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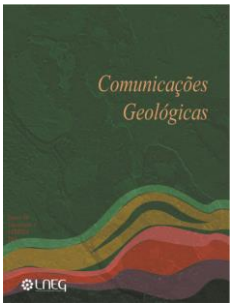
Preliminary dating of the Vale de Parreiras Formation of the late Famennian age, Iberian Pyrite Belt, Portugal, based on palynomorphs



Datações preliminares da Formação de Vale de Parreiras de idade Famenniano superior, Faixa Piritosa Ibérica, Portugal, com base em palinomorfos

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Original article

Abstract: New palynostratigraphic data were obtained from phyllites interbedded with quartzwackes of the Vale de Parreiras Formation, located to the south of the Grândola Fault in the Azinheira de Barros region, Portugal. The studied outcrops are located in the eastern bank of the Sado river. A mid-late Famennian age has been assigned based on significant presence of the key miospore species *Grandispora* cf. *cornuta* and *Rugospora flexuosa*, indicating a VCo Miospore Biozone for the Vale de Parreiras Formation. This age is older than previously considered for this formation, even despite the lack of palaeontological information and geochronological age determinations. This new attained palynological age provides helpful informations for the interpretation of regional tectonic structures. Also, its stratigraphic position could be reinterpreted and correlated to other late Famennian age units of Iberian Pyrite Belt, for instance, to the Phyllite-Quartzite Group. The new palynological age indicates that the Vale Parreiras Formation lithologies were deposited and belong to the same palaeogeographic realm as the former group during Late Devonian times. It may also suggest important post Variscan uplift of the Iberian Pyrite Belt in the area east of the Corona-Sado Fault and south of the Grândola Fault. These results also indicate a significant exposure of the mid-late Famennian basement wich can be considered a less favourable scenario to mineral exploration in this Iberian Pyrite Belt sector.

Keywords: Vale de Parreiras Formation, Phyllite-Quartzite Group, Palynostratigraphy, Famennian, Iberian Pyrite Belt.

Resumo: Dados palinoestratigráficos obtidos recentemente permitiram datar os filitos intercalados em quartzovaques da Formação Vale de Parreiras, situada na área noroeste da Faixa Piritosa Ibérica (FPI), em Portugal. Os afloramentos estudados localizam-se a sul da falha de Grândola, na margem este do rio Sado. A presença das espécies guia *Grandispora* cf. *cornuta* e *Rugospora flexuosa*, indicam a Biozona de Miosporos VCo, do Famenniano médio a superior, permitindo atribuir esta idade à Formação Vale de Parreiras. Esta datação pressupõe uma idade mais antiga que a previamente estimada para esta formação por correlação estratigráfica, mas sem dados paleontológicos de suporte. A nova idade palinológica alcançada fornece informações úteis para a interpretação das estruturas tectónicas regionais. A posição estratigráfica da Formação Vale de Parreiras pode ser reinterpretada e correlacionada com outras unidades do Famenniano superior da Faixa Piritosa Ibérica, nomeadamente com o Grupo Filito-Quartzito. Estes dados permitem inferir que a Formação Vale de Parreiras faria parte desta bacia paleogeográfica, durante o Devónico Superior. A nova idade palinológica da Formação Vale de Parreiras sugere um importante *uplift* pós-Varisco neste setor da FPI, localizado a este da falha de Corona-vale do rio Sado e a sul da falha de Grândola. Estes resultados sugerem ainda uma forte exposição do substrato Famenniano, sendo por isso, considerado um cenário menos favorável à exploração mineral nesta região da Faixa Piritosa Ibérica.

Palavras-chave: Formação Vale de Parreiras, Grupo Filito-Quartzítico, Palinoestratigrafia, Famenniano, Faixa Piritosa Ibérica.

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1. Introduction

The Vale de Parreiras Formation was identified and mapped within the scope of the Sheet 42-B Azinheira de Barros of Portuguese Geological Map, scale 1/50 000 (Oliveira *et al*., 2013a) (Fig. 1). This unit was mapped with an unclear stratigraphic position and located between the Famennian to late Visean Volcano-Sedimentary Complex, of the Iberian Pyrite Belt and the late Visean Mértola Formation of the Baixo Alentejo Flysch Group. The lack of fossil record was the main reason for the ambiguous stratigraphic position of the Vale de Parreiras Formation, as was for the geology of Azinheira de Barros region. Recent palynological research in this later formation allowed preliminary age determinations described in this study, helping to improve the understanding of the Azinheira de Barros regional geological framework.

2. Geological setting and lithostratigraphic framework

The Vale de Parreiras Formation is a siliciclastic sequence composed of mudstones, silts and quartzwackes. The quatzwacke beds exhibit sedimentary structures (Bouma sequence) indicating deposition by turdidity currents (Oliveira *et al*., 2013a). According to these authors the quartzwackes are quartz-rich and present minor feldspar (albite), muscovite and biotite clasts in a sericite+chlorite matrix. The lithologies of the Vale de Parreiras Formation are intensively deformed showing three phases of folding and two tectonic cleavages. Commonly S_0 and S_1 are crenulated by S_2, defining a N36W strike L_2 tectonic lineation. Internal N80W trending folds can be observed.

