FIRST RECORD OF A LOWER PALEOZOIC MACROINVERTEBRATE FAUNA DOMINATED BY CRINOIDS IN THE SERRA GRANDE GROUP (PARNAÍBA BASIN, NORTHERN BRAZIL): A PRELIMINARY DISCUSSION

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ABSTRACT – This contribution presents the first record of crinoids to the Serra Grande Group (Silurian of Parnaíba Basin) in the state of Tocantins, Brazil. They also represent the oldest record in Brazil. Before this communication, the earliest crinoids in Brazil were dated as Devonian (from Amazon, Parnaíba and Paraná Basins). Their occurrence is characterized mainly by scattered isolated stem discs and also by semi articulated stems. Holdfasts that serve as a means of attachment to the sea bed are also present. Neither calyx nor arms were recorded so far. Based upon pluricolumnal and columnal fragments, six different morphotypes were assigned to the crinoids here described. Besides, three morphotypes seem to be sufficiently distinctive to be tentatively assigned to the families Cyclopagodidae, Exaesiodiscidae, and Fluctichara cidae (*Laudonomphalus* sp.). A second macroinvertebrate group occurs associated with this crinoid assemblage, namely brachiopods of uncertain taxonomic identification. Nevertheless, they are extremely rare when compared with the abundant crinoids. This poorly diversified fauna is compatible with cold circumpolar palaeoclimates proposed for South American Gondwana during Silurian times. However, taphonomic bias also might have hidden other taxa that were not preserved in this depositional environment.

Keywords: Parnaíba Basin, Serra Grande Group, Tianguá Formation, Silurian, Crinoidea, Brachiopoda

RESUMO – Este trabalho apresenta o primeiro registro de crinóides para o Grupo Serra Grande (Siluriano da Bacia do Parnaíba) no estado do Tocantins, Brasil. Este material também representa o mais antigo registro brasileiro de crinóides. Antes deste trabalho, materiais mais antigos deste grupo foram datados como pertencendo ao Devoniano (Bacias do Paraná, Parnaíba e Amazonas). O material ocorre principalmente na forma de discos isolados e parcialmente articulados e é consideravelmente fragmentário. Estruturas de ancoragem ao substrato marinho também estão presentes. Tanto cálices quanto braços não foram registrados até o momento. Com base nos fragmentos pluricolunais, seis diferentes morfótipos foram atribuídos aos crinóides. Além disso, três deles parecem ser suficientemente distintos para serem tentativamente atribuídos às famílias Cyclopagodidae, Exaesiodiscidae, and Fluctichara cidae (*Laudonomphalus* sp.) Um segundo grupo de macroinvertebrados, os braquiópodes, ocorre associado aos crinóides. Contudo, eles são raros quando comparados com os abundantes crinóides. Esta fauna pouco diversificada é compatível com aquela esperada para climas circum-polares propostos para o Gondwana sulamericano durante o Siluriano. Contudo, problemas tafonômicos também podem estar escondendo outros táxons que, embora presentes neste ecossistema, não foram preservados neste ambiente deposicional.

Palavras-chave: Bacia do Parnaíba, Grupo Serra Grande, Formação Tianguá, Siluriano, Crinoidea, Brachiopoda

INTRODUCTION

Crinoids are the only pelmatozoan echinoderms that survived until present days, ranging from the Ordovician to Holocene. They radiated during Silurian, reaching their maximum diversity during Lower Carboniferous. Crinoids are the best represented echinoderms in the fossil record, mainly during Paleozoic times (Simms

et al., 1993). By that time, they were widespread in Pangea and are amongst the most frequently encountered macroinvertebrates in marine deposits. Crinoids are usually preserved as fragments, corresponding to parts of stems. The material herein described represents the oldest record of crinoids in Brazil. Before that, Paleozoic crinoids were previously recorded in the Itararé Subgroup (Carboniferous of Paraná Basin) and Itaituba Formation (Upper Carboniferous of Amazonas Basin). It was reported the genus *Erisocrinus* from the Upper Carboniferous of Amazonas Basin; the genera *Ctenocrinus*, *Exaesyodiscus*, *Laudonomphalus* and *Monstrocrinus* from the Devonian of Amazonas Basin (Ferreira & Fernandes, 1989). Recently, Scheffler *et al* (2002) performed a morphological analysis of pluricolumnal crinoid stems from Ponta Grossa Formation (Devonian of Paraná Basin) and identified nine different pluricolumnal crinoid morphotypes to that unit. Also, Scheffler & Fernandes (2005) performed a review of pelmatozoans from Ponta Grossa Formation, reporting the genera *Ophiucrinus, Cyclocaudex, Crenatames e Laudonomphalus*). In Parnaíba Basin, Kegel (1953) preliminarily reported fragments of crinoids in Devonian strata. The information regarding the record of crinoids in Brazil is incomplete, and a review of brazilian crinoids is being performed by Scheffler (Scheffler *in prep*.).

The present contribution reports the first record of crinoids to the Serra Grande Group (Tianguá Formation, Landoverian of Parnaíba Basin) in the state of Tocantins, Brazil (Figure 1). Their occurrence is characterized mainly by scattered isolated stem discs and also by partially articulated stems. Holdfasts that serve as a means of attachment to the sea bed were also identified. Neither calyx nor arms were recorded so far. Brachiopods also occur in association with the crinoid material.

GEOLOGICAL SETTING

The Parnaíba Basin constitutes a large Ordovician-Cretaceous intracratonic depocenter filled with both continental and marine rocks. This basin spreads over an area of 600.000 km^2, entirely within Brazil. It extends over the states of Piauí, Maranhão, Tocantins, Pará, Ceará and Bahia. Its lowermost sequence is represented by the Serra Grande Group, composed of the formations Ipú (Lower Silurian), Tianguá (Upper Lower Silurian/Lower Middle Silurian) and Jaicós (Upper Middle Silurian/Upper Silurian) (Goes & Feijó, 1994).

Serra Grande Group

Three environmental sedimentary sequences are recognized to the Serra Grande Group, from bottom to top: (1) fluvial/fluvial-glacial (Ipú Formation); (2) neritic (Tianguá Formation) and (3) fluvial (Jaicós Formation). The fluvial Ipú formation is considered, at the present, afossiliferous, so the marine fossil assemblage herein presented was recovered from Tianguá Formation. The overlaying Jaicós Formation, also fluvial, is dated as Silurian/Devonian based upon its microfossiliferous content (Grahn, 1992).

