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NEW PALYNOSTRATIGRAPHICAL DATA OF NW SOUTH AMERICA PALEOCENE-EOCENE OF THE MIDDLE MAGDALENA VALLEY, COLOMBIA.

Nouvelles données palynostratigraphiques de la région nord-occidentale de l'Amérique du Sud. Paléocène-Eocène de la Vallée Moyenne de la Magdalena, Colombie.

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RESUME

L'étude palynologique d'une séquence de 2000 mètres de dépôts fluviatiles et côtiers de l'intervalle Paléocène supérieur – Eocène moyen au bord est de la Vallée Moyenne du Magdalena (Colombie) a donné un assemblage riche et diversifié de pollen et spores. Dans cet article, on présente la distribution stratigraphique détaillée des principales espèces considérées comme marqueurs et une comparaison avec les biozones générales disponibles est établie.
Mots-clés : Colombie – Vallée de la Magdalena – Paléocène-Eocène – Palynologie – Stratigraphie.

ABSTRACT

The palynological study of 2000 m thick coastal and fluvial rocks from the Upper Paleocene-Middle Eocene interval in the eastern border of the Middle Magdalena Valley Basin (Colombia) gave a rich and diverse assemblage of pollen and spores. In the present work, a distribution of stratigraphically useful pollen species and the comparison of these data with the available general biozonal schemes are presented.
Key words : Colombia – Magdalena Valley – Paleocene-Eocene – Palynology - Stratigraphy

INTRODUCTION

The Middle Magdalena Valley Basin (MMVB) of Colombia is a physiographic expression used to designate a depressed area that is limited by the Eastern Cordillera to the east and the Central Cordillera to the west (Fig. 1A).

This area embraces approximately 32000 Km^2 (MORALES *et al.*, 1958). It is conformed by rocks which ages ranging from Paleozoic to recent, formed in different tectonic settings; a great part of the recent configuration of this valley is due to the Andes uplift. The MMVB stratigraphy has been studied by several authors specially linked to the oil and gas exploration (GÓMEZ, 2001; MORALES *et al.*, 1958; PILSBRY and OLSSON, 1935; SUAREZ, 1997a; SUAREZ, 1997b; WHEELER, 1935). The Upper Cretaceous rocks of this area are characterized by shallow marine and coastal deposits that, in general, comprise a regressive sequence. During the Paleocene-Eocene a continuous sedimentation occurred in the basin that existed in the northeast region of Colombia and the west of Venezuela (Fig. 2); more than 2000 m of fluvial and coastal clastic sediments were accumu-

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lated in some parts of this area. Some of them can now be studied in outcrops in synclines and anticlines at the eastern border of the MMVB (e.g. the Nuevo Mundo synclinal; Fig. 1B). The most common fossils present in these rocks are pollen and spores. Nevertheless, in spite of the fact that many oil companies have studied these fossils during the last 40 years, information about their stratigraphic distribution remains still unavailable. The present study shows the stratigraphic distribution of some potentially useful species of pollen and spores in two sections of the eastern flank of the MMVB. Finally, these data are compared with the traditional biozonal schemes available for northwest South America.

Different stratigraphic nomenclatures have been used by the oil companies in the MMVB (PORTA, 1974). Here, we apply the terminology of GOMEZ (2001), MORALES *et al.* (1958) and VAN DER HAMMEN (1958). For the Paleocene-Eocene interval, three units have been recognized from base to top: (1). The Lisama Formation is composed of vary-colored, red-brown, light-gray to gray mottled shales, with medium to fine grained sandstone interbeds; some coal layers are present in the middle part; the sandstones become coarser grained towards the top. The thickness of this unit ranges up to 1225 meters; its lower contact is conformable and gradual with the Campanian-Maastrichtian Umir Formation and usually it is placed at the lowermost well-developed sandstone layer (MORALES *et al.*, 1958). In our section, the contact between the Lisama-Umir Formations and some intervals of the lower part of the Lisama Formation are covered by recent fluvial deposits (Fig. 3). (2). The La Paz Formation consists of by gray massive to cross-bedded sometimes conglomeratic sandstones, with minor mudstone and shale intercalations mainly in its lower and middle part; the shally levels contain poorly preserved plant remains. In the type section this formation is approximately 1000 m thick although it is variable across the MMVB (MORALES *et al.*, 1958). In the eastern MMVB its lower contact with the Lisama Formation is a paraconformity but to the west, this unit rest on Cretaceous units in angular unconformity. (3). The Esmeraldas Formation consists of thinly bedded sandstones and gray mudstones interbedded with gray and green to red-brown mottled shales; some isolated coal beds are present. This formation is about 1200 m thick and thickens to the north (PORTA, 1974). To its lower contact is gradational with the La Paz Formation, whereas the upper boundary is unconformable with the Mugrosa Formation (Porta, 1974); nevertheless, MORALES *et al.* (1958) noted that the nature of the contact is not well established. The Esmeraldas and La Paz Formations are included by MORALES *et al.* (1958) in the Chorro Group (see PORTA, 1974 for detailed historical account).

METHODOLOGY

Two stratigraphic sections have been analyzed in this study (Figs. 1, 3). The first one was previously studied by JARAMILLO & DILCHER (2001); it is located along the Rio Sucio, near Uribe-Uribe town (department of Santander, Middle Magdalena Valley; 7° 13' 19"N - 73° 21' 18"W). In the present work new samples were analyzed, especially in the lower part of the sequence (Lisama Formation and the lower part of La Paz Formation). The second section, 16 km to the south of Uribe-Uribe town (7° 5 ' 48.38 N - 73° 23 ' 59.33 W), is a composite log of nine wells of the "Rio Sogamoso Hydroelectric Project" near the Bucaramanga-Barrancabermeja road. The log data are available from the Colombian core library of the Instituto Colombiano de Petroleo (ICP; Bucaramanga, Colombia). The sedimentological information, such as lithology and sedimentary structures is based on PARDO (1997), but the cores were restudied and sampled by the authors. Hundred forty-seven samples were treated for the palynologic study, among them, 59 can be used for biostratigraphic analysis (40 in the Uribe section and 19 in the Río Sogamoso section) (Fig. 3). Dark colored fine sandstones, siltstones, shales and coals were mainly selected.

