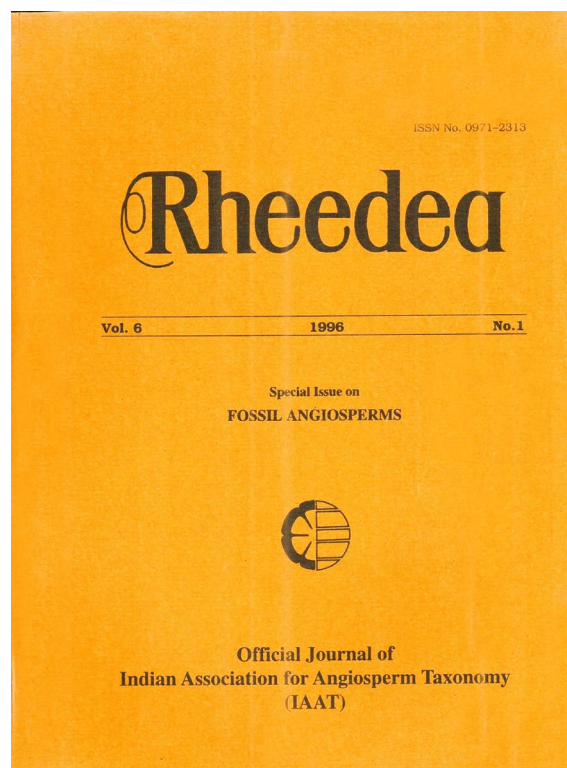




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Additions and preliminary study of an Oligo–Miocene Palynoflora from Chiapas, Mexico

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Abstract

Palynomorphs and plant macrofossils are reported from the Oligo-Miocene La Quinta Formation at Simojovel, state of Chiapas, Mexico. The plant fossils presently recognized group into three paleocommunities—mangrove (*Pelliceria*, *Rhizophora*), marsh (*Ceratopteris*), lowland tropical rain forest (*Pteris*, *Sphaeropteris*/*Trichipteris*, *Crudia*, *Hymenaea*, *Pachira*, *Tapirira*), and upland woods (*Pinus*, *Podocarpus*, Asteraceae/Compositae (wideranging), *Engelhardia*-type, *Ilex*). There is no evidence from this preliminary study of an extensive temperate deciduous forest with northern affinities as found in younger floras from adjacent regions (e. g., the middle Pliocene Paraje Solo flora of coastal southeastern Veracruz, Mexico). Paleoelevation is estimated at ~1000–1200 m in the vicinity of the Simojovel site to allow for upland woods, but not for a higher-elevation *Pinus–Abies* woods. A mean annual temperature (MAT) near that of the present (~24°C) at mid- to low elevations would accommodate the paleocommunities as presently defined. The absence of major highlands in the immediate region probably contributed more to the lack or poor representation of northern cool-temperate elements than significantly warmer and/or drier climates. Cooperative efforts, confirmed identification of the biological affinities of the palynomorphs, and interpretations made within the context of available independent marine invertebrate and geologic data will be required ultimately to present a full and consistent picture of the Oligo–Miocene biotic and paleoenvironmental history of the region.

INTRODUCTION

The state of Chiapas is located in southern Mexico adjacent to the Guatemalan border (Fig. 1). The present topography is varied and consists of a series of basins and low to moderately-elevated mountains. The village of Simojovel (17° N latitude) is in the Front Ranges physiographic province and upland from the bordering Gulf Coast Plain. During the middle Tertiary, however, the sea extended further inland and a series of limestones, sandstones, and lignites were deposited in the vicinity of Simojovel. These lignites are evident

