolules with prominent striations are found in Fabaceae and Connaraceae, but the shape of this leaflet is similar to extant *Ormosia* (Fabaceae) such as *Ormosia nitida* Vog. and *O. monosperma* (Sw.) Urb. (Rudd 1965). The shape, base, margin, and venation is similar to fossil *Ormosia* sp. 2 (Herendeen 1992). Extant species of *Ormosia* can be found in the tropics of Asia, Australia, Madagascar, and America (Herendeen 1992).

Material examined.—UF18810-34395.

Swartzia sp.

(Fig. 7, D-H, J, L; Fig. 13, A, B)

Description.—Lamina of leaflet narrowly elliptic to elliptic, symmetrical, 3.7-8 cm long by 1.3-4 cm wide, length/width ratio 2:1 – 2.8:1; apex angle acute to obtuse, retuse; base angle acute to obtuse, with convex to concave flanks; margin entire. Petiolule missing. Venation pinnate; secondary venation strongly brochidodromous, angle of divergence 50-60°, secondary veins alternate, with 5-6 pairs, straight from midvein to near margin, then arching upwards. One pair of weak acute basal secondary veins, and 1-2 strong intersecondary veins per intercosta. Tertiary veins orthogonal reticulate. Associated pod incomplete (UF 34419a, not figured), apex missing, base curving with basal portion missing. Parallel oblique striations near base, marginal suture well developed.

Discussion.—Although the morphology and venation are similar to numerous species of *Swartzia* (Fabaceae) such as *Swartzia parvifolia* Schery, *S. apetala* Raddi, and *S. corrugata* Benth (Cowan 1968), future anatomical work is needed to confirm this determination. The shape, size, margin, apex, base, and venation of the leaflets, and pod shape and size are similar to the fossil species *Swartzia* sp. 1 (Herendeen 1992), although the leaflet determination was based mainly on anatomical characters. Fabaceous pollen is recorded in the upper Claiborne of the Mississippi Embayment (Frederiksen 1980a). Extant species of *Swartzia* are distributed in the Neotropics and Africa (Herendeen 1992).

Material examined.—UF18810-34388a, 34391, 34393, 34394, 34419a, 34420.

Fagales

Fagaceae

Berryophyllum tenuifolia (Berry) Jones et

Dilcher

(Fig. 17, H; Fig. 18, B)

Specimen description.—Leaf incomplete, lamina linear, symmetrical, ~ 9 cm long by 0.4 cm wide at

middle; apex missing; base angle acute, with cuneate flanks; margin serrate for most of leaf length. Petiole missing. Venation pinnate; secondary venation craspedodromous, angle of divergence 40° , secondary veins alternate, straight to leaf margin, one entering the tooth, the adjacent vein running alongside leaf margin.

Discussion.—The shape, size, margin, and venation are similar to leaves of Fagaceae, and the fossil species *Banksia tenuifolia* proposed by Berry which was renamed *Berryophyllum tenuifolia* (Berry) Jones et Dilcher (Berry 1916; Jones & Dilcher 1988). Fagaceous pollen (*Quercoidites*, *Cupuliferoi-pollenites*) is recorded in the upper Claiborne of the Mississippi Embayment (Frederiksen 1980a, 1988) and from the Lawrence (*Quercus*) and Warman (*Quercoidites*) clay pits (Elsik & Dilcher 1974; Potter 1976).

Material examined.—UF18810-34389.

Berryophyllum sp.

(Fig. 17, E-G)

Description.—Leaves incomplete, lamina narrowly elliptic, symmetrical, ~20 cm long by 2 cm wide at middle; apex and base missing; upper 25% of leaf attenuate, lower 25% of leaf cuneate. Margin serrate in upper 75% of leaf; teeth sharp, prominent, 1 mm long, basal side straight to convex, apical side concave. Petiole missing. Venation pinnate; basal secondary venation camptodromous, secondary venation craspedodromous in mid and upper portions of leaf, angle of divergence $50-60^\circ$, secondary veins alternate, arching gradually from midrib to margin, one vein entering each tooth, adjacent 1-2 veins running parallel to margin. Secondary veins forked just below tooth, of equal strength, one entering tooth medially and the other running parallel to margin. One to two intersecondary veins per intercosta. Tertiary veins percurrent, simple to branched. Quaternary veins random.

Discussion.—The leaf characters seem to be intermediate between *Berryophyllum warmanense* Jones et Dilcher and *B. saffordii* (Lesq.) Jones et Dilcher. The tooth shape and the way the secondary veins enter the teeth are characters that match *B. warmanense*, while the leaf size, margin, and secondary venation match *B. saffordii* (Jones & Dilcher 1988). It has been suggested that *Trigonobalanus* and *Colombobalanus* may be related extant genera that are found in tropical Asia, and the mountains of Colombia (Dilcher 2000b).

Material examined.—UF18810-34396, 34408a.

Knightiophyllum wilcoxianum Berry

(Fig. 16, B, C, G)

Description.—Lamina narrowly elliptic, symmetrical, ~11-13 cm long by 1.8-2.5 cm wide; apex and base angle acute, with cuneate flanks. Margin serrate and confined to the middle and distal half of the leaf; teeth short, less than 1 mm, basal flank convex, apical flank concave. Petiole missing. Venation pinnate; secondary venation camptodromous to semicraspedodromous, angle of divergence $40-60^\circ$, secondary veins alternate, arching gradually from midvein to near margin then joining the superadjacent vein. One to two intersecondary veins per intercosta. Tertiary veins orthogonal, tertiary veins arising from a secondary marginal loop enter the teeth. Ultimate veins freely ending and one branched.

Discussion.—The shape, size, apex, base, margin, and venation are similar to *Knightiophyllum wilcoxianum* Berry (Berry 1916; Dilcher & Mehrotra 1969) except in this material the teeth are only in the distal half of the lamina. The systematic placement of this genus appears to be with Fagaceae but no modern genera have been found that are similar to *K. wilcoxianum* (Dilcher & Mehrotra 1969). Morphological features such as leaf margin with a few teeth, general looping of the secondary veins, tertiary vein from secondary looping entering teeth, and intersecondary veins common, are characteristic of Fagaceae, notably *Quercus* section *Erythrobalanus* (Jones 1984), near *Quercus viminea* but the teeth are not as prominent as in *Q. viminea* (Villarreal 1986).

Material examined.—UF18810-34424, 34425a

Malpighiales

Salicaceae

Populus sp.

(Fig. 16, D; Fig. 17, A)

Specimen description.—Leaf incomplete, lamina elliptic, symmetrical, ~6 cm long by ~3 cm wide; apex and base missing. Margin serrate/dentate; teeth apex obtuse (they appear to be glandular) to acute, sinus rounded. Petiole missing. Venation pinnate; secondary venation semicraspedodromous, with one subactinodromous vein, angle of divergence 60° basally, $40-50^\circ$ apically. Intersecondary veins per intercosta one or absent. Tertiary veins not well preserved.

Discussion.—Although the leaf is incomplete, and tertiary veins are not well preserved, characters such as shape, subactinodromous and semicraspedodromous venation, and toothed margins are similar to extant leaves of *Populus* (Salicaceae; Eckenwalder 1980) and "Tiliaceous" species *Dicraspidia donnell-smithii* Standley (Robyns 1964) and young seedlings of *Tilia americana* L. (UF6174). In *D. donnell-smithii* and *T. americana*, the secondary venation is mostly

craspedodromous, the teeth lack glands, and the sinus of the teeth are angular. The shape of some forms of *Cercidiphyllum japonicum* Siebold & Zucc. with toothed margins, and teeth with a rounded sinus is similar to the fossil, but in *C. japonicum* the secondary venation is brochidodromous (UF1965). The presence of glandular teeth is characteristic of *Populus*. The venation and teeth are similar to middle/upper portions of *Grewiopsis tennesseensis* Berry (1916) which is considered similar to *Populus cinnamomoides* (Lesq.) MacGinitie (Eckenwalder 1977, 1980). The fossil described here may be an intermediate form between a linear juvenile and deltoid adult leaf of *Populus* (Eckenwalder 1980).

Material examined.—UF18810-34397.

Rosales
Moraceae
Pseudolmedia sp.
(Fig. 14, B, D)

Description.—Lamina obovate, slightly inequilateral, ~14 cm long by 6.3 cm wide; apex angle acute (not illustrated, UF 34425b); base angle acute, with asymmetrical flanks; margin entire. Petiole missing. Venation pinnate; secondary venation brochidodromous, ~ 14 pairs of secondary veins present, angle of divergence 40-50°, secondary veins alternate, straight from midvein to near margin then arch sharply upward joining superadjacent veins. Basal pair of secondary veins, occasional 1-2 intersecondary veins per intercosta usually extending less than ½ the distance from midrib to margin. Tertiary veins alternate percurrent and forked, at right angles to secondary veins. Excostal veins uniseriate, close to leaf margin.

Discussion.—The large size, margin, and the basal pair of secondary veins are typical characters of Moraceae. The combination of characters such as shape of the apex and base, margin, number and angle of secondary vein pairs, intersecondary veins, and percurrent tertiary veins are common in *Pseudolmedia*. These characters also can be found in *Naucleopsis* but in *Naucleopsis* the percurrent tertiary veins are in a distinct double layer in the intercostal area (Berg 1972; FLAS 132816; UF1483). Berry (1916) recognized *Pseudolmedia* in the Wilcox flora (now Claiborne Flora) of Tennessee but the leaves he described are narrower and the secondary veins arise from the midvein at a 90° angle. The extant genus *Pseudolmedia* is distributed in the Neotropics (Berg 1972; Burger 1977).

Material examined.—UF18810-34417, 34425b.

Ficus-like sp.

(Fig. 8, C, D)

Specimen description.—Lamina elliptic, symmetrical, 9.5 cm long by 3.7 cm wide; apex angle obtuse, with convex flanks; base angle acute, with concave flanks; margin entire. Petiole missing. Venation pinnate; secondary venation brochidodromous, 14 pairs of secondary veins, angle of divergence basally 60-70°, apically 40-50°, secondary veins subopposite basally to alternate apically, straight from midvein to near margin, then arching upward parallel to margin, then arching medially joining superadjacent vein, also a prominent secondary loop above this lower loop. One pair of low angled basal secondary veins present, 1-3 strong to weak intersecondary veins per intercosta, extending to less than ½ distance to margin. Excostal veins in 2-3 series. Tertiary veins reticulate.

Discussion.—The general shape and size, apex, base, margin, brochidodromous venation with high angled basal secondary veins, 1-3 strong and weak intersecondary veins, and reticulate tertiary veins are characteristic to the families Moraceae and Lecythidaceae, although in Lecythidaceae the intersecondary veins can extend to more than ½ leaf distance from midrib to margin, and they lack a pair of basal low angle secondary veins. In Moraceae, the lowermost basal secondary vein angle is different from other basal secondary veins, and a prominent secondary loop over the junction of the secondary vein with the superadjacent vein is evident in many species. Leaf shape, size, base shape, and venation of this specimen is similar to the fossil *Ficus purpureaensis* Berry (1916) and extant *Ficus* (Burger 1977), although in Berry's description the secondary venation angle is nearly 90° while the figures (Plate XXVIII) are closer to our measurements. The secondary vein angle is in the low range for extant *Ficus*. *Ficus* pollen has been recorded in the upper Claiborne of Alabama (Gray 1960). Berry's (1916, 1930) floras included an excessive number of species in the genus. A detailed re-evaluation of the genus is needed in order to evaluate the real nature of all the so-called *Ficus* leaves from the Claiborne of southeastern North America.

Material examined.—UF18810-34446.

Rhamnaceae
Berhamniphyllum claibornense Jones et
Dilcher
(Fig. 12, A, B)

Specimen description.—Leaf incomplete, lamina narrowly elliptic, symmetrical, ~ 11 cm long by 4 cm wide; apex angle acute, with cuneate flanks; base miss-

ing; margin entire. Petiole missing. Midvein straight; venation pinnate; secondary venation eucamptodromous, angle of divergence 20-30°, secondary veins opposite basally to alternate apically, straight to slightly curved from midvein to near margin then arching abruptly upward to the margin. Secondary veins rarely divided near the margin. Tertiary venation barely perceptible, percurrent, straight, perpendicular to the midrib.

