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Ordovician to Lower Silurian palynomorphs from the Sierras subandinas (Subandean ranges), northwestern Argentina: a preliminary report.

[Palynomorphes de l'Ordovicien et du Silurien inférieur des Sierras subandinas ("Chaînes sub-andines"), nord-ouest de l'Argentine : rapport préliminaire]

Claudia Viviana RUBINSTEIN [1]

Key Words: Ordovician; Silurian; palynomorphs; biostratigraphy; palaeogeography; palaeoenvironment

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Mots-Clefs : Ordovicien ; Silurien ; palynomorphes ; biostratigraphie ; paléogéographie ; paléoenvironnement

Introduction

Ordovician clastic sediments of the Central Andean Basin, northwestern Argentina, were deposited in a proto-Andean foreland basin on the western margin of Gondwana (ASTINI, 2003; ASTINI & MARENGO, 2003). The Sierras Subandinas (Subandean Ranges) represent the outermost exposures of this Ordovician basin, where proximal environmental settings and their related palynological content are currently being analysed. These platform facies are exposed in the Eastern Cordillera, where palynological knowledge has increased remarkably in recent years (RUBINSTEIN & TORO, 2001; RUBINSTEIN, 2003). On the other hand palynological information on the deep marine facies exposed in the Puna is still meager and involves only the Ordovician-Silurian boundary (RUBINSTEIN & VACCARI, 2004) (Pl. 1).

The outermost portion of the foreland basin, the Sierras Subandinas, is characterized by alternating shallow-marine deltaic systems and estuarine environments, which indicate repeated changes in the coast line caused by fluctuations in relative sea-level (ASTINI & MARENGO, 2003) (Pl. 1). These authors undertook a detailed study of sequence stratigraphy in the Ordovician-earliest Silurian rocks of this region. However, determination of their age is difficult because of the scarcity in some units of biostratigraphically useful fossils.

Ordovician and earliest Silurian rocks are well exposed along the Río Capillas, in the Sierra de Zapla, Jujuy Province (Fig. 1). The lowest unit is the Zanjón Formation, considered as middle-late Arenig. It is followed in succession by the Labrado Formation with its two sub-units, the late Arenig Laja Morada Member and the early-middle Llanvirn Lagunillas Member; the Capillas Formation, of late Llanvirn-basal Caradoc age; the Centinela Formation, considered to be not older than late Caradoc, and the Zapla Formation of Hirnantian age. The uppermost Ordovician is overlain by the Silurian Lipeón Formation that initiates a separate supercycle (ASTINI & MARENGO, 2003; ASTINI *et alii*, 2003).

This work analyses the succession of palynological assemblages throughout the Ordovician and lower Silurian, and attempts to determine the biostratigraphic control of the units, their palaeogeographic affinities, and the palaeoenvironmental changes related to recurrent fluctuations in sea level.

Palynological results

All units involved in this study yielded palynomorph assemblages that include acritarchs and related marine forms, chitinozoans and cryptospores (Pl. 1). Their abundance, diversity and preservation range widely in accordance with stratigraphic level and sedimentary facies.

Detailed descriptions and illustrations of the palynological assemblages from all units discussed herein are currently in progress.

The Zanjón Formation is characterized by repeated tidal parasequences that shallow-upward into heterolithic and muddy intervals. It yielded a rich acritarch assemblage containing *Striatotheca principalis parva* BURMANN 1970, *Arbusculidium filamentosum* (VAVRDOVÁ) VAVRDOVÁ 1972 emend. FATKA et BROCKE 1999, *Aureotesta clathrata* var. *simplex* (CRAMER *et alii*) emend BROCKE *et alii* 1998, *Cymatiogalea*

[1] *CONICET, Unidad de Paleopalinología, IANIGLA, CRICYT, C.C. 131, 5500 Mendoza (Argentina)*
crubinst@lab.cricyt.edu.ar

