45 mm

LATE PLEISTOCENE (IONIAN-TARANTIAN) BRACHIOPODS FROM THE RIO GRANDE DO SUL SHELF, AS RECORDERS OF COLD CLIMATE CONDITIONS NEAR THE BRAZIL-MALVINAS CONFLUENCE ZONE

Marcello G. Simões[1]; Cristiano M. Chiessi[2]; Carla B. Kotzian[3]; Jürgen Pätzold[4]
profmgsimoes@gmail.com
1- Instituto de Biociências, UNESP, Botucatu, 18.610-000, SP, Brasil; 2- Escola de Artes, Ciências e Humanidades, USP, São Paulo, 03.828-000, SP, Brasil; 3- Departamento de Biologia, UFSM, Santa Maria, 97.105-970, RS, Brasil; 4- MARUM-Center for Marine Environmental Sciences, University of Bremen, Bremen, 28334, Germany.

Key-words: *South Atlantic, Late Quaternary, Rhynchonelliform brachiopods, Magellanic Province, Younger Dryas event*

1. INTRODUCTION

Living brachiopods of the Brazilian continental margin are distributed over the latitudinal range of 00˚ 30'S (Manuel Luis reef) to 33˚ 23'S (Chuí creek, near the Plata River mouth). In this area, brachiopods are mainly recorded in shallow water settings (<200 m) and the fauna is patchy distributed, locally abundant and dominated by small specimens (~2mm) (Simões and Leme, 2010). In the southernmost Brazilian shelf (Rio Grande do Sul State), the fauna is mainly dominated by the cosmopolitan species *Argyrotheca* cf. *cuneata* and the endemic species *Bouchardia rosea*. This dominance is remarkably distinct from the Argentinean fauna, which is dominated by cold water species (*e.g.*, *Terebratella dorsata*, *Magellania venosa*, *Liothyrella uva*), which occur in waters as cold as 3.8°C (Roux and Bremec 1996). Much noticeable is that the Present-day southernmost occurrence of the warm water brachiopod species *B. rosea* is at 33˚S (Chuí creek) (Simões and Leme, 2010) and the northernmost occurrence of the cold water brachiopod species *M. venosa* is around 36°S (Foster, 1989, p. 294). These Present-day limits roughly coincide with the Brazil-Malvinas Confluence (BMC) zone a major oceanographic feature that dominates the circulation of the western subtropical South Atlantic (*e.g.*, Olson *et al.*, 1988; Peterson and Stramma, 1991). As we will show here, this scenario was quite distinct during the Late Pleistocene.

2. MATERIAL, METHODS AND REPOSITORY

The Pleistocene brachiopods studied here were recovered in 1981, during the GEOMAR XVII Expedition. They were found in two collecting sites (Station-07 - 33˚36'7''S/50˚59'50''W and Station-12 - 33˚36'7''S/51˚57'7''W), at 183 and 25m water depth, respectively. In these stations the bottom is sandy (>89%) with low contents of fine grained sediments. In order to compare our Pleistocene shells with those of brachiopods of the Present-day Magellanic Zoogeographic Province (Brattstrom and Johanssen, 1983) and the

45 mm

Argentinean Province (Boschi, 2000a, b) we also examined the data provided by RV Meteor cruise M46/3 (Bleil *et al.*, 2001). In special, findings of *M. venosa* in the GeoB6347-3 Station (42˚48’52’’S/58˚56’56’’W/153 m water depth) are of particular interest, since they were recorded within the Present-day limits of *M. venosa* in the Argentinean continental margin. The brachiopod shells from the Geomar Station-12 were sent to Beta Analytic Laboratory, USA, for AMS-radiocarbon dating. Subsequently, we applied the MARINE09 (Reimer *et al.*, 2009) radiocarbon calibration curve with the Calib 6.0 software (Stuiver and Reimer, 1993) in order to convert radiocarbon dates into calibrated years before the present (cal yr BP). The studied material are all housed in the Scientific Collection of the Department of Zoology, IBB/UNESP, at Botucatu campus, under the code DPZ.

