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PALYNOMORPHS FROM ABRA LÍMITE, ZENTA RANGE, EASTERN CORDILLERA, NORTHWESTERN ARGENTINA

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ABSTRACT – This study presents the first Devonian palynological record in the Zenta Range in Eastern Cordillera, Argentina. Two associations were recognized on the basis of differences in palynomorphs and palynofacies. The palynoassemblage AL1, from the lower part of the outcrop, is characterized by chitinozoans, such as *Cingulochitina* sp. cf. *C. serrata* and *Hoegisphaera* sp. cf. *H. glabra,* accompanied by a few species of phytoplankton, which suggests the Lochkovian *s. l.*, and palynofacies indicate a marine paleoenvironment. The appearance of *Diboliporites farraginis* in the palynoassemblage AL2 suggests a Middle Devonian. The concurrence of some fresh or brackish water taxa, sporomorphs and very few acritarchs, denotes littoral conditions in this part of the succession. The transgression for the Early Devonian is recorded in AL1.

Key words: palynology, Devonian, palaeonvironment, northwestern Argentina.

RESUMO – Apresenta-se o primeiro registro palinológico devoniano da Faixa Zenta, Cordilheira Oriental, Argentina. Com base nas diferenças qualitativas e palinofácies duas associações foram reconhecidas. A associação palinológica AL1, ocorrente na parte inferior do afloramento, é caracterizada principalmente por quitinozoários, como *Cingulochitina* sp. cf. *C. serrata* e *Hoegisphaera* sp. cf. *H. glabra*, com o registro subordinado de táxons fitoplanctônicos permite posicionamento no Lochkoviano *s. l*, com características palinofaciológicas de ambiente marinho. O registro de *Diboliporites farraginis* na associação palinológica AL2 sugere correspondência com o Devoniano Médio. A ocorrência de determinados táxons de água doce ou salgada juntamente com esporomorfos e acritarcos, denota condições ambientais costeiras para a parte superior da sucessão. O marco transgressivo proposto para o Devoniano inicial, relacionado à origem da expansão da bacia sedimentar, está registado na associação palinológica AL1.

Palavras-chave: palinologia, Devoniano, paleoambientes, noroeste da Argentina.

INTRODUCTION

The Zenta Range (Figure 1) covers a surface of over 15,000 km^2 in the northern provinces of Salta and Jujuy, Argentina, reaching up to 5,000 m above sea level. In Jujuy, it comprises one of the main mountain chains on the east flank of the Eastern Cordillera. Several localities have been surveyed stratigraphically and palynologically (Vergel *et al.*, 2008a). This study presents a detailed palynological analysis recovered from a succession at Abra Límite locality (23º10.858' S, 65º0.343' W). This locality, begins over a polimictic conglomerate with Fe nodules and comprises heterolithic facies at the base followed by thick packages of sandstones interbedded with less thick beds of conglomerates and shales to fine-grained sandstones (*ca*. 250 m thick) and finishes with a greenish-grey diamictitic bed (*ca*. 50 m thick) in unconformable contact (Figure 2).

The stratigraphic distribution of the species is analysed and compared with their global ranges to assess the age and correlation of the assemblage. Palynofacies and taphonomical features are considered in order to improve previous palaeoenvironmental interpretations.

STRATIGRAPHY

The stratigraphic units of the Late Silurian to Devonian rocks from northern Argentina and southern Bolivia have been assigned to supersequence hierarchies by Starck (1995, 1999). This includes a Silurian-Jurassic tectonic-stratigraphic interval that is divided into two units separated by a regional unconformity at the end of the Devonian. In the first Silurian-Devonian unit, the Cinco Picachos, Las Pavas and Aguaragüe Supersequences are characterized by stacked, kilometre-scale, coarsening-upward shale and sandstone facies bounded by first order flooding surfaces. Under this scheme, at the Eastern Cordillera, the Baritú and Porongal formations are part of the Cinco Picachos Supersequence. The lower Baritú Formation comprises a sequence of coarsening-upward facies with a strong cyclicity. These facies become more arenaceous with medium scale crossbeding at the top. Several invertebrates, like *Australocoelia tourteloti*, *Australospirifer antarcticus* and trilobites have been found in this unit, which indicates the Early Devonian (Cuerda & Baldis, 1971; Turner, 1972). The Porongal Formation consists of conglomerates with interbedded mudstones. The Las Pavas Supersequence, at the Eastern Cordillera, is constituted by the Pescado and Cerro Piedras formations, the former composed of cross-bedding fine-grained sandstones with interbedded grey to dark grey carbonaceous shales. The Cerro Piedras unit has the highest fossil content with plant remains, trilobites, pelecypods, brachiopods and gastropods. Begining with a polimictic conglomerate and following upward by dark green to black shales (Padula *et al.*, 1967; Aceñolaza *et al.*, 1999). Padula *et al.* (1967) correlated the Cerro Piedras shales with the Icla Formation. This succesion ends with an unconformable surface where Upper Palaeozoic sediments are deposited (Padula *et al.*, 1967; Cuerda & Baldis, 1971; Starck *et al.*, 1993a,b).

