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HOW OLD IS THE TRIASSIC FLORA OF SONORA AND TAMAULIPAS AND NEWS ON LEONARDIAN FLORAS IN PUEBLA AND HIDALGO, MEXICO

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ABSTRACT

About 7,000 fossil plant specimens support the Carnian (and probably Norian) age of the Santa Clara Formation (Sonora State) and the Leonardian age of the Matzitzi Formation (Puebla State). The gigantopterid *Lonesomia mexicana* gen. nov., sp. nov. is described from the Matzitzi Formation. In addition, *Sigillaria ichthyolepis* and *S. brardii* reported from the same formation, provide key evidence in the discussion. The Late Triassic (but not Rhaetic) age of the fossil plants known to occur in the Huizachal Formation (original report: "La Boca Formation"), Novillo Canyon, Peregrina anticlinorium, Tamaulipas State, is confirmed as well. The "Huizachal" floristic assemblage of the San Mateo/Tlahualompa area, Huayacocotla anticlinorium, Hidalgo State, which was assigned previously to the Late Triassic, is discussed and allocated in part in the Leonardian, because it includes *Sigillaria* bark and *Cyperites* leaves. Another part of this flora may belong to the Jurassic Huayacocotla Formation. Further field-work is recommended to check this proposal.

Key words: fossil plants, Permian, Triassic, biostratigraphy, new genus, Sonora, Tamaulipas, Hidalgo, Mexico.

RESUMEN

Con base en unos 7,000 especímenes paleobotánicos, se confirma la edad cárnica (y probablemente nórica) de la Formación Santa Clara, Estado de Sonora, y la edad leonardiana de la Formación Matzitzi, Estado de Puebla. La gigantopteridal *Lonesomia mexicana* gen. nov., sp. nov. se describe de esta última formación. Además, *Sigillaria ichthyolepis* y *S. brardii*, referidas de la misma formación, son evidencia central en la discusión. Se verifica la edad de la flora triásica tardía—mas no rética—de la Formación Huizachal (referencia original: "Formación La Boca"), del Cañón de Novillo, Anticlinorio de La Peregrina, Estado de Tamaulipas. En contraste, el conjunto florístico "Huizachal" del área de San Mateo/Tlahualompa, en el anticlinorio de Huayacocotla, Estado de Hidalgo, previamente atribuido al Triásico, se asigna, en parte, al Leonardiano, porque incluye corteza de *Sigillaria* y hojas de *Cyperites*; y se sugiere que otra parte de este material tenga edad jurásica, correspondiendo a la Formación Huayacocotla. Se recomienda la realización de trabajo de campo adicional para elucidar las dudas restantes.

Palabras clave: plantas fósiles, Pérmico, Triásico, bioestratigrafía, nuevo género, Sonora, Tamaulipas, Hidalgo, México.

INTRODUCTION

Paleobotany has been considered to be of little help to unravel the historical geology of Mexico; however, clearly biostratigraphic purposes guided paleobotanical studies on the plant-bearing Late Triassic Santa Clara Formation of Sonora, which is poor in classical index fossils (invertebrates), and on the Early Permian Matzitzi Formation of Puebla, where other fossils besides plants are missing. Since palynomorphs have proven to be difficult to recover from apparently suitable rocks of these formations, the present study may be particularly appropriate to show, certainly not for the first time, how useful fossil megaplant assemblages can be in the regional correlation of continental rocks.

The taphofloras of both the Santa Clara and Matzitzi Formations are very abundant at many localities and are deemed basic in the regional biostratigraphic correlations considered here. In addition to these floras, some other more or less coeval florules are found elsewhere in Mexico. After discussing on the proposed age ranges of the Santa Clara and Matzitzi Formations, two other fossil floras are outlined herein with the purpose of confirming the previously assigned age of the first and to reconsider the age of the second one: (1) the Late Triassic flora of the "La Boca Formation" (Mixon *et al.*, 1959), Novillo Canyon, Tamaulipas; and (2) an assumedly Late Triassic floristic assemblage, said to belong to the "Huizachal Formation", near San Mateo-Tlahualompa, Hidalgo (Silva-Pineda, 1963, 1981; Carrillo-Bravo, 1965).

Due to space limitations, the problems of regional stratigraphy and stratigraphic nomenclature considered in this paper cannot be discussed in detail; no changes of stratigraphic names are proposed formally herein. The revised stratigraphic nomenclature of Rueda-Gaxiola and collaborators (1993a, b) is not used thoroughly here, in order to avoid terminological overweight.

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MATERIAL

This study is based chiefly on fossil material collected by the author and collaborators during 25 years, totalling about 7,000 specimens. The localities of the outcrop area of the Santa Clara Formation were plotted on maps by Weber (1985a) and Weber and Zamudio-Varela (1995). Some localities of the Matzitzi Formation are marked in Figure 1. The locality numbers given in the map, the text and the plate captions are those of the official catalog of paleontological localities of Mexico, compiled by the Instituto de Geología, Universidad Nacional Autónoma de México (CLP-IG-UNAM). Maps of the area with plant-bearing outcrops near San Mateo, Hidalgo, were published by Silva-Pineda (1963, 1981), but the geological information of these maps is outdated. Most of the material mentioned above is housed in the Paleontological Museum, Instituto de Geología, UNAM. Some specimens from the Matzitzi Formation, however, belong to the Paleontological Museum, Facultad de Ciencias, UNAM. One holotype and some other figured specimens from the latter material were transferred for permanent housing to the Paleontological Museum, Instituto de Geología, UNAM. The specimens used by Silva-Pineda (1963, 1970, 1981), which are restudied here, are also housed in the Paleontological Museum, Instituto de Geología, UNAM. In addition, some specimens from the Late Triassic of Tamaulipas, belonging to the National Museum of Natural History in Washington, are studied and figured here. They received new specimen numbers. Numbers are given in the plate captions.

All fossil plants mentioned or discussed herein are impressions without cuticles. Their successful use in unraveling a number of biostratigraphic problems sheds light again on the need of studies about impression fossils, which are not superfluous at all even in floras yielding occasionally compressions with cuticles or structurally preserved plant organs.

EXPLANATION OF PLATES

Where no magnification is specified, the fossils are reproduced at natural scale. The photographs were taken and processed by A. Altamira and H. Hernández-Campos, in close cooperation with the author. No collector is mentioned for specimens found by the author. All specimens are deposited in the type collection of the Paleontological Museum, IG-UNAM, or in the National Museum of Natural History, Smithsonian Institution, Washington (Plate 4, figures 2–5, 8).

PREVIOUS RESEARCH AND NEW DATA

THE FLORA OF THE SANTA CLARA FORMATION

Descriptive and floristic work on fossil plants from the coal and graphite-bearing Santa Clara Formation (Alencáster, 1961a) has been published since the past century (Newberry, 1876; Aguilera *in* Aguilera and Ordóñez, 1893, 1896; Humphreys, 1916; Read *in* King, 1939; Brown *in* Wilson and Rocha, 1946; Silva-Pineda, 1961; Weber, 1980, 1985a-c, 1995, 1997; Weber *et al.*, 1980a, b; Weber and Zamudio-Varela, 1995; Zambrano and Weber, 1985). As to the age, there was from the beginning a consensus among paleobotanists and geologists, that this flora indicated a Late Triassic age. Silva-Pineda (1961), seconded later by Weber and collaborators (1980a) and by Ash (1980), assigned the plants more exactly to the Carnian, with additional support of fossil invertebrates (Alencáster, 1961a, b). Ash (1980), claiming even better resolution, placed the Santa Clara flora in the Eoginkgoites-zone of his stratigraphic subdivision of the Newark Supergroup, *i.e.*, in the lower Carnian.

Thereafter, a modification to the age of the Santa Clara flora was made by Weber (1985a), who assigned the Santa Clara flora again to the Carnian, but suggested that the formation at least in the southernmost part of its outcrop area, grades into—or belongs to—the Norian. This was done because the Norian ammonite *Acanthinites* Mojsisovich (Alencáster *in* Martínez-Jiménez, 1984) had been found in strata equivalent to the Santa Clara Formation, near the town of Álamos, southern Sonora, which yield also graphite beds. This strata-equivalence was supported by lithological similarity (Martínez-Jiménez, 1984) and by one fossil plant collected from the Álamos area and identified as *Laurozamites* ex gr. *fragilis* by the present writer. This genus is very common in the Santa Clara flora of central Sonora. To further support a possible Carnian-Norian age range, Weber (1985a) highlighted the finding of two plants in the Santa Clara Formation, which occur mostly in the Early Jurassic all over Laurasia, *Phlebopteris angustiloba* (Plate 1, figures 2, 3) and *Scoresbya dentata* (Weber, 1995). On the other hand, Ash (1992), impressed by *Phlebopteris angustiloba* and *Scoresbya*, proposed a Rhaetian age for the Santa Clara Formation, instead of his earlier assignment of this unit to the Eoginkgoites-zone.

The systematic study of the Santa Clara plants is a long-term task of the writer. No floristic list is given here due to space limitation (*cf.* Weber, 1985a). Some taxa mentioned in the text are illustrated and commented in the captions of Plates 1 and 4.

THE FLORA OF THE MATZITZI FORMATION

The Matzitzi taphoflora was discovered at the end of the past century, as summarized by Silva-Pineda (1970) and Weber and collaborators (1989). It was, however, studied by a paleobotanist not earlier than in the late sixties, although material had been collected by T. Flores in the first decade of the present century. This material was examined by G.R. Wieland in 1906, while he visited the Geological Institute of Mexico to begin his studies on the Jurassic flora of the Mixteca Alta; but he did not realize that the Matzitzi and Mixteca floras differ in age (Wieland, 1914–1916). Thus, he reinforced the earlier but

