

UPPER DEVONIAN PALYNOMORPHS FROM THE REPRESA AND PHYLLITE-QUARTZITE FORMATIONS, MINA DE SÃO DOMINGOS REGION, SOUTHEAST PORTUGAL : TECTONOSTRATIGRAPHIC IMPLICATIONS

by

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RESUMO

Na região da Mina de São Domingos, a nordeste da Faixa Piritosa portuguesa, as unidades litoestratigráficas que aí ocorrem pertencem a dois domínios tectonoestratigráficos distintos, i.e, Faixa Piritosa e Antiforma do Pulo do Lobo. A Formação Filito-Quartzítica é a unidade mais antiga da Faixa Piritosa, e a Formação da Represa é a unidade mais recente do flanco sul da Antiforma do Pulo do Lobo. A ocorrência de palinóforos (esporos e acritarcos) do Fameniense superior, em ambas as unidades, prova que elas são cronoestratigraficamente equivalentes.

Em vários locais da Faixa Piritosa, e também na região estudada, tanto uma como outra destas formações aparecem sobrepostas ao Complexo Vulcano Sedimentar da Faixa Piritosa, de idade compreendida entre o Tournaisiano inferior e o Viséano superior baixo. Esta sobreposição anormal é devido à existência de carreamentos intimamente associados à tectónica peculiar que afectou a região a partir do Viséano superior.

ABSTRACT

The lithostratigraphic units recognized in the Mina de São Domingos, SE of Portugal, belong to two distinct tectono-stratigraphic domains, i, e, Pyrite Belt and Pulo do Lobo Antiform. The Phyllite-Quartzite formation is the oldest unit of the Pyrite Belt and the Represa Formation is the upper unit of the south flank of the Pulo do Lobo Antiform. The occurrence of upper Famennian palynomorphs (spores and acritarchs) in both units support their time stratigraphic correlation. In several places of the Pyrite Belt, and also in the studied area, either the Phyllite-Quartzite Formation or the Represa Formation overlain the Vol-

cano Sedimentary Complex of the Pyrite Belt, whose age ranges from lower Tournaisian to lower upper Viséan. This abnormal superposition is due to folded overthrusts related to the thinskin tectonism which affected the area upper Viséan onwards.

PALAVRAS CHAVE

Faixa Piritosa, Fameniense, palinóforos, carreamentos, Portugal.

KEY WORDS

Pyrite Belt, Famennian, palynomorphs, overthrusts, Portugal.

1. INTRODUCTION

One of the main difficulties concerning the geology of the South Portuguese Zone, Southern Iberia Peninsula, is the lack of reliable fossil associations to characterize the age of important segments of the lithostratigraphic sequence. In the Pulo do Lobo Antiform, where several formations are recognized, only the upper unit of the north flank (Horta de Torre Formation) has yielded spores and acritarchs of middle to upper Famennian age (Oliveira *et al.*, 1986, Giese *et al.*, 1986). In the Pyrite Belt, age control of the stratigraphic sequence is better, but still unsatisfactory. From this tectono-stratigraphic domain are dated the following part of the lithostratigraphic succession : shales and limestone lenses of the upper part of the Phyllite-Quartzite (PQ) Formation, which provided rare macrofaunas and rich conodont assemblages of middle to upper Famennian age (Pruvost, 1912 ; Boogaard, 1963, 1967 ; Fantinet *et al.*, 1976 ; Boogaard & Schermerhorn, 1980, 1981) ; limestone lenses interbedded in the Volcano-Sedimentary (VS) Complex yielded conodonts of upper Tournaisian age (Boogaard, 1963 ; Boogaard & Schermerhorn, 1975) ; finally, rare conodonts and goniatites of the

