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Adrian P. Hunt

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PLANT FOSSILS AND LITHOSTRATIGRAPHY OF THE ABO FORMATION (LOWER PERMIAN) IN THE SOCORRO AREA AND PLANT BIOSTRATIGRAPHY OF ABO RED BEDS IN NEW MEXICO

ADRIAN HUNT
Research Assistant
New Mexico Bureau of Mines and Mineral Resources
Socorro, New Mexico 87801

INTRODUCTION

Plant megafossils are present and "locally even abundant" in the Abo Formation (Lower Permian) of New Mexico (White, 1936), but the paleoflora has been little collected. Although records of plant remains from the Abo are abundant in the literature (Read in King, 1942; Wilpolt and others, 1946; Kottlowski and others, 1956; Read in Bachman and Hayes, 1958; Kottlowski, 1963; Read and Mamay, 1964; Vaughn, 1969; Cappa, 1975; Ash and Tidwell, 1982; Hatchell and others, 1982; Maulsby, 1982; Myers, 1982; Broadhead and others, 1983) taxonomic, geographic, and stratigraphic data on localities are sparse. Furthermore, there are several inaccuracies in the literature.

The objects of this paper are threefold: (1) to present preliminary data on a new plant locality in the Abo Formation near Canoncito de la Uva, east of Socorro, (2) to draw together scattered lithostratigraphic data on the Abo Formation in the Socorro area and to place the new locality and other reports of plants from the Socorro area within this context, and (3) to place the plants of the Abo Formation, in the Socorro area, in adequate biostratigraphic and paleoecological context.

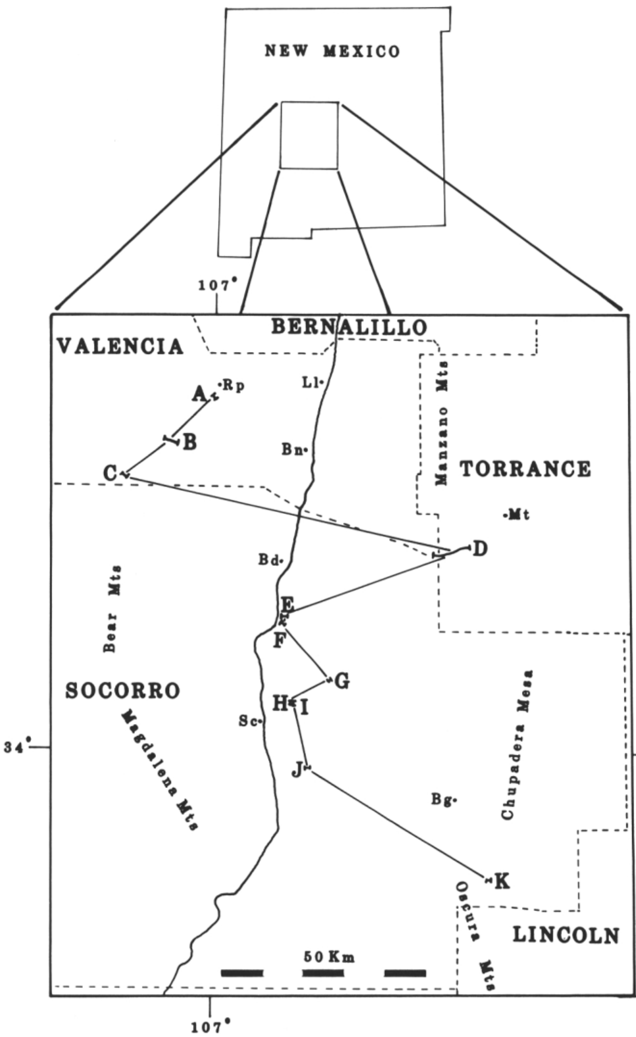

Figure 1. Location of area considered in this report and stratigraphic sections (labeled A to K). Towns are labeled: Bd (Bernardo), Bg (Bingham), Bn (Belen), Ll (Los Lunas), Mt (Mountainair), Rp (site of the village of Rio Puerco), and Sc (Socorro).

GEOLOGICAL BACKGROUND

The geographic area discussed in this paper stretches from the Oscura Mountains in the southeast to the site of the village of Rio Puerco in the northwest (fig. 1). Henceforth, this area will be referred to as the Socorro area. Strata of the Abo Formation in this area are part of a large complex of early Permian red beds which covered much of New Mexico (fig. 2). Environments of deposition represented by the Abo Formation in the Socorro area are broadly deltaic (Eberth and Berman, 1983).

