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The first record record of the comatulid crinoid *Sievertsella* Radwańska, 2003 and its implications for the Miocene of the Bragança-Viseu Basin, Brazil

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ABSTRACT:

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The first record of a comatulid crinoid *Sievertsella* cf. *polonica* (Radwańska, 1987), from the Pirabas Formation (Miocene of NE Brazil) is documented. The record points out to a shallow coastal tropical or subtropical paleoecosystem with rocks or reefs in the Miocene from Bragança-Viseu Basin on Brazilian equatorial margin.

Key words: Crinoidea; Comatulida; Miocene; Brazil.

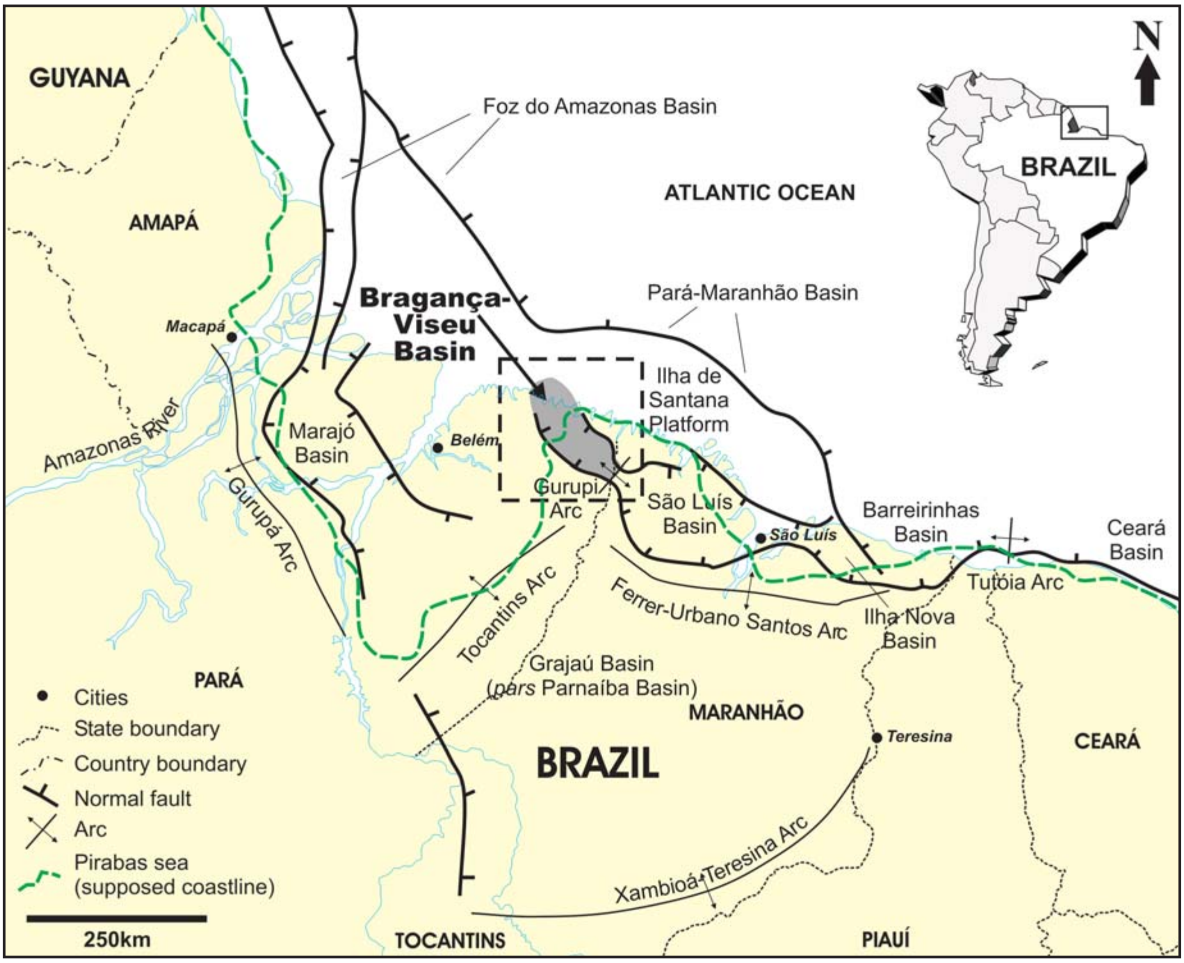
INTRODUCTION

The state of Pará in northern Brazil (see Text-fig. 1) hosts one of the most important sequences related to the marine transgression that affected South America during the Miocene. The Pirabas Formation, which corresponds to the Miocene of the Bragança-Viseu Basin, is an echinoid-rich stratigraphic