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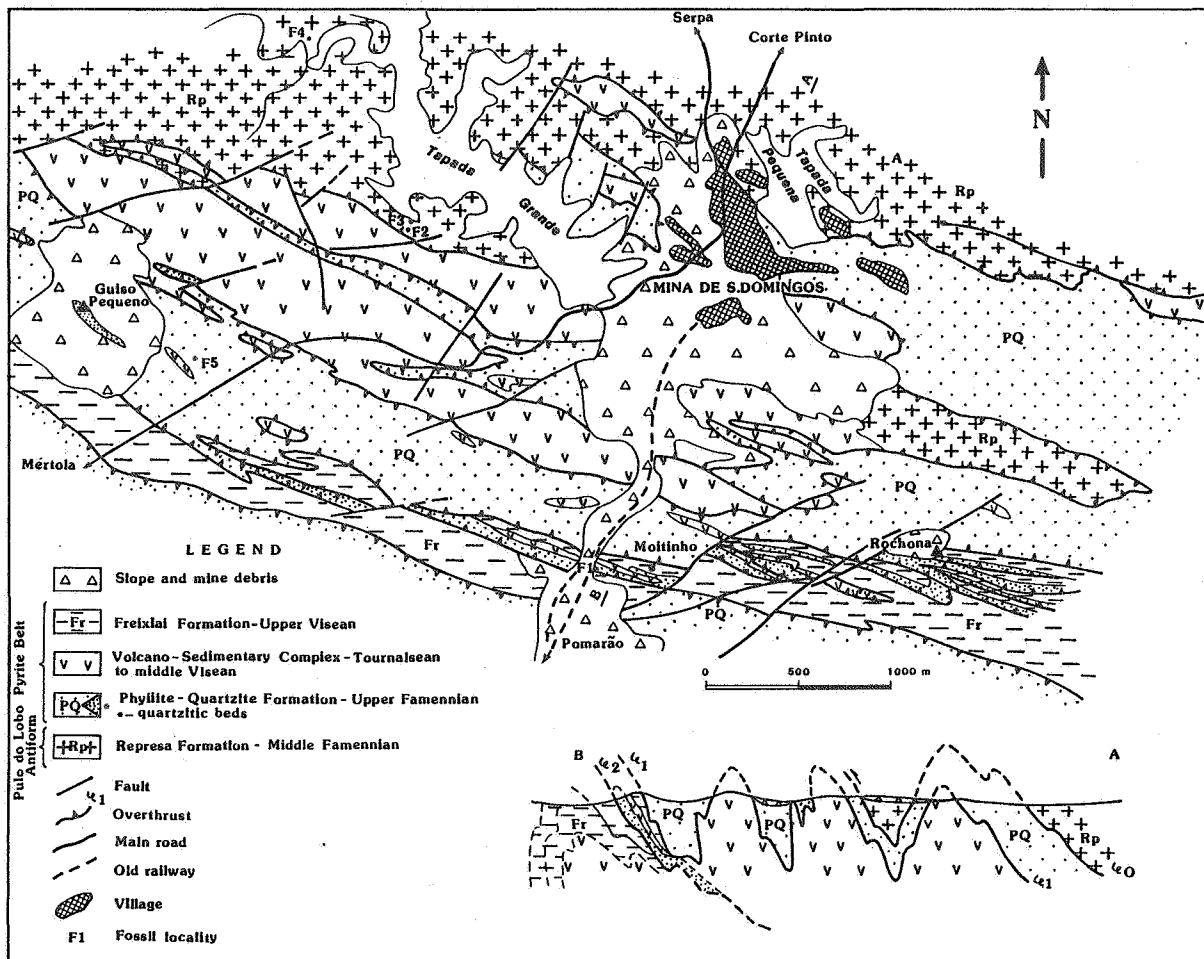


Figure 1. : Geological map of the Mina de São Domingos region.

upper part of the VS Complex indicate a lower upper Visean age (Oliveira, 1983 ; Oliveira & Wagner Gentis, 1983). Givetien spores collected in the PQ Formation of the Rio Tinto region, Spain (Lake *et al.*, 1987) are unique and apparently aberrant.

According to these faunal assemblages it is of common usage to consider the PQ Formation of middle to upper Famennian age and the VS Complex of Tournaisian to middle Visean age.

This poor biostratigraphic information coupled with impressive tectonic complications offered room to some speculations and controversies. Under these circumstances, stratigraphic and paleontological research may play a fundamental role in the understanding of the regional geology.

Recent work in the Mina de São Domingos region, Southeastern Portugal, led to the discovery of upper Devonian palynomorphs in the Represa and the PQ Formations. These age determinations prove to be helpful for the interpretation of the regional tectonic structure and for more global geodynamic reconstructions.

2. LITHOSTRATIGRAPHIC FRAMEWORK

The lithostratigraphic units recognized in the Mina de São Domingos region, belong to two distinct tectono-stratigraphic domains, i.e., Pulo do Lobo Antiform and Pyrite Belt. These domains are separated by a folded overthrust (Fig. 1).

The Represa Formation (Carvalho, 1976), is the upper unit of the southern flank of the Pulo do Lobo Antiform. It is composed of greywackes, quartzwackes, siltsones and shales. Red and green shales, and tuffites appear locally interbedded in the lithological sequence. This formation is lithologically similar to the underlying Gafo Formation and both units from together a flysch like succession. This flyschoid succession is affected by three episodes of folding and the tectonism does not allow the determination of the units thickness.

The stratigraphic units of the Pyrite Belt are, from base to top :

- Phyllite-Quartzite (PQ) Formation - a terrigenous succession of shales with intercalations of quartzite beds and lenses. The stratigraphic thickness is in excess of 300 meters (base not seen). This formation is deformed and sheared by two coaxial and north-west trending episodes of folding. The