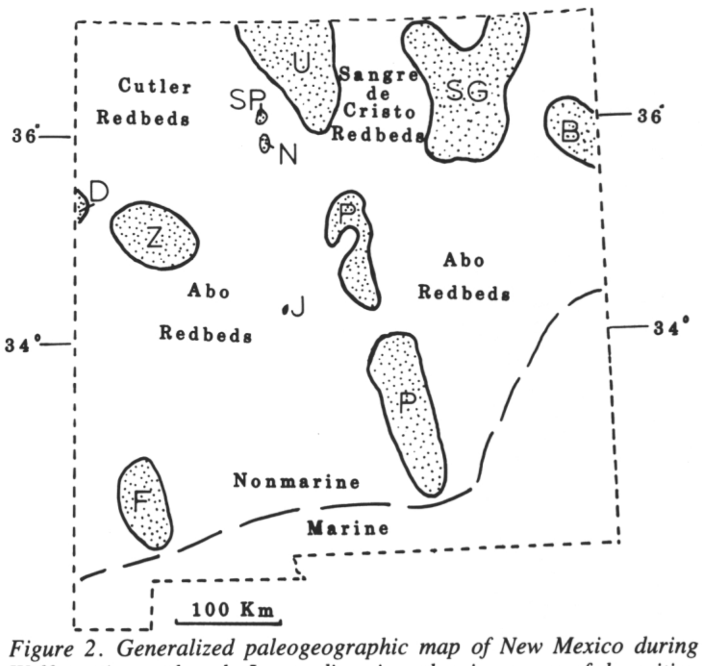

Figure 2. Generalized paleogeographic map of New Mexico during Wolfcampian and early Leonardian time showing areas of deposition of major red bed facies. Positive areas are indicated by a stippled pattern: B, Bravo uplift; D, Defiance uplift; F, Florida islands; J, Joyita uplift; N, Nacimiento uplift; P, Pedernal uplift; SP, San Pedro uplift; SG, Sierra Grande uplift; U, Uncompahgre uplift; Z, Zuni uplift. Map compiled from Baars (1962), Hills, (1963), Kottlowski (1963), Dixon (1967), McKee (1967), McKee and others (1967), Oriel and others (1967), Kottlowski and Stewart (1970), and Berman and Riesz (1980).

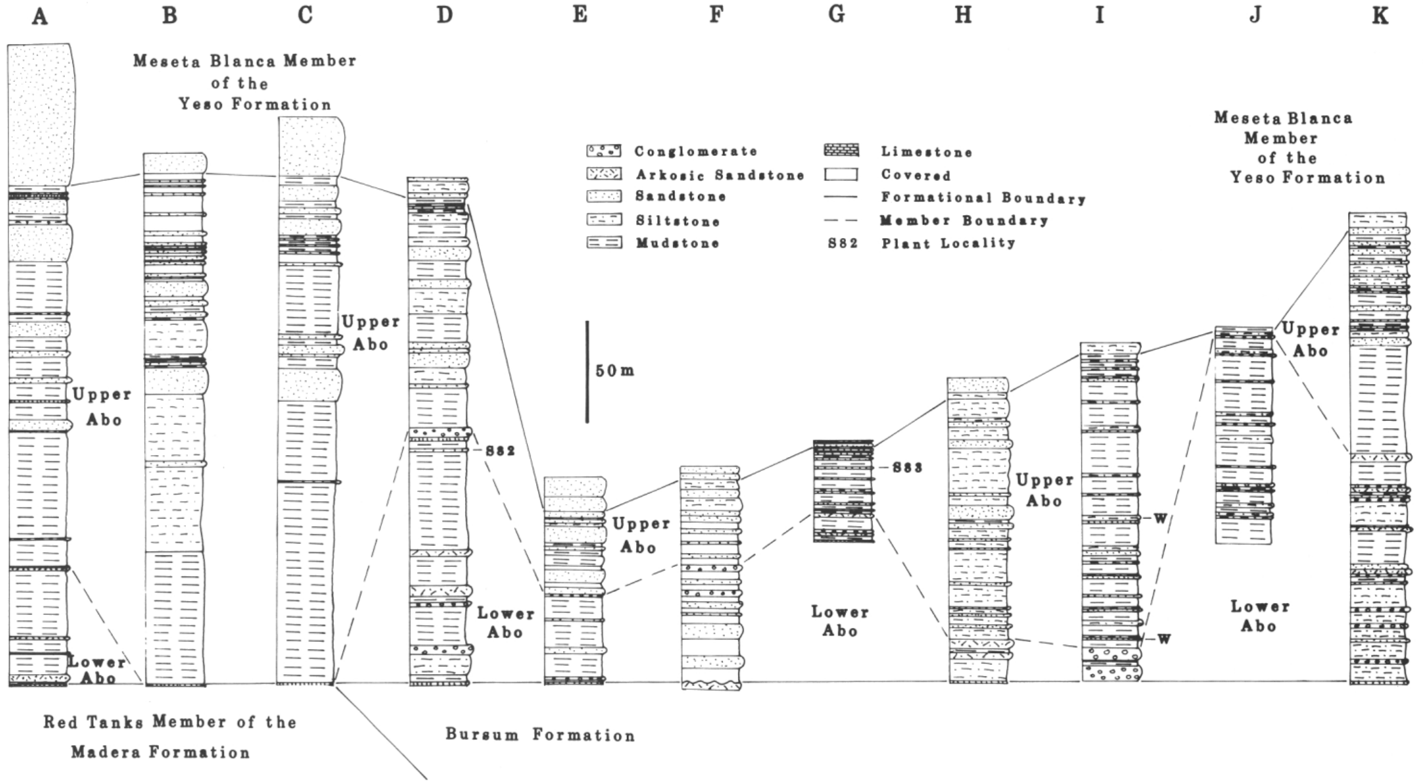

Figure 3. Stratigraphic sections of the Abo Formation in the Socorro area. Location of sections shown in Figure 1; sections A, B, and C after Kelley and Wood (1946); D after Needham and Bates (1943) and Wilpolt and others (1946); E and F after Wilpolt and others (1946); G measured in NW1/4 sec. 11, T2S, R2E by A. Hunt and T. Matula (April, 1983); H and K after Wilpolt and Wanek (1951); I after Cappa (1975); and J after Fagrelius (1982). A maximum of 15 m of Abo has been faulted out of section I, between the lower and upper members (Cappa, 1975). Datum is base of Abo. Section G is positioned assuming a constant increase in thickness between F and H. Section J is positioned based on increasing thickness trend between I and K and on probable thickness of the Abo at this locality, estimated from a cross section of Fagrelius (1982, p. 137). For discussion of informal members see text. Plant localities are S82, a Supaia *flora reported by Read (in Hatchell and others, 1982); S83 is a* Supaia *flora described in this report; and W are localities containing poorly preserved material referrable to the genus* Walchia.

