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Columnar stromatolites in the Sumidouro of the Carrapato river, Lagamar, State of Minas Gerais

Record of columnar dolomitic constructions by cyanobacteria in the Proterozoic of Brazil

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In the Site named Sumidouro of the Carrapato River, localized in the Lagamar district, northwestern portion of the Minas Gerais State, excellent outcrops of dolomites show columnar stromatolites with convex laminations of the Baicalia type and with conical laminations of the Conophyton metula Kirichenko type intercalated with oncolitic and laminated dolomites, belonging to the Vazante Group in the external zone of the Brasília Fold Belt. These stromatolites, which are characteristic of the Middle to Upper Proterozoic, were deposited in a peritidal marine environment with shallow waters and high energetic tidal currents.

Keywords: bioherms; stromatolites; Conophyton; dolomite; Vazante Group; Proterozoic.

INTRODUCTION

The stromatolitic occurrences described in this text (Figs. 1, 2, 3) have been discovered in 1973 by the geologists of METAMIG (Celio Freitas and Mario Campos Neto) and of University of Brasilia (Marcel Dardenne) during mapping and exploration for lead and zinc in the Minas Gerais State (Dardenne & Campos Neto 1976, Campos Neto 1984, Dardenne 1979). Additional geological works were developed in the area for Master of Science (Nogueira 1993, Nogueira & Dardenne 1992) and research for CNPQ (Dardenne & Schobbenhaus 2001, Dardenne 2000).

LOCALIZATION

Leave the Brasília-Belo Horizonte highway (BR-040) in Paracatu, and follow to Guarda-Mor (89 km), Vazante (39 km) and Lagamar (29 km). The stromatolitic formations occur a few kilometers west of the city (Fig.4). The best expositions are near the farms Silva, Onório, Cacheta, Faria and Oliveira, beyond the Sumidouro local where the Carrapato River disappears into the dolomites (Fig.5). The geographic coordinates are 18°12'00"S; 46°51'04" W.

REGIONAL GEOLOGY CONTEXT

The stromatolitic formations integrate the Lagamar Formation of the Vazante Group (Dardenne 2000, 1979, Campos Neto 1984), which are localized in the external zone of the Brasília Fold Belt. The

schematic geological map (Fig.5) shows a major synclinorium oriented north-south, where the dolomitic massive lenses are covered by dense tropical forest that stand out in the slates characterized by dendritic drainage system and grass cover.

The slates, dark gray to black, sometimes greenish, homogeneous or laminated, turn progressively calcareous towards the dolomitic lenses. The dolomites show the following facies (Fig.6):

- Micritic laminated dolomites, with yellow, gray or pink color, frequently intercalated with intraformational breccias;
- Dolomites with lamellar pink or light gray micritic intraclasts, abundant at the base of the section and related to desiccation features;
- Microbial laminated dolomites (Fig.7), with dark gray or black color, showing sinuous irregular laminae and frequent convolute structures associated to silicification;
- Intraclast-rich dolomites, with dark to light gray color, cemented by microcrystalline sparite;
- Oncolitic dolomites (Fig.8), with pink color, showing cross and graded bedding. The grainstones are coarse (1,0 to 2,0 mm) and are composed of countless small oncolites (0,1 to 0,4 mm) agglomerated and kept together by concentric bacterial envelopes. The oncolites are cemented by characteristic fibrous sparite;
- Pink dolomites with columnar stromatolites;
- Brown dolosiltites, showing striking cross-laminations and intercalated at the base of the column with oncolitic dolomites



Figure 1 – Typical aspect of columnar pink stromatolites with convex laminations in the Carrapato River – Sumidouro Site. The stromatolite represents the *Baicalia* type.



Figure 2 – Pink transversal sections of Conophyton in the gray micritic matrix.



Figure 3 – Vertical section of pink stromatolite of Conophyton type, with gray material between the columns.



Figure 4 - Localization of the columnar stromatolite site Lagamar, Minas Gerais State, Brazil.