Discussion.—Leaf venation characters such as secondary venation eucamptodromous and percurrent tertiary veins perpendicular to the midrib, are characteristic of Rhamnaceae. The general shape, apex, margin, and venation are similar to the fossil leaves *Berhamniphyllum claibornense* Jones et Dilcher (Jones & Dilcher 1980). *Berhamniphyllum claibornense* is closely related to the tribe Rhamneae (Richardson et al. 2000), and possibly the extant genera *Berchemia* and *Rhamnidium* (Jones & Dilcher 1980) that have primarily tropical distributions (Record 1939; Brizicky 1964). The fossil leaves have frequently been reported as *Rhamnus* however identifications to extant genera can not be validated without fruiting material, even if perfectly preserved leaves complete with cuticular material (even extant leaves) are preserved. A new genus was proposed by Jones and Dilcher (1980) to indicate that only the family Rhamnaceae and tribe Rhamneae can be determined based upon leaf material.

Material examined.—UF18810-34384.

Berhamniphyllum sp.

(Fig. 9, D, G, H)

Specimen description.—Lamina elliptic, symmetrical, 6.3 cm long by 3 cm wide; apex angle acute, retuse; base angle acute, with convex flanks; margin entire. Petiole missing. Venation pinnate; secondary venation eucamptodromous, angle of divergence 40°, basal secondary veins opposite, becoming alternate towards the apex, secondary veins straight to slightly curved as they extend from the midvein then arch abruptly upward to near the leaf margin.

Discussion.—Although the lack of tertiary venation creates difficulty in the identification of this fossil, the general shape and size, base, margin, and secondary venation is very similar to *Berhamniphyllum claibornense* Jones et Dilcher (Jones & Dilcher 1980). The apex is retuse, which is not in the species description of *B. claibornense* (Jones & Dilcher 1980), but is found in species of *Rhamnidium* such as *R. ellipticum* Britton et P. Wilson and *R. shaferi* Britton et P. Wilson (Britton 1915).

Material examined.—UF 18810-34427.

Sapindales
Sapindaceae
Cupanites sp.
(Fig. 17, B, D)

Specimen description.—Leaflet incomplete, lamina narrowly oblong, asymmetrical, ~ 7 cm long by 2.1 cm wide; apex missing; base angle acute, with convex and asymmetrical flanks. Margin with a few serrate teeth from middle to apical portion of leaf. Petiole ~ 1 mm long and expanded at base. Midvein stout; venation pinnate; secondary venation semicraspedodromous, angle of divergence 50-60°, secondary veins alternate to subopposite, straight from midvein to near margin, then divided, one continuing toward margin and teeth, one arching upward joining superadjacent vein. One to two intersecondary veins per intercosta. Tertiary veins at right angle to secondary veins. Excostal veins in one series.

Discussion.—The general shape and size, margin with serrate teeth, asymmetrical base, and venation is similar to leaflets of Sapindaceae and Juglandaceae, although in Juglandaceae the secondary vein divides just before entry into the tooth, one entering the tooth, the other going towards the sinus. The leaflet is similar to the fossil species *Cupanites* (Berry 1916, 1930) and extant *Cupania glabra* (Standley & Steyermark 1949; UF310), although in Berry's *Cupanites*, the venation is craspedodromous and the teeth extend along the full length of the leaf. *Cupania*-like pollen (*Cupanieidites*) and megafossils are recorded in the upper Claiborne of Mississippi and Alabama (Gray 1960; Engelhardt 1964; Frederiksen 1980a, 1988). Distribution of extant *Cupania* is Neotropical (Standley & Steyermark 1949).

Material examined.—UF18810-34401.

Cornales
Nyssaceae
Nyssa eolignitica Berry
(Fig. 18, G, K)

Specimen description.—Endocarp ovate, 2 cm long by 0.8 cm wide, apex acute, base rounded. Fruit trilocular with numerous longitudinal ridges on the surface.

Discussion.—This fruit is similar to *Nyssa eolignitica* Berry (Berry 1916; Dilcher & McQuade 1967) and *N. wilcoxiana* Berry (1916, 1930). *Nyssa*-like pollen (*Nyssapollenites*) is recorded in the upper Claiborne of Mississippi and Alabama (Gray 1960; Engelhardt 1964; Frederiksen 1980a). Distribution of the extant genus *Nyssa* is temperate, cool/warm temperate of the United States and China to the tropics of Mexico/Central America, East Asia and Malaysia/Indonesia (Dilcher 2000b).

Material examined.—UF18810-34392

Ericales

Theaceae

Ternstroemites sp.

(Fig. 16, E, F; Fig. 17, C, I; Fig. 18, A, E)

Description.—Lamina mostly elliptic to narrowly elliptic, sometimes obovate, symmetrical, 5.8–14.5 cm long by 3.2–3.3 cm wide, length/width ratio 2.6:1–4.4:1; apex angle acute to obtuse, with emarginate to acuminate flanks; base angle acute, with cuneate to decurrent flanks. Margin crenulate to serrate to near the base; some teeth with glands (UF34405). Petiole 2 cm long and expanded at base. Midvein stout, ~ 1 mm wide at middle section of leaf. Venation pinnate; secondary venation camptodromous to semicraspedodromous, 9–10 pairs of secondary veins, angle of divergence 40–60°, secondary veins alternate to subopposite, straight to slightly curved from midvein dividing 1–2 times before joining superadjacent vein. Excostal veins in two series, some terminating in crenulate to serrate teeth. One to two intersecondary veins per intercosta. Tertiary veins percurrent and forked.

Discussion.—The shape and size, venation, and presence of glandular teeth are characteristic of Theaceae and Ternstroemiaceae, but whether the glands are deciduous (Ternstroemiaceae) or permanent (Theaceae) is not evident in the fossil specimens (Weitzman et al. 2004; Stevens et al. 2004). Characters such as venation, crenate to serrate margin, and glandular teeth are similar to extant *Gordonia lasianthus* (L.) Ellis (Theaceae, UF5191). Overall, these characters can be found in *Eurya*, *Adinandra* and *Ternstroemia* (Ternstroemiaceae, Kobuski 1939, 1942a,b, 1943, 1947), although not in any one particular species. For exact systematic placement of the fossil *Ternstroemites* sp., a leaf venation comparison study is needed for Theaceae and Ternstroemiaceae. A detailed study of the leaves of *Gordonia* and related genera is in progress by Dilcher and Wang. Distribution of extant species of *G. lasianthus* and *Ternstroemia* is warm temperate to predominately Neotropical (Kobuski 1942a,b, 1943; Dilcher 2000b).

Material examined.—UF18810-34390, 34399, 34405, 34426, 34429.

cf. *Gordonia* sp.

(Fig. 18, C, I)

Specimen description.—Flower, ~ 1.8 cm by ~ 5 mm basal width, 5 sepals, the lobes with 3–5 longitudinal striations per 1 mm. Petals and carpels missing. About 46 stamen impressions in 2–3 series, ovary 3.5 mm basal width.

Discussion.—The flower is tentatively allied with the leaves, *Ternstroemites*. However, a total re-study of the fossil record of this complex is in progress. Grote and Dilcher (1989) described fruits that are also related to these leaves and flowers. One species, *Andrewsiocarpon henryense* Grote & Dilcher was recognized as totally extinct today but closely related to *Franklinia alatamaha* Marsh. The leaves and flowers mentioned here form part of this complex and are typical of *G. lasianthus* found in the swamp forests of north Florida today. The flower width of *G. lasianthus* is 8 cm including petals, absent in the fossil (Godfrey 1988), 3–4 cm in *Ternstroemia* sp. (Kobuski 1942a,b, 1943), and 2 cm in *Adinandra parvifolia* Ridley (Kobuski 1947). A similar flower (*Antholithes ternstroemioides* Berry), slightly larger than our specimen, was reported by Berry (1930) as similar to *G. lasianthus*.

Material examined.—UF18810-34438.

Gentianales

Apocynaceae

Apocynophyllum sp.

(Fig. 11, D, E)

Specimen description.—Leaf incomplete, lamina elliptic, symmetrical, ~ 12 cm long by ~ 4.5 cm wide; apex missing; base angle acute, with slightly decurrent flanks; margin entire. Petiole width at blade base 1 mm, width at petiole base 2 mm. Venation pinnate; secondary venation brochidodromous, angle of divergence 40–50°, secondary veins widely spaced, straight from midvein to near margin, then arching upward and medially to superadjacent vein. Tertiary veins reticulate.

Discussion.—The incomplete and poorly preserved nature of this specimen makes further determination difficult. The leaf is similar to the acute basal form of *Apocynophyllum mississippiensis* Berry, except for the widely spaced secondary veins and reticulate tertiary veins (Berry 1916, 1930; Dolph 1975). Dolph (1975) undertook an extensive study of *Apocynophyllum* leaf types from the Claiborne sediments of several clay pits in western Tennessee and Kentucky. He recognized two distinct subspecies of this extinct genus and after extensive research has been unable to ally it systematically with any extant family.

Material examined.—UF18810-34441.

Rubiaceae

cf. *Paleorubiaceophyllum* sp.

(Fig. 9, A, B)

Specimen description.—Leaf incomplete, lamina elliptic, symmetrical, ~ 7.5 cm long by 3.5 cm wide; apex

missing; base angle obtuse, with short cuneate flanks; margin entire. Petiole incomplete, ~ 5 mm long. Midvein stout; venation pinnate; secondary venation brochidodromous, angle of divergence 50-60°, more than 10 pairs of secondary veins, sub-opposite to alternate, straight from midvein to near margin then arching abruptly upward to superadjacent vein. One to two intersecondary veins per intercosta. Excostal veins in one series and looped. Tertiary veins inconspicuous.

Discussion.—The incomplete nature of this leaf makes our determination uncertain but the general shape and size, base, margin, and secondary venation are similar to *Paleorubiaceophyllum eocenicum* (Berry) Roth et Dilcher (Roth & Dilcher 1979). Additional specimens are needed to determine if the petiole does have a stipule attached to its base. This feature is common to all species of *Paleorubiaceophyllum*.

Material examined.—UF18810-34431

Apiales
Araliaceae

Dendropanax eocenensis Dilcher et Dolph
(Fig. 6, A-D)

Description.—Lamina obovate, palmately 3-4 lobed, 5.4-6.7 cm long by 5.8-8.5 cm wide, lobes entire and sometimes with secondary lobes; apex angle acute, with cuneate flanks; base angle acute, with concave flanks. Petiole missing. Venation actinodromous, single vein entering each lobe; secondary venation interior, basal sub-primary vein running along margin of basal lobe. Tertiary venation reticulate.

Discussion.—The shape and size, lobing, and venation are similar to *Dendropanax eocenensis* Dilcher et Dolph (Dilcher & Dolph 1970) except for the lobing of one specimen that has four lobes, while the specimens described as *D. eocenensis* have three or five lobes. Rare Araliaceous pollen is recorded in the Cockfield Formation of Mississippi (Engelhardt 1964). The distribution of extant *Dendropanax* is tropical America and eastern Asia (Mabberley 1989).

Material examined.—UF18810-34380, 34382a, 34383.

Lamiales
Oleaceae leaf morphotype
(Fig. 11, F; Fig. 12, F)

Specimen description.—Leaf incomplete, lamina possibly elliptic, symmetrical, ~ 7.5 cm long by 3.5 cm wide; apex missing; base angle acute, with asymmetrical and slightly decurrent flanks; margin entire. Petiole slender, 1 mm wide. Venation pinnate; secondary venation eucamptodromous, angle of divergence 60°, sec-

ondary veins opposite to alternate, straight from midvein to near margin, then arching upward to margin. One to two intersecondary veins per intercosta, traversing up to 1/2 distance to leaf margin. Tertiary veins at right angle to secondary veins, straight and divide to adjacent secondary.

Discussion.—An acute and asymmetrical leaf base, plus a slender petiole are traits of Oleaceae and many other families. Further samples are needed for a clear indication of the distal portion of the leaf for characterization and possible generic determination. Cuticular characters might also be helpful. Berry (1916) assigned leaves to *Fraxinus* and *Osmanthus*, while Berry (1916) and Call and Dilcher (1992) described samaras of *Fraxinus*. Oleaceous pollen (*Salixipollenites*) is recorded in the upper Claiborne of the Mississippi Embayment (Frederiksen 1980a, 1988).

Material examined.—UF18810-34430

Incertae sedis
Entire Margin Morphotype 1
(Fig. 9, C, E, F)

Specimen description.—Leaf incomplete, lamina narrowly elliptic, symmetrical, ~ 5 cm long by 2.1 cm wide; apex and base missing; margin entire. Petiole missing. Midvein stout; venation pinnate; secondary venation brochidodromous, angle of divergence 40-50°, ~ 10 pairs of secondary veins mostly alternate, arching from midvein to near margin, then arching upward and parallel with the margin, then arching medially to join the superadjacent vein. One to three weak to strong intersecondary veins per intercosta, the strong vein extending 1/2 to 3/4 width of leaf before dividing and joining secondary veins. Excostal veins in one series. Tertiary veins at right angle to secondary veins, joining intersecondary and secondary veins.