Tianguá Formation

The Tianguá Formation is 200 m thick and characterized by shales, siltstones and thin sandstones. It presents cross-bedded sandstones intermeshed with laminar siltstones and shales, being interpreted as shallow marine (a near shore deposition)

environment (for a better understanding of the stratigraphy of Parnaíba Basin, see Goes & Feijó, 1994, and Santos & Carvalho, 2004, among others). The age of the Tianguá Formation is based upon its correlation with Pitinga Formation (Amazonas Basin) due to the presence in Tianguá Formation of the silurian graptolitid genus *Monograptus*, also found in Pitinga Formation (Cruz & Sommer, 1985). Later, Grahn (1992) also reported the silurian graptolitid *Climacograptus* to Tianguá Formation. Palinologic studies performed by Caputo & Lima (1984) also point out a silurian age to this unit. According to Quadros (1982), acritarcs (*Baltisphaeridium* sp., *Dactylofusa maranhensis*, *Leitofusa bersnega*, *L. striatifera*, *Micrhystridium stellatum*, *Veryhachium carminae* and *V. trispinosum*) and quitinozoans (*Ancyrochitina ancyrea*, *Conochitina dolosa*, *Cyathochitina* sp., and *Desmochitina* sp.) are also present in Tianguá Formation. These fossils are comparable to those found in silurian basins in Africa, Europe and North America (Santos & Carvalho, 2004).

MATERIAL

Preservation and mode of occurrence

The material is relatively well preserved. Isolated discs and semi articulated pluricolumnal stems are the main preserved structures. In less extent, holdfasts are also present. Neither calyx nor arms were recorded so far. A second macroinvertebrate group occurs associated with this crinoid assemblage. It is composed of brachiopods, tentatively assigned to the Orders ?Productida, ?Spiriferia and ?Rhynchonellida (Figure 2). Nevertheless, they are extremely rare when

compared with the abundant crinoids. The description of the brachiopod material figured here is beyond the scope of the present paper and it will fully described elsewhere. None of the macroinvertebrates was recovered *in situ*, so the exact stratigraphic level where the material was deposited could not be established, once that no fossils within sedimentary rocks were recovered so far. The fossils were collected in a secondary route that crosses the TO 020 (a local highway between the municipalities of Palmas and Aparecida do Rio Negro (state of Tocantins).

Abbreviations

UFT, Universidade Federal do Tocantins; **t**, Tianguá Formation

Description

Holfasts: represented by the materials under collection numbers UFT 0162, UFT 0169 and UFT 0177 (Figure 3). They are probably holdfast structures of encrusting type, as described by Ubaghs (1978). The material here figured is represented by several peduncles of different organisms that joined together through the secretion of secondary stereom. This secretion extends over hard marine substracts and tends to transform the holdfast into a tick calcareous mass.

Remarks. This kind of structure occurs mainly in crinoids that inhabit reefs or live in turbulent environments. The Tianguá Formation is interpreted as deposited under shallow marine conditions, under tidal influence, so the presence of holdfasts of encrusting type in these deposits corroborates this interpretation. Besides, the diameter of these peduncular structures is relatively large, being frequently found in turbulent environments. According to Le Menn *et al*. (1997), laudonomphalids (see below the description of morphotype 3t) had clear preference by high energy environments, as it is claimed for Tianguá Formation.

Discs and columns: six different pluricolumnal and isolated disc morphotypes were identified, so they are separately described. The criterion used for institutional numeration of the material was based on the diameter of the fragments, before the elaboration of the present work. So, some different morphotypes can have the same number. In these cases, they are sub nominated as "UFT (number) fragment a, b, c..." (see below). Only better preserved and more representative fragments of which morphotype are figured in the illustrations. The anatomical terminology used here was based on Moore *et al.* (1968) and Webster (1974). The description and identification follows the parataxonomy proposition by Moore & Jeffords (1968).

Morphotype 1t. Represented by the materials under collection numbers UFT 0158 (fragment a), UFT 0186 (fragment a), and UFT 0188 (Figure 4). This morphotype is known only by the morphology of the articular facet, which is circular, slightly concave. Its crenularium extends from the periphery to the pentagonal lumen. The lumen can be either pentagonal or circular, medium or large sized. Crenularium with 50 to 60 thin, straight, long and simple culmina. Developed epifacet bearing rounded nodules with varied size and number, however usually in number of five with columnal to pentagonal aspect.

Remarks. This morphotype probably belongs to the family Cyclopagodidae Moore & Jeffords, 1968 due to the well developed crenularium that borders a large pentagonal or circular lumen, and also by the absence of areola and perilumen.

Morphotype 2t. Represented by the materials under collection numbers UFT 0153, UFT 0155 (fragment a), UFT 0158 (fragment b), UFT 0184, UFT 0185 (fragment a), UFT 0186 (fragment b) and UFT 0187 (Figure 5). Also, this morphotype is known only by the morphology of the articular facet. Circular facet well depressed (bowl-shaped) to the attachment of the internodals, small when compared to the columnal diameter (facet occupies 1/3 to 1/2 of the columnal diameter); large circular lumen. It was not possible visualize the existence of crenularium. Epifacet well developed, deeply convex and smooth (without ornamentation).

Remarks. This morphotype probably belong to the family Exaesiodiscidae Moore & Jeffords, 1968 mainly due to the large size of the epifacet when compared with the articular facet.

Morphotype 3t. Represented by the materials under collection numbers UFT 0155, UFT 0158, UFT 0185 (fragment b) and UFT 0186 (fragment c and d) (Figure 6). Again, this morphotype is known only by the morphology of the articular facet. Concave circular facet, crenularium with 30 to 40 thin, long, straight and usually peripherally bifurcated culmina, ending in a perilumen that surround a small and circular to pentagonal lumen. Nodal epifacet well developed and deeply convex, in many cases making the circular aspect of the columnal irregular, due to the variable presence of rounded and not salient, tubercles.

Remarks. This morphotype probably belong to the family Flucticharacidae Moore & Jeffords, 1968 due to the presence of long crenularium with prominent lumen, without areola. It also could be tentatively assigned to the genus *Laudonomphalus* Moore & Jeffords, 1968, by the nudinodals; crenularia that internally ends in a raised perilumen; and also by the small lumen.

Morphotype 4t. Represented by the material under collection number UFT 0245 (Figure 7). Noditaxis with 4 columnals, nodal taller than the half height of noditaxis, with epifacet well developed only where the tubercles are placed. The number of tubercles is variable and they are elongated and protuberant; priminternodal and secundinternodal with smooth, longitudinally straight and symmetrical lateral, without epifacet; crenulated sutures. Circular flat articular facet, with crenularium bearing 40 to 50 medium-sized, short and simple culmina.

