

PALYNOMORPHS FROM THE LATE CARBONIFEROUS CAÑO INDIO AND RÍO PALMAR FORMATIONS OF VENEZUELA

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ABSTRACT

Well preserved palynological assemblages have been recovered from reconnaissance samples from the thermally mature Caño Indio and Río Palmar formations which crop out in the Sierra de Perijá, Zulia State, northwestern Venezuela. They contain diverse terrestrial microfloras with subordinate marine phytoplankton (acritarchs), foraminiferal test linings and scolecodonts. The terrestrial component is dominated by Peri-gondwanan saccate pollen and camerate miospores. Other microfloral elements are of Euramerican aspect and provide the key to correlation with independently dated palynostratigraphies from North America and Europe. Assemblages from the Caño Indio Formation are comparable to assemblages from the Morrowan *Spelaeotriletes triangulus* Biozone of the Amazonas Basin and are similar to early Morrowan assemblages from Euramerica. Assemblages from the Río Palmar Formation are comparable to material from the Morrowan and Atokan *S. triangulus* and *Striatomonosaccites incrassatus* biozones of the Amazonas Basin, but are most closely comparable to assemblages from the (late Morrowan) upper part of the *S. rara* - *L. desmoinesensis* Biozone and the (early Atokan) lower part of the *M. nobilis* - *E. globiformis* Biozones of North America.

INTRODUCTION

Several inliers of Palaeozoic strata crop out in the Sierra de Perijá, Zulia State, northwestern Venezuela (Fig. 1a). The Palaeozoic stratigraphy of the area was described by Bowen (1972) and reinterpreted by G. Benedetto (1980), J.L. Benedetto (1984) and Berry (1993). In the area around the valley of Caño Colorado biostratigraphically constrained Late Carboniferous strata are represented by the Caño Indio and Río Palmar formations. These overlie the Campo Chico Formation which was considered by G. Benedetto (1980) and J.L. Benedetto (1984) to be of Devonian to Early Carboniferous age, and to be conformably overlain by the Caño Indio Formation. Although this view persists in the literature (see Rocha Campos 1998) the presence of the Late Devonian progymnosperm *Archaeopteris* (Berry and Edwards 1996, p. 106) and Frasnian miospore and acritarch assemblages (research in progress by C.H.) in the Upper Member of the Campo Chico Formation indicates the presence of a considerable stratigraphical gap between the top of the Campo Chico Formation and the base of the Caño Indio Formation (Fig. 2). The base of the Caño Indio Formation is marked by a 50m thick sequence of unfossiliferous quartzitic sandstones above which lies a 2m thick fossiliferous black limestone containing the Late Carboniferous foraminifera *Millerella* (G. Benedetto 1980). Above this the formation consists of a sequence of fossiliferous calcareous mudstones with interbedded sandstones and siltstones (Fig. 3). This interval provides diverse early Pennsylvanian marine macrofaunas (G. Benedetto 1980) which

are interpreted as Morrowan to earliest Atokan in age. Significantly, the brachiopod faunas (and associated miospore assemblages) described from the Caño del Noroeste Formation by Bowen (1972) and interpreted by him as Namurian-early Westphalian in age, were reassigned to the younger Caño Indio Formation by J.L. Benedetto (1984). The Río Palmar Formation conformably overlies the Caño Indio Formation and consists of fossiliferous, often oolitic, limestones with occasional interbedded fine sandstones and calcareous siltstones. A diverse marine fauna of *inter alia* brachiopods, bryozoa, foraminifera and corals is recorded (Bowen 1972, G. Benedetto 1980, Scrutton 1972).

Bowen (1972) and G. Benedetto (1980) provide extensive faunal lists, however, no palynological data from these Late Carboniferous sequences are present in the literature. Bowen (1972 pp. 746, 750) tantalisingly refers to the existence of palynofloral assemblages which suggest similar stratigraphical ages to those provided by the invertebrates. The current paper provides a reconnaissance of the palynology of the Caño Indio and Río Palmar formations, with a view to ascertaining the character and significance of the palynomorph assemblages.

MATERIAL AND METHODS

All palynological slide material is housed in the collection of the Centre for Palynology, University of Sheffield. Samples were taken from three localities (Fig. 2): (1) Grey-green, fine to medium sandstones with hematite staining at the base of the Caño Indio Formation where it outcrops in the stream bed of