Discussion.—The lack of an apex and base makes determination to any known leaf type difficult. The lamina of the fossil leaf appears to have a slight V-configuration in which the midvein is depressed. In the specimen figured in Figure 9, C, E, and F, we see the abaxial side of the leaf so the midvein appears to stand out and the lamina is an inverse V-configuration. Overall shape, and venation are similar to those of extant *Maranthes* (Chrysobalanaceae) (Prance 1972), *Allophylus*, *Deinbollia*, *Meliococca*, *Scyphonychium*, and *Talisia* (Sapindaceae) (Standley & Steyermark 1949), and the fossil *Chrysobalanus inaequalis* (Lesq.) Berry (Berry 1916).

Material examined.—UF 18810-34433.

Entire Margin Morphotype 2

(Fig. 8, A, B)

Description.—Lamina of leaflet elliptic, symmetrical, ~ 6.5-9.5 cm long by 2.5-3.2 cm wide; apex angle acute, with acuminate flanks; base angle acute, with convex flanks; margin entire and undulate. Petiole missing. Venation pinnate; secondary venation eucamptodromous, angle of divergence 40-50°, secondary veins mostly alternate, arching from midvein to very near margin, extending to but not merging with the marginal vein or one areole loop away from the margin. Secondary veins connected to superadjacent veins by a series of tertiary cross veins. One or two intersecondary veins per intercosta, intersecondary veins traversing up to ¾ distances to the leaf margin. Tertiary veins reticulate.

Discussion.—Our specimens lack a petiole which results in fewer characters useful in systematic placement. The general shape and size, apex, base, margin, and venation are similar to *Aegiphila* (Lopez-Palacio 1977) in the Verbenaceae but petiole characters are important. The Anacardiaceae may have leaves or leaflets with revolute or undulate margins that also have secondary veins that arch very close to the leaf or leaflet margins.

Material examined.—UF18810-34444a, b, 34412.

Entire Margin Morphotype 5

(Fig. 15, B, D)

Specimen description.—Leaf incomplete, lamina elliptic, symmetrical, ~12 cm long by 5.5 cm wide; apex and base missing; margin entire. Petiole missing. Venation pinnate; secondary venation brochidodromous, ~ 7 pairs of secondary veins, angle of divergence 30-40°, secondary veins alternate, arching slightly to straight from midvein to near margin, then arch medially joining superadjacent vein, with further weaker vein looping above. Excostal veins in one series. Intercosta of basal portion of leaf with 1-2 mostly weak intersecondary veins extending less than ½ distance to leaf margin. Intercosta of middle and apical portion of leaf with 1-3 intersecondary veins extending up to ½ distance to leaf margin. Tertiary veins weak and appear percurrent.

Discussion.—The incomplete set of characters for this specimen makes it difficult to place systematically. The shape and size, margin, and venation are similar to species such as *Gonzalagunia dicocca* Cham. & Schldl. (Rubiaceae), *Markea coccinea* Rich. (Solanaceae) (Mori et al. 2002), or *Magnolia* (Magnoliaceae).

Material examined.—UF18810-34448.

Tooth Margin Morphotype 1

(Fig. 15, E; Fig. 19, A)

Specimen description.—Leaf incomplete, ~ 2 cm wide; apex angle acute, with attenuate flanks; base missing. Margin variable, midsection of leaf serrate, apical section entire. Venation pinnate; secondary venation variable, midsection venation semicraspedodromous, apical section brochidodromous, angle of divergence 40-50°, secondary veins alternate, arching slightly from midvein to near margin, secondary vein divides at base of tooth, one branch entering tooth, other branch joins superadjacent vein as a tertiary vein. One to two intersecondary veins per intercosta. Tertiary veins percurrent and forked.

Discussion.—The fragmentary nature of this specimen limits the characters available for systematic placement of this leaf morphotype. However, the shape, margin, apex, and secondary venation are similar to *Ilex* species living in the swamps near Gainesville, Florida.

Material examined.—UF18810-34445.

Reproductive Structure Morphotype 1

(Fig. 18, F, J)

Specimen description.—Reproductive structure elliptic, 11 mm long by 5 mm medial width. Apex short acuminate, base obtuse. Numerous closely spaced longitudinal striations or veins, eight near the base dividing to 20 at the midpoint and then rejoining adjacent veins or striations distally.

Discussion.—Berry (1916) placed this type of structure in *Avicennia eocenica* Berry but the systematic placement was not clearly demonstrated. *Avicennia* fruits are much larger, obpyriform or ovate in shape, and the striations are widely spaced. The characters of this fossil do not match *Avicennia*. This structure appears to be the remains of a fruit that is presently undetermined.

Material examined.—UF18810-34434.

Minor Faunal Elements

Insecta

Trichoptera

Insect cases

Folindusia sp.

(Fig. 19, D, G)

Specimen description.—Case straight, 3 cm long, width of posterior end 3 mm, width of anterior end 8 mm. Six transverse leaf pieces cover the case, 2-8 mm in length.

Discussion.—The use of leaf material to build the insect case, the number of leaf pieces, and the case size is similar to extant caddisfly larval cases (Trichoptera) and fossil cases of *Folindusia wilcoxiana* Berry (1927) and *Folindusia* sp. (Johnston 1998). Such insect cases

are typical of fresh water, shallow lakes.

Material examined.—UF18810-34436.

Terrindusia sp.

(Fig. 19, E, F)

Specimen description.—Case incomplete, 4 mm wide. Case covered with minute leaf pieces, woody material and sand grains.

Discussion.—The use of sand grains to build the insect case is similar to that illustrated by Johnston (1998) but in our specimen organic material is mixed with the sand grains.

Material examined.—UF18810-34437.

DISCUSSION

The Paleobotany and Palynology Collection of the Florida Museum contains collections from clay deposits in western Tennessee and Kentucky, beginning in 1959 with Dilcher's collections from Puryear. Dilcher continued to collect fossil plants from this area from the 1960s onward with the help of assistants, students, colleagues and collaborators. Thousands of fossils, including leaves, fruits and seeds, flowers, wood, pollen, and spores have been collected from over 30 localities in western Tennessee, western Kentucky, Mississippi, Alabama, Arkansas, Texas and Louisiana. Among the most recent collections are those from the Powers Clay Pit and nearby localities. This report is a presentation of the Powers Clay Pit flora that is available in our collection at this time. It is the first of a series of reports, detailing the nature of the floras from many of the clay pits with the best preserved and most complete collections of fossil plants.

As additional reports of the middle Eocene localities become available, they will provide the data necessary to ask many interesting and important questions involving the deposition, evolution, distribution and paleobiology of plants from the Gulf Coast of North America. The composition of these floras is expected to have a direct link to the relationships between fossil and modern floras of North America, Central America, northern South America, Africa and tropical Asia (Graham 1999; Dilcher 2001; Jaramillo & Dilcher 2001). Many of these fossil localities given in figure 2 represent a similar depositional environment, but not all of them fall into the same category. There is a distinct probability that each locality represents its own specific time and climate. Therefore, each flora represents a unique part in the evolution of plants, through change in the mixture of floristic elements, and a unique climate. This could occur over a few million years in the upper

middle Eocene. The Powers Clay Pit flora, presented here, is just the beginning of assessing the paleofloristics of this area, the individual plant fossils and their sediments. It is anticipated that a floristic database for each locality will be developed at the Florida Museum of Natural History, and made available to the public on the Internet. Also, the plates of this initial report of Powers Clay Pit will be available at the Paleobotany and Palynology web site (<http://www.flmn.h.ufl.edu/paleobotany/>).

The present discussion is centered upon the Powers Clay Pit fossils. This includes their relationship to fossil plants of other clay pits in the area, realizing that no detailed flora of each locality has yet been done. Much of the floristics of the Powers Clay Pit is established upon leaf morphotypes and comparisons that can be made with leaf types of extant and fossil taxa. The authors feel it is better to publish the available data now rather than to wait until detailed studies have been completed for each leaf type. Detailed studies of individual leaf types are labor intensive in the comparisons of fine venation and cuticle with living and fossil leaves. While this type of research is continuing and is included here for those leaves already studied, we feel that the unique floristic nature of the individual localities of the middle Eocene is also of primary interest and should be presented separately.

Taxa described from the Powers Clay Pit flora allow for character comparisons with other local middle Eocene localities. Detailed species accounts from Powers Clay Pit have documented the first occurrence of a lobed *Platanus* leaf (Fig. 7, A-C), and a *Liquidambar* fruit (Fig. 18, D, H) that is described and illustrated. Also, new leaf characters presented here enhance our knowledge of fossil leaf variation. An example is the intermediate form of *Berryophyllum* sp. where teeth, margin, venation and leaf size demonstrates variations not previously recognized (Jones & Dilcher 1988). Other character variations include the leaf apex of *Berhamniphyllum* sp., and leaf shape in the intermediate form of *Populus* sp. Such variations in leaf form were also found in other localities, along with variations in cuticular characters (Dilcher & Mehrotra 1969; Roth & Dilcher 1979). These authors suggested that the reason for these variations involved the possibility that each fossil locality is of a specific age, with leaf characters changing through time, demonstrating microfeatures of evolution. Some variations may be related with sample size, so an increase in the number of specimens may widen the range of variation. Also, the differences noted between localities were consistent over a large number of specimens from each locality (Roth & Dilcher 1979).

The Powers Pit flora also contains readily identifiable taxa based upon gross morphological features of the megafossils. These include *Berryophyllum tenuifolia* (Berry) Jones et Dilcher (Berry 1916; Jones & Dilcher 1988), *Berhamniphyllum claibornense* Jones et Dilcher (Jones & Dilcher 1980), *Nyssa eolignitica* Berry (Berry 1916; Dilcher & McQuade 1967), and *Dendropanax eocenensis* Dilcher et Dolph (Dilcher & Dolph 1970). Dilcher and Mehrotra (1969) found that consistent cuticular differences could be observed in *Knightiophyllum* leaves between localities but differences were not apparent in the gross features of the leaves.

A recurring problem when identifying extant taxa based upon fossil leaves is the convergence in foliar characters in numerous plant families and genera (Berry 1914). Detailed analyses of venation patterns may help alleviate this problem, such as differences in intersecondary vein branching in Vochysiaceae and Myrtaceae, which in turn helps to identify fossil *Myrcia*. Intersecondary venation and basal secondary venation helps distinguish Moraceae from Lecythidaceae, leading to the identification of *Ficus*. Analyses of secondary vein angles and ultimate venation helped distinguish extant *Duguetia* from *Magnolia* which lead to the identification of fossil *Duguetia*. The determining character used to suggest that Berry's *Magnolia* fossil leaves were really *Duguetia* (Annonaceae) was trichome type (Roth 1981; Dilcher & Roth, unpublished data). Tertiary venation is important, such as in distinguishing similar leaflet forms of Fabaceae from Connaraceae, where overall tertiary venation is more prominent in Connaraceae. Also, *Smilax* and *Dioscorea* leaves are very similar except that in *Dioscorea* the tertiary veins are distinctly opposite percurrent. Sometimes, further morphological studies are needed to distinguish between two closely related families, such as Theaceae and Ternstroemiaceae where venation patterns may confirm placement of *Ternstroemites* sp. within Theaceae. Other morphological features are important in distinguishing between similar leaf forms. Extant *Cladrastis* and *Sapindus* are very similar but the leaf base of *Cladrastis* is straight, while *Sapindus* has a curved, often inequilateral base, leading to the identification of fossil *Cladrastis*. Morphological leaf characters may not be enough, so future anatomical studies are needed that incorporate cuticular characters. Such characters are important in determining *Swartzia* to the species level since similar morphological and venation patterns are present in numerous species of *Swartzia*. Use of cuticular characters is also important for *Ocotea* even though this fossil leaf has been linked with extant *O.*

quianensis here, and in Berry (1916). Some leaves from Powers Clay Pit have an uncertain systematic placement, including Entire Margin Morphotype's 1, 2, 5, Tooth Margin Morphotype 1, and Reproductive Structure Morphotype 1. This would include *Knightiophyllum wilcoxianum* Berry where placement in Fagaceae is open to question. *Knightiophyllum wilcoxianum* does not match any extant genus and represents an extinct member of Fagaceae. Specimens that are incomplete and problematic in placement include *Apocynophyllum* sp., cf. *Paleorubiaceophyllum*, and Oleaceae, with *Apocynophyllum* and *Paleorubiaceophyllum* representing extinct taxa (Dilcher 2001).

