

Original article

A Middle Cambrian edrioasteroid from the Murero biota (NE Spain) with Australian affinities

Un édríoastéroïde avec des affinités australiennes dans le Cambrien moyen du biote de Murero (NE de l'Espagne)

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Abstract

A Middle Cambrian edrioasteroid belonging to the genus *Cambraster* is described from the Middle Cambrian Murero biota (Cadenas Ibéricas, NE Spain). Up to now, this genus was known only from Australia and France. This represents the first record of the class Edrioasteroidea in the Cambrian of Spain. Moreover, preliminary results on the diversity and biostratigraphic position of *Cincta*, *Eocrinoidea* and *Edrioasteroidea* from this area are reported.

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Résumé

Un échantillon d'édríoastéroïde du genre *Cambraster* provenant du biote de Murero (Cambrien moyen des chaînes Ibériques, NE de l'Espagne) est décrit. Jusqu'à présent, ce genre n'était connu qu'en Australie et en France. C'est la première fois qu'un représentant de la classe Edrioasteroidea est décrit dans le Cambrien espagnol. De plus, des résultats préliminaires concernant la diversité et la position biostratigraphique des *Cincta*, *Eocrinoidea* et *Edrioasteroidea* des chaînes Ibériques sont également présentés.

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Keywords: Edrioasteroid; *Cambraster*; Middle Cambrian; Murero biota; Spain

Mots clés : Édríoastéroïde ; *Cambraster* ; Cambrien moyen ; Biote de Murero ; Espagne

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1. Introduction

Professor Georges Ubaghs (1916–2005) was one of the most important palaeontologists who ever studied Palaeozoic echinoderms. His papers have inspired many researchers to work on various interesting and problematic fossil groups. His contribution to the knowledge of Spanish Cambrian echinoderms was particularly notable (Colchen and Ubaghs, 1969; Ubaghs and Vizcaïno, 1990). Following his path, we present here some new results on echinoderms from the Cambrian of Murero biota (Cadenas Ibéricas, NE Spain).

Edrioasteroids are a small group of early echinoderms with the characteristic 2-1-2 ambulacral pattern, and flattened thecae (at least, in early forms), ranging from Early Cambrian to Early Carboniferous.

Several Cambrian echinoderms have been conventionally classified as edrioasteroids (Smith, 1985). They can be included into the eight genera *Cambraster*, *Cambroblastus*, *Chatsworthia*, *Edriodiscus*, *Hadrodiscus*, *Stromatocystites*, *Totiglobus*, and *Walcottidiscus*. Up to now, they have been recorded from the Czech Republic (Pompeckj, 1896), France (Cabibel et al., 1959; Termier and Termier, 1969; Ubaghs, 1971, 1998), North America (Bell and Sprinkle, 1978; Sprinkle, 1985; Guensburg and Sprinkle, 1994; Smith, 1985), Australia (Jell et al., 1985; Smith and Jell, 1990), China (Parsley, 2002), Morocco (Clausen, 2004a) and Iran (Kruse and Zhuravlev, in press).

Although other echinoderm groups have been described from the Cambrian of Spain (Prado et al., 1860; Barrois, 1882; Gislén, 1927; Richter and Richter, 1940; Henningsmoen, 1958; Schroeder, 1973; Ubaghs and Vizcaïno, 1990; Friedrich, 1993; Sdzuy, 1993; Gil Cid and Domínguez, 1995, 2002; Clausen, 2004a, 2004b), edrioasteroids were only mentioned (Liñán et al., 1996; Lefebvre and Fatka, 2003) or briefly described (Schmitt, 1974). Here, we report the first complete description of a Spanish Cambrian edrioasteroid. It consists in a single specimen of *Cambraster*, with strong Australian affinities.

2. Geological setting and stratigraphy

De Verneuil (1862) first discovered Cambrian trilobites (the primordial fauna) near the village of Murero. Since the works of Lotze (1961) and Sdzuy (1961), Murero was considered a reference locality for the study of the Lower–Middle Cambrian in Europe, because of its stratigraphical continuity and accurate trilobite zonation. Since the work of Conway Morris and Robison (1986), the presence of Burgess Shale-type faunas has also been documented.

