Quaternary International xxx (2016) 1–13

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Palaeoenvironmental interpretations based on molluscs from mid-Holocene lacustrine limestones, Mato Grosso do Sul, Brazil

Giselle Utida [a, *], Emiliano Castro Oliveira [b], Maurice Tucker [c], Setembrino Petri [d], Paulo Cesar Boggiani [d]

[a] Programa de Pós-graduação em Geoquímica e Geotectônica, Instituto de Geociências, Rua do Lago, 562, Cidade Universitária, São Paulo, SP CEP 05508-080, Universidade de São Paulo, Brazil
[b] Departamento de Ciências do Mar, Instituto do Mar, Universidade Federal de São Paulo, Brazil
[c] School of Earth Sciences, University of Bristol, BS8 3RW, England, UK
[d] Departamento de Geologia Sedimentar e Ambiental, Instituto de Geociências, Rua do Lago, 562, Cidade Universitária, São Paulo, SP CEP 05508-080, Universidade de São Paulo, Brazil

ARTICLE INFO

Article history:
Received 30 November 2015
Received in revised form
1 November 2016
Accepted 6 November 2016
Available online xxx

Keywords:
Gastropods
Taphonomy
Tufa
Lake
Serra da Bodoquena
Pantanal

ABSTRACT

In central Brazil there are continental carbonate rocks in three different geological contexts – the Pleistocene wackestones in the Corumbá city (Xaraiés Formation), the mid-Holocene limestones lenses in the Pantanal Plain (Pantanal do Miranda) and old and modern tufas in the Serra da Bodoquena (Serra da Bodoquena Formation). We present here a systematic and taphonomic study of the molluscs found in the carbonate deposits in the Serra da Bodoquena and the limestones lenses of the Pantanal do Miranda, which provide information concerning the carbonate palaeoenvironments of these two distinct areas. Seven molluscan species were found: the gastropods *Marisa* sp., *Pomacea canaliculata*, an unidentified hydrobiid, *Idiopyrgus* sp., *Biomphalaria* sp. and *Megalobulimus* sp., and the bivalve *Pisidium* sp. The gastropods include species still living in the area today, which supports a Holocene age for the limestones, as indicated by published ^{14}C dates. Overall, the data obtained from the Serra da Bodoquena carbonates suggest a freshwater environment with minimal current-wave action, in an area probably fed by springs, close to a terrestrial environment, in view of the assemblage composed of *Pomacea canaliculata*, the unidentified hydrobiid, *Idiopyrgus* sp., *Biomphalaria* sp. and *Megalobulimus* sp. The lacustrine palaeoenvironment in the Pantanal do Miranda area was different, as indicated by the presence of *Marisa* sp. and absence of shallow-water species such as *Biomphalaria* sp. The gastropods from Serra da Bodoquena and Pantanal do Miranda are predominantly aquatic and amphibious; they are probably younger than the terrestrial gastropods reported from fine-grained limestones in the Corumbá area.

1. Introduction

Continental Quaternary carbonate deposits occur widely in state of Mato Grosso do Sul (Brazil) and were first described by Almeida (1945) from Corumbá as the Xaraiés Formation. Almeida (1945) distinguished four categories of rocks: calcareous tufa with fossil plants, soft porous tufa, conglomerate with calcareous cement, and a micritic limestone with fossil gastropods. In the micritic limestone, Mendes (in Almeida, 1945) identified the land gastropods *Stenogyra (Opeas) misera*, *Zonitoides* sp. and *Bulimulus* sp. (Binney and Bland, 1869; Oliveira and Almeida, 1999). Almeida (1945) suggested a Pleistocene or Pliocene age for these limestones, based on the gastropods, because they are living taxa.