unit. Its fauna has similarities across the area stretching between Florida and the Caribbean, the region which was still connected to the Pacific Ocean during the Miocene, as the Panama Isthmus was not yet formed. This work presents the first record of the comatulid crinoid *Sievertsella* Radwańska, 2003 from the Pirabas Formation.

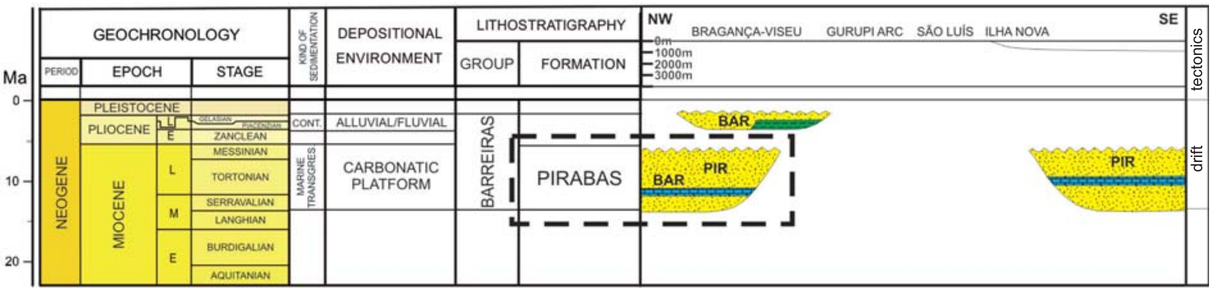
GEOLOGICAL SETTING

The Bragança-Viseu Basin, located in the north-eastern region of Pará and the north-western Maranhão (Text-fig. 1), is a part of a set of small east-west pull-apart basins, which evolved in the Aptian-Albian (Early Cretaceous) (e.g. Lima *et al.* 1995; Zalán 2007). Its Cenozoic succession is, however, the best-known part of the succession due its extensive exposures along the coastal area of the basin. The stratigraphy of the oldest parts of the Cenozoic succession is poorly known, restricted to that originating from two wells drilled in the 1960s.

The Pirabas Formation represents the Miocene of the Bragança-Viseu Basin (Text-fig. 2). It is com-