The Abo Sandstone was named by Lee (1909) for a sequence of coarse-grained sandstone, conglomerate and shale, "dark red to purple in color," which are exposed in Abo Canyon at the south end of the Manzano Mountains. Needham and Bates (1943) measured a type sec- tion of the unit and renamed it the Abo Formation. Subsequently, North- rop and Wood (1946) and Bates and others (1947) placed the uppermost Abo of Needham and Bates (1943) in the Yeso Formation as the Meseta Blanca Member. In northwest New Mexico, north of latitude 36°N, red beds equivalent to the Abo are mapped as Cutler Formation (Northrop and Wood, 1946), and to the northeast in the Rowe-Mora basin, Permo- Pennsylvanian red beds are assigned to the Sangre de Cristo Formation (Read and Wood, 1947).

Lower Permian red beds in New Mexico were deposited in a series of basins largely controlled by the distribution of Late Paleozoic positive elements (McKee, 1967). During late Virgilian and early Wolfcampian time many of the uplifts, formed dominantly by Precambrian basement, were rejuvenated and vast amounts of clastic detritus was shed into adjoining basins and troughs-7550 km3 in Orogrande basin alone (Kottlowski and Stewart, 1970). At least by middle Wolfcampian time, detritus from the northern Uncompahgre uplift had buried most of the uplifts (Kottlowski and Stewart, 1970; Broadhead, 1983, fig. 2). By the time of deposition of the latest Abo, uplifts remained uncovered only locally, such as at Pajarita Mountain (Kottlowski and Stewart, 1970).

In southeastern New Mexico the Abo Formation is an important source of natural gas (Broadhead, 1982) and, locally, the Abo contains sandstone copper deposits (LaPoint, 1976; Soule, 1956).

LITHOSTRATIGRAPHY

The lithostratigraphy of the Abo Formation in the Socorro area is summarized in Figure 3. The base of the Abo has been drawn at the top of the highest fossiliferous limestone (King, 1945), except in section F where the Abo unconformably overlies the Bursum Formation. The upper contact of the Abo with the Meseta Blanca Member of the Yeso Formation becomes less distinct in the Socorro area from north to south. All upper contacts in Figure 3 follow the original authors. In section G the upper contact follows Wilpolt and Wanek (1951). The Meseta Blanca can be distinguished from the Abo in the field by a change in color from red to pink, by the presence of more laterally continuous sandstone bodies in contrast to lenticular beds, by a decrease in the volume of shale present, and by the presence of salt casts. The contact is sharp in the north end of the Socorro area, but more gradational to the south. At its type locality and further north, the Abo shows fairly constant thickness (fig. 3), but in the vicinity of the Joyita Hills it thins dramatically, gradually thickening again to the south. The presence of an uplift in the Joyita Hills area during Early Permian time (Kottlowski and Stewart, 1970) accounts for the thinness of Abo strata in that vicinity. To judge from overall thickness trends within the Abo, sub- sidence would seem to have been greater in the basin of deposition to the north of the Joyita Hills than to the south.

Two members or facies of the Abo Formation can be delineated in the Socorro area. Previously, the Abo has been informally subdivided into members, both locally (Kelley and Wood, 1946; Tonking, 1957; LaPoint, 1976; Myers, 1977; Hatchell and others, 1982; Speer, 1983) and regionally (Broadhead, 1983). A lower member can be distinguished