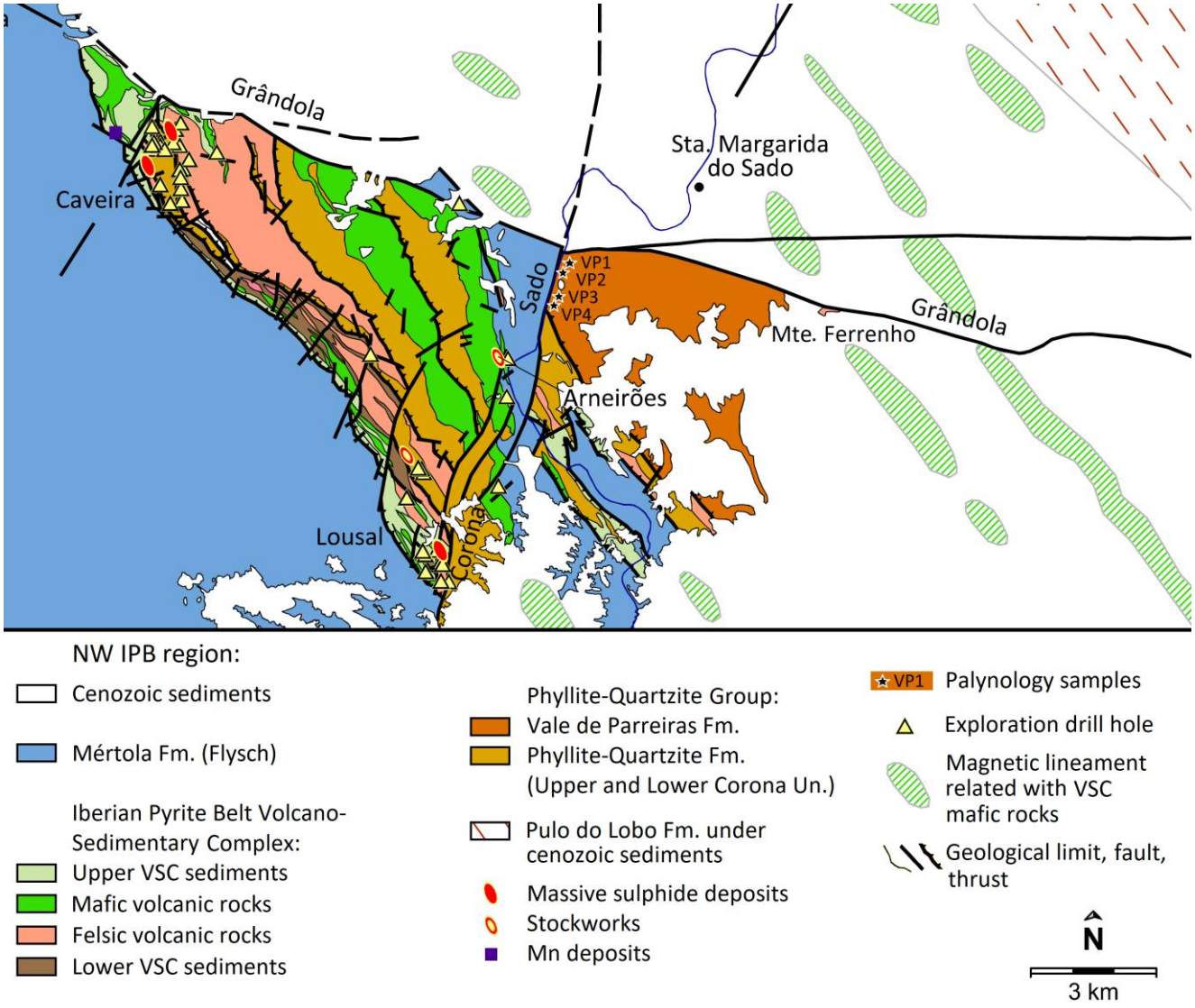

Figure 1. Geological Map of Lousal – Caveira Volcano-Sedimentary Complex / Phyllite-Quartzite Group structure and Vale de Parreiras Formation, Azinheira dos Barros area. (Adapt. of sheets 42-A Grândola (Dias *et al*., 2016) and 42-B Azinheira de Barros (Oliveira *et al*., 2013a) of Portugal Geological Map, scale 1/50 000). Aeromagnetic lineaments by Represas *et al*., 2016b.

Figura 1. Mapa geológico da estrutura Comp. Vulcano-Sedimentar / Formação Filito-Quartzítica de Lousal – Caveira e da Formação Vale de Parreiras, na região de Azinheira dos Barros. (Adapt. das folhas 42-A Grândola (Dias *et al*., 2016) e 42-B Azinheira de Barros (Oliveira *et al*., 2013a) da Carta Geológica de Portugal, escala 1/50 000). Alinhamentos aeromagnéticos por Represas *et al*., 2016b.