It has been over 145 years since the first investigation of fossil plants from the Claiborne flora (Lesquereux 1859) and about 90 years since the first detailed locality to locality comparisons of these fossil plants (Berry 1916). Since that time, fossil plants from new sites have been collected and investigated, increasing the number of localities in western Tennessee, western Kentucky, Mississippi and Alabama from 10 (Berry 1916) to 30. With the taxa presented here from Powers Clay Pit, a preliminary comparison can be made with the limited taxa that have been studied and identified from other pits in western Tennessee and western Kentucky. Taxa shared with Powers Pit have been found at the Puryear Clay Pit (15 taxa), Willbanks I Clay Pit (14 taxa), Lamkin Clay Pit (seven taxa), Warman Clay Pit (seven taxa), and Lawrence Clay Pit (six taxa) (Table 2). As our research continues, it is anticipated that new morphotypes will be discovered, increasing our understanding of the floristics for each locality. Even though the present data is preliminary, interesting comparisons have been found.

Of the 35 fossil plant taxa recognized from Powers Clay Pit, the number of taxa that overlap range from 15 at Puryear Clay Pit to six at Lawrence Clay Pit. In other words, less than half the known taxa overlap localities. Although Warman Clay Pit is only 400 meters north of Powers Clay Pit, the two sites seem to share very few taxa. Lawrence is 8 KM away, but also shares few taxa with Powers Pit. Willbanks Clay Pit shares 14 taxa and is only 1 KM west of the Powers Clay Pit. Puryear Clay Pit is about 25 KM north north-east, and Lamkin is about 65 KM north of Powers Clay Pit. It is interesting to note that distance does not seem to relate to similarity of floristic elements. This disparity could be explained by sample size, environmental factors, or that these clay pits may not represent one common age. Certainly, more research needs to be done to understand the floristic relationships between the clay pit localities.

Table 2. Taxa shared with Powers Clay Pit, and five other clay pits.

Puryear	Willbanks	Lamkin	Warman	Lawrence
<i>Ocotea</i>	<i>Ocotea</i>	<i>Ocotea</i>	<i>Smilax?</i> (Fossil type 5)	<i>Berryophyllum</i>
<i>Duguetia</i>	<i>Duguetia</i>	<i>Myrcia</i>	<i>Berryophyllum</i>	<i>Knightiophyllum</i>
<i>Smilax</i>	<i>Smilax</i>	<i>Ficus</i>	<i>Knightiophyllum</i>	<i>Berhamniphyllum</i>
<i>Myrcia</i> (<i>Calyptanthus</i>)	<i>Ormosia</i>	<i>Berhamniphyllum</i>	<i>Berhamniphyllum</i>	<i>Nyssa</i>
<i>Cladrastis</i> (<i>Gleditsiophyllum</i>)	<i>Berryophyllum</i>	<i>Ternstroemites</i>	<i>Ternstroemites</i>	<i>Paleorubiaceophyllum</i>
<i>Berryophyllum</i>	<i>Knightiophyllum</i>	<i>Apocynophyllum</i>	<i>Paleorubiaceophyllum</i>	<i>Dendropanax</i>
<i>Knightiophyllum</i>	<i>Populus</i>	<i>Paleorubiaceophyllum</i>	<i>Dendropanax</i>	
<i>Populus</i> (<i>Grewiopsis</i>)	<i>Berhamniphyllum</i>			
<i>Ficus</i>	<i>Nyssa</i>			
<i>Berhamniphyllum</i> (<i>Rhamnus</i>)	<i>Ternstroemites?</i> (<i>Gordonia</i>)			
<i>Cupanites</i>	<i>Apocynophyllum</i>			
<i>Nyssa</i>	<i>Paleorubiaceophyllum</i>			
<i>Ternstroemites</i>	<i>Dendropanax</i>			
<i>Apocynophyllum</i>	<i>Folindusia?</i> (Caddisfly case)			
<i>Paleorubiaceophyllum</i>				

The relationships of fossil specimens to extant genera can give us a glimpse of past ecosystems. Many of the fossil specimens from Powers Pit appear to be related to extant genera that have primarily subtropical or tropical distributions. These include *Ocotea*, *Swartzia*, *Ormosia*, *Berryophyllum*, *Ternstroemites*, *Dendropanax*, *Duguetia*, *Moraceae*, *Myrcia*, and *Berhamniphyllum*. Fossil specimens related to extant genera that have primarily cool to warm temperate to subtropi-

cal distributions include *Liquidambar*, *Populus*, *Nyssa*, *Cladrastis*, and *Platanus*. Berry (1916, 1924) concluded that the climate of the "Wilcox" (now Claiborne) flora was warm tropical. Miranda and Sharp (1950), Sharp (1951), Gray (1960) and Engelhardt (1964) compared the Eocene flora to the eastern Mexican escarpment region and suggested a mixture of temperate and tropical conditions. Dorf (1960) considered the climate as tropical, while Axelrod (1966) and Dilcher (1973) con-

cluded that the climate was warm temperate to cool subtropical or cooler temperate, and Dilcher (1973) suggested that there were definite seasonal dry periods. Elsik (1974) suggested a tropical to subtropical climate while Wolfe (1975, 1978), Wolfe and Poore (1982), Frederiksen (1980b, 1988) and Graham (1999) considered a winter dry tropical to marginal humid subtropical climate. The fossil specimens presented here suggest a subtropical climate that can accommodate warm tropical to cool temperate species. While the lowlands provided tropical plant species, possible uplands with an influence from the Appalachian area may have provided cool temperate species (Cain 1943; Dilcher 1973). The unique mixture of elements living in temperate, subtropical, and tropical climates today suggests that they may represent parts of an ancient non-analogue climate. That is, a climate that is unique in the characteristics of its temperature and moisture that is found nowhere in the world today. Plants that may be related to these fossils continue living today in various places and in slightly different climates as they have shifted their distributions and evolved various ecological tolerances to accommodate present conditions.

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Table 3. Leaf Morphology Key

1. Leaves lobed.	
2. Lobes entire.	<i>Dendropanax eocenensis</i>
2. Lobes toothed.	<i>Platanus</i>
1. Leaves simple (leaf and leaflet).	
3. Leaf margin entire.	
4. Leaves small (leaf length < 8 cm).	
5. Leaves elliptic.	
6. Venation brochidodromous.	
7. Lamina ratio 2-3:1.	
8. Secondary veins 5-6 pairs	<i>Swartzia</i>
8. Secondary veins more than 10 pairs	cf. <i>Paleorubiaeophyllum</i>
7. Lamina ratio 4:1.	<i>Ormosia</i> sp. 2
6. Venation eucamptodromous	<i>Berhamniphyllum</i> sp.
5. Leaves lanceolate, brochidodromous.	<i>Cladrastis</i>
4'. Leaves medium (leaf length 8-15 cm).	
9. Leaves elliptic.	
10. Intramarginal vein.	<i>Myrcia</i>
10'. Venation brochidodromous	
11. Base obtuse	<i>Duguetia</i>
11. Base acute	
12. Flanks convex	<i>Ormosia</i> sp. 1
12'. Flanks decurrent	<i>Apocynophyllum</i>
12''. Flanks concave	<i>Ficus</i>
10''. Some venation eucamptodromous.	
13. Leaves lack ascending basal veins	
14. Angle of divergence 20-30°	<i>Berhamniphyllum claibornense</i>
14. Angle of divergence 60°	Oleaceae
13. Leaves with ascending basal veins	<i>Ocotea</i>
10'''. Venation acrodromous/campylodromous	<i>Smilax</i>
9. Leaves obovate.	<i>Pseudolmedia</i>
4''. Leaves large, elliptic (>15 cm).	<i>Duguetia</i>
3. Leaf margin toothed.	
15. Leaf medium (6-11 cm).	
16. Leaf elliptic.	
17. Teeth confined to mid-upper portion.	<i>Knightiophyllum wilcoxianum</i>
17. Teeth entire length	
18. Teeth serrate.	<i>Ternstroemites</i> sp.
18. Teeth mostly dentate	<i>Populus</i> sp.
16'. Leaf oblong.	<i>Cupanites</i> sp.
16''. Leaf obovate.	<i>Ternstroemites</i> sp.
16'''. Leaf linear.	<i>Berryophyllum tenuifolia</i>
15. Leaf large, elliptic (> 11 cm).	
19. Teeth confined to mid-upper portion.	
20. Teeth prominent.	<i>Berryophyllum</i> sp.
20. Teeth short	<i>Knightiophyllum wilcoxianum</i>
19. Teeth entire length.	<i>Ternstroemites</i> sp.

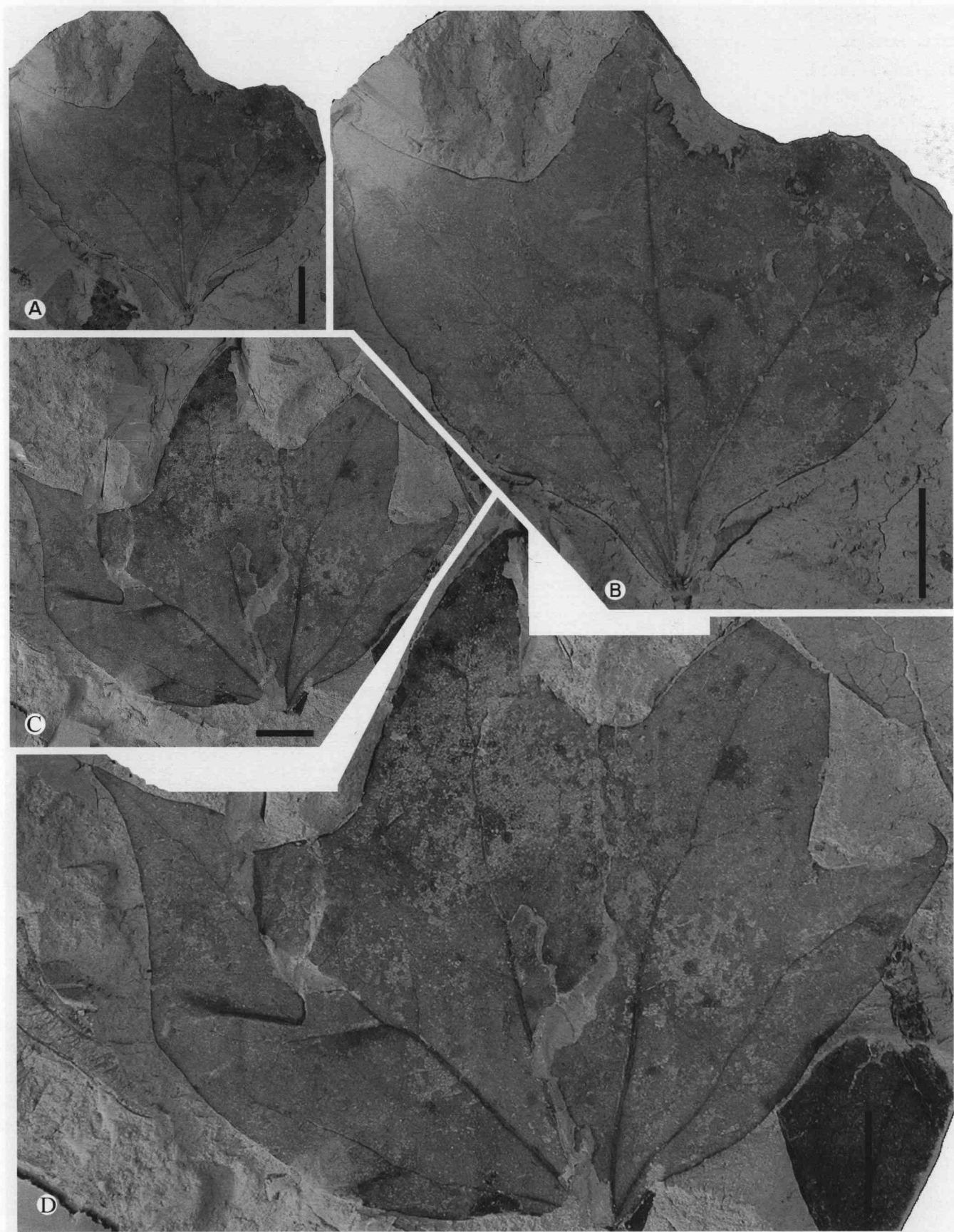


Figure 6. *Dendropanax eocenensis*. A, B, Three lobed leaf, UF18810-34383, 1x, 2x. C, D, Four lobed leaf, UF18810-34382a, 1x, 2x. Bar-10 mm (A, C), 20 mm (B, D).