Morphotype 5t. Represented by the material under collection numbers UFT 0174, UFT 0181 and UFT 0236 (fragment a) (Figure 8). Noditaxis with 4 columnals; nodals with large, convex, symmetrical to slightly asymmetrical epifacet. Nodals taller than the half height of noditaxis. Priminternodal and secundinternodal with smooth, slightly convex and symmetrical

latera. Sutures with slightly evident, thin crenulations. Concave articular surface of the nodal with crenularium bearing around 50 thin, long, peripherally bifurcated culmina; areola circular and small; lumen small and circular.

Morphotype 6t. Represented by the material under collection number UFT 0236 (fragment b) (Figure 9). Noditaxis with 4 columnals; nodal with large, longitudinally angled and smooth epifacet; nodal taller than the half height of noditaxis. Internodals short with small diameter; priminternodal height almost half of nodal and secundinternodal small. Internodals lateral smooth, slightly convex, longitudinally symmetrical and without epifacet. Circular articular facet; crenularium with thin and straight culmina. Lumen of small size, that seems to be surrounded by a flat areola.

DISCUSSION

In general, the systematic classification of crinoids is almost entirely based upon morphological characters present in their crown. However, the occurrence of fossil crinoids with this anatomical feature is quite rare, once that, during taphonomic process, calyx's plates and peduncular discs usually are rapidly disarticulated. As Gluchowski (2002) pointed out, dissociated crinoid stems are neglected by paleontologists, due to the impossibility of linkage of them with crowns. This constraints their classification within a "natural" system. So, in these cases, higher rank units are used provisionally, under subcategories such as 'uncertain' or 'indeterminate'. Thus, it should take into account that taxonomy using stem-based genera does not express true evolutionary relationships. In spite of the limited taxonomic significance of crinoid anatomic parts other than crowns, several authors had claimed the usefulness of pluricolumnal stems in crinoid taxonomy (Moore &

Jeffords, 1968; Moore *et al.*, 1968; Donovan, 1984; Le Menn, 1987; Stukalina, 1988; Donovan, 2001; and Glochowski, 2002; among others). The material here presented is almost completely composed of pluricolumnal stems. Through the use of the parataxonomy proposed and used by the authors cited above, it was possible the identification of six different crinoid morphotypes (Morphotypes 1t, 2t, 3t, 4t, 5t and 6t). Besides, the morphotypes 1t, 2t and 3t, seem to be sufficiently distinctive to be tentatively assigned to the families Cyclopagodidae, Exaesiodiscidae, and Flucticharacidae (*Laudonomphalus* sp.) respectively. It is important to point out that more than one pluricolumnal morphotype can be assigned to the same pedunculum. In other words, two columnal morphotypes would belong to the same species. This might be the condition encountered for morphotypes 5t and 6t. However, most morphotypes presented here probably belong to different species. In this work, growth pattern and morphological changes related to different ontogenetic stages could not be stablished, once that the number of columnals in each pluricolumnal is generally small. So, the pluricolumnal status (xenomorphic or heteromorphic) of this crinoid population could not be surely identified. This constraints a more accurate pluricolumnal characterization, in which morphotypes can serve as tools in the reconstruction of complete crinoidal pedunculums. Thus, the classification here presented is preliminary and should be seem with caution. It represents the first attempt of description and systematic classification of the crinoid material from Parnaíba Basin. Regarding the brachiopods, they occur closely associated with the crinoids. As mentioned before, they are rare when compared with the abundant crinoids. The crinoids are quite diverse, but taking into account the entire fossil content reported herein (crinoids and brachiopods), this assemblage could be considered poorly diverse, being compatible with those usually found in locations of

cold circumpolar paleoclimates proposed for South American Gondwana during Silurian times. However, taphonomic bias might have hidden other taxa that were not preserved in this depositional environment.

CONCLUSION

This is the first communication of a fossil assemblage dominated by crinoids in Parnaíba Formation, the oldest record of this group in Brazil. In spite of the fragmentary nature of the material which lacks informative taxonomic characters, several considerations have been made. Six different columnal morphotypes (three of them tentatively assigned to three different families) and at least three different orders of brachiopods could be preliminarily reported. Thus, the attempt of classification here presented should be used with caution. The morphology and mode of occurrence of the crinoid holdfasts corroborate the interpretation of a shallow marine (near shore) environment claimed for Tianguá Formation. Concluding, further efforts in prospecting are needed in order to find more complete material that could help to understand the taxonomy, paleobiology and paleobiogeographic affinities of this interesting macroinvertebrate palaeocommunity from South American Gondwana.

ACKNOWLEDGEMENTS

The second author would like to thank the Universidade Federal do Tocantins for the field transportation, the facilities provided during the present study, and the airplane travel tickets granted to present a short communication of this work in the

XIX Congresso Brasileiro de Paleontologia e VI Congresso Latino Americano de Paleontologia in August (2005) in Aracajú, Sergipe.

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EXPLANATIONS OF FIGURES

Figure 1: Location of the main outcrop from where the crinoid material was recovered.

Figure 2: Brachiopds associated to the crinoid fauna. In a, ?Productida; in b, ?Spiriferia; in c, ?Rhynchonellida. Scale bar represents 10 mm.

Figure 3: Holdfast crinoid structure. General view of the material under collection number UFT 0162; in detail, view of the holdfast structure. Scale bar represents 30 mm.

Figure 4: Morphotype 1t, tentativelly assigned to Cyclopagodidae. Material in the center belongs to UFT 0186. Surrounding discs belong to UFT 0188. Scale bar represents 10 mm.

Figure 5: Morphotype 2t, tentativelly assigned to Exaesiodiscidae. Left column belongs to UFT 0184. Right Column belongs to UFT 0155. Scale bar represents 10 mm.

Figure 6: Morphotype 3t, tentativelly assigned to Flucticharacidae (genus *Laudonomphalus*). UFT 0185. Scale bar represents 10 mm.

Figure 7: Morphotype 4t. UFT 0245, in a, lateral view of the pluricolumnal; in b, articular facet. Scale bar represents 10 mm.

Figure 8: Morphotype 5t. UFT 0181, in a, lateral view of the pluricolumnal; in b, articular facet. Scale bar represents 10 mm.

