2012

Microfossils in micrites from Serra da Bodoquena (MS), Brazil: taxonomy and paleoenvironmental implications

An. Acad. Bras. Ciênc.,v.84,n.2,p.245-262,2012
http://www.producao.usp.br/handle/BDPI/38019

Anais da Academia Brasileira de Ciências (2012) 84(2): 245-261
(Annals of the Brazilian Academy of Sciences)
Printed version ISSN 0001-3765 / Online version ISSN 1678-2690
www.scielo.br/aabc

Microfossils in Micrites from Serra da Bodoquena (MS), Brazil: Taxonomy and Paleoenvironmental Implications

GISELLE UTIDA[1], SETEMBRINO PETRI[2], EMILIANO C. OLIVEIRA[1] and PAULO C. BOGGIANI[2]

[1] Programa de Pós-graduação em Geoquímica e Geotectônica, Instituto de Geociências, Universidade de São Paulo, Rua do Lago, 562, Cidade Universitária, 05508-080 São Paulo, SP, Brasil

[2] Departamento de Geologia Sedimentar e Ambiental, Instituto de Geociências, Universidade de São Paulo, Rua do Lago, 562, Cidade Universitária, 05508-080 São Paulo, SP, Brasil

Manuscript received on August 24, 2010; accepted for publication on December 1, 2010

ABSTRACT

Microfossils present in Quaternary micrites from Serra da Bodoquena, Mato Grosso do Sul State, Brazil, are here described for the first time. The studied taxa are: a) ostracods: *Candona* sp., *Candonopsis* sp., *Cyclocypris* sp., *Cypria* sp., *Cypridopsis* sp., *Notodromas* sp., *Ilyocypris* sp., *Cyprideis* sp., *Wolburgiopsis* cf. *chinamuertensis* (Musacchio 1970), *Darwinula* sp. and 5 morphotypes; b) microgastropod *Acrobis* sp., and c) Characeae remains and gyrogonites *Chara* sp.. The presence of these microfossils suggests clear-water shallow lacustrine paleoenvironments and the presence of aquatic vegetation. Similarities between microfossils and the living taxa suggest possible Holocene ages for these deposits, which is in accordance with previous C^{14} dates.

Key words: micrite, Characeae, lacustrine sediments, Ostracoda, Serra da Bodoquena.

INTRODUCTION

Continental carbonate sediments with gastropods were first described in Corumbá, near the Pantanal plain and Serra da Bodoquena, Mato Grosso do Sul State, Brazil, and were assigned to Xaraiés Formation (Almeida 1945).

Serra da Bodoquena has yielded Quaternary unconsolidated micrite deposits, more than 5 m thick, with well-preserved gastropod fossils, known since Almeida (1965), which were also assigned to Xaraiés Formation. According to Mendes (in Almeida 1945), these mollusks belong to a living genera and, as a result, these sediments were dated as Quaternary in age (Almeida 1945).

From Almeida (1965) to 2007, no specific research was conducted regarding fossils in these carbonates. New data describing microfossils and gastropods have been produced by Utida et al. 2007, 2008 and Utida 2009. In other recent studies, ^{14}C dating yielded an age between 6,300 and 2,700 years BP for the beginning of the carbonate sedimentation (Sallun Filho et al. 2009a, b).

The aim of the present paper is to describe the microfossils taxa from Serra da Bodoquena micrites, making possible to interpret the paleoenvironmental evolution of these carbonatic sediments.

Correspondence to: Giselle Utida
E-mail: giselleutida@hotmail.com

STUDY AREA

The study area is located at Serra da Bodoquena, Mato Grosso do Sul State, Brazil, near the south of the Pantanal Basin. The range is approximately 200 km long and 400 to 800 m high (Almeida 1965, Sallun Filho et al. 2004). This is a touristic area, especially the city of Bonito, and part of a "Geological Site" of the Brazilian Commission of Geological and Paleobiological Sites (SIGEP) (Boggiani et al. 2002).

Serra da Bodoquena lies in the southernmost portion of the Neoproterozoic Paraguay Belt. It is composed of limestones and dolomites from the Ediacaran, (Corumbá Group), calcretes from the Pleistocene, age based on fossils of gastropods and plants, which are very similar to recent specimens according to Almeida (1945), and micritic sediments, alluvium and calcareous tufa possibly from the Holocene (Xaraiés Formation), according to the C^{14} dating obtained by Boggiani et al. (2002) and Sallun Filho et al. (2009a, b).

The Cenozoic carbonates from Serra da Bodoquena were assigned to the Xaraiés Formation by Almeida (1965). Recently, Sallun Filho et al. (2009a) have proposed a new lithostratigraphic nomenclature for these limestones, Serra da Bodoquena Formation, and also assigned the micrites to Fazenda São Geraldo as member.

The bottom layer of the Xaraiés Formation is composed of calcretes, and the top layer is composed of micritic sediments and tufas. They usually rest on Ediacaran carbonates of the Corumbá Group (Almeida 1945, 1965) (Figure 1).

These Precambrian carbonates were subjected to groundwater dissolution, resulting in many caves (Boggiani et al. 2002, Sallun Filho et al. 2009a). The high bicarbonate content of the ascending groundwater, associated to a high evaporation in the paleoenvironment, was responsible for the deposition of lacustrine sediments and tufa carbonates (Almeida 1965, Sallun Filho et al. 2004, 2009a, Oliveira et al. 2009).

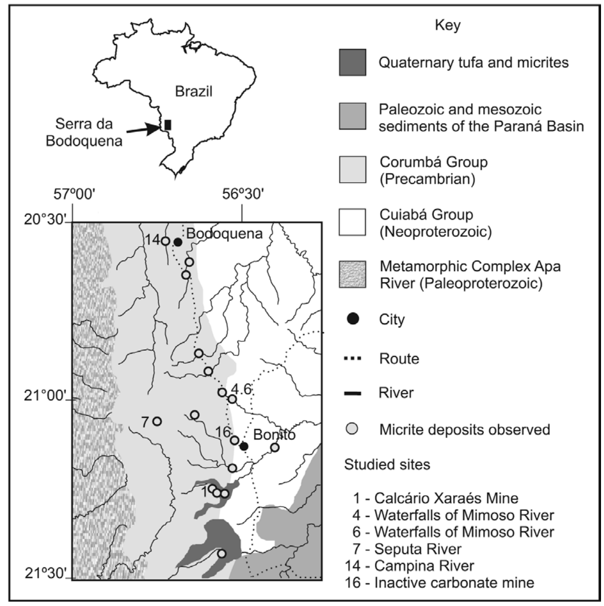


Figure 1 – Map of the study area. Location of Serra da Bodoquena, Brazil. Numbered circles indicate study sites of micrites, other circles indicate mapped areas of micrites. The micrite deposits are probably bigger than that. Modified from Sallun Filho (2005).

Micrites, with their color ranging from beige to gray, are unconsolidated and have a high content of carbonates, up to 100% of calcium carbonate as calcite, and small quantities of terrigenous sediments. They are easily found next to river channels due to fluvial erosion, or in areas where there is economic exploitation (Oliveira 2009, Sallun Filho et al. 2009a, Utida 2009).

The biggest occurrence of carbonates, with approximately 110.000 m^2, is found at São Geraldo farm, which is exploited by the Calcário Xaraés Mine and used as soil corrective. Oncoids were found at the base of the deposits. There are 1 m of clay sediments and 4 m of unconsolidated micrites above these deposits, where macrogastropods can be found from 2 m above the base up to the top (Table I) (Utida et al. 2007).

Samples were collected manually at the Calcário Xaraés Mine, where carbonates are cropping out, and by auger drilling, where they are not exposed, resulting in a composite section of about 5 m (Figure 1, Table I).

Other similar deposits, which are not so extensive, were also studied (Figure 1). In these deposits, samples were collected manually from the outcrops. The carbonates of deposit 4, with 80% of $CaCO_3$, have been affected by the fluvial erosion of Mimoso River in a vegetated area. Within approximately 50 m of this locality, deposit 6, with 65% of $CaCO_3$, is composed of more compact sediments due to weathering action. There are very friable buff color micrites with 100% of $CaCO_3$ in the neighborhood of deposit 7 and in the bed of Seputa River. Deposit 14, which was eroded by Campina River and has approximately 60% of $CaCO_3$, is friable, but not so porous. The carbonates of deposit 16 are most similar to those of the Calcário Xaraés Mine, where two kinds of carbonates differentiated by weathering action were collected. One of them was a very friable carbonate with 98% of $CaCO_3$, which was collected in a vegetated area. The other one was a consolidated carbonate with 96% of $CaCO_3$, which was collected in an area without vegetation.