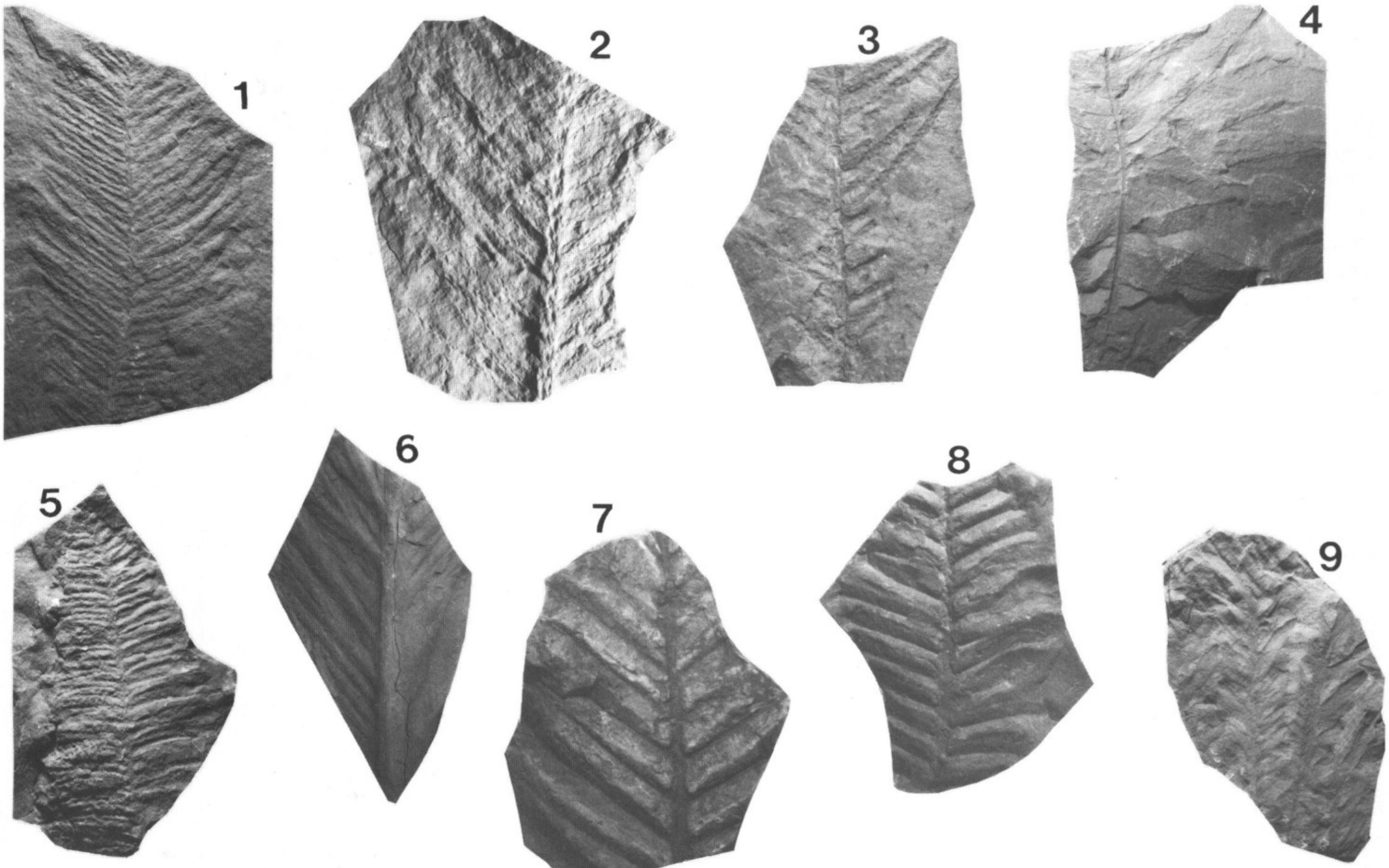

Figure 4. Plant fossils from Canoncito de la Uva locality: 1. Walchia *sp. ×0.4; 2.* Walchia *sp. ×0.52; 3.* Brachyphyllum *sp. ×0.5; 4. ?*Callipteris *sp. ×0.26; 5.* Walchia *sp. ×0.42; 6. unidentified foliage ×0.157; 7.* Supaia *cf.* S. thinnfeldoides *×0.6; 8.* Supaia *cf.* S. thinnfeldoides *×0.45; 9. cf.* Glenopteris simplex *×0.41. All specimens are uncatalogued and reposited in the paleobotanical collection of New Mexico Bureau of Mines and Mineral Resources, Socorro, New Mexico.*

which is composed of conglomerate, coarse arkosic sandstone, and mudstone. An upper member consists of fine sandstones, siltstones, and mudstones. The boundary between the two members is drawn at the top of the stratigraphically highest conglomerate or arkosic sandstone. This twofold division of the Abo agrees with that suggested by Kelley and Wood (1946), Tonking (1957), Myers (1977), and Broadhead (1983). A similar division of the Abo can be correlated regionally in central New Mexico (Broadhead, 1983).

The coarse grain size and mineralogic immaturity of the beds in the lower member of the Abo suggests deposition in the proximity of uplifts. Thickness trends in the lower member therefore have paleogeographic implications. The relative thinness of the Abo in sections E and F (fig. 3) suggests that the lower member in that area was deposited on the shoulders of the Joyita uplift. Southward, the lower member thins, both absolutely and relatively (sections H and I, fig. 3) with increasing distance from the Joyita Hills. Thickening of the lower member further southward (sections J and K, fig. 3) suggests increasing influence of the Pedernal uplift which lay approximately 80 km to the east (Kottlowski, 1963, fig. 12). Northwest of Abo Pass (sections B and C, fig. 3), the lower member wedges out, presumably in more distal regions of the basin of deposition. The appearance of the lower member in the most northerly section (section A, fig. 3) suggests the proximity of another source area, possibly in the center of the Albuquerque Basin (Baars, 1982, fig. 4). Most plant remains occur in the upper member of the Abo; however, the locality at Abo Pass (section D, fig. 3) occurs at the top of the lower member.

It is apparent that away from the major uplifts, lithostratigraphic and depositional patterns of the Abo Formation are complex and in need of further study.

CANONCITO DE LA UVA LOCALITY

This locality lies within the upper portion of the Abo Formation (section G, fig. 3) in a thin, laterally continuous, very fine grained sandstone. Plant megafossils are locally abundant occurring as poor impressions. The following discussion represents only a preliminary study of the flora.

Approximately 90 percent of the flora is composed of one genus of conifer. Rigid branchlets, as much as 15 cm long and 0.5 cm in width, bear twigs which open at angles from 45 degrees to 90 degrees. Twigs are as much as 6 cm long and 0.2 cm wide and are sheathed in small, poorly preserved falcate, needlelike leaves. Based on morphological variation as many as three species may be present. These specimens are assigned to the genus *Walchia,* but because of poor preservation specimens cannot be assigned with certainty at the species level (fig. 4, nos. 1, 2, and 5). Specimens show similarities to those illustrated by White (1929) as representing *Walchia dawsoni, Walchia piniformis,* and *Walchia gracillum. Walchia* is a lebachiacean genus which represents "an aggregate of similar forms rather than a single species" (White, 1929). *Lebachia* and *Ernestrodendon* were separated from *Walchia* based on stomata] characters, but the genus *Walchia* was retained for specimens lacking such detail (Tidwell and others, 1970), such as those under discussion. The genus *Walchia* is abundant in Permian floras in several areas of the world and also occurs, but less abundantly, in the Upper Pennsylvanian (Darrah, 1936). *Walchia* has been reported and/or illustrated from the Abo Formation by several authors (White, 1936; Daugherty, 1941; Read and Mamay, 1964; Vaughn, 1969; Cappa, 1975; Ash and Tidwell, 1982; Read in Hatchell and others, 1982; Maulsby, 1982; Broadhead and others, 1983).