Figure 9: Morphotype 6t. UFT 0236, in a, lateral view of the pluricolumnal; in b, articular facet. Scale bar represents 10 mm.

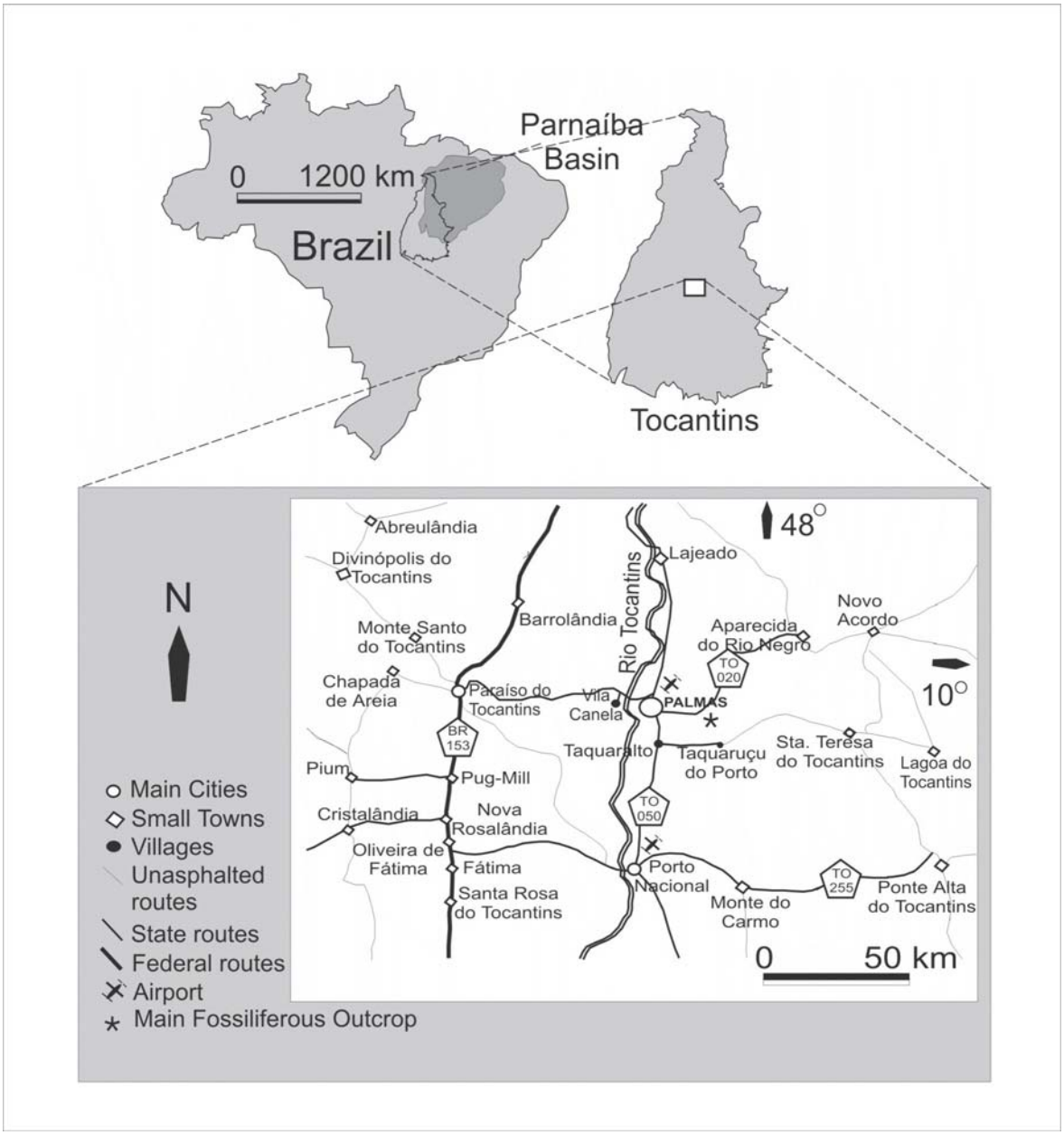
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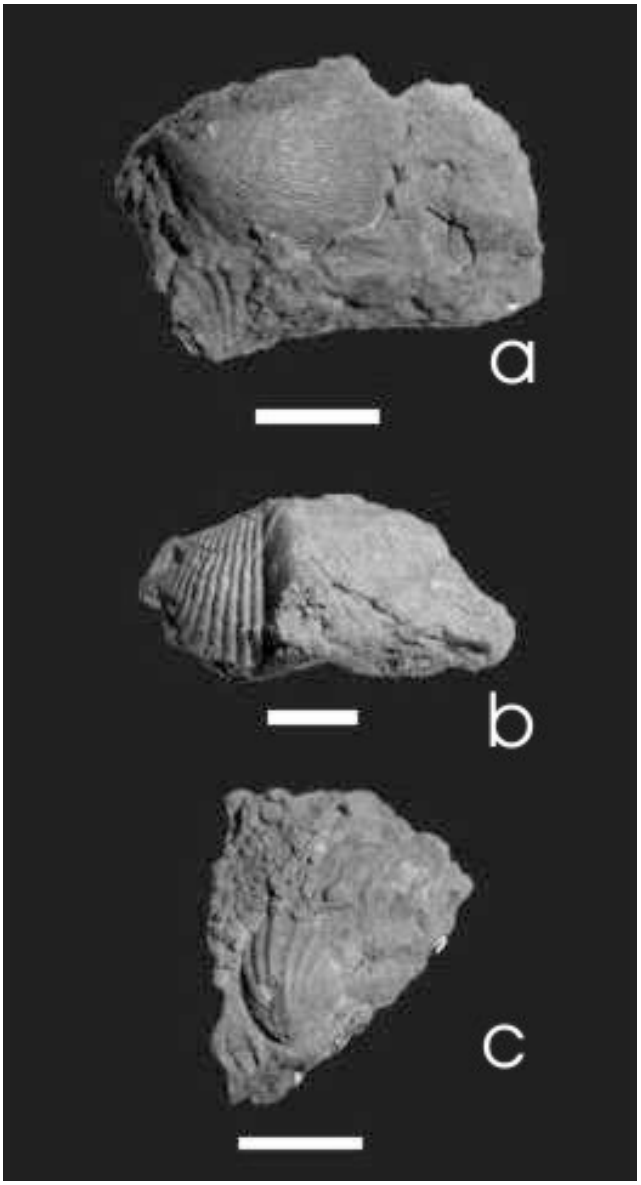
Figure 1