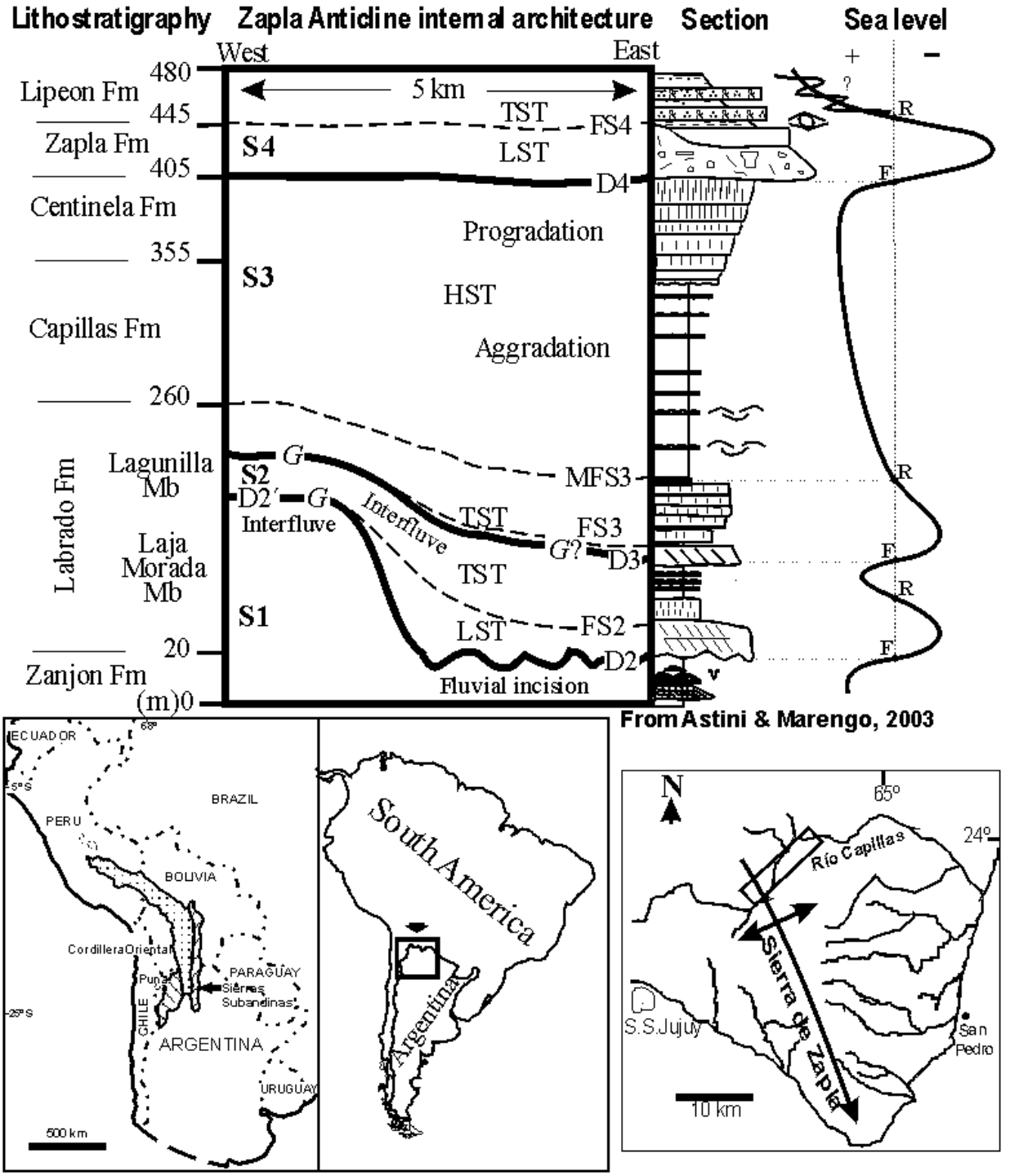


Figure 1: Location map of the study area, in the Sierras Subandinas, north-west Argentina. Ordovician and Lower Silurian stratigraphy of the Sierra de Zapla, recognized sequences, lithologies and sea-level curve from ASTINI & MARENGO, 2003.

granulata VAVRDOVÁ 1966, *Cymatiogalea messaoudensis* JARDINÉ *et alii* 1974 var. *messaoudensis* autonym, *Rhopaliophora palmata* (COMBAZ et PENIGUEL) PLAYFORD et MARTIN 1984, *Dactylofusa velifera* COCCHIO forma *brevis* ALBANI 1989, *Eisenackidium orientalis* RUBINSTEIN *in* RUBINSTEIN *et alii*, 1999, *Coryphidium* sp., and *Vogtlandia* sp.. This assemblage can be correlated with acritarchs of the Acoite Formation in the Cordillera Oriental. Consequently, its age is not younger than middle Arenig, although stratigraphic correlation suggests that it includes the late Arenig.