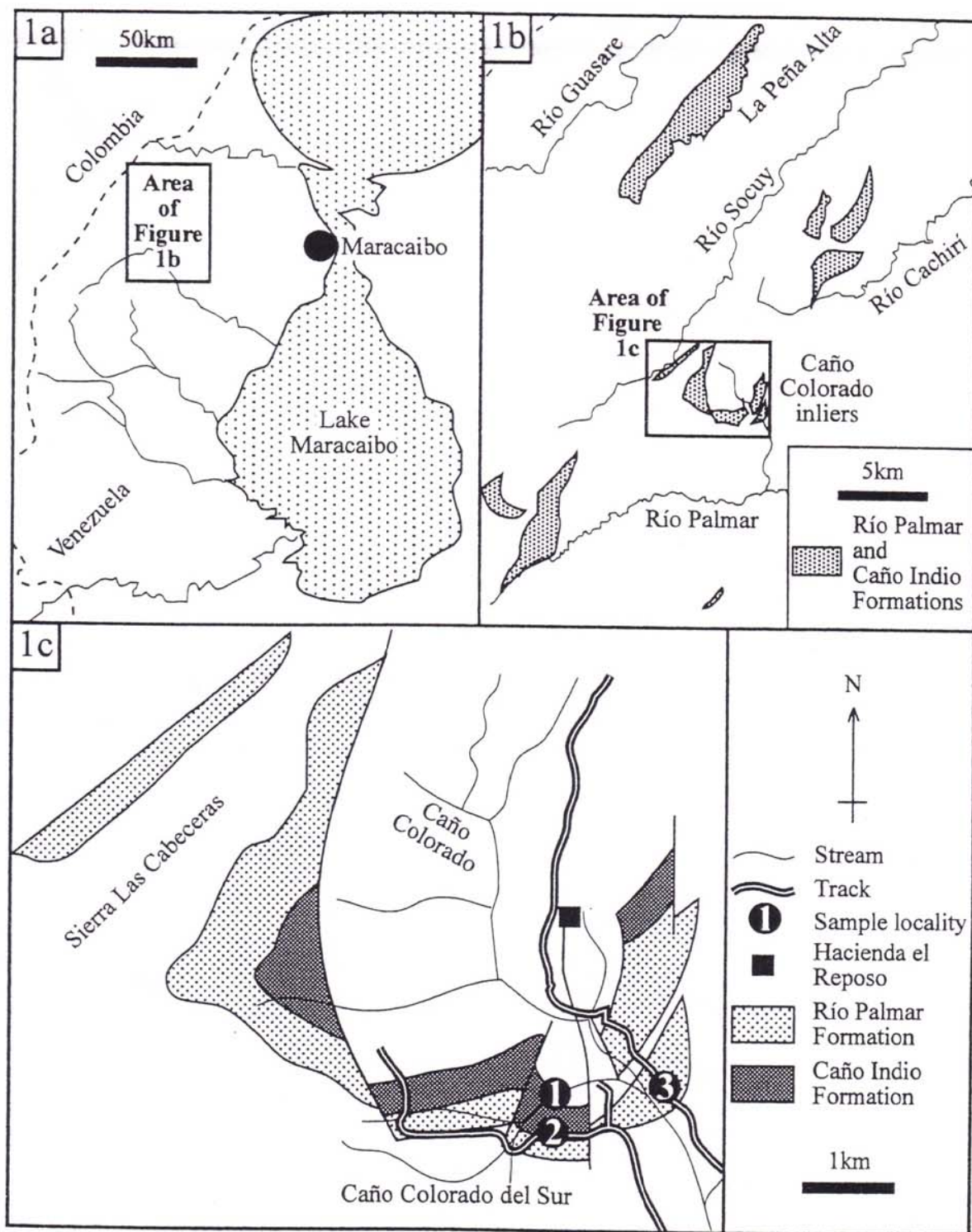


Figure 1. 1a. Geographical location of the study area; 1b. Location of the Caño Colorado Carboniferous outcrop; and 1c. Location of sampled sections in the Caño Colorado area.

the Caño Colorado del Sur. Palynological slide numbers ML2318/1-2; (2) Indurated, finely laminated, grey-green siltstones in the upper part of the Caño Indio Formation collected

from the outcrop at the side of the road to San José de Los Altos 0.7km from the track leading to the Caño Colorado del Sur and 2.8km from the junction with the road to Río Socuy.

Chronostratigraphy		Bowen (1972)	Benedetto (1980) Rocha Campos (1998)	Berry (1993)	This paper
Permian		"Palmarito" Fmn.	"Palmarito" Formation	"Palmarito" Formation	"Palmarito" Formation
	Pennsylvanian	Virgilian			
		Missourian			
		Desmoinesian			
		Atokan	Río Palmar Formation	Río Palmar Formation	Río Palmar Formation
Morrowan	Caño Indio Formation Caño del Noroeste Fmn.	Caño Indio Formation	Caño Indio Formation	Caño Indio Formation	
Mississippian	Chesterian				
	Meramecian				
	Osagean				
	Kinderhookian				
Devonian	Famennian				
	Frasnian	Campo Chico Formation		Campo Chico Fmn.	Upper Mbr.
	Givetian	Caño del Oeste Fmn.	Caño del Oeste Fmn.	Lower Mbr.	Lower Mbr.