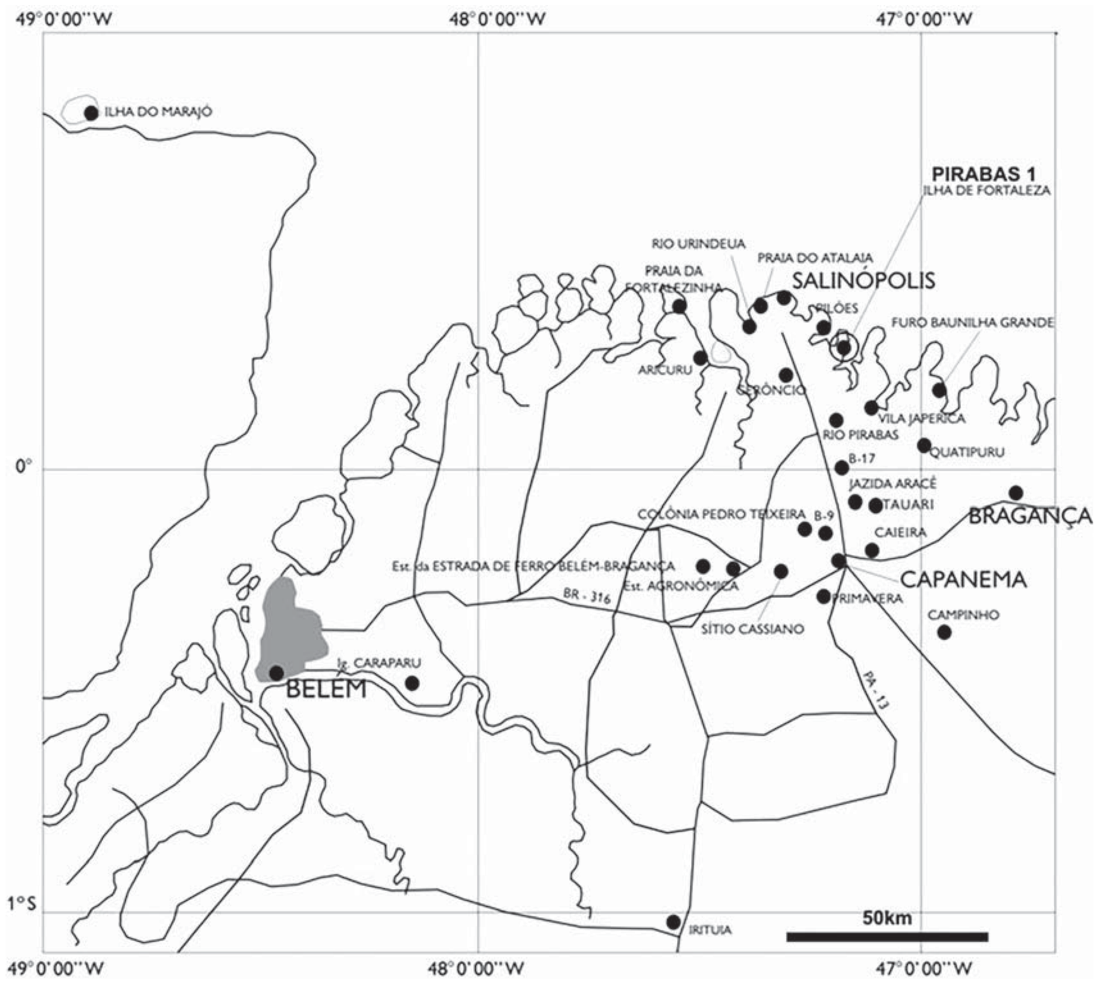
Text-fig. 1. Localization map of the Bragança-Viseu Basin, indicating the supposed extension of the Pirabas sea (dashed green line; modified from Soares *et al.* 2011)



Text-fig. 2. Cenozoic stratigraphic chart from the Bragança-Viseu, São Luís and Ilha Nova basins (Zalán 2007)

posed of sandstones, shales and limestones overlying unconformably the Cretaceous strata.

The limestones are composed of biocalcirudites and biocalcarenites. The biocalcirudites yield a great diversity of fossils, represented by entire or fragmented individuals of variable sizes, embedded in a carbonate-bioclastic sand-grained matrix, cemented by calcite, and are locally dolomitized. Bivalves, gastropods, echinoderms, coelenterates, bryozoans, crustaceans, cephalopods, porifera, planktonic and benthic foraminifera, ostracods and articulated fragments of vertebrates (e.g. fish, reptiles, and Sirenia) constitute the most common bioclasts. The biocalcarenites occur as massive or laminated strata (Góes *et al.* 1990) yield-



Text-fig. 3. Localization map of the Pirabas 1 (modified of the Távora et al. 2010)

ing sparser and sometimes fragmented fossil remains. Marls, shales, mudstones and corallinean bioherms occur sporadically (Távora *et al.* 2013).