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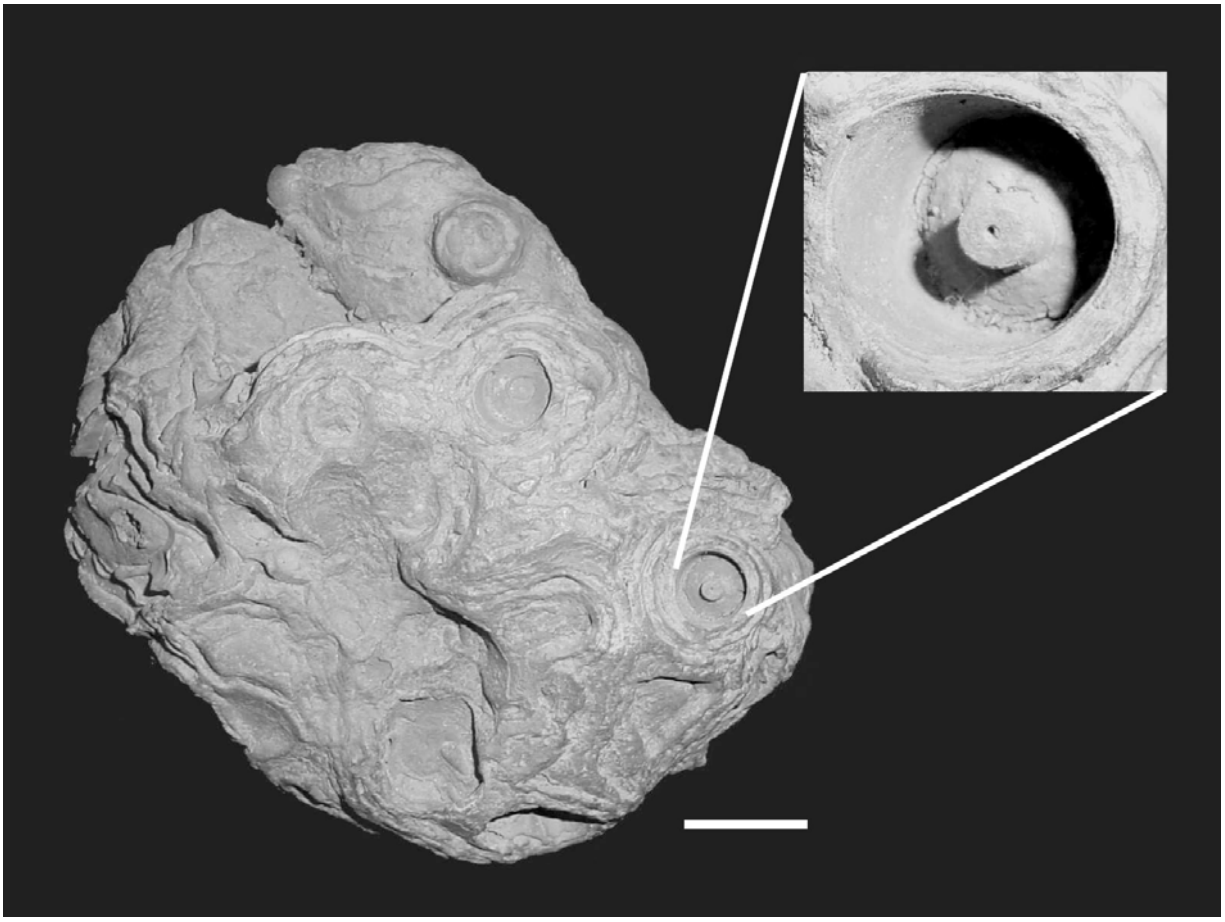

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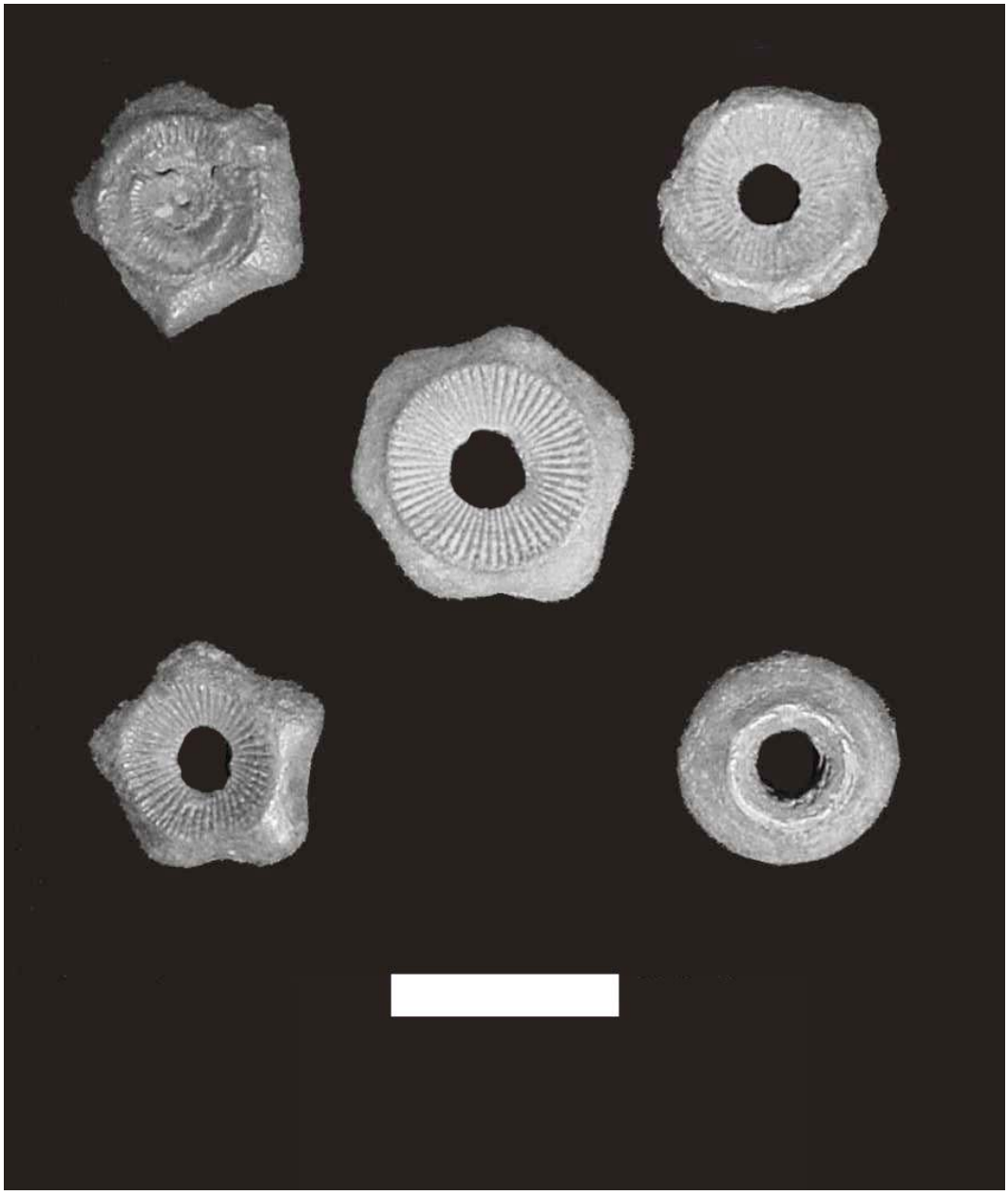