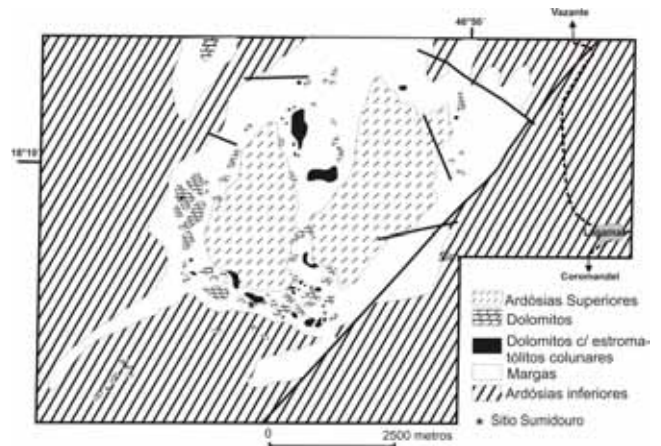


Figure 5 - Simplified geological map of the Lagamar area, showing the main columnar stromatolitic occurrences (after Dardenne & Campos Neto 1976).

DESCRIPTION OF THE SUMIDOURO SITE

Basically, two types of columnar stromatolites have been differentiated from the form of the laminae that can be convex or conical. Excellent expositions of the columnar stromatolites occur everywhere in the dolomitic bioherms of the area, but the best ones

appear at the place denominated Sumidouro of the Carrapato River.

Columnar Stromatolites with Convex laminae

The stromatolitic columns show a typical pink color, which stands out on the blue-gray surrounding

dolomites. These columns, which can reach two meters or more height, stand straight or gently inclined in relation to the bedding. They are irregularly subcylindrical, with abrupt contractions and expansions giving a tuberous or bulbous aspect to the stromatolitic construction (Fig.9). The ramification of the columns is active or passive with two or more branches developing for each division. Sometimes the daughter columns start laterally before raising. There is no envelopment of the lateral surface and no marginal zone. The laminae are convex, locally recovering one another, with irregular sharp edges intruding the surrounding rock.

The microstructure is formed by dark micritic laminae alternating with light dolosparitic layers. The former are continuous, sinuous and rarely interrupted, with thickness varying from 0,4 to 0,08 mm.

Some pellets and intraclasts of organic nature are still recognized in these laminae. Interruptions are apparently caused by recrystallization of the dolomite. The later form irregular crystalline layers with coarser sparite at the base of the laminae. The thickness ranges between 0,04 and 0,4mm. The surrounding rock is blue-gray fine-grained dolomite where lamellar microbial pink intraclasts are floating. They are some mm to cm length and are interpreted as erosion products of the stromatolitic columns by the currents. In transversal sections the columns show forms more or less circular to elliptic with concentric pink lamina. Some open cavities, classified as stromatactis, which still remain after the sedimentation and the compacting, show a flat base and progressive filling by coarse sparite and quartz. Other cavities can be preserved under the protuberance of the laminae and are characterized by internal graded sedimentation of pellets, micrite and coarse sparite in an upward succession.

Classification of the columnar stromatolites with convex laminae

These columnar stromatolites show straight affinities with the Tungussides Supergroup (Raaben 1969) and were classified in a first approximation as belonging to the *Baikalia* Group, which is characterized by an active branching and by frequent contractions of the columns. However, it should be stressed the fact that the column morphology seems to be largely induced by the action of strong erosive tidal currents during the growth of the stromatolite framework.

Columnar stromatolites with cylinder-conical laminae

Exceptional pink microbial constructions are observed in the blue-gray fine grained dolomite, forming conical columns, extremely dense and close one to another, inserted at the base, with around one or two meters high. In longitudinal vertical cross-sections, the laminae show a very characteristic conical

form, the same being interrupted on the border of the column without marginal recovering (Fig.10). In the well-defined axial zone, they show a flattened morphology with accentuated undulations. They are alternating dark and light gray (Fig.11). The micritic dark ones are continuous and sinuous, with thickness remaining between 0,1 and 0,4 mm, while the light laminae are slightly thinner, between 0,05 and 0,3 mm, being constituted by microdolosparite. In transversal cross-section, the columns show circular to elliptic, or triangular forms with diameter from 5 to 15 cm. Here it is possible to observe some “ protuberances”, which crosscut the surrounding rock.

Classification of the columnar stromatolites with conical laminae

The continuity of the laminae, the absence of marginal envelopment and the major relative thickness of the dark laminae (Fig.12) permit to classify the stromatolites with conical laminae as of the type *Conophyton metula* Kirichenko described by Komar *et al.* (1965).