The fossils of the Pirabas Formation are indicative of warm, shallow and agitated open marine deposition, with lagoons, estuaries and tidal flats, appearing as cyclically related environments, suggesting frequent fluctuations in sea-level (Góes *et al.* 1990). The great diversity and abundance of fossils in the biocalcirudites suggest catastrophic events during their deposition; entire assemblages fossilized in life position have been reported. In the inner portions of the carbonate platform, a lagoon-paralic system protected by barrier islands developed. Marls, mudstones, shales and non-stratified biocalcarenites are recorded (Góes *et al.* 1990).

The deposition of the Miocene sequence was initially transgressive, under strong tectonic control, occurring in incised-valleys along fault zones (e.g. Rossetti and Góes 2004; Soares Jr. *et al.* 2011). This caused the sea to advance circa 150 km onto the continent relative to the current shoreline (Text-fig.1). After the initial transgression a regressive phase started, with higher continental terrigenous input which inhibited the maintenance of the carbonate platform. The transition between the Pirabas Formation and the siliciclastic sediments of the Barreiras Group seems to be gradual (e.g. Fernandes 1984; Góes *et al.* 1990). In this paper, the Pirabas Formation is interpreted as a unit within the Barreiras Group though many authors still interpret these as separate units (e.g., Arai *et al.* 1988; Góes *et al.* 1990; Rossetti 2006).

MATERIAL AND METHODS

The material studied comes from the locality Pirabas 1 (Text-fig. 3) and was discovered in the sediment left after preparation of fossil echinoids. The studied specimen is a calyx and is housed with the echinoderm collection of the Fundação Paleontológica Phoenix, in Aracaju, Sergipe, Brazil. The identification follows that of Hess and Messing (2011).

The specimen was metalized with carbon and photographed under a scanning electron microscope.

The locality description follows the pattern adopted by Bengtson (1983, pp. 30–31) for the Sergipe-Alagoas Basin, Brazil. The coordinates were obtained on the Córrego Alegre datum and rounded to the nearest 50 meters. UTM coordinates are referenced to the central 45°meridian. The code after the location identifies the outcrop on the map.

Pirabas 1 (PRB-01) – UTM 9.924.550N/258500E. Topographic map sheet: SA.23-V-A-V-2 Porto da Praia.

THE AGE OF THE PIRABAS LIMESTONE

The Pirabas limestone was first attributed to the Cretaceous (White 1887; Katzer 1903, confirmed also by von Ihering, 1907, who stated that no Tertiary deposits with marine fossils existed of the Brazilian coast). In 1913 Maury (in Maury 1925) attributed a Tertiary age to the marine fossils from the Pirabas River and from an area known as “Estação Agronômica”, both in Pará. On the geological map of Branner (1919), the exposed layers in Pirabas were referred to the lower Eocene, based on the assumption of its equivalence with the Maria Farinha Formation in Pernambuco. Maury (1918) confirmed the marine character of the fauna, emphasizing, however, that they are younger than the Eocene. She compared the fauna to the lower Miocene fauna of Panama, Santo Domingo, Jamaica and Florida. In her 1925 monograph, Maury provided a detailed systematic study of this fauna, maintaining its assignment to the lower Miocene.

Petri (1957) did the first studies on the microfossils from this unit, confirming a Miocene age based on foraminifers.

Palynological studies carried out in the “Bragantina” region (northeastern Pará) indicated a Miocene age of the Pirabas Formation (Leite et al. 1997). The presence of *Crototricolpites annemariae*, *Echitricolporites maristellae*, *Polypodiaceoisporites potoniei*, *Psilastephanocolporites tesseroporus* and *Crototricolpites americanus*, and the absence of *Crassoretitriletes vanraadshoovenii*, indicate the *Psiladiporites–Crototricolpites* Biozone (Concurrent Range Zone, *sensu* Hoorn 1993). The pollen content of the upper Barreiras Group (the presence of *Crassoretitriletes vanraadshoovenii*, *Ilexpollenites* sp., *Bombacacidites baculatus* and *Thymelipollis retisculpturius*, and absence of *Grimsdalea magnaclavata*) placed it in the *Crassoretitriletes* Interval Zone (*sensu* Lorente 1986) of the Miocene.