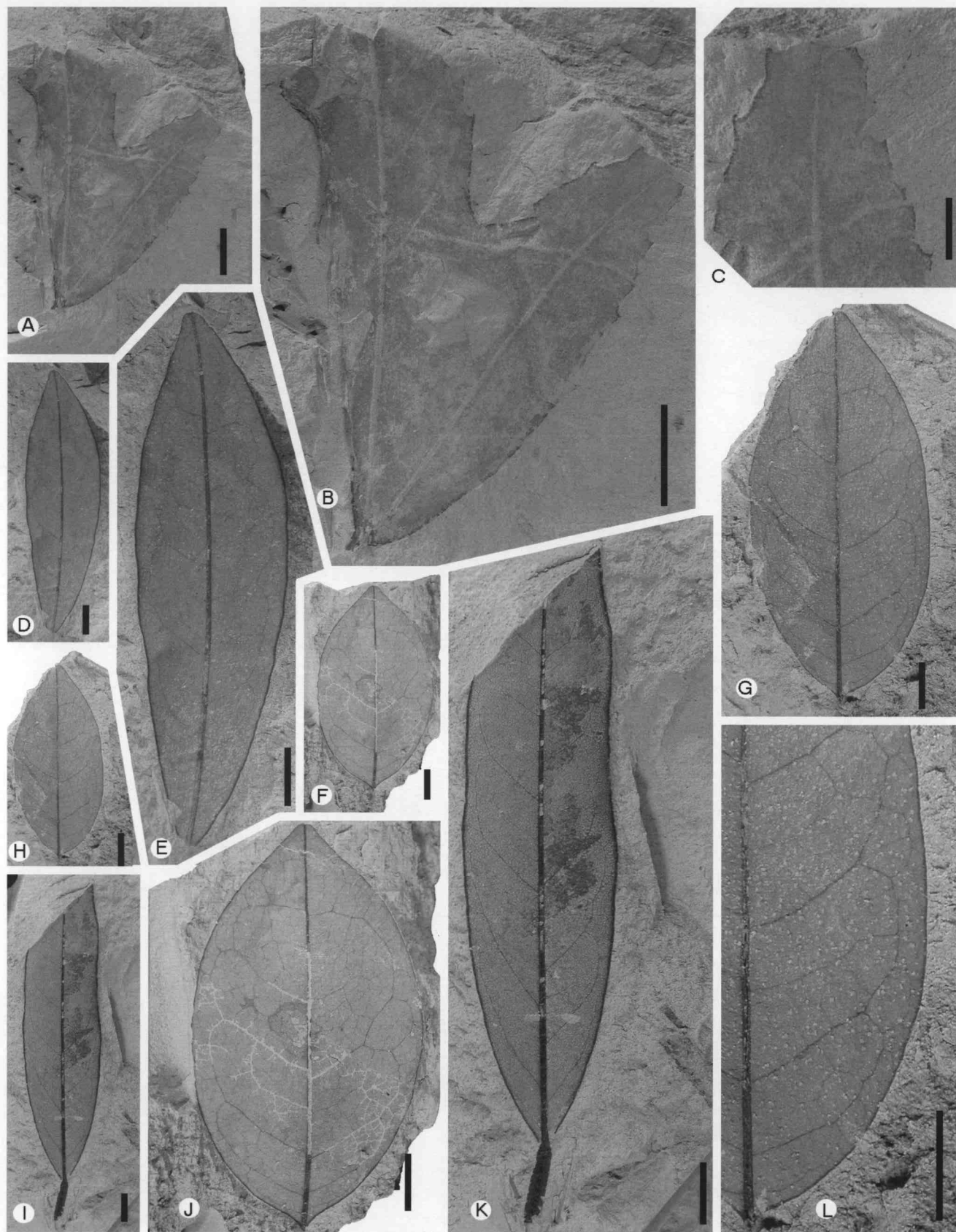


Figure 7. Lobed and entire leaves. A-C, *Platanus* sp., UF18810-34439, 1x, 2x, 3x. D-H, J, L, *Swartzia* sp. D, E, UF18810-34391, 1x, 2x. F, J, UF18810-34394, 1x, 2x. G, H, L, UF18810-34393, 2x, 1x, 4x. I, K, *Ormosia* sp. 2, UF18810-34395, 1x, 2x. Bar-5 mm (C-F, I-L), 10 mm (A, B, G, H).

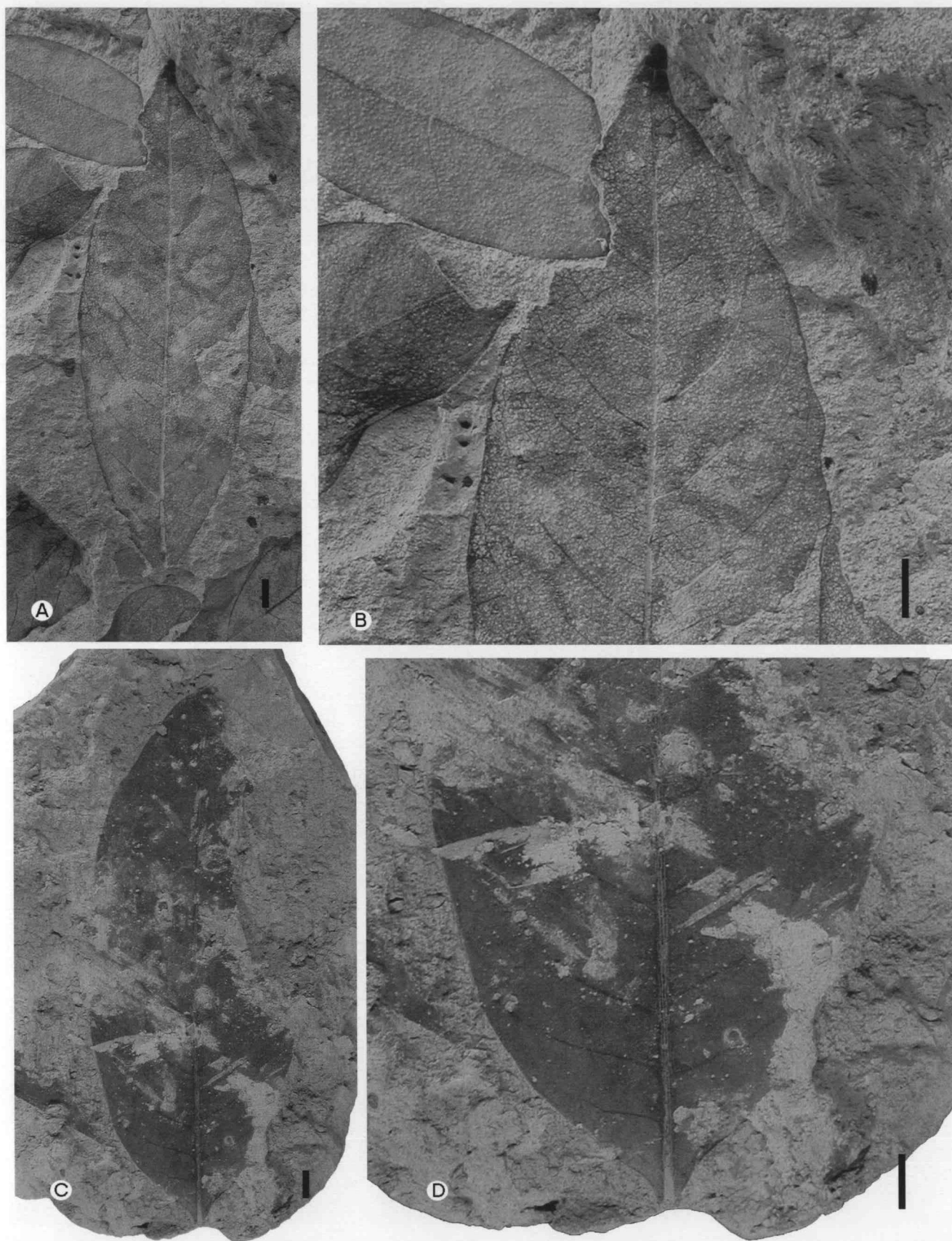


Figure 8. Entire leaves. A, B, Entire Margin Morphotype 2, UF18810-34444b, 1x, 2x. C, D, *Ficus* sp., UF18810-34446, 1x, 2x. All bars at 5 mm.

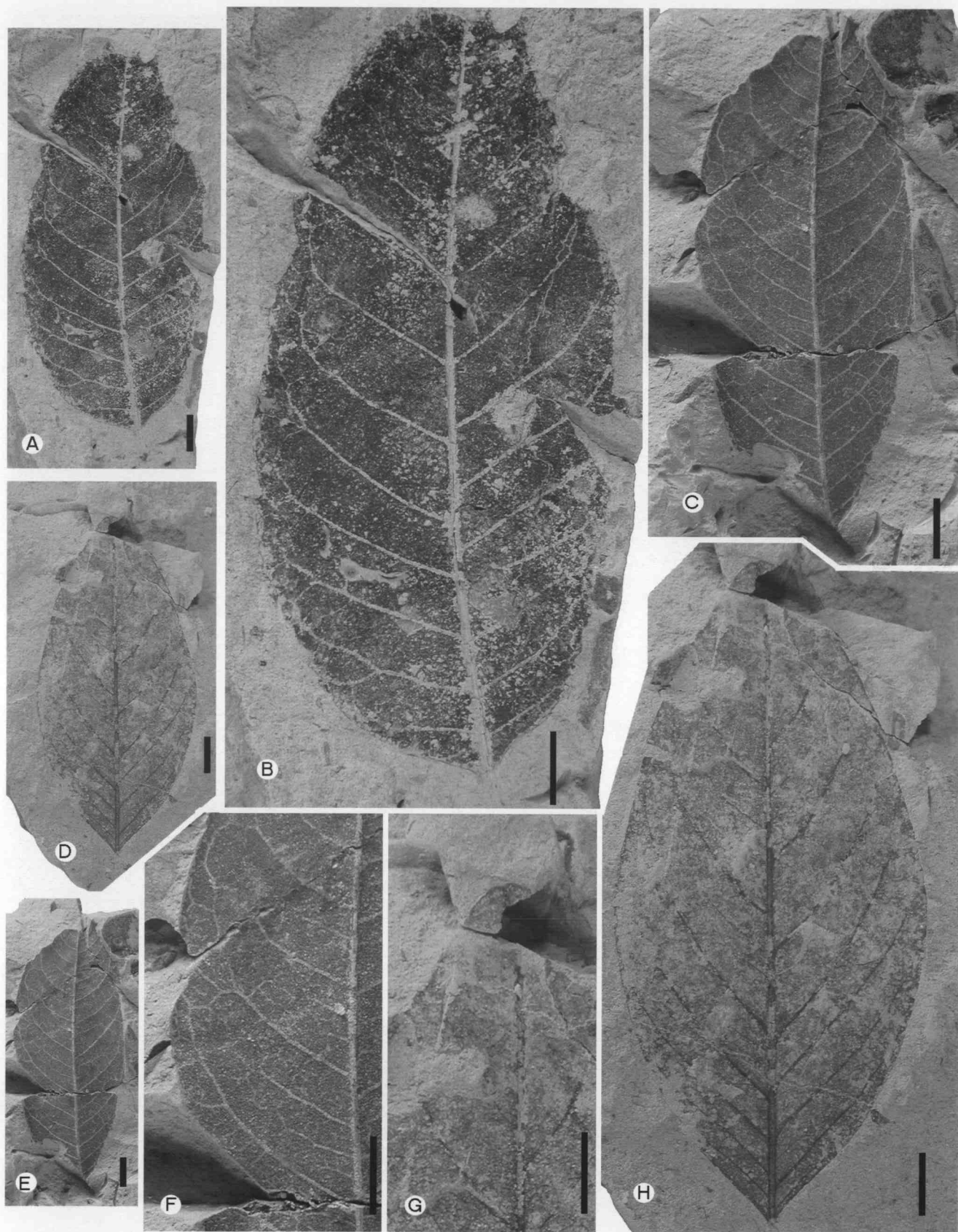


Figure 9. Entire leaves. A, B, cf. *Paleorubiaceophyllum* sp., UF18810-34431, 1x, 2x. C, E, F, Entire Margin Morphotype 1, UF18810-34433, 2x, 1x, 3x. D, G, H, *Berhamniphyllum* sp., UF18810-34427, 1x, 3x, 2x. All bars at 5 mm.