To the south in the Serra da Bodoquena, Almeida (1965) also assigned Quaternary carbonate deposits to the Xaraiés Formation and later the Holocene age was confirmed (Turcq et al., 1987; Boggiani et al., 1998). Sallun Filho et al. (2009a) proposed a separation of these deposits from the Xaraiés Formation to a new one, the Serra da Bodoquena Formation, due to differences in lithological characteristics, the existence of clear and abrupt contacts, and the relatively easy mapping of the unit. Boggiani et al. (2002) discovered some gastropods in these deposits, *Biomphalaria* sp., *Physa* sp. and *Aquidauana* sp. These species are typically from

* Corresponding author.
E-mail addresses: giselleutida@hotmail.com (G. Utida), emiltri@gmail.com (E.C. Oliveira), maurice.tucker@bristol.ac.uk (M. Tucker), spetri@usp.br (S. Petri), boggiani@usp.br (P.C. Boggiani).

http://dx.doi.org/10.1016/j.quaint.2016.11.007
1040-6182/

freshwater but they have an amphibious habit (Davis, 1979; Malek, 1983; Utzinger et al., 1997; Oliveira and Almeida, 1999; Utzinger and Tanner, 2000).

Gastropods also are preserved in wetlands of Pantanal, in Pantanal do Miranda within lenticular carbonate deposits and in calcium carbonate layers in margins and bottoms of recent ponds of alkaline waters (Turcq et al., 1987; Assine and Soares, 2004). Turcq et al. (1987) described the lenticular carbonates of Pantanal do Miranda as belonging to the Xaraiés Formation, and bearing the gastropods *Pomacea* sp. and *Biomphalaria* sp. (Boggiani and Coimbra, 1995; Boggiani et al., 1998). Utida et al. (2009, 2012) described freshwater micro- and macro-fossils from the Xaraiés Formation in the Pantanal, and suggested a lacustrine palaeoenvironment for carbonate deposition.

These fossiliferous micritic carbonates are widespread between the Serra da Bodoquena and Pantanal do Miranda. They contain a diversity of fossils but molluscs are found only in the upper part of the deposits where microfossils were not found (Utida et al., 2012). The presence of molluscs may indicate a different palaeoenvironment from that where the microfossils occur.

We present here a taphonomic study of the molluscs found in the carbonate deposits of the Xaraiés Formation collected in Serra da Bodoquena and the carbonate lenses of the Pantanal do Miranda, which provide information concerning the carbonate palaeoenvironments of these two distinct areas, Serra da Bodoquena and Pantanal do Miranda.

2. Regional setting

The Serra da Bodoquena is on the southern margin of the Pantanal and is a range of hills 200 km in length and 400–800 m in height. The Quaternary carbonates overlie Neoproterozoic/Ediacaran carbonates of the Corumbá Group (Fig. 1); the latter have been extensively dissolved by groundwater to create major cave systems. Emerging groundwater from the carbonates provides bicarbonate (and calcium) to the rivers and lakes of the area, where tufa and micrite are widely precipitated (Almeida, 1965; Boggiani and Coimbra, 1995; Sallun Filho, 2005; Sallun Filho and Karmann, 2007).

The sedimentary characteristics of the studied deposits are different in terms of their geology and geomorphology. The Serra da Bodoquena is much affected by normal faults with a NNW-SSE direction in the northern part and NW-SE, NE-SW and NS directions in the south-central portion. This range is made up of Neoproterozoic carbonate basement rocks, occurring up to 600 m above sea level, with overlying occurrences of Quaternary continental carbonates. The Pantanal do Miranda is located in the Pantanal basin, with altitudes of 90 m approximately, directly on the oldest lobe (Pleistocene) of a megafan of the Taquari River (Assine and Soares, 2004); in this region there are many occurrences of restricted lenses of continental carbonates (Fig. 2).

