

Lower Devonian palynomorphs from the Barrancos region, Ossa Morena Zone, Portugal

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ABSTRACT – The stratigraphic succession of the Barrancos region has been considered as a reference for understanding the Palaeozoic geology of the Ossa Morena Zone. The succession consists of: Cambrian to Ordovician terrigenous sediments; a black shale/lidite interval of Silurian age; a thin-bedded carbonate unit of Early Devonian age; and a poorly dated flysch interval. Palynological study reveals the presence of Lower Devonian spores in three distinct lithostratigraphic units ("Xistos Raiados", Russianas, and Terena Formations). Acritarchs and chitinozoans are also present. The palynological data enable refinement of previous age determinations based on macrofossils and are fundamentally important in structural and palaeogeographic syntheses.

RIASSUNTO – [Palinomorfi del Devoniano Inferiore della regione Barrancos, Zona Ossa Morena, Portogallo] – La successione stratigrafica della regione Barrancos è stata considerata come un riferimento per comprendere le geologie del Paleozoico della Zona Ossa Morena. La successione è composta da sedimenti terrigeni del Cambriano e dell'Ordoviciano, seguiti da un intervallo a "black-shale" e liditi del Siluriano, da un episodio a carbonati sottilmente stratificati del Devoniano Inferiore ed infine da un flysch di età incerta. Recenti ricerche palinologiche hanno rivelato la presenza di spore del Devoniano inferiore, in tre distinte unità litostratigrafiche (Formazioni "Xistos Raiados", Russianas e Terena). Sono presenti anche acritarchi e chitinozoi. Questi risultati aiutano a precisare meglio le precedenti datazioni basate su macrofossili e si sono rivelate di fondamentale importanza per le ricostruzioni strutturali e paleogeografiche.

INTRODUCTION

The stratigraphic succession of the Barrancos region, Portugal, has traditionally been considered as fundamental to understanding the Palaeozoic geology of the Ossa Morena Zone (OMZ), Iberian Meseta (Text-fig. 1). The lithostratigraphic sequence of the Barrancos area were first established by Delgado (1908) and later modified by Perdigão *et al.* (1982) and Oliveira *et al.* (1991). These authors defined a succession of Upper Cambrian to upper Ordovician terrigenous sediments, a black shale/lidite interval of Silurian age, a thin-bedded silty/shale carbonate unit of Early Devonian age, and a poorly dated flysch interval. The aim of the present work is to investigate the palynological content of the "Xistos Raiados", Russianas, and Terena Formations in the upper part of the sequence (Text-fig. 2).

The "Xistos Raiados" Formation is characterized by alternating dark shales and psammites with interbedded fine quartzitic layers. This unit was traditionally dated as Wenlock-early Ludlow (Delgado, 1908; Perdigão *et al.*, 1982). More recently, however, an age range of Late Silurian (Ludlow-Pridoli) to Early Devonian has been favoured (Oliveira *et al.*, 1991; Oliveira *et al.*, 1993; Piçarra *et al.*, 1998a).

The Russianas Formation is composed of shales, psammites, and calcareous siltstones. The calcareous siltstones contain profuse crinoids and bryozoans of questionable Lochkovian age. The shales contain