MATERIAL AND METHODS

Seven samples (BAFC-Pl 2086 to 2092) were collected from a succession, of dark grey laminated fine pelites interbedded with coarse sandstones and is considered possibly Devonian (G. Aceñolaza, pers. comm.). The sample from the diamictite at the top (BAFC-Pl 2093) was studied by di Pasquo & Vergel (2008) yielding a microflora akin to the Pennsylvanian. The base of the succession, considered possibly Ordovician, is the subject of this study.

Standard palynological methods were performed to obtain organic residues from the samples. They were crushed and treated first with hydrochloric and then with hydrofluoric acid to remove carbonate, silica and silicates, respectively. The residue was sieved with a 25 μm mesh and finally mounted on slides with glycerine jelly.

The identification of palynomorphs was undertaken using both Leitz Orthoplan and Nikon Eclipse 80i trinocular transmitted light microscopes, with x1,000 maximum magnification. The photomicrographs were obtained with Motic (2.0 megapixels) and Pax-it (3.1 megapixels) video cameras and the illustrations are labelled with BAFC-Pl numbers followed by an England Finder reference. The studied samples are deposited in the Department of Geology, Faculty of Natural and Pure Sciences, University of Buenos Aires.

RESULTS

Composition of the assemblages and palaeoenvironmental considerations

The whole assemblage, recovered along the investigated interval, is composed of relatively poorly-preserved species (Appendix 1) representing diverse palynological groups such as cryptospores and trilete spores, microplankton including acritarchs and Prasinophycean, other Chlorophycean algae like *Quadrisporites*, and chitinozoans. The thermal maturity (TAI) varies between 2 and 3 according to the scale of Utting *et al.* (*in* Utting & Wielens, 1992). Two assemblages are defined based on the presence of key taxa and palynofacies differences (Figures 2-3).

Palynoassemblage AL1. This assemblage comprises five productive samples of clay/siltstone beds obtained from the basal to medium portion of the outcrop (Figure 2). It is composed mostly of marine elements (86%) mainly represented by chitinozoans (Figure 3). The biodiversity is