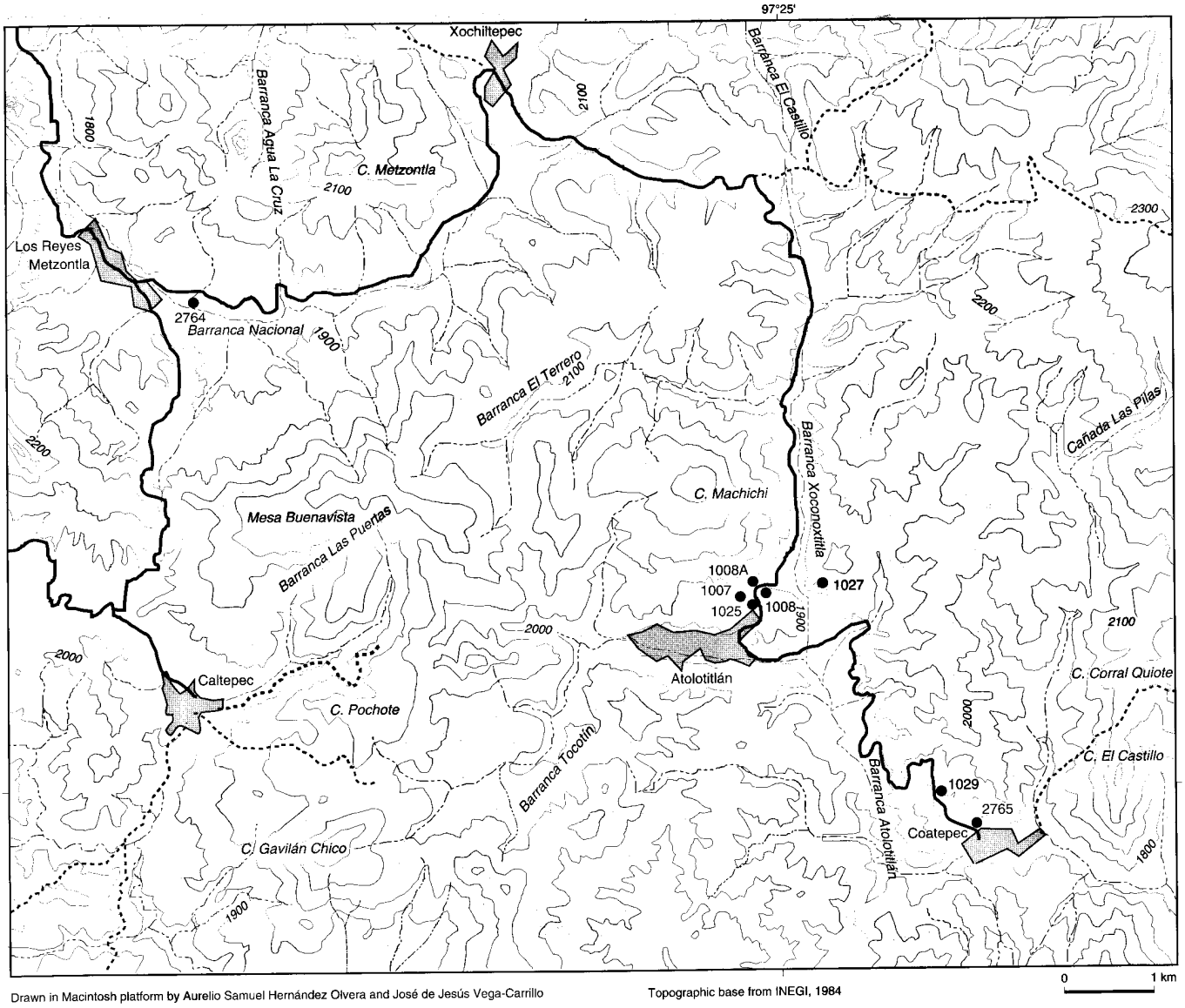
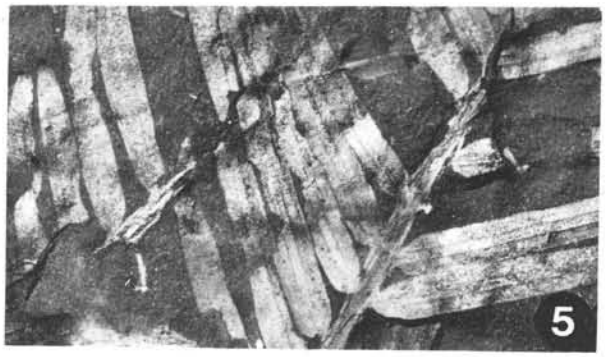


Figure 1. Location map of the Los Reyes Metzontla area, State of Puebla, showing some plant fossil localities in the Matzitzi Formation.

tentative assignment of the Matzitzi flora to the Late Triassic (Aguilera, 1896). This age was accepted until 1970 with only those modifications made in agreement with changes in the age of the flora of the Mixteca Alta: Liassic (Wieland, 1914–1916), Rhaeto-Liassic/Dogger (Burckhardt, 1930) and Early to Middle Jurassic (Müllerried, 1933). The first descriptive work on Flores's material and the Matzitzi taphoflora (Silva-Pineda, 1970) resulted in its assignment to the late Paleozoic (Pennsylvanian).

In 1975, during occasional studies on the Matzitzi flora, the present author began to challenge this assignment to the Pennsylvanian, and additional collecting by himself, his students and several independent workers lead to the discovery of a number of species, not reported by Silva-Pineda (1970), which indicated that the Matzitzi flora might be "Permo-Carboniferous" in age. This ambiguous age assignment was reported by Weber and collaborators (1987); it was worked out in more detail, including more shortcomings, by the author (*in* Weber *et al.*, 1989); but finally, Weber (*in* Weber and Cevallos-Ferriz, 1994) decided to place the Matzitzi Formation in the Leonardian, after the discovery of the gigantopteridalean plant *Lonesomia mexicana*, described below (Plate 3). This was done, because the American gigantopterids are restricted to the Leonardian, and in spite of the presence of *Sigillaria ichthyolepis* and *S. brardii* and of *Holcospermum* in the Matzitzi (Plate 5, figures 1–4, 6–8).

In addition, the plants unknown to Silva-Pineda (1970) include the fern genus *Fascipteris*, described chiefly from the Permian of China (Magallón-Puebla, 1991), *Taeniopteris* aff. *multinervis*, a cycadophyte recalling *Pterophyllum*, a *Rhipidopsis* or *Ginkgoites* sp. (Plate 2, figures 5–10) and, last but not least, cf. *Sphenophyllum* ex gr. *thonii* (Plate 2, figures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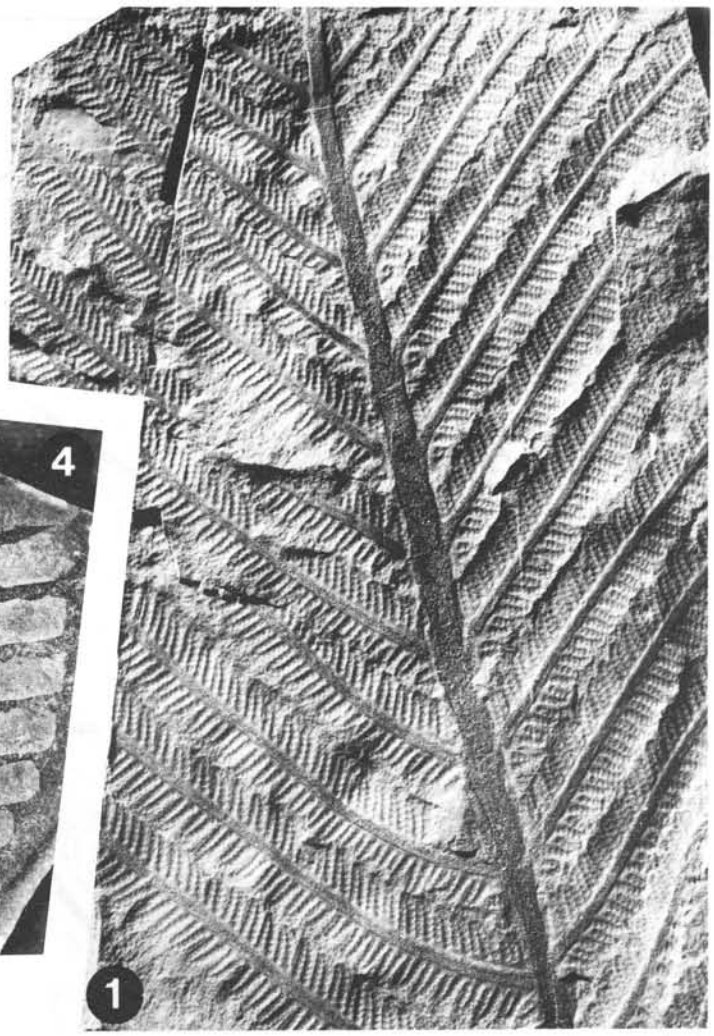
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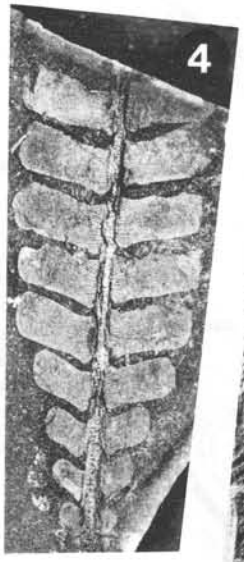
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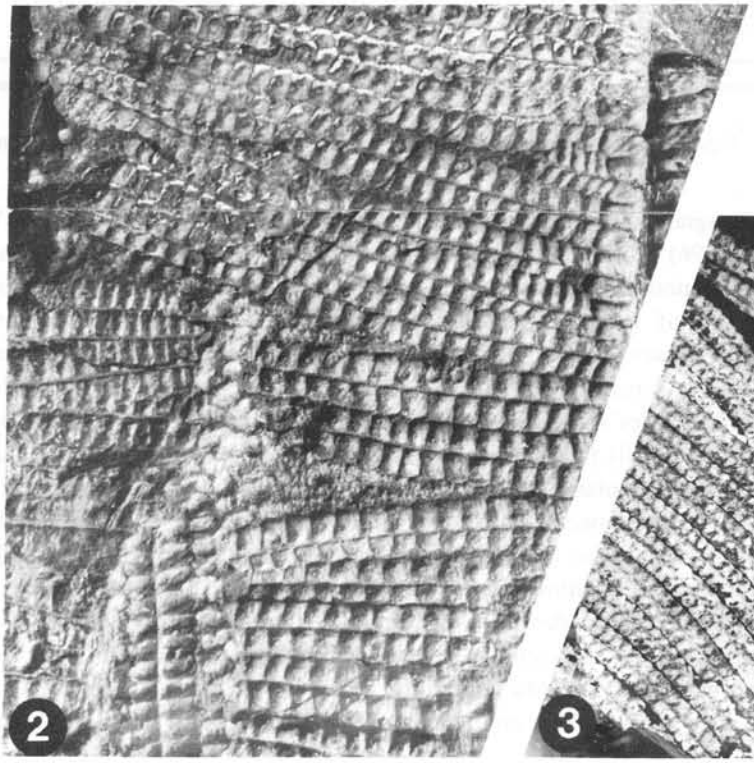
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1–4). This species, represented in the author's material by one leafy axis and a number of detached leaves with occasionally anastomosing venation, was reported originally as "*Glossopteris*" or a glossopteridalean (Weber *et al.*, 1987, 1989).

The "*Glossopteris*" identification was based on similarities with the former "*Glossopteris verticillata*" from the Late Triassic of South Africa, and with *Gangamopteris walkomii* from the Permian of Australia. In 1990, however, the author became aware of the fact that Anderson and Anderson (1989) had assigned the former "*Glossopteris verticillata* Thomas" from the Late Triassic of South Africa, to a new genus, *Gontriglossa* (incertae sedis). In 1991, the author examined the original material of *Gontriglossa* at Pretoria. It differs from the Matzitzi material in its much larger leaves and very well developed reticulate venation. On the other hand, Rigby (1967) observed in his original paper on *Gangamopteris walkomii*, that the leaves of this species are attached in apparent whorls—or condensed spirals—of more than six leaves per whorl.