Two specimens of conifer are distinct from those assigned to *Walchia.* Twigs, 2 mm wide, diverge from 3-mm-wide branchlets at angles of about 60 degrees. Twigs are sheathed in small scalelike leaves. These specimens are assigned to *Brachyphyllum* sp., a genus *(fig.* 4, no. 3) previously reported from the Abo Formation by Read (in Bachman and Hayes, 1958; in Hatchell and others, 1982).

Two specimens represent portions of the rachis of fernlike foliage. The tapering rachis in the specimens varies from 0.2 cm to 0.3 cm in width. Pinnules 2.5 to 3.5 cm in length and averaging 0.7 cm in width are set obliquely to the rachis at an angle of approximately 20 degrees. Venation is poorly preserved, but is characterized by a thick midrib which appears to extend almost to the apex of the pinnule. These specimens are referred to *Supaia* cf. *S. thinnfeldoides (fig.* 4, nos. 7 and 8) and are similar to specimens assigned to that species by White (1929). The pteridosperm *Supaia* is known only from Arizona and western and central New Mexico, in rocks of supposed early to middle Leonardian age (Read and Mamay, 1964). *Supaia* has previously been reported from the Abo Formation by Read (in Bachman and Hayes, 1958; in Hatchell and others, 1982), Read and Mamay (1964), Ash and Tidwell (1982), and a *Supaia* floral assemblage has been reported by Read (in King, 1942).

Five small pinnate fronds, distinct from those assigned to *Supaia,* are preserved on two blocks from the Canoncito de la Uva locality (fig. 4, no. 9). The rachis averages 0.3 cm in width and narrow pinnules from 1.5 to 2.5 cm in length diverge from it at an angle of about 30 degrees. There is equal development of pinnae on either side of fronds. These specimens are tentatively assigned to cf. *Glenopteris simplex* and are very similar to material of that species illustrated by Read and Mamay (1964, Pl. 14). *Glenopteris* is only known from Kansas and is in many respects similar to *Supaia* (Read and Mamay, 1964), and thus the taxonomic assignment is questionable. A major difference between *Supaia* and *Glenopteris* is the presence of forked rachis in the former, but this character has not been observed in the specimens under study. Lack of unequal development of pinnae also argues against an assignment of these specimens to *Supaia.*

In the collection are two badly damaged fronds from which all pinnules have been stripped *(fig.* 4, no. 4). They show a close similarity to specimens assigned to *Callipteris* sp. (White, 1929, Pl. 35; Remy and Remy, 1977, Bild 164). Although in one instance the rachis is dichotomous, the two forks are not of equal width, indicating that the specimen does not represent *Supaia.* These specimens are tentatively referred to *?Callipteris* sp. *Callipteris* has been reported from the Abo Formation by Read and Mamay (1964) and Ash and Tidwell (1982), and plants of the *Callipteris* assemblage, probably containing the type genus, have been noted by Read (in King, 1942; in Bachman and Hayes, 1958).

In summary, the following forms are considered to be present in the Canoncito de la Uva local flora:

Walchia sp.
Brachyphyllum sp.
Supaia cf. *S. thinnfeldoides*
cf. *Glenopteris simplex*
?Callipteris sp.

The assemblage appears to be a representative of the *Supaia* flora which is known only from a few localities on the western flank of the ancestral Rocky Mountains (Read and Mamay, 1964). The *Supaia* flora represents a conifer-pteridosperm association lacking the lycopods an true ferns that are abundant in other Permian floras. The *Supaia* for is also known from the Hermit Shale of Arizona and is an age equivaler of the older *Gigantopteris* floras of the Garber Sandstone of Oklahom and the Belle Plains and Clyde Formations of North Texas, and th *Glenopteris* flora of the Sumner Group of Kansas (Read and Mama3 1964).

BIOSTRATIGRAPHY OF ABO PLANTS

Plant megafossils, from strata deposited prior to the rise to dominanc of the angiosperms, have proved very useful for biostratigraphy (Real and Mamay, 1964; Ash, 1980; Banks, 1980). In the Paleozoic (Silurian Permian) a biostratigraphic framework has been developed utilizin: floral assemblages of plant megafossils (Table 1). Assemblage zone of the Permian, with elements reported from the Abo Formation, an the *Callipteris* zone of Wolfcampian age and the zone of the geograph ically isolated, but isochronous, older *Gigantopteris, Glenopteris* am *Supaia* floras, all of Leonardian age (Read and Mamay, 1964).

Conventionally, the Abo Formation is considered to contain twl floras, a lower flora of the zone of *Callipteris* and an upper flora of th zone of the older *Gigantopteris* and *Supaia* floras (Read in King, 1942 Read in Bachman and Hayes, 1958; Read and Mamay, 1964; Ash am Tidwell, 1982). Unfortunately, as noted earlier, stratigraphic, geo

Table 1. Upper Paleozoic floral assemblage zones, Devonian and Silurian after Banks (1980) and Mississippian, Pennsylvanian, and Permian after Read and Mamay (1964).

Permian	younger *Gigantopteris* older *Gigantopteris/Glenopteris/Supaia* *Callipteris*
Upper Pennsylvanian	*Danaeites* *Lescuropteris* *Neuropteris flexuosa* and *Pecopteris*
Middle Pennsylvanian	*Neuropteris rarinervis* *Neuropteris tenuifolia* *Megalopteris*
Lower Pennsylvanian	*Neuropteris tennessee + Mariopteris pygmaea* *Mariopteris pottsvillea + Aneimites* *Neuropteris pocahontas + Mariopteris eremopteroides*
Mississippian	*Fryopsis* and *Sphenopteridium* ? *Triphylloptris* *Adiantites*
Upper Devonian	? *Rhacophyton* *Archaeopteris*
Middle Devonian	*Svalbardia* *Hyenia*
Lower Devonian	*Psilophyton* *Zosterophyllum*
SILURIAN	*Cooksonia*

graphic, and taxonomic data on Abo plant localities are scarce. In several cases where stratigraphic data are available these data are disputed. Read (in King, 1942) reported a *Supaia* flora (no taxonomic data) from a stratigraphic interval considered by him to be at the top of the Abo, but regarded by Kottlowski (1963) as belonging in the Meseta Blanca Member of the Yeso Formation. Later, Read (in Bachman and Hayes, 1958) reported a *Supaia* flora (no taxonomic data) from the uppermost Abo in beds considered by Bachman and Hayes (1958) to lie within the Otero Mesa Member of the Yeso, but considered by Kottlowski (1963) to be the Lee Ranch Tongue of the Abo.