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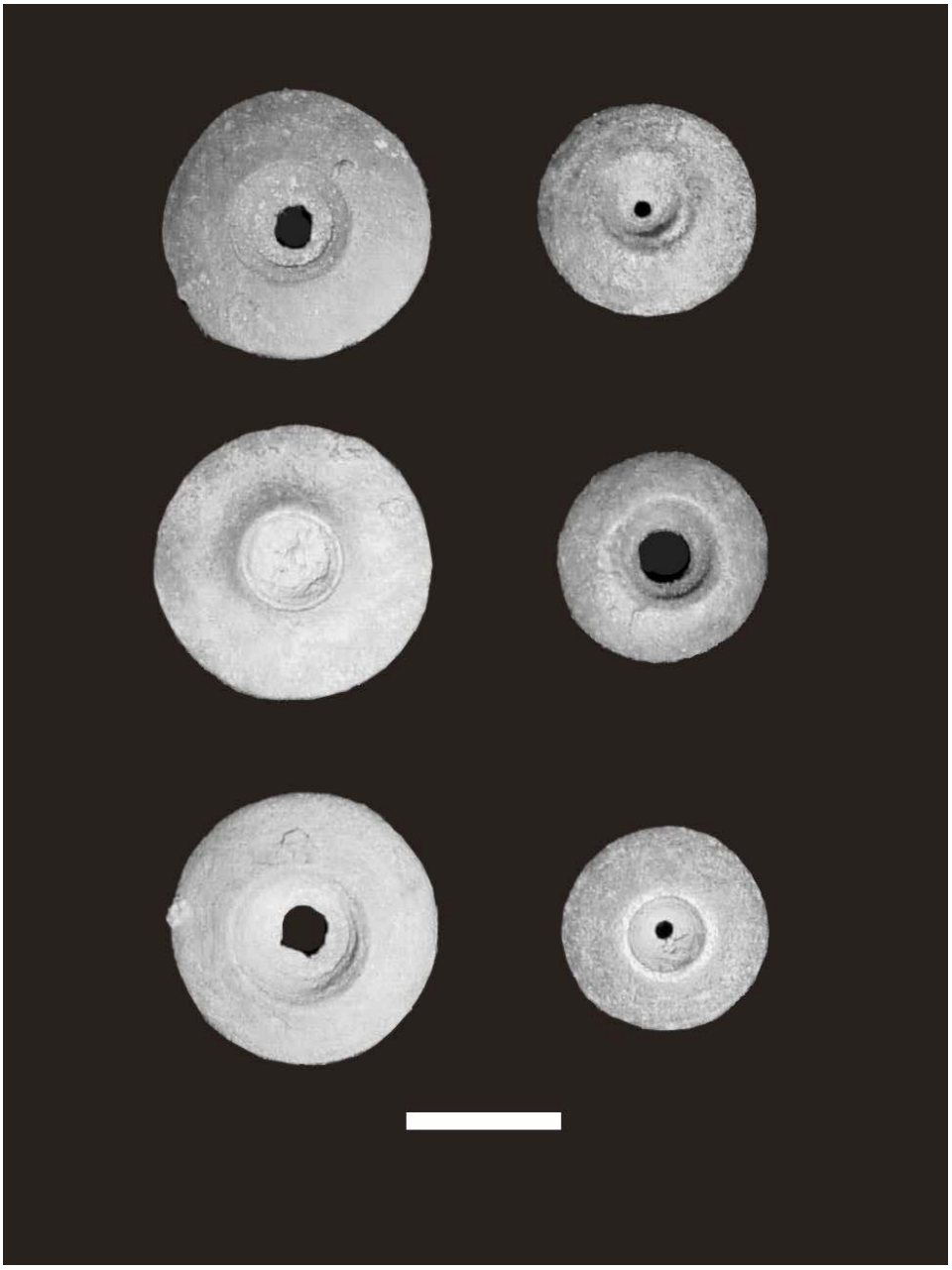

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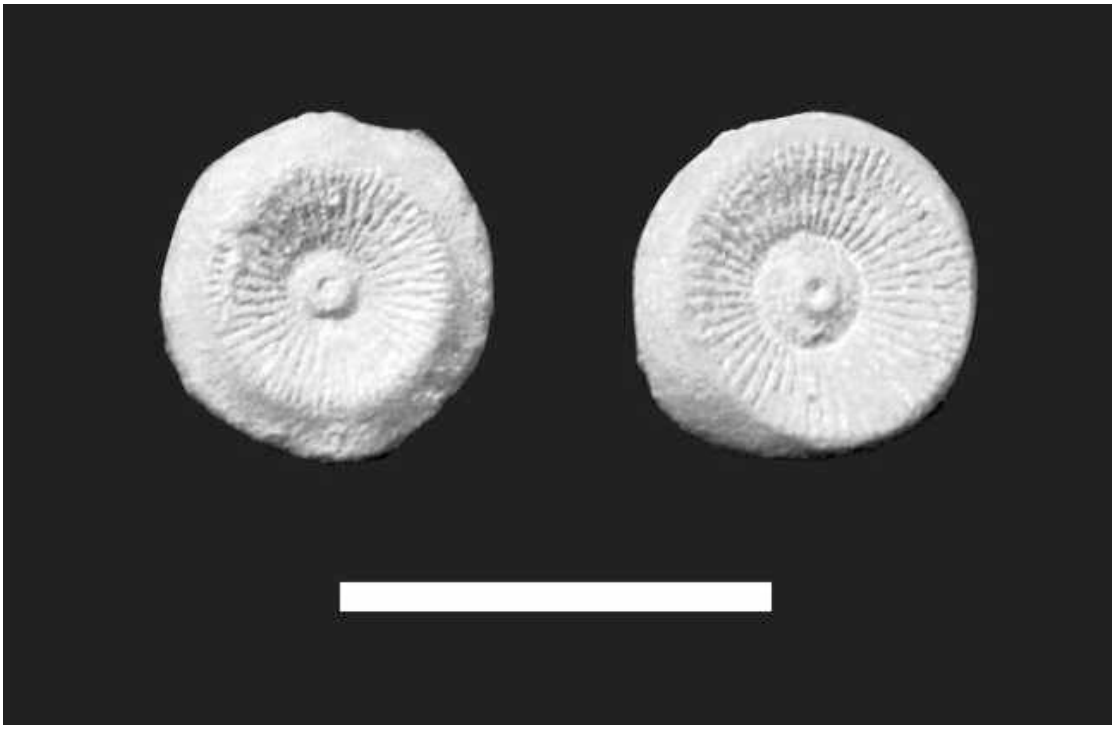