Even later, in 1996, the author saw another important specimen with a leafy twig of cf. *Sphenophyllum* from the Matzitzi Formation, collected and figured by Velasco-Hernández and Lucero-Arellano (1996, fig. 4). This poor photograph does not show the well preserved, open venation lacking anastomoses of this particular specimen, which may also belong to a species different from the one figured here (Plate 2, figures 1-4), as suggested by the presence of characteristic twisted teeth on the leaf margins. The collector, Velasco-Hernández, neither deposited the specimen in a public collection, nor did he make it available for further study, unfortunately. However, the scarceness of vein anastomoses in the many specimens seen by the author allows, *cum grano salis*, to place this material in cf. *Sphenophyllum*. Anastomoses might have been present occasionally in the venation of the leaves of this genus.

At the time of the final revision of this paper, an additional specimen with two detached leaves of cf. *Sphenophyllum* ex gr. *thonii* was discovered in old paleontological materials of the Instituto de Geología, UNAM, by Katia Adriana González-Rodríguez. No vein anastomoses can be observed in the poorly preserved leaves. The fossil was collected in April, 1931, by F.K.G. Müllerried, near Coatepec, certainly from the Matzitzi Formation, but no stratigraphic data are given on labels. On the original label, handwritten by Müllerried, the leaves are identified as (?) *Glossopteris* sp. At first, he had called them *G. linearis* McCoy, in agreement with Wieland (1914), but later, he erased the epithet. Thus, the present author was not first in suggesting erroneously a glossopteridalean affinity for this plant now thought to be a sphenophyll. Other than the present author, however, Müllerried was confident that Wieland's (1914) record of *Glossopteris* from the Mixteca Alta Jurassic was correct, and, therefore, did not consider a Paleozoic age for this fossil. The case shows that the plant discussed here is indeed suggestive of both, the glossopterids and the sphenophylls, but in fact might be none of these. The finding of the corresponding reproductive organs is necessary for proper taxonomic placement.

From a phytogeographic viewpoint, the Matzitzi flora was assigned to the mixed floras with Cathaysian and Gondwanan elements, due to the above "record" of "*Glossopteris*" (Weber *et al.*, 1989). However, the writer had to learn that he was wrong. Neither endemic nor nearly endemic elements of the Permian vegetation of Gondwanaland are present in the Matzitzi flora; but doubtless, there is an affinity with the flora of Cathaysia.

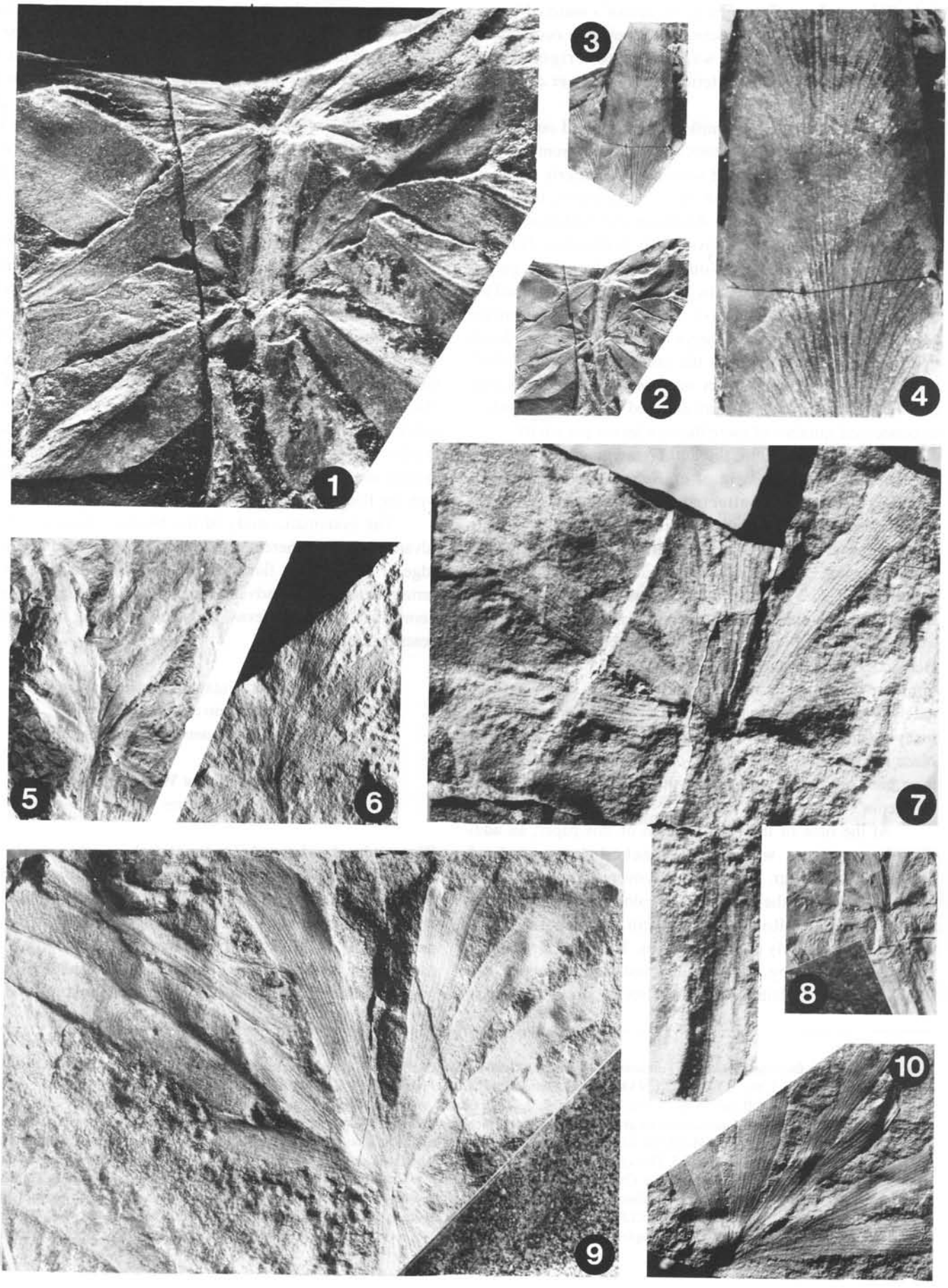
The systematic study of the Matzitzi flora is not very advanced due to inherent difficulties. It requires a firm knowledge of the Permian floras of eastern Asia, and depends to a certain extent on the advancement of the investigation on the Leonardian floras of Texas. Only the following new genus is described formally here:

Order: Gigantopteridales
Family: no assignment
Form-Genus: *Lonesomia* Weber, gen. nov.

***Lonesomia mexicana* Weber, sp. nov.**
(Plate 3, figures 1–3)

Diagnosis—Leaf simple, symmetrical, sessile or with very short petiole, blade elliptic to lanceolate, lamina leathery, arched between midrib and margin, base rounded, tip rounded or retuse, margin entire, lamina reaching about 5 cm in width and over 20 cm in length. Length/width ratio about 5. Petiole to 5 mm in width. Midrib straight, to 3 mm wide at lamina base, slendering to the tip. Venation of at least three orders,

Plate 1. Fossil plants from the Santa Clara Formation, Late Triassic, Sonora, Mexico. Figure *1*, *Asterotheca santaclarae* Weber (specimen IGM-PB-515-1044 A; loc. La Barranca, Section 1, no. 515 CLP-IG-UNAM; coll. G. Hernández-C.; x 1). Figures *2, 3*, *Phlebopteris angustiloba* (Braun) Hirmer and Hörhammer, fertile fronds (loc. El Crucero, Bed B, no. 537B CLP-IG-UNAM; coll. A. Torres-Romo and coworkers); *2*, (specimen IGM-PB-537-565B, verso, x 2); *3*, (specimen IGM-PB-537B-1045). Figure *4*, *Laurozamites* ex gr. *fragilis* (Newberry) Weber and Zamudio-Varela (specimen figured by Weber *et al.*, 1980a, b, under the number IGM-PB-WG75-483; new no. IGM-PB-501-531B; loc. Santa Clara, Shaft "Santa Rosa", no. 501 CLP-IG-UNAM); similar material was reported from the Huizachal Formation, Tamaulipas. Figure *5*, *Elatocladus carolinensis* (Emmons) Weber; twig showing opposite leaves with grooves on both sides of the midveins (specimen IGM-PB-538-1046 A; locality La Chinita, no. 538 CLP-IG-UNAM); similar material was found in the Huizachal Formation, Tamaulipas. Figure *6*, Conifer bark, possibly belonging to *Elatocladus* cf. *carolinensis*, illustrated here for comparison with *Sigillaria ichthyolepis* and *S. brardii* (specimen IGM-PB-548-1047; loc. Cerrito 1979, no. 548 CLP-IG-UNAM; coll. A. Bello). Figure *7*, *Chiropteris* Kurr?, sp. A; the leaf cannot be identified with certainty, because the leaf base (with petiole?) is not complete (specimen IGM-PB-543B-1048; loc. Chamina Sur, bed B; no. 543B CLP-IG-UNAM; coll. A. Zambrano-García).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secondaries inserted at the midrib at 75 to 80°, tertiaries inserted on these at about 45°.

Holotype—specimen IGM-PB-1027-1059 A, B (Plate 3, figure 2).

Type locality—"Escurridero" at the knee of Barranca Xoconoxtitla, about 0.5 km north northeast of San Luis Atolotitlán, Puebla State (loc. 1027, CLP-IG-UNAM); 18°11'36''N, 97°24'46''W).

Type stratum and age—Matzitzi Formation, Leonardian (Early Permian).

Derivation of name—*Lonesomia*: Anagram of the name *Evolsonia*, with graphic modification of one letter; *mexicana* (mod. lat.): the species is described from Mexico.

Most American gigantopterids have been placed in monotypic genera *(cf.* Taylor and Taylor, 1993). *Lonesomia* is closest to the genera *Evolsonia* (Mamay, 1989) and *Delnortea* (Mamay *et al.*, 1988), which possess non-forked leaves. *Delnortea* is clearly distinct in its very regular venation pattern with four orders of veins, crenate leaf margin, sinal termination of secondaries and a marginal thickened rim. *Evolsonia* has very large (to over 80 cm in length—inferred) and vaulted leaves with entire or, mostly, shallowly to deeply sinuous margins. The venation shows four orders of veins. The material from the Matzitzi Formation does not show the mentioned characters of *Delnortea* and has much smaller leaves than *Evolsonia*, with constantly entire margins and possibly only three orders of veins. The venation of the Mexican species cannot be observed clearly in the leaves at hand. Most probably, the blade surfaces were covered by a layer of trichomes. As long as there is no clear picture of the venation in the Mexican material, it cannot be placed in one of the previously described genera. All North American gigantopterids are known from shed and isolated leaves. The specimen figured in Plate 3, figure 1, shows an axis with three leaves attached to it spirally. This specimen is unusually complete and well preserved. In a way, it stands alone.