North of the Socorro area, the Abo Formation contains a flora of the *Callipteris* zone containing, near the Spanish Queen Mine (southwest of Jemez Springs), *?Dichophyllum* sp., *Callipteris conferta, Gomphostrobus bifidus* and *Walchia piniformis* (Read and Mamay, 1964). Read and Mamay (1964) report *Callipteris lyratifolia* from 1.6 km south of Coyote, and although this taxa is not restricted to the zone of *Callipteris,* it is assigned to such, presumably on the basis of unreported taxa. All of the above specimens are reported to have come from the lower portion of the Abo (Read and Mamay, 1964). Of the four unquestioned taxa present, three are not restricted to the zone of *Callipteris (Walchia piniformis, Callipteris lyratifolia* and *Callipteris conferta).*

In the Socorro area, at Abo Pass, Read (in King, 1942) reported a *Callipteris* flora from the upper unit of the Magdalena Group, from shale beds associated with marine invertebrates. Read's upper unit of the Magdalena is probably equivalent to the Abo (DeFord and Lloyd, 1942). Ash and Tidwell (1982) consider the *Callipteris* flora to have come from the Abo but association with beds bearing marine invertebrates may indicate that the flora come from the Bursum Formation underlying the Abo. Also at Abo Pass a *Supaia* flora is present in the upper Abo Formation (Read in King, 1942; Read in Hatchell and others, 1982) which contains *Supaia thinnfeldoides, Walchia piniformis* and *Brachyphyllum* sp. (Read in Hatchell and others, 1982). Hatchell and others (1982) are incorrect in stating that *Walchia pimformis* is indicative of the zone of *Callipteris*. *Walchia* sp. from the central Socorro area is not indicative of the zone of *Callipteris* sp. (Broadhead and others, 1983). In the area of the Joyita Hills, Los Pinos Mountains, and northern Chupadera Mountains, Read found a flora indicating "that at least the upper portion" of the Abo is of Leonard age (Wilpolt and others, 1946). Presumably the flora was of the *Supaia* zone, as is that collected at Canoncito de la Uva. In the southeastern portion of the Socorro area, in the Oscura Mountains, Read (in King, 1942) reported both a *Supaia* and a *Callipteris* flora (no taxa listed), but the *Supaia* flora probably came from the lower Yeso Formation (Kottlowski, 1963) and the locality of the *Callipteris* flora is described in identical terms to that recovered from Abo Pass; thus it may actually have come from the Bursum.

South of the Socorro area, Read (in King, 1942) reported *Callipteris* and *Supaia* floras (no taxa listed) from the San Andres Mountains. Kottlowski (1963) considered that the *Supaia* flora came from the basal Yeso Formation. The *Callipteris* flora, as at Abo Pass and in the Oscura Mountains, may have come from the Bursum, associated as it was with beds containing marine invertebrates. At Otero Mesa, Read reported a *Supaia* flora which included *Supaia* sp. and *Brachyphyllum arizonicum* (in King, 1942; in Bachman and Hayes, 1958). Finally, in the Sacramento Mountains, east of Alamogordo, Read (in King, 1942) reported a *Callipteris* flora (no taxa listed), although its exact stratigraphic position is subject to the problems discussed above for the *Callipteris* flora at Abo Pass. Otte (1959) considers that the *Callipteris* flora actually came from the Laborcita (Bursum). Formation. Also in the northern Sacramento Mountains, at Caballero Canyon, a *Supaia* flora (no taxa listed) has been reported from the lower Abo (Read in Bachman and Hayes, 1958) and an older *Gigantopteris* flora (no taxa listed) from the Upper Abo (Read in Bachman and Hayes, 1958). This suggests that the *Callipteris* flora, being older than the *Supaia* flora, probably did come from the Laborcita. There is a conflict in the literature in that Read and Mamay (1964) contradict Read (in Bachman and Hayes, 1958) and state that the only occurrence of the *Gigantopteris* flora in the Abo is from near Orogrande (Otero Mesa) and consists of a fragment of *Gigantopteris* sp. Vaughn (1969) mentions the presence of *Walchia* sp. low in the Abo in the northern Sacramento Mountains.

It is apparent from the above review of the literature that it is by no means clear that regionally the Abo contains two successive floras of the zone of *Callipteris* and the zone of the older *Gigantopteris* and *Supaia* floras (Table 2). North of the Socorro area only a *Callipteris* flora has been reported. In the Socorro area, a *Supaia* flora is present in the Abo, but the occurrence of a *Callipteris* flora has not been adequately documented. It is not clear what floras are present in the Abo in the San Andres Mountains, but at Otero Mesa and in the northern Sacramento Mountains, all floras definitely reported from the Abo are of the zone of the older *Gigantopteris* and *Supaia* floras of Leonardian age. It would appear, based on the evidence of plants, that the Abo is not the same age at all localities; this has been suggested previously (Fracasso, 1980; Vaughn, 1970). The fact that the ages of marine beds underlying the Abo (Laborcita Formation—Bursum Formation—Red Tanks Member of Madera Formation) vary from Virgilian to early Wolfcampian (Jahns, 1955; Kottlowski,1963; Steiner and Williams, 1968; Tidwell and Ash, 1982) is the strongest evidence that the Abo does not represent an isochronous unit. Accurate correlations of Permo-Pennsylvanian red beds of the Colorado Plateau are only convincing when the red beds immediately overlie or intertongue with marine units (Baars, 1962; Eberth and Berman, 1983). Detailed intraformational correlations within the Abo, based on plant fossils, will require more and better documented localities.