Figure 2. Upper Paleozoic stratigraphy of the Sierra de Perijá, western Venezuela. The stratigraphy preferred here is essentially the same as that proposed by Bowen (1972) since J.L. Benedetto (1984) recognized his Caño del Noroeste Formation as being part of the Caño Indio Formation. There is no evidence for a pre-Pennsylvanian age for the lower part of the Caño Indio Formation as indicated by Berry (1993).

Palynological slide numbers ML2319/1-6; and (3) Indurated, blue-grey, calcareous mudstones in the lower part of the Río Palmar Formation collected from an outcrop on the side of the road to Río Socuy 2km from the junction with the road to San José de Los Altos. Palynological slide numbers ML2320/1-13.

In the absence of suitable information it is not possible to indicate how these localities relate stratigraphically to the horizons indicated by Bowen (1972).

Samples were demineralized using standard palynological techniques (Wood *et al.* 1996). Resultant insoluble organic residues contain well preserved, diverse and abundant miospores and acritarchs but these are of relatively high thermal maturity and appear opaque in transmitted light. Problems similar to those described by Marshall (1980) in the oxidation and mounting these palynomorphs were encountered. These were overcome by the application of oxidation and stable mounting techniques developed by Harvey (in press) for the preparation of mature Late Devonian palynomorphs of the Sierra de Perijá. All samples were weighed, prepared and logged quantitatively.

PRESENTATION OF RESULTS

The sample from the base of the Caño Indio Formation at locality 1 provided only 73 palynomorphs per gram. This is not surprising given its relatively coarse-grained lithology. The

material from locality 2 (Caño Indio Formation) provided relatively abundant (2970 palynomorphs per gram), diverse, well-preserved, thermally mature palynomorph assemblages which included spores and pollen, algae, acritarchs and scolecodonts. Assemblages from locality 3 (Río Palmar Formation) were similar and preserved in slightly greater abundance (7260 palynomorphs per gram). The distribution of taxa from the two formations is shown in Table 1.

Assemblages from the middle part of the Caño Indio Formation (locality 2) are dominated by fragments of saccate pollen (mainly *Plicatipollenites malabarensis* and *Potonieisporites* spp.) and by the miospore taxa *Apiculiretusispora* spp., *Calamospora* spp., *Deltoidospora* spp., *Knoxisporites stephanephorus*, *Lycospora pusilla*, *Punctatisporites* spp., *Retusotriletes* spp. and *Spelaeotriletes* sp.A.

Assemblages from the middle part of the Río Palmar Formation (locality 3) have similar dominant taxa to those from the Caño Indio Formation (fragmentary saccates plus *Apiculiretusispora* spp., *Calamospora* spp., *Hymenospora* sp. cf. *H. caperata*, *Punctatisporites* spp. and *Spelaeotriletes* sp. A), but have a more diverse accessory assemblage. Dominant taxa include saccate pollen taxa, notably *Plicatipollenites malabarensis* and a complex of forms of *Potonieisporites* spp. The latter are comparable to species described by Gutierrez (1993)