Figure 6 - Synthetic lithostratigraphic column of the Lagamar region (after Dardenne & Campos Neto 1976).



Figure 7 - Laminated dolomites with bacterial mats.

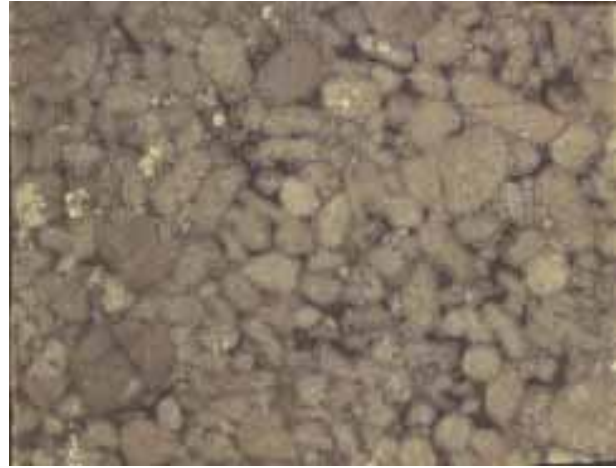


Figure 8 - Macroscopic aspect of the oncolitic dolomites.



Figure 9 - Outcrop of columnar stromatolite with convex laminations.



Figure 10 - Outcrop showing a vertical longitudinal section of Conophyton.

SEDIMENTARY ENVIRONMENT

The information on the sedimentary environment are deduced from the characteristics of the stromatolitic constructions and from their relationship with the surrounding rocks:

- The dolomitization is an early diagenetic process, penecontemporaneous with the sedimentation;
- The early lithification of the stromatolitic columns is necessary for the preservation of the columnar constructions in a high energetic environment, and is probably contemporaneous with the dolomitization;

- The pink color of the stromatolitic constructions suggests an oxidant environment, that could take place in tidal to shallow subtidal conditions under the action of strong tidal currents;
- A high energetic level is corroborated by the erosive features observed on stromatolitic columns, specially with convex lamina, resulting in erosive products as intraclasts and fragments of the microbial lamina floating in the micritic mud between the columns. In this sense, the contractions observed on the columns with convex laminae can be related to the action of strong tidal currents. The cross and graded oncospiritic dolomites, intercalated with the columnar stromatolites, present well exposed discontinuity surfaces and sharp basal erosional contacts at the top of the stromatolitic columns, strengthening great variations of the energetic level;
- The sedimentation in the area of stromatolitic constructions is almost exclusively carbonated, with very limited contribution of clastic particles as some quartz silt grains trapped by bacterial laminae;
- The depth conditions of the sedimentation are difficult to estimate. However, it is evident that the most part of the columns was submersed in function of the micritic mud encountered between the columns. It is probable that the stromatolitic columns with convex laminations and strong erosive features have grown in shallower marine conditions as tidal environment. In opposition, the stromatolitic columns with conical laminae have certainly grown in deeper marine conditions reflecting a quiet environment. This conclusion is corroborated by the observation that the *Conophyton* beds are frequently separated from those of columns with convex laminae. In the transition zone, the presence of *Jacutophyton* (characterized by the growth of small inclined columns with convex laminae from a conical one) is frequently observed and can signify a progressive change of depth and environment conditions.

AGE OF STROMATOLITIC CONSTRUCTIONS

As shown by Russian authors (Komar *et al.* 1965, Raaben 1969), o genus *Conophyton* is known only in the Precambrian and more specifically in the Proterozoic. This fact has been further confirmed in United States of America (Cloud & Semikhatov 1969), in Canada (Hofmann 1969, 1972), in Australia (Walter & Preiss 1972, Preiss 1972), and in Africa (Bertrand-Sarfati 1972, Trompette 1969). In Brazil, the first *Conophytons* have been identified in the dolomites of the Itaiacoca Group (Paraná State), in the dolomites of the Vazante Group (Moeri 1972, Dardenne *et al.* 1971, 1972, Cloud & Dardenne 1973, Dardenne & Campos Neto 1976), in the Macaúbas Group (Schöll 1976), and in the dolomites of the Paranoá Group (Dardenne *et al.*

1973, 1976, Laranjeira & Dardenne 1993, Guimarães & Dardenne 1994).