It is unfortunate that more detailed locality data are not available for plant fossils in the Abo Formation as there are apparent problems with the biostratigraphic framework of Read and Mamay (1964). Kottlow ski (1963) has pointed out that the Lee Ranch Tongue of the Abo contains an older *Gigantopteris* and/or *Supaia* flora in the Sacramento Mountains (see above), supposedly both of Leonardian age (Read and Mamay, 1964); however, the Abo intertongues with the Hueco Limestone which is Wolfcampian in age based on fusilinids. This strongly suggests that at least part of the older *Gigantopteris* and/or *Supaia* floras are of Wolfcampian age. If Read (in Pray, 1961; in Bachman and Hayes, 1958) is correct in that an older *Gigantopteris* flora (cf. Read and Mamay, 1964) occurs above a *Supaia* flora in the Caballero Canyon

Table 2. Stratigraphic distribution of floral assemblage zones. Zones are C, Callipteris *zone; G, older* Gigantopteris *zone; and S,* Supaia *zone. Locality information for 1. Read and Mamay, 1964; 2. Tidwell and Ash, 1980; 3. Read* in *King, 1942; Read* in *Hatchell and others, 1982; 4. Wilpolt and others, 1946; this report; 5. Read* in *King, 1942; Kottlowski, 1963; 6. Read* in *King, 1942; Kottlowski, 1963; 7. Read* in *King, 1942; Read* in *Bachman and Hayes, 1958; Otte, 1959; 8. Bachman and Hayes, 1958; Read and Mamay, 1964.*

GEOGRAPHIC AREA		NORTH OF SOCORRO AREA	SOCORRO AREA				SOUTH OF SOCORRO AREA		
		JEMEZ-COYOTE AREA 1	CARRIZO ARROYO 2	ABO PASS 3	CENTRAL SOCORRO AREA 4	OSCURA MTS 5	SAN ANDRES MTS 6	N. SACRAMENTO MTS 7	OTERO MESA 8
ROCK UNIT	MESETA BLANCA (YESO)					S	S		
	ABO FM	C		S	S			G S	S or G
	UNITS UNDERLYING ABO FM		C	C?	C?	C?	C?	C?	
		RED TANKS MBR OF MADERA FM			BURSUM FM			LABORCITA FM	PENNSYLVANIAN

area, it seems likely that the relationship between the two floras has an age component as well as a geographic/paleoecological one. If, however, an older *Gigantopteris* flora only occurs at Otero Mesa (Read and Mamay, 1964) there is still a problem, as a *Supaia* flora is also known from that area (Read in King, 1942; Read in Bachman and Hayes, 1958). Read and Mamay (1964) state that the "horizontal ranges of these floras are not known to overlap." The relationship between the older *Gigantopteris* flora and the *Supaia* flora is in need of clarification; absolute age assignments based on these floral assemblages should be treated with caution.

Regarding the *Callipteris* flora, Read and Mamay (1964) note that "the difference between the uppermost Pennsylvanian floras and those of early Permian age are commonly so slight that only the presence of the index genus *Callipteris* Brongniart may serve to distinguish a lowermost Permian flora." However, as noted by Kottlowski (1963), Otte (1959) reported that Read's *Callipteris* flora from the northern Sacramento Mountains, supposedly from the Abo Formation, actually came from the basal Laborcita Formation which is Virigilian in age based on fusilinids (Kottlowski, 1963). Further taxonomic and stratigraphic data from the Sacramento Mountains could be of use in clarifying the stratigraphic use of *Callipteris* as a Permian index fossil. There is disagreement as to whether the appearance of the genus *Callipteris* (Read and Mamay, 1964) or the species *Callipteris conferta* (Gillespie and others, 1975; Havlena, 1975) should be used to define the base of the Permian. The association of *Callipteris* specimens with marine units of known age could help to resolve this problem.

In conclusion, based on plant biostratigraphy, it appears that the Abo Formation varies in age from Wolfcampian *(Callipteris* zone) to lower Leonardian *(Supaia* and older *Gigantopteris* floras), both vertically and possibly laterally. Most vertebrate faunas from the Abo are usually assigned to middle to late Wolfcampian age (Langston, 1953; Romer, 1960; Berman and Reisz, 1980).

PALEOECOLOGY

The lower Permian represents a period of transition in plant evolution. In the Pennsylvanian, coal-forming plant assemblages were cosmopolitan and long established. By the end of Lower Permian time, floras showed strong geographic variation and were subject to much harsher and more arid climates (Read and Mamay, 1964).

The *Callipteris* flora, representatives of which are found at least locally in the Abo Formation, had a circumpolar distribution and contained some characteristically Pennsylvanian forms. The succeeding *Supaia, Glenopteris* and older *Gigantopteris* floras lost any Pennsylvanian aspect' and were geographically restricted (Read and Mamay, 1964). From the Pennsylvanian (Pfefferkorn and Thompson, 1982) to the end of the lower Permian, a climatic trend toward increased aridity is evidenced by plants (White, 1929; Read and Mamay, 1964; Ash and Tidwell, 1982), sediments and vertebrates (Romer, 1958, 1960; Vaughn, 1969). Climatic temperatures may have increased from the Wolfcampian to the Leonardian (McKee and others, 1967).