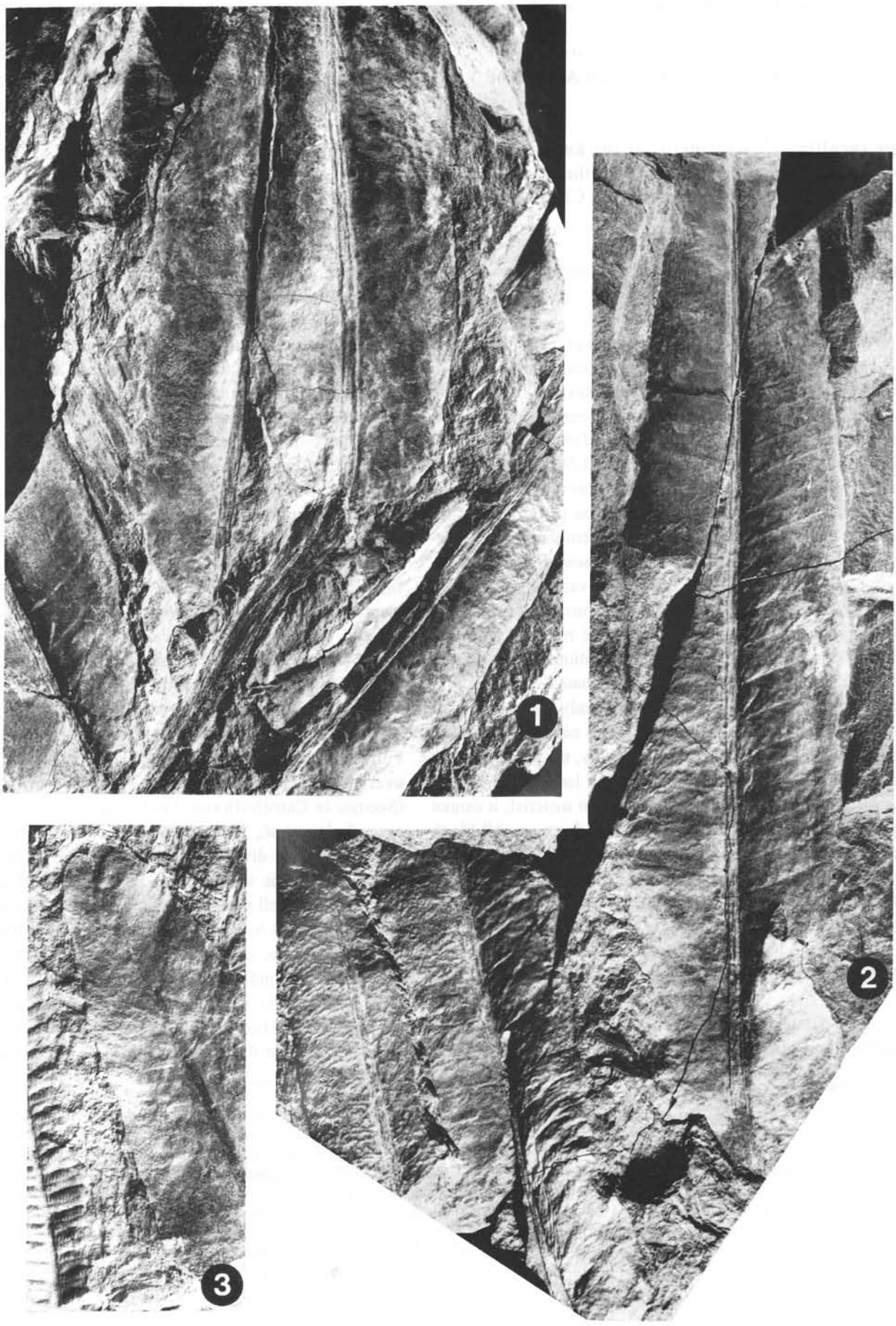
THE HUIZACHAL FLORA OF TAMAULIPAS

Only little information on Mexican Late Triassic taphofloras outside Sonora is available. Mixon and collaborators (1959) found Late Triassic plants in their "La Boca Formation" in the Novillo Canyon, Peregrina anticlinorium, Tamaulipas. They collected (1) *Laurozamites yaqui*—reported by them as "*Pterophyllum fragile*" (*cf.* Weber and Zamudio-Varela, 1995). (2) A species corresponding to a group of bennettitaleans that needs revision, assigned sometimes to "*Ctenophyllum braunianum*", s.l.—reported as "*Pterophyllum inaequale* Fontaine". (3) *Elatocladus* ex gr. *carolinensis (cf.* Weber, 1980, fig. 1; 1985, a–c)—as "*Cephalotaxopsis carolinensis*". And (4) questionable fragments of *Podozamites*. All these plants are either known from the Santa Clara Formation of Sonora, or are represented there by closely related species, and occur also in other, mainly Carnian formations of North America. *Podozamites* is rare in the Santa Clara, but was reported from several Late Triassic floras of North America. Without specific identification, it is worthless in biostratigraphy. It is important to add that none of these species was found in Jurassic strata of Mexico.

The original specimens collected by Mixon and collaborators (1959) are housed in the Smithsonian Institution, but they were never described or illustrated. Some of them are illustrated herein (Plate 4, figures 2–5, 8) for the first time. Closely similar plants from the Santa Clara Formation are figured here side by side with those from Tamaulipas (Plate 1, figures 4, 5; Plate 4, figures 1, 6, 7). The writer confirms the identifications as updated above and the Late Triassic age of the "La Boca" plants, which are about the same age as the Santa Clara plants. He does not agree, therefore, with their assignment to the Rhaetian by Carrillo-Bravo (1961). Their accurate age is Carnian or, perhaps, Norian.

According to the previous literature, the concept La Boca Formation, as defined by Mixon and collaborators (1958), overlaps the concept Huizachal Formation of other authors (Seemes *in* Carrillo-Bravo, 1961: *fide* Fries *et al.*, 1962; *non sensu* Imlay *et al.*, 1948, *et seq.*). The complicated history of the stratigraphic division and nomenclature of the lower and middle Mesozoic strata of the Peregrina and Huayacocotla anticlinoria is well summarized in Rueda-Gaxiola and collaborators (1993a). It is worthwhile to mention here the recent discovery of Jurassic vertebrates in the La Boca Formation of the Huizachal Canyon (Fastovsky *et al.*, 1987, 1995). According to these authors, the La Boca Formation seems to be entirely Jurassic in the Huizachal canyon. Consequently, it became doubtful, whether the plant beds of the Triassic locality in the

Plate 2. Fossil plants from the Matzitzi Formation, Leonardian, Puebla, Mexico. The specimens figured on this plate were transferred from the collections of the Paleontological Museum, Facultad de Ciencias, UNAM, to the Paleontological Museum, Instituto de Geología, with kind permission of Sara Quiroz-Barroso and Francisco Sour-Tovar. Figures *1–4*, cf. *Sphenophyllum* ex gr. *thonii*; *1, 2*, axis with two whorls of leaves, with six leaves each; no true midvein is present, but several strong veins are concentrated along the midline (specimen IGM-PB-2764-626; loc. Los Reyes Metzontla, no. 2764 CLP-IG-UNAM, coll. S. Quiroz-Barroso and F. Sour-Tovar and students); *1*, (x 3). *3, 4*, Detached leaf showing venation with occasional anastomoses (specimen IGM-PB-1028-1053; loc. Los Reyes Metzontla, no. 1028 CLP-IG-UNAM; coll. S. Magallón-Puebla); *4*, (x 3). Figures *5–10*, *Rhipidopsis* Schmalhausen or *Ginkgoites* Seward, sp.; these ginkgoid leaves cannot be assigned definitively to one of these genera; *Ginkgoites*, however, might be the better choice (loc. Coatepec 1, about 300 m NW Coatepec, roadside, loc. no. 2765 CLP-IG-UNAM; coll. P. Barrera-García, F. Sour-Tovar, S. Magallón-Puebla and R. Weber); *5*, (specimen IGM-PB-2765-1054); *6*, (specimen IGM-PB-2765-1055); *7, 8*, (specimen IGM-PB-2765-1056); *7*, (x 3); *9*, (specimen IGM-PB-2765-627, x 3); *10*, (specimen IGM-PB-2765-1057).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Novillo Canyon are actually in the La Boca Formation, even *sensu* Mixon and collaborators (1959). On the other hand, Rueda-Gaxiola and colleagues (1989), after palynological studies, divided the Huizachal Formation *sensu* Carrillo-Bravo (1961), in the Huizachal and Huayacocotla Alloformations, the first restricted to the Peregrina anticlinorium, and the latter to the Huayacocotla anticlinorium. Furthermore, in accordance with Rueda-Gaxiola and collaborators (1993b, fig. 1), the certainly Late Triassic "La Boca" plants do not seem to belong to the La Boca Alloformation, but to the Huizachal Alloformation. The present writer agrees with these authors in that the old concept of Huizachal Group is no longer useful.

THE SAN MATEO FLORA OF HIDALGO

An assumedly Triassic taphoflora was reported by Silva-Pineda (1963) from the Huayacocotla anticlinorium in the vicinity of San Mateo, northeast of Tlahualompa, Hidalgo. Preliminary results of her work were also quoted by Carrillo-Bravo (1965), who assigned this flora to the lowermost level of the "Huizachal Formation". In 1981, Silva-Pineda reported additional material and revised her earlier identifications.

Silva-Pineda's (1963) material includes the following species: (1) The ferns "*Todites carrilloi*" and "*Mertensides bullatus*"—that were identified as "*Asterotheca merianii*" in the later revision (Silva-Pineda, 1981). (2) The fern "*Thaumatopteris* cf. *kochibei*", whose identification was based on very fragmented material; (3) "*Stenopteris* cf. *desmomera*"—discussed in detail below—that was identified as "leaves resembling *Lepidodendron*" later (Silva-Pineda, 1981); and finally, she included the cycadophyte leaves (4) "*Pterophyllum longifolium*" and (5) *Otozamites hespera*. *O. hespera* is a Jurassic species known from Mexico (Wieland, 1914–1916), but was erroneously reported by Hope and Patterson (1969) also from the Late Triassic Pekin Formation of North Carolina, USA (see Weber and Zamudio-Varela, 1995). *Pterophyllum longifolium* is a Late Triassic form, but its record in Hidalgo is inaccurate. *P. longifolium*, the type species of *Pterophyllum*, was first described from the Carnian flora of Switzerland (Brongniart, 1828), but is also very well represented in the coeval flora of Lunz, Austria. The pinnae of the leaves of this species and of the closely related *P. jaegeri* and *P. brevipenne* are normally much narrower than those in the specimen from Hidalgo. Kräusel and Schaarschmidt (1966) restudied the European species in modern terms and established the importance of pinnae dimensions in the taxonomic classification of this group. Especially the length/width ratio of the pinnae has been used by these authors. This ratio is not known in the material from Hidalgo, because the pinnae are not complete; but in addition, the pinnae in the mentioned group of species from Europe are narrowing near the base and widening again at attachment, so that the pinnae are slightly more separate close to the base than more distally. The specimen from Hidalgo does not show this character. Many *Pterophyllum* specimens from widely dispersed fossil floras were identified erroneously as *P. longifolium* by authors who did not pay careful attention to the material from Neuewelt.