The lower subdivision of the Labrado Formation, the Laja Morada Member, records exposure during a lowering of relative sea level indicated by subaerial features and a gradual change toward purple-red colours near the top. Consequently, the only palynomorphs present are leiospheres and other prasinophycean algae such as *Cymatiosphaera*, all devoid of

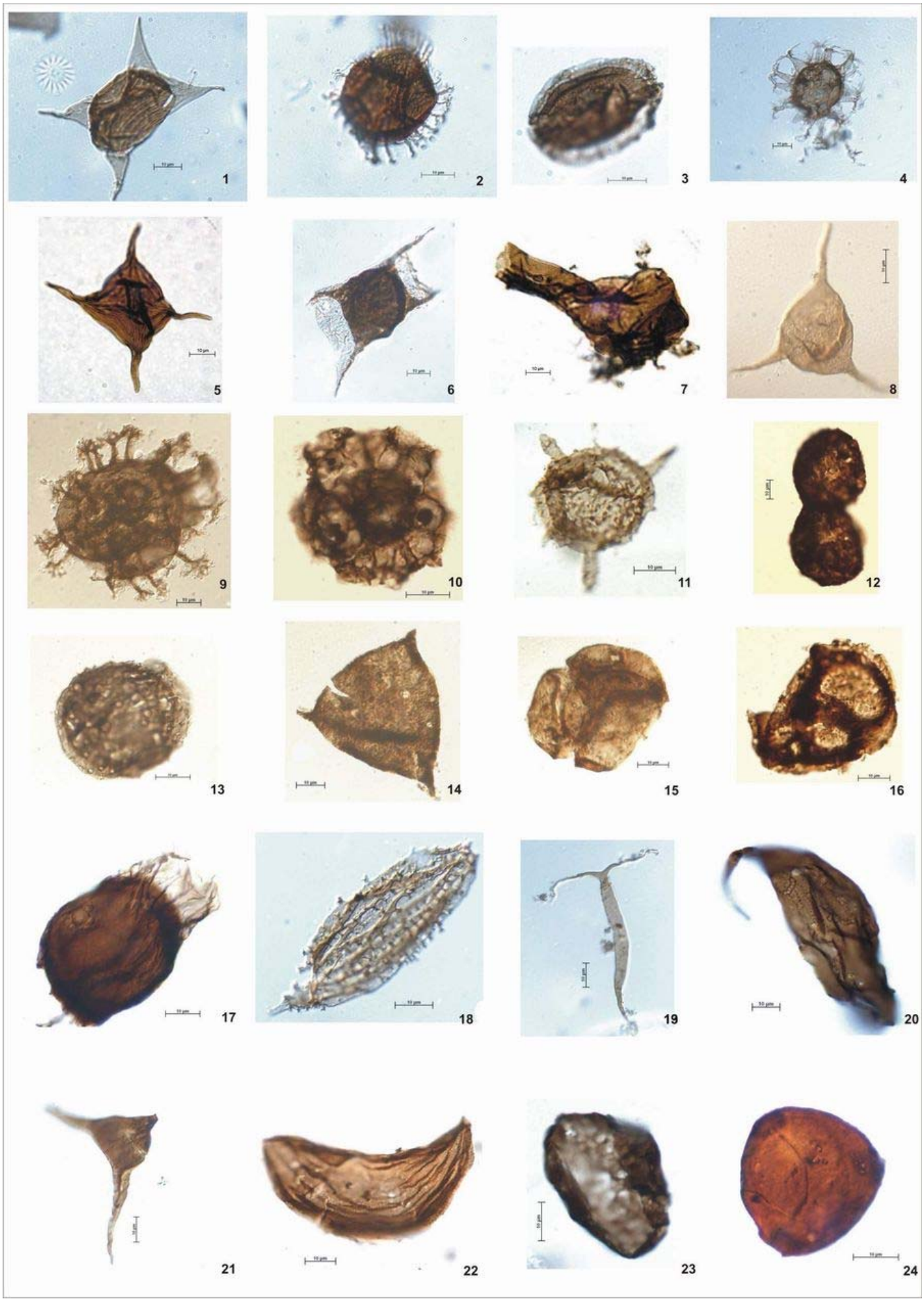
stratigraphic value. The upper Lagunillas Member, representing restricted estuarine facies, yielded a poorly diversified assemblage with some acritarchs such as ? *Aremoricanium simplex* LOEBLICH & MCADAM 1971, in addition to leiospheres.