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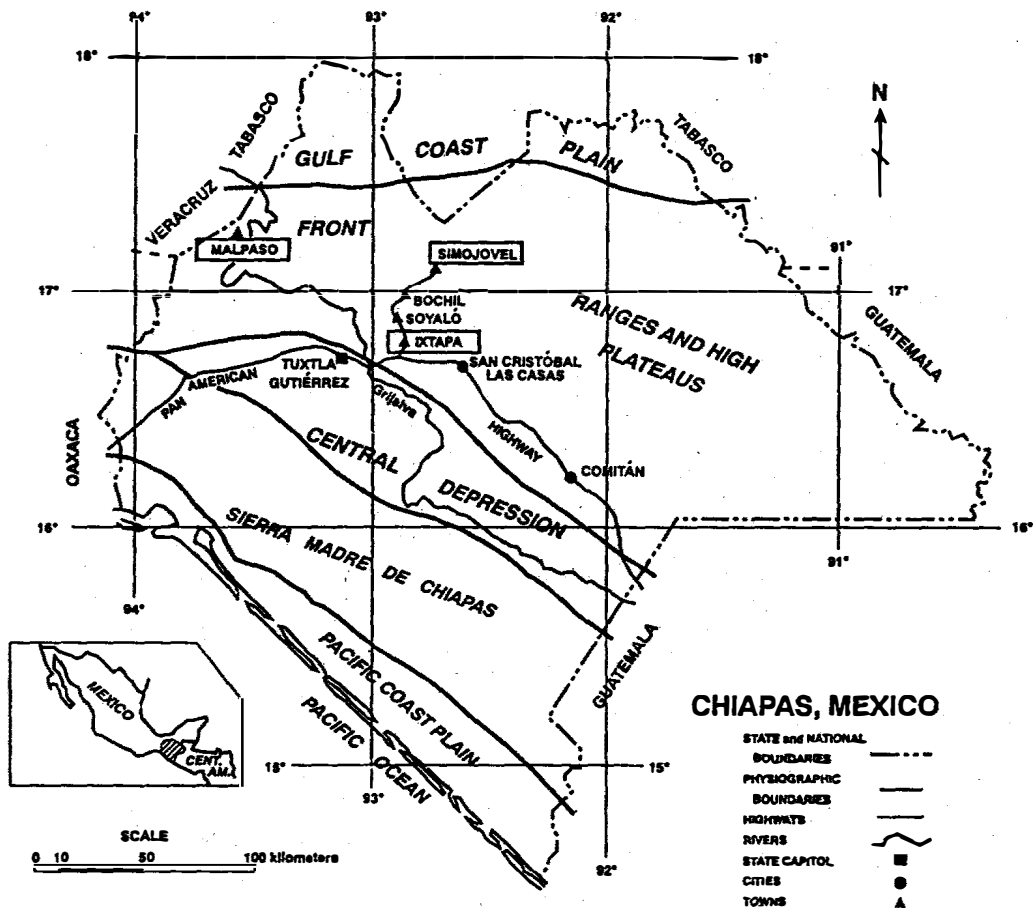


Fig. 1. Physiographic diagram of Chiapas. (After Frost and Langenheim, 1974, text-fig. 1. Used with permission).

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along roadcuts, stream banks, and landslides. The Simojovel Landslide is located east of the Simojovel Cemetery, where an ~8 m vertical section of lignites and lignitic sandstones is exposed. The thickest lignite is ~10 cm and it contains a diverse assemblage of fossil pollen and spores.

The geology of the region is complex (de Cserna, 1989; Ferrusquia-Villafranca, 1993), but all studies place the deposits in the vicinity of the Simojovel site at the transition between the late Oligocene and early Miocene. According to the Stratigraphic charts in Frost and Langenheim (1974; Fig. 2), sediments at the collecting locality belong to the La Quinta Formation which is transgressive across the latest Oligocene to the earliest Miocene. Allison (1967) divided the La Quinta Formation into the Camino Carretero, Florida Limestone, and Finca Carmito members. It is the Florida Limestone that is exposed at the Simojovel Landslide site, and in the descriptions in Frost and Langenheim (1974, p. 29) lignites are mentioned only in this member. According to these authors (p. 31), "The Florida Limestone Member contains a coral fauna which is unequivocally Early Miocene" and "Thus the Florida Limestone Member and the uppermost part of the Camino Carretero Member are Early Miocene." The tripartite division of the La Quinta Formation into three members is not evident at all sites, and no subsequent detailed stratigraphic studies have been published. For purposes of this preliminary study the flora is considered part of the Florida Limestone Member of the La Quinta Formation and probably of early Miocene age.