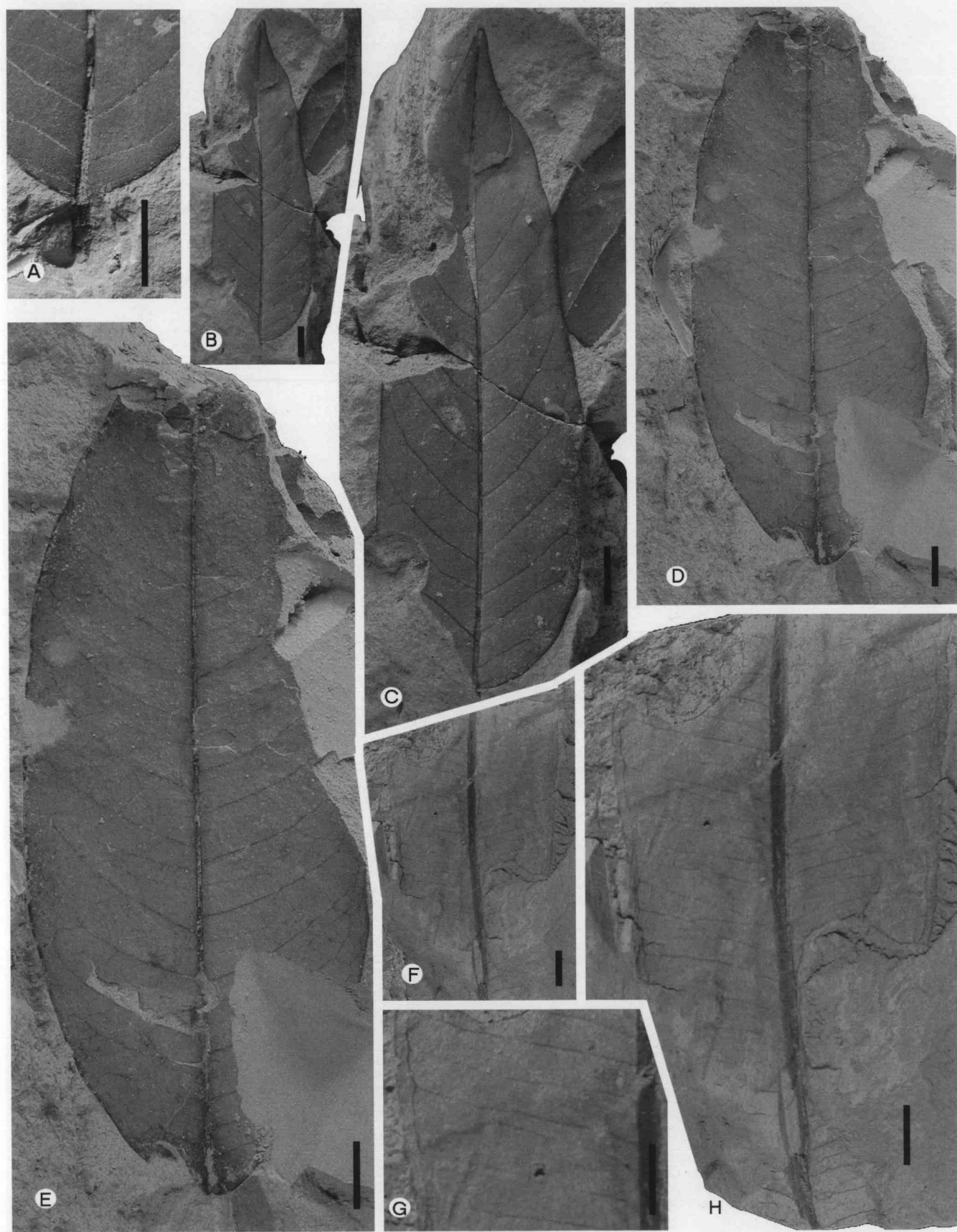


Figure 10. Entire leaves. A-C, *Cladrastis* sp. A, UF18810-34413a, 1x. B, C, UF18810-34402, 1x, 2x. D, E, *Duguetia* sp., UF18810-34407, 1x, 1.5x. F-H, *Myrcia* sp., UF18810-34386, 1x, 3x, 2x. All bars at 5 mm.

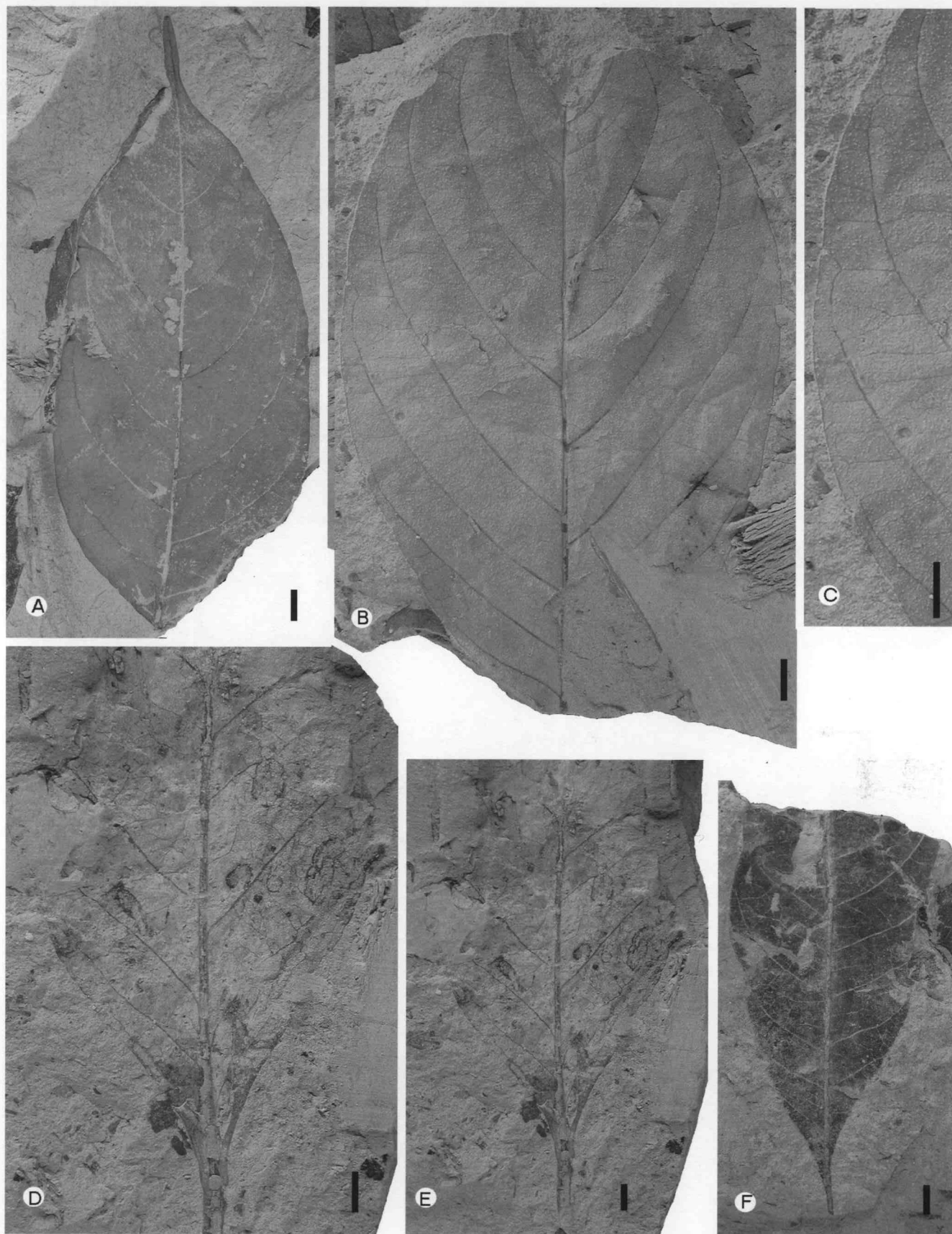


Figure 11. Entire leaves. A-C, *Ormosia* sp. 1. A, UF18810-34406, 1x. B, C, UF18810-34404a, 1.5x, 2x. D, E, *Apocynophyllum* sp., UF18810-34441, 1.5x, 1x. F, Oleaceae, UF18810-34430, 1x. All bars at 5 mm.

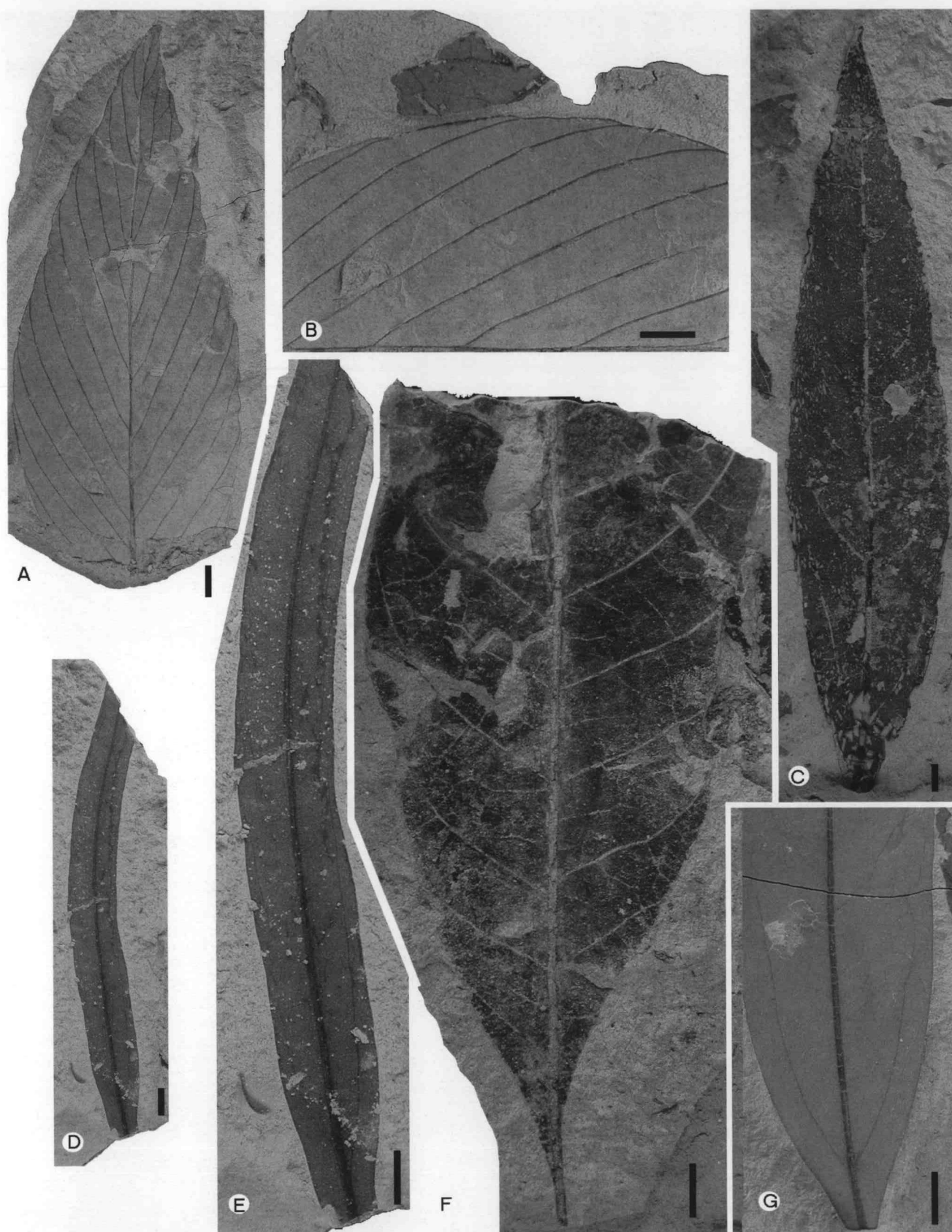


Figure 12. Entire leaves. A, B, *Berhamniphyllum claibornense*, UF18810-34384, 1x, 2x. C-E, G, *Ocotea* sp. C, UF18810-34409, 1x. D, E, UF18810-34410a, 1x, 2x. G, UF18810-34411, 2x. F, *Oleaceae*, UF18810-34430, 2x. All bars at 5 mm.