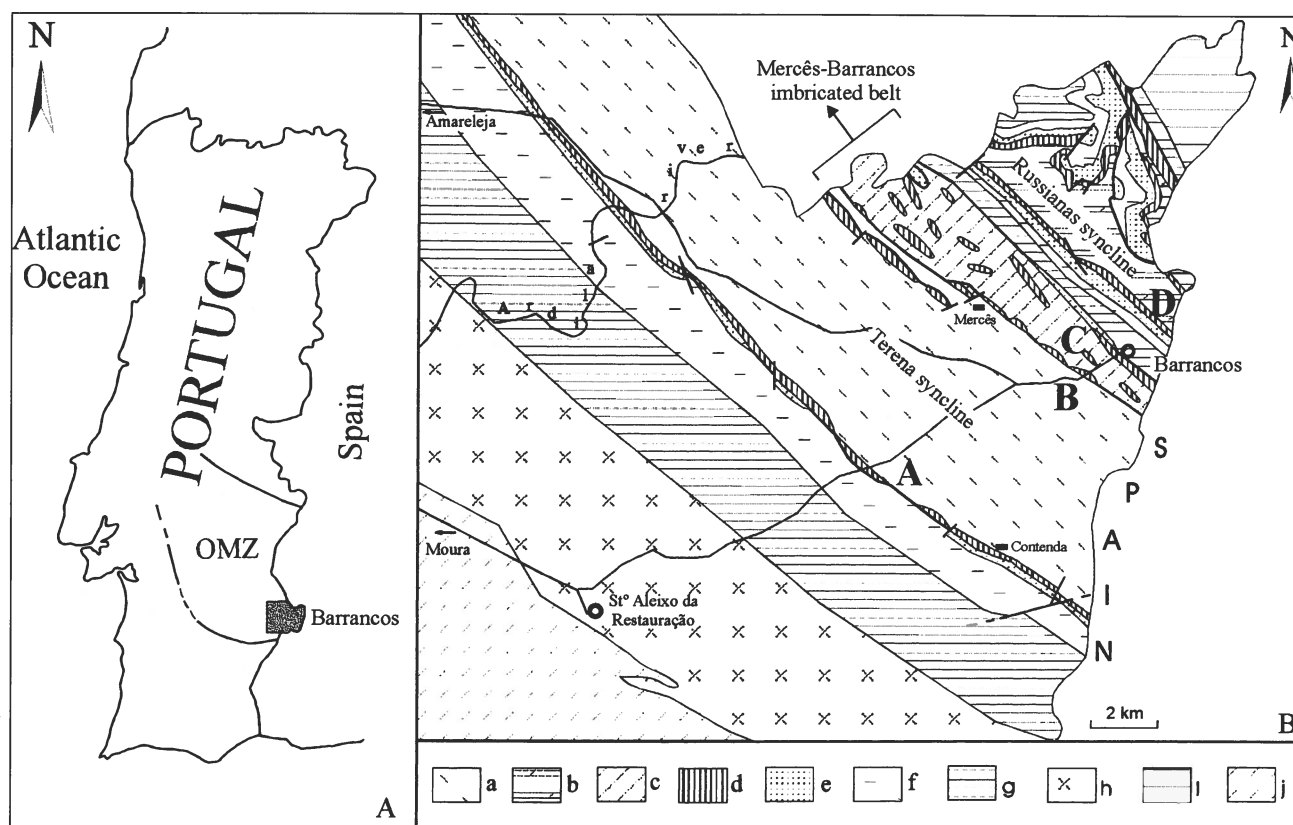
trilobites, brachiopods, and bivalves of Pragian-Emsian age (Perdigão *et al.*, 1982).

The Terena Formation is a turbiditic sequence of pelites and greywackes with some conglomeratic intercalations. This unit was dated by Teixeira (1951) as Early Devonian on the basis of plant remains. More recently, it has been regarded as Late Devonian-Early Carboniferous, and considered as closing a first Variscan orogenic episode of Middle Devonian age (Schermerhorn, 1971; Perdigão *et al.*, 1982; Ribeiro *et al.*, 1990). However, Piçarra's (1998) identification of graptolites of the Lochkovian *Monograptus hercynicus* graptolite Zone in the formation's lowermost levels confirmed the Early Devonian dating.

PALYNOLOGY

The 109 samples constituting the basis of this study were collected from the main road cuts and outcrops of the Barrancos region (Text-fig.1B). Standard palynological laboratory procedures were employed in the extraction and concentration of the palynomorphs from the host sediments. The slides were examined with transmitted light, per Olympus BX40 microscope equipped with automatic 35 mm camera facility. All samples, residues, and slides are stored in the "Instituto Geológico e Mineiro", S. Mamede Infesta, Portugal.