Several Tertiary palynofloras are known from the states of Chiapas and adjacent Veracruz. The middle Pliocene Paraje Solo flora is known from lignite and associated sediments from coastal southeastern Veracruz (Graham, 1976a, b). Palacios Chávez and Rzedowski (1993) described an assemblage from the lower to middle Miocene Méndez Formation in the region of Pichucalco/Raudales de Malpaso, and Martínez-Hernández Highway 195 near Ixtapa in Chiapas (Fig. 1). A sequence of palynofloras from Eocene to latest Oligocene age from the region of Simojovel, including ones from the La Quinta Formation, were studied by Tomasini-Ortiz and Martínez-Hernández (1984). Other material from the La Quinta Formation at the Simojovel Landslide site has been collected previously for palynological study, but no detailed published results are available. There is an unpublished thesis by Biaggi (1978), and a brief abstract by Biaggi et al. (1976). Another study of the flora from several sites was made by Langenheim et al. (1967), but its specific purpose was to reconstruct the depositional environment for amber contained in the Simojovel sediments. We regard the paper by Langenheim et al. (1967) as the starting point for establishing the composition of the La Quinta flora because the results have been published and the identifications are documented by photographs. They report pollen of the mangroves *Rhizophora* and *Pelliceria*; *Pachira* - type, a genus which today grows in wet lowland forests adjacent to marshes, rivers, and lakes; and an upland component of *Pinus*, *Podocarpus*, and *Engelhardia*. *Rhizophora* is the most abundant plant microfossil, reaching 90% of the assemblage tabulated by Langenheim et al. (1967) from the Simojovel Landslide locality. In our scans of new material collected from this site, a few hundred specimens of *Rhizophora* may be encountered before any other palynomorphs are found. *Pelliceria* is the next most abundant, followed by *Ceratopteris* and *Engelhardia*-type.