The Murero biota (late Lower to Middle Cambrian in age) is composed of highly diverse assemblages of both skeletonized and soft-bodied fossils. Skeletonized fossils are represented by trilobites, bradoriids, brachiopods, echinoderms, and small shelly fossils. The soft-bodied fossils consist in algae, sponges, lobopods, crustaceans (*Isoxys*, *Tuzoia*), palaeoscoleuids, sponges (*Leptomitus*, *Crumillosporgia*, *Choia*) and *incertae sedis* groups. Trace fossils are also present. The more abundant fossils are trilobites by far, with seventy species recorded in a 200 m-thick succession of shales representing *ca.* 10 million years.

The Murero biota occurs in the late Lower through Middle Cambrian shales of the upper Valdemedias, Mansilla and Murero formations, cropping out in several localities near the village of Murero (Cadenas Ibéricas, Zaragoza province, NE Spain). All these fossiliferous sites share a taxonomical composition, age, and preservational style.

The specimen described herein was collected from the Murero Formation in the valley of Isuela river (Zaragoza province; Fig. 1). The Murero Formation (which is the uppermost unit of

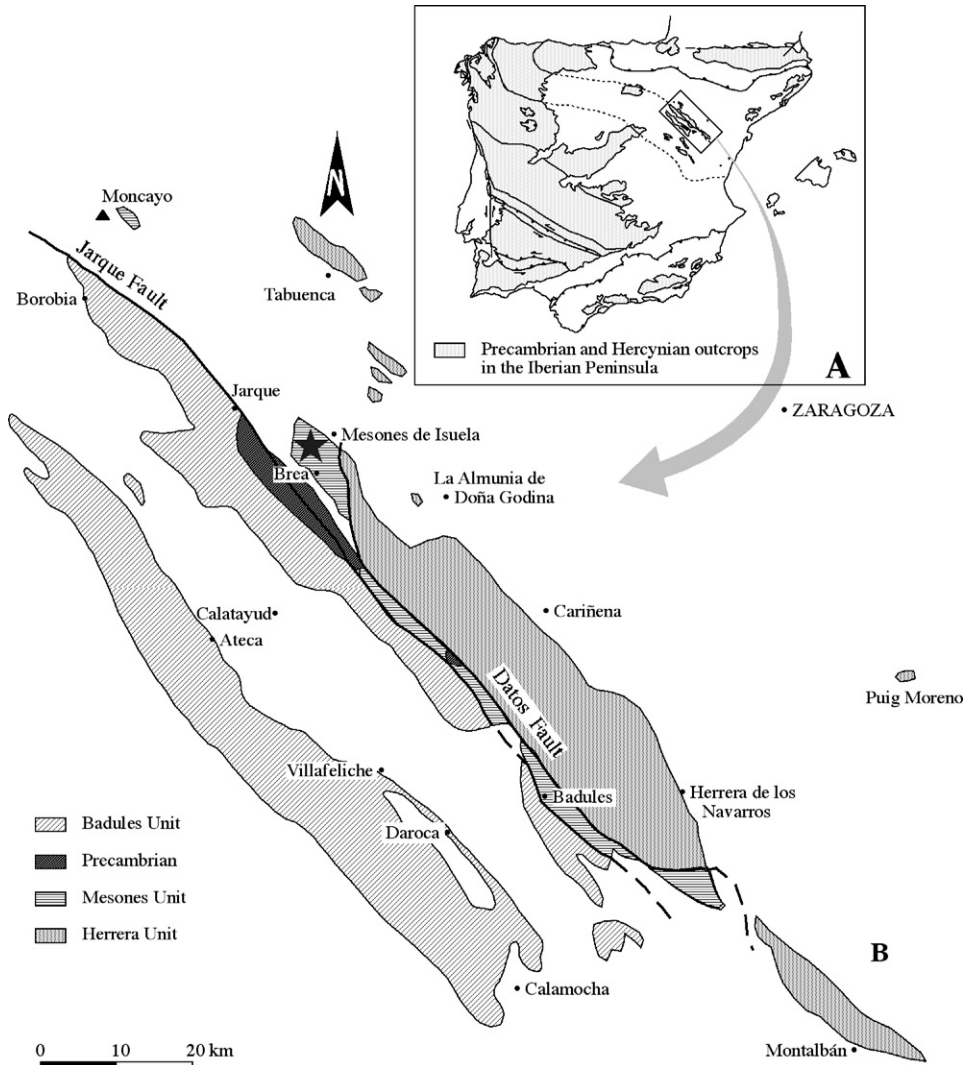


Fig. 1. Geographic and geological setting of the Cadenas Ibéricas (modified from Gozalo and Liñán, 1988) and location of the studied site (indicated with the star).

Fig. 1. Situation géographique et géologique des chaînes Ibériques (modifié d'après Gozalo et Liñán, 1988) et localisation du gisement étudié (marqué par une étoile).

the Mesones Group; Fig. 2) is composed of greenish and blue-greenish lutites with a few marly beds and abundant carbonate nodules. Very fine-grained sandstone beds appear at the top of the unit, when carbonate nodules are less frequent.

The herein described specimen was found together with the trilobite association of *Conocoryphe heberti heberti*, *Paradoxides (Eccaparadoxides) brachyrhachis brachyrhachis*, *Solenopleuropsis verdiagana*, and *Solenopleuropsis riberoi*, belonging to the *S. verdiagana* + *S. riberoi* biozone (Liñán and Gozalo, 1986) of the Upper Caesaraugustian (Middle Cambrian).

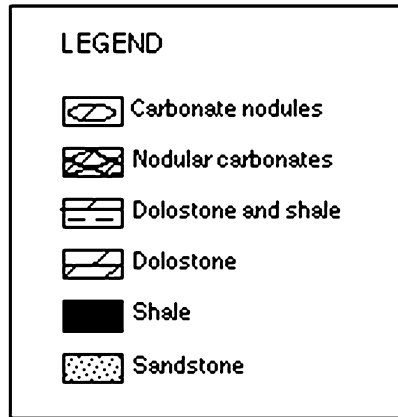
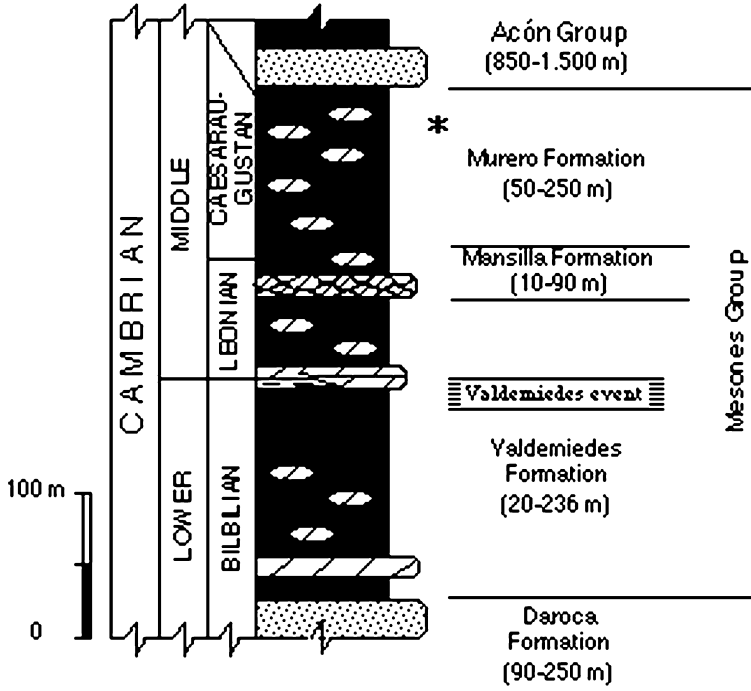


Fig. 2. Stratigraphy of the upper Lower to Middle Cambrian Mesones Group (modified from Liñán et al., 1996).