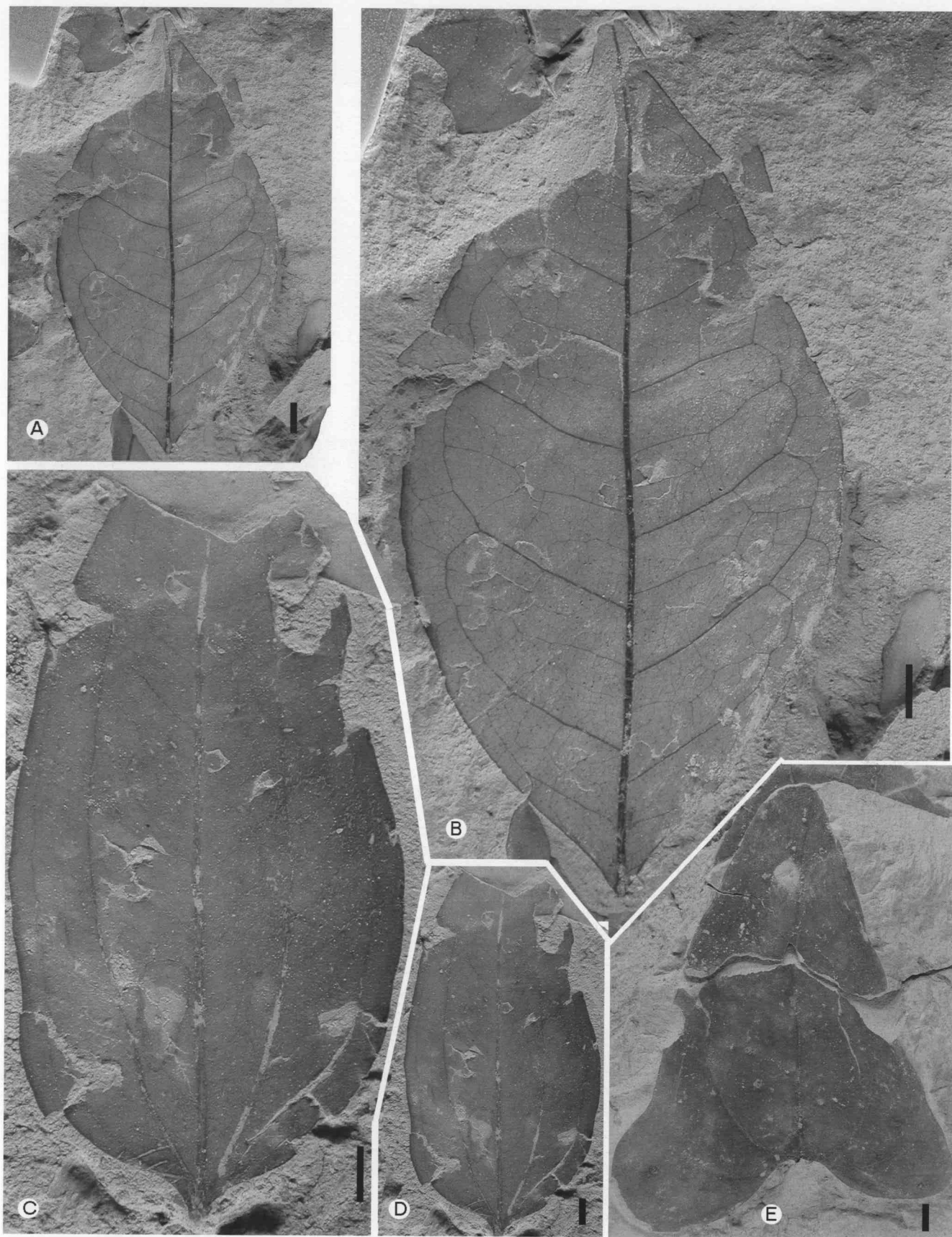


Figure 13. Entire leaves. A, B, *Swartzia* sp., UF18810-34388a, 1x, 2x. C, D, *Smilax* sp. 1, UF18810-34415, 2x, 1x. E, *Smilax* sp. 2, UF18810-34435, 1x. All bars at 5 mm.

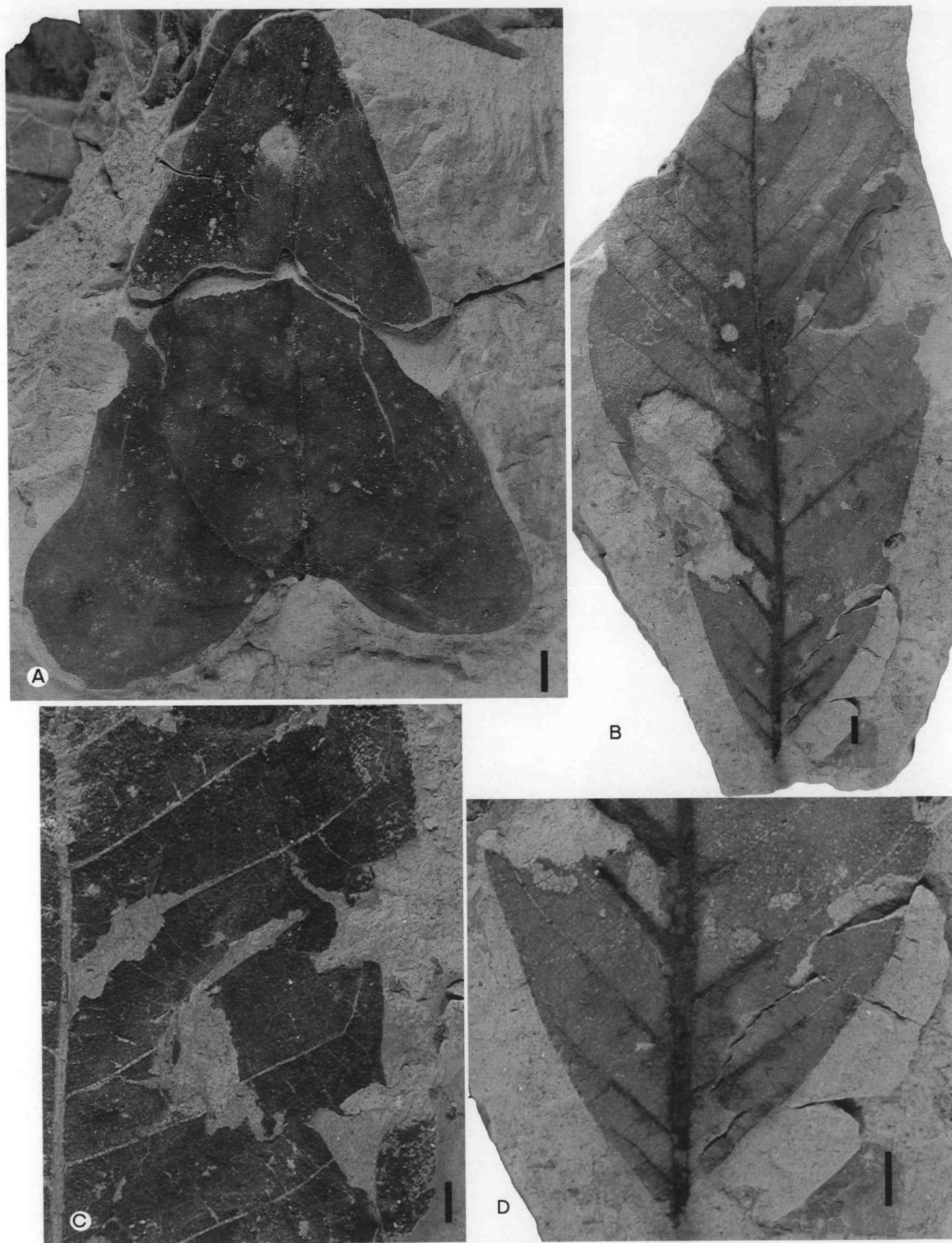


Figure 14. Entire leaves. A, *Smilax* sp. 2, UF18810-34435, 1.5x. B, D, *Pseudolmedia* sp., UF18810-34417, 1x, 2x. C, *Duguetia* sp., UF18810-34418, 1.5x. All bars at 5 mm.

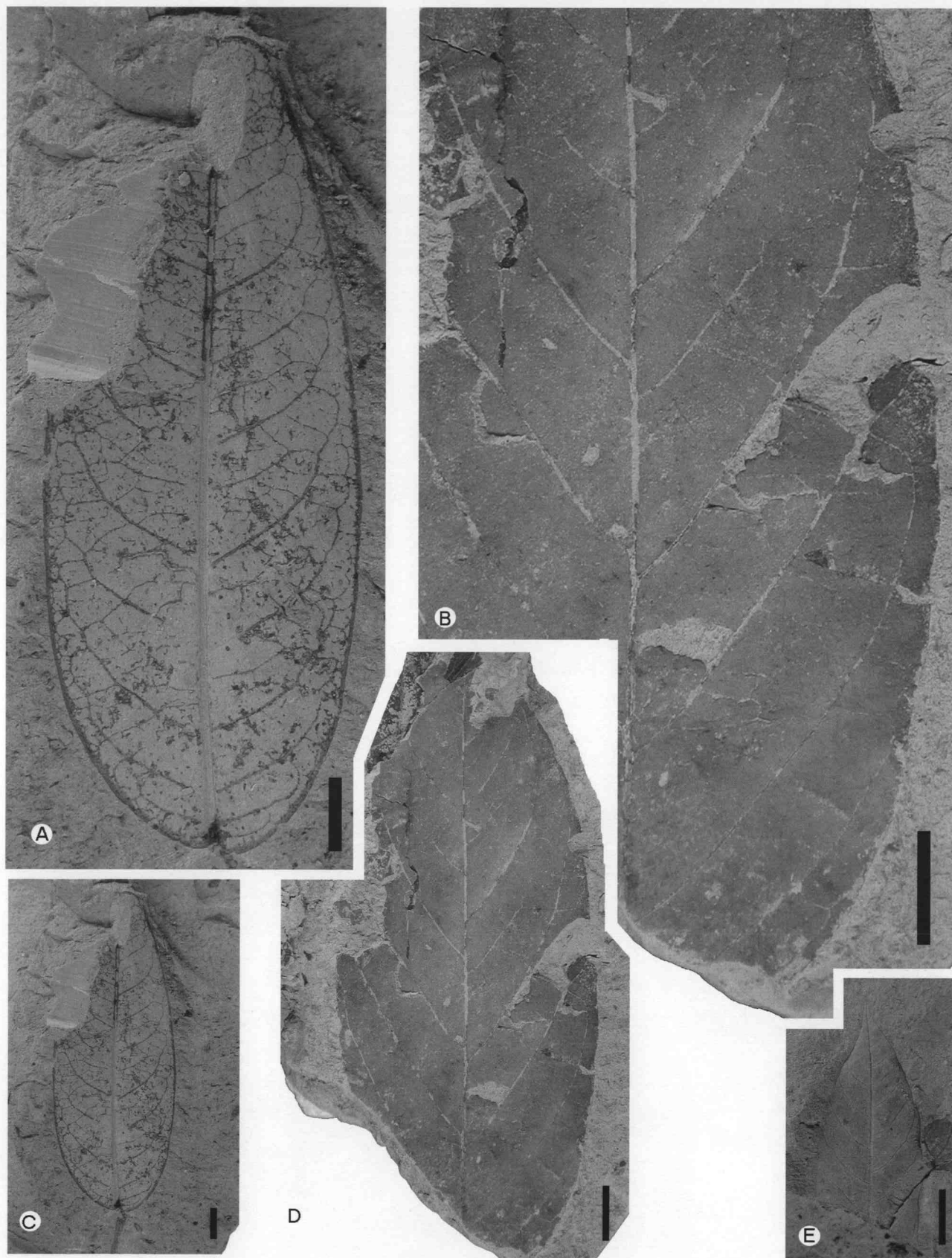


Figure 15. Entire and toothed leaves. A, C, Entire Margin Morphotype 3, UF18810-34450, 2.5x, 1x. B, D, Entire Margin Morphotype 5, UF18810-34448, 2x, 1x. E, Toothed Margin Morphotype 1, UF18810-34445, 1x. Bar-5 mm (A, C), 10 mm (B, D, E).

