

Estudios Geológicos  
julio-diciembre 2019, 75(2), e100  
ISSN-L: 0367-0449  
<https://doi.org/10.3989/egeol.43595.555>

## Reassessing the taphonomy of *in situ* *Cloudina* assemblages from the Tagatiya Guazu Formation, Ediacaran Itapucumi Group, Paraguay

### *Reevaluación de la tafonomía de las asociaciones conservadas in situ de Cloudina en la Formación de Tagatiya Guazu, Grupo ediacárico de Itapucumi, Paraguay*

L. Inglez<sup>1</sup>, L.V. Warren<sup>1</sup>, J. Okubo<sup>1</sup>, M.G. Simões<sup>2</sup>

<sup>1</sup>Departamento de Geologia Aplicada, Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista, Avenida 24A, 1515, Rio Claro 13506-900, Brazil. Email: [lucas.inglez@hotmail.com](mailto:lucas.inglez@hotmail.com); ORCID ID: <http://orcid.org/0000-0002-2815-8788>, <http://orcid.org/0000-0002-2050-6514>, <http://orcid.org/0000-0001-9160-9994>

<sup>2</sup>Departamento de Zoologia, Instituto de Biociências, Universidade Estadual Paulista, Distrito de Rubião Júnior, Botucatu 18618-000, Brazil. ORCID ID: <http://orcid.org/0000-0002-8706-3199>

#### ABSTRACT

The fossil assemblage from the Tagatiya Guazu Formation (Ediacaran Itapucumi Group, Paraguay) represents a unique opportunity to investigate paleoecological parameters and contribute with taxonomic information regarding *Cloudina* associations in SW Gondwana.

**Keywords:** *Cloudina*; Tagatiya Guazu Formation; Ediacaran; Paraguay.

#### RESUMEN

La asociación fósil de la Formación de Tagatiya Guazu (Grupo ediacárico de Itapucumi, Paraguay) representa una oportunidad única para investigar los parámetros paleoecológicos y contribuir con información taxonómica sobre las asociaciones de *Cloudina* en Gondwana SW.

**Palabras clave:** *Cloudina*; Formación de Tagatiya Guazu; Ediacárico; Paraguay

#### Introduction

*Cloudina* is one of the main index fossils of the Ediacaran Period commonly occurring in carbonate platform settings as *in situ* clusters or loosely packed parautochthonous bioclastic deposits in

close association with microbial facies. However, despite these taphonomic and sedimentologic attributes found in almost all *Cloudina* accumulations worldwide, many doubts persist regarding the (a) phylogenetic affinity, (b) palaeoecology and (c) taphonomy of this biomineralized metazoan.

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Recibido el 10 de mayo de 2019; Aceptado el 1 de julio de 2019; Publicado online el 19 de noviembre de 2019

**Citation / Cómo citar este artículo:** Inglez, L. et al. (2019). Reassessing the taphonomy of *in situ* *Cloudina* assemblages from the Tagatiya Guazu Formation, Ediacaran Itapucumi Group, Paraguay. *Estudios Geológicos* 75(2): e100. <https://doi.org/10.3989/egeol.43595.555>.

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One of the greatest issues concerning the interpretation of *Cloudina* palaeobiology is related to the preservational quality of the fossils, which varies according to distinct rock matrixes, in some cases precluding the precise interpretation of its tridimensional morphology. This also hampers the use of detailed morphometric parameters (i.e., oblique/transverse annulations at the exterior surface of funnels) that can be easily or better observed in those individuals preserved in phosphatized material (Cai *et al.*, 2017). When the preservation occurs in carbonate rocks, the lack of compositional contrast between recrystallized shell walls and carbonate rock matrix that embeds them, hindering mechanical or chemical separation of individuals, or even the assessment through micro-CT scanning. On the other hand, size distribution of tubes in autochthonous *Cloudina* assemblages has demonstrated to be a useful, and sometimes the only approach possible to define taxonomic characters and assess information on the structure of palaeocommunities, modes of reproduction and ontogeny. Indeed, at the type locality of the Nama Group, taxonomic classification within two species of *Cloudina* (*C. hartmanae* and *C. riemkeae*) was mainly based on differences in tube diameter (Germis, 1972). Additionally, morphometry was also used to infer size variations in response to environmental changes, suggesting generalist and adaptable growth strategies for this taxon (Wood *et al.*, 2017).