Ranges of selected taxa recovered are shown in Text-fig. 3. Stratigraphically important and character-



Text-fig. 1 - A = Locality map of Ossa Morena Zone (OMZ) and Barrancos region, Portugal. B = Geological sketch map of Barrancos region, indicating main sectors (A-D) from which palynological samples were collected. Key to lithostratigraphic units: a) Terena Fm. (Lochkovian-Emsian); b) Russianas Fm. (Pragian); c) "Xistos Raiados" Fm. (Pragian-Emsian); d) "Xistos com Nódulos" Formation (Silurian); e) Colorada Formation (Ordovician); f) "Xistos com *Phyllocytes*" Fm. (Ordovician); g) Barrancos Fm. (Ordovician); h) Ossa Fm. (Ordovician); i) Fatuquedo Fm. (Middle-Upper Cambrian); j) Palaeozoic (undifferentiated).

istic taxa are illustrated in Plate 1. The Lower Devonian spore biozones defined by Richardson & McGregor (1986), complemented by the scheme advanced by Streel *et al.* (1987), is adopted herein.

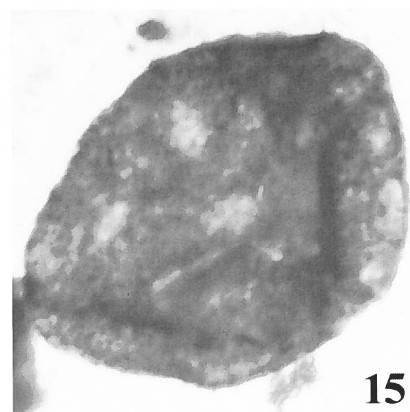
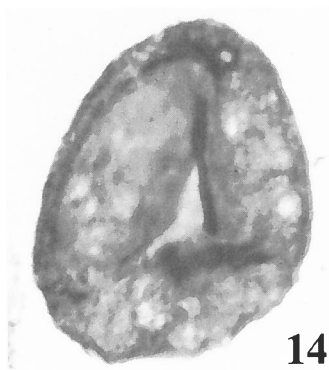
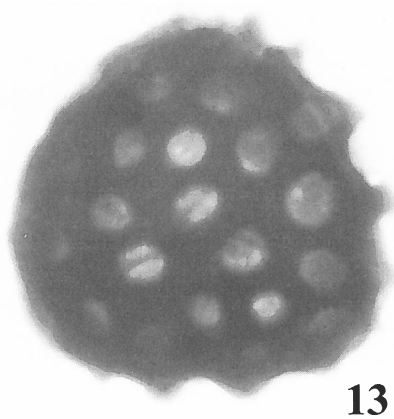
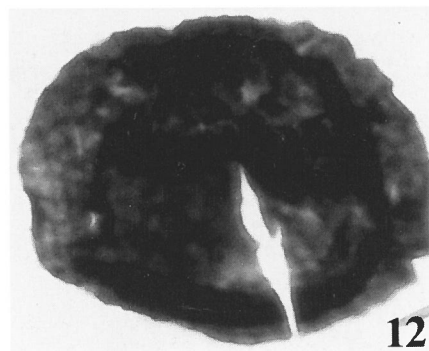
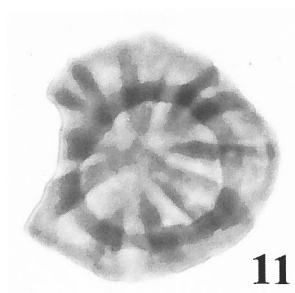
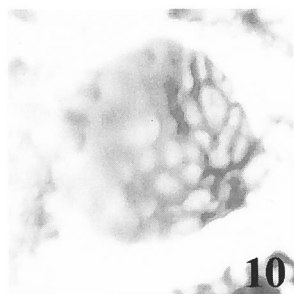
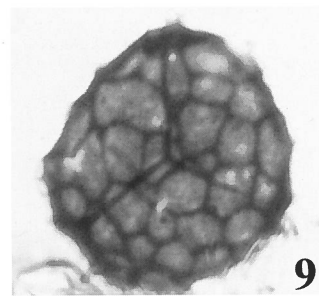
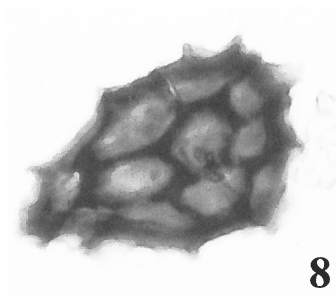
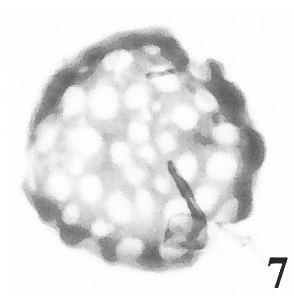
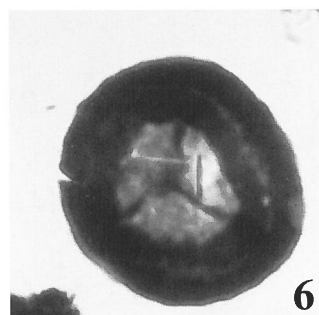
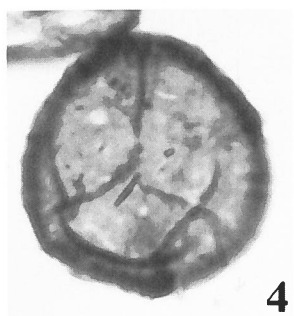
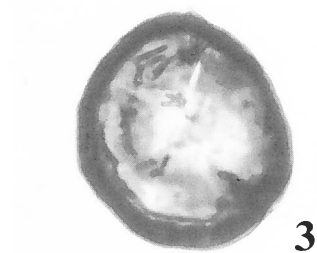
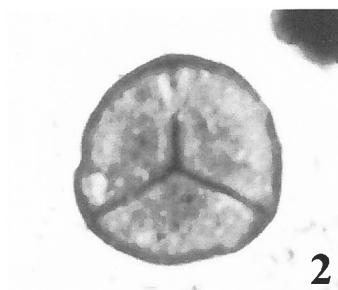
The *Verrucosiporites polygonalis*-*Dictyotriletes emsiensis* (PE) and *Emphanisporites annulatus*-*Camarozonotriletes sextantii* (AS) zones of Richardson & McGregor (1986) were used owing to lack of the