TABLE I
Section of carbonates from the Calcário Xaraés Mine. The point 0.01 represents the base of the deposit.

Section of carbonates from the Calcário Xaraés Mine		
Sample	Section (m)	Composition
Manual collection	5.16	94-99% $CaCO_3$+ macrogastropods
	4.46	
	3.96	
	3.46	
	2.96	
Auger drilling	2.36	
	2.18	
	2.08	
	1.94	96-98% $CaCO_3$
	1.38	
	1.06	45-52% $CaCO_3$ + clayminerals
	0.51	
	0.01	56% $CaCO_3$+ oncoids + clayminerals

MATERIALS AND METHODS

The method used to separate the microfossils is routinely developed at Micropaleontology Laboratory "Setembrino Petri" at the Geosciences Institute, University of São Paulo. A portion weighing approximately 20g was separated from the collected samples and then dried. This subsample was mixed with water and heated to 80°C, which helped to disintegrate the sediments. After this procedure, the subsample was sieved with water through a series of sieves with meshes of 0.5, 0.125, 0.063 and 0.021 mm, and then filtered through a 3μm filter paper and dried again.

The sediments were later immersed in trichloroethylene. Carbonate microfossils float because they have smaller specific weight than the trichloroethylene. Then, they were filtered through a 3μm filter paper and dried. Microfossils were put in a Petri dish, picked up under a stereomicroscope and fixed to numbered graph papers using alcatira gum (formaldehyde, alcohol, water and gum).

After a previous identification, the microfossils that were considered representative of morphologically similar groups were observed in a SEM (Scanning Electron Microscope). The collected specimens were stored in the Micropaleontology Scientific Collection of "Setembrino Petri" laboratory.

The taxonomy of modern ostracods is based on their soft parts, and older fossil forms are very different from those found at Serra da Bodoquena. Consequently, descriptions were based on morphological characteristics, especially on muscular impressions (Van Morkhoven 1963, Gross 2008), ornamentation and other elements. Microgastropods were identified according to Simone (2006) based on morphological elements. The identification of gyrogonites of Characeae algae was based on Feist et al. (2005). Taxonomic names were classified according to the Paleobiology Database (available at <http://www.paleodb.org>) and the Integrated Taxonomic Information System (available at <http://www.itis.gov/>), as well as the taxonomic order.

RESULTS

Ostracods

The ostracods were identified as *Candona* sp., *Candonopsis* sp., *Cyclocypris* sp., *Cypria* sp., *Cypridopsis* sp., *Notodromas* sp., *Ilyocypris* sp., *Cyprideis* sp., *Wolburgiopsis* cf. *chinamuertensis* (Musacchio 1970) and *Darwinula* sp.. Other 5 carapaces could not be identified and were described and termed sp. 1-5. Many recent and fossil lacustrine ostracods are not well known, which hampers the interpretation. Some ostracods could not be described due to carbonate incrustations or fragmentations.

Phylum ARTHROPODA Latreille, 1829
Subphylum CRUSTACEA Brünnich, 1772
Class OSTRACODA Latreille, 1802
Order PODOCOPIDA Müller,1894
Suborder CYPRIDOCOPINA Jones 1901
Superfamily CYPRIDOIDEA Baird, 1845
Family CANDONIDAE Kaufmann, 1900
Subfamily CANDONINAE Kaufamann, 1900
Genus *Candona* Baird, 1845
Type species: *Cypris reptans* Baird, 1835;
SD Baird, 1846

Candona sp.
Figure 2, a-d; Table II

Material and origin: 6 valves from 2.18 at the Calcário Xaraés Mine, 4 right and 2 left valves. 2 right valves from 2.36, 1 left valve from 1.06, both at the Calcário Xaraés Mine. 1 entire carapace from deposit 04. 1 right and 1 left valve from deposit 06. 2 entire carapaces from deposit 07, probably of young ostracods, and 1 left valve.
Repository: GP/5T-2509.4.1, GP/5T-2509.4.2, GP/5T2509.4.5, GP/5T-2509.7.1, GP/5T-2509.26.1, GP/5T-2509.50.2, GP/5T-2510.29, GP/5T-2511.7.
Dimensions: Around 410 μm long and 200 μm wide.
Description: Muscular impressions are typical of the Subfamily Candoninae (Figure 2 c-d); there are 6 adductor scars, 4 of them grouped into a first column and 2 in the posterior portion, in front of them, and there are 2 mandibular impressions in the inferior portion and 1 frontal impression in the superior portion. Carapace kidney-shaped, with spaced pores, without depressions or tubercles.
Note: Among those specimens classified as *Candona* sp., some may belong to the genus *Pseudocandona*, which differs only in soft parts (Van Morkhoven 1963, Gross 2008). They live in mud and continental waters (Gross 2008), but can adapt to several environmental conditions (Davies and Griffiths 2005). Gross (2008) described a reticulated ornamentation on carapaces of Candona sp., similar to those found at site 2.36. The genus is cosmopolitan and its range is Tertiary-Recent (Moore 1961).

TABLE II
Identified ostracods from micrites. Only right or left valves are counted.

		Fossils ostracods from micrites									
Sites		*Candona* sp.	*Candonopsis* sp.	*Cyclocypris* sp.	*Cypria* sp.	*Cypridopsis* sp.	*Notodromas* sp.	*Ilyocypris* sp.	*Cyprideis* sp.	*Wolburgiopsis* cf. *chinamuertensis*	*Darwinula* sp.
Calcário Xaraés Mine (m)	5.16	-	-	-	-	-	-	-	-	-	-
	4.46	-	-	-	-	-	-	-	-	-	-
	3.96	-	-	-	1	-	-	-	-	-	1
	3.46	-	-	-		-	-	-	-	-	-
	2.96	-	1	-	1	-	-	-	-	-	-
	2.36	2	-	-	1	-	-	-	-	1	1
	2.18	4	-	-	2	-	-	1	1	2	1
	2.08	-	-	-	1	-	-	-	1	-	1
	1.94	-	-	-	-	-	-	-	-	-	1
	1.38	-	-	-	1	-	-	-	-	-	-
	1.06	1	-	-	-	-	-	-	-	-	-
	0.51	-	-	-	1	-	-	-	-	-	-
	0.01	-	-	-	-	-	-	-	-	-	-
Other deposits	4	1	-	-	-	-	1	1	-	-	26
	6	2	-	-	-	-	-	-	-	-	-
	7	3	-	2	-	2	-	-	-	-	-
	14	-	-	-	-	-	-	-	-	-	1
	16B	-	-	2	-	-	-	-	-	-	1
	16D	-	-	-	-	-	-	-	-	-	-