The palynological samples were prepared with a standard technique: breaking down of 25 gr. of the rock; disintegration of mineral matrices with HCl and HF (24 hours); cleaning with hot HCl; sieving using a 12 mm mesh; oxidation with HNO_3 of organic fraction and mounting of permanent preparation slides using Hydroxylethyl Cellulose (HEC) to homogenize the organic parti-

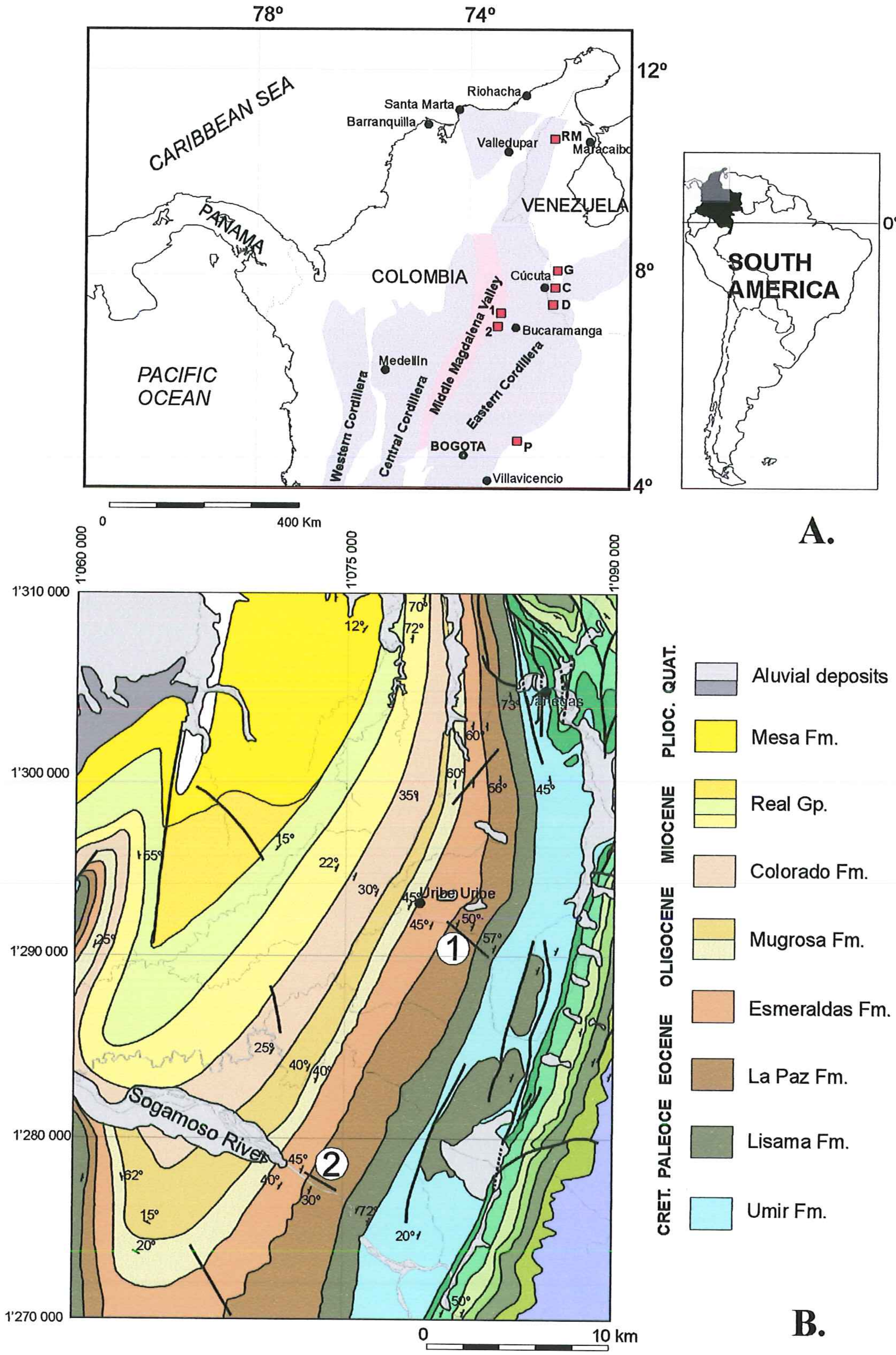

Fig. 1. A. Location of the Middle Magdalena Valley Basin (MMVB) and the sections studied in this work. 1. Uribe Section; 2. Río Sogamoso section. Letters: some stratigraphic sections mentioned in the text: P: Piñalerita section (JARAMILLO & DILCHER, 2001); RM. Riecito Maché section (RULL, 1999); D: The Delicias section; C: Quebrada La Capacha section; G: Río Guarumito sections (COLMENARES & TERAN, 1993). In gray: Andean mountain ranges. B. Geology of the Nuevo Mundo synclinal (INGEOMINAS, 1969) and location of the studied sections. 1. Uribe Section; 2. Río Sogamoso section. In green and purple: Cretaceous and Jurassic units.