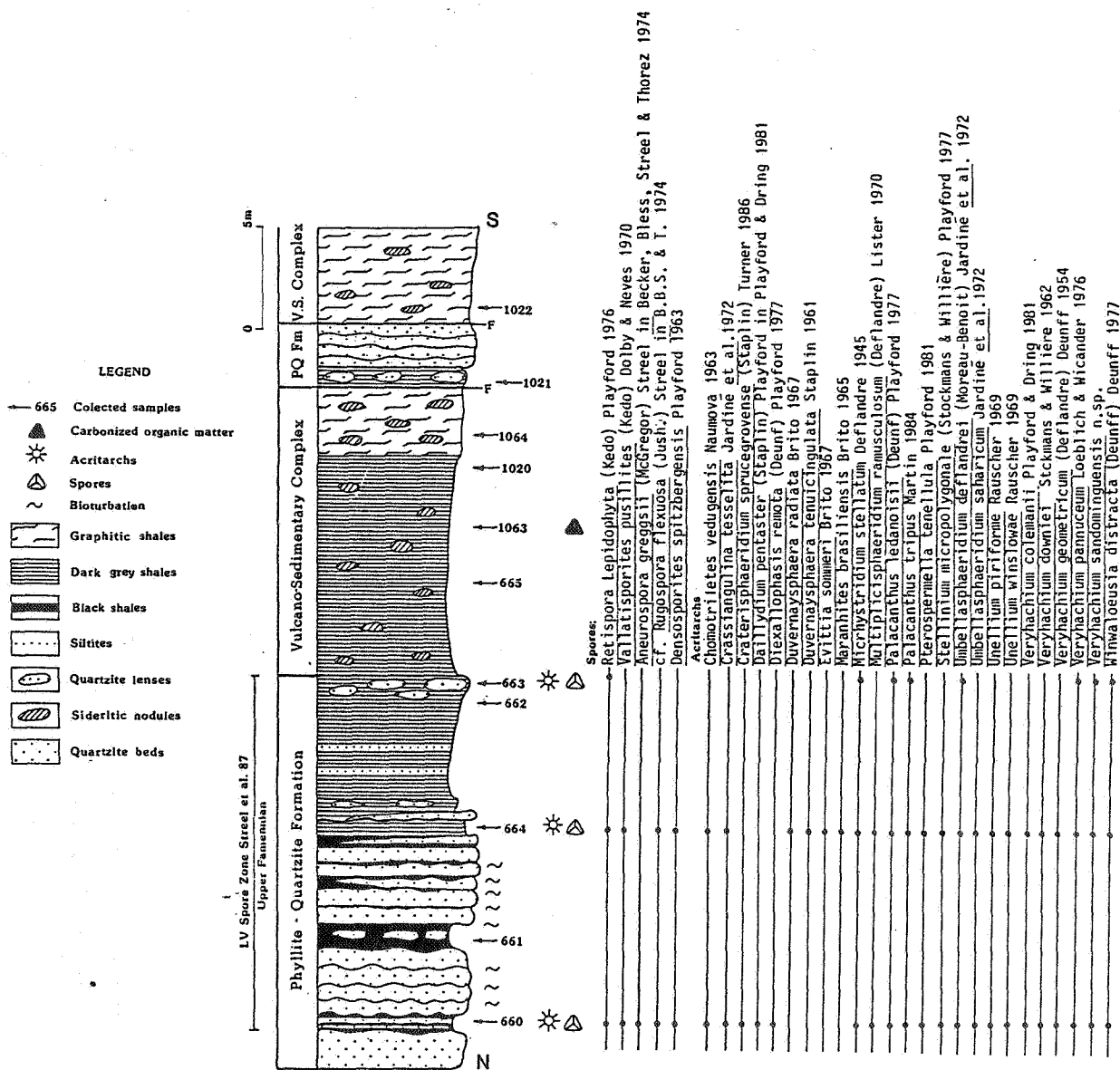


Figure 2. : Stratigraphic log of the PQ Formation/V.S. Complex in the São Domingos region (Loc. F1).

quartzite beds and interbedded black shales form, in places, continuous ridges some hundred of metres of length (Fig. 1).

- Volcano-Sedimentary (VS) Complex - this complex is composed of acid and basic volcanics that interfinger with dark and purple shales, tuffites and lenses of jaspers (these lithologies are not differentiated in Fig. 1). The thickness changes from few metres to about 600 metres. Metric thick successions of dark siliceous shales and tuffites that overly continuous beds of quartzites, in Rochona and Moitinho areas (Fig. 1), are considered facies variations of the VS Complex. Tectonic deformation is similar to that of the PQ Formation.

- Freixial Formation - This unit is composed of shales and greywackes that show turbiditic sedimentary structures. However, the greywacke beds may be very thin in places, and in this case the unit is very shally. The Freixial Formation is also affected by two episodes of folding.

3. PALYNOLOGY

The location of palynomorph productive samples in the studied region is shown in Figure 1. Locality F1 corresponds to a well exposed section, that comprises quartzites and black shales of the PQ Formation and dark and black siliceous shales, with interbedded sideritic nodules, of the VS Complex

LOC. F - 4 (G2 - 7)	LOC. F - 2 (G2 - 5)	LOC. F - 3 (G2 - 2)	
			Spores:
X	X	X	<i>Aneurospora greggsii</i> (McGregor) Streeel in B.B.S.&T. 1974
X	X	X	<i>Auroraspora asperella</i> (Kedo) V. der Zwan 1980
		X	<i>Auroraspora solisorta</i> Hoffmeister, Staplin & Malloy 1955
X	X	X	<i>Grandispora gracilis</i> Hacquebard 1957
	X	X	<i>Pustulatisporites rugulatus</i> (Taug.-Lantz) Loboziak & Streeel 1981
	X	X	<i>Retusotriletes inchohatus</i> Sullivan 1964
	X	X	cf. <i>Retusotriletes planus</i> Dolby & Neves 1970
X	X	X	<i>Retusotriletes</i> sp.
X			<i>Rugospora flexuosa</i> (Jushko) Streeel in B.B.S.&T. 1974
			Acritarchs:
X	X	X	<i>Cymatiosphaera</i> sp.
	X	X	<i>Daillyidium pentaster</i> (Staplin) Playford & Dring 1981
	X	X	<i>Maranhites britoi</i> Stockmans & Willièere 1969
		X	<i>Maranhites moesii</i> (Sommer) Brito 1967
X	X	X	<i>Pterospermella</i> sp. A
	X	X	<i>Pterospermella tenellula</i> Playford 1981
	X	X	<i>Unellium piriforme</i> Rauscher 1969
X	X	X	<i>Villosacapsula</i> sp.