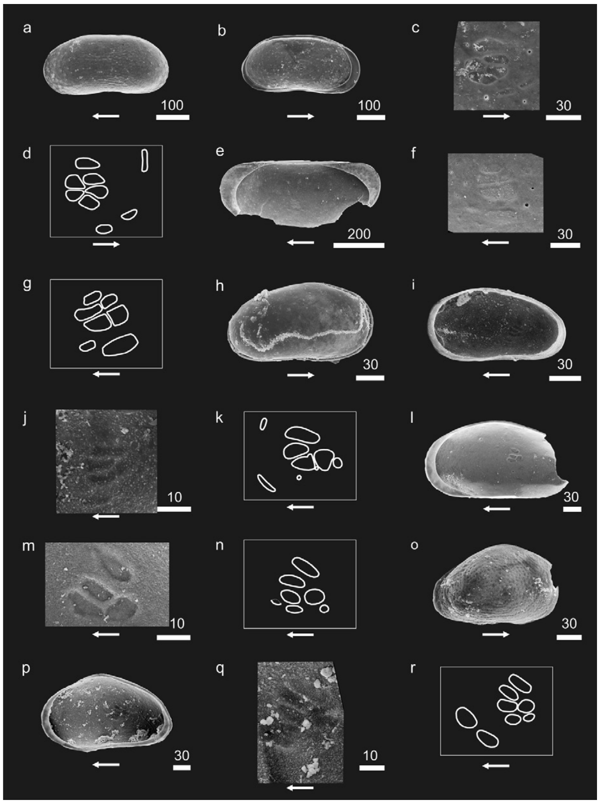


Figure 2 – SEM images of ostracods collected in micrite carbonates from Bodoquena Range and schemes of muscular impressions. a-d - *Candona* sp.. a - Left valve, lateral view. b - Left valve, internal view. c - Muscular impressions. d - Scheme of muscular impressions based on Van Morkhoven (1963) and Gross (2008). e-g - *Candonopsis* sp.. e - Left valve, internal view. f -Muscular impressions. g - Scheme of muscular impressions based on Van Morkhoven (1963). h-k - *Cyclocypris* sp.. h - Lateral view of carapace. i - Right valve, internal view. j - Muscular impressions. k - Scheme of muscular impressions, based on Van Morkhoven (1963) and Gross (2008). l-n - *Cypria* sp.. l - Right valve, internal view. m - Muscular impressions. n - Scheme of muscular impressions based on Van Morkhoven (1963) and Gross (2008). o-r - *Cypridopsis* sp.. o - Right valve, lateral view. p - Right valve, internal view. q - Muscular impressions. r - Scheme of muscular impressions based on Gross (2008). Scale in µm.

Genus *Candonopsis* Vávra, 1891
Type species: *Candona kingsleyi* Brady and Robertson, 1870

Candonopsis sp.
Figure 2, e-g; Table II

Material and origin: Calcário Xaraés Mine, 2.96, 1 right and 1 left valve, both fragmented.

Repository: Specimens could not be recovered.
Dimensions: Around 650 µm long.
Description: The genus *Candonopsis* was identified by muscular impressions (Figure 2 f-g). 5 adductor impressions similar to those of *Candona* sp., and a smaller impression in front of a big inferior impression. Many marginal pores on the carapace. The specimens were fragmented, preventing further details of description.
Note: The genus *Candonopsis* comprises typical freshwater inhabitants (Van Morkhoven 1963). It is cosmopolitan and restricted to Recent deposits (Moore 1961).

Family CYPRIDIDAE Baird, 1845
Genus *Cyclocypris* Brady and Norman, 1889
Type species: *Cypris globosa* Sars, 1863

Cyclocypris sp.
Figure 2, h-k; Table II

Material and origin: Deposit 07: 2 left valves and 1 right valve. Deposit 16B: 1 entire carapace and 1 right valve.
Repository: GP/5T-2509.26.2, GP/5T-2509.29.1.
Dimensions: Between 150 and 170 µm long and 70 µm wide.
Description: The genus can be identified through muscular impressions (Figure 2 j-k). It has 3 adductor impressions along the same column, followed by 1 impression on the anterior portion and 2 oblong impressions in front of them. The mandibular impression is present on the inferior portion and the frontal impression on the superior portion. The carapaces are smooth and inflated, sub-oval in lateral view and rounded at terminal portions. The maximum width is located at a central point. Many of the collected carapaces may be young specimens.
Note: The genus occurs in fresh to oligoalkaline waters, mainly vegetated. Specimens of this genus are active swimmers (Van Morkhoven 1963), some of them indicate standing waters and permanent water bodies (Davies and Griffiths 2005).

The genus is cosmopolitan, ranging from Tertiary to Recent (Moore 1961).

Genus *Cypria* Zenker, 1854
Type species: *Cypris exculpta* Fischer, 1854

Cypria sp.
Figure 2, l-n; Table II

Material and origin: Some sites of the Calcário Xaraés Mine: 3.96, 1 fragmented right valve; 2.96, 1 fragmented right and 1 left valve; 2.36, 1 fragmented right valve; 2.18, 2 right valves and 2 left valves; 2.08, 1 left valve; 1.38, 1 left valve; 0.51, 1 right valve.
Repository: GP/5T-2509.2.2, GP/5T-2509.4.3, GP/5T-2509.4.4, GP/5T-2509.4.5, GP/5T-2509.7.2, GP/5T-2511.7, GP/5T-2511.27.
Dimensions: Around 400 µm long and 190 µm wide.
Description: Muscular impressions (Figure 2 m-n): 3 or 4 adductor muscular impressions, followed by 1 large impression and 2 small impressions, sometimes absent. The genus is trapezoidal in shape, with reticulate ornamentation and salient pores distributed mainly on the margins.
Note: The genus is common in continental waters, present in every small pond and channel. It can also live in saline waters (Gross 2008). It prefers vegetated environment and it is a swimmer. Some species could indicate standing waters or permanent water bodies (Davies and Griffiths 2005). The genus is cosmopolitan, ranging from Tertiary to Recent (Moore 1961). It can be said, based on muscular impressions, that other specimen from site 2.96 at the Calcário Xaraés Mine, with a smooth carapace with small pores around 300 µm long and 140 µm wide is probably a young one.

Subfamily CYPRIDOPSINAE Kaufmann, 1900
Genus *Cypridopsis* Brady, 1867
Type species: *Cypria vidua* O. F. Muller, 1776; SD Brady and Norman, 1889

Cypridopsis sp.
Figure 2, o-r; Table II

Material and origin: 2 right valves and 1 fragmented left valve from deposit 07.
Repository: GP/5T-2509.26.1.
Dimensions: Around 150 µm long and 100 µm of maximum width.
Description: The genus *Cypridopsis* is recognized by muscular impressions according to Gross (2008) (Figure 2 q-r). It has 4 adductor stacked muscular scars followed by 2 scars at the posterior region. There are 2 oblong mandibular scars in the inferior portion. Which is oval and inflated at the central portion. Posterior region oblong and depressed at the margins. Ornamentation punctuated and smooth reticulated.
Note: The specimens of *Cypridopsis* are active swimmers, mainly at lake margins with vegetation, and tolerant to oligoalkaline conditions (Namiotko et al. 2003). The left valve is fragmented, so it is not possible to describe its morphology. The identification of this genus was based on the muscular impressions. The genus is cosmopolitan, ranging from the Cretaceous to Recent (Moore 1961, Gross 2008).

Subfamily NOTODROMATINAE Kaufmann, 1900
Genus *Notodromas* Liljerborg, 1853
Type species: *Cypris monacha* O.F. Müller, 1776

Notodromas sp.
Figure 3, a; Table II

Material and origin: 1 entire carapace from deposit 04.
Repository: GP/5T-2509.57.
Dimensions: Around 320 µm long and 250 µm wide.
Description: Oval shape, rectilinear ventral region, oblong at the anterior portion. Weak punctuated ornamentation.

Note: The specimens of Notodromadidae are typical of freshwater. The genus is found only in the Recent (Moore 1961).