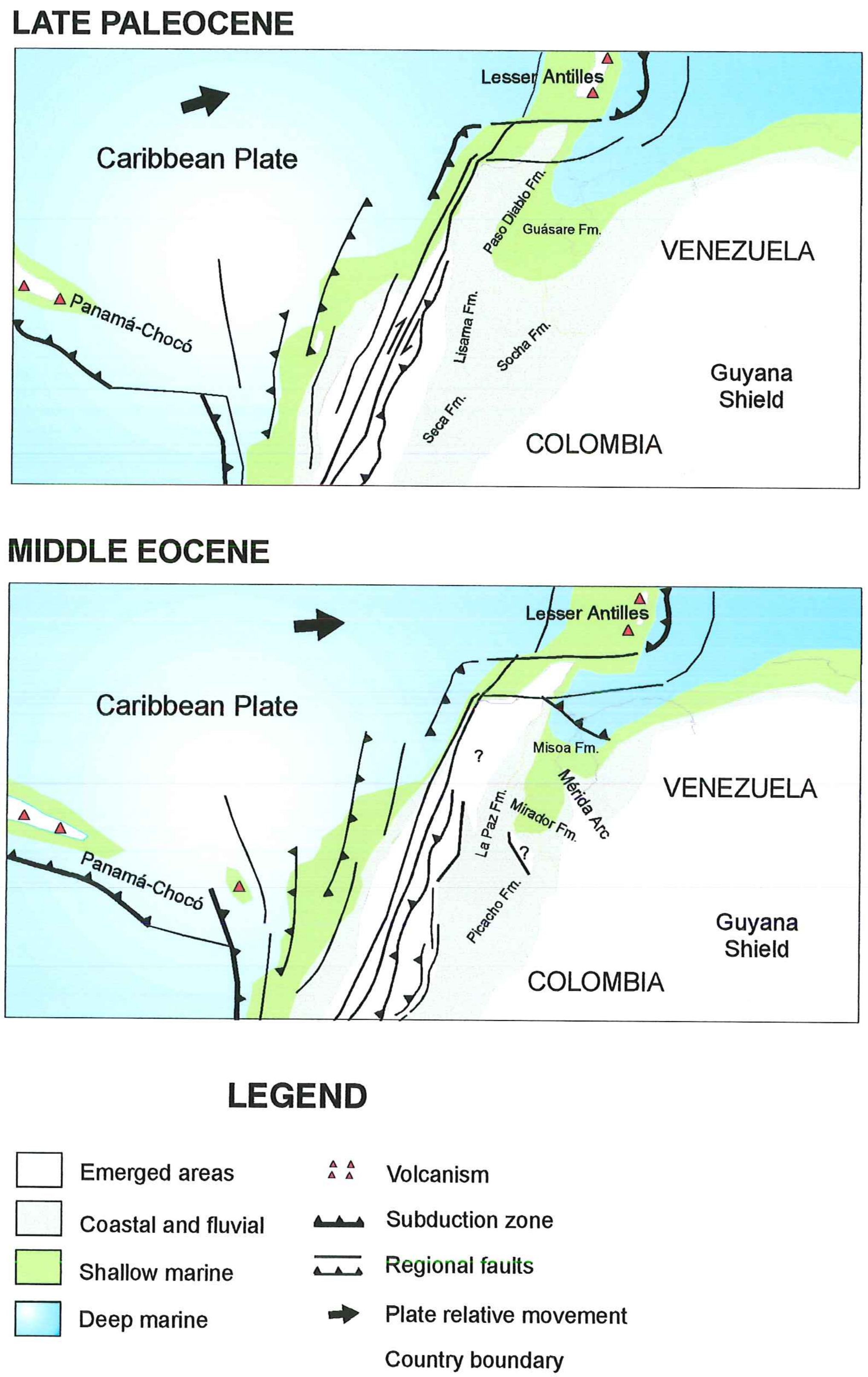

Fig. 2. Paleogeographic map of north western South America with the distribution of main Paleocene-Eocene depositional environments and tectonic structures (modified from MORENO & PARDO, in press).

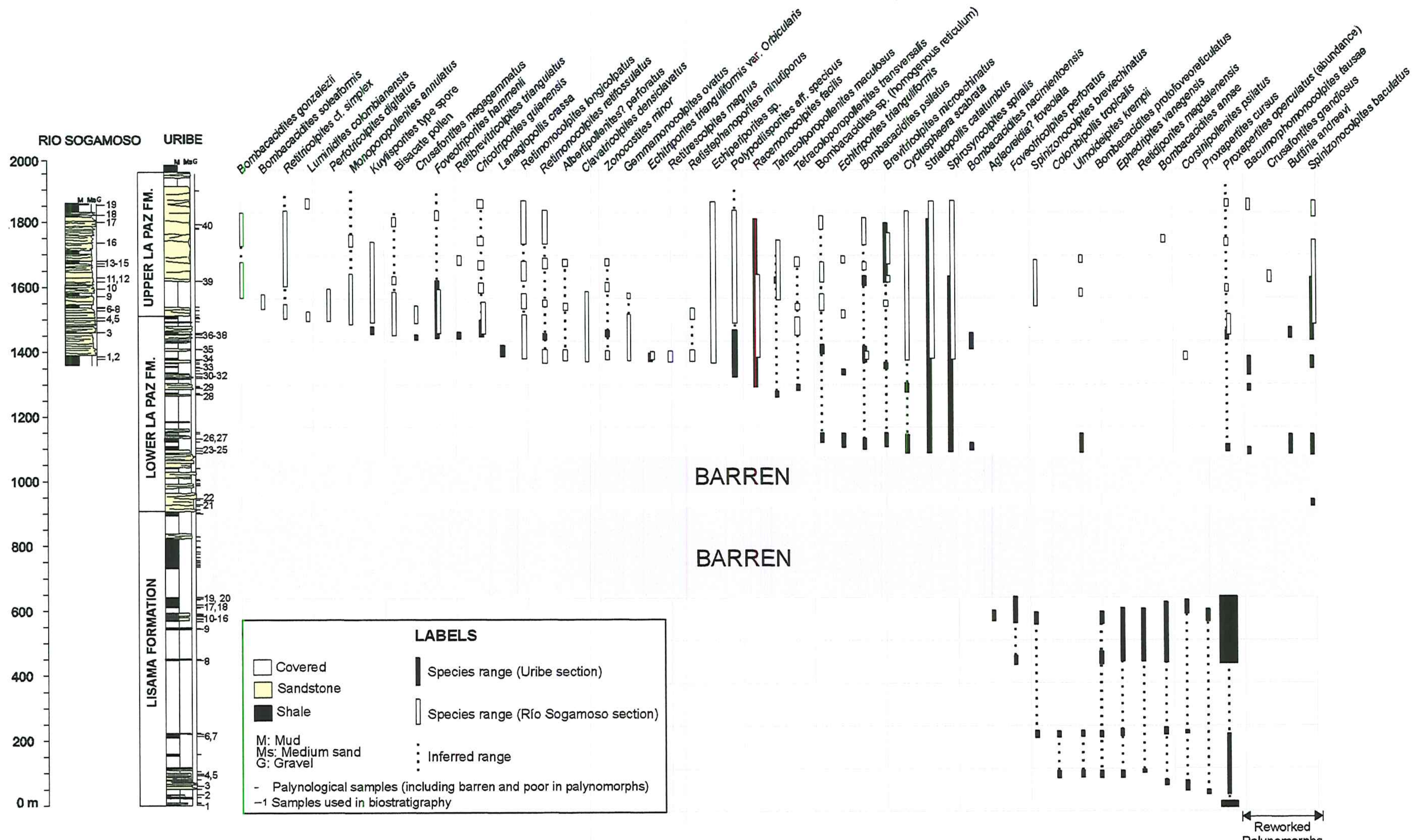

Fig. 3. Sedimentological characteristics and distribution of selected pollen and spore species in the studied sections.