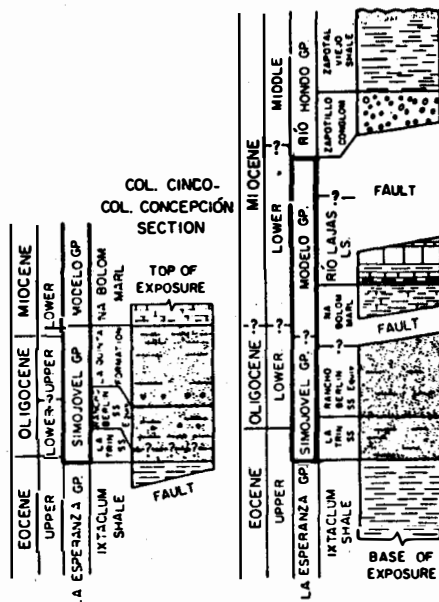
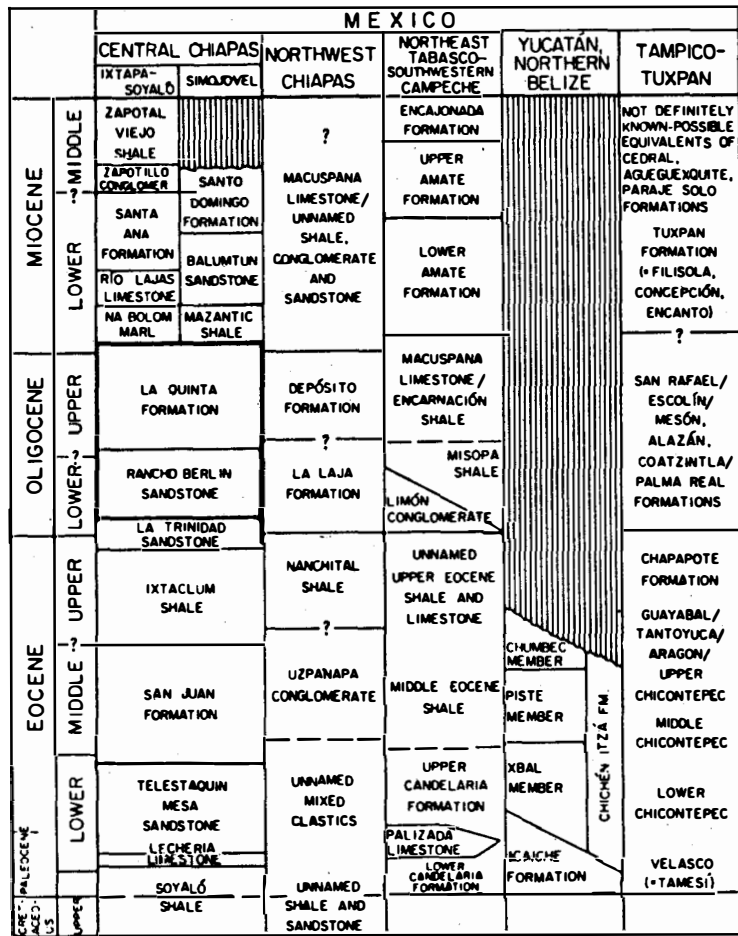


Fig. 2. Stratigraphic sections and correlations of Tertiary sections of Chiapas and vicinity (From Frost and Langenheim, 1974, text fig. 9. Used with permission).

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The presence of *Hymenaea* (Fabaceae/Leguminosae, Caesalpinioideae) can be assumed from indirect evidence. Although we did not observe amber at the Simojovel Landslide site during our March/April, 1993 field season, Langenheim et al. (1967, plate XXXVIII) illustrate a piece in the same lignite band, and it occurs widely in other Oligo-Miocene sediments in the vicinity. Infrared spectrophotometry has revealed the source of the amber as *Hymenaea* (Langenheim, 1966). Also, macrofossils have been identified from the Simojovel amber which include leaflets and possibly sepals of *Hymenaea*, a fossil flower described as *Tapirira durhamii* Miranda (Anacardiaceae), and a leaf of *Acacia* (Fabaceae/Leguminosae, Mimosoideae; Miranda, 1963). *Hymenaea* is a genus of ~20 species with its center of distribution in the Amazon Basin. One species *H. courbaril* L. is widespread from central Mexico through northern South America. This species grows in the tropical rain forest and in dry semi-deciduous forests, and it is common along coastal plains and rivers that enter mangrove estuaries. This is the depositional setting of the Simojovel sediments from which the fossil amber and the palynomorphs were recovered. The species is also found on beaches and sandy ridges interdigitating with lagoons (Langenheim et al., 1967, p. 292-293). *Tapirira* includes ~15 species found in warm humid habitats from central Mexico to South America. The flower of *Tapirira durhamii* is similar to that of *T. quianensis* Aubl. and *T. mexicana* March. The former is a widespread South American species.

As part of our studies on Tertiary pollen and spores from the Simojovel region several other genera were recovered. The purpose of this paper is to record additional palynomorphs not previously reported in the published literature on the La Quinta Formation.

Ceratopteris (Pteridaceae; Fig. 3, A). Amb oval-triangular to circular, apices rounded; trilete, laesurae straight, narrow, 30-32 μ , extending 1/2 to 2/3 distance to spore margin; striate, striae in numerous broad, flat bands 4-5 μ wide, area between bands 1-2 μ wide; wall 2-3 μ thick; size 140 μ (estimated, folded). Langenheim et al. (1967) locality D-621=Simojovel Landslide site; England Slide Finder (ESF) coordinates F-39.