Figure 3. : Distribution of Palynomorphs in the Represa Formation.

(Fig. 2). Palynomorphs were recovered from the black shales of the PQ Formation.

Samples of the Represa Formation were collected from finely laminated dark and green shales that are interbedded in greywackes and siltstones (localities F2, F3 and F4). Tectonic deformation does not allow the construction of a representative stratigraphic log.

Samples were treated according to the method proposed by Streeel (1964), with minor modifications. The organic residue was concentrated by filtration through a 12 µm metallic net. For darkened palynomorphs, reoxidation operations with a concentrated Schulze Solution were made.

Palynomorphs obtained from the black shales of the PQ Formation are abundant and varied (Fig. 2 ; Plates 1, 2, 3). The spore assemblage is clearly placed in the *LV (lepidophyta-verrucosa) Zone*, of the uppermost Famennian, defined in the Ardenne-Rhenish regions of western Europe (Streeel *et al.*, 1987). It fits also the *Pusillites-lepidophyta Zone* of latest Famennian age, defined in the Old Red Sandstone Continent (Richardson & McGregor, 1986). This palynologically inferred age is in good agreement with previous upper Famennian age determinations obtained by means of conodonts and clymenids from the carbonate lenses and shales that form the upper part of the PQ Formation (Pruvost, 1912 ; Boogaard, 1963, 1967 ; Boogaard & Schermerhorn, 1980, 1981 ; Fantinet *et al.*, 1976 ; Oliveira *et al.*, 1986). The rich assemblage of acritarchs, although not specific for the upper Famennian, is common in middle to upper Devonian strata. In the acritarch assemblage a new species (*Verhachium sandominguensis* n. sp.) has been found and is described in addendum.

The Represa Formation provided a much poor assemblage of palynomorphs (Fig. 3 ; Plate 4). The spore assemblage has yielded, among others, the characteristic species *Rugospora flexuosa* (Jushko) Streeel in Becker, Bless, Streeel & Thorez, 1974 (one specimen from Loc. F4, Plate 4, Fig. 1), *Pustulatisporites rugulatus* (Taugourdeau-Lantz) Loboziak & Streeel, 1981 (one specimen from Loc. F2, Plate 4, fig. 10) and *Grandispora gracilis* Hacquebard, 1957 (two specimens from Loc. F3 and F4, Plate 4, Fig. 2). These occurrences combined with the absence of the typical uppermost Famennian species like *Retispora lepidophyta* or *Vallatisporites pusillites* (which occurs in the PQ Formation), indicate an early Upper Famennian age for the Represa Formation. This result, although based in a few number of characteristic species, is compatible with other stratigraphic and structural data, as discussed below. The acritarch assemblage of the Represa Formation, like that of the PQ Formation, does not indicate a very precise stratigraphic distribution, but is also common in middle to upper Devonian deposits worldwide.

4. SYSTEMATICS

Group *ACRITARCHA* Evitt 1963

Genus *Verhachium* Deunff 1954

Verhachium sandominguensis n. sp.

Pl. 3, Fig. 6, 11, 14

Description - Vesicle triangular in outline with sides of approximately equal length, 16-24 µm long. Three long laevigate conical processes, 8-10 µm long, one at each angle of the vesicle are drawn out in the same plane as the sides of vesicle. Near the

base of processes the vesicle is slightly of frankly bulbous. From the bases, the processes taper to a blunted tip. Surface of vesicle is scabrate and wrinkled, with wrinkles asymmetrically disposed, generally not parallel to the sides of vesicle and ending near the base of processes which are not wrinkled.

Remarks - The particular system of ribs asymmetrically disposed, not paralleling the sides of vesicle and the scabrate surface of vesicle, distinguishes this species from the other wrinkled triangular species formerly described.

Specific name - Derived from the name of the locality - Mina de São Domingos - where the species has been described.

Types -

Holotype : Pl. 3, Fig. 6 (660 - L.872/1726)
 Paratypes : Pl. 3, Fig. 11 (660 - L.844/0995)
 Pl. 3, Fig. 14 (660 - L.832/0353)

Occurrence - Black shales of the upper part of the Phyllite-Quartzite (PQ) Formation - upper Famennian.

5. TECTONO - STRATIGRAPHIC IMPLICATIONS

The occurrence of upper Famennian palynomorphs, particularly spores, in both the Represa and PQ Formations, has important tectono-stratigraphic implications :

a - The age of the turbiditic succession (Gafó and Represa Fm.) has been the aim of some discussion. Work by Pfefferkorn (1968), Schermerhorn (1971), Carvalho *et al.* (1976) and Salpeteur (1976), has reach the conclusion that this succession stratigraphically overlies the VS Complex and should so be of middle to upper Viséan age. On the other hand, Oliveira (1982), Silva (1985), Oliveira *et al.* (1986) and Silva *et al.* (in press), based on lithostratigraphic and structural data from

Mina de São Domingos and Mértola regions, suggested that the Represa Formation is older than the VS Complex, or even the PQ Formation, and should be considered of upper Devonian age. Present work (Fig. 4) confirms the last interpretation and precise the age of the Represa Formation as early upper Famennian.

