

Late Ordovician-Early Silurian palynomorphs from the Cordillera Oriental, Central Andean Basin, northwestern Argentina: a contribution to the advent of vascular plants in South America

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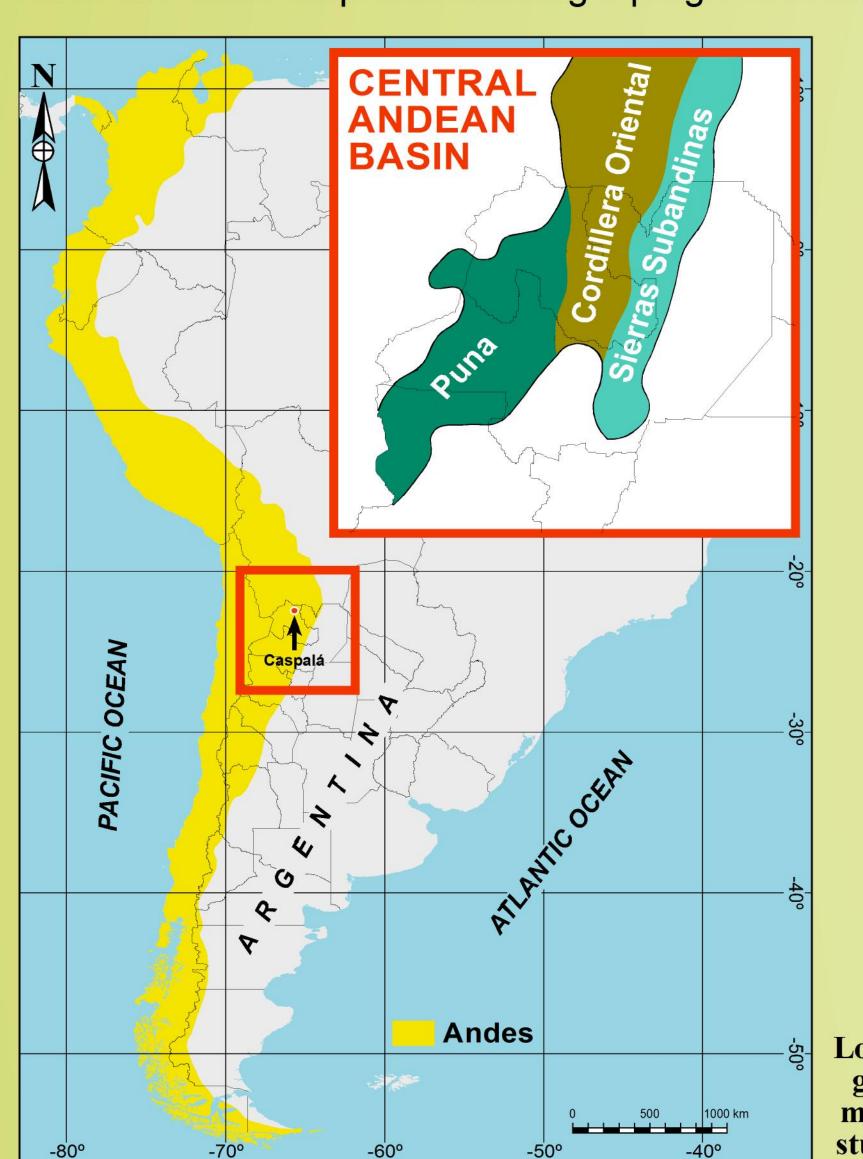