The Vale de Parreiras Formation outcrops south of Santa Margarida do Sado in a NW-SE trending structure located NE of the Volcano-Sedimentary Complex/Phyllite-Quartzite Group, Lousal-Caveira lineament (Oliveira *et al*., 2013a, b; Matos *et al*., 2014; Dias *et al*., 2016) (Fig. 1). Included in the Palaeozoic Iberian Pyrite Belt basement rocks of the Cenozoic Alvalade Basin (Pais *et al*., 2013; Oliveira *et al*., 2013a; Dias *et al*., 2016), the Vale de Parreiras Formation is concealed under Miocene and Pliocene age sediments to the south, east and north. Its southwest contact with the Phyllite-Quartzite Group Formation was mapped as a probable fault contact. To the north, the Vale de Parreiras Formation is limited by the WNW-ESE late Variscan Grândola Fault (Fig. 1), which presents a listric geometry with significant downthrow of the northern block in the Santa Margarida do Sado region (Carvalho *et al*., 2011). The Vale de Parreiras Formation western contact is a N-S trending late Variscan fault, the Corona – Sado Valley Fault with a complex dextral strike slip movement and important downthrow to the western block (Fig. 1). Volcano-Sedimentary Complex rocks are present to the east of Vale de Parreiras Formation, in a small inlier near Monte Ferrenho, where felsic volcanic lavas were dated by U/Pb with 348.6 ± 0.88 Ma (Tournaisian, Solá *et al*., 2019) and subcropping in large areas under the Cenozoic Alvalade Basin, as indicated by N50W trending aeromagnetic lineaments (Represas *et al*., 2016b; Matos *et al*., 2020) (Fig. 1).

The Vale de Parreiras Formation intense tectonic deformation is characterized by three phases of deformation (Oliveira *et al*., 2013a). This is a particular structural scenario unknown in Iberian Pyrite Belt sequences, but it characterizes the structural style of some stratigraphic unis of the Pulo do Lobo Domain, namely, the Pulo do Lobo, Ribeira de Limas, Atalaia and Gafo formations (*e.g.* Corte Gafo and Corte Pinto regions, Silva *et al*., 2013; Oliveira *et al*., 2019). Considering the Vale de Parreiras Formation geological setting an uplift block can be considered with exposition of lower structural horizons with higher deformation.

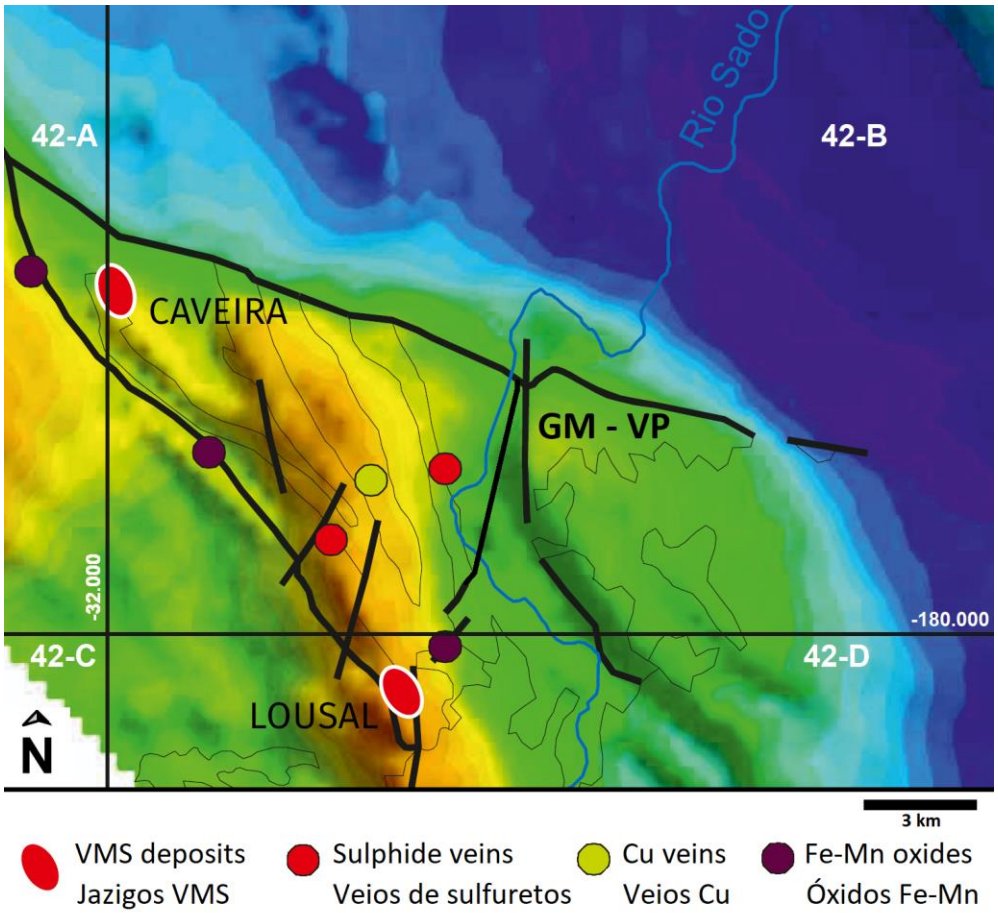

Figure 2. Garcia de Menino (GM-VP) Bouguer anomaly located over the Vale Parreira Formation. Extract of the Iberian Pyrite Belt Portuguese sector gravity map (Represas *et al*., 2016a, density 2.6). Grid limit of the 1 :50 000 Geological Map Series (LNEG; 42-A Grândola, Dias *et al*. 2011; 42-B Azinheira de Barros, Oliveira *et al*., 2006) (Coordinate system Hayford-Gauss Lisbon IPCC, in meters).