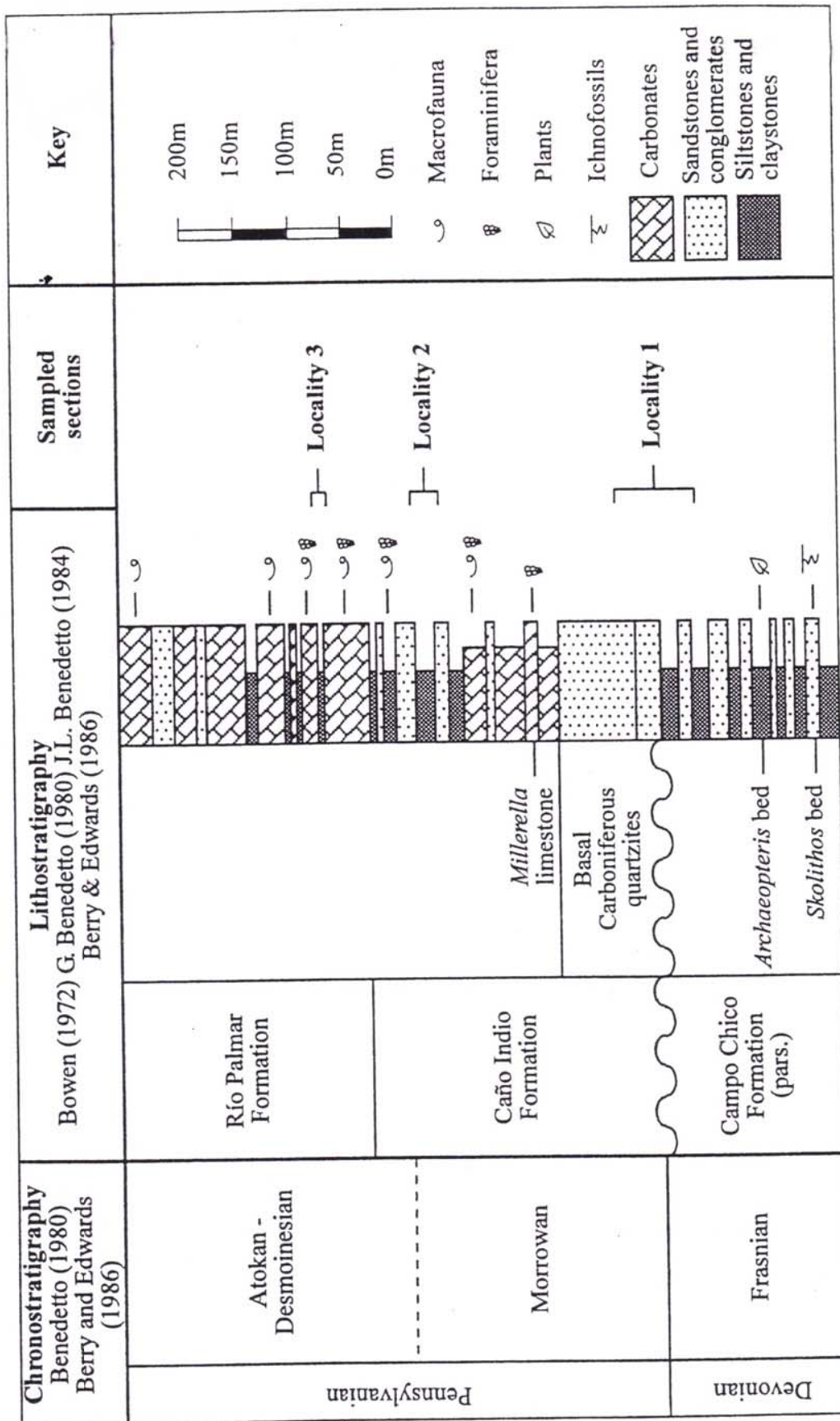


Figure 3. Composite stratigraphical section of the Carboniferous of the Caño Colorado Carboniferous outcrops and stratigraphical location of sampled sections.

	Caño Indio Formation	Río Palmar Formation
Spores and Pollen		
<i>Apiculatasporites aculeatus</i> (Ibrahim) Ravn 1986	.	
<i>Apiculiretusispora</i> sp. A	.	.
<i>Aurorasora</i> sp. cf. <i>A. macra</i> Sullivan 1968	.	.
<i>Auroraspora solisortus</i> Hoffmeister <i>et al.</i> 1955	.	
<i>Auroraspora velata</i> (Felix and Burbridge) Ravn 1991	.	
<i>Calamospora</i> spp.	.	.
<i>Cannanaropollis janakii</i> Potonié and Sah 1958	.	
<i>Cirratriradites</i> sp. cf. <i>C. rarus</i> (Ibrahim) Schopf <i>et al.</i> 1944	.	.
<i>Colatisporites</i> sp. A	.	
<i>Convolutispora flexuosa</i> Hacquebard 1957	.	.
<i>Convolutispora mellita</i> Hoffmeister <i>et al.</i> 1955	.	.
<i>Convolutispora vermiformis</i> Hughes and Playford 1961	.	.
<i>Corrugitriteles radiatus</i> Turner and Spinner 1992	.	
<i>Cristatisporites</i> sp. cf. <i>C. menendezii</i> (Menéndez and Azcuy) Playford 1978	.	
<i>Cyclogranisporites</i> spp.	.	
<i>Cymbosporites hormiscoides</i> Balme 1988*	.	.
<i>Deltoidospora</i> spp.	.	.
<i>Densosporites pseudoannulatus</i> Butterworth and Williams 1958	.	.
<i>Discernisporites irregularis</i> Neves 1958	.	
<i>Discernisporites micromanifestus</i> (Hacquebard) Sabry and Neves 1971	.	
<i>Endosporites zonalis</i> (Loose) Knox 1950	.	
<i>Florinites</i> sp. cf. <i>F. volans</i> (Loose) Potonié and Kremp 1956	.	.
<i>Florinites</i> spp.	.	
<i>Grandispora</i> spp.*	.	
<i>Granulatisporites granulatus</i> Ibrahim 1933	.	.
<i>Granulatisporites microgranifer</i> Ibrahim 1933	.	.
<i>Hymenospora</i> sp. cf. <i>H. cuperata</i> Felix and Burbridge 1967	.	.
<i>Knoxisporites stephanephorus</i> Love 1960	.	.
<i>Kraeuselisporites</i> sp. cf. <i>K. ornatus</i> (Neves) Owens <i>et al.</i> 1966	.	.
<i>Kraeuselisporites</i> sp. cf. <i>K. volkheimerii</i> Azcuy 1975	.	
<i>Laevigatosporites desmoinesensis</i> (Wilson and Coe) Schopf <i>et al.</i> 1944	.	.
<i>Laevigatosporites minor</i> Loose 1934	.	
<i>Limitisporites</i> sp. cf. <i>L. diversus</i> Lele and Karim 1971	.	
<i>Limitisporites</i> sp. cf. <i>L. rectus</i> Leschik 1956	.	
<i>Lophotriletes granoornatus</i> Artüz 1957	.	.
<i>Lophotriletes</i> spp.	.	.
<i>Lycospora noctuina</i> Butterworth and Williams emend. Smith and Butterworth 1967	.	.
<i>Lycospora orbicula</i> (Potonié and Kremp) Smith and Butterworth 1967	.	.
<i>Lycospora pusilla</i> (Ibrahim) Schopf <i>et al.</i> 1944	.	.
<i>Microreticulatisporites concavus</i> Butterworth and Williams 1958	.	.
<i>Plicatipollenites malabarensis</i> (Potonié and Sah) Foster 1975	.	.
<i>Potonieisporites</i> spp.	.	.
<i>Protohaploxypinus</i> sp.	.	.
<i>Punctatisporites</i> spp.	.	.
<i>Punctatisporites granifer</i> Potonié and Kremp emend. Alpern and Doubinger 1973	.	.
<i>Raistrickia</i> sp. cf. <i>R. fulva</i> Artüz 1957	.	.
<i>Retusotriletes</i> spp.	.	.
<i>Spelaeotriletes</i> sp. A	.	.
<i>Spelaeotriletes arenaceus</i> Neves and Owens 1966	.	.
<i>Stenozonotriletes</i> sp.	.	.