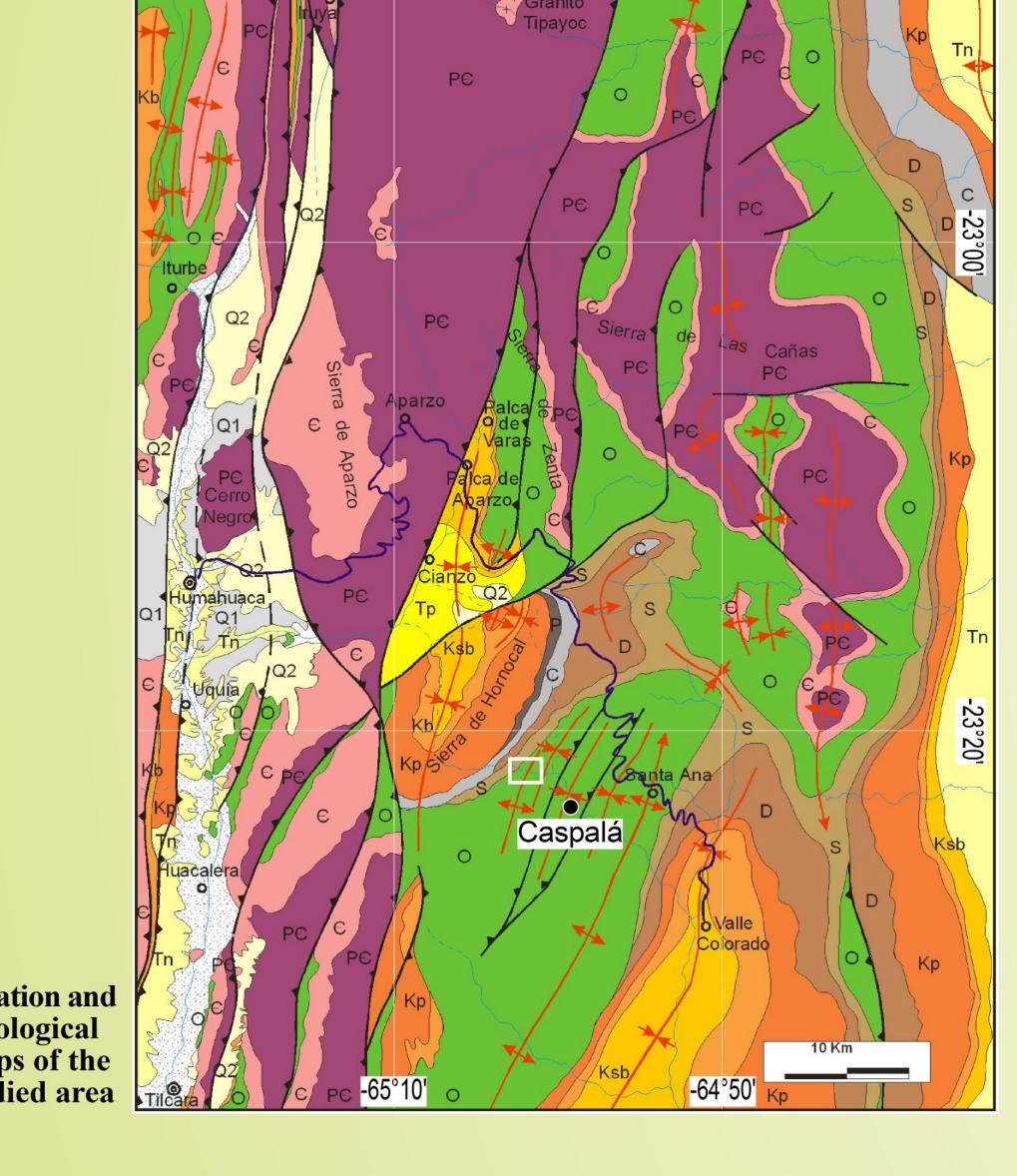
The Hirnantian "glacial horizon" has been recognized across the Central Andean Basin in northwestern Argentina. It is represented by glaciofluvial to glaciomarine facies which unconformably overly Lower to Middle Ordovician stratigraphic units. In the Caspalá area, in the eastern margin of the Cordillera Oriental, the glacial deposits are assigned to the Caspalá Formation. The Lower Silurian postglacial deposits of the Lipeón Formation sharply truncate the underlying Caspalá Formation.