The author dealt with the whole material of Silva-Pineda (1963, 1980) in teaching and curating, and began to question the assumedly Late Triassic age many years ago. The problem was tackled at first by a re-examination of the original material and an attempt to recognize the localities it had been collected from, and later in a point-by-point critical reading of the corresponding publications. The revision of the localities of the previous authors in the field, however, had to be postponed, and it is suggested to re-study the corresponding section, instead.

A first lot of specimens studied by Silva-Pineda (1963) was collected from two different localities (see below), which are neither specified on labels nor mentioned in Silva-Pineda's descriptions of species. Consequently, it is not possible to distinguish the fossils from each locality with only the specimens and her publication at hand. Carrillo-Bravo (1965) did not report the exact location of these collections, but he enumerated the fossil plants found at one of these localities (see below). Much later, Silva-Pineda (1981) collected herself a second lot of specimens. Fortunately, it is easy to distinguish the two lots of actual specimens.

The examination of Silva-Pineda's material resulted in the discovery of two important pieces of positive evidence: Firstly, in her first and older lot, there is a specimen not taken into account by herself in the corresponding publication (Silva-Pineda, 1963). It shows a fragment of *Sigillaria* bark in poor "Syringodendron-preservation", which is discussed in context below (Plate 5, figure 5). This fragment was associated with linear, grass or sedge-like leaves, first identified by Silva-Pineda (1963) as *Stenopteris* cf. *desmomera*, but belonging instead to the form genus *Cyperites*, which represents, *pars pro toto*, *Sigillaria*.

Secondly, in the same first lot of material (Silva-Pineda, 1963), there are, among others, several specimens with *Otozamites* and *Pterophyllum*. It is important to notice that these particular specimens show only such cycadophyte leaves

Plate 3. *Lonesomia mexicana* sp. nov. from the Matzitzi Formation, Leonardian, Puebla, Mexico (loc. Escurridero at the knee of Barranca Xoconoxtitla, 0.5 km NNE Atolotitlán, Puebla, no. 1027 CLP-IG-UNAM; coll. S. Magallón-Puebla, F. Sour-Tovar and others). The specimens figured on this plate were transferred from the collections of the Paleontological Museum, Facultad de Ciencias, UNAM, to the Paleontological Museum, Instituto de Geología, with kind permission of Sara Quiroz-Barroso and Francisco Sour-Tovar. Figure *1*, Leafy twig showing probably dispersed phyllotaxy (specimen IGM-PB-1027-1058). Figure *2*, Holotype; fragment of three leaves, venation recognizable grossly; the leaves possess a midrib, secondary veins and, parallel among these, false secondaries or zones of confluence of tertiary venation; the entire leaves of this species resulted from compaction of originally at least bipinnate leaves; the false secondaries originated at the lines of fusion of the neighboring pinnae (specimen IGM-PB-1027-1059 A). Figure *3*, Leaf with cleft apex (specimen IGM-PB-1027-1060 A).


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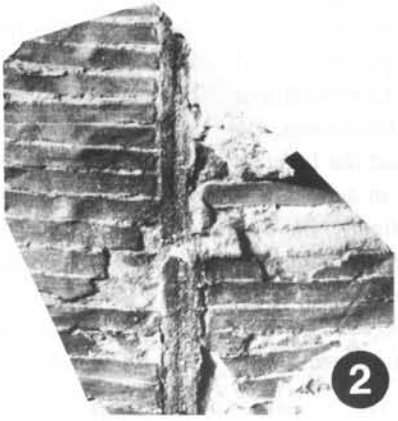
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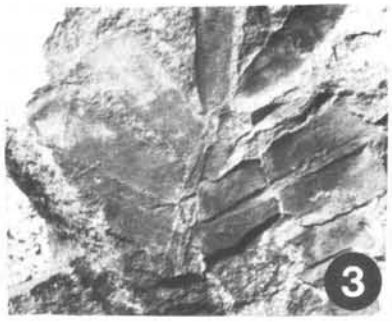
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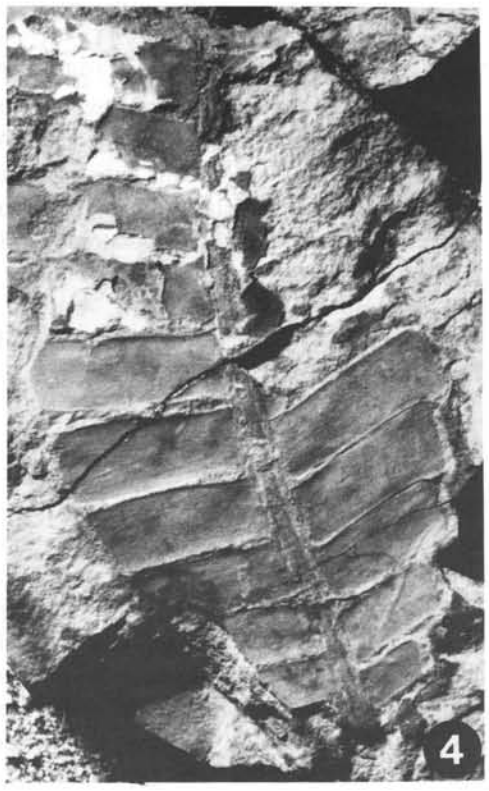
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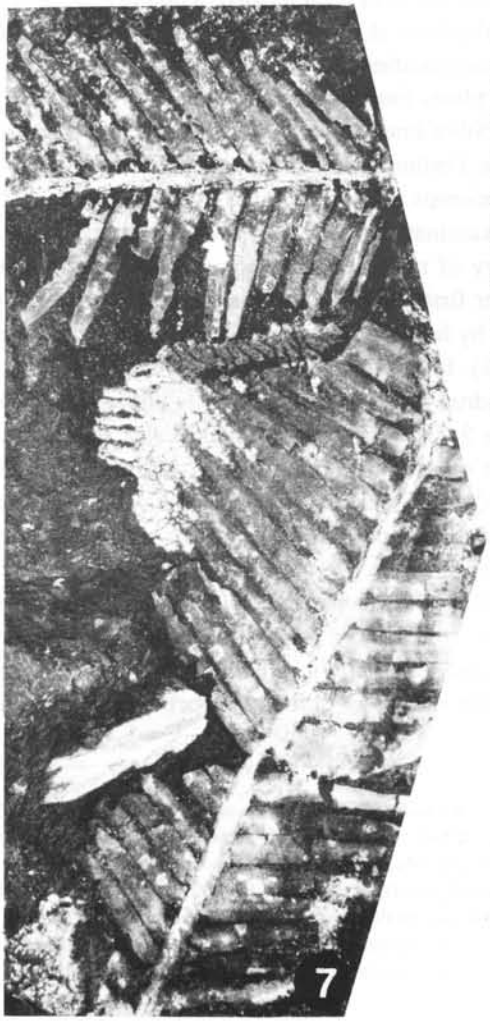
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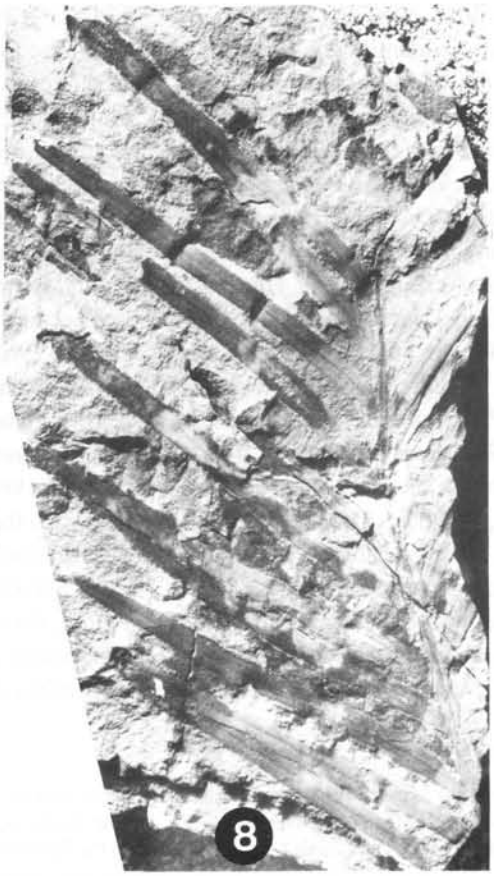
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and, rarely, additional non-identifiable fragments of ribbon-like leaves and other badly degraded remains, but neither *Cyperites* nor fern leaves. Also in the same lot, there are some slabs which physically link *Cyperites* and *Pecopteris* together, *i.e.*, these genera belong to a single floristic assemblage along with the *Sigillaria* bark, that is in turn linked with *Cyperites* by taxonomic relationship. If from the two lots of Silva-Pineda (1963, 1981) those specimens agreeing floristically in both are eliminated, those with cycadophyte leaves and the fragments called "*Thaumatopteris* cf. *kochibei*" are left over. They must have been collected, at least in part, from one distinct locality, as confirmed indirectly by Carrillo-Bravo (1965) in his species list for one of the localities studied by Silva-Pineda. After this list, the specimens identified by Silva-Pineda (1963) as "*Thaumatopteris* cf. *kochibei*" belong to the assemblage of the locality with ferns, *Sigillaria* and *Cyperites* (locality 1; see below). Only the cycadophytes belong to a clearly distinct assemblage and were collected from a second locality (locality 2; see below).

To corroborate the Late Triassic age of all these plant remains, Carrillo-Bravo (1965) forwarded shale samples from the locality with *Sigillaria* bark and leaves to a North American oil company, for palynological study. The samples turned out to be rich in organic residues, but the only palynomorph reported with its taxonomic name is the genus *Monosulcites*. Furthermore, the samples were compared with a core drilled in Alaska and assigned without explanation to the Triassic. Upon the writer's request, a rock sample cut from a specimen studied by Silva-Pineda (1963) showing *Cyperites* leaves on one surface, was examined palynologically by E. Martínez-Hernández. Indeed, the sample was also very rich in organic matter, especially kerogene, indicating a swampy continental paleoenvironment. A well preserved monosulcate palynomorph, *Cycadopites*, was found besides a number of badly degraded forms suggestive of spores. According to Traverse (1988), the monosulcate forms are: "A group of sporomorphs that originated in the 'Paleophytic' but became very significant in the Permo-Triassic and remain so through the 'Mesophytic'—*Entylissa* is one form, already present in the Carboniferous, but there are a number of others such as species of *Monosulcites* and *Cycadopites*". According to Traverse (1988, fig. 10.1), *Cycadopites* existed already in the Artinskian. The meager palynological data given by Carrillo-Bravo (1965) are deemed unsuitable to prove a Triassic age of the material under investigation.