In the Pulo do Lobo Antiform, a time stratigraphic correlation between the units of the Chança Group (south flank) and the units of the Ferreira-Ficalho Group (north flank) has been suggested (Schermerhorn, 1971 ; Carvalho *et al.*, 1976 ; Oliveira *et al.*, 1986, Oliveira, in press). The age obtained for the Represa Formation shows that this unit is coeval of the Horta da Torre Formation (the upper unit of the Ferreira-Ficalho Group). This fact and the strong lithological similarities between the formations of the Chança and Ferreira-Ficalho Groups suggest time stratigraphic correlations between the units of these groups.

b - In the Pyrite Belt occur quartzites and shales that overly the VS Complex apparently in normal stratigraphic order. This has led some authors (Carvalho, 1976 ; Routhier *et al.*, 1980) to consider that these quartzites and shales are younger than the VS Complex and should be differentiated from those of the PQ Formation. The quartzites and shales of the Mina de São Domingos area were informally designated as Sabina Formation (Carvalho, 1976). Detailed work along the Guadiana river valley, north of Mértola, has shown that quartzites and shales are in allochthonous position over the VS Complex (Silva, 1985 ; Silva *et al.*, in press). A *Gonyoclymenia* specimen collected in locality F5 (Fig. 1 ; Oliveira *et al.*, 1986) and the palynomorphs recovered from locality F1 (Fig. 1), indicate that the Sabina Formation quartzites and shales are of upper Famennian age, that is, older than the VS Complex. This age determination and the strong lithological affinities between the Sabina and the PQ Formations, show that there is no reason to consider the Sabina Formation as a distinctive lithostratigraphic unit. The

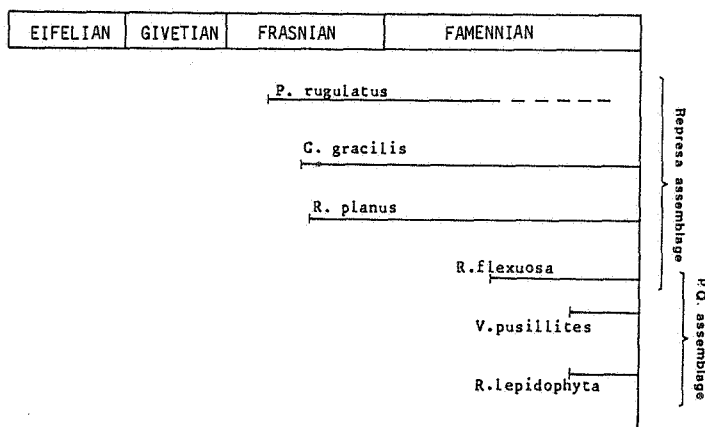


Figure 4. : Stratigraphic distribution of the most characteristic species of the PQ and Represa Formation.

quartzites and shales of the Mina de São Domingos area belong to the PQ Formation and, as in other areas of the Pyrite Belt, they are in allochthonous position over the VS Complex (Fig. 1).

6. CONCLUSIONS

Stratigraphic research in Mina de São Domingos region, Southeast Portugal, led to the discovery of early and late Upper Famennian palynomorphs in the Represa and PQ Formations. From these results it is concluded that the Represa Formation is time stratigraphic equivalent to the Horta de Torre Formation which crops out in the north limb of the Pulo do Lobo Antiform. This lateral correlation supports previous interpretations by which the terrigenous units of the north and south flanks of this antiform formed a continuous detritic cover. The quartzites and shales of this region are of upper Famennian age and belong to the PQ Formation. Like other quartzites and shales of the Pyrite Belt, these are also allochthonous over the VS Complex, a fact that confirms the thin-skinned style of tectonic deformation for this region (Ribeiro & Silva, 1983; Silva *et al.*, in press).

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PLATE I

(all photos are X 1000)

PALYNOMORPHS FROM THE PQ FM. (Loc. F1)

- 1, 2 - *Retispora lepidophyta* (Kedo) Playford 1976
 - 1 - 660 - L.839/0699-0746
 - 2 - 660 - L.865/0985
- 3, 6 - *Vallatisporites pusillites* (Kedo) Dolby & Neves 1970
 - 3 - 664 - L.866/0599-0646
 - 4 - 660 - L.865/1770
- 4 - cf. *Rugospora flexuosa* (Jushko) Strel in B.B.S.&T. 1974
 - 660 - L.872/1962-2011
- 5 - *Densosporites spitzbergensis* Playford 1963
 - 664 - L.844/1363-1314
- 7 - *Daylidium pentaster* (Staplin) Playford in Playford & Dring 1981
 - 660 - L.839/1245-1244
- 8 - *Aneurospora greggsii* (McGregor) Strel in B.B.S.&T. 1974
 - 660 - L.865/0648
- 9 - *Crassiangulina tessellata* J.C.M.P. & V. 1972
 - 664 - L.832/1160-1052
- 10 - *Craterisphaeridium sprucegrovensis* (Staplin) Turner 1986
 - 660 - L.865/1468-1516. Hemisphere.
- 11 - *Veryhachium downiei* Stockmans & Willière 1962
 - 664 - L.832/0010-0059
- 12 - *Chomotriletes vedugensis* Naumova 1953
 - 660 - L.832/0983
- 13 - *Cymatiosphaera* sp.
 - 660 - L.866/0147-0146