GEOLOGY

The Caspalá Formation are composed of a massive diamictite with few pebbles and oversized striated boulders overlying a strongly disturbed substrate, indicating soft-sediment folding, deformation, and partial reworking of the previous older sedimentary record, followed by graded quartz-rich arenites with a few fine-grained partitions toward

The Lipeón Formation sharply truncates the glacial deposits with both marked grain-size diminution and strong compositional change. It shows a more homogeneous appearance although its detailed inspection allows the recognition of a heterolithic stratofabric with interbedded dark gray shales and fine-grained lenticular to tabular thin beds of sandstones strongly mottled and affected by burrowing (intense bioturbation - Ichnofabric indexes 4 & 5 of Droser and Bottjer, 1986). Progressively toward the top, thicker beds of graded and laminated sandstones are more and more frequent indicating a progradational arrangement.





PALYNOLGICAL RESULTS

Palynomorph assemblages across the Ordovician/Silurian boundary are mainly marine, exhibiting a clear predominance of chitinozoans and organic-walled phytoplankton.

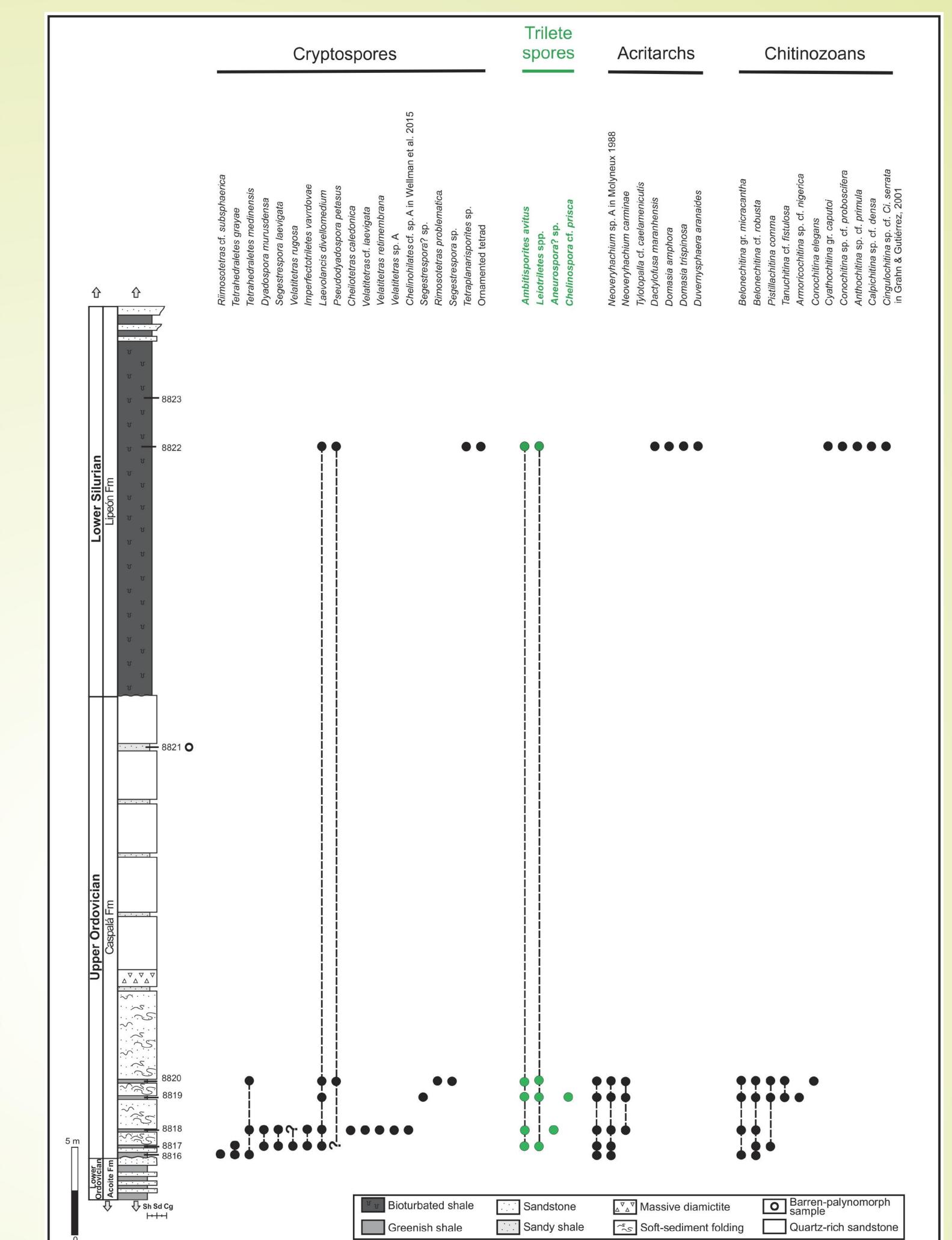
CHITINOZOANS

n the Caspalá Formation, chitinozoans were recovered from the lower levels of the glacial deposits (samples 8816-8820) characterized by extensive reworking. The assemblages yielded Katian chitinozoans mostly represented by broken specimens. The lower samples (8816, 8817 and 8818) contain an early Katian association mainly composed of Belonechitina gr. micracantha, Belonechitina cf. robusta and Pistillachitina comma. The following samples, from upper levels (samples 8819 and 8820), additionally contain late Katian chitinozoan species such as Tanuchitina cf. fistulosa, Conochitina elegans and Armoricochitina cf. nigerica. Chitinozoans from the outcrops of the Lipeón Formation derive from the lower half of the unit, which is characterized by intense

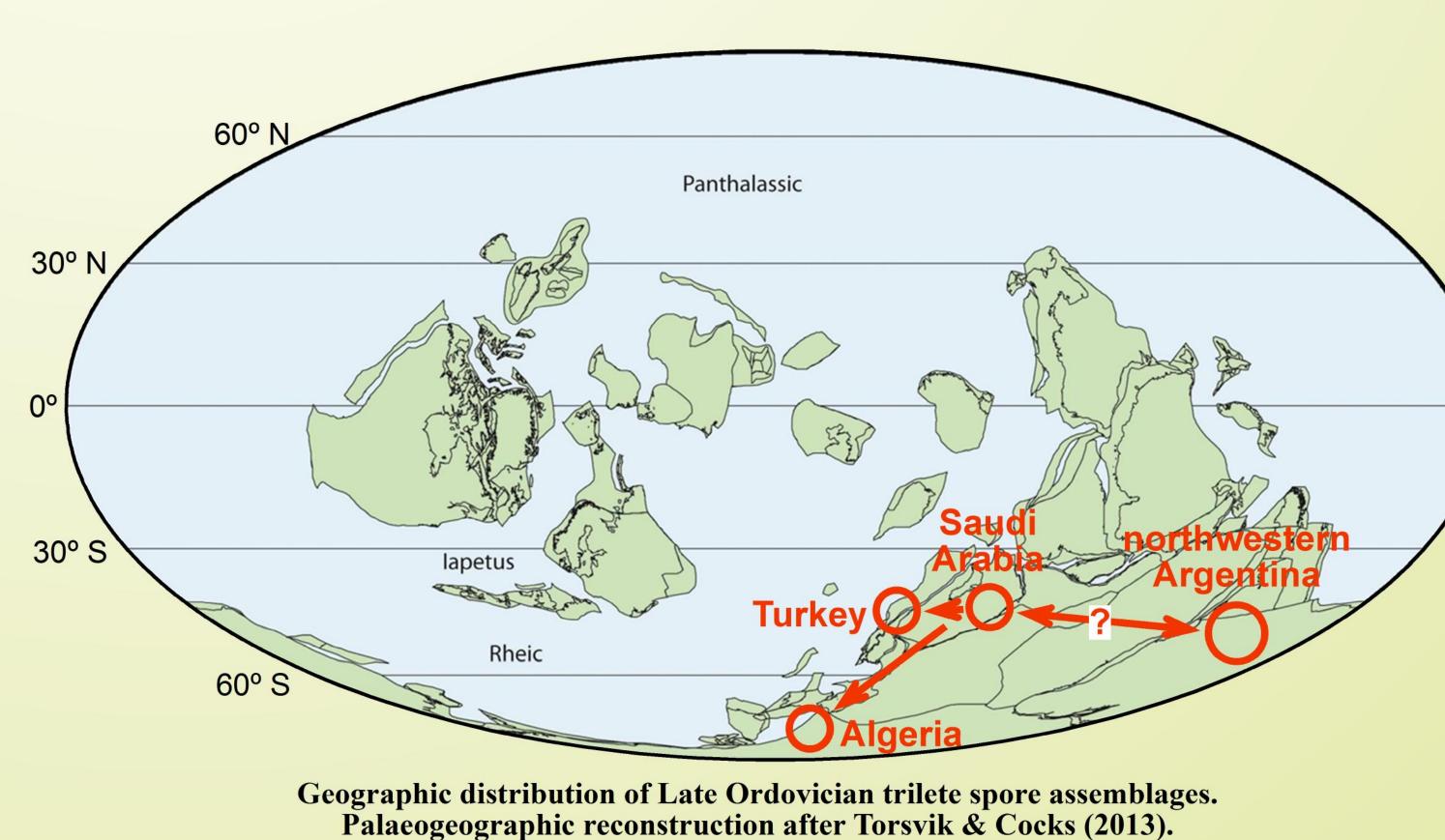
The recovered chitinozoan association contains Cyathochitina gr. caputoi, Conochitina cf. proboscifera, Anthochitina cf. primula, Calpichitina cf. densa and Cingulochitina cf. serrata, thus indicating a Telychian age for the Silurian deposits in this area.