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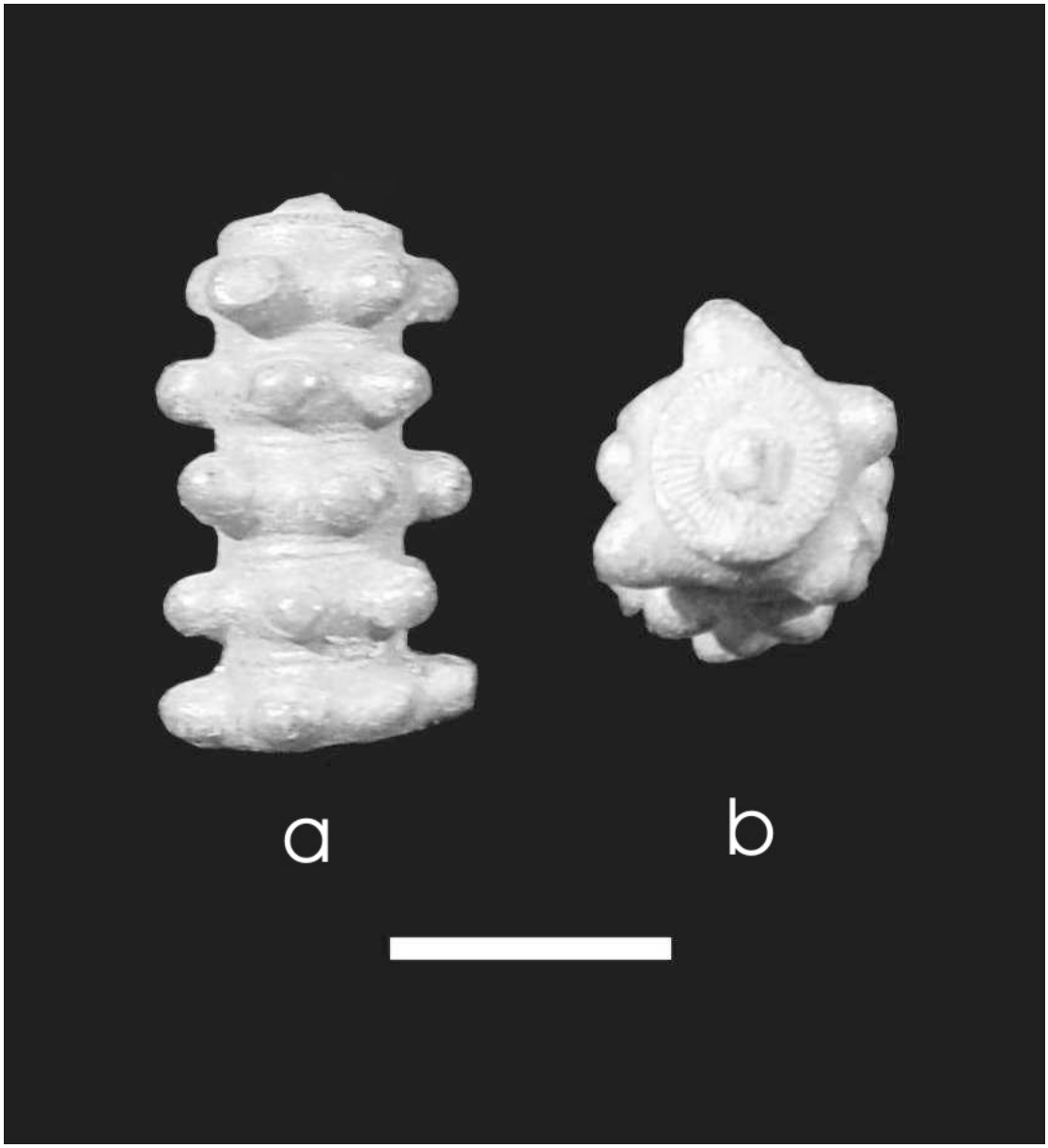