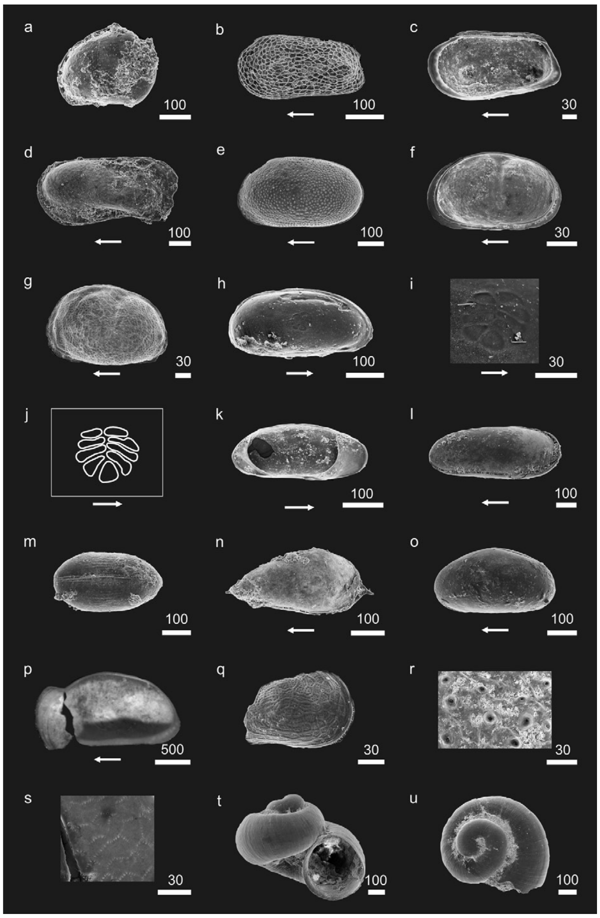


Figure 3 - SEM images of microfossils collected in micrite carbonates from Bodoquena Range and scheme of muscular impressions. a - *Notodromas* sp.. Lateral view of carapace. b-c - *Ilyocypris* sp. 1. b - left valve, lateral view. c - right valve, internal view. d - *Ilyocypris* sp. 2, lateral view of carapace. e - *Cyprideis* sp.. Left valve, lateral view. f-g - *Wolburgiopsis* cf. *chinamuertensis* (Musacchio 1970). f - Right valve, internal view. g - Left valve, lateral view. h-j - *Darwinula* sp.. h - Right valve, internal view. i - Muscular impressions. j - Scheme of muscular impressions based on Van Morkhoven (1963). k-p - Indeterminate family and genus of ostracods. k - Indet. 1. left valve, internal view. l - Indet. 1. lateral view of carapace. m - Indet. 2. dorsal view of carapace. n - Indet. 3. lateral view of carapace. o - Indet. 4. Lateral view of carapace. p - Indet. 5. Right valve, internal view, obtained in stereomicroscope. q-s - Ornamentation. q - Reticulated and punctuated with few pores. r - Reticulated with papilla-shape pores. s - Thin reticulated forming pentagons. t-u - Gastropod, Family Planorbidae, Genus *Acrobis*. t - Lateral view. u - Apical view. Scale in μm.

Family ILYOCYPRIDIDAE Kaufmann, 1900
Subfamily CYPRIDEINAE Martin, 1940
Genus *Ilyocypris* Brady and Norman, 1889
Type species: *Cypris gibba* Rhamdohr, 1808

Ilyocypris sp.1
Figure 3, b-c; Table II

Material and origin: Right and left valve from site 2.18 at the Calcário Xaraés Mine.
Repository: GP/5T-2509.4.3, GP/5T2511.26.
Dimensions: Around 350 μm long and 160 μm wide (measured in the central point of the carapace).
Description: Oblong in form, with sub-rectangular lateral lines. Anterior and posterior sides rounded. Strong reticulation as ornamentation and 2 tubercles present above the carapace.
Note: It occurs in limnic to weak oligoalkaline environments (Van Morkhoven 1963, Sames 2008). The genus is cosmopolitan, Triassic to Recent (Moore 1961).

Ilyocypris sp. 2
Figure 3, d, Table II

Material and origin: 1 entire carapace from deposit 04.
Repository: GP/5T-2509.50.2.
Dimensions: Around 660 μm long and 320 to 280 μm width.
Description: Sub-rectangular form, with depressed edges projected over the center of carapace in the inferior-anterior and superior-posterior regions. Weak reticulated ornamentation and 2 smooth tubercles over the carapace.

Suborder CYTHEROCOPINA Gründel, 1967
Superfamily CYTHEROIDEA Baird, 1850
Family CYTHERIDEIDAE Sars, 1925
Subfamily CYTHERIDEINAE Sars, 1925
Genus *Cyprideis* Jones, 1857
Type species: *Candona torosa* Jones, 1850

Cyprideis sp.
Figure 3, e; Table II

Material and origin: 1 right valve from 2.18 of the Calcário Xaraés Mine, and there is a fragmented specimen at the same deposit site 2.08.
Repository: GP/5T-2509.4.4.
Dimensions: Around 520 μm long and 290 μm of maximum width at the center of carapace.
Description: Oblong and oval carapace with big punctuations, and a small vertical groove on the antero-dorsal region.
Note: It is similar to those specimens described by Krstić et al. (2005), Upper Pliocene from Balkan Peninsula. This genus is typical of meso-polihaline environments and small lakes with high salinity (Van Morkhoven 1963). The range of this genus is Miocene-Recent (Moore 1961).

Family LIMNOCYTHERIDAE Klie, 1938
Subfamily LIMNOCYTHERINAE, Klie 1938
Genus *Wolburgiopsis* Uliana and Musacchio, 1978
Type species: *Wolburgia neocretacea* Bertels, 1972
Wolburgiopsis cf. *chinamuertensis* (Musacchio 1970)

1970 *Wolburgia chinamuertensis* Musacchio: p. 306-308, est. 1, figs 6-8.
Figure 3, f-g; Table II

Material and origin: 1 right valve at site 2.36 at the Calcário Xaraés Mine, and 2 right valves and 1 left valve at site 2.18.
Repository: GP/5T-2509.4.3, GP/5T-2509.4.4, GP/5T-2511.25. Other carapaces could not be recovered after SEM.
Dimensions: Around 350 μm long and 160 μm wide.
Description: Small size, sub-rectangular in shape, bi-grooved in the center, ornamented with warts and many pores. Both posterior and anterior margins bear depressions, the anterior one projected centerward.
Note: Non-marine ostracod. This species is known only in South America, Lower Cretaceous in age (Carmo et al. 2004). The limited number of studies with lacustrine ostracods is probably the reason for the lack of references of this species in beds younger than Lower Cretaceous.

Suborder DARWINULOCOPINA Sohn, 1988
Superfamily DARWINULOIDEA Brady and Normann, 1889
Family DARWINULIDAE Brady and Norman, 1889
Genus *Darwinula* Brady, and Robertson, 1885
Type species: *Polycheles stevensoni* Brady and Robertson, 1870

Darwinula sp.
Figure 3, h-j; Table II

Material and origin: Calcário Xaraés Mine: site 3.96, 1 left valve; site 2.36, 1 left valve; 2.18, 1 right valve; 2.08, 1 right valve and 1.94, 1 right valve. 26 entire carapaces from deposit 04. 1 entire carapace from deposit 14, and 1 entire carapace from deposit 16B.
Repository: GP/5T-2509.2.2, GP/5T-2509.3.1, GP/5T-2509.3.3, GP/5T-2509.4.1, GP/5T-2509.4.4, GP/5T2509.26.1,GP/5T-2509.29.2,GP/5T-2509.50.1, GP/5T-2509.50.2, GP/5T-2511.30.
Dimensions: Large specimens vary from 415 to 460 μm length and 185 to 240 μm width, small specimens vary from 272 to 366 μm length and 127 to 178 μm width. Small forms are probably young.
Description: The genus is easily identified through adductor muscular impressions in form of rose (Figure 3 i-j). The carapace is oblong and smooth, the posterior region is rounded and the anterior portion is elongated.
Note: The genus is cosmopolitan in all continental waters, but rare in the tropics (Van Morkhoven 1963, Carmo et al. 2004, Gross 2008). It ranges from Carboniferous to Recent (Moore 1961).

Family and Genus indeterminate

Fam. et gen. Indet. 1

Figure 3, k-l

Material and origin: Calcário Xaraés Mine, 1 left valve from site 2.18. Deposit 04, 5 entire carapaces, and deposit 14, 1 entire carapace.
Repository: GP/5T-2509.50.3, GP/5T-2509.50.1, GP/5T2513.5, GP/5T-2513.33, GP/5T-2509.25.3. The specimen of site 2.18 could not be recovered after SEM.
Dimensions: Around 350 µm long and 140µm wide at the center of the carapace.
Description: Oblong, with rounded margins and some pores; the carapace is smooth. Lamellas do not extend through the edge. The anterior portion is more elongated toward the center of the carapace than the posterior portion. Right carapace is smaller than the left.

Fam. et gen. Indet. 2

Figure 3, m

Material and origin: Deposit 14, 1 entire carapace.
Repository: GP/5T-2509.26.1.
Dimensions: Around 360 µm long. The width could not be measured due to the position in the SEM image.
Description: Elliptical. Left and right carapaces approximately the same size. The ornamentation is reticulated.

Fam. et gen. Indet. 3

Figure 3, n

Material and origin: Deposit 04, 1 entire carapace.
Repository: GP/5T-2509.50.3.
Dimensions: Around 480 µm long and 180 µm of maximum width in the posterior portion.
Description: Carapace drop-shape. Acicular projections in both extremities of the carapaces, some pores present but without ornamentation.