Ceratopteris consists of four species of aquatic ferns, with two species in the New World (Tryon & Tryon, 1982; Tryon & Lugardon, 1991). The genus occurs from the southern United States to Argentina. It most commonly grows floating in fresh water lagoons, rivers, and lakes, or rooted in wet soil or shallow water; occasionally it ranges into brackish water habitats. *Ceratopteris* is indicative of warm-temperate to tropical conditions and grows between sea level and ~300 m. Fossil spores are described in the stratigraphic literature as *Magnastriatites* and they range from the late Eocene to Recent.

Pteris (Pteridaceae; Fig. 3, C). Amb oval, apices rounded; laesurae straight, narrow, ~15 μ long, extending nearly to spore margin; conspicuous flange present, 6-7 μ wide, smooth, outer flange margin entire; distal surface laevigate, proximal surface with few flat verrucae; wall 2 μ thick; size 45 μ . Langenheim et al. (1967) locality P1-7, Pabuchil (Rancho Alegre) slide area, two miles northwest of Simojovel; ESF P-34, 3.

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Pteris is represented in the American tropics by ~55 species. It ranges through a wide variety of habitats, including wet forests, along the margin of clearings, and in thickets, cloud forests, gallery forests, and on cliffs. The elevational range is from sea level to ~2000 m (Tryon & Tryon, 1982; Tryon & Lugardon, 1991). Fossil spores of *Pteris* are described as *Polypodiaceoisporites* and they are known from many formations of Tertiary age in northern Latin America (see Graham, 1991a).

Sphaeropteris/Trichipteris (Cyatheaceae; Fig. 3, D). Amb oval-triangular, outer margin lobate due to pits; trilete, laesurae straight, narrow, ~18 μ long, extending ~2/3 distance to spore margin; wall conspicuously pitted, pits circular, 1.5-4 μ in diameter, inner margin entire, raised border ~1.5 μ wide, irregularly distributed; size 45 μ . Langenheim et al. (1967) locality PI-7; ESF coordinates T-30, 1.

Sphaeropteris is a genus of tree ferns with ~23 species in the American tropics. It is distributed from Veracruz, Mexico to Andean South America, Peru, Bolivia, and Amazonian and Southeastern Brazil. It occurs mostly in the lowland tropical rain forest, but ranges into more upland habitats (to ~2000m elevation). The tree fern *Trichipteris* is a tropical American genus of ~55 species distributed from Veracruz, Mexico to Corrientes, Argentina and Rio Grande do Sul, Brazil. Ecologically it is very diverse, and occurs in lowland rain forests, wet montane and cloud forests, and occasionally in savannas, grasslands, abandoned and burned fields, swamps, and brackish-water habitats. It grows mostly at elevations to ~2000m but can extend up to 3500 m (Tryon & Tryon, 1982; Tryon & Lugardon, 1991). Microfossils of the *Sphaeropteris/Trichipteris* type have been reported previously from the middle Pliocene Paraje Solo Formation (Graham, 1979).

Asteraceae/Composite (Fig. 3, E). Rare, small (~20 μ), tricolporate, long-spined pollen of the Compositae were recovered. This is consistent with the initial appearance of rare shorter-spined Compositae pollen by the latest Oligocene in the Caribbean region (Graham, 1996).

Crudia (Fabaceae/Leguminosae, Caesalpinioideae; Fig. 3, B). Prolate; tricolporoidate, colpi equatorially arranged, meridionally elongated, equidistant, straight, 32-37 μ long, extending nearly entire length of grain, pore area faint, circular, situated at midpoint of colpus; distinctly and coarsely striate, striae generally oriented parallel to long axis of grain, surface of striae psilate, margin entire, occasionally appearing beaded from underlying pores in foot layer/endexine; tectate but with occasional separation between sculpture elements, wall 2 μ thick, homogeneous (at 400X magnification); size 50 x 34 μ . Langenheim et al. (1967) locality D-621; ESF coordinates K-30.