Figure 7

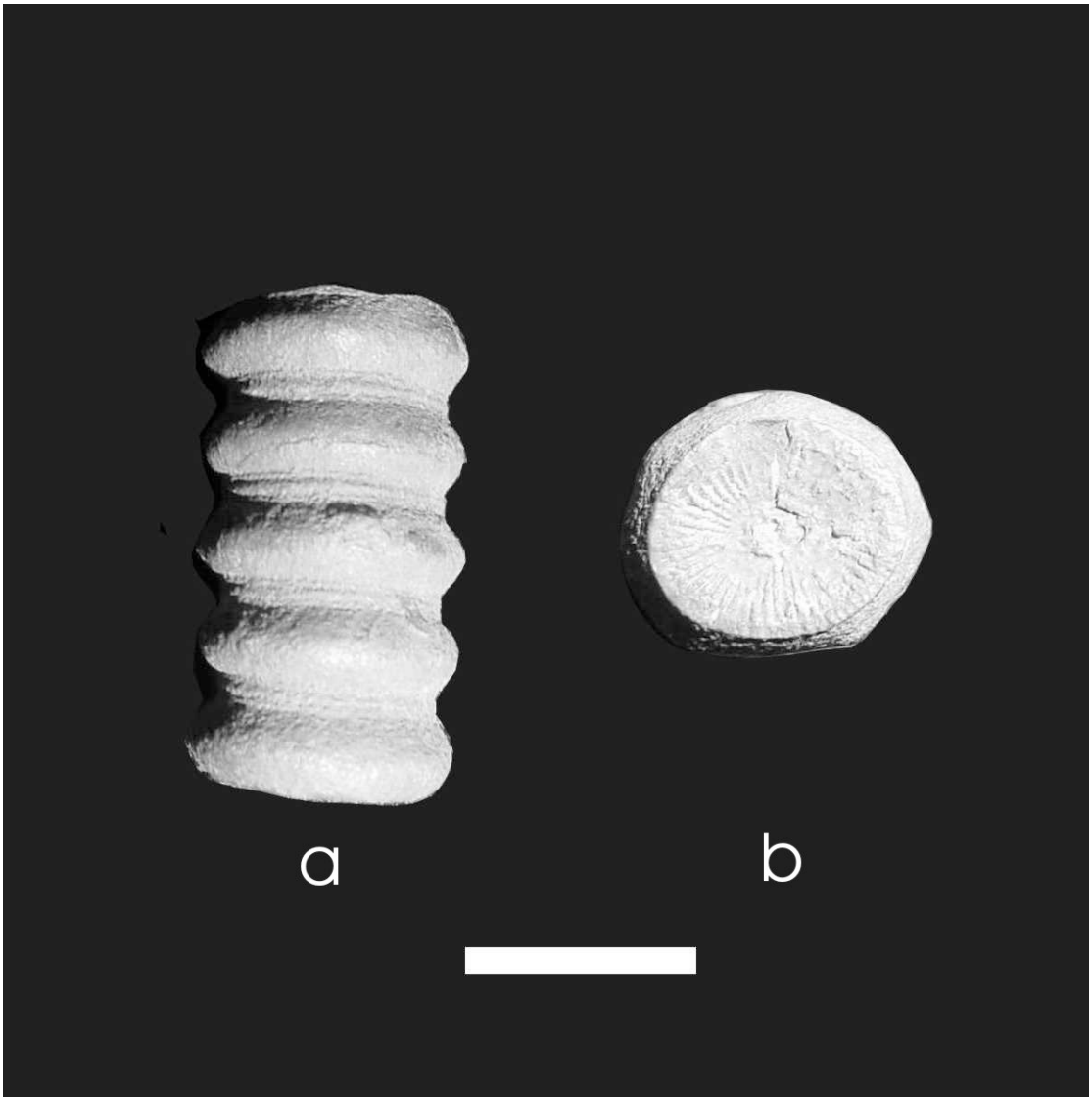

Figure 8

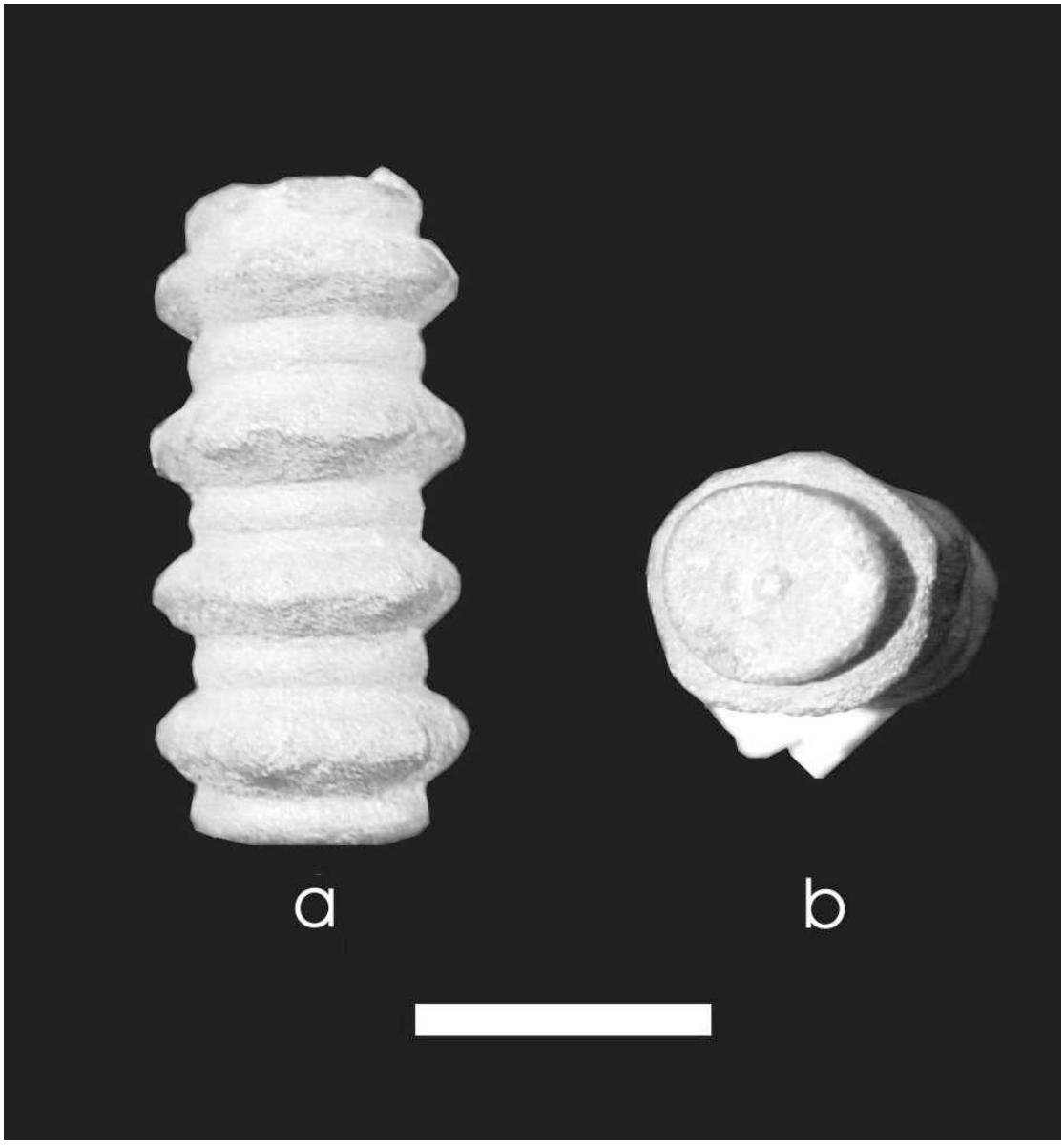

Figure 9