Figura 2. Anomalia de Bouguer Garcia de Menino (GM-VP) localizada sobre a Formação de Vale de Parreiras. Extrato do mapa gravimétrico do setor português da Faixa Piritosa Ibérica (Represas *et al*., 2016a, densidade 2,6). Grelha limite dos mapas 1/50 000 (LNEG; 42-A Grândola, Dias *et al.* 2011; 42-B Azinheira de Barros, Oliveira *et al*., 2006) (Sistema de coordenadas Hayford-Gauss Lisboa IPCC, em metros).

This fault controlled block setting is also reflected by the Garcia Menino Bouguer large gravity anomaly focused in the Vale de Parreiras Formation outcrops (SFM 507 Bouguer 2.7 Gravity 1/25 000 scale Map, Unp. Map Marques Bengala, LNEG Aljustrel Archive; Represas *et al*., 2016a; Matos *et al*., 2020) (Fig. 2).

3. Material and methods

Four phyllite samples were collected from Vale de Parreiras Formation outcrops and analysed for testing the presence of palynomorphs, following standard extraction and concentration laboratory procedures (Wood *et al*., 1996). Oxidation of the palynomorphs was carried out using Schultze solution. Oxidation time lasted approximately one hour, resulting in one productive sample yielding very well preserved palynomorphs (the other three samples were barren). The location of all studied samples is shown in figure 1**.** The kerogen residue of the productive sample was mounted in slides, and subsequently examined with a Nikon Eclipse Ci transmitted light microscope. All samples, residues and slides are stored in the LNEG – Portuguese Geological Survey.

The miospore biozonal scheme used follows the late Famennian Western Europe Miospore biozonal scheme (Higgs *et al*., 2000, 2013; Pereira *et al*., 2008). A selected palynomorph assemblage is presented in figure 3 and the list of all taxa mentioned in this work is accessible in Appendix. Important stratigraphic taxa are illustrated in plate 1.

The studied section is located in the eastern bank of the Sado river along an agriculture dirtroad. Vale de Parreiras 1 sample (VP1) was collected near the A2 highway bridge pillars, representing phyllites interbedded with impure quartzites intensively deformed, showing two tectonic cleavages and quartz veins subparallel to S_1 tectonic cleavage. The dense vegetation and concentration of fractures related with the Sado valley fault zone, prevent good outcrop exposure of this formation. South of the A2 highway the geological section is dominated by shale units represented by grey siliceous shales (VP2 sample) and black shales (VP3 and VP4 samples), locally with quartz veins parallel to S_1 commonly with N70W to N80W trend. No palynological results were found in these sediments.

4. Biostratigraphic results

The productive sample from Vale de Parreiras Formation provided a diverse, well-preserved and abundant miospore assemblage. The assemblage includes abundant taxa of the species *Grandispora* cf. *cornuta, Rugospora explicata*, and *R. flexuosa.* Moreover, common to abundant presence of the taxa *Cristicavatispora dispersa* and *Cyrtospora cristifera* are also a distinct feature in the studied assemblage. Another characteristic miospores includes, common *Ancyrospora? implicata, Ancyrospora* sp., *Aneurospora greggsii*, abundant *Chelinospora concinna*, *C. timanica*, *Chelinospora* sp., *Convolutispora* sp., *Cristatisporites* cf. *deliquescens*, abundant *Cristatisporites inusitatus*, *C. triangulatus*, *Cristatisporites* sp., *Diducites poljessicus*, *Geminospora lemurata*, *G. spongiata*, *Grandispora gracilis*, *G. famenensis* var. *famenensis*, *G. famenensis* var. *minuta*, *Grandispora* sp., rare *Indotrirradites* sp., *Punctatisporites minutus*, *P. solidus*, *Punctatisporites* sp.,

Raistrickia sp., *Retusotriletes planus*, *R. triangulatus*, *Retusotriletes* sp., *Verrucosisporites scurrus*, *V. premnus*, and *Verrucosisporites* sp..

Rare acritarchs (*Gorgonisphaeridium* sp.) and common prasinophyte algae from *Maranhites* genus completes the assemblage.

6. Discussion

The assemblage recovered in VP1 sample, and the co-presence of *Grandispora* cf. *cornuta*, *Rugospora explicata*, and *Rugospora flexuosa*, which have their first occurrences in the base of VCo Miospore Biozone, indicating a late Famennian age (see Fig. 3). Assemblage is complemented by the common presence of the species *Cristicavatispora dispersa*, and *Cyrtospora cristifera*. These last taxa are common in late Famennian age palynoflora assemblages recorded from Western Europe (Richardson and McGregor, 1986; Clayton *et al*., 1977; González *et al*., 2004, 2005; Pereira *et al*., 2007, 2008).