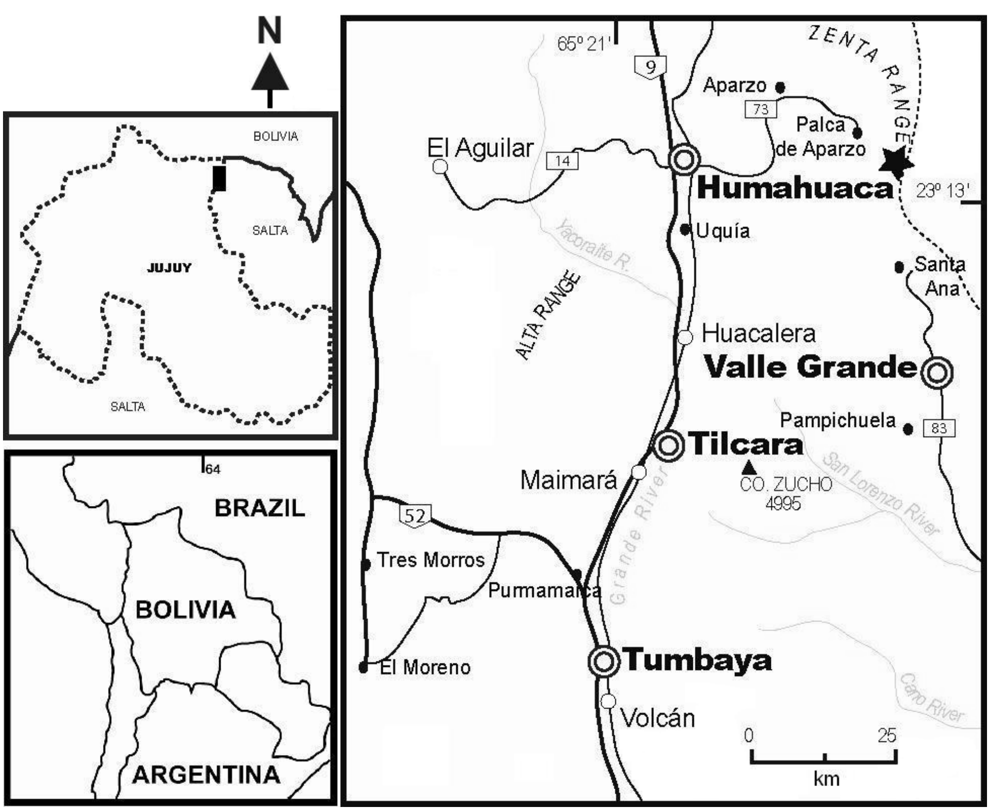

Figure 1. Map of northwestern Argentina, showing the location of the study area.

relatively high in comparison with the palynoassemblage AL2. The preservation is variable, from fairly good to quite poor, so the identification of many palynomorphs was rather difficult. The palynofacies is characterized by a high concentration of finely particulate amorphous organic matter (AOM) and a lower proportion of gelified material. A marine depocentre is supported based on the qualitative composition of the assemblage together with the palynofacies and lithology characters.

Palynoassemblage AL2. This assemblage is represented by the last 80 m of the upper part below the contact with the diamictite. It is comprised of predominantly continental elements (97%), including spores (65%) and fresh to brackish water microplankton characterized by species of *Quadrisporites* (32%). The biodiversity decreases with respect to the underlying assemblage and taxa, such as acritarchs and chitinozoans, are rare to absent, respectively (Figure 3). Dark cuticle composes the majority of the phytodebris. It is noteworthy that the brackish specimens, like *Quadrisporites* spp., ?coenobial algae, and only one spore tetrad (Figure 4M) occur in the uppermost sample (BAFC-Pl 2092, see Figures 2-3).