EXPLANATION OF PLATE 1

Each specimen is referenced by collection number, sample number, slide number, and England Finder (EF) coordinates.

- Fig. 1 - *Ambitisporites* sp. B of Moreau Benoit, 1976. IGM 9891; sample 56,1; slide 1, EF N16/4.
- Fig. 2 - *Retusotriletes warringtonii* Richardson & Lister, 1969. IGM 9892; sample 32, 2; slide 3, EF P29/2.
- Fig. 3 - *Archaeozonotriletes chulus* (Cramer) Richardson & Lister, 1969. IGM 9893; sample 32, 2; slide 3, EF T34/0.
- Fig. 4 - *Emphanisporites protophanus* Richardson & Ioannides, 1973. IGM 9894; sample 35,2; slide 2, EF F31/4.
- Fig. 5 - *Emphanisporites micromatus* Richardson & Lister, 1969. IGM 9895; sample 32,1; slide 1, EF H18/2.
- Fig. 6 - *Amicosporites streelii* Steemans, 1989. IGM 9896; sample 35,2; slide 2, EF K13/4..
- Fig. 7 - *Brochotriletes* sp. IGM 9897; sample 35,2; slide 2, EF U7/0.
- Fig. 8 - *Dictyotriletes emsiensis* (Allen) McGregor, 1973. IGM 9898; sample 76,1; slide 1, EF N9/3.
- Fig. 9 - *Dictyotriletes subgranifer* McGregor, 1973. IGM 9899; sample 32,2; slide 3, EF U46/0.
- Fig. 10 - *Dictyotriletes gorgoneus* Cramer, 1967. IGM 98100; sample 172,1; slide 4, EF H18/3.
- Fig. 11 - *Emphanisporites annulatus* McGregor, 1961. IGM 98101; sample 64,2; slide 3, EF O33/2.
- Fig. 12 - *Dictyotriletes canadiensis* McGregor, 1973. IGM 98102; sample 35,2; slide 3, EF F37/0.
- Fig. 13 - *Brochotriletes foveolatus* Naumova, 1953. IGM 98103; sample 70,1; slide 3, EF W10/2.
- Fig. 14 - *Apiculiretusispora brandtii* Streel, 1964. IGM 98104; sample 172,1; slide 6, EF H43/0.
- Fig. 15 - *Apiculatasporites microconus* (Richardson) McGregor & Camfield, 1982. IGM 98105; sample 172,1; slide 6, EF B22/0.