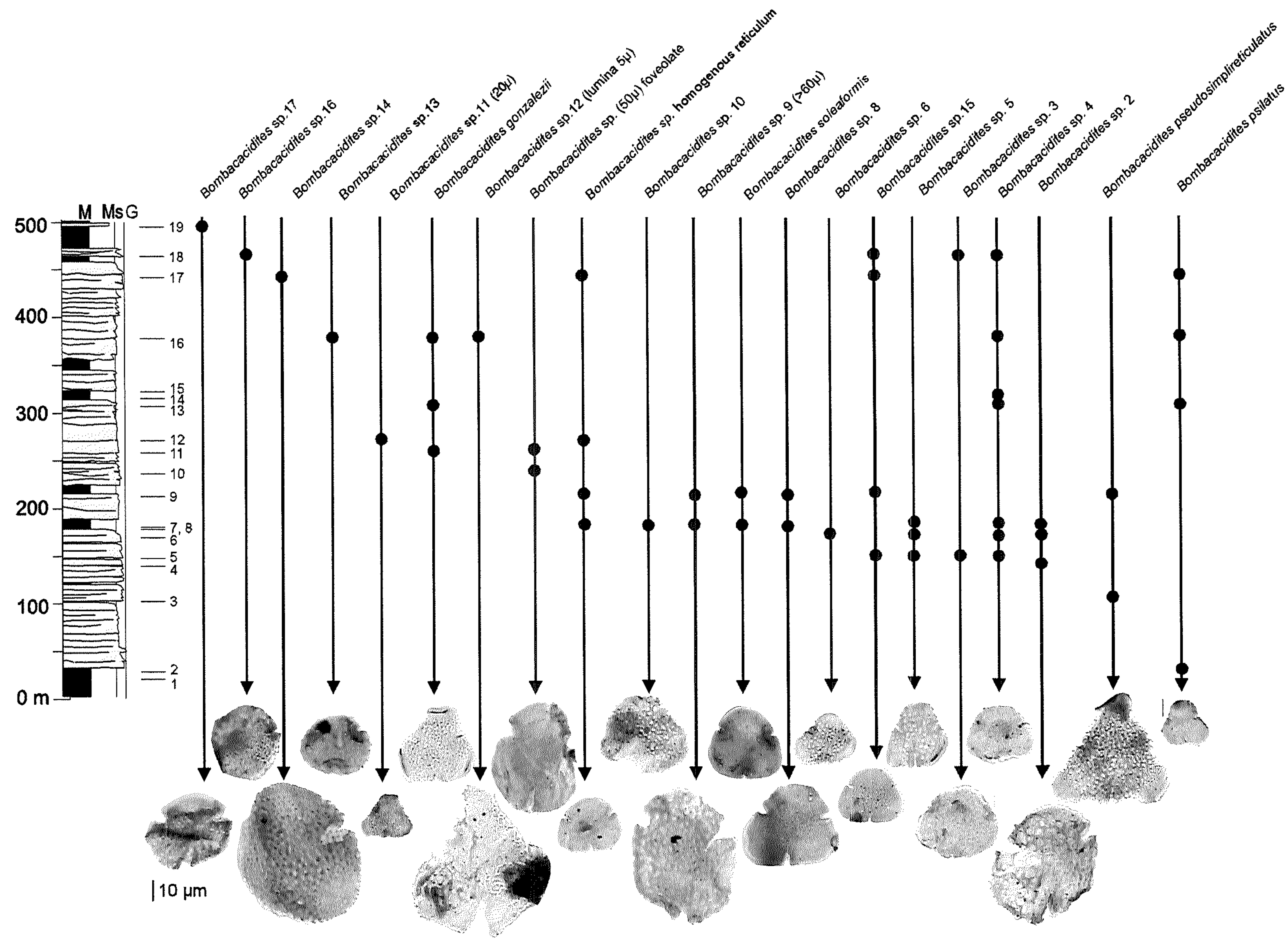

Fig. 4. Stratigraphic distribution of some forms of *Bombacacidites* (Rio Sogamoso section).

cles on the glass slide and Euparal to permanently fix the coverslip. The coal samples were treated using the ISSEP (Belgium) technique as follows: crushing the sample in a mortar; sieving through a 65 μm-1.65 mm mesh; mixing 1 gr. of coal plus 2 gr. of pulverized $KClO_3$ with 25 ml of fuming HNO_3; dilution in 2 liters of water and sieving through a 12 μm mesh; centrifugation and mounting on slides using Hydroxylethyl Cellulose (HEC) and Euparal. The palynological slides were studied with a 40x and 100x immersion objectives for identification of the pollen species; the best-preserved specimens were photographed and located in coordinates using England Finder (EF). The morphological characteristics of the fossils were compared to descriptions, photographs and diagrams in the available Paleogene publications. After identification of the species, each slide was rescanned to count at least 100-300 pollen specimens; sometimes two or three slides were necessary to fulfill this goal. The description uses the nomenclature of PUNT *et al.* (1994). The slides and holotypes of this research are available in the Instituto Colombiano de Petroleo (ICP; Bucaramanga, Colombia).

RESULTS

The palynological information is grouped in a composite distribution diagram (fig. 3). The section of the Rio Sogamoso is palynologically equivalent to the upper part of the lower La Paz, upper La Paz and Lower Esmeraldas Formations the Uribe section, 16 km to the north. This is supported by the first appearance of *Foveotriporites hammenii, Cricotriporites guianensis, Echitriporites trianguliformis* var. *orbicularis, Kuylisporites* type spore and *Retimonocolpites retifossulatus* (fig. 3). In this study more than 300 pollen and spore species were identified, many of them are in process of description; among them 47 biostratigraphic potentially useful taxa are presented here (fig. 3). Their selection is based on their occurrence in other sections described in the literature, their narrow stratigraphic range and/or their use in previous stratigraphic studies.

The palynological association of the Lisama Formation is characterized by the abundance of different types of *Proxapertites* (e.g. *P. operculatus, P. cursus*), some species of *Bombacacidites* (e.g. *B. annae, B. protofoveoreticulatus*), *Retidiporites magdalenensis* and different monocolpate species (*e.g. Mauritiidites franciscoi*). Similar associations have been described in the Los Cuervos Formation in the Catatumbo region in the southwest of Venezuela (e.g. COLMENARES and TERÁN, 1993) or in the Arcillas del Limbo and Socha Formations in the central part and eastern border of the Cordillera Oriental of Colombia (JARAMILLO and DILCHER, 2001) and in the Paso Diablo Formation to the north west of Venezuela (RULL, 1999). The last 266 m of the Lisama Formation and the base of the La Paz Formation are characterized by barren mottled shales; this phenomenon probably results from the oxidation of the organic matter in well-drained alluvial soils. In the La Paz Formation appears a great number of species, the first appearance datum (FAD) of which has been considered indicative of an early-middle Eocene age (e.g. *Cyclusphaera scabrata, Foveotriporites hammenii, Monoporopollenites annulatus, Perfotricolpites digitatus, Spirosyncolpites spiralis, Striatopollis catatumbus, Tetracolporopollenites maculosus, Bombacacidites soleaformis* among others). In the upper La Paz Formation a great number of new species appears; in the Río Sogamoso section the diversity in Bombacacidites is remarkable (Fig. 4). It is important to indicate that in the La Paz Formation late Cretaceous reworked species are noted in appreciable percentage (e.g. *Dinogymnium acuminatum, Buttinia andrevi, Bacumorphomonocolpites tausae and Spinizonocolpites baculatus*).

Different authors have proposed palynological zonations to subdivide the Paleogene of the northwestern South America (e.g. GERMERAAD *et al.*, 1968; GONZALEZ, 1967; MULLER *et al.*, 1987; VAN DER HAMMEN, 1957b). The most employed are those from GERMERAAD *et al.* (1968) and MULLER *et al.* (1987). GERMERAAD *et al.* (1968) divided the upper Paleocene-Eocene in four palynologic zones, one of pan-tropical extension (*Monoporites annulatus*), another trans-Atlantic one (*Retibevitricolpites triangulatus*) and two inter-continental (*Ctenolophonidites lisamae* and *Foveotricolpites perforatus*; fig. 5). They have included in their study of the Tertiary palynology of tropical regions a sequence from the Middle Magdalena Valley. It is located 13 Km to the northeast of the Uribe section (the "Río Lebrija" section). In this section they mentioned the presence of the *Foveotriletes margaritae* and *Ctenolophonidites lisamae* in the lower half of the Lisama Formation; the *Foveotricolpites perforatus* zone in the upper part of the Lisama Formation and the base of the La Paz Formation and the *R. triangulatus* zone that reaches the last meters of the La Paz Formation where it is in paraconformity with the R. guianensis zone. Unfortunately, the location of the samples and the stratigraphic distribution of the pollen species were not published. Some of our data differ from those of GERMERAAD *et al.* (1968): among the species used to define the upper Paleocene biozones three of them, *B. annae, F. perforatus and P. cursus* are well recorded in our studied section (fig. 3).