Fam. et gen. Indet. 4

Figure 3, o

Material and origin: Deposit 04, 11 entire carapaces. Deposit 14, 1 entire carapace.
Repository: GP/5T-2509-50.1, GP/5T-2513.5, GP/5T-2513.33.
Dimensions: Around 400 µm long and 200 µm of maximum width in the median portion.
Description: Oval-shaped. Straight lateral line in the ventral part and rounded ended portions. Smooth with some pores.

Fam. et gen. Indet. 5

Figure 3, p

Material and origin: Fragments of large ostracods were collected at the Calcário Xaraés Mine in site 1.38 and in the deposit 07.
Repository: GP/5T-2509.5.1, GP/5T-2512.13, GP/5T-2509.28.1.
Dimensions: One of the fragments is around 1,600 µm long.
Description: Smooth carapaces, oval-shaped and with yellow color, which may be of weathering cause.

Ornamentations in fragmented carapaces

Ostracod fragments were collected from all deposits. In some of them it was possible to observe ornamentations, especially in those from the Calcário Xaraés Mine. In the study site 5.16 the fragments show a punctuated ornamentation. In site 3.96 the ornamentation is reticulated and punctuated, with few pores (Figure 3, q). In site 2.36 the ornamentation is also reticulated, but with papilla-shaped pores (Figure 3, r), similar to those described from the Cretaceous beds of Portugal by Cabral et al. (2008). These ostracods, which were adapted to salt waters, were classified as *Globotalicypridea* sp.. Also in site 2.36 other fragments have thin reticulations forming pentagons in some parts (Figure 3, s), which are similar to those described by Gross (2008) in female specimens of *Candona* sp.. Some other fragments have delicate punctuations. In site 1.06 fragments have thin reticulated ornamentation similar to that described for *Cypria* sp.. In site 0.51 some fragments have reticulated ornamentation similar to that described for *Ilyocypris* sp.1.

Phylum MOLLUSCA Cuvier, 1795
Class GASTROPODA Cuvier, 1797
Subclass ORTHOGASTROPODA
Ponder and Lindberg, 1996
Infraclass HETEROBRANCHIA J.E. Gray, 1840
Superorder EUTHYNEURA Spengel, 1881
Order PULMONATA Cuvier in Blainville, 1814
Suborder BASOMMATOPHORA
Keferstein, 1864
Superfamily PLANORBIOIDEA
Rafinesque, 1815
Family PLANORBIDAE Rafinesque, 1815
Subfamily PLANORBINAE Rafinesque, 1815
Genus *Acrobis* Odhner, 1937
Holotype: *Acrobis odhneri* Scott, 1960

Acrobis sp.
Figure 3, t-u

Material and origin: Calcário Xaraés Mine, 2 specimens at site 2.96, sites 2.36 and 2.18 with 4 specimens each, and 7 and 3 specimens at sites 2.08 and 1.94, respectively. Deposit 14 with 3 specimens, deposit 04 with 39, and 06 with 18 specimens.
Repository: GP/5T-2515.11; GP/5T-2516.14; GP/5T-2516.26; GP/5T-2511.19; GP/5T-2518.37; GP/5T-2518.42; GP/5T-2519.25; GP/5T-2509.3.2; GP/5T-2520.11; GP/5T-2521.3; GP/5T-2513.16; GP/5T-2513.17; GP/5T-2513.18; GP/5T-2513.19; GP/5T-2513.20; GP/5T-2510.5; GP/5T-2510.6; GP/5T-2510.7.
Dimensions: From 369 to 1337 μm maximum diameter and 302 to 1248 μm height.
Description: Shells smooth circular in shape viewed from above. Older spirals higher than newer spirals. Umbilicus deep. Growth lines are visible at SEM image. Aperture rounded without ornamentations.
Note: The specimens of Order Pulmonata are common in temporarily overflowing areas and margins of lotic aquatic systems. These gastropods are either amphibious or aquatics and fitted for the paleoenvironment in the studied area (Brown et al. 1998). It is a South American genus (Simone 2006).

Phylum CHAROPHYTA Migula, 1897
Class CHAROPHYCEAE Smith, 1938
Order CHARALES Lindley, 1836
Suborder CHARINAE
Feist and Grambast-Fessard, 1991
Family CHARACEAE Agardh, 1824
Subfamily CHAROIDEAE Braun in Migula, 1897
Genus *Chara* Linnaeus, 1753

Chara sp.
Figure 4, a-f, Table III

Material and origin: Calcário Xaraés Mine, sites 2.18, 2.08 and 1.94, and some fragments at 5.16 and 4.46, as well as at deposits 04, 06, 07 and 16D (Table III).
Repository: GP/5T-2509.3.3, GP/5T-2509.4.2, GP/5T-2509.6.3, GP/5T-2509.25.2, GP/5T-2509.28.2, GP/5T-2509.28.1, GP/5T-2509.33, GP/5T-2509.51, GP/5T-2509.52, GP/5T-2509.53, GP/5T-2509.54, type 1: GP/5T-2509.6.1, GP/5T-2509.55; type 2: GP/5T-2509.6.3, GP/5T-2509.29.3; type 3: GP/5T-2509.3.1, GP/5T-2509.3.2, GP/5T-2509.6.1, GP/5T-2509.6.3, GP/5T-2509.56.; type 4: GP/5T-2509.4.2.
Dimensions: From 205 to 725 μm wide and 306 to 1027 μm height.
Description: Gyrogonites exhibit 5 sinistrally spiraled cells, each one connected at the apex through an interrupt line. The final portions of apical cells are larger. Apex is psilocharoid and convex. Periapical depression and apical nodules are absent. Apex and base are typical of the genus

(Figure 4, a-b). Gyrogonites spheres are elliptical to cylindrical, some of them very elongated. They have 10 to 12 spiraled cells in lateral view. Some gyrogonites present calcified portions protected by spiraled cells, which is probably the organic wall of sporopollenin that receives the oospore after the fertilization (Figure 4, b and e). Some gyrogonites have carbonate incrustations, which prevents descriptions. The genus occurs from Middle Eocene to Recent.

Note: 4 morphological varieties of *Chara* sp. were recognized:

Chara sp. type 1

Oval shape with convex apex, base vertically elongated and tapering down to the base (Figure 4, c).

Chara sp. type 2

Elliptical shape with convex apex, base is slightly elongated (Figure 4, d).

Chara sp. type 3

Oval shape with convex apex, base is not elongated (Figure 4, e).

Chara sp. type 4

Similar to type 1, with its shape oval, convex apex and elongated base. At lateral view each spiraling cell is depressed on the center. Maybe type 4 is the same of type 1 but modified by weathering and incrustation (Figure 4, f).

All these gyrogonite types are probably the same species, with the morphological varieties being caused by paleoenvironmental changes such as pH, water temperature, ontogenetic algal development and population density.

Only one type of *Chara* is present in the Calcário Xaraés Mine at sites 1.94, 2.08 and 2.18, and at deposits 07 and 16D (Table III). The presence of only one type of gyrogonite may indicate environmental stability, unlike the conditions at deposits 04 and 06 where *Chara* sp. type 1, 2 and 3 is present (Table III).