Table 1. Distribution of palynomorphs. Taxa marked with an asterisk are or may be reworked from older strata.

<i>triquitrites</i> sp. cf. <i>T. tribullatus</i> (Ibrahim) Schopf <i>et al.</i> 1944			
<i>Verrucosporites</i> sp. cf. <i>V. cerosus</i> (Hoffmeister <i>et al.</i>) Butt. and Williams 1958			•
<i>Waltzispora</i> sp. cf. <i>W. sagittata</i> Playford 1962			•
Algae			
<i>Biannulatisphaerites simplex</i> Neville in Neves <i>et al.</i> 1973			•
<i>Pterospermella</i> sp.			
Acritarchs			
<i>Cymatiosphaera</i> sp.*		•	
<i>Diexallophasis</i> spp.*		•	•
<i>Elektoriskos</i> sp.*		•	
<i>Gorgonisphaeridium</i> spp.*		•	
<i>Leiosphaeridia</i> sp.		•	
<i>Lophosphaeridium</i> spp.*		•	•
<i>Micrhystridium</i> spp.*		•	
<i>Multiplicisphaeridium</i> sp.*		•	
<i>Navifusa</i> spp.*		•	
<i>Tylotopalla</i> sp.*		•	
<i>Veryachium</i> sp.*		•	
<i>Veryachium trispinosum</i> (Eisenack) Stockmans and Willièrè 1962*		•	
<i>Villosacapsula</i> spp.*		•	
Other palynomorphs			
Chitinozoa*			•
fish remains		•	•
foraminiferal test linings		•	•
scolecodonts		•	

Table 1. continued.

but are here not speciated as they provide a plexus of integrading morphological forms. Non-dominant but common taxa include monosaccate and bisaccate pollen (*Florinites* spp., *Limitisporites* sp. cf. *L. rectus*) and trilete miospores (*Auroraspora macra*, *Colatisporites* sp.A, *Deltoidospora* spp., *Lophotriletes* spp., *Lycospora pusilla* and *Spelaeotriletes* spp. Rare acid-resistant remains of marine microorganisms also occur. These include acritarchs (Pl. 1, figs. 16-18), scolecodonts (Pl. 1, fig. 15) and foraminiferal test-linings (Pl. 1, figs. 13, 14). Of these the acritarchs and scolecodonts predominate. The acritarchs are of low diversity and are restricted to morphologically simple forms. Their colour and translucency under transmitted light is generally like that of the miospores and pollen although several specimens are conspicuously darker and almost opaque.

DISCUSSION

NATURE OF THE MARINE MICROFOSSILS

Although the diverse marine macro- and microfaunas in the Caño Indio and Río Palmar formations (G. Benedetto 1980, J.L. Benedetto 1984) are undoubtedly of Late Carboniferous age it is not certain that this is true of the marine microflora.