Transition to the open marine deposits of the Capilla Formation is indicated by a maximum flooding surface. This formation yielded a rich and well-preserved acritarch assemblage containing such taxa as *Arbusculidium filamentosum*, *Striatotheca* spp., *Arkonia* sp., *Dactylofusa* cf. *D. striatogranulata* JARDINÉ *et alii* 1974, *Ericanthea pollicipes* CRAMER et DÍEZ 1977, *Liliosphaeridium* cf. *L. intermedium* (EISENACK) PLAYFORD *et alii* 1995 and *Leprotolypa evexa* COLBATH 1979. It also contains cryptospores of the morphon *Dyadospora murusattenuata* STROTHER et TRAVERSE 1979 *sensu* STEEMANS *et alii* 1996, and *Sphaerasaccus glabellus* STEEMANS *et alii* 2000. The latest record of *Arbusculidium filamentosum*, independently dated, is probably lowermost Llanvirn. But other less well age-constrained records of its occurrence attain the Llanvirn and may reach the Caradoc strata (TONGIORGI *et alii*, 2003). The genus *Striatotheca* may also extend up to the Caradoc (VECOLI & LE HÉRISSÉ, 2004). The genus *Arkonia*, and the species *Ericanthea pollicipes* and *Liliosphaeridium* cf. *L. intermedium* were recorded from Llanvirn strata (TONGIORGI *et alii*, 2003; VECOLI & LE HÉRISSÉ, 2004) and *Dactylofusa striatogranulata*, previously known only in the Ashgill has recently been found in the middle Arenig (uppermost Lower Ordovician) of Argentina (ACHAB *et alii*, in press). Furthermore, *Leprotolypa evexa* is unknown below the base of the Caradoc (VECOLI & LE HÉRISSÉ, 2004). Although there is some dispersion in the stratigraphic ranges of the acritarch species, a late Llanvirn-earliest Caradoc age assignment for the Capilla Formation based on the presence of *Sacabambaspis janvieri* (Vertebrata), roughly agrees with the age inferred from the palynomorph assemblages.

The Centinela Formation contains mainly leiospheres, pre-cryptospores and simple acanthomorph acritarchs, and testifies to a possible progradation of localized deltaic complexes. At its upper limit a regional unconformity correlated with a major eustatic fall in sea-level caused by the Hirnantian glaciation separates the Centinela Formation from the uppermost Ordovician Zapla Formation.

The palynomorph assemblages of the Zapla glacial horizon are dominated by marine elements such as *Villosacapsula* sp., subordinate acanthomorph acritarchs (*Polygonium*, *Micrhystridium*, *Multiplicisphaeridium*) and leiospheres, but also contain terrestrial cryptospores (mainly tetrads). Stratigraphically, the Zapla Formation is dated latest Ordovician, probably corresponding to the Hirnantian Glaciation. However, chitinozoans indicate an Aeronian *s.l.* to early Telychian age (GRAHN & GUTIÉRREZ, 2001). Acritarch assemblages are meager and not well preserved so they do not provide accurate stratigraphic control. In addition, transgressive-regressive events frequently caused reworking of fossils. Nevertheless, it should be noted that no typical Silurian forms were found among acritarchs or cryptospores. Further investigations, particularly on chitinozoans from the levels under discusssion, may shed some light on this controversy.

The Lipeón Formation initiates a new supercycle with the deposition of oolitic ironstones during the transgression that followed the Hirnantian glaciation. These Silurian deposits correspond to a series of high-frequency sea-level fluctuations. In the area studied the lowermost levels of the Lipeón Formation have yielded abundant, diverse and well-preserved palynomorphs. The assemblage is dominated by acritarchs and prasinophyte algae, but also contains cryptospores and chitinozoans. Acritarch species include *Domasia trispinosa* DOWNIE 1960, *Domasia elongata* DOWNIE 1960, *Dactylofusa estillis* CRAMER et DIEZ 1972, *Dactylofusa maranhensis* BRITO et SANTOS 1965, *Beromia rexroadii* WOOD 1996, *Baiomeniscus camurus* LOEBLICH 1970, *Carminella maplewoodensis* CRAMER 1968, *Eupoikilofusa striatifera* (CRAMER) CRAMER 1970, among others. Cryptospores are represented by tetrads and also *Imperfectotriletes vavrdovae* (RICHARDSON) STEEMANS *et alii* 2000 and *Laevolancis chibrikovae* STEEMANS *et alii* 2000. The acritarch assemblage shares some species with those described by BULTYNCK & MARTIN (1982) from the lower part of the unit, dated late Llandovery-early Wenlock, and also has species in common with acritarch assemblages from the Vargas Peña Formation, in Paraguay (WOOD & MILLER, 1997). The palynomorphs of the Lipeón Formation have particularly strong affinities with the assemblage of the Tianguá Formation, in the Brazilian Parnaíba Basin (LE HÉRISSÉ *et alii*, 2001). In the Subandean Ranges, the lower part of this unit was referred to the early Llandovery (*Parakidograptus acuminatus- Atavograptus atavus* graptolite biozones) by RICKARDS *et alii* (2002). On the other hand, in the Río Capillas section, chitinozoans indicate a late Telychian age for the lower part of this formation (GRAHN & GUTIÉRREZ, 2001). Nevertheless, the acritarch assemblage of the Lipeón Formation suggests an age probably near the Aeronian/Telychian boundary and not older than late Aeronian (RUBINSTEIN & TORO, in press).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◀ **Plate 1:** The palynological slides are housed in the Paleopalynological Slide Collection of the Unit of Paleopalynology, IANIGLA, CRICyT, Mendoza. Specimen locations are referred to using England Finder coordinates.
1- *Eisenackidium orientalis* RUBINSTEIN *in* RUBINSTEIN *et alii*, 1999. Zanjón Fm, 7999d, U33/1.
2- *Cymatiogalea granulata* VAVRDOVÁ 1966. Zanjón Fm, 7999d, K41/2.
3- *Dactylofusa velifera* COCCHIO forma *brevis* ALBANI 1989. Zanjón Fm, 8000d, N35/3.
4- *Cymatiogalea messaoudensis* JARDINÉ *et alii* 1974 var. *messaoudensis* autonym. Zanjón Fm, 7999c, E34/0.
5- *Striatotheca principalis parva* BURMANN 1970. Zanjón Fm, 7587i, A24/1.
6- *Aureotesta clathrata* var. *simplex* (CRAMER *et alii*) emend BROCKE *et alii* 1998. Zanjón Fm, 7999d, C37/2.