Plants from the Abo Formation are dominated by forms such as *Walchia* and *Supaia,* which are considered xerophytic (White, 1929; Moore and others, 1936; Cridland and Morris, 1963; Read and Mamay, 1964). In the Socorro area, sedimentological features such as abundant mudcracks, paleocaliche development, and the occurrence of aestivating lungfish (Berman, 1976, 1979) suggest an arid, seasonally dry climate.

Climatic differences existed between New Mexico and Texas during Wolfcampian and early Leonardian time (Romer, 1960; Vaughn, 1970) and are reflected in the presence of the more normal older *Gigantopteris* flora in Texas and the more restricted *Supaia* flora in New Mexico (Read and Mamay, 1964). Given that the older *Gigantopteris* flora occurs somewhere in southern New Mexico, there must have been climatic differences between this area and the central and northern parts of the state during Leonardian time. Occurrence of an older *Gigantopteris* flora within the geographic range of *Supaia* flora, as seems to occur in southern New Mexico, presents problems for the biostratigrapher but not the paleoecologist. As Kottlowski (1963) succinctly noted, these floras "appear to be areally limited facies floras and probably are environment indicators rather than strict guide fossils" and their occurrence together merely suggests an expected environmental interface. The possible occurrence of *Glenopteris* in New Mexico may suggest locally saline conditions (Read and Mamay, 1964).

SUMMARY

Plants from the Canoncito de la Uva locality are of the *Supaia* flora, probably of Leonardian age. This and most other plant remains occur in the "upper member" of the Abo Formation. Based on present knowledge, it appears that within the Abo there is no regionally simple story of a *Callipteris* flora being succeeded by a *Supaia* or older *Gigantopteris* flora. The Abo probably does not represent an isochronous unit.

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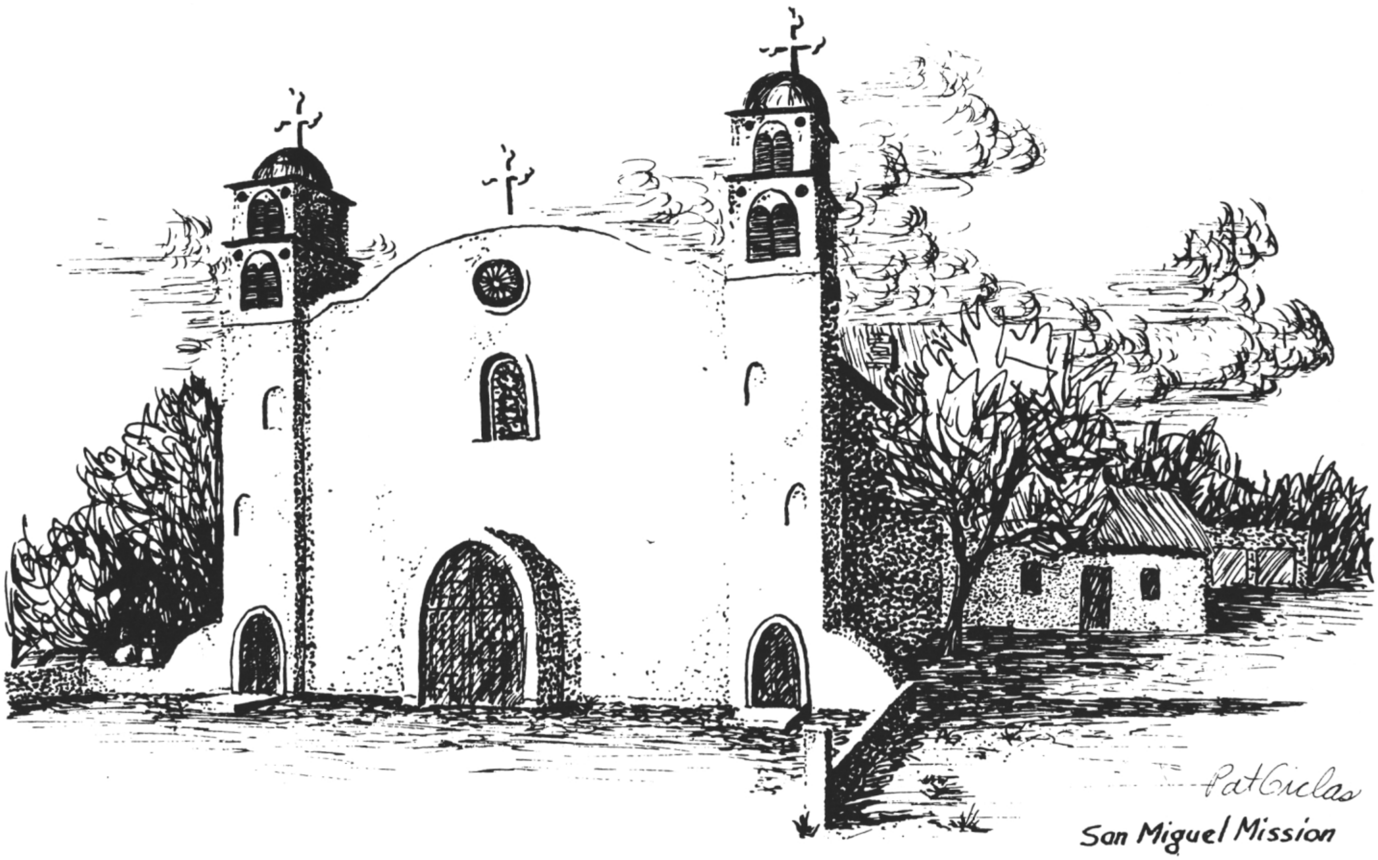

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