The late Famennian (Upper Devonian) sediments are well-known along Iberian Pyrite Belt, and corresponds to the Phyllite-Quartzite Group, dated mid Givetian to late Famennian (Mendes *et al*., 2020; Oliveira *et al*., 2013b, 2019; Pereira and Oliveira, 2000; Pereira *et al*., 2007, 2008, 2014, 2020 *in press*).

The Phyllite-Quartzite Group extending along more than 300 km from north of Seville, in Spain, to the Alcácer do Sal region (Matos *et al*., 2018), in Portugal, comprehends the Phyllite-Quartzite Group Formation representing its more extensive unit, the Barranco do Homem Formation and its lateral equivalent the Represa Formation (Oliveira 1990; Oliveira and Silva 1990; Oliveira and Silva, 2007), and at the upper part of the sucession, the Nascedios and Forno da Cal formations (limestone units).

The Barranco do Homem Formation is composed of quartzwackes, impure quartzites, siltstones and mudstones, dated of late Famennian age (based in palynomorphs assigned to the VH Biozone, Faria *et al*., 2015). The Vale de Parreiras Formation also shows a flysch-like sequence, comparable to the Barranco do Homem Formation age and lithologies. Thus, we suggest that the Vale de Parreiras and the Barranco do Homem formations may represent contemporal deep water depositional facies of the same or contiguous basin, although, the Barranco do Homem Formation shows a more complex tectonic history.

Similar lithologies are also found in Gafo Formation of the Pulo do Lobo Domain, with a succession of intensively deformed greywackes and interbedded slates, with minor intercalations of volcanic sandstones, intruded by metric-thick felsic and mafic volcanic rocks (Quesada *et al*., 2019). This formation is also affected by three phases of folding but its age is assigned to GF Miospore Biozone from middle Famennian age (Pereira *et al*., 2006a, b, 2008, 2020), so being slightly older than Vale de Parreiras sediments.

The Garcia Menino positive Bouguer anomaly (Fig. 2) reflects the Vale de Parreiras Formation sediments outcrops. This gravity anomaly is probably related with geological and structural sources, namely the Phyllite-Quartzite Group basement where Vale de Parreira Formation can be included.

Stratigraphically above the Vale de Parreiras Formation, the Volcano-Sedimentary Complex sequence occurs in small Palaeozoic inliers, located to the east. One of these inliers located at Monte Ferrenho (Fig. 1), consists of felsic volcanic rocks, siliceous shales and jaspers. U-Pb zircon age dating gave a concordia age of 348.6 ± 0.88 Ma, corresponding to a late Tournaisian age (Solá *et al*., 2019).

The newly late Famennian age assigned to the Vale de Parreiras Formation excludes any stratigraphic correlation with identical flysch-like sequences of the Baixo Alentejo Flysch Group, as the Mértola and Freixial formations, as interpreted by Oliveira *et al*. (2013a). The Mértola Formation has been extensively dated using high resolution stratigraphy of mid late Visean to early Serpukhovian age (Oliveira *et al*., 2004; Pereira *et al*., 2008, 2014). Near the studied area, the Mértola Formation includes greywacke beds with clay-rich mudstones dated of late Visean age (NM Biozone) in the Caveira mine (Pereira *et al*., 2008).