In contrast, *C. lisamae, G. gemmatus and F. margaritae* are absent or rarely present. Consequently, the *F. margaritae* and *C. lisamae* zones cannot be well identified at the base of our section. Nevertheless, they may be pr esent in the covered part of the Lisama Formation in our studied area (Fig. 3). The limit of the *F. perforatus* and *R. triangulatus* zones in the Río Lebrija section was located by GERMERAAD *et al.* (1968, p. 249) near to the base of La Paz Formation. The new information obtained in Colombia shows that there is a thick barren stratigraphic interval that encompasses the Upper Lisama -Lowermost La Paz Formations (Fig. 3). This phenomenon has been reported by JARAMILLO & DILCHER (2001) in other Colombian sections several hundred kilometers apart, a criterion to include a sterile biostratigraphic interzone in this region. The "Late Paleocene-Early Eocene" zone *Retibrevitricolpites triangulatus* has been defined by GERMERAAD *et al.* (1968) by the first appearance of *Retibrevitricolpites triangulatus, Striatopollis catatumbus* and *Lanagiopollis crassa* species; this zone was specially observed in western Venezuela and Nigeria (GERMERAAD *et al.*, 1968). In our section, this zone was recognized by the FAD of *S. catatumbus*, which is the only species that has continuous stratigraphic distribution. In contrast, *R. triangulatus* and *L. crassa* were found only in two and one stratigraphic levels respectively (fig. 5). The FAD of *M. annulatus* zone can be recognized at the base of the upper La Paz Formation. Nevertheless difficulties occur when trying to recognize the sub-zones defined by GERMERAAD *et al.* (1968) in the studied section; *R. operculatus*, indicator of one of these sub-zones, is not recorded. The species *R. guianensis* is common in the Esmeraldas Formation but it is not recorded in the La Paz Formation; this indicates that the *R. guianensis* sub-zone is not present at the top of the La Paz Formation in the Nuevo Mundo synclinal area as was previously proposed by GERMERAAD *et al.*(1968).

MULLER *et al.* (1987) subdivided the Paleocene-Eocene of NW South America in 10 palynological zones (zones 15 to 24), some of the species used to define them correspond to those of GERMERAAD *et al.* (1968), others are new (fig. 6). When we try to apply this scheme to our section multiple difficulties arise: *G. gemmatus* used as indicator of the zone 15 is not recorded; the species *Rugutricolporites felix*, indicator of the zone 17, is not found in the studied area; *Echitriporites trianguliformis* Form. A. (formally named *Echitriporites trianguliformis* var. *orbicularis* by JARAMILLO and DILCHER, 2001), appears only in one stratigraphic level (fig. 6); *Bombacacidites* sp. B is not recorded; *Retitrescolpites magnus* is present in a single stratigraphic level; *Bombacacidites soleaformis*, indicator of the zone 20, is found only in two levels of the MMVB (2 specimens); *B. foveoreticulatus*, J. *pentaradiatus* and *E. estelae* are not found in the studied interval. The biozones 21-24 of MULLER et al. (1987) could thus not be identified.

DISCUSSION

The great variety of pollen and spores found in the studied sections seem to have a great potential to perform accurate correlations through the basin; however the lateral distribution of certain taxa along the basin still remains to be proved. The preliminary data show that certain species recently defined by JARAMILLO & DILCHER, (2001) 250 km to the southeast, are present in the MMVB: *Aglaoreidia? foveolata* for the upper part of the Lisama Formation; *Bombacacidites gonzalezii, Luminidites colombianensis, Clavatricolpites densiclavatus, Cyclusphaera scabrata* and *Brevitricolpites*

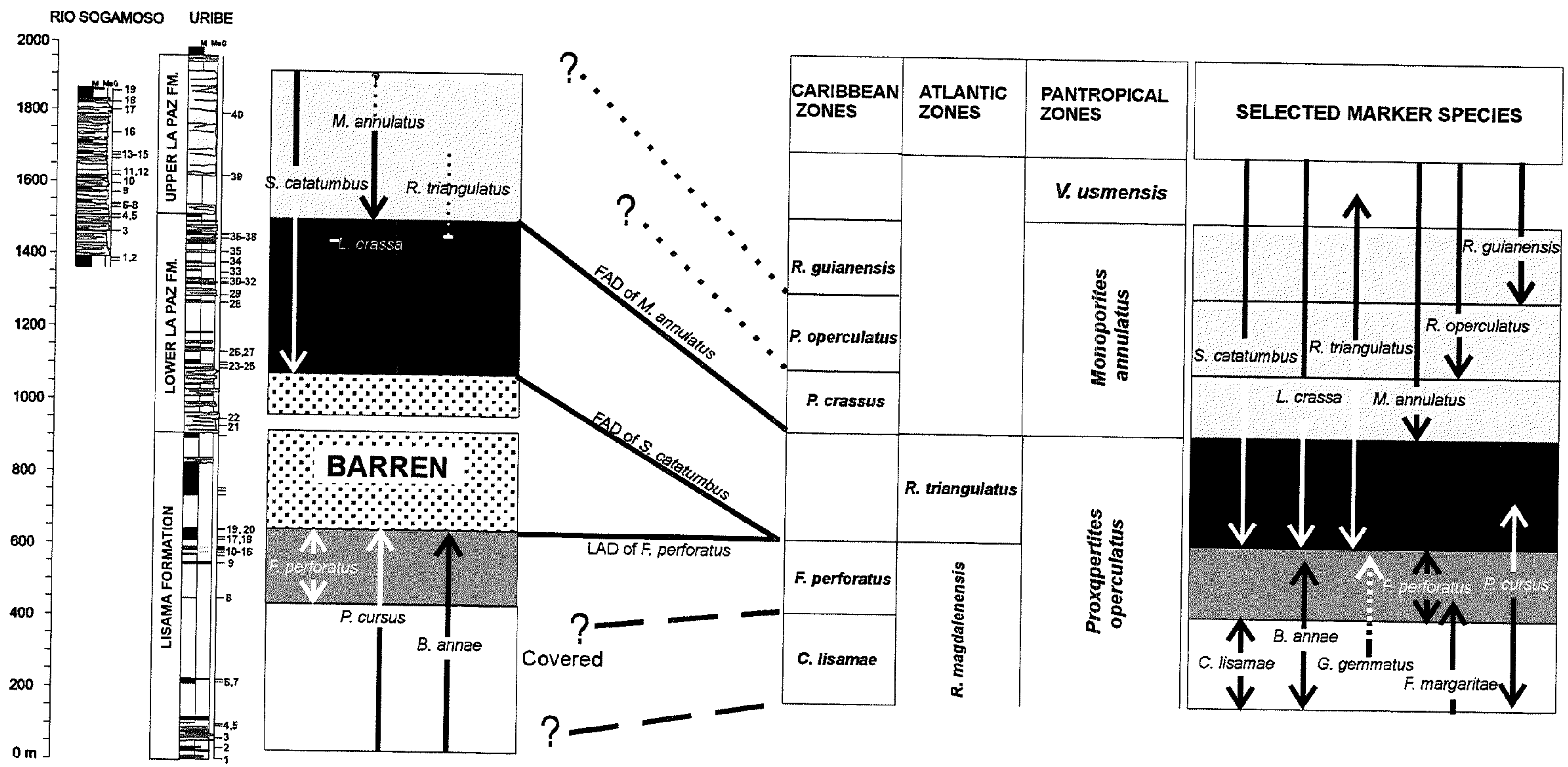

Fig. 5. Correlation of the Paleocene-middle Eocene palynologic zones of GERMERAAD et al. (1968) with the studied sections.