## Results

The fossil-bearing Tagatiya Guazu Formation (Itapucumi Group), on northeastern Paraguay is characterized by an intercalation of grainstone, mudstone and microbial facies interpreted as deposited in a protected lagoonal environment. This unit is particularly rich in bioclastic concentrations of *Corumbella*, *Namacalathus* and *Cloudina* skeletal remains (Warren *et al.*, 2017). When associated to microbialite facies, previous taphonomic analysis (Warren *et al.*, 2013) has demonstrated that *Cloudina* occur as either vertically oriented tubes or as prostrate carapaces with little or no taphonomic signatures (fragmentation, abrasion) indicating extensive lateral transport and prolonged residence time at the sediment-water interface (Fig. 1). These features

strongly suggest that they possibly represent autochthonous individuals.

Here we analyzed both types of occurrences in (i) naturally weathered surfaces, (ii) polished slabs and (iii) thin sections in order to identify faciological, taphonomical and morphological parameters. We have taken systematic measurement of the carapace diameters from distinct types of assemblages and use Shapiro-Wilk test to determine the normality of their distribution. The Kolmogorov-Smirnov tests was employed to statistically compare the distinct assemblages. Based on detailed observation and quantitative analysis we identified that autochthonous *Cloudina* assemblages can occur with two different patterns of carapace concentrations (subdivisions of the Type 2 shell concentration proposed by Warren *et al.*, 2013).

The first accumulations (Pattern A) (Fig. 1A-D), is characterized by relatively sparse to dense aggregations of mainly large rectilinear to slightly curved *Cloudina* carapaces (between 0.25 and 2.77 mm in diameter). Sometimes diagnostic morphological features such as well-pronounced flaring apertural rims (Fig. 1B, D) and transverse annulations in funnels outer surface are preserved. Tubes generally possess constant diameters along its length, but few may present a slight enlargement in diameter towards the apertural end (modes of growth A and B after Wood *et al.*, 2017). They either occur vertical, horizontal or obliquely oriented in massive to clotted (thrombolitic) carbonatic matrix. This association often preserves fragmentary and sparse remains of *Corumbella* and *Namacalathus* skeletal elements. The second type of accumulation (Pattern B) (Fig. 1E-J), is characterized by sparse to dense concentrations of visibly smaller specimens of *Cloudina* than those observed in the Pattern A (between 0.12 and 0.90 mm in diameter). The specimens are highly recrystallized and mostly filled with sparry calcite cement, which precludes the observation of detailed external morphological features in the carapaces. Tubes possess constant diameters (modes of growth B or C, after Wood *et al.*, 2017) and have a high degree of sinuosity, with curves sometimes approaching 90° (Fig. 1H-J). They occur associated with thin-laminated grainstone and planar microbialites mostly horizontally to bedding, but also in vertically oriented.