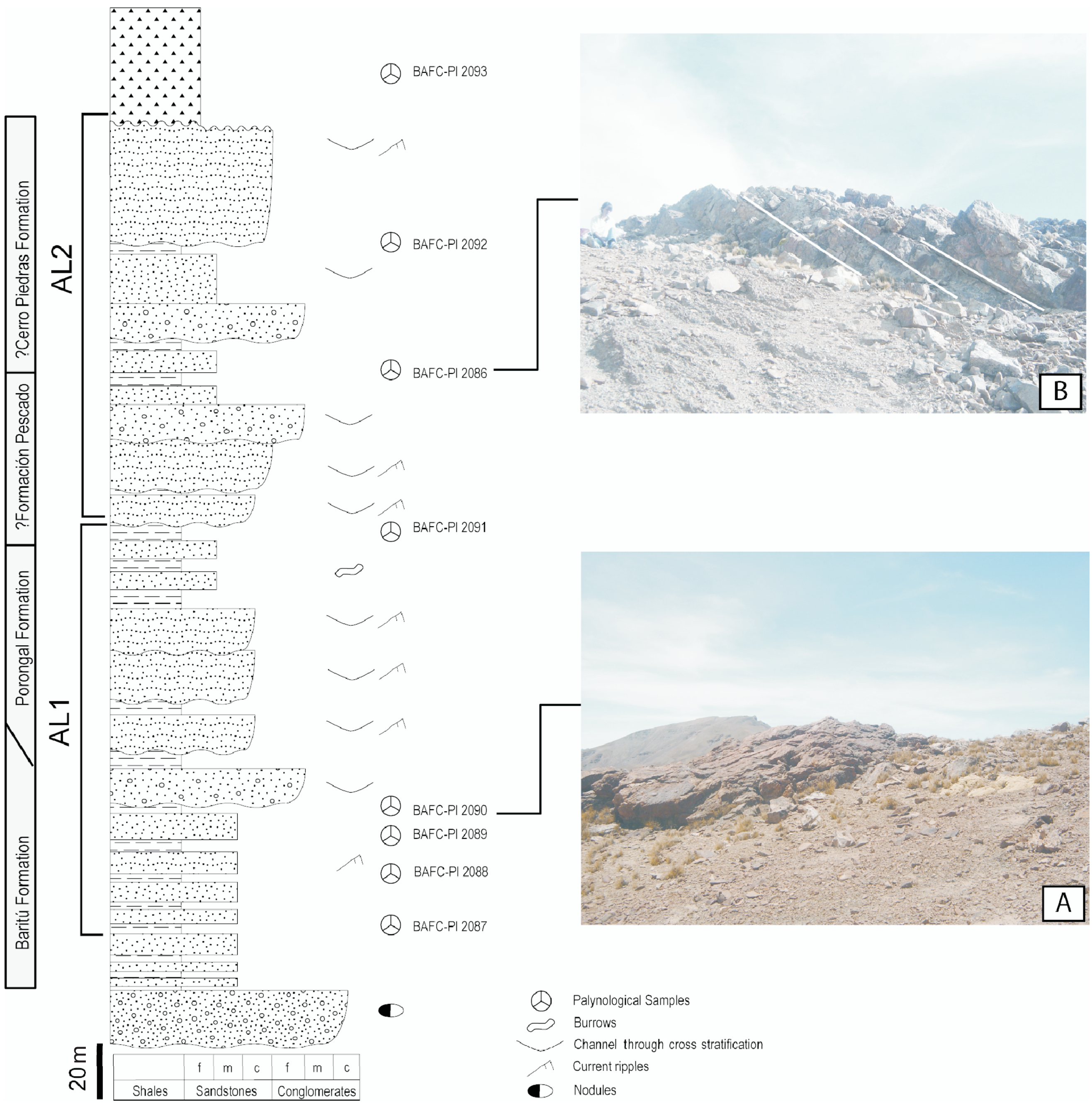

Figure 2. Stratigraphic section from the Abra Límite locality with the position of the studied samples, quoted with the BAFC-Pl acronym. **A**, channel over the fine sandstones and shale from where the sample BAFC-Pl 2090 was collected; **B**, channel erosive contact over fine sandstones and shales and lateral accretion surfaces. **Abbreviations**: **AL1**, palynoassemblage 1; **AL2**, palynoassemblage 2.

The palynofacies variations support palaeoenvironmental changes during the deposition of the succession. It is likely that the low proportion of marine elements, the high occurrence of miospores and the appearance of *Quadrisporites* spp. in the AL2 are evidence of littoral to brackish palaeoenvironments developed in this region.

Age assessment and correlation

Palynoassemblage AL1. The presence of *Hoegisphaera* sp. cf. *H. glabra* ranging from the Upper Lochkovian and to the Givetian (see Grahn *et al.*, 2003; Grahn, 2005), suggests a Lochkovian (?Late Lochkovian) age, supported by the co-occurrence of species with affinity to *Angochitina chlupaci*, characteristic of the Lochkovian strata for the Northern Hemisphere such as in Canada (Achab & Asselin, 1993; Burden *et al.*, 2002), Czech Republic (Paris *et al.*, 1981; Fatka *et al.*, 2003), Bulgaria (Lakova, 1993), the Balkan Peninsula (Haydoutov & Yanev, 1997), Austria (Priewalder, 2000) and Romania (Vaida & Verniers, 2005, 2006); *Ancyrochitina tomentosa* and *Cingulochitna serrata* which mark the upper part of the *A. chlupaci*-*A. tomentosa* Interval zone ranged as Middle-Upper Lochkovian (Lakova, 1993). The fact that there are not any species restricted to the late Silurian also supports a Lochkovian *s.l.* for AL1.

Palynoassemblage AL2. The age of this assemblage would be delimited by the appearance of *Dibolisporites farraginis*, a species that is noted from the Upper Eifelian to the Lower Frasnian (see di Pasquo, 2007). This species is accompanied by *Quadrisporites* spp. and several other species left in open nomenclature due to the poor preservation. Thus there is a paucity of diagnostic elements which reduces the confidence of the age assignment for AL2. On the other hand, the diamictite, dated as Pennsylvanian (di Pasquo & Vergel, 2008), supports the proposition of a Middle Devonian age for AL2; Vergel *et al.* (2008b) indicate a Late Devonian to Mississippian hiatus at this locality.

CONCLUSIONS

The recovered palynological material provides valuable stratigraphic and palaeonvironmental information for the stratigraphy previously established without fossils for the Zenta Range in northwestern Argentina. The stratigraphic distribution of taxa together with palynofacies differences support the recognition of two associations. The palynoassemblage AL1 is dated as Lochkovian *s.l.* based on the chitinozoans primarily, whilst the appearance of *Dibolisporites farraginis* in the palynoassemblage AL2 suggests a Middle Devonian age.

The lower part of the outcrop here studied bearing the AL1, is likely attributed to the Baritú and Porongal formations (Cinco Picachos Supersequence) in agreement with Starck (1999), although the presence of chitinozoans and other phytoplankton species enable us to reinterpret it as a marine palaeoenvironment. Instead, the upper part of this outcrop bearing the AL2 agrees with the littoral to proximal shelf Pescado and Cerro Piedras formations (Las Pavas Supersequence).