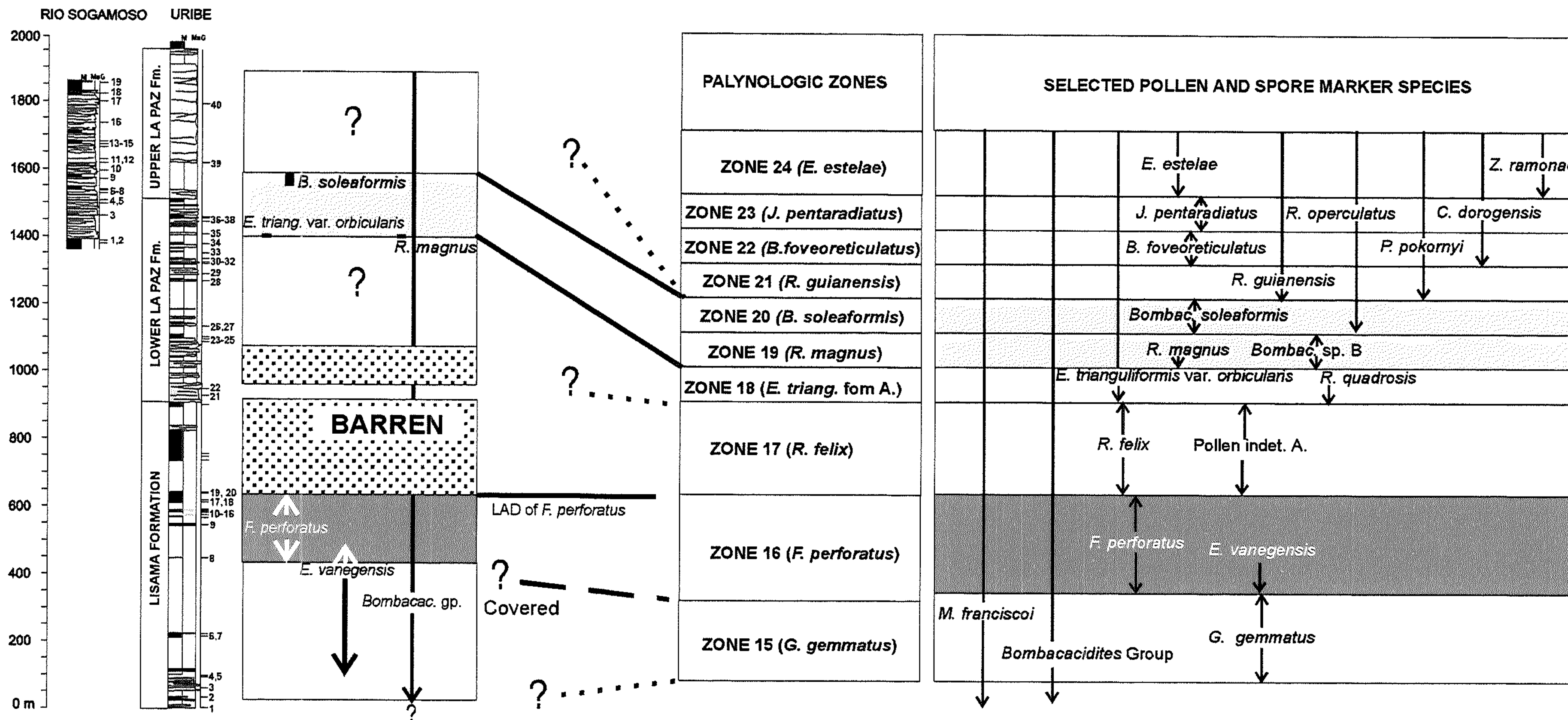

Fig. 6. Correlation of the Paleocene-middle Eocene palynologic zones of MULLER et al. (1987) with the studied sections.

microechinatus for the La Paz Formation. Therefore, these taxa could be useful for biostratigraphic purposes. On the other hand, the upper La Paz Formation gave one of the most varied associations of *Bombacacidites* described in northwestern South America (fig. 4). These species are always in low quantity in the samples, and detailed counting in each stratigraphic level is thus necessary.

The current palynologic information shows that the lower limit *Retibrevitricolpites triangulatus* biozone of GERMERAAD *et al.* (1968) can be placed near the base of La Paz Formation with the first appearance of *Striatopollis catatumbus*. This species is very similar to the pollen of the genus *Crudia (Fabaceae)* (GERMERAAD *et al.*, 1968), common in alluvial plains; on the contrary, *Retibrevitricolpites triangulatus* and *Lanagiopollis crassa*, the other species that define the biozone, were only identified in a single stratigraphic level in the Middle Magdalena Valley but they are abundant in Venezuela. This difference could be explained by environmental factors that controlled the lateral distribution of these taxa. The great similarity among *L. crassa* with the mangrove pollen *Pelliciera rhizophorae* (LANGENHEIM *et al.*, 1967 in GERMERAAD *et al.*, 1968: 332) seems to support this idea. Accordingly, their distribution would be more important in Venezuela where marine influence in the sedimentation is stronger (fig. 2). This hypothesis would also explain the absence of the *Psilatricolporites* crassus zone in the Middle Magdalena Valley. It might be due to environmental controls and is not to be interpreted as a consequence of a hiatus, as was originally proposed by GERMERAAD *et al.* (1968). The upper limit of the *Retibrevitricolpites triangulatus* biozone is based on the first regular appearance of *Monoporopollenites annulatus*, a species of regional distribution in the basin. This type of pollen is associated with the Poaceae family (Gramineae), wind pollinated plants with great distribution and preservation potential, good reasons to consider it as a good stratigraphic marker.