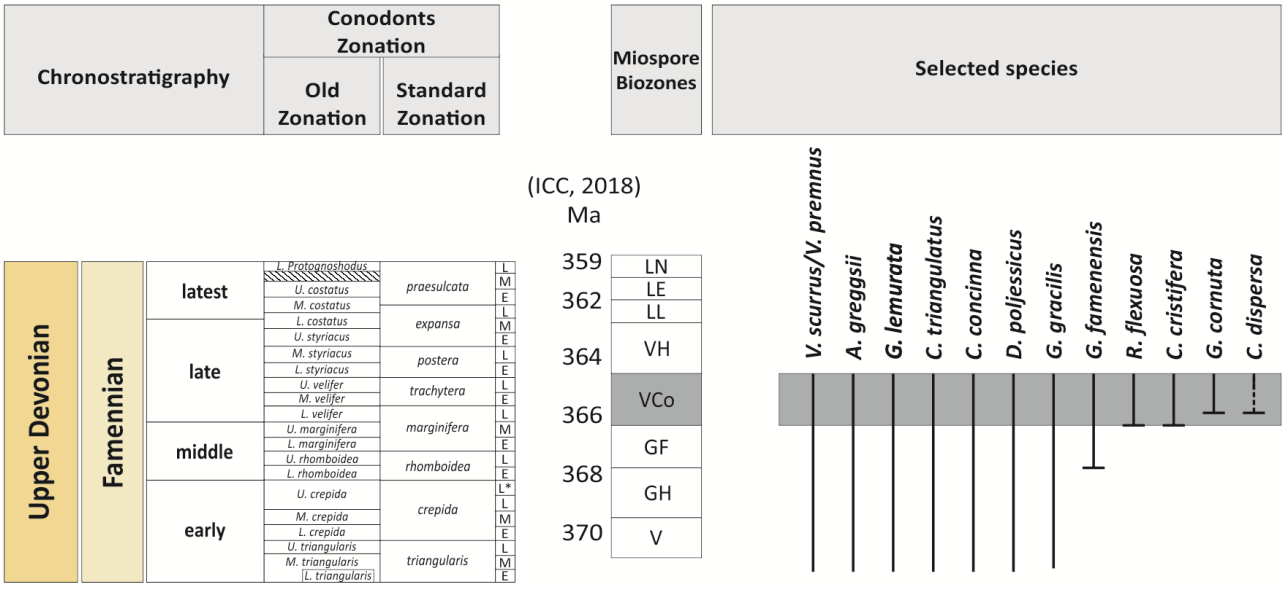

Figure 3. Conodonts and Miospore Biozonal schemes, and selected miospore taxa recovered in Vale de Parreiras Formation sediments. The zonal schemes follow Streel *et al*. (2000), Higgs *et al*. (2000, 2013) and Pereira *et al*. (2008).

Figura 3. Esquema Biozonal de Conodontes e Miosporos, com os espécimenes de miosporos recuperados em sedimentos da Formação Vale de Parreiras. Os esquemas zonais seguem Streel *et al*. (2000), Higgs *et al*. (2000, 2013) e Pereira *et al*. (2008).

The redefinition of a lower stratigraphic positioning of Vale de Parreiras Formation compared with previous knowledge may have local geological setting implications. In fact, it is now associated with the pre-orogenic Phillite-Quartzite Group and Barranco do Homem Formation geological basement rather then with the uppermost syntectonic Freixial flysch Formation.

As mentioned above, the Vale de Parreiras area corresponds to an anomalous positive gravity sector (Fig. 2) bordered by syn or late syn-tectonic thrusting over Phillite-Quartzite Formation to the SW, by a late N-S tectonic (post-Variscan *sensu lato*) faulting to the west, and by a WNW-ESE late fault to the north (Fig. 1).

Nevertheless, a fullpicture from tectonic point of view of this tectonic area should be investigated in the future.

5. Conclusions

This preliminary palynological study allowed, for the first time, the age determination for the Vale de Parreiras Formation in Iberian Pyrite Belt NW region, indicating a late Famennian age, based on the presence of well-preserved miospore assemblage, assigned to VCo Miospore Biozone. The dating of this unit may contribute to clarify the discussion of the stratigraphic position of Vale de Parreiras Formation.

The Vale de Parreiras Formation is correlated to the Barranco do Homem Formation of Phyllite-Quartzite Group, suggesting a close affinity between these formations. Both are flysch-type sequences consisting of quartzwackes interbedded with mudstones, interpreted as sedimentation on the distal sectors of deep-sea fans. However, more biostratigraphic and geochronology sedimentary provenance studies are needed to ascertain and refine this model.

The tectonic setting of the Vale de Parreiras Formation is particular and defined by intense deformation including three folding stages. The new age data is spatially correlated with the Garcia de Menino gravity Bouguer positive anomaly, showing a large exposure of Famennian age basement rocks east of the Sado valley late variscan fault zone. This setting can be correlated with a late variscan to eo-alpine fault movements and probable uplift of the block represented by the Vale de Parreiras Formation outcropping area.

This geological setting shows a less favourable scenario to mineral exploration in this Iberian Pyrite Belt sector.