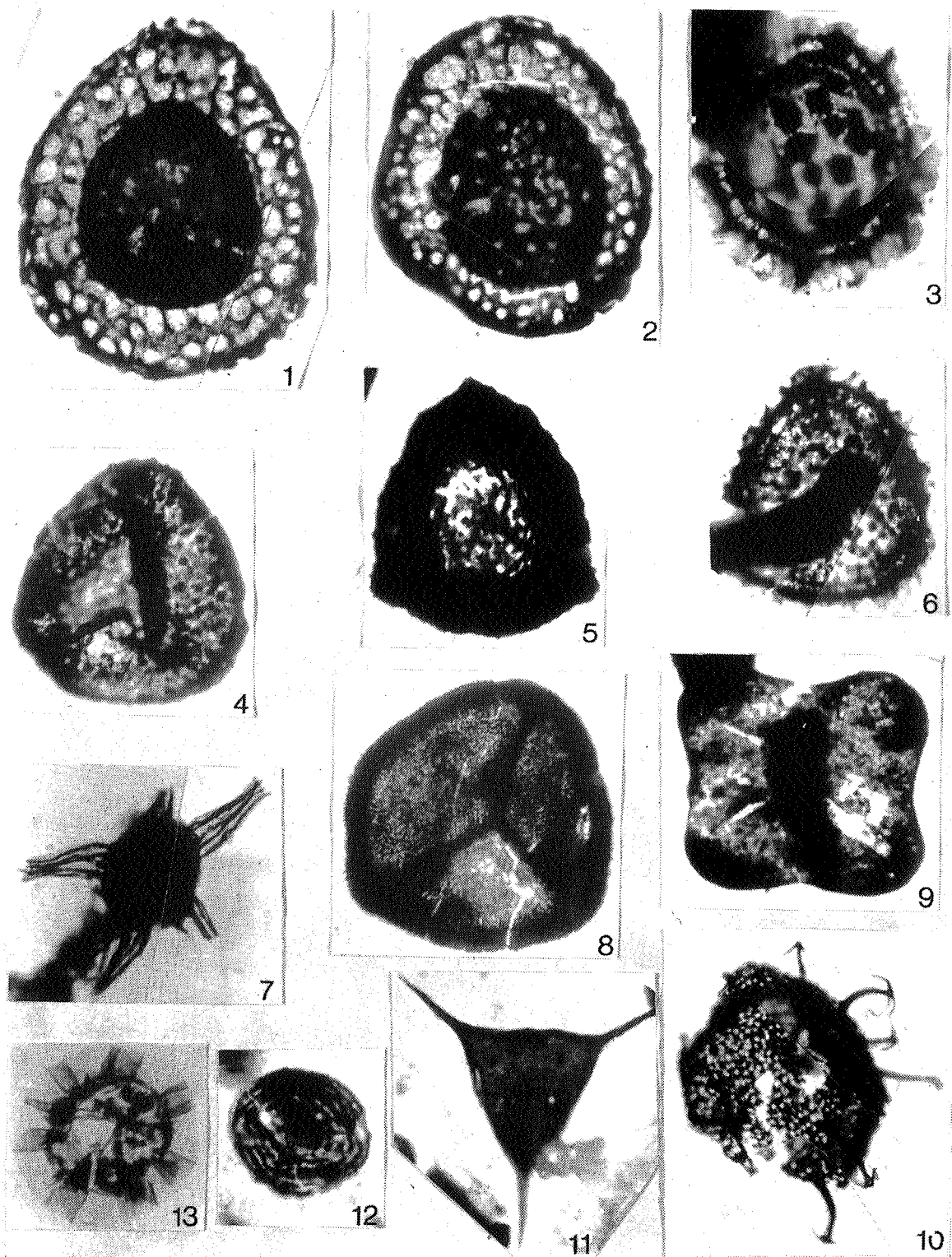


PLATE 2

(all photos are X 1000)

PALYNOMORPHS FROM PQ FM. (Loc. F1)

- 1 - *Diexallophasis remota* (Deunff 1955) Playford 1977
664 - L.841/1083-1036
- 2 - *Duvernaysphaera radiata* Brito 1967
664 - L.839/0621-0668
- 3 - *Duvernaysphaera tenuicingulata* Staplin 1961
660 - L.844/0206-0159
- 4 - *Evittia sommeri* Brito 1967
660 - L.866/1272-1321
- 5 - *Gorgonisphaeridium* sp.
660 - L.832/0016-0017
- 6 - *Micrhystridium stellatum* Deflandre 1945
660 - L.844/0579
- 7 - *Maranhites brasiliensis* Brito 1965
660 - L.866/0233
- 8 - *Maranhites* sp.
660 - L.832/0012
- 9 - *Unellium winslowae* Rauscher 1969
660 - L.832/0825-0778
- 10 - *Pterospermella tenellula* Playford 1981
664 - L.841/0945
- 11 - *Stellinium micropolygonale* (Stock. & Will.) Playford 1977
660 - L.844/0461
- 12, 13, 14 - *Palacanthus ledanoisii* (Deunff) Playford 1977
12 - 660 - L.866/1106
13 - 660 - L.844/1481
14 - 664 - L.865/1325
- 15 - *Unellium piriforme* Rauscher 1969
664 - L.839/2073