DISCUSSION

THE AGE OF THE SANTA CLARA FORMATION

The assignment of the Santa Clara to the Carnian is reinforced by the assemblage of the plant genera, many of which became extinct during the Late Triassic at least in western Laurasia. There are some ferns, above all *Asterotheca santaclarae* (Plate 1, figure 1), and in addition, *Mertensides* and *Cynepteris*, known from the Late Triassic, but not from the Early Jurassic in North America and Europe. *Tranquilia*, *Cynepteris* and *Mertensides* are only known from the Carnian (and perhaps the Norian: Santa Clara Formation) in North America. In addition to the ferns, there is *Chiropteris* (Plate 1, figure 7), possibly a ginkgophyte, the first one reported from North America and figured for the first time, here. In conclusion, the writer subscribes that the Santa Clara Formation is Carnian in age, leaving open the choice of partial assignment to the Norian: Carnian and probably Norian. Carnian and Norian megafloras are very similar, at least in western Laurasia.

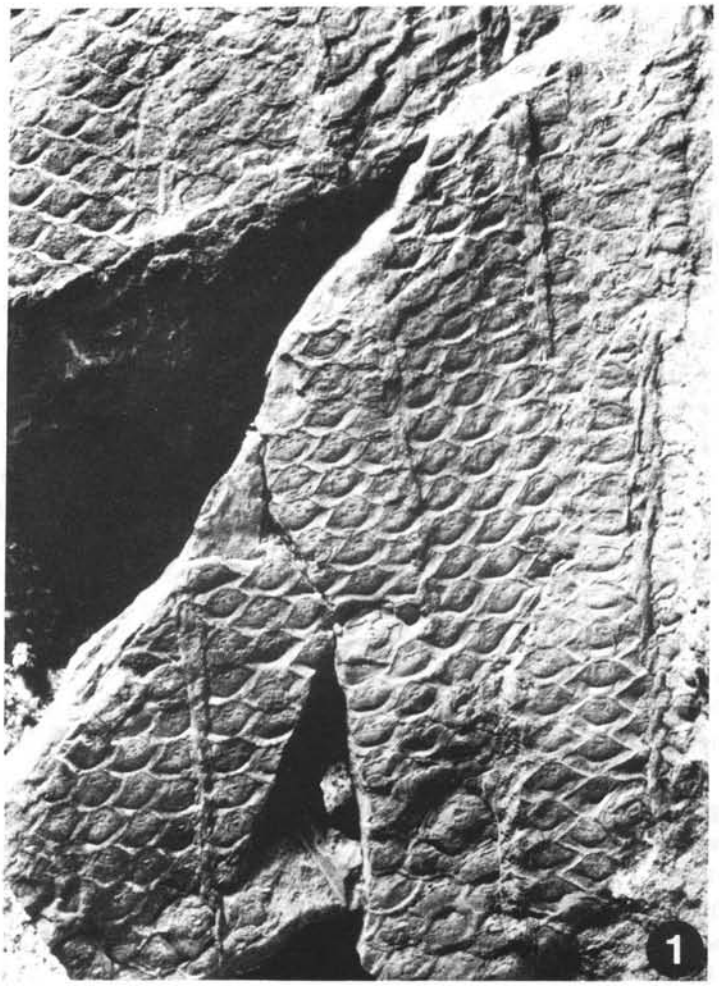
The Rhaetian age, adscribed to the Santa Clara Formation by Ash (1992) on the basis of Weber's (1985a-c) arguments, was never discussed *in extenso* (Ash, personal communication, 1997). In this regard, it was possible to show that *Scoresbya* has Late Triassic representatives in Laurasia, and that it is exclusively Late Triassic in Gondwanaland (Weber, 1995). *Phlebopteris angustiloba* is probably present in the Carnian of Germany (*fide* van Konijnenburg van Cittert, personal communication, 1996; *cf.* Kelber and Hansch, 1995, p. 61, fig. 122). Hence, *Scoresbya dentata* and *Phlebopteris angustiloba*, that imprint on the flora an apparently younger aspect, are nothing less than good character fossils. The assignment of the Santa Clara Formation to the Rhaetian by Ash (1992) is rejected here.

THE AGE OF THE MATZITZI FORMATION

It is not possible to review here the fossil plants from the Matzitzi Formation, studied by Silva-Pineda (1970) in the light of the new Leonardian age.

Shortly after the publication of this age by the writer (Weber and Cevallos-Ferriz, 1994), a *Sigillaria* of the ichthyolepis-type was reported from the Leonardian of north-central Texas, under the name *S.* cf. *brardii*, which corroborates the

Plate 4. Comparison of fossil plants from the Santa Clara Formation, Sonora (figures *1, 6*, and *7*), and the Huizachal Alloformation, Tamaulipas (figures *2–5* and *8*). The specimens illustrated in the latter figures are housed in the Smithsonian Institution, National Museum of Natural History, Washington, USA. All from west wall of Novillo Canyon below the apex of Cerro La Cuchilla del Burro, loc. 9510 on labels of the specimens. All x 1. Figures *1, 2*, "*Ctenophyllum braunianum*" sensu lato; *1*, leaf from Sonora (specimen GIM-PB-537B-1031; loc. Crucero B, 537B CLP-IG-UNAM); *2*, leaf from Tamaulipas (specimen USNM-496773). Figures *3–6*, *Laurozamites yaqui* Weber and Zamudio-Varela; *3, 4, 5*, two specimens from Tamaulipas; *3, 4*, apical and basal portion of large leaf (specimen USNM 496774); *5*, smaller leaf (specimen USNM 496775); 6, leaf from the Sonoran type paleodeme of *Laurozamites yaqui* Weber and Zamudio-Varela (specimen IGM-PB-515-1032). Figures *7, 8*, *Elatocladus* sp.; *7*, *Elatocladus* sp. from Sonora (specimen IGM-PB-543-1033; loc. 543 CLP-IG-UNAM); *8*, *Elatocladus* ex gr. *carolinensis* from Tamaulipas (specimen USNM 496776). This specimen is intermediate between *Elatocladus carolinensis* (Plate 1, figure 5) and the specimen of this plate, figure *7*. Most probably, the three figures show three different species.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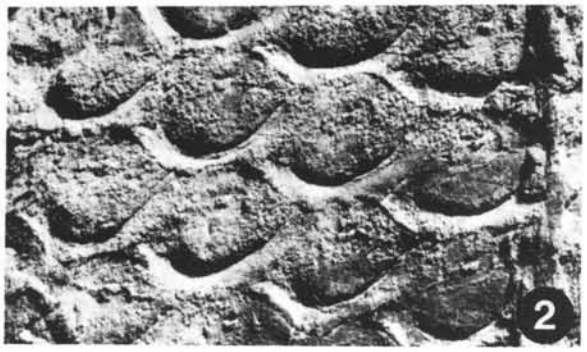
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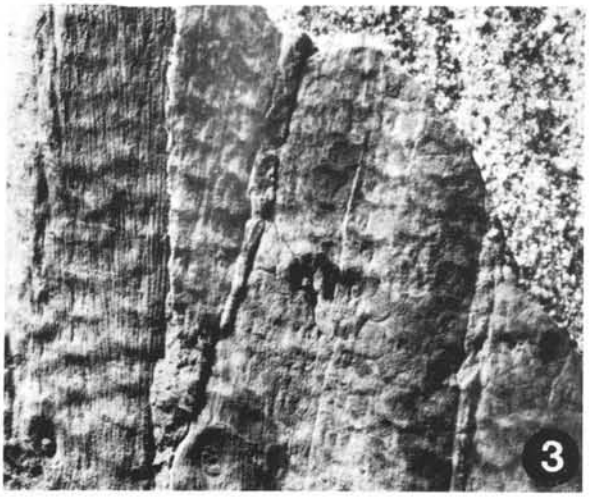
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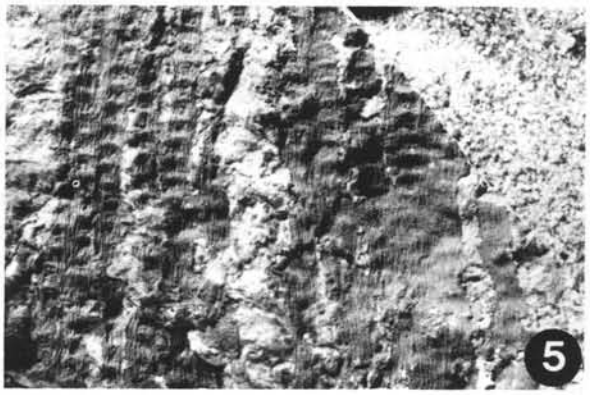
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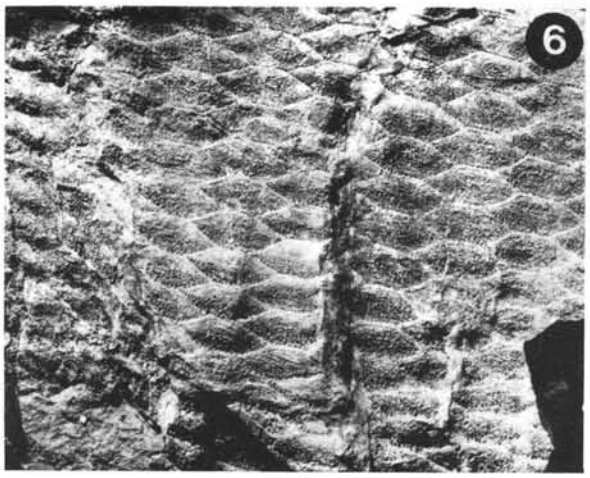
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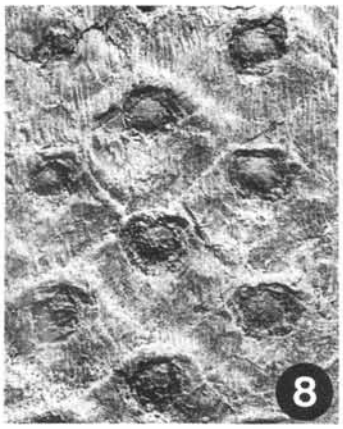
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Leonardian age of the Matzitzi (Mamay *et al.*, 1996; Di Michele, personal communication, 1997; Chaney, personal communication, 1997). It is important to add here, that the names *Sigillaria ichthyolepis* and *S. brardii* are very old. The taxonomy of *Subsigillaria* they belong to is difficult, and some authors consider the said species names to be synonyms (Wagner, 1991, personal communication). However, this taxonomic problem does not hamper the conclusions in the present context. *S. ichthyolepis* is rather common in the Matzitzi flora (Plate 5), and had been considered during a long time as an index fossil of the Late Pennsylvanian by the author (*cf.* Chaloner, 1967; Remy and Remy, 1977). The finding in Texas eliminated the main obstacle hindering the age-correlation of the Leonardian strata of Texas with the Matzitzi Formation.