In the schema of MULLER *et al.* (1987), some zones that were originally defined in Venezuela are difficult to identify in the studied area, specially the "Eocene" interval (zones 17-24). The *Rugutricolporites felix* zone was not observed in the VMMB. A possible explanation is that taphonomical factors related to the oxidation of the organic matter at the base of the La Paz –Top of the Lisama Formations precluded its preservation. Nevertheless, in NW Venezuela in the Riecito Maché section (Rull, 1999) where this sterile interval does not exist, the FAD of this species is about 1000 m higher than the *Foveotricolpites perforatus* zone. This fact is incoherent with the scheme of MULLER *et al.* (1987). As mentioned above, the species *R. magnus* is restricted to a single stratigraphic level in the studied section; in contrast, this species is abundant in the Piñalerita section of JARAMILLO & DILCHER (2001), 250 km to the south, at the eastern border of the Eastern Cordillera of Colombia. It could suggest a hiatus in the MMVB. However, under the FAD of *R. magnus*, in the lower La Paz Formation still includes a 150 m thick interval, which could not be included in the zones proposed by MULLER *et al.* (1987); this could suggest an environmental control on the distribution of this species, and consequently a lowering in its stratigraphic value. On the other hand, COLMENARES & TERAN (1993), have shown that in several Paleogene sections of southwestern Venezuela (the Delicias, Quebrada La Capacha and Río Guarumito sections) (Fig. 1A), where apparently no important stratigraphic hiatuses occur, only 5 out of the 10 Late Paleocene-Middle Eocene palynologic zones proposed by MULLER *et a*l. (1987) can be identified.

CONCLUSIONS

More than 300 species of pollen and spores were identified in the Upper-Paleocene-Lower Eocene interval of the MMVB. Within them: *Aglaoreidia? foveolata, Bombacacidites gonzalezii, Luminidites colombianensis, Clavatricolpites densiclavatus, Cyclusphaera scabrata* and *Brevitricolpites microechinatus* and several forms of Bombacacidites, are reported for the first time in this area. Their importance for biostratigraphical studies is to be tested, as new sections will be available.

The general Paleocene-middle Eocene biozones of GERMERAAD *et al.* (1968) can be recognized in the sections studied in Colombia; however, the presence of a regional barren interval among the *Foveotricolpites perforatus* and *Retibrevitricolpites triangulatus* justifies the creation of a sterile interzone in the MVVB area. On the contrary, the Eocene Sub-zones of GERMERAAD *et al.* (1968) and the biozones of MULLER *et al.* (1987) are difficult to identify in the studied section. In the current state of knowledge it is difficult to decide if this is due to stratigraphic hiatuses, poor preservation or environmental restrictions. Study of new sections is necessary to obtain a clear image of the vertical and lateral variation of the pollen associations.

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PLATE 1

Some Paleocene-Eocene Pollen and spores from the Middle Magdalena Valley Basin. For location of the samples see the figure 3. EF: England finder coordinate. The bar represents 10 μm.

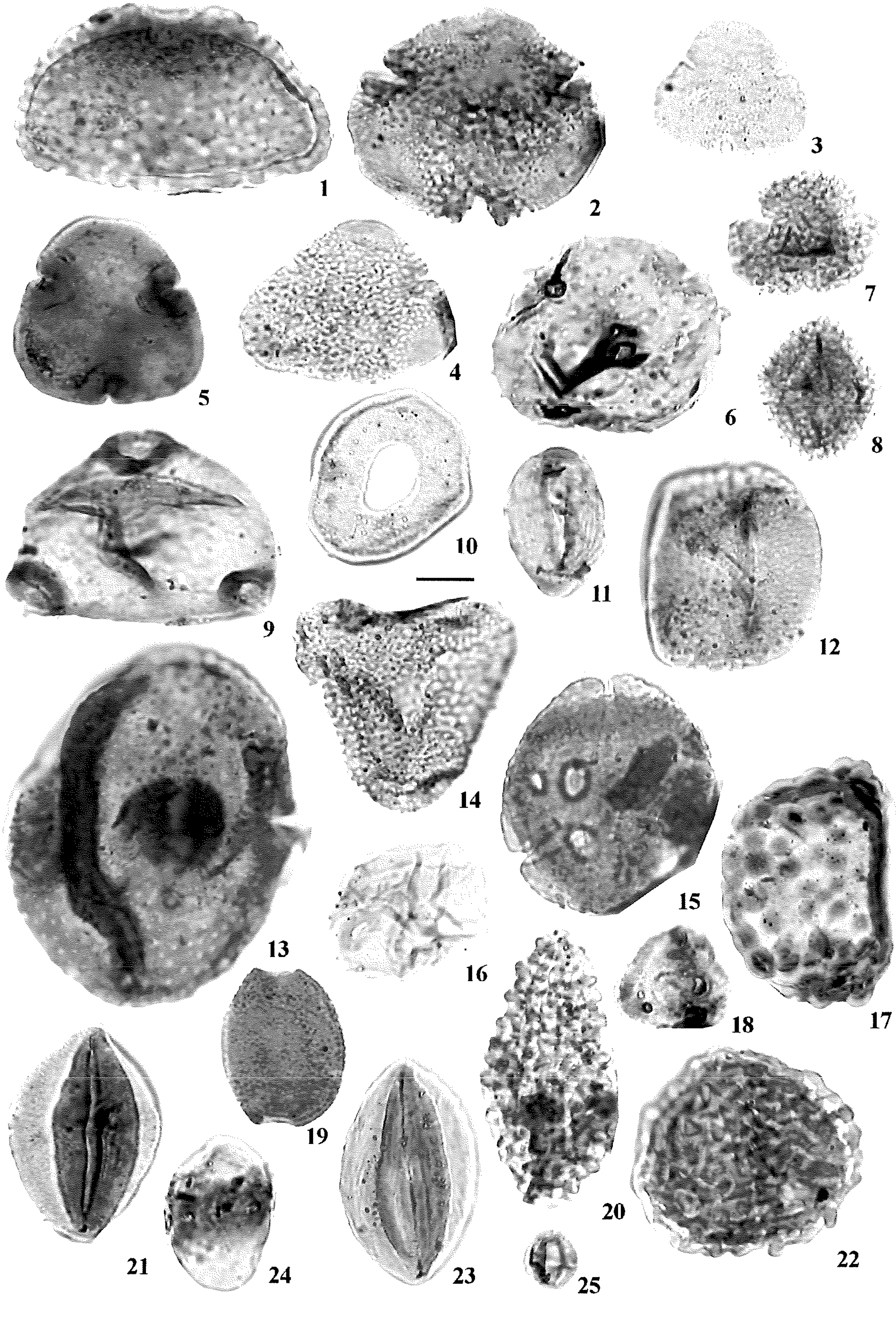
1. *Aglaoreidia? Foveolata* Jaramillo & Dilcher 2001. Sample 12 (Uribe section). Lame 57155. EF: Q36/1.
2. *Bombacacidites annae* (Van der Hammen 1954) Germeraad et al. 1968. Sample 10 (Uribe section). Lame 57112 ; EF: W37/2.
3. *Bombacacidites sp (homogenous reticulum).* Sample 27 (Uribe section); slide 57839 ; EF: G53-3
4. *Bombacacidites gonzalezii Jaramillo* & Dilcher 200. Sample 13 (Río Sogamoso section). Slide 55979(2); EF: T35/2.
5. *Bombacacidites soleaformis* Muller *et al.* 1987. Sample 9 (Río Sogamoso section). Slide 55926(2). EF: D56-1.
6. *Brevitricolpites microechinatus* Jaramillo & Dilcher 2001. Sample 14 (Río Sogamoso section). Slide 55996(2). EF: N45/3

7-8.*Clavatricolpites densiclavatus* Jaramillo & Dilcher 2001 Polar view: Sample 2 (Río Sogamoso section). Slide 56058. EF: G41. Equatorial view: Sample 3 (Río Sogamoso section). Slide 55764 (1). EF: E54.