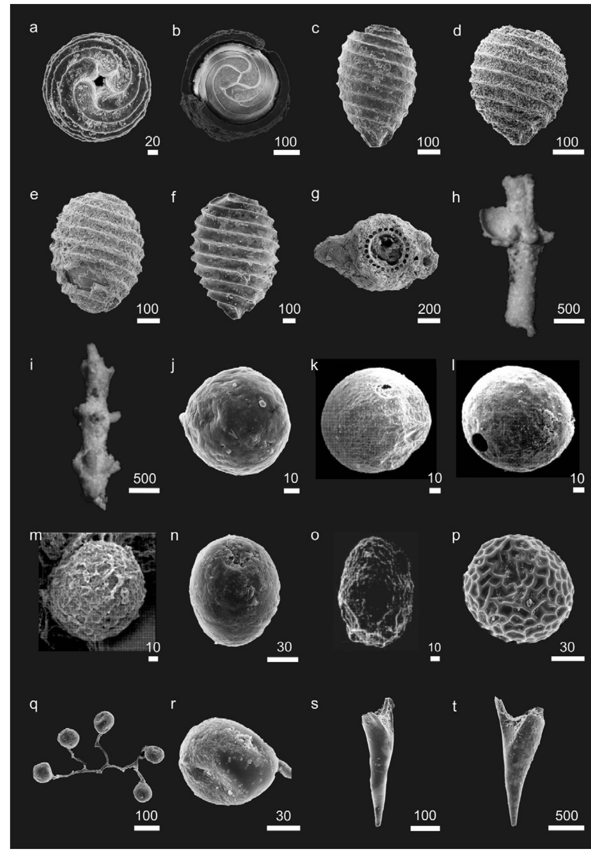


Figure 4 - SEM images of gyrogonites and other fossils from Bodoquena Range. a-f - Gyrogonites. a - Base view. b - Apical view. c - *Chara* sp. type 1. d - *Chara* sp. type 2. e - *Chara* sp. type 3. f - *Chara* sp. type 4. g-i - Characeae stems. g - Complete haplostichous stem. h - Stem with fragments of gyrogonites above the nodes. i - Stem with nodes. j-o - Eggs. j - Spherical egg. k-l - Ostracod eggs studied by Smith (1999) in the Santana Formation (Cretaceous), Northeast Brazil. m - Recent ostracod egg of *Heterocypris incongruens* raised in laboratory by Smith (1999). n - Elongated egg. o - Recent ostracod egg of *Darwinula stevensoni* raised in laboratory by Smith (1999). p - Heliozoan. q-r - Fungi. q - Sporangiums connected to sporangiophores. r - Isolated sporangium. s-t - Porifera spicules. Scale in µm.

TABLE III
Morphological variations of gyrogonites of *Chara sp.* collected from micrite deposits of Serra da Bodoquena. Indet.: not identified gyrogonites.

Morphological variations of gyrogonites of *Chara sp.*							
	Sites	type1	2	3	4	Indet.	Total
Calcário Xaraés Mine (m)	2.18	-	-	2	-	1	3
	2.08	-	-	2	-	1	3
	1.94	-	-	1	-	3	4
Other deposits	04	2	1	3	-	10	16
	06	2	3	7	-	3	15
	07	-	-	-	11	9	20
	16D	-	1	-	-	-	1

Other Structures

Characeae stems

The elongated structures found in samples collected from all deposits were interpreted as Characeae stems. Some of them have 18 to 24 sequential cortical cells, representing the complete haplostichous stem and resulting in external striped aspect, which is typical of the genus *Chara* (Figure 4, g). Samples with diplostichous aulacanthous cortex and 9 secondary cortical cells placed between 2 primary cortical cells were also collected. Several lengths of stems were collected, ranging in size from micrometer to centimeter scale (Figure 4, g-i). The precipitation of carbonates is influenced by the presence of CO_2 during photosynthesis occuring also around stems (Feist et al. 2005). This aspect is similar to that noted in the deposition of carbonates and was observed in stems of all deposits.

In deposit 07 there are well-preserved stems, with striated marks, nodes probably of bracteoles, and fragments of gyrogonites above the nodes (Figure 4, h-i). Characeae fragments were collected from the Calcário Xaraés Mine at site 0.51 up to the top of the deposit. Stems from sites 1.94 to 1.06 are not well preserved, and in site 3.46 they are strongly calcified.

Spherical structures

Spherical structures were collected from micrite deposits, excluding site 0.01 of the Calcário Xaraés Mine and deposit 16D. When observed in SEM, it was possible to identify them as ostracod eggs, heliozoans and fungi (Figure 4, j, n, p-r).

The structures interpreted as ostracod eggs are similar to those described by Carmo (1998), Smith (1999) (Figure 4, k-m, o) and Gobbo-Rodrigues (2002). They are smooth, with no holes, but sometimes some depressions can be found. Their diameter varies from 65 to 100 μm (Figure 4, j), almost the same interval described by Smith (1999) in eggs of the Santana Formation (Cretaceous), Northeast Brazil (85 to 110 μm) (Figure 4, k-l). Some of them are elongated and have holes (Figure 4, n). They show nearly the same egg morphology of *Darwinula stevensoni* (Figure 4, o), a recent ostracod also studied by Smith (1999). According to him, these holes could be the result of hatching.

Other specimens were here identified, based on their spherical shape covered by polygonal pores located in depressions in a continuous reticular frame, as members of the taxon of the Order Desmothoraca, Class Actinopoda of the Subclass Heliozoa (Moore 1954). The pores are not open and may be covered and filled with carbonate. Such structures are possibly made of chitin with impregnations of silica or, sometimes, made only of silica.

The chitin frame is better preserved than the silica frame in carbonate sediments. Heliozoans are free-living, freshwater, lakes, ponds and wetlands inhabitant protozoans (Moore 1954).

Other clustered spherical structures connected to the stem were easily found in deposit 14 (Figure 4, q-r) and interpreted as fungi. They are similar to recent sporangiums connected to sporangiophores as, for example, those fungi recently described by Pires-Zottarelli and Rocha (2007) in Fontes do Ipiranga (state of São Paulo, Brazil), or those described by Kar et al. (2010) in the Dulte Formation (Miocene), Northeast India. The fungi probably developed after the extinction of the deposit, colonizing pores in the carbonate sediments.

Spherical structures were also stored in the repositories: GP/5T-2522, GP/5T-2523, GP/5T-2524, GP/5T2525, GP/5T2518, GP/5T-2516, GP/5T-2515, GP/5T-2512, GP/5T-2513, GP/5T-2510, GP/5T-2527, GP/5T-2521, GP/5T-2526, GP/5T-2528, GP/5T-2509.1.1, GP/5T-2509.4.4, GP/5T-2509.7.1, GP/5T-2509.6.1, GP/5T-2509.25.2, GP/5T-2509.25.3, GP/5T-2509.29.1 and GP/5T-2509.49,2.

Pointed structures

The samples from the Calcário Xaraés Mine in sites 2.08 and 2.18, as well as in deposit 06, contain pointed structures with a tripartite base externally grooved and with some pores, measuring from 400 to 500 μm (Figure 4, s-t). It is suggested that these structures are body parts of invertebrates as, for example, spicules of freshwater Porifera. Porifera spicules are made either of calcite, providing a better preservation in alkaline environments, or of opaline silica (Moore 1955).

Pointed structures were also stored in the repositories: GP/5T-2511, GP/5T-2513, GP/5T2514, GP/5T2510, GP/5T-2509.4.1 and GP/5T-2509.6.2.

DISCUSSION

The ostracods identified in the micritic deposits of Serra da Bodoquena are typical of freshwater environment, especially stagnant lakes and small ponds. The paleoenvironmental interpretation was reinforced by the presence of the amphibian microgastropod *Acrobis* sp. living in quiet and stagnant waters, as well as the presence of Heliozoa and sponge spicules. The presence of Characeae indicates shallow waters with high alkalinity and small turbidity.

The conditions for fossilization were excellent. However, the vegetation that currently covers the deposits and the unconsolidated carbonates favor the water percolation and, consequently, the weathering processes. In spite of these unfavorable conditions, the preservation of delicate fossils, such as some ostracods, may be the result of rapid deposition of sediments, which demonstrates the relative high production of carbonate sediment burying the organism before there was an advanced decomposition.