Crudia is a pantropical genus, and the ~10 species in the New World grow primarily in the lowland Amazonian rain forest. They also occur in fresh water swamps and along the margins of streams and rivers. Pollen of extant species and related genera has been studied by Graham and Barker (1981). The microfossils are described in the stratigraphic literature

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as *Striatocolpites cataumbus*, and are known from the Eocene Gatuncillo, early Miocene Cucaracha and La Boca, and Mio-Pliocene Gatun formations of Panama (Graham, 1985, 1988, 1989a, 1991b). Fruits and leaflets have been described from the middle Eocene Claiborne Formation of western Tennessee (Herendeen & Dilcher, 1990).

Ilex (Aquifoliaceae; Fig. 3, F). Oblate-spheroidal, tricolporoidate (colpi occasionally obscured by structural elements), colpi meridionally elongated, equatorially arranged, equidistant, straight, 16-18 μ long, pore poorly defined, situated at mid-point of colpus; intectate, clavate, wall 3-4 μ thick; 28 x 25 μ .

Ilex is widespread in northern Latin America, and is found in premontane to montane, wet to drier forest habitats.

Paleocommunities

These early results allow only a provisional estimate of the paleocommunities composing the La Quinta flora and the paleoenvironments under which they grew. The most prominent community in the flora is the mangrove (manglar) as represented by *Rhizophora* and *Pelliceria*. Plants common to the lowland tropical rain forest are *Pteris*, *Sphaeropteris*, *Trichopteris*, *Crudia*, *Hymenaea*, *Pachira*, and *Tapirira*, although several of these range into other forest types. *Ceratopteris* belongs to a floating aquatic/fresh water marsh community, and an upland forest is indicated by pollen of *Pinus*, *Podocarpus*, and *Engelhardia*.

As yet, there is no evidence in the La Quinta flora for a prominent temperate deciduous forest that includes northern temperate elements as found in the middle Pliocene Paraje Solo Formation in Veracruz (Graham, 1976a). In the slightly younger lower to middle Miocene Méndez Formation of Chiapas, Palacios Chávez and Rzedowski (1993) do identify pollen of surprisingly diverse temperate component of *Larix*, *Pseudotsuga*, *Sequoia*, *Acer*, *Alnus*, *Castanea*, *Celtis*, *Carpinus*, *Carya*, *Cornus*, *Corylus*, *Fagus*, *Fraxinus*, *Juglans*, *Liquidambar*, *Liriodendron*, *Magnolia*, *Myrica*, *Nyssa*, *Platanus*, *Populus*, *Salix*, *Tilia*, and *Ulmus*-type. Also included are a number of high-altitude (*Abies*, *Picea*), Old-world (*Cedrus*, *Keteleeria*, *Platycarya*), and southern hemisphere (*Nothofagus*) elements. Similarly, Biaggi (1978), in an unpublished study, identifies several of these and others from the La Quinta flora — *Cedrus*, *Larix*, *Acer*, *Alnus*, *Carpinus*, *Corylus*, *Casuarinidites* (to the extent it implies *Casuarina*), *Fagus*, *Fraxinus*, *Liquidambar*, *Nyssa*, *Phytocrene* (presently southeast Asia, Malaysia), cf. *Platanus*, *Populus*, *Pterocarya*, *Salix*, and *Tilia*. These have not been reported in the published record of the slightly older to contemporaneous La Quinta flora (Langenheim et al., 1967; Miranda, 1963; this report), or in the younger middle to late Miocene Ixtapa Formation (Martínez-Hernández, 1992) of Chiapas. Certainly the presence of northern North American and eastern Asian temperate taxa, and southeast Asian tropical elements, in moderate-altitude and coastal habitats in Chiapas during the Oligo-Miocene would be of great biogeographic and paleoclimatic importance. Several of these taxa are known from the Tertiary of western United

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States and Canada, and identifications need to be confirmed to confidently establish their presence in southern Mexico.