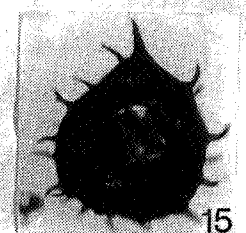
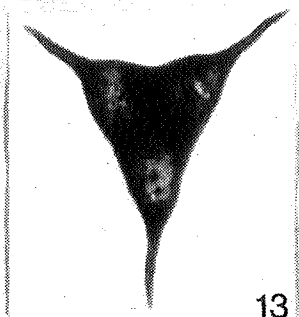
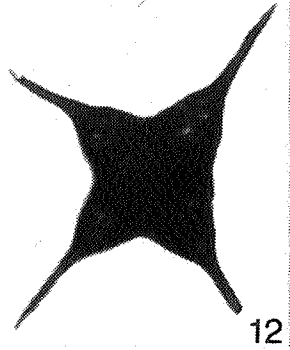
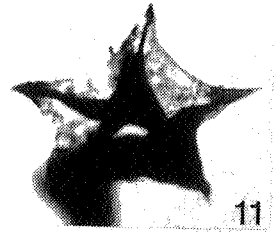
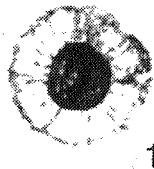
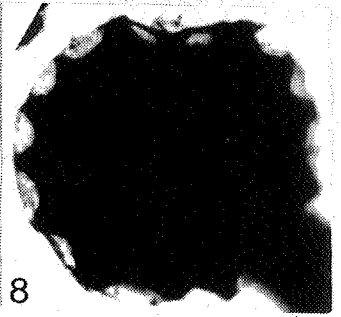
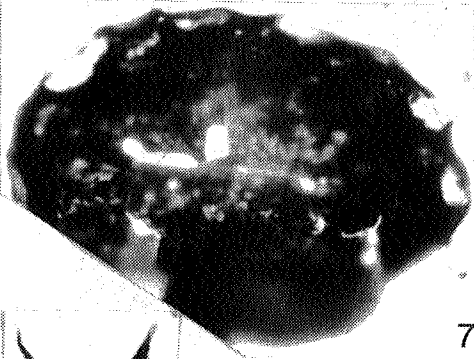
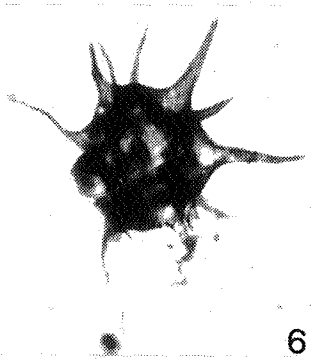
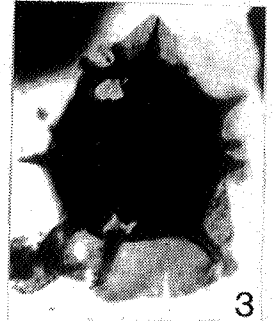
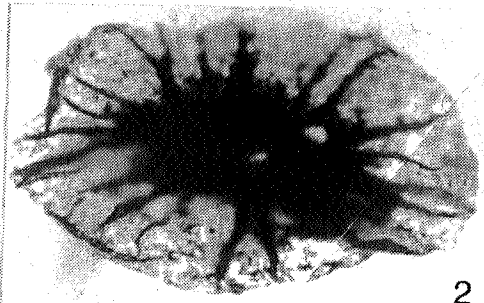


PLATE 3

(all photos are X 1000)

PALYNOMORPHS FROM THE PQ FM. (Loc. F1)

- 1 - *Palacanthus tripus* Martin 1984
664 - L.865/1403-1450
- 2, 5 - *Umbellasphaeridium saharicum* J.C.M.P.&V. 1972
2 - 664 - L.841/1072-1119
5 - 660 - L.832/0346
- 3, 4 - *Umbellasphaeridium deflandrei* (Moreau-Benoit 1967)
3 - 664 - L.841/0534-0486
4 - 664 - L.839/1661-1710
- 6, 11, 14 - *Veryhachium sandominguensis* n. sp.
6 - 660 - L.872/1726-1679 (holotype)
11 - 660 - L.844/0995 (paratype)
14 - 660 - L.832/0353 (paratype)
- 7 - *Veryhachium colemanii* Playford & Dring 1981
660 - L.832/1670
- 8 - *Umbellasphaeridium* sp.
664 - L.865/0902-0853. Processes are covered by a thin transparent membrane.
- 9 - *Veryhachium geometricum* (Deflandre) Deunff 1954
660 - L.844/0773
- 10, 12, 13 - *Veryhachium pannuceum* Wicander & Loeblich 1977
10 - 660 - L.832/1552
12 - 664 - L.839/2371
13 - 660 - L.844/0168
- 15, 16 - *Winwaloeusia distracta* (Deunff) Deunff 1977
15 - 664 - L.841/1419-1468
16 - 664 - L.865/1368