All figures x400.



CRON.		Richardson <i>et al.</i> , 1986	Streel <i>et al.</i> , 1987	BARRANCOS MAIN SECTORS			
				A	B	C	D
				TERENA SYNCLINE		MERCÊS-BARRANCOS	RUSSIANAS SYNCLINE
				SW	NE	IMBRICATED BELT	
LOWER DEVONIAN	EMSIAN	AS	AB	Terena Fm.	Terena Fm.		
	PRAGIAN	PE	PoW				
	LOCHKOVIAN	BZ	BZ			"Xistos Raiados" Fm.	Russianas Fm.
		MN	MN				
				?	"Xistos Raiados" Fm.		"Xistos Raiados" Fm.
SILURIAN	PRID.	TS		"Xistos Raiados" Fm.			
	LUDLOW	LP		?		?	?
				"X Nódulos" Fm.	"X Nódulos" Fm.	"X Nódulos" Fm.	"X Nódulos" Fm.

Text-fig. 2 - Age of the "Xistos Raiados", Russianas, and Terena Formations.

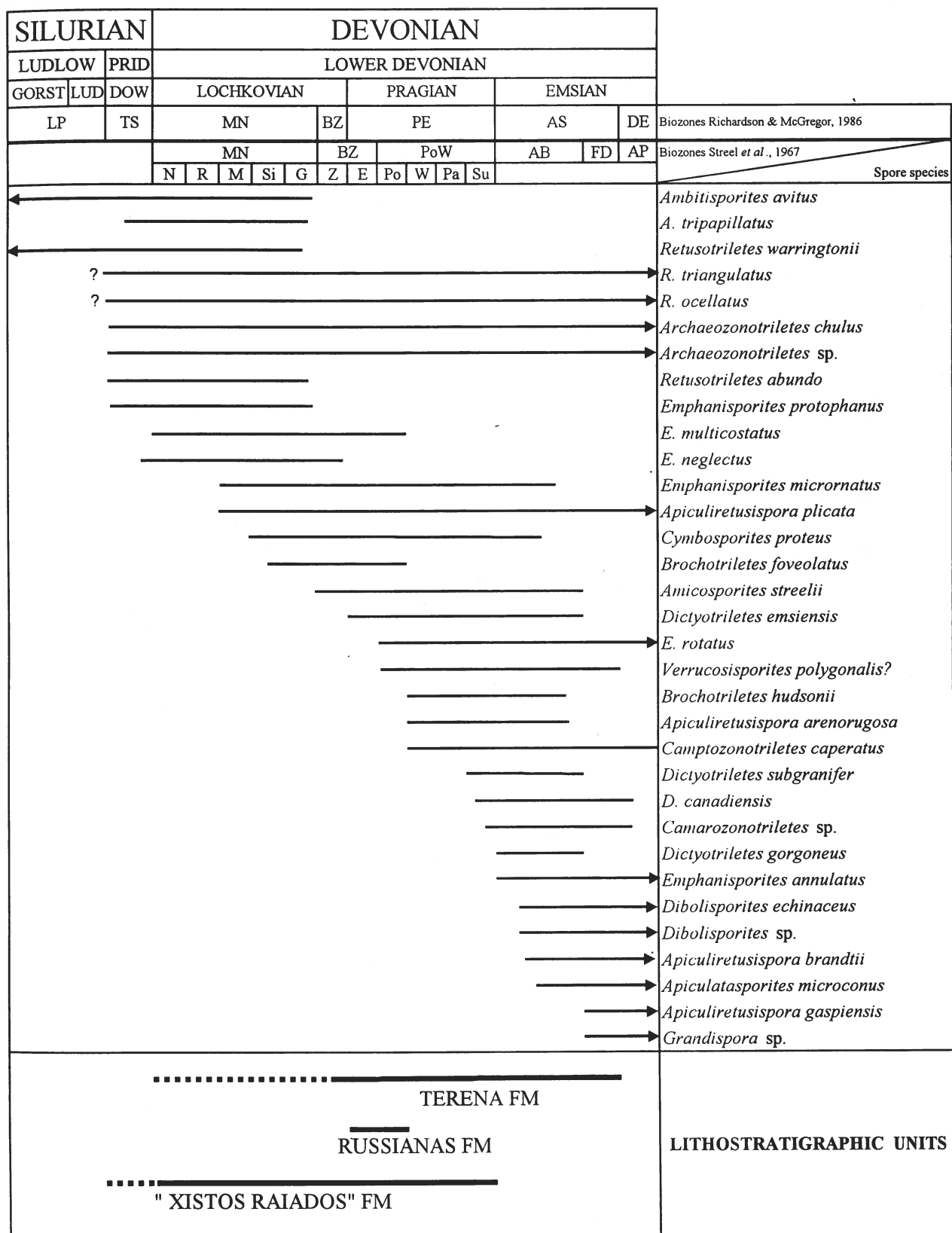
most important guide species of the Streel *et al.* (1987) zonation (*Verrucosporites polygonalis*-*Dibolisporites wetteldorfensis*, PoW zone and *Brochotriletes bellatulus*, AB zone). Correlation with the Streel *et al.* (1987) spore zonation is made whenever possible in order to facilitate precise dating of the present assemblages.