The proposed transgression for the Early Devonian, which marks the origin of the basin expansion, is registered in the palynoassemblage AL1 based on the presence of several marine taxa. In contrast, the abundance of some brackish elements such as *Quadrisporites variabilis*, *Quadrisporites granulatus*, ?coenobial algae and continental sporomorphs, the scarcity of acritarchs and the lack of chitinozoans in the palynoassemblage AL2 denote a littoral depocenter in the upper section of the studied outcrop.

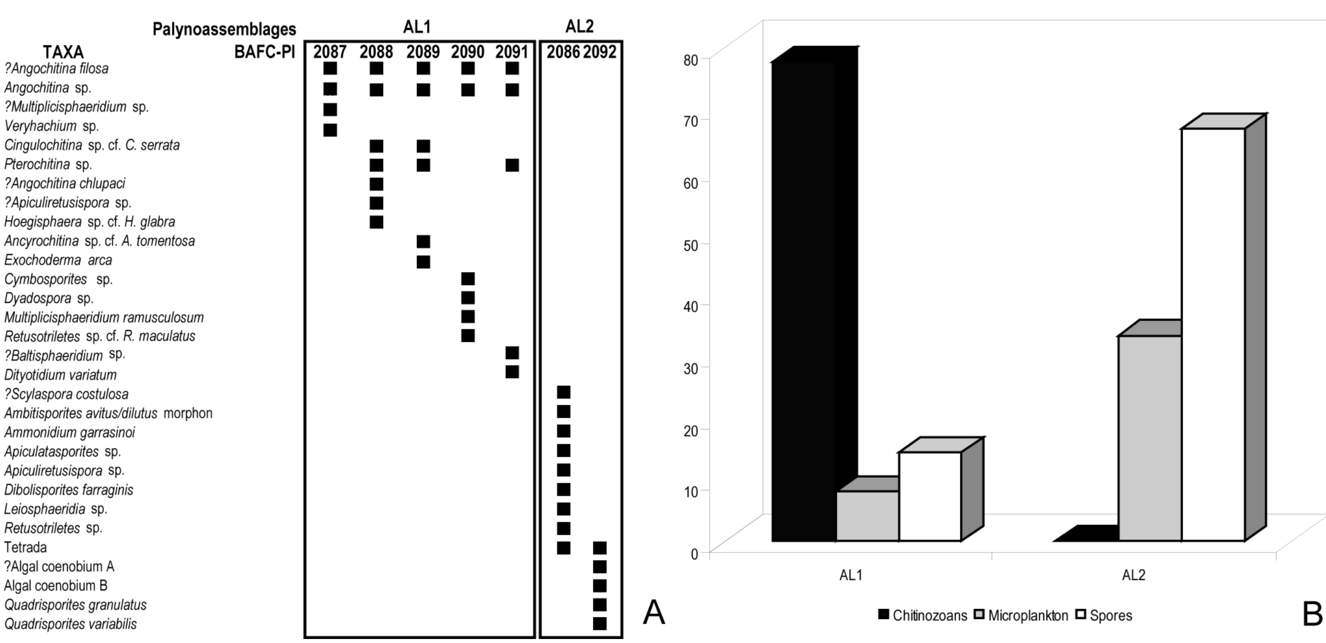

Figure 3. A, distribution of the recognized species in each one of the assemblages; **B**, statistical distribution of the main groups conforming the palynoassemblages AL1 and AL2.