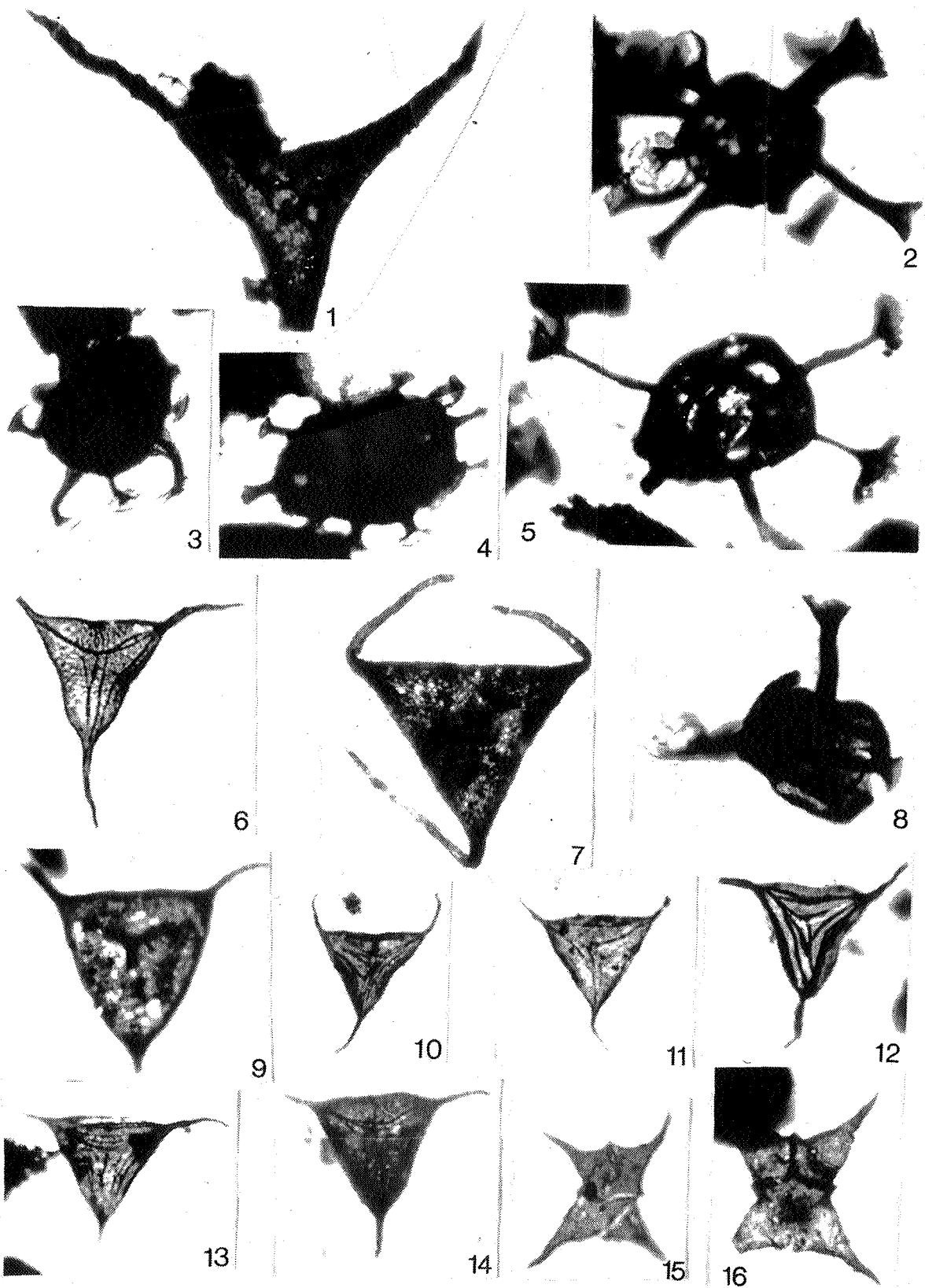


PLATE 4

(all photos are X 1000)

PALYNOMORPHS FROM THE REPRESA FM. (Loc. F2, F3, F4)

- 1 - *Rugospora flexuosa* (Jushko) Streel in B.B.S.&T. 1974
Loc. F4 (G2-7b) - L.746/0036
- 2 - *Grandispora gracilis* Hacquebard 1957
Loc. F4 (G2-7b) - L.791/0741-0790
- 3, 4 - *Aneurospora greggsii* (McGregor) Streel in B.B.S.&T. 1974
3 - Loc. F4 (G2-7b) - L.746/0048
4 - Loc. F4 (G2-7b) - L.746/0034
- 5 - cf. *Retusotriletes planus* Dolby & Neves 1970
Loc. F2 (G2-5b) - L.813/2221-2172
- 6 - *Retusotriletes incohatus* Sullivan 1964
Loc. F2 (G2-5a) - L.724/0212
- 7 - *Pterospermella tenellula* Playford 1981
Loc. F2 (G2-5a) - L.694/1520
- 8 - *Unellium piriforme* Rauscher 1969
Loc. F3 (G2-2) - L.692/0637
- 9 - *Villosacapsula* sp.
Loc. F4 (G2-7b) - L.723/0266-0315
- 10 - *Pustulatisporites rugulatus* (Taugourdeau-Lantz) Loboziak & Streel 1981
Loc. F2 (G2-5a) - L.711/0453-0406
- 11 - *Maranhites mosesii* (Sommer) Brito 1967
Loc. F3 (G2-2) - L.756/1017
- 12 - *Pterospermella* sp.
Loc. F3 (G2-2) - L.713/0019
- 13 - *Auroraspora asperella* (Kedo) Van der Zwan 1980
Loc. F4 (G2-7b) - L.791/1850-1803