This paper would be incomplete without mentioning *Holcospermum* ovules collected from the Matzitzi Formation. The author does ignore whether this genus has been found elsewhere in Permian rocks. Its occurrence in the Matzitzi Formation extends the age range of this genus, such as the finding of *Archaeocalamites* in the Leonardian of Texas (Mamay and Bateman, 1991) extended the range of that genus. No pteridosperm foliage that might be correlated with *Holcospermum* is known in the Matzitzi Formation.

A complementary piece of evidence favoring the new age is the radiometric age (K/Ar-plagioclase) of a probably contemporary tonalite intrusive body found in the Matzitzi Formation near Los Reyes Metzontla (Ricardo Torres-Vargas, personal communication, 1997), which coincides fairly well with a Leonardian age (240 ± 12 and 266 ± 13 Ma).

However, the Matzitzi Formation might also get younger than Leonardian, hypothetically. The gigantopterids appeared in the Permian of the United States of America at the Wolfcampian-Leonardian boundary. The youngest continental rocks with fossil plants and gigantopterids in North America belong to the Leonardian (Mamay *et al.*, 1984); but these plants may have lived longer without leaving fossil evidence in the United States, as did the Asian gigantopterids, which had their maximum development in the Late Permian. In the author's opinion, however, the Matzitzi Formation most probably belongs to the Leonardian, as this formation is correlative with rocks bearing Leonardian plants and, sometimes, invertebrates and foraminifers in several areas in Mexico, including the States of Hidalgo, Puebla and Chiapas (Guacamaya Formation—Calnali, Hidalgo [Silva-Pineda, 1987]; San Mateo, Hidalgo [Carrillo-Bravo, 1965]; Patlanoaya Formation, Patlanoaya, Puebla [Villaseñor-Martínez *et al.*, 1987]; Paso Hondo Formation, Chiapas [Hernández-García, 1973; Silva-Pineda, personal communication, 1979; Vachard *et al.*, 1993; Vachard and Pantoja, 1997]).

THE AGE OF THE FLORA FROM SAN MATEO, HIDALGO

The plants described by Silva-Pineda (1963, 1981) from the "Huizachal" Formation, near San Mateo and Tlahualompa, in Hidalgo, are totally different from both the flora of the Santa Clara Formation of Sonora and its grossly coeval counterpart from Tamaulipas. Silva-Pineda (*op. cit.*) did not make a point of that difference, which can be explained hypothetically in several ways, outlined here in the order of increasing proximity to the present writer's explanation. These hypotheses are focused in the methodically necessary assumption that the above report of *Sigillaria* might be wrong.

(1) The San Mateo "Triassic" flora might in fact be correlated with the Late Triassic Santa Clara flora, but they differ owing to a major geographic distance or on paleoecological grounds. The Late Triassic distance of the floras of Sonora and Hidalgo was larger than today, *i.e.*, more than 1,500 km—due to Laramide fold and thrust shortening. However, the distance between the Santa Clara Formation (or Nevada) and the fossil floras of North Carolina or Virginia, in the United States of America, is larger, about 3,000 km on a modern map—and more in the Late Triassic: shortening—but the corresponding coeval floras are rather similar, sharing a couple of species and a high number of genera. The Late Triassic floras of the Santa Clara Formation and the Huizachal of Tamaulipas are also quite similar. The geographic distance between the latter and the San Mateo plants was certainly never much larger than today. Since all the considered floras lived in similar paleoenvironmental and sedimentary settings, and their paleolatitudes were also not too different, no paleoecological considerations must be added. Because no unquestionable index fossil of the Late Triassic was described by Silva-Pineda (1963, 1981) in this flora, and since the known Triassic floras of Mexico and the USA are clearly distinct, it is not advisable to adopt this first hypothesis.

(2) The plants from San Mateo might differ from the mentioned true Late Triassic floras in age, and might be younger. The species recorded by Silva-Pineda (1963), if accurately identified, would support a Jurassic rather than a Triassic

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Plate 5. *Sigillaria ichthyolepis* (Presl) Corda and *S. brardii* Sternberg, Matzitzi Formation, Leonardian, Puebla, Mexico (except figure *5*, showing a specimen from the "Huizachal Formation", San Mateo, Hidalgo, Mexico). Figures *1–4*, *Sigillaria ichthyolepis,* bark fragment preserved as part and counterpart (specimen IGM-PB-1029-1049 A, B; loc. Coatepec 2, roadside about 1 km NW Coatepec, Puebla); *1*, impression of bark surface with leaf and cone scars, especially well preserved at lower right hand; *2*, the same (x 2); *3, 4*, counterpart of figures *1* and *2*; *3*, At left a stripe of cortex in Syringodendron preservation; compare with cortex in figure *5*; *4*, observe the cone scars in the lower half of the picture; *5*, poor *Sigillaria* bark in Syringodendron preservation; the morphological elements of this fossil are smaller than in the figured specimens from the Matzitzi Formation (specimen IGM-PB-1592-1051; loc. San Mateo no. 1592 CLP-IG-UNAM; coll. Carrillo-Bravo; compare figure *3*); *6*, *Sigillaria ichthyolepis* piece of bark with well-preserved outlines of leaf scars (specimen IGM-PB-1008-1052; loc. roadside talus at the base of Matzitzi Hill, near San Luis Atolotitlán. Loc. 1008 CLP-IG-UNAM). Figures *7, 8*, *Sigillaria brardii* Sternberg (specimen IGM-PB-1008-1050; loc. roadside talus at the base of Matzitzi Hill, near San Luis Atolotitlán, no. 1008 CLP-IGM-UNAM); *8*, (x 2).

age. The regional geological framework might suggest an Early or Middle Jurassic age. However, the fossil plants published by Díaz-Lozano (1916) from the Early to Middle Jurassic Huayacocotla Formation of Puebla and Veracruz, as well as the plants known from the lowermost part of the same formation in the Otongo area of Hidalgo (*cf.* Ochoa-Camarillo, 1997; Weber, unpublished work), are also completely different from the supposedly Triassic plants collected in the San Mateo-Tlahualompa localities, except the cycadophytes identified as *Otozamites hespera* and *Pterophyllum longifolium* by Silva-Pineda (1963). It is important to recall in this context, that Carrillo-Bravo (1965) reported material of *Otozamites hespera* and *O. reglei*, from the upper part of his "Huizachal Formation", at a wayside locality between Tlahualompa to San Mateo, which must be different from the localities discussed below. This flora was explicitly assigned to the Lower Jurassic. Consequently, it is tempting to correlate all the "Triassic" material from San Mateo with the floristic assemblage of the Jurassic Huayacocotla Formation. However, this is impossible, because no *Sigillaria*-like plants are known in the Jurassic. Therefore, it is obviously unappropriate to adopt this hypothesis either.

(3) On the contrary, the "Triassic" plants from San Mateo might also be considerably older than suspected by Silva-Pineda (1963, 1980). They resemble to a degree not only those of the Matzitzi Formation, but also the Leonardian plants from the vicinity of Calnali, Hidalgo (*cf.* Silva-Pineda, 1987). Additional Leonardian plants had already been reported, but neither described nor illustrated, from the "Guacamaya Formation" by Carrillo-Bravo (1965), from a site very close (certainly less than 1 km) to the "Triassic" localities, in the vicinity of San Mateo. These plants were reported by Carrillo-Bravo (1965) as *Calamites* and *Annularia* or *Lobatannularia*?, *Pecopteris* spp. *Pecopteris unita* among them, *Sphenopteris*, cf. *Validopteris*, *Taeniopteris*, *Neuropteris*, and cf. *Gigantopteris* sp. Finally, *Cordaites* sp. and *Walchia* sp. were reported as well. Therefore, it was suspected by the present writer, that the "Triassic" plants from the "Huizachal" Formation of San Mateo-Tlahualompa (Silva-Pineda, 1963; 1981) could be altogether Leonardian in age, which was deemed possible because cycadophyte-like leaf fossils had been collected also from the Leonardian Matzitzi Formation. This hypothesis was defended by the author at the Hermosillo meeting in January, 1997. But even this one is not the most accurate hypothesis.

(4) The most suitable proposal seems to be the following: One part of Silva-Pineda's (1963) material and all her (1981) specimens are Leonardian in age. Leonardian and Early or Middle Jurassic materials were mixed up in her first study (Silva-Pineda, 1963), but not so in the second paper which deals only with Leonardian plants (Silva-Pineda, 1981). The *Otozamites* and *Pterophyllum* species recorded by Silva-Pineda (1963) represent the Jurassic part of the material. This will be reinforced in the following lines.

LOCALITIES NEAR SAN MATEO

Some words on localities are required here, because all specimens used by Silva-Pineda (1963) and re-examined by the author have the same locality number of the CLP-IG-UNAM. No specific locality data are found on the slabs themselves or on labels. Furthermore, the localities are neither specified in the descriptions of species by Silva-Pineda (1963) nor recorded in catalogs, unfortunately. As said above, the locality data of Carrillo-Bravo (1965) are also poor. The following is based in part on assumptions, and cannot be documented fully with published data. The discussion could not be illustrated with a new map. Therefore the interested reader should use the maps quoted in the following lines. Non-formal locality numbers are used here to ease the understanding.

According to the map published by Silva-Pineda in 1963 (pl. 1), her first lot of material was collected by Carrillo-Bravo and Patiño from two localities. The first one (locality 1) is marked in this map on the old muleteers way from Tlahualompa to San Mateo, near the latter village, and a second one (locality 2) about 2 km to the southeast from there. Carrillo-Bravo (1965) published a preliminary list of species from locality 1, but none from locality 2, which was not even mentioned by him. Almost twenty years after her first paper, Silva-Pineda (1981) wrote that her second lot of specimens, "was obtained from the basal part of the Huizachal Formation, ... on the wayside from Tlahualompa ... to San Mateo", *i.e.*, locality 1. In fact, Carrillo-Bravo had guided her to the locality 1, as confirmed by Silva-Pineda (personal communication, 1997; *cf.* G. Alencáster and B.E. Buitrón, personal communication, 1997). But in her modified map (Silva-Pineda, 1981, fig. 1), only locality 2 appears. Hence, the map is misleading.