3. RESULTS

The size and general shell outline of the studied specimens are similar to that of living long-looped brachiopod *Magellania venosa* (Fig. 1). The shells are closed articulated, but disarticulated valves are also present in the examined collection. Generally, the shells are very well preserved without any taphonomic feature (*e.g.*, fragmentation, abrasion, rounded margins) that could be indicative of extensive lateral transport or residence time at the sediment/water interface. AMS-radiocarbon dating of the studied shells has yielded the following ages: 12555-12737 cal yr BP, or 10670-11130 +/- 50 ka BP (uncalibrated).

4. DISCUSSION AND FINAL THOUGHTS

This is the first record of Pleistocene brachiopods that are typical members of the Magellanic Province in the Brazilian continental shelf. This result has important implications. **1- Taphonomic Implications**: The occurrence of Pleistocene fossils in surficial sediments of the Brazilian continental shelf is an exceptional example of Biological Remanié (*i.e.*, relict shells from older deposits, sense Craig, 1966). Despite of that, the taphonomic evidence indicate that they are autochthonous to parautochthonous specimens (Fig. 1). **2- Paleoclimatic Implications**: *Magellania* and its closely related allies are exclusively confined to cold-temperate sites of the Southern Hemisphere, and living populations of *M. venosa* are recorded in cold waters (colder than 12°C) (see a compilation of data on *Magellania* distribution and ecology – extant and fossil - in C. Emig, 2011, http://paleopolis.rediris.es/BrachNet/Antarctic-brachiopoda/BRACHS/Magellania.html#). Presently, the largest populations of *M. venosa* are recorded in areas with clean shelly/rocky bottoms and persistent, strong but not turbulent currents (McCammon, 1973, p. 270; see also Bitner, 1996). According to McCammon (1973, p. 269), the water temperature acceptable to *M. venosa* is from 3° to 12°C. Yet, brachiopods thriving in aquaria have only tolerated short periods in water temperature of 20°C (McCammon, 1973). When kept more than one day at this “high” temperature the specimens died soon (McCammon, 1973, p. 269). Additionally, when kept at 16°C in an open system with fresh seawater flushing through, the specimens of *M. venosa* survived for only a week

45 mm

(McCammon, 1973, p. 269). Hence, if we treat our Pleistocene specimens, as living under similar conditions of the extant representatives of *Magellania*, the sea water in the Rio Grande do Sul shelf, during the transition Ionian-Tarantian, may have reached significantly colder temperatures than at the Present-day (mean annual temperature at Geomar Station-12 at 25 m water depth is ca. 20°C, Locarnini *et al.*, 2010). This plea is noteworthy because the age (12555-12737 cal yr BP) of the studied material coincides with the conspicuous climatic transition from the warm Bølling-Allerød to the cold Younger Dryas periods in the North Atlantic realm (*e.g.*, Rasmussen *et al.*, 2006), when the Atlantic Meridional Overturning Circulation experienced a major shift from a strong mode into a sluggish mode (*e.g.*, McManus *et al.*, 2004). Although this shift is believed to cause major Atlantic-wide reorganization in surface (*e.g.*, Stouffer *et al.*, 2006) and intermediate water (*e.g.*, Rühlemann *et al.*, 2004) conditions, there is so far almost no evidence coming from the western subtropical South Atlantic. In our presentation we will show a conceptual model that links the very occurrence of *Magellania* cf. *M. venosa* in the Rio Grande do Sul shelf with the major climatic events that characterized the transition from the Ionian to the Tarantian.

Figure 1- Two specimens of the long-looped brachiopod *Magellania*. Left- Well preserved Pleistocene specimen (*Magellania* cf. *M. venosa*) from the southernmost Brazilian shelf (33˚S); Right- Living specimen of *M. venosa* collected by RV Meteor, GeoB6347-3 Station (42˚S), along the Argentinean continental margin.

45 mm

REFERENCES

Bitner, M.A., 1996b. Brachiopods from the Eocene La Meseta Formation of Seymour Island, Antarctic Peninsula. In: A. Gaździcki ed., Palaeontological Results of the Polish Antarctic Expeditions. Part II. *Palaeontologia Polonica*, vol. 55, pp. 65-100.