SYSTEMATIC PALAENTOLOGY

Class Crinoidea Miller, 1821
Subclass Articulata Zittel, 1879
Order Comatulida Clark, 1908
Family Comatulidae Fleming, 1828
Genus *Sievertsella* Radwańska, 2003
Sievertsella cf. *polonica* (Radwańska, 1987)
(Text-figs 5, 6)

Compare:
1987 *Sievertsia polonica* sp. n.; U. Radwańska, pp. 117–119, figs 2, 1–5, pl. 1, figs 1–3, pl. 2, figs 1–4.

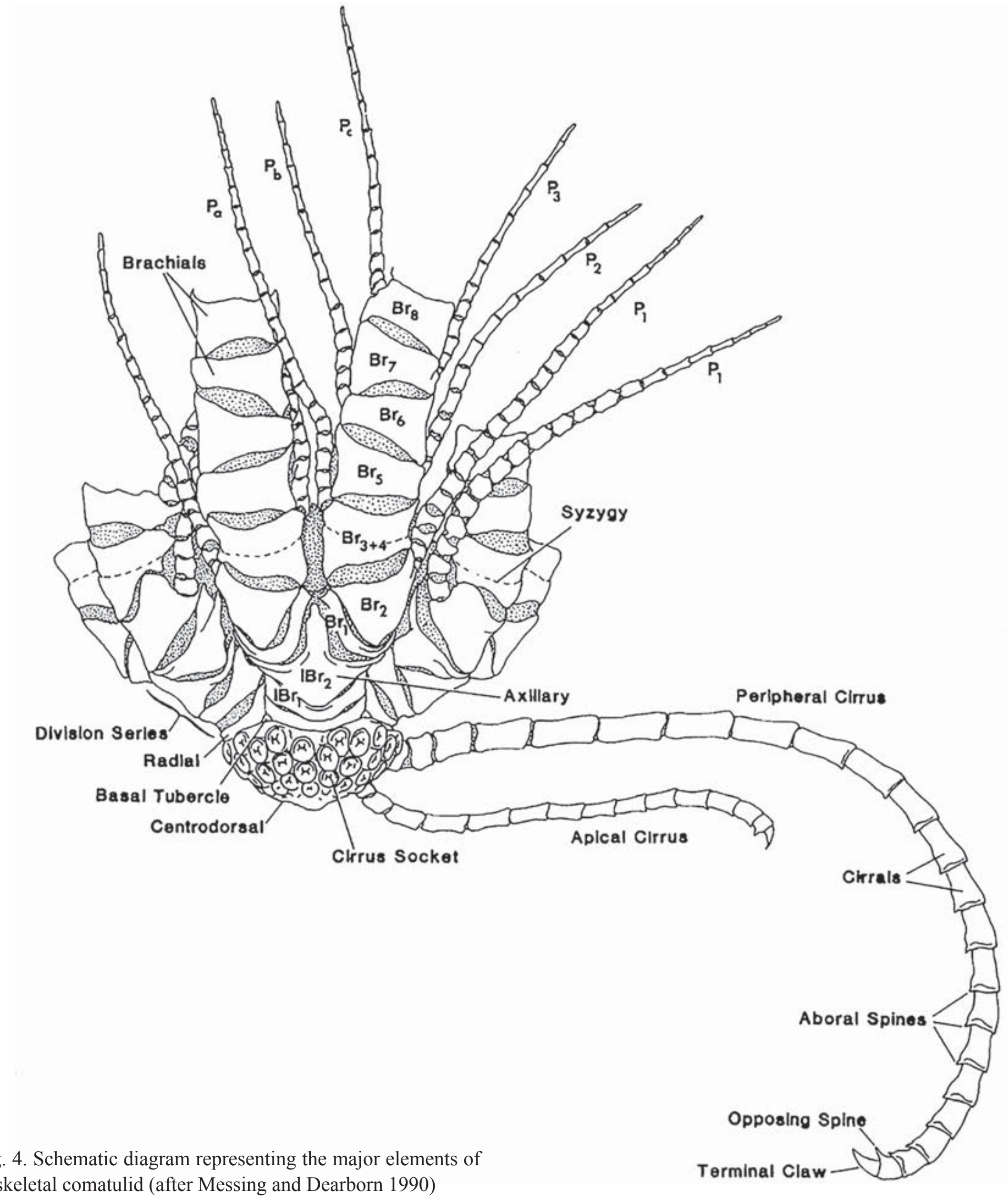
LOCALITY: Pirabas 1, Fortaleza Island, Pará State, Brazil.