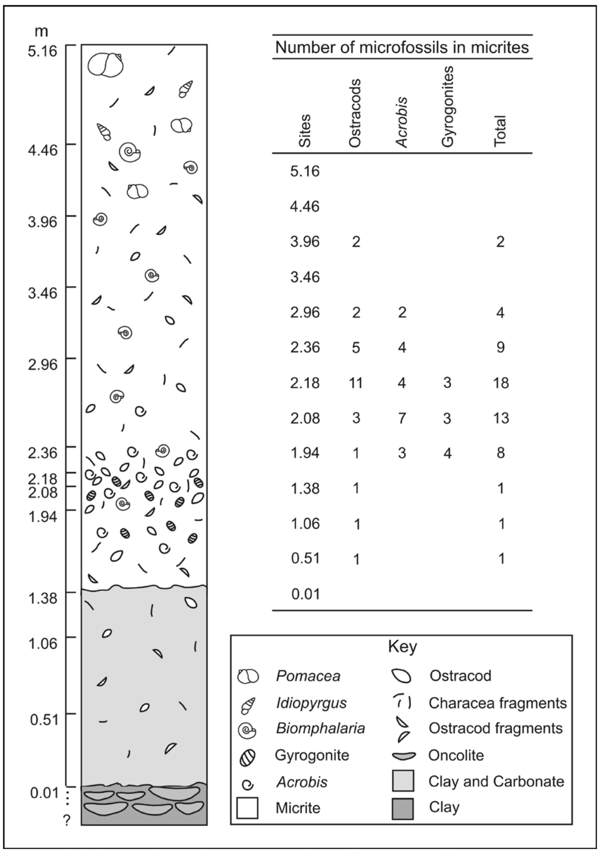
The Calcário Xaraés Mine

At the base of the micrite deposits there are discoid-shaped oncoids, less than 10 cm in diameter, which were originated by microbial action in a very shallow stream where currents circled them, forming calcareous laminations on both sides. Oncoids on development were seen in some remote parts of the region. Therefore, the oncoids are interpreted as developed in a paleoenvironment that is different from that of the micrite. No aquatic plants and invertebrates were preserved in the oncolite bed (Figure 5).

Above the oncolite bed, from 0.01 to 1.38 m, the carbonate and clay sediments of the studied section mark the inception of a lake paleoenvironment. Some whole valves and fragments of ostracod carapaces and Characeae stems were collected from this interval, which is evidence of an early colonization (Figure 5).

Next in the section, from 1.38 to 2.18 m, the paleolake community was composed of ostracods, microgastropod *Acrobis* and Characeae algae. The last one was represented by gyrogonites and stems, suggesting shallow and limpid waters (Figure 5). The interval 1.94-2.18 contains the largest number of ostracod specimens, about the same for gyrogonites and *Acrobis*, which demonstrates a close relationship among them. However, it is important to highlight that the distribution of the ostracods in the section is larger than the distribution of other organisms. This part of the section represents a significant period of stability, which was mainly related to the water quality and level, allowing the development of a more complex community. The genus *Biomphalaria* (gastropod) is found from 2.08 to the top, which is in accordance with the interpretation of shallow water condition for this interval (Utida et al. 2007, 2008, Utida 2009).

In the uppermost bed, from 2.36 m to the top, there are no gyrogonites and *Acrobis*. Ostracods started to decline and only a few carapace fragments can be observed there (Figure 5). In addition to that, the genus *Biomphalaria* (macrogastropod), which indicates shallow waters, as well as *Pomacea* and *Idiopyrgus*, developed in this interval, with a higher concentration on the top (Utida et al. 2007, 2008, Utida, 2009). These macrogastropods were probably responsible for the decline of ostracods and *Acrobis* (Figure 5).



Sites	Ostracods	*Acrobis*	Gyrogonites	Total
5.16				
4.46				
3.96	2			2
3.46				
2.96	2	2		4
2.36	5	4		9
2.18	11	4	3	18
2.08	3	7	3	13
1.94	1	3	4	8
1.38	1			1
1.06	1			1
0.51	1			1
0.01				

Figure 5 – Section of micrites from the Calcário Xaraés Mine and number of organisms found. Details in the text.

Fragments of Characeae stems were collected from this interval, but no gyrogonite was found, which suggests that the conditions were not ideal for the reproduction of these algae. No sedimentary structures indicative of water movement and sediment tractive deposits were recognized. These kinds of structures and deposits could be an evidence of the transportation of these algae. However, these areas were probably associated with river channels, forming contiguous dams as observed in satellite images by Sallun Filho et al. (2009a).

Since the carbonate deposition continued, there have been two changes in the paleoenvironment. The disappearance of the gyrogonites and *Acrobis* and the gradual decrease of the ostracods allow the proposition of two alternative, but not exclusive hypotheses: 1) the appearance of macrogastropods was the cause of the decline of the population of microgastropods and ostracods due to the competition, and the decline of Characeae due to predation, and 2) a gradual change in the paleoenvironment due to the lake size reduction caused by drying. Only the taxa able to adapt to this new paleoenvironment survived.

Therefore, the events that occurred during the formation of the micrite carbonate deposits can be summarized as follow: a) oncolite bed formation followed by clay and carbonate sedimentation; b) carbonate sedimentation and stable colonization of ostracods, Characeae gyrogonites and microgastropods; c) disappearance of microgastropods and Characeae gyrogonites, and development of macrogastropods; d) the macrogastropods were present until the lake was completely silted up (Figure 5).

The suggested age for the deposition of micritic sediments is possibly Holocene. This is based on unconsolidated micrites, good preservation of the described taxa and similarities of these taxa with living organisms.

Other Deposits

Deposits 04 and 07 have been modified by fluvial erosion, which may be the cause of the addition of recent organisms due to calcareous reworking. The wide variety of specimens (Table IV) found in the deposits and their good preservation, although they are very encrusted, are evidence of this addition. On the other hand, deposit 14 has also been affected by the same circumstances and show a small variety of specimens (Table IV), which was interpreted as the result of the action of erosion.

In deposit 06 there are few ostracods and a great number of gastropods and gyrogonites (Table IV), which are more resistant to weathering than ostracods due to their thickness.

Deposits 16B and 16D are from the same area of deposition and, therefore, almost the same fossil assemblage was expected to be seen there, but they were under different weathering conditions. Deposit 16B was covered by vegetation and soil, whereas deposit 16D was completely exposed to atmosphere weathering, which destroyed the fossil assemblage (Table IV) due to dissolution and caused the recrystallization of micrite.

In the shallow lake paleoenvironment, although weathering has affected the fossils, the assemblage retains the characteristics of the living organism, which are very similar to those described in the Calcário Xaraés Mine. Therefore, all studied deposits were possibly considered Holocene in age.

TABLE IV
Total number of organisms found in micrites from Serra da Bodoquena excluding the Calcário Xaraés Mine.

Total number of fossils in micrites				
Sites	Ostracods	Acrobis	Gyrononites	Total
4	79	39	16	134
6	2	18	15	35
7	9	-	20	29
14	4	3	-	7
16B	13	-	-	13
16D	-	-	1	1

CONCLUSION

The paleoenvironments in which micritic deposits from Serra da Bodoquena were formed are here discussed based both on sedimentary features and microorganisms, and are possibly Holocene in age. Micrites were deposited in floodplains with clear-water shallow lakes. These places were isolated flooded areas associated with river channels. Currently, most of these river channels have waterfalls and natural dams made of calcareous tufas.

The organisms described in this study possibly suggest a Holocene age for these deposits based on their similarities with the living taxa, as well as the similarities regarding geomorphologic features and the sedimentary characteristics of the deposits. This suggested age is in accordance with the C^{14} analysis in micrites of the Calcário Xaraés Mine, which yielded an age around 6,530 cal years BP for the beginning of the sedimentation (Sallun Filho et al. 2009a, b), although specific geocronological studies are needed to establish this age.

Future researches on these carbonates may generate other paleontological and geochemical data, resulting in a more detailed knowledge about the paleoenvironmental changes in this area.

ACKNOWLEDGMENTS

The authors are grateful to Geraldo Majella Pinheiro, the owner of the Calcário Xaraiés Mine, for allowing them to conduct the study in the mine area, CNPq for the financial support (proc. 479500/2007-0), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) for the Master Scholarships, "Setembrino Petri" Micropaleontology Laboratory, SEM Laboratory and the Graduate Program in Geochemistry and Geotectonics (Geosciences Institute – USP).

RESUMO

Diversos microfósseis provenientes de micritos quaternários da Serra da Bodoquena, estado de Mato Grosso do Sul, Brasil são aqui descritos pela primeira vez. Os taxa descritos são os seguintes: a) ostracodes: *Candona* sp., *Candonopsis* sp., *Cyclocypris* sp., *Cypria* sp., *Cypridopsis* sp., *Notodromas* sp., *Ilyocypris* sp., *Cyprideis* sp., *Wolburgiopsis* cf. *chinamuertensis* (Musacchio 1970), *Darwinula* sp. e 5 morfotipos; b) microgastrópode *Acrobis* sp., e c) restos de Characeae e girogonites de *Chara* sp..

A presença destes microfósseis sugere paleoambiente lacustre raso de águas límpidas e presença de vegetação aquática. As semelhanças dos microfóssseis com *taxa* viventes sugerem idades possivelmente holocênicas para estes depósitos, concordando com datações prévias por C^{14}.