Fig. 2. Stratigraphie du Groupe de Mesones, Cambrien inférieur terminal à moyen (modifié d’après Liñán et al., 1996).

3. The echinoderm record in the Murero biota

Recent fieldwork and laboratory studies indicate that echinoderms from the Murero biota are an extremely diverse group showing a long and complete fossil record (Liñán et al., 1996; Zamora Iranzo et al., 2005, 2006; Fig. 3). Detailed taxonomic descriptions will be provided in subsequent papers, some notes of which are presented herein.

Series	Stage	Mediterranean zones	Edrio.	Eocrinoidea	Cincta	
MIDDLE CAMBRIAN	Languedocian	Unnamed				
		<i>S. thoralis</i> + <i>S. marginata</i>				
	Caesaraugustan	Upper	<i>Solenopleuropsis simula</i>			
			<i>S. verdiagana</i> + <i>S. rubra</i>			
			<i>S. riberoi</i> + <i>S. verdiagana</i>			
		Middle	<i>Solenopleuropsis riberoi</i>			
			<i>Pard. szuyi</i> + <i>S. riberoi</i>			
			<i>Pardailhanian multispinosa</i>			
	Lower	<i>Pardailhanian hispanica</i>				
		<i>Pardailhanian hispida</i>				
		<i>Badulesia/Badulesia paschi granieri</i> / <i>Badulesia juliverti</i>				
	Leonian		<i>Badulesia tenera</i>			
			<i>Eccaparadoxides asturianus</i>			
			<i>Eccaparadoxides szuyi</i>			
			<i>Acadaparadoxides mureroensis</i>			
L.C.	Bilbilian (pars)	<i>Prototremus jillocamus</i>				

Fig. 3. Biostratigraphic distribution of Cincta, Eocrinoidea and Edrioasteroidea in the uppermost Lower Cambrian and Middle Cambrian of the Cadenas Ibéricas. Trilobite zonation, after Gozalo et al. (2003). Distribution lines include data from previous works (Schroeder, 1973; Friedrich, 1993; Szuy, 1993; Clausen, 2004a, 2004b), as well as unpublished data.

Fig. 3. Distribution biostratigraphique des Cincta, Eocrinoidea et Edrioasteroidea dans le Cambrien inférieur terminal et le Cambrien moyen des chaînes Ibériques. Zonation des trilobites d'après Gozalo et al. (2003). Les extensions stratigraphiques sont basées sur des données de Schroeder (1973), Friedrich (1993), Szuy (1993) et Clausen (2004a, 2004b), ainsi que sur des observations inédites.

Echinoderms are one of the most common groups in the Murero biota. Up to now, only representatives of the classes Cincta (with six taxa; Schroeder, 1973; Friedrich, 1993; i.e., *Gyrocyrtis platessa*, *G. testudiformis*, *G. badulesiensis*, *G. erecta*, *Progyrocyrtis disjuncta*, and *Sucocystis melendezi*) and Eocrinoidea (with the only taxon *Rhopalocystis? mesonesensis*; Clausen, 2004b) have been described.

With respect to eocrinoids, Clausen (2004b) reported the oldest record of this group in the Murero biota from Lower Cambrian (Bilbilian) beds of the Valdemedes Formation. It consists of isolated calix plates assigned to *Rhopalocystis? mesonesensis* Clausen, 2004b. Disarticulated calix plates of Gogiidae and *Eocystites* are common at many levels of the Middle Cambrian Murero biota (from Leonian to Caesaraugustan in age), yet complete and articulated eocrinoid material comes only from the upper part of the Murero Formation (Caesaraugustan, Middle Cambrian), belonging to *Gogia* and a new gogiid genus.

Cinctans are the most common echinoderm group in the Murero biota. They are first recorded in the lower part of the Mansilla Formation (Upper Leonian, lower Middle Cambrian), where only isolated plates have been recognised. The first complete specimen comes from the upper Mansilla Formation. From these levels upwards, cinctans are common throughout the Murero Formation (Caesaraugustan, Middle Cambrian). They are represented by various species belonging to the

genera *Gyrocystis*, *Progyrocystis*, *Sotocinctus*, *Sucocystis*, and to two additional, new genera, which are now under study.