MATERIAL: One specimen (PBR-01-80).

DESCRIPTION: A very small calyx of slightly pentagonal outline formed by centrodorsal, basal and radial plates. This set of plates measures 3.0 mm in diameter and 1.0 mm in height. The centrodorsal plate has a shallow rounded shape (Text-fig. 5C). On the ventral side, the centrodorsal plate has a large cavity (Text-fig. 5B). The cirrus sockets’ cavities are arranged approximately [in] two circles, containing 18 cirrus sockets (Text-fig. 5A). The nine apical cirrus sockets have half the diameter of the remaining peripheral sockets, indicating that [the] peripheral cirrus were thicker and probably stronger than the apical, which would be fine and delicate. The dorsal area of the centrodorsal plate is naked. The basal tubercles have three rays (Text-fig. 5A). The five radial plates are trapezoidal and have [a] fossae for passage of the nerve (Text-fig. 5B) at the distal median margin, and it is separated by a narrow structure from the lateral fossae.

PALEOGEOGRAPHIC DISTRIBUTION: Poland (Radwańska 1987) and Brazil (this paper).

DISCUSSION: As the specimen consists only of the calyx, without the remains of any arms (Text-fig. 4), no further analysis is possible. However, the characteristics of the centrodorsal plate are similar to



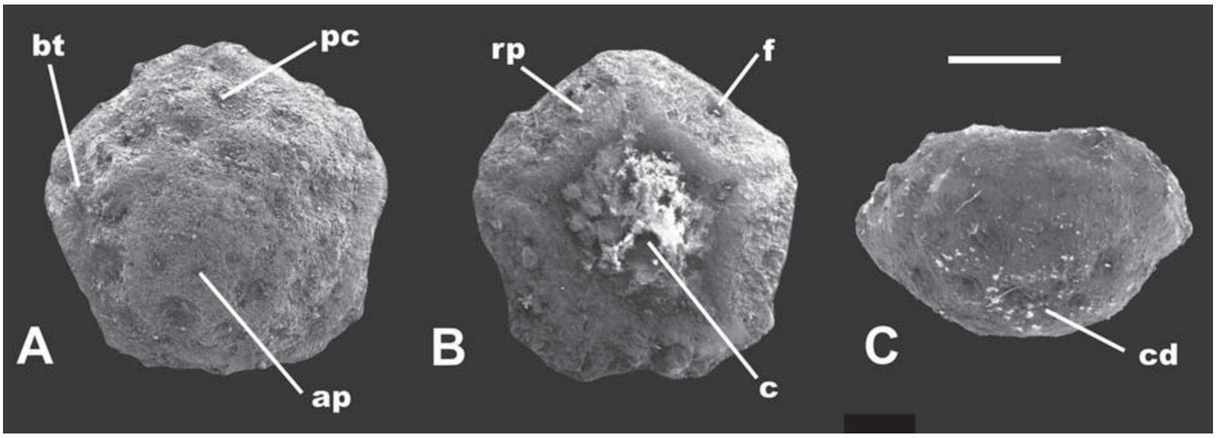
Text-fig. 4. Schematic diagram representing the major elements of a skeletal comatulid (after Messing and Dearborn 1990)

those of *Sievertsella polonica* (Radwańska, 1987), a comatulid from the Middle Miocene of Poland. According to Jagt (2000), the discrimination between adult comatulids' species can be very safely done based on their centrodorsal plate. In recent comatulids, the great variability among species suggests that the diversification of these crinoids continues till the present day (Messing 1997).