In the southwestern Terena Syncline, samples from the basal beds of the Terena Formation in the Contenda section (Text-fig. 2, A) yielded probable Lochkovian spore assemblages containing *Ambitisporites avitus* Hoffmeister, 1959, *Archaeozonotriletes chulus* (Cramer) Richardson & Lister 1969, *Brochotriletes* sp., *Emphanisporites micromatus*? Richardson & Lister, 1969, and *Retusotriletes warringtonii* Richardson & Lister, 1969. The spores are very poorly preserved, and no spore zone was positively identified. These data were correlated with those from graptolites assigned to

the Lochkovian *Monograptus hercynicus* graptolite Zone (Piçarra, 1998).

Stratigraphically above, in a cut of the Stº Aleixo-Barrancos road section (km 95; Text-fig. 2, A), the spores indicate a younger age, corresponding to the upper part of the PE zone, based on the presence of *Dictyotriletes canadiensis* McGregor, 1973 and *D. subgranifer* McGregor, 1973. *D. subgranifer* marks the base of Su zone of Streel *et al.* (1987).

Higher in the Stº Aleixo-Barrancos road section (km 96.5-97) are first occurrences of *Emphanisporites annulatus* McGregor, 1961 and *Dictyotriletes gorgoneus* Cramer, 1967, which mark the base of the Emsian AS zone. In addition to the index species, *E. annulatus*, characteristic taxa of this zone include *Apiculatasporites microconus* (Richardson) McGregor & Camfield, 1982, *Apiculiretusispora brandtii* Streel, 1964, *Dibolisporites echinaceus* (Eisenack) Richard-



Text-fig. 3 - Ranges of selected taxa in studied sequence of the Barrancos region, with spore-zonal and chronostratigraphic attributions.

son, 1965, and *Dibolisporites* sp. Completing the assemblage are common species of the preceding PE zone. The upper part of the AS zone is identified by the presence of *Apiculiretusispora gaspiensis* McGregor, 1973 and *Grandispora* sp. This low-diversity assemblage is dominated by *Apiculatasporites* spp. and *Apiculiretusispora* spp.

In the northeast limb of the Terena Syncline, pelites and fine greywackes sampled from the Terena Formation along the Str° Aleixo-Barrancos road section (Text-fig. 2, B) yielded well-preserved spores assigned to the PE zone. The assemblage contains *Dictyotrilletes emsiensis* (Allen) McGregor, 1973, *Emphanisporites multicostatus* Rodrigues, 1978, *E. neglectus* Vigran, 1964, *E. rotatus* McGregor, 1961, and *Retusotrilletes warringtonii*. In the upper levels of this section, the first occurrence of *E. annulatus* marks the base of the AS zone, and is associated with typical species of the preceding PE zone.