The global paleotemperature curve (e.g., Miller et al., 1987) shows drops in Mean Annual Temperature (MAT) in the late Eocene/early Oligocene, Middle Miocene, and late Pliocene. As noted elsewhere (Graham, 1995), the drop in the middle Miocene was a propitious time for the introduction of northern temperate elements into the northern Latin American biota, although individual elements may have arrived at different times and by

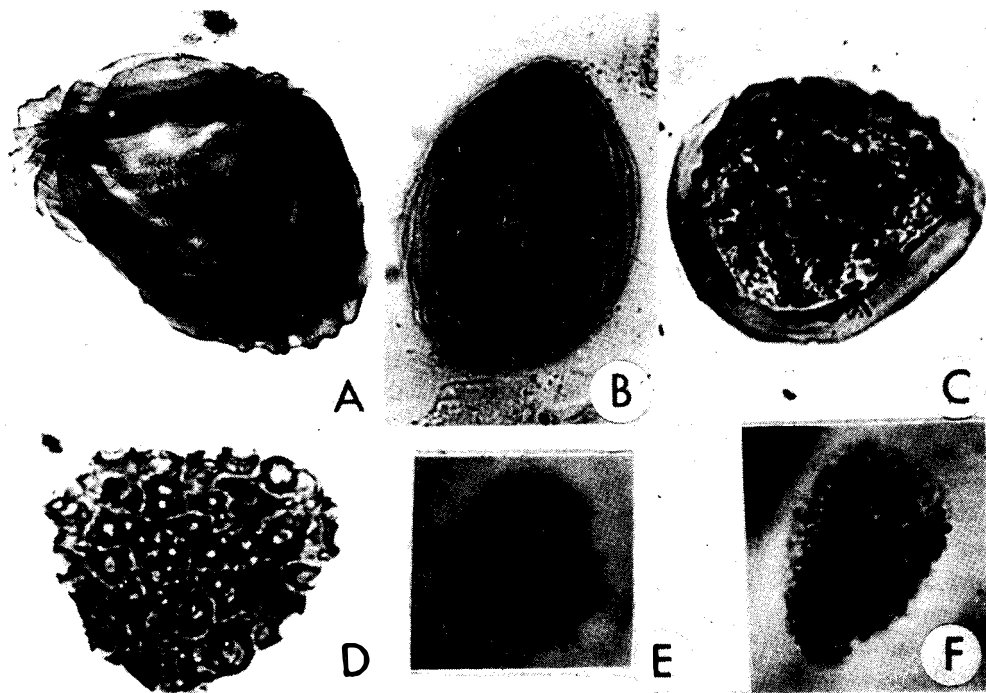


Fig. 3. A - F. Fossil spores and pollen from the Oligo-Miocene La Quinta Formation, Simojovel, Chiapas, Mexico. A. *Ceratopteris*; B. *Crudia*; C. *Pteris*; D. *Sphaeropteris/Trichipteris*; E. *Ilex*; F. *Asteraceae/Compositae*.

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various routes, including long-distance dispersal. Their presence in the middle Pliocene Paraje Solo flora, and their absence or poor representation in the Oligo-Miocene La Quinta flora is consistent with this model based on the paleobotanical data currently available.