ORGANIC-WALLED PHYTOPLANKTON (ACRITARCHS)

Acritarch assemblages from the Caspalá Formation are relatively diverse, with scarce Late Ordovician (Katian-Hirnantian) diagnostic species such as Neoveryhachium carminae, Neoveryhachium sp. A in Molyneux, 1988 and Tylotopalla cf. caelamenicutis and high participation of Early and Middle Ordovician taxa. The overlying Lipeón Formation yielded a diverse acritarch assemblage. Among these acritarchs, index-taxa such as Dactylofusa maranhensis, Domasia amphora, Domasia trispinosa and Duvernaysphaera aranaides can be highlighted.



Schematic stratigraphic column of the Caspalá and Lipeón formations in the Caspalá area



PALAEOBIOGEOGRAPHY OF MARINE PALYNOMORPHS

In the Caspalá Formation, the presence of acritarchs such as Tylotopalla caelamenicutis, Neoveryhachium carminae and Neoveryhachium sp. A locates the Central Andean Basin of northwestern Argentina in the high latitude Gondwanan palaeophytoprovince. In the same way, Late Ordovician chitinozoan assemblages display affinities with high latitude Gondwanan faunas.

In the Lipeón Formation, marine palynomorphs also support Gondwanan and peri Gondwanan affinities particularly indicated by the presence of Dactylofusa maranhensis, that exclusively occurs in Gondwanan and peri-Gondwanan

MIOSPORES

Cryptospores recovered from the lower levels of the Caspalá Formation (8816, 8817 and 8818) are represented by permanent tetrads and dyads. Moreover, spores physically separated from cryptospore polyads, laevigate and ornamented hilate spores, and trilete spores are present at levels 8817 and 8818. The first record of trilete spores occurs at the levels 8817 and 8818, together with early Katian chitinozoan species. The chitinozoan association was most likely recycled during the Hirnantian glacial pulses observed in northern Gondwana localities. No definitive evidences of Hirnantian markers have been found among the acritarchs of these levels.