7- ?*Aremoricanium simplex* LOEBLICH et MCADAM 1971. Labrado Fm, Lagunilla Member, 7595a, M26/1.
8- *Arkonia* sp. Capillas Fm, 7589g, N38/0.
9- *Liliosphaeridium* cf. *L. intermedium* (EISENACK) PLAYFORD *et alii* 1995. Capillas Fm, 7589c, W45/4.
10- *Ericanthea pollicipes* CRAMER et DIEZ 1977. Capillas Fm, 7589h, V40/2.
11- *Leprotolypa evexa* COLBATH 1979. Capillas Fm, 7588c, B22/1.
12- Morphon *Dyadospora murusattenuata* STROTHER et TRAVERSE 1979 *sensu* STEEMANS *et alii* 1996. Fm. Capillas, 7589h, F23/0.
13- *Sphaerasaccus glabellus* STEEMANS *et alii* 2000. Capillas Fm, 7589h, P36/1.
14- *Villosacapsula* sp. Zapla Fm, 7590e, B23/0.
15- Tetrad 1. Zapla Fm, 7590d, W35/3.
16- Tetrad 2. Zapla Fm, 7583d, S28/0.
17- *Carminella maplewoodensis* CRAMER 1968. Lipeón Fm, 7592d, W43/0.
18- *Dactylofusa maranhensis* BRITO et SANTOS 1965. Lipeón Fm, 7582e, Y34/2.
19- *Domasia elongata* DOWNIE 1960. Lipeón Fm, 7582e, L33/2.
20- *Dactylofusa estillis* CRAMER et DIEZ 1972. Lipeón Fm, 7592g, P30/0.
21- *Beromia rexroadii* WOOD 1996. Lipeón Fm, 7582e, M27/0.
22- *Baiomeniscus camurus* LOEBLICH 1970. Lipeón Fm, 7592g, Y38/0.
23- *Laevolancis chibrikova*e STEEMANS *et alii* 2000. Lipeón Fm, 7592f, Y44/2.
24- *Imperfectotriletes vavrdovae* (RICHARDSON) STEEMANS *et alii* 2000. Lipeón Fm, 7582e, F25/2.

Conclusions

Although still in a very preliminary stage, the analyses in this contribution provide biostratigraphic, palaeogeographic and palaeonvironmental information about the palynomorph assemblages of the Central Andean Basin. They cover almost all of Ordovician, the Ordovician/Silurian transition and the Lower Silurian.

The acritarch assemblages of the Zanjón Formation provide the first age constraint for this unit. For the Capillas Formation, acritarch assemblages support the age suggested by other fossils. The palynomorph assemblages of the Zapla and Lipeón formations allow an independent age assessment.

From a palaeogeographic viewpoint, it is significant that acritarchs from the Zanjón Formation clearly show affinities to those of the peri-Gondwana province. Acritarchs of the lower Silurian also have Gondwanian affinities.

Palynological assemblages recovered from the several depositional settings vary in diversity, composition and abundance, thus indicating the existence of a relationship between palynomorphs and local palaeoenvironments.

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