The writer visited in 1971 a different roadside locality (locality 3), slightly to the north from locality 1 near San Mateo, together with J. Rzedowski, J. Rueda-Gaxiola, E. Salas and others. Doubtless Paleozoic material, including *Annularia* or cf. *Lobatannularia* sp., was collected in that occasion. The mentioned Leonardian material of Carrillo-Bravo (1965), which was considered also by Silva-Pineda and Villalobos-Carmona (1987), was said during this visit to have been collected from the same locality 3. It does not affect the present reasoning however, that it might also stem from a different locality 4, closer to San Mateo. After the available maps and the author's field experience, the distance between localities 1 and 3 is very short. The Leonardian plants from locality 3 and one part of the "Late Triassic" plants of Silva-Pineda (1963, 1981) were collected almost from the same site, perhaps from different strata of the same package, at the point marked in Silva-Pineda's (1963) first map. If Triassic and Permian plants had actually been collected at the wayside localities 1 and 3, this point should logically also mark an important stratigraphic hiatus, perhaps a tectonic contact; but neither a fault nor even an erosional contact is on the map at exactly this point. A formational contact is drawn farther to the north, however,

between the localities 1 and 3 and San Mateo. In addition, E. Centeno-García, during recent preliminar field work done on the author's request, did not confirm the existence of an unconformity at locality 1 or close to it to the north (Centeno-García, personal communication, 1997). Consequently, there seems to be no compelling stratigraphic evidence supporting the "Late Triassic or Huizachal" age of the plants from the roadside locality (locality 1).

The original material of Silva-Pineda (1963, 1981) permits to infer the following: Locality 1, was sampled twice; it yielded *Cyperites* (*Sigillaria*) leaves, the *Sigillaria* bark and the ferns assigned to *Pecopteris* ex gr. *cyathea*, which are Leonardian in age. The cycadophyte material mentioned above was collected from locality 2, and belongs to a Mesozoic, probably Jurassic flora. Clearly, further collecting is necessary to elucidate this point. Such cycadophyte material was not collected again by Silva-Pineda for her second paper (1981).

SOME FOSSIL PLANTS FROM SAN MATEO

Only a few previous paleobotanical records will be discussed briefly. *Stenopteris* cf. *desmomera* Saporta (a Jurassic genus), was reported by Silva-Pineda (1963), as noted above. *Stenopteris* is known to include (bi)-pinnate leaves, which allowed South-American paleobotanists to assign the Gondwana species of *Xylopteris* (or *Dicroidium* subgen. *Xylopteris*) to *Stenopteris* during a time (Frenguelli, 1943). Silva-Pineda's (1963) identification of *Stenopteris* was probably based on Frenguelli's publication. The *Xylopteris* leaves are forked once and the resulting main segments are either pinnate or bipinnate; the linear pinnules have one vein each. On the contrary, the material from Hidalgo includes only simple linear leaves with characteristic grooves. No pinnate leaf fragments were observed at all. Coincidentally, during his studies on the Matzitzi flora, the writer encountered good material of *Cyperites* (unpublished as yet) in the late seventies and became aware of the similarity with Silva-Pineda's (1970, pl. 28) *Cyperites* leaves from the Matzitzi and her *Stenopteris* material from the "Triassic" of Hidalgo (Silva-Pineda, 1963, pl. 5).

Shortly before the publication of Silva-Pineda's second paper on the San Mateo plants (Silva-Pineda, 1981), the author suggested to that author that the *Cyperites* leaves from the Matzitzi and from Hidalgo together allowed to predict the presence of *Sigillaria* in that flora. However, in that publication, she called her former *Stenopteris* cf. *desmomera* now "leaves resembling *Lepidodendron*", adding that "it was not possible either, to place them in *Lepidodendron* with full certainty" (Silva-Pineda, 1981). Only much later, in 1996, the bark fragment mentioned above (Plate 5, figure 5) was recognized as *Sigillaria* by the writer. It resembles closely *Sigillaria ichthyolepis* (or *S. brardii*?) from the Matzitzi flora (Plate 5), found there in Syringodendron preservation (Plate 5, figure 3) besides the more common imprints of the defoliated bark surface (Plate 5, figures 1, 2, 6). The bark impression of figure 3 shows the counterpart of what is seen in the neighboring portion of figure 1; these figures represent together along their joint edges both surfaces of a stripe of bark preserved with surface sculpture, at left (figure 1), and as Syringodendron at right (figure 3).

The main difference between the Matzitzi specimens figured here and the San Mateo *Sigillaria* lies in the dimensions, as stated by Silva-Pineda (1981). Indeed, the *Sigillaria* leaves from Hidalgo (and the associated bark fragment: Plate 5, figure 5) are smaller, than those from the Matzitzi Formation. However, the unpublished material of *Sigillaria* from the Matzitzi Formation, housed in the Instituto de Geología, includes several bark impressions with leaf scars smaller than those illustrated here. In the specimen shown on Plate 3, figure 1, there are about four and one half scars per 2 cm in a vertical row; the San Mateo bark shows about eight scars; but there are specimens from the Matzitzi Formation, with five and one half (locality unknown), six and one half and even eight and one half scars per 2 cm (loc. 1018 CLP-IG-UNAM). These differences depend probably on the age of the individual trees or the position of the fragment in the whole *Sigillaria* tree. In addition, the overall similarity of all these bark fragments is so high, that a close relationship below generic level cannot be questioned. *Sigillaria* was indeed present in the "Triassic" of San Mateo.

The writer ignores which other Late Triassic lycophyte genus this material might be placed in. Triassic tree-like lycophytes are known from the Early Triassic (for example *Pleuromeia* and *Ferganodendron*), with barks different from that found in Hidalgo. In the Late Triassic, they are represented by small, more or less herbaceous forms (for example *Lepacyclotes*, in North America, and *Annalepis*, in Europe), which do not resemble the material considered here. It may be mentioned marginally, that the conifer bark, figured from the Santa Clara Formation (Plate 1, figure 6) also does not fit the character pattern of the *Sigillaria* barks.

Starting from the finding of *Sigillaria* bark and the recognition of the corresponding leaves, the writer's revision of Silva-Pineda's (1963, 1981) material continued with the reported ferns. As a result, it is proposed here to reject "*Thaumatopteris* cf. *kochibei*", which after Carrillo-Bravo (1965) was collected at the same locality as the *Sigillaria* remains. It is based on material too poorly preserved for identification. Especially, it does not show the diagnostic net venation of *Dictyophyllum*, which includes *Thaumatopteris* as a subgenus (Herbst, 1992). It is also suggested to place *Todites carrilloi* and *Mertensides bullatus*, later redescribed jointly as *Asterotheca merianii* by Silva-Pineda (1981), in *Pecopteris* ex gr. *cyathea*. This is supported by the specimen of Silva-Pineda (1963, pl. 2, fig. 1), showing the sudden apical decrease in width of the penultimate pinna typical of *P. cyathea* (*cf.* Zodrow, 1990). On the other hand, the author examined mater-

ial of *Asterotheca merianii* in the Museum of Natural History at Vienna, in 1991. This species has stout fronds, characterized by non overlapping last order pinnae (or pinnae of penultimate order, when the pinnae of the ultimate order are not called pinnules). The synangia of *A. merianii*, a species originally described from Switzerland, but extremely well preserved in many specimens from the Carnian flora of Lunz, Austria, are stout and form a very orderly, almost military pattern of rows which are strictly parallel to the last order rachis and the pinnule midveins. The material from San Mateo differs in these characters from *A. merianii*. The accurate identification of the San Mateo ferns will be possible only after collecting enough specimens with well preserved venation.

The strongest argument of Silva-Pineda (1963) for placing her plants from San Mateo in the Triassic was doubtless the presence of cycadophyte remains, the mentioned *Otozamites hespera* and "*Pterophyllum longifolium*". After the discovery of several cycadophyte leaves in the Matzitzi Formation, this is no longer a strong argument, at least in general terms. However, circumstantial evidence indicates that these leaves were collected from a distinct locality yielding a Lower or Middle Jurassic flora (see above), which was not recorded by Carrillo-Bravo (1965). The information on the provenance of this cycadophyte material is extremely vague in all available publications.

It must be recalled now, that the "Huizachal Formation" *sensu* Carrillo-Bravo (1965) ranges into the Lower Jurassic in the Huayacocotla anticlinorium and, especially, in the Tlahualompa-San Mateo area, such as it does in the Peregrina anticlinorium. This was proposed, among other grounds, owing to the presence of the Jurassic plants *Otozamites hespera* and *O. reglei* in its uppermost part, at a locality on the road from Tlahualompa to San Mateo, which was not mentioned before in the discussion, and which might be called locality 5. The same species had been found earlier by Díaz-Lozano (1916) in the Huauchinango and Huayacocotla region, Puebla and Veracruz, and by Wieland (1914) in the Jurassic of the Mixteca Alta, Oaxaca, and may range from the Lower to the Middle Jurassic. It is quite sure, that these plants are not older than Hettangian in age. Thus, they correspond to the Huayacocotla Formation *sensu* Ochoa-Camarillo (1997, fig. 2), who allows to include the Hettangian at its base.

CONCLUSIONS

No Pennsylvanian flora exists in Mexico, according to present knowledge. The Matzitzi flora from Puebla is Leonardian in age and can be correlated with most of the fossil flora in the Tlahualompa-San Mateo area, Hidalgo, which was assigned previously to the Leonardian and the Late Triassic. The advisable re-naming of the Paleozoic sedimentary rocks in the San Mateo area must be postponed as long as modern stratigraphic re-study of the area is underway. The Santa Clara flora of Sonora is Carnian (and probably Norian) in age. It correlates grossly with the flora reported from the "La Boca Formation", Huizachal Group, from Novillo Canyon, Tamaulipas, which is also Late Triassic in age. The use of the name La Boca Formation for the plant-bearing unit is, however, questionable, after the discovery of Jurassic vertebrates in the La Boca Formation of the Huizachal Canyon, and after the revision of the lower and middle Mesozoic sequence in the Peregrina anticlinorium by Rueda-Gaxiola and collaborators (1989, 1993a, b). It is suggested that the plants belong to the Huizachal Formation—or Alloformation—*sensu* Rueda-Gaxiola. The previous records of Triassic plants and "Huizachal Formation" in the San Mateo-Tlahualompa area of Hidalgo are untenable. The presence of Jurassic fossil plants in the San Mateo area is not only proposed tentatively here, based on material studied by Silva-Pineda (1963), but it was also documented by Carrillo-Bravo (1965). This flora may range from Early to Middle Jurassic in age. It must be studied in detail after further collecting. Since there is no compelling evidence of the presence of Triassic plants and rocks in the San Mateo-Tlahualompa area, and since nothing disproves the assignment of the lowermost Jurassic rocks in the same region to the Huayacocotla Formation—or Huayacocotla Alloformation *sensu* Rueda-Gaxiola and collaborators (1989)—it is proposed herewith again to discard the use of the stratigraphic concept Huizachal Formation in the Huayacocotla anticlinorium, in disagreement with Imlay and collaborators (1948), Carrillo-Bravo (1965), and a number of other authors. The paleobotanical facts do not support such a transfer from the Peregrina anticlinorium to the Huayacocotla anticlinorium.

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