Cryptospores and trilete spores of these levels could have consequently been reworked as the other palynomorphs.

If land-derived palynomorphs had also been reworked, the age of the spores would be early Katian or even older. If the miospores were in situ, they would be Hirnantian.

The subsequent level (8819) is characterized by reworked late Katian chitinozoan species and the first appearance of Chelinospora cf. prisca, which is compatible with a late Katian

Hilate spores, mainly represented by Laevolancis divellomedium, first occur at the same level as the trilete spores and range to the Telychian of the Lipeón Formation. Summarizing, the hilate and trilete spores of the Caspalá Formation should have an age ranging from early-late Katian to Hirnantian.

CONCLUSIONS

- The earliest vascular plants appear to have emerged at high to middle latitudes in Gondwanan and peri Gondwanan areas (Saudi Arabia, Argentina, Turkey and Algeria), under cold
- The trilete spores of the Caspalá Formation constitute their oldest record in South America and therefore represent the advent of vascular plants in the region.
- If the Argentine trilete spores were considered Hirnantian, they would have appeared almost at the same time than the trilete spores in Turkey and Algeria, though being more complexly ornamented than Turkish and Algerian forms
- If Katian, the Argentine miospore assemblage would be almost coeval with the oldest trilete spores known from Saudi Arabia dated as middle-late Katian (Wellman et al., 2015). The issemblage presently studied is less diverse and preser ess complex morphological features, probably indicating more primitive degree of evolution.
- The transgressive Telychian deposits of the Lipeón Formation show a notable decrease in abundance and diversity terrestrial palynomorphs in agreement with adverse palaeoenvironmental conditions established at the end of the glaciation (Steemans et al., 2010).
- The trilete spores of the Lipeón Formation in the Caspalá area, dated as Telychian, constitute the first record of Llandovery trilete spores in Argentina, therefore revealing the earliest evidence of Silurian vascular plants of Argentina.

Terrestrialization Process: Modelling Complex Interactions at the Biosphere-Geosphere Interface.

Wellman, C.H., Steemans, P., Miller, M.A., 2015. Spore assemblages from Upper Ordovician and lowermost Silurian of Palaeobotany and Palynology 212, 111-126.

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- seems to have occurred in Argentina, at the western margin of west Gondwana (Rubinstein et al., 2010).

The new miospore data, particularly those related to the records, should be revaluated.