9.*Corsinipollenites psilatus* Jaramillo & Dilcher 2001. Sample 1 (Río Sogamoso section). Slide 56686. EF: H50.

10. Cyclusphaera scabrata Jaramillo & Dilcher 2001. Sample 17 (Río Sogamoso section). Slide 56024. EF: X38/3.
11. *Ephedripites vanegensis* Van der Hammen & García 1966. Sample 12 (Uribe section). Slide 57155. EF: Q53/1.
12. *Foveotricolpites perforatus* Van der Hammen & García 1966. Sample 18 (Uribe section). Slide 57245. EF: K41.
13. *Foveotriporites hammenii* González 1967. Sample 18 (Río Sogamoso section). Slide 56254(1). EF: V51/2.
14. *Luminidites colombianensis* Jaramillo & Dilcher 2001. Sample 19 (Río Sogamoso section). Slide 56265(1). EF: L36/2-4
15. *Lanagiopollis crassa* (Van der Hammen & Wymstra 1964) Frederiksen 1988. Sample 35 (Uribe section). Slide 57365. EF: V48.
16. *Monoporopollenites annulatus* (Van der Hammen 1954) Jaramillo & Dilcher 2001. Sample 11 (Río Sogamoso section). Slide 55963(1). EF: M40/2.
17. *Polypodiisporites* aff. *specious* SAH 1967. Sample 8 (Río Sogamoso section). Slide 55847(1). EF: N44.
18. *Retibrevitricolpites triangulatus* Van Hoeken-Klinkenberg 1966. Sample 15 (Río Sogamoso section). Slide 55996(2). EF: Q47/3
19. *Retidiporites magdalenensis* Van der Hammen & García 1966. Sample 8 (Uribe section). Slide 57109. EF: S52/1.
20. *Retitrescolpites magnus* (González 1967) Jaramillo & Dilcher 2001. Sample 2 (Río Sogamoso section). Slide 55711(1). EF: V56/2.
21. *Retitricolpites* cf. *simplex* González 1967. Sample 16 (Río Sogamoso section). Slide 56035(1). EF: J47.
22. *Spirosyncolpites spiralis* González 1967. Sample 6 (Río Sogamoso section). Slide 55803(1). EF: M59/3.
23. *Striatopollis catatumbus* (González 1967) Takahashi & Jux 1989. Sample 2 (Río Sogamoso section). Slide 56058. EF: R53/3-4.
24. *Tetracolporopollenites transversalis* Dueñas 1980. Sample 16 (Río Sogamoso section). Slide 56035(1). EF: H40/3.
25. *Zonocostites minor* Jaramillo & Dilcher 2001. Sample 10 (Río Sogamoso section). Slide 55939(2). EF: R56/3.

PLATE 1



LIST OF SPECIES MENTIONED IN THE TEXT

Note: the authors of each species are not included in the references.

Aglaoreidia? Foveolata Jaramillo & Dilcher 2001
Bacumorphomonocolpites tausae Sole De Porta 1971
Bombacacidites annae (Van der Hammen 1954) Germeraad *et al.* 1968.
Bombacacidites gonzalezii Jaramillo & Dilcher 200
Bombacacidites nacimientoensis (Anderson 1960) Elsik 1968
Bombacacidites protofoveoreticulatus Jaramillo & Dilcher 2001
Bombacacidites psilatus Jaramillo & Dilcher 2001
Bombacacidites soleaformis Muller et al. 1987
Brevitricolpites microechinatus Jaramillo & Dilcher 2001
Buttinia andreevi Boltenhagen 1967
Clavatricolpites densiclavatus Jaramillo & Dilcher 2001
Ctenolophonidites lisamae Van der Hammen & Garcia 1966
Colombipollis tropicalis Sarmiento 1992
Corsinipollenites psilatus Jaramillo & Dilcher 2001
Cricotriporites guianensis Leidelmeyer 1966
Crusafontites megagemmatus Jaramillo & Dilcher 2001
Cyclusphaera scabrata Jaramillo & Dilcher 2001
Dinogymnium acuminatum Evitt et al. 1967
Echiperiporites sp. Van der Hammen & Wijmstra 1964
Echitriporites trianguliformis Van Hoeken-Klinkenberg 1964
Echitriporites trianguliformis var. *Orbicularis* Jaramillo & Dilcher 2001
Ephedripites vanegensis van der hammen & García 1966
Foveotricolpites perforatus Van der hammen & García 1966
Foveotriletes margaritae (Van der Hammen 1954) Germeraad *et al.* 1968
Foveotriporites hammenii Gonzalez 1967
Gemmamonocolpites ovatus Gonzalez 1967
Gemmastephanocolpites gemmatus Van der Hammen & García 1966
Kuylisporites genus Potonie 1956.
Luminidites colombianensis Jaramillo & Dilcher 2001
Lanagiopollis crassa (Van der Hammen & Wymstra 1964) Frederiksen 1988
Mauritiidites franciscoi (Van der Hammen 1956) Van Hoeken-Klinkenberg 1964
Monoporopollenites annulatus (Van der Hammen 1954) Jaramillo & Dilcher 2001
Perfotricolpites digitatus González 1967
Polypodiisporites aff. *specious* Sah 1967
Proxapertites operculatus Van der Hammen 1956b
Proxapertites cursus Van Hoeken-Klinkenberg 1966
Racemonocolpites facilis González 1967
Ranunculacidites operculatus (Van der Hammen & Wymstra 1964) Jaramillo & Dilcher 2001
Retibrevitricolpites triangulatus Van Hoeken-Klinkenberg 1966
Retidiporites magdalenensis Van der Hammen & García 1966
Retimonocolpites longicolpatus Lorente 1986
Retimonocolpites retifossulatus Lorente 1986
Retistephanoporites minutiporus Jaramillo & Dilcher 2001
Retitrescolpites magnus (González 1967) Jaramillo & Dilcher 2001
Retitricolpites cf. *simplex* González 1967
Rhoiphites guianensis (Van der Hammen & Wymstra 1964) Jaramillo & Dilcher 2001
Rugutricolporites felix González 1967
Spinozonocolpites baculatus Muller 1968
Spinizonocolpites breviechinatus Jaramillo & Dilcher 2001
Spirosyncolpites spiralis González 1967
Striatopollis catatumbus (González 1967) Takahashi & Jux 1989
Tetracolporopollenites maculosus (Regali et al. 1974) Jaramillo & Dilcher 2001
Tetracolporopollenites transversalis Dueñas 1980
Ulmoideipites krempii (Anderson 1960) Elsik 1968
Zonocostites minor Jaramillo & Dilcher 2001