Paleoelevation

The absence of high-altitude elements in the La Quinta flora (e.g., *Abies*, *Picea*) suggest low to moderate paleoelevations in the immediate vicinity during the Oligo-Miocene. Present altitudes in Chiapas are lower than in the Transvolcanic Belt to the north (5650 m, Pico de Orizaba). In the Chiapas Highlands the average elevation is presently about 2000 m, and the highest peak is San Cristobal de Las Casas at 3004 M (de Cserna, 1989). In the Sierra de Chiapas the average elevation is ~1000 m with the highest peak in the far southwest near the Guatemalan border (4000 m; Breedlove, 1973). Sedimentation was essentially continuous from the latest Mesozoic until the earliest Miocene. Compressive deformation from northeast to southwest subsequently gave rise to the highlands. Plio-Pleistocene strata show little deformation, which brackets the age of the principal upthrusting of the Sierra de Chiapas between early Miocene and Plio-Pleistocene. The beginning of deformation was at about the time of deposition of the Simojovel flora, and continued into the time of the younger Pichucalco and Ixtapa floras. A maximum altitude for the eastern end of the Transvolcanic Belt during the Mio-Pliocene was estimated at ~2500 m based on the composition of the Paraje Solo flora (Graham, 1989b). The palaeoaltitude in the region of the La Quinta flora in the Oligo-Miocene is estimated at 1000 to 1200 m. This would allow for a *Pinus-Podocarpus-Engelhardia* paleocommunity (present lower altitudinal range to 1200-1500 m), but not a pine-fir community (present lower range to ~2500 m). The uplift of the region by ~1000 m between the early Miocene and the Plio-Pleistocene augmented the middle Miocene temperature decline, and both events were involved in the appearance and spread of temperate habitats and biotic elements in the region.

Paleoclimate

At present only a general estimate can be made of the paleoclimate. The coastal environment was tropical as indicated by the presence of elements of the mangrove and lowland tropical rain forest. In the uplands a warm-temperate climate is suggested by *Pinus*, *Podocarpus* and *Engelhardia*. The mean annual rainfall in the region of Simojovel is presently ~2500 mm and summer wet. Slightly greater precipitation of somewhat more even distribution would likely support a rain forest in the coastal environments without converting the upland *Pinus-Podocarpus-Engelhardia* woods into more tropical forests. A MAT near that of the present (~24° C), and perhaps 2°—3° C warmer than during the Mio-Pliocene, is consistent with the composition of the La Quinta flora. The absence of upper montane cool-temperate taxa is probably more a reflection of the absence of highlands in the immediate vicinity than of substantially higher MATs.

The critical location and paleophysiographic diversity of Chiapas, Mexico have allowed a variety of biotas to occupy the region during the physical changes and climatic shifts of the Cenozoic. Lowland basins of deposition accumulated lignites and associated fine-grained sediments that preserved the history of terrestrial and near-shore vegetation in the form of

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pollen, spores, and other plant micro- and macrofossils. The study of these floras, in the context of the available marine invertebrate and geologic record, can reveal the biotic and environmental history of this important province. For this reason, it is especially desirable that independent efforts be coordinated, identification of the microfossils be confirmed, and preliminary results be discussed with other investigators interested in the region. This is essential to resolve problems of interpretation, and to insure the greatest consistency possible among the paleobotanical investigations and with the ancillary context information.

Preliminary summary of the composition of the La Quinta flora.

- Cyatheaceae
 - Sphaeropteris/Trichipteris*
- Pteridaceae
 - Ceratopteris*
 - Pteris*
- Pinaceae
 - Pinus*
- Podocarpaceae
 - Podocarpus*
- Anacardiaceae
 - Tapirira*
- Aquifoliaceae
 - Ilex*
- Bombacaceae
 - Pachira* - type
- Asteraceae/Compositae
- Juglandaceae
 - Engelhardia* (*Alfaroa/Engelhardia/Oreomunnea*)
- Fabaceae/Leguminosae
 - Caesalpinioideae
 - Crudia*
 - Hymenaea*
 - Mimosoideae
 - Acacia*
- Pelliceriaceae
 - Pelliceria*
- Rhizophoraceae
 - Rhizophora*

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