The studied fossils of the Serra da Bodoquena occur within the deposit of the Mineração Calcário Xaraés. The carbonate deposit here is composed of unconsolidated fossiliferous wackestone in the form of tabular and lenticular beds, 0.5–3.0 m thick. This facies crops out over Middle Pleistocene wackestone and a thin bed of oncolitic rudstone, and is commonly covered by boundstone (soft tufa) younger than 5500 years (Fig. 2) (Ribeiro et al., 2015; Oliveira et al., 2016). These limestones are beige to grey in colour, with 60–95% calcium carbonate and some terrigenous sediment, mostly quartz silt, but also some clay (Fig. 3 a, b). They mostly occur close to rivers where they have been exposed by erosion through meandering, but they are also seen in quarries where they are being exploited for agriculture (Utida et al., 2012). Turcq et al. (1987) obtained an age of 5200 (±230 years BP) from ^{14}C dating of shells in these carbonates, and suggested that they were deposited on an alluvial plain. According to the recent calibration curve of Hogg et al. (2013), this age would recalculated to 5931 (±473 year cal BP). Sallun Filho et al. (2009b) confirmed the Holocene ^{14}C ages for shells from the Mineração Calcário Xaraés, with a range of 2850 to 2720 cal yr BP (in the upper part of the deposit), to 6530 to 6310 cal yr BP (at a depth of 3 m into the deposit), but they interpreted the facies as lacustrine (Sallun Filho et al., 2009b; Utida, 2009).

The Pantanal do Miranda is located just to the south of the extensive alluvial fan of the Taquari River, and limestones are exposed on the Park Road of Pantanal Sul, and elsewhere in the area. These rocks are mostly lenticular deposits, and they are generally quartz and fossil-rich wackestones, from 0.3 to 1.0 m thick and a lateral extension of 10–15 m, rarely up to 50 m (Fig. 3 c, d). These Pantanal do Miranda limestones were probably deposited in a lacustrine palaeoenvironment, when fluvial influence was minimal (Almeida, 1965; Boggiani et al., 1998; Ribeiro et al., 2001), during the mid-Holocene according to a ^{14}C date of 3910 (±100 years BP) (Boggiani et al., 1998), or 4255 (±279 years cal BP), according to the calibration curve of Hogg et al. (2013). They were deposited in localized areas upon a laterally-extensive unconsolidated fine quartz sand surface, probably in the lower reaches of an alluvial fan. The Pantanal limestones were probably deposited under a more arid climate, which existed during the period ~5600 to 2600 years BP (Mcglue et al., 2012).

3. Material and methods

Fossiliferous micritic limestones were collected from 14 sites in the Serra da Bodoquena and Pantanal do Miranda (Table 1, Figs. 1 and 3. The deposits of the Mineração Calcário Xaraés (site 1) and Pantanal do Miranda (site 13) were the same outcrops where Sallun Filho et al. (2009b) and Boggiani and Coimbra (1995) collected shells and obtained the carbon ages described above.

The fossils studied from the Serra da Bodoquena belong to the lacustrine facies association of wackestones, oncolitic rudstones and fossil-rich wackestones Oliveira et al., 2016 (Fig. 2). The thickness of this association ranges between 15 cm and 6 m and it covers an area of between 50 m^2 and 20 km^2. The fact that this facies association is dominated by micritic carbonate, with ostracods, gastropods and bivalves, and is located in low, flat areas near the base of hills, in the form of discontinuous and elongated lenses, is compatible with a lacustrine environment (Utida et al., 2012).

The fossils studied from the Pantanal do Miranda belong to a palustrine facies association, which is formed of quartz sand-rich wackestones, with a thickness ranging between 1.5 and 0.5 m, and covering an average area of around 200 m^2. The textures include rhizoliths (and preserved roots) and mud cracks, and well-rounded and well-sorted quartz sandy sediments of the Pantanal carbonates (Oliveira et al., 2016). The geographical location of these occurrences, in the oldest lobe of the Taquari River megafan, suggests the introduction of carbonate-rich groundwater from the Neoproterozoic carbonate basement.

3.1. Fossil sampling

Samples from fourteen sites (Table 1) were collected manually where carbonates are cropping out. At the Mineração Calcário Xaraés (site 1, Fig. 3 a), samples were collected by hand from the first 2 m at the top of the outcrop, and by auger drilling where there is no exposure, resulting in a composite section of about 5 m depth, with carbonates collected at each 0.5 m. In the laboratory shells were extracted manually or with tools such as tweezers, brushes and sieves, from carbonate hand samples of around 100 g. Molluscs

Please cite this article in press as: Utida, G., et al., Palaeoenvironmental interpretations based on molluscs from mid-Holocene lacustrine limestones, Mato Grosso do Sul, Brazil, Quaternary International (2016), http://dx.doi.org/10.1016/j.quaint.2016.11.007