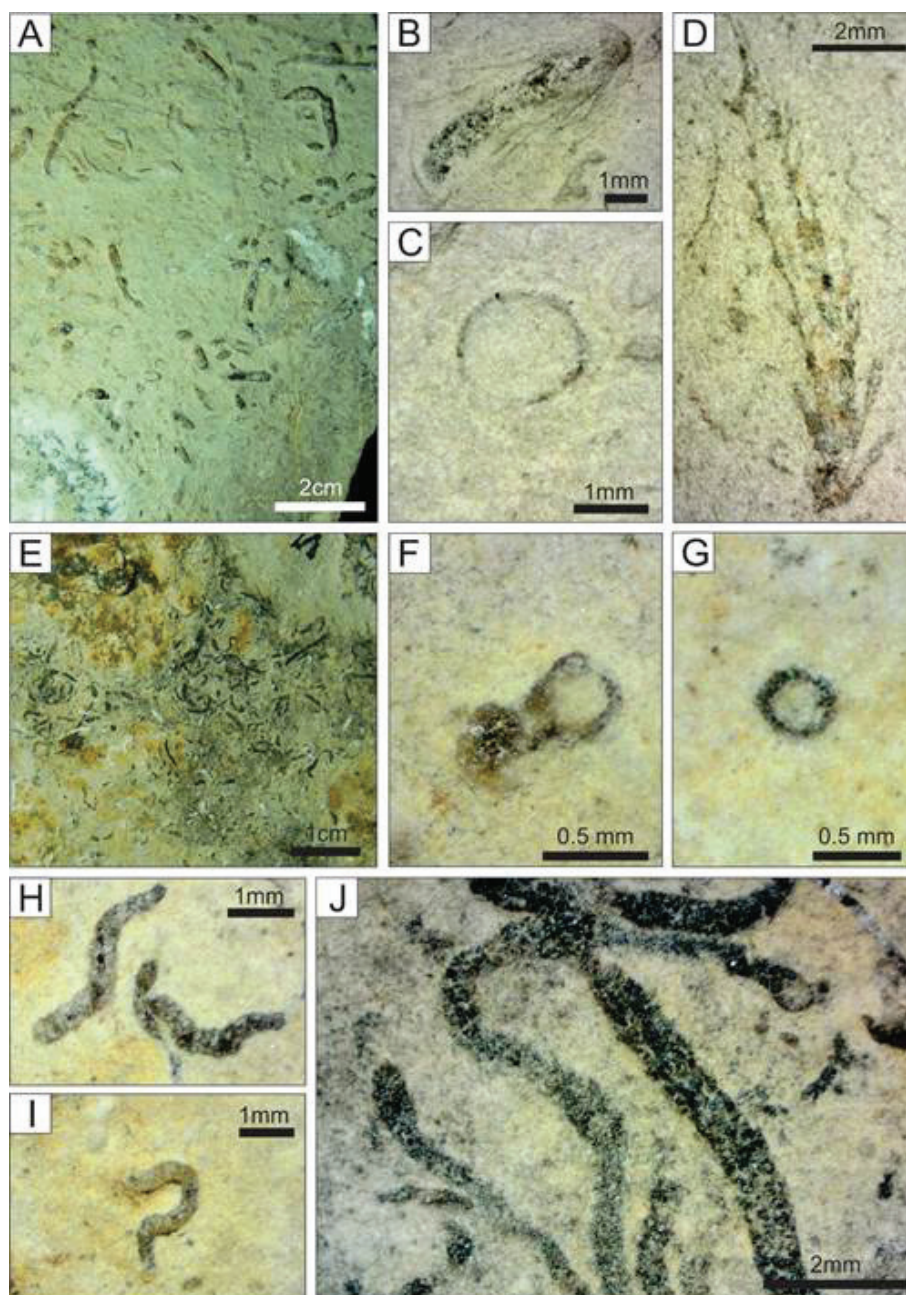


Figure 1.—Distinct autochthonous assemblages from the Tagatiya Guazu Formation, Itapucumi Group. A-D. *In situ* assemblage of Pattern A, with large *Cloudina* specimens partially preserved in life-position (A and C). A. general view of naturally weathered surface with recrystallized *Cloudina* tubes. B. Well preserved specimen with pronounced apertural rims in funnels flaring outwards. C. Transverse section of vertically oriented tube. D. Idem B. E-J. Autochthonous assemblages dominated by small *Cloudina* carapaces showing high degree of sinuosity of the tubes. E. General view of carapace distribution in the bedding plan. F-G. Vertically (*in situ*?) oriented tubes interpreted as preserved in life position. H-J. Recrystallized specimens with pronounced sinuosity of tubes.

## Conclusions

Our preliminary data suggests a strong correlation between sedimentary facies, and distinct morphotypes

and sizes of *Cloudina* carapaces from *in situ* assemblages. In general, autochthonous accumulations dominated by small and highly sinuous specimens are preserved in laminated grainstone in contrast to

assemblages of large and rectilinear carapaces that are usually found in thrombolitic facies. Further investigation is necessary in order to test whether these characteristics might represent paleoecological responses to different environmental contexts, or could be controlled by taphonomic processes.

## ACKNOWLEDGMENTS

This research is sponsored by FAPESP (grant 2018/26230-6).

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