Acknowledgements

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PLATE
ESTAMPA

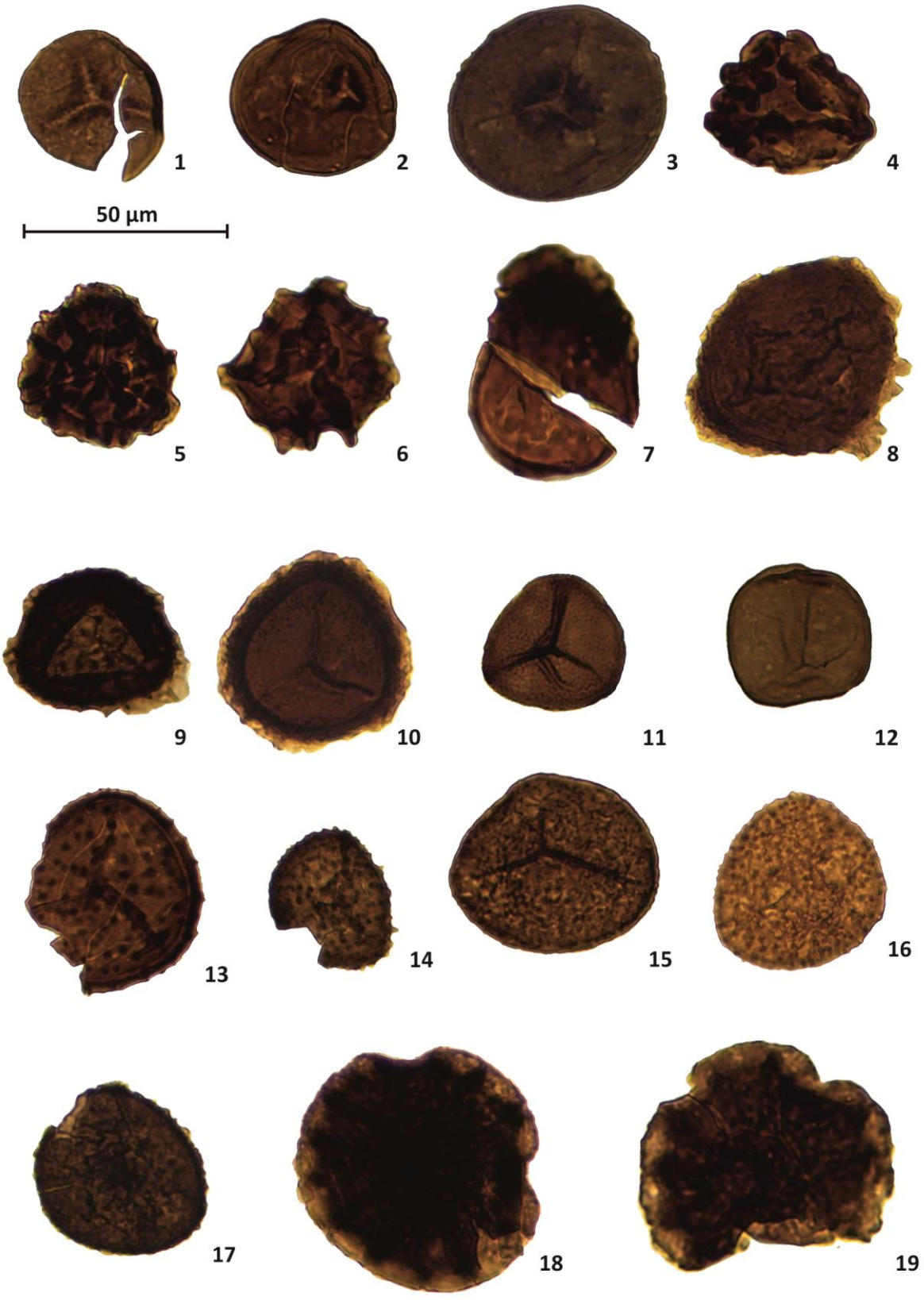

Plate 1. Selected palynomorph specimens from Vale de Parreiras Formation, Iberian Pyrite Belt. Plate caption give the taxonomic name of the figured specimen, followed by sample number, slide and photograph number, and microscope coordinates (MC). Scale bar: 50 µm. **1.** *Retusotriletes planus*, VP1 sample, slide T3(1), photo 52, MC 1628/326; **2.** *Retusotriletes triangulatus* (Streel) Streel, 1967, VP1 sample, slide T3(1), photo 28, MC 950/372; **3.** *Retusotriletes triangulatus* (Streel) Streel, 1967, VP1 sample, slide T3(1), photo 18, MC 1091/407; **4.** *Verrucosisporites* sp., VP1 sample, slide T3(1), photo 86, MC 1055/212; **5.** *Chelinospora concinna* Allen 1965, VP1 sample, slide T1(1), photo 78, MC 1137/245; **6.** *Chelinospora* sp., VP1 sample, slide T3(1), photo 94, MC 1055/190; **7.** *Cyrtospora cristifera* (Luber) emend. Van der Zwan, 1979, VP1 sample, slide T2(1), photo 32, MC 1014/132; **8.** *Cristatisporites inusitatus* (Allen) McGregor and Camfield, 1982, VP1 sample, slide T3(1), photo 49, MC 1111/329; **9.** *Cristatisporites triangulatus* (Allen) McGregor and Camfield, 1982, VP1 sample, slide T1(1), photo 82, MC 982/210; **10.** *Indotrirradites* sp., VP1 sample, slide T3(1), photo 14, MC 1028/425; **11.** *Geminospora lemurata* (Balme) emend. Playford, 1983, VP1 sample, slide T3(1), photo 2, MC 1103/493; **12.** *Geminospora lemurata* (Balme) emend. Playford, 1983, VP1 sample, slide T3(1), photo 35, MC 1035/358; **13.** *Grandispora* cf. *cornuta* Higgs, 1975, VP1 sample, slide T1(1), photo 100, MC 1000/67*;* **14.** *Grandispora gracilis* (Kedo) Streel in Becker *et al*., 1974, VP1 sample, slide T2(1), photo 24, MC 1060/290; **15.** *Rugospora explicata* González, Playford and Moreno, 2005, VP1 sample, slide T1(1), photo 74, MC 1053/257*;* **16.** *Rugospora flexuosa* (Jushko) Streel, 1974, VP1 sample, slide T1(1), photo 70, MC 1000/278*;* **17.** *Rugospora flexuosa* (Jushko) Streel, 1974, VP1 sample, slide T1(1), photo 34, MC 1038/391*;* **18.** *Maranhites* sp., VP1 sample, slide T1(1), photo 22, MC 1082/455; **19.** *Maranhites* sp., VP1 sample, slide T1(1), photo 10, MC 1085/466.