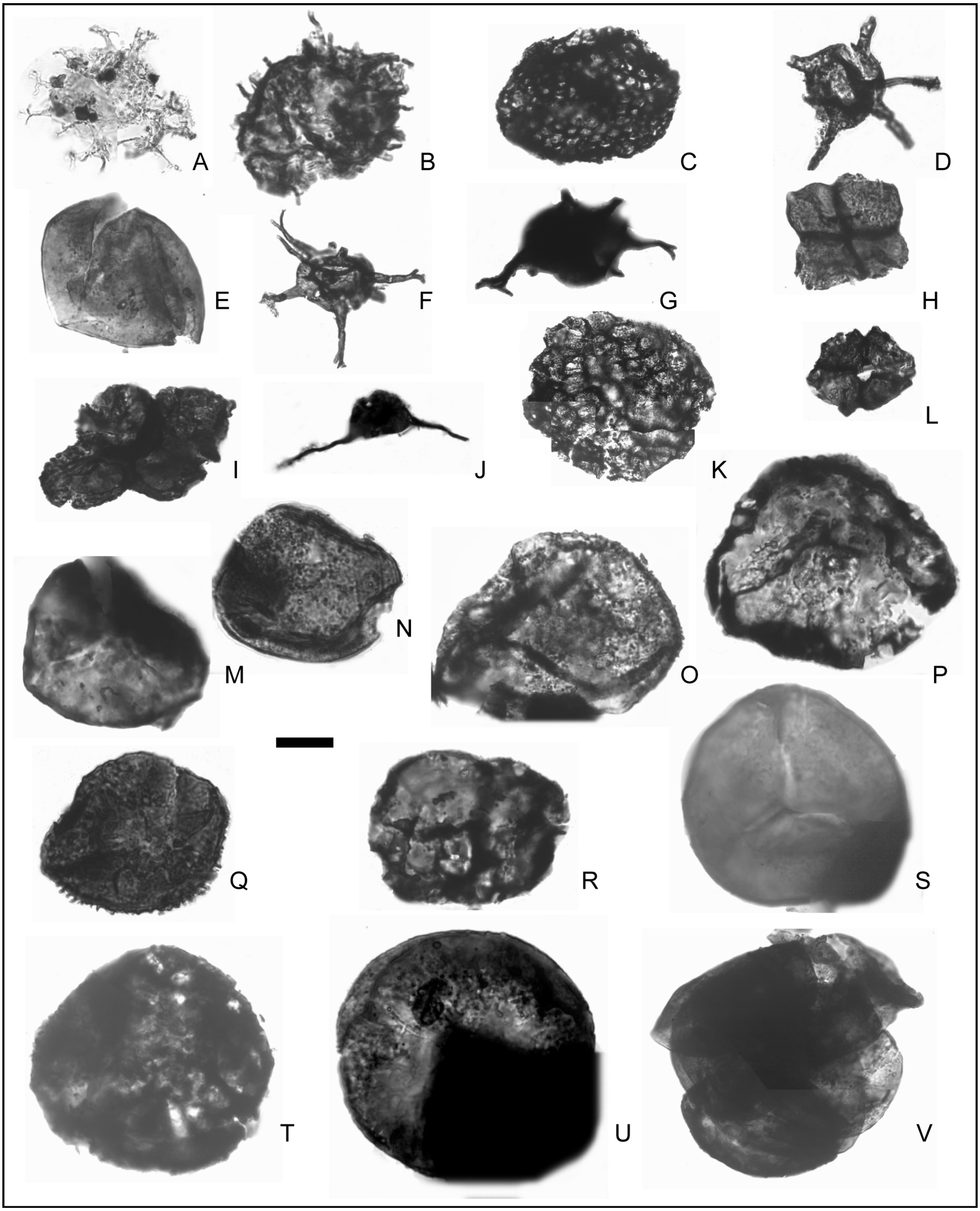

Figure 4. A, *Ammonidium garrasinoi* (BAFC-Pl 2086(1), EF: Y43/1); **B**, *Baltisphaeridium*? sp. (BAFC-Pl 2091(1), EF: F48); **C**, *Dictyotidium variatum* (BAFC-Pl 2091(1), EF: V52/3); **D**, *Exochoderma arca* (BAFC-Pl 2089(1), EF: T49/3); **E**, *Leiosphaeridia* sp. (BAFC-Pl 2086(1), EF: C26); **F**, *Multiplicisphaeridium ramusculosum* (BAFC-Pl 2091(1), EF: B48/2); **G**, ?*Multiplicisphaeridium* sp. (BAFC-Pl 2087(1), EF: C32/2); **H**, *Quadrisporites granulatus* (BAFC-Pl 2092(1), EF: X46); **I**, *Quadrisporites variabilis* (BAFC-Pl 2092(1), EF: V38/1); **J**, *Veryhachium* sp. (BAFC-Pl 2087(1), EF: C41); **K**, ?Algal coenobium A (BAFC-Pl 2092(1), EF: W34/1); **L**, Algal coenobium B (BAFC-Pl 2092(1), EF: Z38/3); **M**, *Ambitisporites avitus/dilutus* morphon BAFC-Pl 2086(1), EF: U51/1); **N**, *Apiculatasporites* sp. (BAFC-Pl 2086(1), EF: C25/1); **O**, *Apiculiretusispora* sp. (BAFC-Pl 2086(1), EF: E25/3); **P**, *Cymbosporites* sp. (BAFC-Pl 2090(1), EF: O31/2); **Q**, *Dibolisporites farraginis* (BAFC-Pl 2086(1), EF: B27/2); **R**, *Dyadospora* sp.(BAFC-Pl 2090(1), EF: S26); **S**, *Retusotriletes* sp. (BAFC-Pl 2086(1), EF: G55/3); **T**, *Retusotriletes* sp. cf. *R. maculatus* (BAFC-Pl 2090(1), EF: Q23/3); **U**, ?*Scylaspora costulosa* (BAFC-Pl 2086(1), EF: E40); **V**, Tetrad (BAFC-Pl 2086(1), EF: Z27/2). Scale bars: A, C-J, V = 20 µm.; B = 10 µm.; K, L = 35 µm.; M-U = 15 µm.