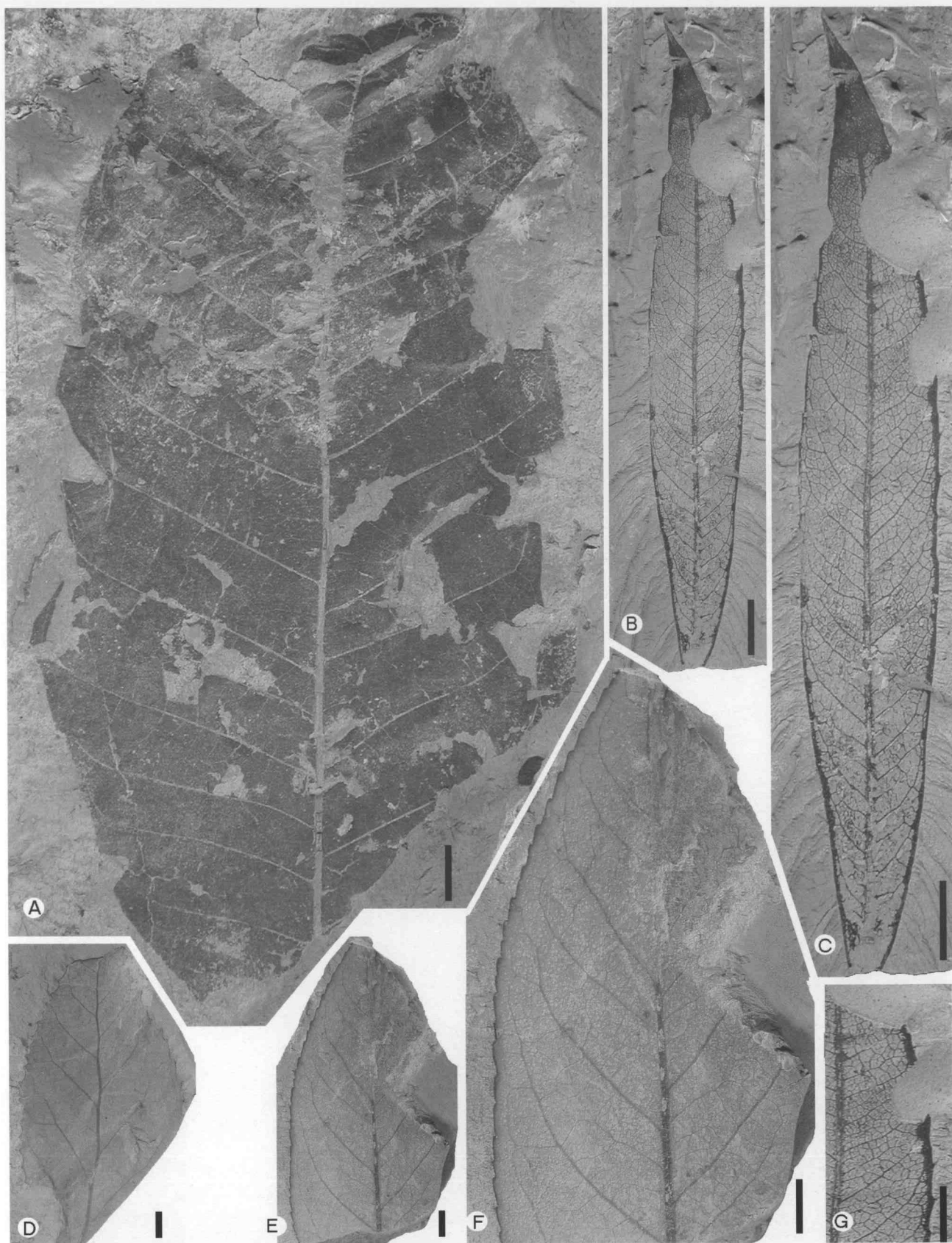


Figure 16. Entire and toothed leaves. A, *Duguetia* sp., UF18810-34418, 1x. B, C, G, *Knightiophyllum wilcoxianum*, UF18810-34425a, 1x, 2x, 2x. D, *Populus* sp., UF18810-34397, 1x. E, F, *Ternstroemites* sp., UF18810-34399, 1x, 2x. Bar-5 mm (D-G), 10 mm (A-C).

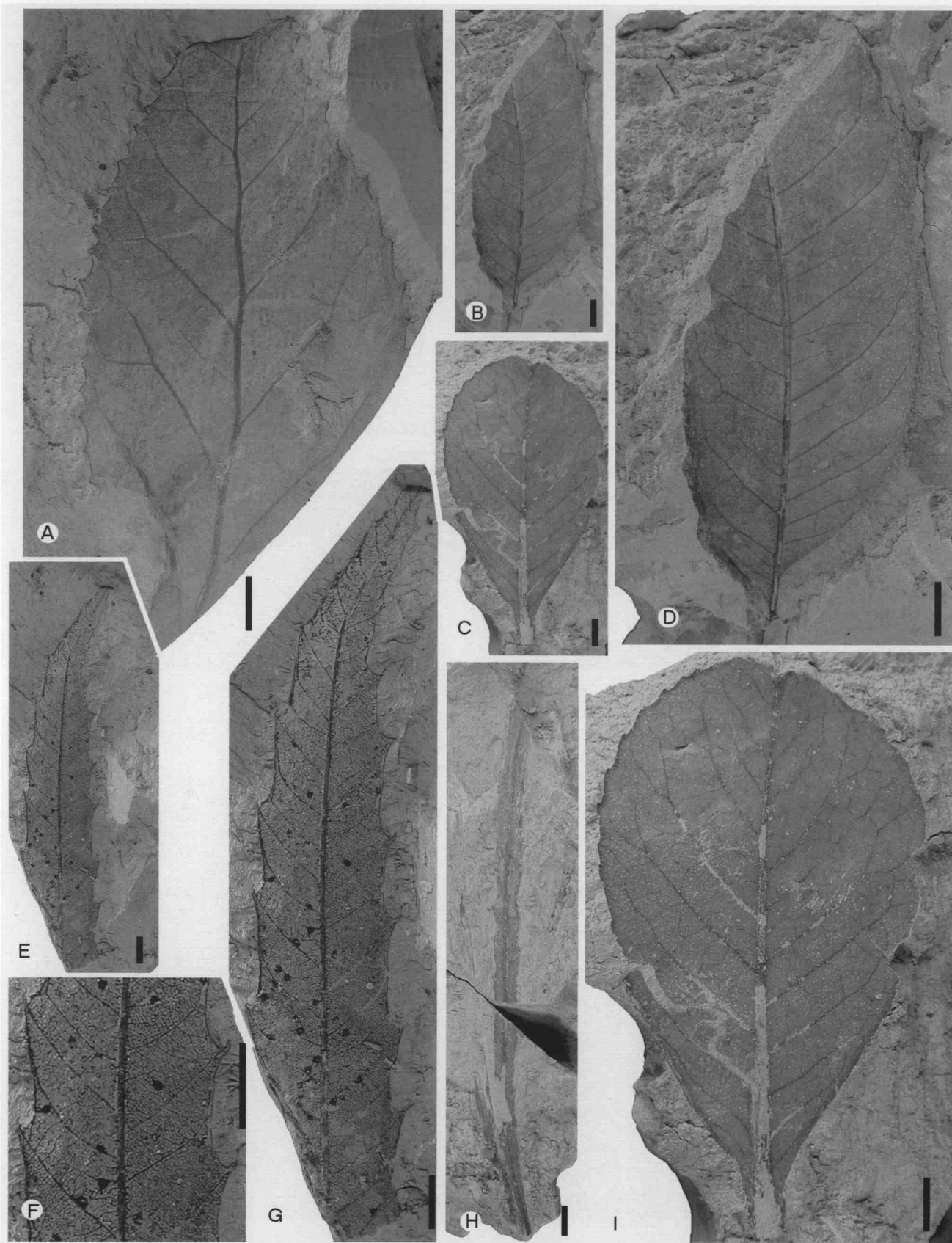


Figure 17. Toothed leaves. A, *Populus* sp., UF18810-34397, 2x. B, D, *Cupanites* sp., UF18810-34401, 1x, 2x. C, I, *Ternstroemites* sp. UF18810-34426, 1x, 2x. E-G, *Berryophyllum* sp., UF18810-34396, 1x, 3x, 2x. H, *Berryophyllum tenuifolia*, UF18810-34389, 1x. All bars at 5 mm.

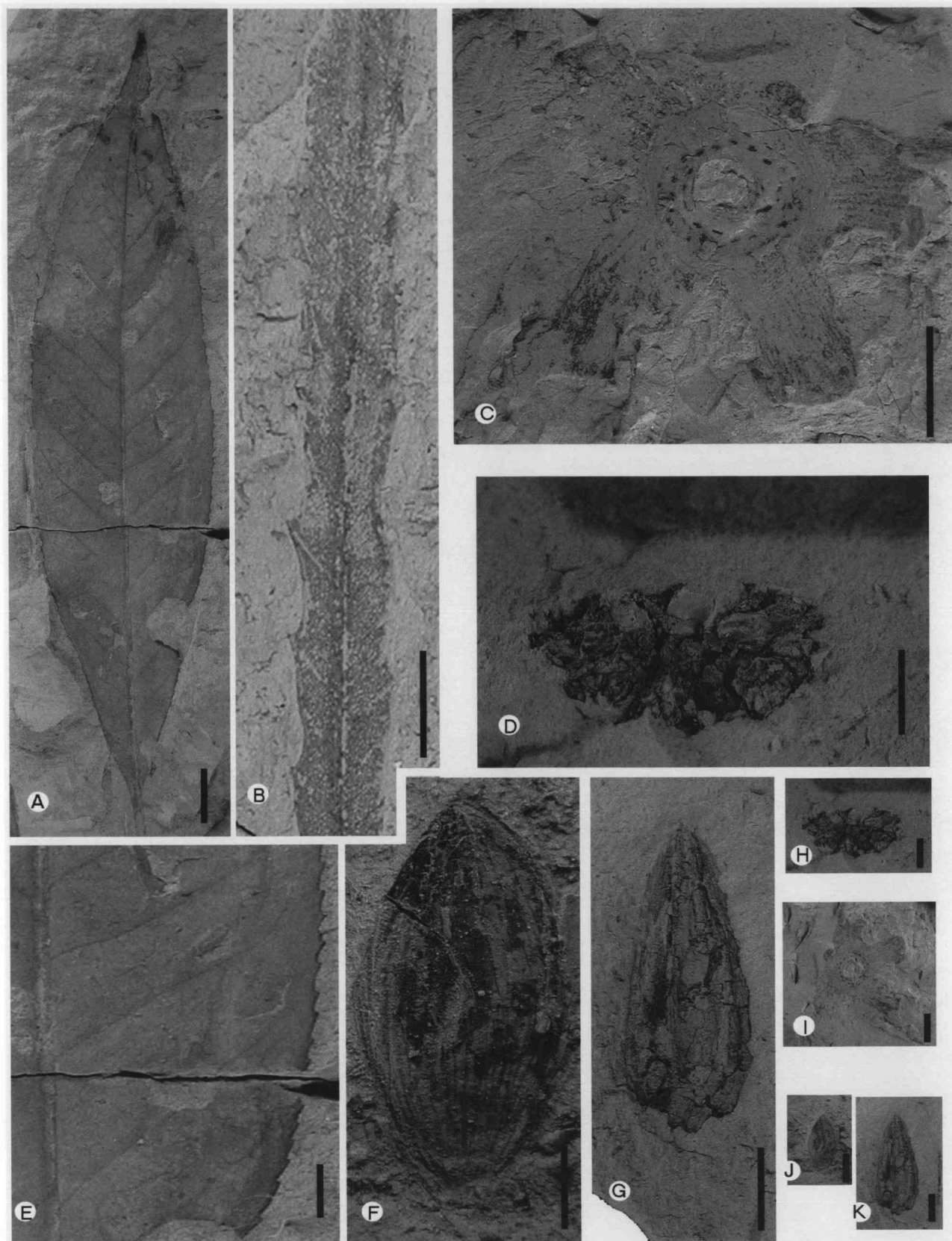


Figure 18. Toothed leaves and reproductive structures. A, E, *Ternstroemites* sp. UF18810-34405, 1x, 2x. C, I, *Gordonia* sp., UF18810-34438, 4x, 1x. B, *Berryophyllum tenuifolia*, UF18810-34389, 4x. D, H, *Liquidambar* sp., UF18810-34432, 3x, 1x. F, J, Reproductive Structure Morphotype 1, UF18810-34434, 7x, 1x. G, K, *Nyssa eolignitica*, UF18810-34392, 3x, 1x. Bar-2 mm (F), 5 mm (B-E, G-K), 10 mm (A).



Figure 19. Leaves and insect larval cases. A, Tooth Margin Morphotype 1, UF18810-34445 cpt., 3x. B, Monocot leaf, UF18810-34400, 1x. C, H, Entire Margin Morphotype 4, UF18810-34449, 1x, 2x. D, G, *Folindusia* sp., UF18810-34436, 1x, 3x. E, F, *Terrindusia* sp., UF18810-34437, 1x, 6x. Bar-5 mm (A, B, D-H), 10 mm (C).

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