The "Xistos Raiados" Formation was sampled in detail along the Str° Aleixo-Barrancos road (km 100-104; Text-fig. 2, C). The pelites and siltites include the following: *Amicosporites streelii* Steemans, 1989, *Apiculiretusispora plicata* (Allen) Streel, 1967, *Brochotrilletes foveolatus* Naumova, 1953, *B. hudsonii* McGregor & Camfield, 1976, *Cymbosporites proteus* McGregor & Camfield, 1976, *Dictyotrilletes emsiensis*, *Emphanisporites microrhatus*, *E. multicostatus*, *E. rotatus*, and *Punctatisporites* sp. These are typical of the PE zone. Associated with these species are the following, all considered to be possibly reworked: *Emphanisporites protophanus* Richardson & Ioannides, 1973, *E. neglectus*, *Retusotrilletes abundo* Rodrigues, 1978, and *R. warringtonii*. The presence of *Dictyotrilletes canadiensis* and *D. subgranifer* signals the upper part of the PE zone, close to the Pragian/Emsian boundary. This unit has yielded the best-preserved spores.

Spores recovered from Russianas Formation in the Russianas Syncline (Text-fig. 2, D) are attributable to the PE zone (Pragian). Typical components include: *Apiculiretusispora plicata*, *Archaeozonotrilletes chulus*, *Brochotrilletes* sp., *Cymbosporites proteus*, *Dictyotrilletes emsiensis*, *D. subgranifer*, *Emphanisporites microrhatus*, *E. multicostatus*, *E. neglectus*, *E. rotatus*, *Punctatisporites* sp., *Retusotrilletes abundo*, *R. warringtonii*, and *Verrucosisporites polygonalis*? Lanninger, 1968. First appearance of the last-named species indicates the base of the Po zone (Streel et al., 1987).

Acritarchs, chitinozoans, and graptolite fragments are very common in the studied units. Acritarch taxa recorded include *Diexallophasis remota* (Deunff) Playford, 1977, *Micrhystridium stellatum* Deflandre, 1945, *Multiplicisphaeridium ramusculosum* (Deunff) Lister, 1970, *Neoveryhachium carminae* (Cramer) Cramer, 1970, *Onondagaella* sp., *Verhachium* sp., *Eliastrea barbata* Downie, 1963, and *Acanthodiacrodium* sp. Specimens of the last two cited species are interpreted as possibly reworked.

CONCLUSIONS

Palynostratigraphy constitutes an important tool for precisely dating Silurian-Devonian sequences of the Barrancos region that have not been adequately dated by macrofossils.

The Russianas Formation is attributed to the Pragian, based on spores. This confirms the previous age assessment from invertebrate fossils (trilobites, brachiopods, and bivalves: Pragian-Emsian). Spores from the "Xistos Raiados" Formation signify an age close to the Pragian/Emsian boundary. This provides much greater precision than prior age determinations; viz., Wenlock to early Ludlow (Delgado, 1908; Perdigo et al., 1982), Late Silurian (Ludlow-Pridoli) to Early Devonian (Oliveira et al., 1991; Oliveira et al., 1993; Piçarra et al., 1998a). However, given the gradational transition to the underlying Silurian "Xistos com Nódulos" Formation, it must be conceded that the "Xistos Raiados" Formation could extend into the upper Ludlow. Spore from the Terena Formation indicates a Lochkovian to Emsian age.

These results refine previous datings based on macrofossils and are of particular importance for structural and palaeogeographic interpretations (Oliveira et al., 1991; Oliveira et al., 1993; Piçarra et al., 1998a; Pereira et al., 1998; Piçarra et al., 1998b). Moreover, the new age determinations suggest that the three studied units interdigitate and are partially coeval, no major unconformity having been detected between the Terena Formation and the other units as previously accepted. The assumption that the Terena Formation completes a first Variscan orogenic episode should be questioned.

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