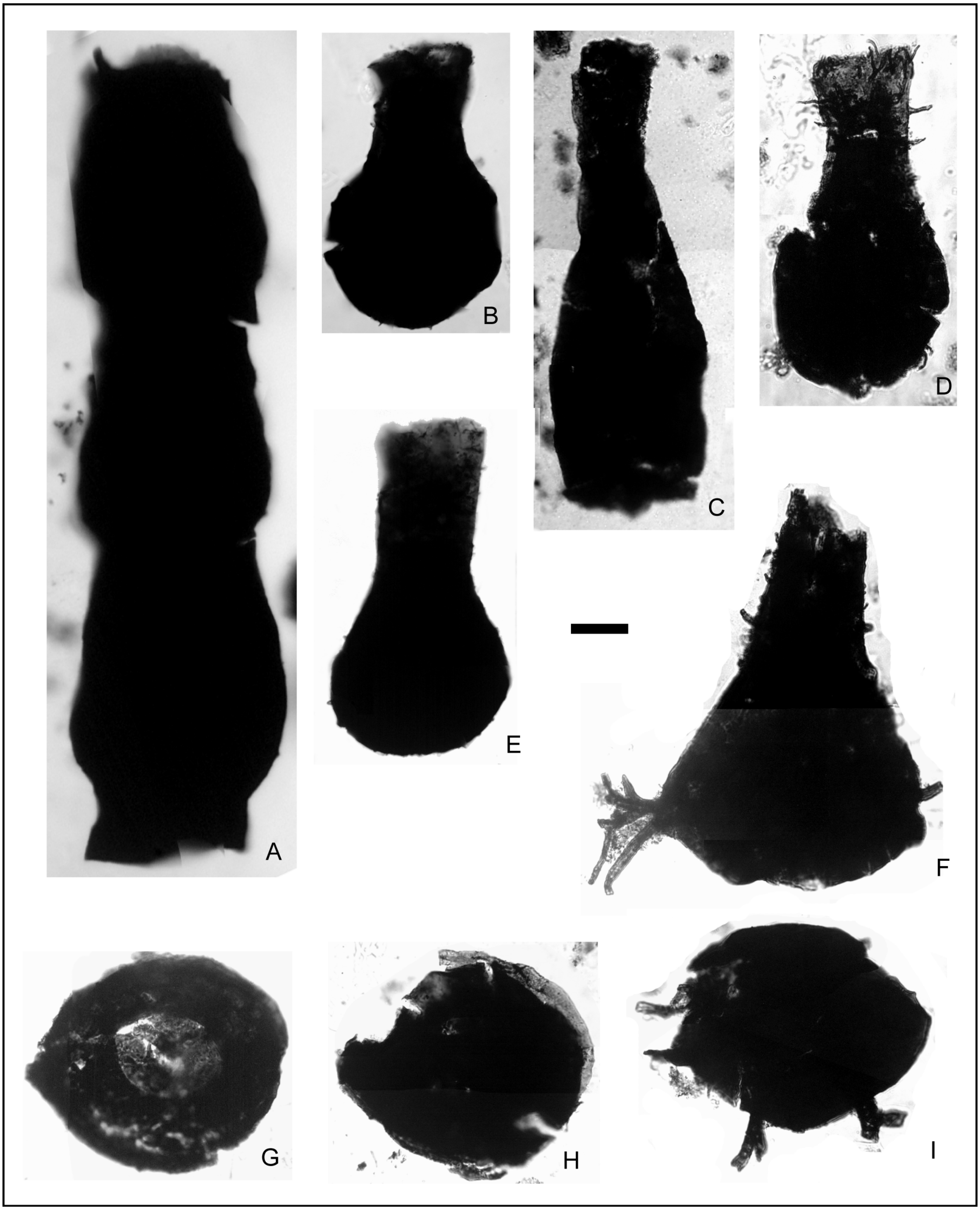

Figure 5. A, *Cingulochitina* sp. cf. *C. serrata* (BAFC-Pl 2088(1), EF: G55); **B**, *Angochitina* sp. (BAFC-Pl 2087(1), EF: E57/3); **C**, ?*Angochitina filosa* (BAFC-Pl 2090(1), EF: S34/3); **D**, *?Angochitina filosa* (BAFC-Pl 2089(1), EF: B28/3); **E**, ?*Angochitina chlupaci* (BAFC-Pl 2088(1), EF: Z46/2); **F**, **I**, *Ancyrochitina* sp. cf. *A. tomentosa* (BAFC-Pl 2089(1), EF: H23/4); **G**, *Hoegisphaera* sp. cf. *H. glabra* (BAFC-Pl 2088(1), EF: B47/3); **H**, *Pterochitina* spp. (BAFC-Pl 2088(1), EF: D45). Scale bar = 20 µm.

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Appendix 1. The species herein identified are reported in the following list by major groups and alphabetical order. Remarks are included when necessary. Some illustrated specimens are grouped at generic level due to their poor preservation which prevents a more specific assignment. Nevertheless, they are included in the stratigraphic distribution of the assemblages, and are figured together with the rest of the species as indicated in brackets (Figures 3, 4, 5).

Phytoplankton

Ammonidium garrasinoi Ottone, 1996 (Figure 4A)
Baltisphaeridium? sp. (Figure 4B). **Remarks**: *Baltisphaeridium*? sp. resembles *Baltisphaeridium* sp. (*in* Quadros, 1982, pl. 4, fig. 6), although the former bears shorter processes. *Elektoriskos* sp. A (*in* Wicander & Wood, 1981) has longer and more numerous processes.
Dictyotidium variatum Playford, 1977 (Figure 4C)
Exochoderma arca Wicander & Wood, 1981 (Figure 4D)
Leiosphaeridia sp. (Figure 4E)
Multiplicisphaeridium ramusculosum Deunff, 1976 (Figure 4F)
?*Multiplicisphaeridium* sp. (Figure 4G). **Remarks**: the specimen resembles *Multiplicisphaeridium* cf. *robertinum* (*in* Dufka & Fatka, 1993), but the poor preservation prevents a more accurate determination.