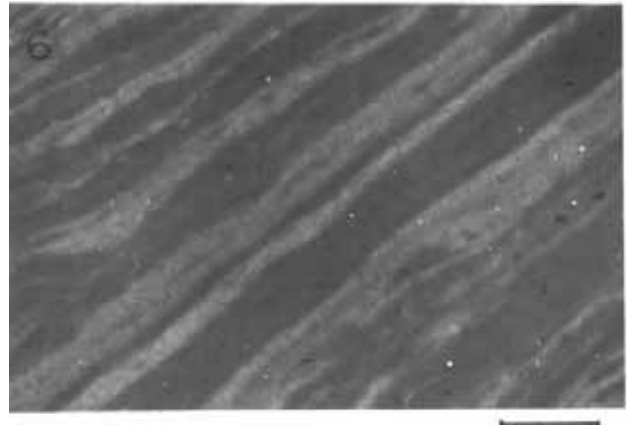


Figure 11 - Microstructure of *Conophyton metula* Kirichenko.

The genus *Conophyton metula* Kirichenko, as the *Baikalia* Group, is considered by the Russian authors (Krylov 1963) as characteristic of Middle Riphean (1350-950 Ma). However, the difficulties observed for the identification of the various types of stromatolites, together with the strong influence of environment conditions, have led to forget the Russian nomenclature and the binomial classification, only remaining the character of *Conophyton* as index fossil of Middle to Upper Proterozoic. In the Brasilia Fold Belt, the occurrence of *Conophyton* is used informally to distinguish the Bambuí Group from the Vazante Group.

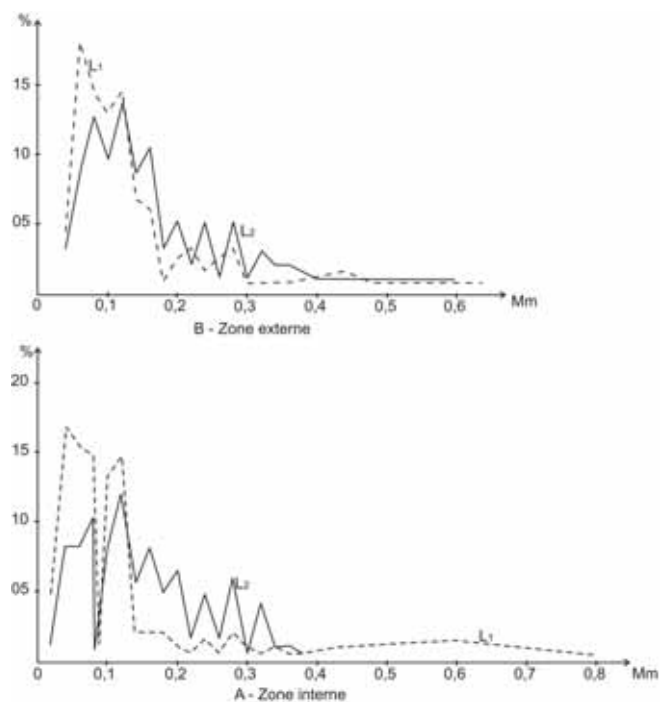


Figure 12 - Relative thickness of dark and light lamination of *Conophyton*.

CONCLUSIONS

The columnar stromatolites of Lagamar present exceptional conditions of preservation in the site denominated Sumidouro of the Carrapato River. This site has to be preserved in function of its stratigraphic, paleontological and paleo environmental importance. The identification of *Conophyton metula* Kirichenko can permit in the future to establish regional and perhaps worldwide correlations. These columnar stromatolites have grown in marine environment, characterized by shallow and oxidant conditions, strongly influenced by tidal currents. The cylinder-conical stromatolites of the type *Conophyton* seem to have grown in deeper and quite marine conditions, while the stromatolites with convex lamina were submitted to intense tidal currents.

PROTECTION MEASURES

As the site is relatively without protection, it is suggested that:

- The DNPM (National Department of Mineral Production) does not give authorization for exploration in the area;
- It will be request the collaboration of the mining companies that exploit limestone and dolomite near the site for its protection;
- The university prepares explicative outdoors on the site.

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