Acritarchs are rare, with the assemblages consisting of simple, relatively long-ranging genera, which are typical of the Devonian and which, furthermore, are similar to assemblages recovered from the Frasnian Campo Chico Formation (in progress research, C.H.). There are few records of acritarchs from Late Carboniferous strata (e.g. Stockmans and Willièrè 1962, Spode 1964) and it is not certain that those which are recorded are not reworked from older deposits. Certainly Late Carboniferous records of acritarchs from the UK Pennine Basin and Midland Valley Basin (McLean 1995b, McLean and Chisholm 1996, Riordan *et al.* 1998), the South Limburg Basin of the Netherlands (Bless and Streel 1976, Van de Laar and Fermont 1989), the Amazonas Basin of Brazil (Dino and Playford 1998, Playford and Dino 2000) and the Tarija Basin of Argentina (di Pasquo and Azcuy 1997b) represent reworked assemblages. The presence of the miospore taxon *Cymbosporites hormiscoides* and several as yet unassigned species of *Grandispora* indicate the presence of reworked material in the Río Palmar Formation. These specimens are again similar to ones recovered from the Frasnian Campo Chico Formation (research in progress by one of us, C.H.) suggesting that Late Devonian sediments provided source material for the Late Carboniferous clastic strata in the Sierra de Perijá.

Other than a few Carboniferous occurrences (Wilson and Clarke 1960, Tasch and Hutter 1978, Massa et al. 1979) which probably represent reworking, chitinozoa are not known from post-Devonian sequences (Miller 1996). It seems likely that the single chitinozoan recorded here from the Río Palmar Formation is reworked from the Devonian. Foraminiferal test linings have not previously been recorded from the Carboniferous (Stancliffe 1996) but are known from the Devonian (Bell and Winchester-Seeto 1999). Their occurrence in association with documented foraminifera may suggest that they are contemporaneous in the Late Carboniferous of Venezuela, not reworked. Scolecodonts and fish-debris are well-known in palynological preparations of Carboniferous material and could also be contemporaneous.

PALEOGEOGRAPHY

Paleogeographical reconstructions place Venezuela 10-20°S of the Late Carboniferous paleoequator (Scotese and McKerrow 1990), although it is possible that the Palaeozoic rocks of the Sierra de Perijá represent part of an allochthonous terrain (the "East Andean Terrane" of Restrepo and Toussaint 1988) which underwent post-Palaeozoic strike-slip lateral accretion. In this latter case, the Carboniferous sequences of the Sierra de Perijá were deposited closer to the paleoequator, some distance to the northeast. Consequently the area should be expected to belong to the Late Carboniferous phytogeographic-paleoclimatic Equatorial Belt of Wagner (1984) but the absence of terrestrial facies precludes it from the Euramerican Coal province as defined by Calder and Gibling (1994). Overall facies and paleogeographic position indicate a similarity to the southern paleotropical region which extended as a belt to include depositional basins in North Africa, Cantabria and northern Saudi Arabia.

Palynological assemblages recovered from the Sierra de Perijá have similarities to coeval assemblages described from both the Equatorial Belt and peri-Gondwanan basins to the south. In particular, they are comparable to assemblages from the southern Midcontinent United States and to the Amazonas Basin of northeastern Brazil. Of significance is the dominance of the assemblages by (albeit fragmented) saccate genera of Gondwanan or peri-Gondwanan aspect (*Limitisporites* spp., *Plicatipollenites malabarensis*, *Potoniesporites* spp. complex) whereas the accessory taxa include many forms more typical of Euramerica with rare Gondwanan forms (Table 1). Many "Euramerican" species (e.g. *Cirratriradites rarus*, *Endosporites globiformis*, *Lycospora pusilla*, *Spelaeotriletes arenaceus*) have long been known from the peri-Gondwanan areas of North Africa and the Middle East (Owens and Turner 1995), and recent research extends the known geographical occurrences of many such taxa into the Gondwanan province (e.g. *Endosporites globiformis*, *E. zonalis*, *Laevigatosporites desmoinesensis* and *Spelaeotriletes arenaceus* in the Amazonas Basin (Dino and Playford 1998, Playford and Dino 2000); *E. zonalis*, *L. desmoinesensis*, *Propriisporites laevigatus*, *Reticulatisporites reticulatus* and *R. polygonalis* in the Tarija

Basin (Di Pasquo and Azcuy 1997a). Conversely, *P. malabarensis* has been recorded from Westphalian strata as far north as Atlantic Canada (G. Dolby, pers comm. August, 1999). Such records suggest that some stratigraphically significant taxa are common to Euramerica and Gondwana. These may provide the key to Euramerican-Gondwanan palynostratigraphical correlations. In this, the significance of shallow-marine basins which lie marginal to the Euramerican Coal Province and Gondwanaland will become apparent, particularly, as in the example of the western Venezuelan basin, where the stratigraphy has independent faunal control.