Bleil, U. & Cruise Participants, 2001. Report and preliminary results of Meteor Cruise M46/3, Montevideo–Mar del Plata, 04.01.– 07.02.2000. *Berichte, Fachbereich Geowissenschaften*, 172. Universität Bremen, Bremen. 161 pp.

Boschi, E.E., 2000a. Species of Decapod Crustaceans and their distribution in the American marine zoogeographic provinces. *Revista de Investigación y Desarrollo Pesquero*, n. 13, pp. 7-136.

Boschi, E.E.,2000b. Biodiversity of marine decapod brachyurans of the Americas. *Journal Crustacean Biology*, vol. 20, pp. 337-342.

Brattstrom, H. & Johanssen, A., 1983. Ecological and regional zoogeography of the marine benthic fauna of Chile. *Sarsia*, vol. 68, pp. 289-339.

Craig. G.Y., 1966. Concepts in palaeoecology. *Earth Sciences Review*, vol. 2, pp.127-155.

Foster M. W., 1989. Brachiopods from the extreme South Pacific and adjacent waters. *Journal of Paleontology*, vol. 63, pp. 268-301.

Locarnini, R.A., Mishonov, A.V., Antonov, J.I., Boyer, T.P., Garcia, H.E., Baranova, O.K., Zweng, M.M. & Johnson, D.R., 2010. World Ocean Atlas 2009, Volume 1: Temperature. S. Levitus, Ed. NOAA Atlas NESDIS 68, U.S. Government Printing Office, Washington, D.C., 184 pp.

McCammon H. M., 1973. The ecology of *Magellania venosa*, an articulate brachiopod. *Journal of Paleontology*, vol. 47, n. 2, pp. 266-278.

McManus, J.F., Francois, R., Gherardi, J.-M., Keigwin, L.D. & Brown-Leger, S., 2004. Collapse and rapid resumption of Atlantic meridional circulation linked to deglacial climate changes. *Nature*, vol. 428, pp. 834–837, doi:10.1038/nature02494.

Olson, D.B., Podestá, G.P., Evans, R.H. & Brown, O.B., 1988. Temporal variations in the separation ofBrazil and Malvinas Currents. *Deep-Sea Research. Part A, Oceanographic Research Papers*, vol. 35, pp. 1971–1990.

45 mm

Peterson, R.G. & Stramma, L., 1991. Upper-level circulation in the South Atlantic Ocean. *Progress in Oceanography*, vol. 26, pp. 1–73.

Rasmussen, S.O. & 15 Others, 2006. A new Greenland ice core chronology for the last glacial termination, *Journal of Geophysical Research*, vol. 111, D06102, doi:10.1029/2005JD006079.

Reimer, P.J. & 27 Others, 2009. INTCAL09 and MARINE09 radiocarbon age calibration curves, 0–50,000 years cal BP. *Radiocarbon*, vol. 51, pp. 1111–1150.

Roux, A. & Bremec, C., 1996. Brachiopoda collected in the Western South Atlantic by R/V Shinkai Maru cruises (1978-1979). *Revista de Investigación y Desarrollo Pesquero*, n. 10, pp. 109-114.

Rühlemann, C., Mulitza, S., Lohmann, G., Paul, A., Prange, M. & Wefer, G., 2004. Intermediate depth warming in the tropical Atlantic related to weakened thermohaline circulation: Combining paleoclimate data and modeling results for the last deglaciation, *Paleoceanography* vol. 19, PA1025, doi:10.1029/2003PA000948

Simões, M.G. & Leme, J.M., 2010. Recent Rhynchonelliform brachiopods from the Brazilian continental margin, Western South Atlantic. In: 6th International Brachiopod Congress, 2010, Melbourne. Program & Abstracts, *Geological Society of Australia Abstracts*, v. 95., p. 104.

Stouffer, R.J. & 22 Others, 2006. Investigating the Causes of the Response of the Thermohaline Circulation to Past and Future Climate Changes. *Journal of Climate*, vol. 19, pp. 1365-1387.

Stuiver, M. & Reimer, P.J., 1993. Extended 14C database and revised CALIB 3.0 14C age calibration 531 program. *Radiocarbon*, vol. 35, pp. 215-230.