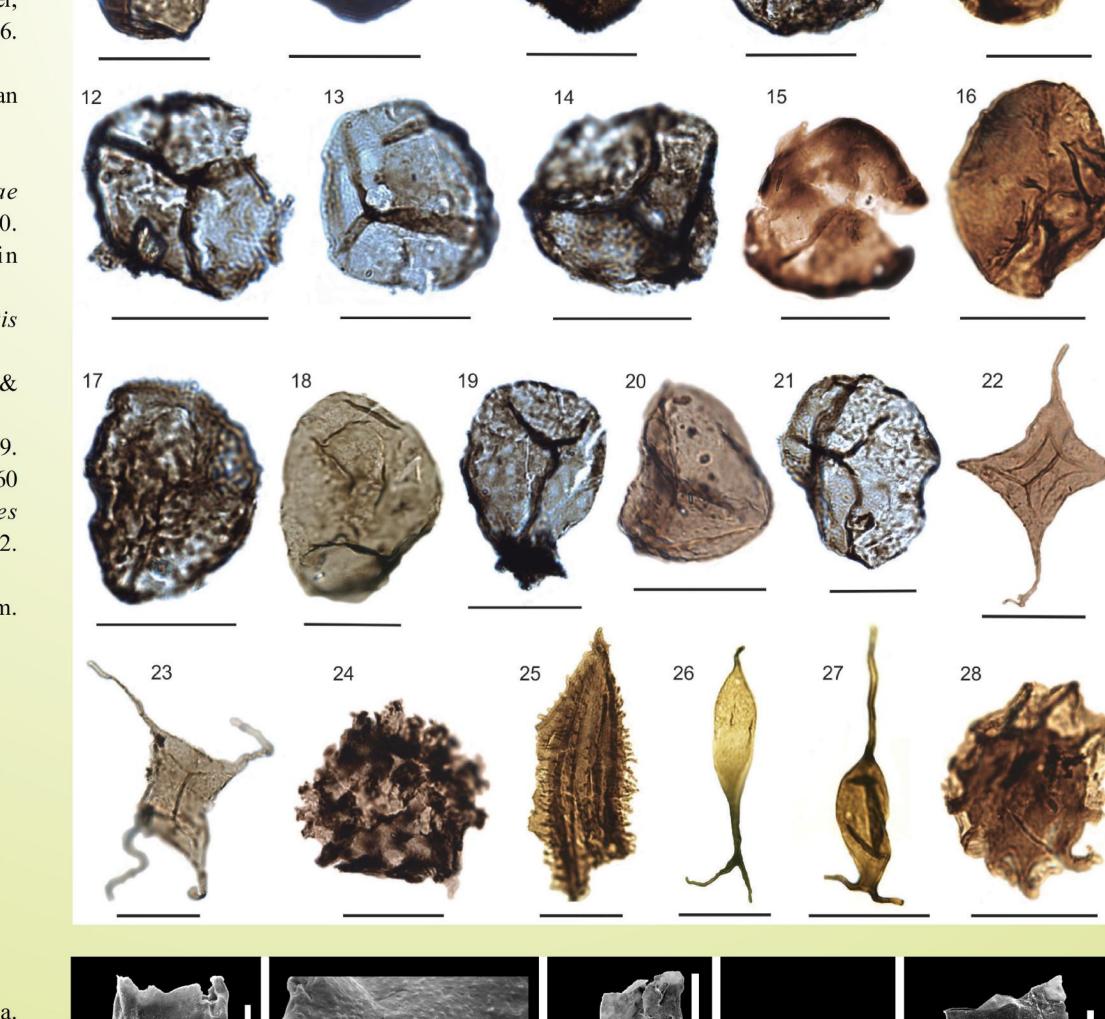


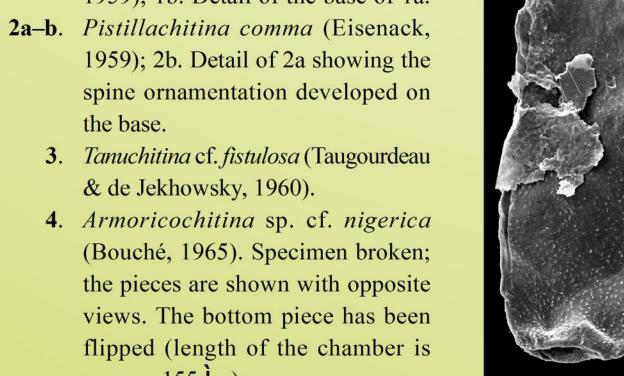
2,3. Imperfectotriletes

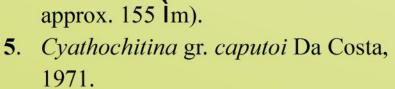
25. Tetrade sp.

- 10-15. Ambitisporites avitus Hoffmeister, 1959 sensu Steemans et al., 1996. **16.** Aneurospora? sp.. 17. Chelinospora cf. prisca Wellman
- 22. Neoveryhachium carminae
- 23. Neoveryhachium sp. A in
- 24. Tylotopalla cf. caelamenicu
- 25. Dactylofusa maranhensis Brito &

The scale bars represent 20 µm.







6. Calpichitina cf. densa (Eisenack,

Eisenack, 1937.; 7b. Detail of the

Scale bars 50 µm for 1a, 2a, 3-7a; 20 µm for details 1b, 2b & 7b.