Estampa 1. Palinomorfos selecionados da Formação Vale de Parreiras, Faixa Piritosa Ibérica. A legenda da estampa fornece o nome taxonómico do espécimen ilustrado, seguido pelo número da amostra, número da lâmina e da fotografia, e pelas coordenadas do microscópio (MC). Escala: 50 µm.
1. *Retusotriletes planus*, VP1 amostra, lâmina T3(1), 52, CM 1628/326; **2.** *Retusotriletes triangulatus* (Streel) Streel, 1967, VP1 amostra, lâmina T3(1), 28, CM 950/372; **3.** *Retusotriletes triangulatus* (Streel) Streel, 1967, VP1 amostra, lâmina T3(1), 18, CM 1091/407; **4.** *Verrucosisporites* sp., VP1 amostra, lâmina T3(1), 86, CM 1055/212; **5.** *Chelinospora concinna* Allen 1965, VP1 amostra, lâmina T1(1), 78, CM 1137/245; **6.** *Chelinospora* sp., VP1 amostra, lâmina T3(1), 94, CM 1055/190; **7.** *Cyrtospora cristifera* (Luber) emend. Van der Zwan, 1979, VP1 amostra, lâmina T2(1), 32, CM 1014/132; **8.** *Cristatisporites inusitatus* (Allen) McGregor and Camfield, 1982, VP1 amostra, lâmina T3(1), 49, CM 1111/329; **9.** *Cristatisporites triangulatus* (Allen) McGregor and Camfield, 1982, VP1 amostra, lâmina T1(1), 82, CM 982/210; **10.** *Indotrirradites* sp., VP1 amostra, lâmina T3(1), 14, CM 1028/425; **11.** *Geminospora lemurata* (Balme) emend. Playford, 1983, VP1 amostra, lâmina T3(1), 2, CM 1103/493; **12.** *Geminospora lemurata* (Balme) emend. Playford, 1983, VP1 amostra, lâmina T3(1), 35, CM 1035/358; **13.** *Grandispora* cf. *cornuta* Higgs, 1975, VP1 amostra, lâmina T1(1), 100, CM 1000/67*;* **14.** *Grandispora gracilis* (Kedo) Streel in Becker *et al*., 1974, VP1 amostra, lâmina T2(1), 24, CM 1060/290; **15.** *Rugospora explicata* González, Playford and Moreno, 2005, VP1 amostra, lâmina T1(1), 74, CM 1053/257*;* **16.** *Rugospora flexuosa* (Jushko) Streel, 1974, VP1 amostra, lâmina T1(1), 70, CM 1000/278*;* **17.** *Rugospora flexuosa* (Jushko) Streel, 1974, VP1 amostra, lâmina T1(1), 34, CM 1038/391*;* **18.** *Maranhites* sp., VP1 amostra, lâmina T1(1), 22, CM 1082/455; **19.** *Maranhites* sp., VP1 amostra, lâmina T1(1), 10, CM 1085/466.

Appendix
Apêndice

All miospores, acritarchs and prasinophytes taxa recovered from the material studiedherein or mentioned in the text are listed alphabetically with full author citations.

Todos os miosporos, acritarcas e algas prasinófitas recuperados do material estudado ou mencionado no texto encontram-se listados por ordem alfabética, acompanhados pelas citações completas dos autores

Miospore
Ancyrospora? implicata González, Playford and Moreno, 2005
Ancyrospora sp.
Aneurospora greggsii (McGregor) Streel, 1974
Chelinospora concinna Allen, 1965
Chelinospora timanica (Naumova) Loboziak and Streel, 1989
Chelinospora sp.
Convolutispora sp.
Cristatisporites cf. *deliquescens* (Naumova) Arkhangielskaya, 1987
Cristatisporites inusitatus (Allen) McGregor and Camfield, 1982
Cristatisporites triangulatus (Allen) McGregor and Camfield, 1982
Cristatisporites sp.
Cristicavatispora dispersa González, Playford and Moreno, 2005
Cyrtospora cristifera (Luber) emend. Van der Zwan, 1979
Diducites poljessicus (Kedo) Van Veen, 1981
Geminospora lemurata (Balme) emend. Playford, 1983
Geminospora spongiata Higgs, Clayton and Keegan,1988
Grandispora cf. *cornuta* Higgs, 1975
Grandispora famenensis (Naumova) Streel, 1974 var. *famenensis*
Grandispora famenensis (Naumova) Streel, 1974 var. *minuta* Nekriata, 1974
Grandispora gracilis (Kedo) Streel in Becker *et al*., 1974
Grandispora sp.
Indotrirradites sp.
Punctatisporites minutus Kosanke, 1950
Punctatisporites solidus Hacquebard, 1957
Punctatisporites sp.
Raistrickia sp.
Retusotriletes planus Dolby and Neves, 1970
Retusotriletes triangulatus (Streel) Streel, 1967
Retusotriletes sp.
Rugospora explicata González, Playford and Moreno, 2005
Rugospora flexuosa (Jushko) Streel, 1974
Verrucosisporites premnus Richardson, 1965
Verrucosisporites scurrus (Naumova) McGregor and Camfield, 1982
Verrucosisporites sp.

Microphytoplankton
Acritarchs
Gorgonisphaeridium sp.

Algae
Maranhites spp.