Palavra-chave: micrito, Characeae, sedimentos lacustres, Ostracoda, Serra da Bodoquena.

REFERENCES

Almeida FFM. 1945. Geologia do Sudoeste Mato-grossense. Min Agricultura, Rio de Janeiro: Div Geol Miner DNPM. Boletim 116, 118 p.

Almeida FFM. 1965. Geologia da Serra da Bodoquena. Min Agricultura, Rio de Janeiro: Div Geol Miner DNPM. Boletim 219, 96 p.

Boggiani PC, Coimbra AM, Gesicki AL, Sial AN, Ferreira VP, Ribeiro FB and Flexor JM. 2002. Tufas Calcárias da Serra da Bodoquena, MS - 183 Cachoeiras petrificadas ao longo dos rios. In: Schobbenhaus C et al. (Eds), Sítios Geológicos e Paleontológicos do Brasil. Vol 1. Brasília: DNPM/CPRM - Comissão Brasileira de Sítios Geológicos e Paleobiológicos (SIGEP), p. 249-259.

Brown KM, Alexander JE and Throp JH. 1998. Differences in the Ecology and Distribution of Lotic Pulmonate and Prosobranch Gastropods. Am Malacol Bull 14(2): 91-101.

Cabral MC, Colin JP and Azerêdo AC. 2008. Taxonomy and Palaeoecology of New Brackish Ostracod Species from the Middle Cenomanian of Lousa, Lisbon Region, Portugal. Palaeogeogr Palaeoclimatol Palaeoecol 264: 250–262.

Carmo DA. 1998. Taxonomia, paleoecologia e distribuição estratigráfica dos ostracodes da Formação Alagamar (Cretáceo Inferior), Bacia Potiguar, Brasil. Tese de Doutorado. UFRGS: Porto Alegre, 156 f.

Carmo DA, Tomassi HZ and Oliveira SBSG. 2004. Taxonomia e distribuição estratigráfica dos ostracodes da Formação Quiricó, Grupo Areado (Cretáceo Inferior), Bacia Sanfranciscana, Brasil. Rev Bras Paleontol 7(2): 139-149.

Davies P and Griffiths HI. 2005. Molluscan and Ostracod Biostratigraphy of Holocene Tufa in the Test Valley at Bossington, Hampshire, UK. The Holocene 15(1): 97-110.

Feist M, Grambast-Fessard N, Guerlesquin M, Kenneth K, Huinan L, Mccourt RM, Qifei W and Shenzen Z. 2005. Treatise on Invertebrate Paleontology. Part B. Protoctista 1. V.1 Charophyta. New York: Geological Society of America and University of Kansas Press, 170 p.

Gobbo-Rodrigues SR. 2002. Carófitas e ostracodes do Grupo Bauru, Cretáceo Superior Continental do Sudeste do Brasil. Dissertação de Mestrado. UNESP: Rio Claro, 137 f. (Unpublished).

Gross M. 2008. A Limnic Ostracod Fauna from the Surroundings of the Central Paratethys (Late Middle Miocene/Early Late Miocene; Styrian Basin; Austria). Palaeogeogr Palaeoclimatol Palaeoecol 264: 263–276.

Kar R, Mandaokar BD and Kar RK. 2010. Fungal Taxa from the Miocene Sediments of Mizoram, Northeast India. Rev Palaeobot Palynol 158: 240–249.

Krstić N, Savić L and Jovanović G. 2005. Ostracodes and Paleolimnology on Examples of Balkan Peninsula. In: XV International Symposium on Ostracoda. Program and Abstracts. Berlin, p. 12-15.

Moore RC (Ed). 1954. Treatise on Invertebrate Paleontology. Part D. Protista 3. New York: Geological Society of America and University of Kansas Press, 195 p.

Moore RC (Ed). 1955. Treatise on Invertebrate Paleontology. Part E. Archaeocyatha and Porifera. New York: Geological Society of America and University of Kansas Press, 122 p.

Moore RC (Ed). 1961. Treatise on Invertebrate Paleontology. Part Q. Arthropoda 3. Crustacea Ostracoda. New York: Geological Society of America and University of Kansas Press, 442 p.

Musacchio EA. 1970. Ostracodos de las superfamilias Cytheracea y Darwinulacea de la Formación La Amarga (Cretacico Inferior) en la Provincia de Neuquén, Republica Argentina. Rev Asoc Paleont Arg 7(4): 301-317.

Namiotko T, Szczechura J and Namiotko L. 2003. Ostracoda of the Eemian Interglacial at Kruklanki in NE Poland. Stud Quart 20: 3–24.

Oliveira EC. 2009. Tufas calcárias da Serra da Bodoquena. Dissertação de mestrado. Instituto de Geociências - USP: São Paulo, 147 f. (Unpublished).

Oliveira EC, Boggiani PC, Utida G and Petri S. 2009. Significado paleoclimático dos calcários Quaternários da Formação Xaraiés. In: 2° Simpósio de Geotecnologias no Pantanal, Anais. Embrapa Informática Agropecuária/INPE, Corumbá, p. 230-239.

Pires-Zottarelli CLA and Rocha M. 2007. Novas citações de Chytridiomycota e Oomycota para o Parque Estadual das Fontes do Ipiranga (PEFI), SP, Brasil. Act Bot Bras 21(1): 125-136.

Sallun Filho W. 2005. Geomorfologia e geoespeleogia do carste da Serra da Bodoquena, MS. Tese de doutorado. Instituto de Geociências - USP: São Paulo, 193 f.

Sallun Filho W, Karmann I and Boggiani PC. 2004. Paisagens cársticas da Serra da Bodoquena (MS). In: Mantesso Neto V et al. (Eds), Geologia do continente sul-americano: evolução da obra de Fernando Flávio Marques de Almeida. São Paulo: Beca, p. 423-433.

Sallun Filho W, Karmann I, Boggiani PC, Petri S, Cristalli PS and Utida G. 2009a. A deposição de Tufas Quaternárias no Estado de Mato Grosso do Sul: Proposta de definição da Formação Serra da Bodoquena. Geol USP, Ser Cient 9(3): 47-60.

SALLUN FILHO W, KARMANN I, SALLUN AEM AND SUGUIO K. 2009b. Quaternary Tufa in the Serra da Bodoquena Karst, West-central Brazil: Evidence of Wet Period. In: International Climate Change: Global Risks, Challenges and Decisions. IOP Conf. Series: Earth and Environmental Science 6. Copenhagen. < http://www.iop.org/EJ/toc/1755-1315/6/7. [10/03/2009].

SAMES B. 2008. Application of Ostracoda and Charophyta from the Late Jurassic to Early Cretaceous Tendaguru Formation at Tendaguru, Tanzania (East Africa) - Biostratigraphy, Palaeobiogeography and Palaeoecology. Palaeogeogr Palaeoclimatol Palaeoecol 264: 213–229.

SIMONE LR. 2006. Land and Freshwater Molluscs of Brazil. São Paulo: EGB, 390 p.

SMITH RJ. 1999. Possible Fossil Ostracod (Crustacea) Eggs from the Cretaceous of Brazil. J Micropalaeontol 18: 81-87.

UTIDA G. 2009. Fósseis em micritos quaternários da Serra da Bodoquena, Bonito-MS e sua aplicação em estudos paleoambientais. Dissertação de Mestrado. Instituto de Geociências - USP: São Paulo, 204 f. (Unpublished).

UTIDA G, OLIVEIRA EC, PETRI S AND BOGGIANI PC. 2008. Microfósseis em micritos quaternários da Serra da Bodoquena - MS como indicadores paleoambientais. In: 44º Congresso Brasileiro de Geologia. Anais. Curitiba, 796 p.

UTIDA G, PETRI S, SALLUN FILHO W AND BOGGIANI PC. 2007. Gastrópodes em tufos calcários da Serra da Bodoquena, Bonito, MS. In: XX Congresso Brasileiro de Paleontologia. Anais. Búzios, 146 p.

VAN MORKHOVEN FPCM. 1963. Post-Palaeozoic Ostracoda: Their Morphology, Taxonomy and Economic Use. Vol. II Generic descriptions. New York: Elsevier, 478 p.