AGE OF THE CAÑO INDIO FORMATION SPORE AND POLLEN ASSEMBLAGES

The overall palynological assemblage composition from the Caño Indio Formation suggests correlation with the Morrowan *Spelaeotriletes triangulus* Biozone in the Amazonas Basin. Assemblages from this biozone are characterised by the presence of common *Plicatipollenites* spp., *Potoniesporites* spp., *Spelaeotriletes* spp. (including *S. arenaceus*) with rare monolete spores (*Laevigatosporites* spp.) and rare taeniate bisaccates (Playford and Dino 2000). Similarly, the co-occurrence of *Biannulatisphaerites simplex*, *Florinites volans*, *Knoxisporites stephanephorus*, *Kraeuselisporites ornatus*, *Laevigatosporites minor*, *Lycospora noctuina*, *Microreticulatisporites concavus* and *Waltzisporea sagittata* suggest correlation with late Namurian to earliest Westphalian strata of western Europe. This interval correlates to the mid to early Morrowan (Peppers 1984, 1996).

AGE OF THE RÍO PALMAR FORMATION SPORE AND POLLEN ASSEMBLAGES

The occurrences of *Endosporites zonalis*, *Laevigatosporites desmoinesensis* and *Lycospora noctuina* in assemblages from the Río Palmar Formation suggest correlation with the latest Morrowan to earliest Atokan coals of North America (Peppers 1984, 1996). The presence of *Punctatosporites granifer* - *P. rotunda* would suggest correlation with slightly younger, late Atokan or younger strata. The same taxa (excluding *P. granifer* - *rotunda*) suggest correlation with mid Langsettian to late Duckmantian strata of Europe (Clayton et al. 1977). In this case the co-occurrence of *Corrugitriletes radiatus*, *Discernisporites irregularis*, *Spelaeotriletes arenaceus* and *Auroraspora solisortus* suggests correlation with the mid to late Langsettian (McLean 1995a) although, again, the presence of *P. granifer* - *rotundus* would suggest correlation with younger (Bolsovian) strata. On balance, assemblages from the Río Palmar Formation are most closely comparable to assemblages from the upper part of the *S. rara* - *L. desmoinesensis* (SR) Biozone to the lower part of the *M. nobilis* - *E. globiformis* (NG) Biozone in the Illinois Basin, and from the *Radiizonates aligerens* (RA) or lower part of the *M. nobilis* - *Florinites junior* (NJ) Biozone of western Europe (Fig. 4). The overall palynological assemblage composition suggests correlation with the Morrowan to Atokan *Spelaeotriletes triangulus*

Series	Illinois Basin Peppers (1984)	Western Europe Clayton et al. (1977)	Amazonas Basin Playford and Dino (2000)	Western Libya Massa et al. (1979)	Northeastern Libya Loboziak and Clayton (1988)	Series
Virgilian	TT <i>Thymospora thysenii</i>	NBM <i>P. novicus</i> - <i>P. bhardwaji</i> - <i>C. major</i>	? ? ?		SI <i>S. indicus</i> - <i>P. goraiensis</i>	Gzhelian
	EM <i>S. exiguus</i> - <i>L. minutus</i>	ST <i>A. splendidus</i> - <i>L. trileta</i>				Kasimovian
Missourian	MO <i>P. minutus</i> - <i>C. obliquus</i>					
Desmoinesian	GM <i>L. granulata</i> - <i>G. medius</i>	OT <i>T. obscura</i> - <i>T. thiessenii</i>			MJ <i>P. malabarensis</i> - <i>C. janakii</i>	Moscovian
	PC <i>S. colchesterensis</i> - <i>T. pseudothiessenii</i>		<i>Raistrickia cephalata</i>			
	MI <i>C. magna</i> - <i>M. inusitatus</i>		<i>Striatosporites heyleri</i>			
Atokan	RD <i>R. difformis</i>	SL <i>T. securis</i> - <i>T. laevigata</i>	<i>Illinites unicus</i>			
	SF <i>T. securis</i> - <i>V. fenestrata</i>		<i>Striatomonosaccites incrassatus</i>	XVII		
Morrowan	NG <i>M. nobilis</i> - <i>E. globiformis</i>	NJ <i>M. nobilis</i> - <i>F. junior</i>	<i>Spelaotriletes triangulus</i>	? ? ?		Bashkirian
	SR <i>S. rara</i> - <i>L. desmoinesensis</i>	RA <i>R. aligerens</i>				
	LP <i>L. pellucida</i>	SS <i>C. saturni</i> - <i>T. sinani</i>				
		FR <i>R. fulva</i> - <i>R. reticulatus</i>		XVI		
		KV <i>C. kosankei</i> - <i>G. varioreticulatus</i>				

Figure 4. Correlation of palynomorph assemblages from the Río Palmar Formation with Biozones of North America, Europe, northern Brazil and Libya. Grey shaded areas indicate Biozones or parts of Biozones to which the Venezuelan assemblages are most closely comparable. No vertical scale implied.

and *Striatomonosaccites incrassatus* Biozones of the Amazonas Basin. Assemblages from these zones are characterised by the presence of common *Plicatipollenites* spp., *Potonieisporites* spp., *Spelaotriletes* spp. and non-taeniate bisaccates (*Limitisporites* spp., etc.) with *Laevigatosporites desmoinesensis* and rare taeniate bisaccates (Playford and Dino 2000).