Quadrisporites granulatus (Cramer) Ströther, 1991 (Figure 4H)
Quadrisporites variabilis (Cramer) Ottone & Rosello, 1996 (Figure 4I)
Veryhachium sp. (Figure 4J)

Incertae sedis

?Algal coenobium A (Figure 4K)
Algal coenobium B (Figure 4L). **Remarks**: this specimen resembles Algal coenobium (*in* Díaz Martínez *et al.* 1999, pl. 4, fig. 3) from the Villa Molino section, Bolivia (Devonian-Carboniferous transition).

Spores and cryptospores

Ambitisporites avitus/dilutus morphon Steemans, Le Hérissé & Bozdogan, 1996 (Figure 4M)
Apiculatasporites sp. (Figure 4N)
Apiculiretusispora sp. (Figure 4O)
Cymbosporites sp. (Figure 4P)
Dibolisporites farraginis McGregor & Camfield, 1982 (Figure 4Q)
Dyadospora sp. (Figure 4R)
Retusotriletes sp. (Figure 4S)
Retusotriletes sp. cf. *R. maculatus* McGregor & Camfield, 1976 (Figure 4T)
?*Scylaspora costulosa* Breuer, Al-Ghazi, Al-Ruwaili, Higgs, Steemans & Wellman (Figure 4U)

Chitinozoans

Ancyrochitina sp. cf. *A. tomentosa* Taugourdeau & de Jekhowsky, 1960 (Figure 5F, I)
?*Angochitina chlupaci* Paris & Laufeld, 1981 (*in* Paris, Laufeld & Chlupáè, 1981 *sensu* Burden *et al.* (2002) (Figure 5E)
?*Angochitina filosa* Eisenack, 1955 (Figures 5C-D)
Angochitina sp. (Figure 5B)
Cingulochitina sp. cf. *C. serrata* Taugourdeau & de Jekhowsky, 1960 (Figure 5A)
Hoegisphaera sp. cf. *H. glabra* Staplin, 1961 (Figure 5G)
Pterochitina spp. (Figure 5H). **Remarks**: some specimens herein identified look similar to *Pterochitina* sp. (*in* Achab & Asselin, 1993) while others resemble *Pterospermella* sp. (*in* Achab *et al.* 2006, pl. 1, fig. 22), but the latter one is smaller. *Pterochitina perivelata* Eisenack 1937 has a much wider flange and *Pterochitina makroptera* Eisenack (*in* Nestor, 1994) is bigger.