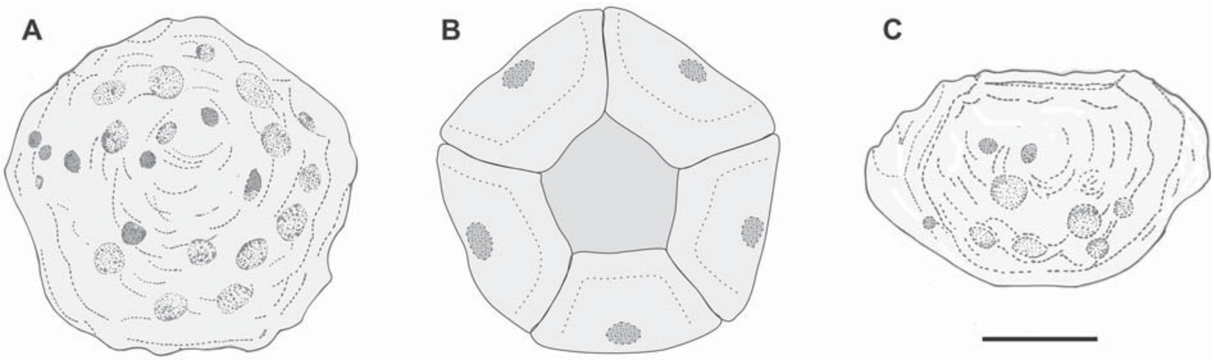
This is the first record of *Sievertsella* cf. *polonica* in the Pirabas Formation and from the Neogene of Brazil.

PALAEOECOLOGY AND PALAEOBIOGEOGRAPHY

Recent comatulids are often found occurring [in] coastal environments attached to rocks or reefs (Hendler *et al*. 1995). Many of the species hide in rock crevices and coral reefs leaving out only the arms for feeding (Liddell 1979). The animals of this order do not have filter feeding abilities, so they are adapted to searching for food directly from marine currents, being able, when necessary, to swim through of the



Text-fig. 5. Scanning electron microscopy of the *Sievertsella* cf. *polonica* (Radwańska): calyx (PBR-01-80) from the Miocene of the Pirabas Formation. A – Dorsal view: bt – basal tubercles; pc – peripheral cirrus; ap – apical cirrus. B – Ventral view: rp – radial plate; f – fossa of radial plate; c – central cavity (infilled by rock material). C – Lateral view of calyx centrodorsal plate (cd). Scale bar = 1 mm



Text-fig. 6. Ink-drawing sketches of the *Sievertsella* cf. *polonica* (Radwańska): calyx (PBR-01-80) from the Miocene of the Pirabas Formation. A – Dorsal view; B – Ventral view; C – Lateral view of calyx centrodorsal plate. Scale bar = 1 mm

movements of their arms. At present, comatulid crinoids are characterized by a high species diversity which may be related to the larval dispersion and food availability (Birkeland 1989). Their larval stage can survive in the plankton for hours or days. They attach themselves then to the substrate, through an adhesive disc (so-called pentacrinoid), and can last in this stage for several months. Finally, they change to a free way of life (Hyman 1955). According to Kroh and Nebelsick (2010), the Oligocene–Miocene crinoids have had an auxiliary role in defining the palaeoenvironment. The crinoids that have columns are rare in shallow coastal palaeoecosystems but are more common in deep water. On the other hand, the stalkless forms (the comatulids) occur mainly in reef environments (e.g. Meyer and Macurda 1997; Kroh and Nebelsick 2010). The comatulid from the Pirabas Formation, reported herein, would have been cryptic, set inside a rock cavity or coral in a more coastal tropical environment, obtaining its food through the movements of its arms mainly during the night, similar to recent forms. The Polish specimens of *Sievertsella polonica*, from the Badenian (Middle Miocene) of the Korytnica Basin, lived in a tropical and / or subtropical environment (Radwańska 1987).

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