The occurrence of rare striate bisaccates with *Spelaotriletes arenaceus* and *Punctatosporites granifer* suggests correlation with the Moscovian (and younger?) Biozone XVII of Massa et al. (1979) although the absence of *Torispora securis* may indicate that the Venezuelan assemblages are older. Correlation with northeastern Libya is difficult. The dominance of saccate taxa with only rare striate bisaccates suggests correlation with the upper (Moscovian) part of the *Plicatipollenites malabarensis* - *Cannanoropollis janakii* (MJ) Biozone of Loboziak and Clayton (1988). However, the description of taxa from the MJ and underlying (Serpukhovian) *Prolycospora rugulosa* - *Spelaotriletes triangulus* (RT) Biozones suggests that late Serpukhovian to early Moscovian strata are not represented in the zonation of Loboziak and Clayton (1988). In other parts of Libya (Massa et al. 1979) the first stratigraphical appearance of saccate pollen is much older (basal Bashkirian) than the Moscovian as suggested for northeastern Libya. It is possible that coeval strata to those sampled in the Río Palmar Formation are not present in northeastern Libya.

CONCLUSIONS

The Frasnian Campo Chico Formation is overlain by the Caño Indio Formation which provided palynological assemblages of early Morrowan age. This indicates the presence of a significant stratigraphical gap between the two formations. Palynological assemblages from the Río Palmar Formation are of late Morrowan to early Atokan age. These interpretations are in agreement with the biostratigraphical determinations of G. Benedetto (1980) made using foraminifera and marine macrofauna. The presence of assemblages dominated by taxa of Gondwanan and peri-Gondwanan aspect but with accessory taxa more characteristic of Euramerica suggests that the Sierra de Perijá sequences may provide a stepping-stone for Euramerican to Gondwanan correlations. The fact that these sequences have independent age control only adds to their potential.

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PLATE 1

(next page)

Representative palynomorphs from the Carboniferous of the Caño Colorado del Sur Carboniferous outcrops. All figured specimens are x500 and are identified by slide number and England Finder reference.

1. *Lycospora pusilla*. Río Palmar Formation, ML2320/4, W47. Diameter 35µm.
2. *Lycospora noctuina*. Río Palmar Formation, ML2320/5, K36.1. Diameter 34µm.
3. *Punctatosporites granifer*. Río Palmar Formation, ML2320/7, K42. Length 28µm.
4. *Laevigatosporites desmoinesensis*. Río Palmar Formation, ML2320/1, X31.4. Length 43µm.
5. *Corrugitriteles radiatus*. Río Palmar Formation, ML2320/8, O30.4. Diameter 46µm.
6. *Endosporites zonalis*. Río Palmar Formation, ML2320/1, V37.1. Diameter 65µm.
7. *Limitisporites* sp. cf. *L. diversus*. Río Palmar Formation, ML2320/1, N40.2. Length 81µm.
8. *Limitisporites* sp. Río Palmar Formation, ML2320/10, G26.2. Length 85µm.
9. *Plicatipollenites malabarensis*. Río Palmar Formation, ML2320/11, M47.2. Diameter 76µm.
10. *Florinites volans*. Río Palmar Formation, ML2320/3, T30. Length 117µm.
11. *Plicatipollenites malabarensis*. Caño Indio Formation, ML2319/2, X35. Diameter 99µm.
12. *Biannulatisphaerites simplex*. Caño Indio Formation, ML2319/4, F29. Diameter 35µm.
13. Foraminiferal test lining. Río Palmar Formation, ML2320/12, C44.3. Length 60µm.
14. Foraminiferal test lining. Río Palmar Formation, ML2320/3, T22.2. Length 51µm.
15. Scolecodont. Caño Indio Formation, ML2319/4, S52.4. Length 53µm.
16. *Micrhystridium* sp. Río Palmar Formation, ML2320/12, O26. Diameter 37µm.
17. *Villosacapsula* sp. Río Palmar Formation, ML2320/9, M36.1. Length 47µm.
18. *Navifusa* sp. Río Palmar Formation, ML2320/13, J38.4. Length 105µm.
19. Chitinozoan. Caño Indio Formation, ML2319/6, V21.1. Length 104µm.