In this paper, we report edrioasteroids from the Murero biota. This is the first description of a representative of this group of echinoderms in the Spanish Cambrian. Two well-preserved specimens (on a single slab), probably belonging to the genus *Stromatocystites*, have been found by our research group in late Bilbilian beds of the Valdemiedes Formation. Furthermore, *Stromatocystites* and *Cambraster* are recognised in the uppermost Murero Formation (Upper Caesaraugustan, Middle Cambrian).

Only the specimen assigned to *Cambraster* will be described below. Along with France and Australia, the Cadenas Ibéricas are the third region in the world to have yielded remains of the edrioasteroid *Cambraster*.

4. Systematic palaeontology

Several classifications of the main edrioasteroid groups have been proposed (Bell, 1976; Smith, 1985; Guensburg and Sprinkle, 1994), all including Cambrian genera. The position of *Cambraster* is problematic (Smith and Jell, 1990; Guensburg and Sprinkle, 1994). Smith (1985) included this genus in the order Isorophida. Smith and Jell (1990), based on some new Cambrian material of edrioasteroids, highlighted that *Cambraster* displays a mixture of characters, and they included it between the *Totiglobus* group and *Edriodiscus*. Finally, Guensburg and Sprinkle (1994) included a large number of taxa in their phylogenetic analysis of edrioasteroids. The adopted classification follows Guensburg and Sprinkle (1994), with *Cambraster* in an uncertain taxonomic position.

Class EDRIOASTEROIDEA Billings, 1858

Order and Family Uncertain

Cambraster Cabibel et al., 1959

Type species: *Trochocystites cannati* Miquel, 1894.

Other species: *C. tastudorum* Jell et al., 1985.

Remarks: Here, we follow the diagnosis proposed by Smith (1985). *Cambraster* has two described species: the type species *C. cannati* (Miquel, 1894), and *C. tastudorum* Jell et al., 1985.

Miquel (1894) was first to report the genus under the carpoid name *Trochocystites*, yet Cabibel et al. (1959) gave its first diagnosis. In addition, they described the genus *Eikosacystis* with two species, *E. couloumanensis* and *E. ? ferralsensis*. Termier and Termier (1969) described three new species: *Cambraster elegans*, *Eikosacystis miqueli*, and *E. courtesolei*.

Ubaghs (1971) agreed with the two species of *Cambraster*. He synonymised *Eikosacystis* (Cabibel et al., 1959) with *Cambraster*, as the only difference between the two forms was their state of preservation.

Later on, Smith (1985) considered that *C. cannati* and *C. elegans* were synonymous. He argued that the main difference between the two forms (i.e., presence of a larger portion of the aboral surface plating around the margin in *C. elegans*) was very likely preservational (postmortem artifact).

The second valid species of the genus is *Cambraster tastudorum*. It was described by Jell et al. (1985), from the Cambrian of Tasmania (Australia). *C. tastudorum* is represented by many well-preserved specimens. It is readily distinguished from *C. cannati* by the distribution of epispines

on interambulacral plates, and by the plate pattern of the central portion of the aboral surface (Jell et al., 1985).

Occurrence: *C. tastudorum* comes from the mid Middle Cambrian of Tasmania, Australia (Jell et al., 1985). *C. cannati* comes from the *Paradoxides mediterraneus* Zone, Middle Cambrian of Montagne Noire (S France).

Cambraster cf. tastudorum Jell et al., 1985 Figs. 4A and B

Material: A single specimen (aboral side) preserved as a natural, outer mold. It is housed in the Museo Paleontológico de la Universidad de Zaragoza-Gobierno de Aragón (MPZ 2006/85).

Description: Only the aboral side of a single specimen was collected. The dimensions of the fossil are 7.0 × 9.5 mm. It is subpentagonal in outline. The aboral surface is concave, with the exception of its marginal and central parts, where two fully-plated circlets are preserved in convex relief. Concentric zonation is observed with three fully-plated circlets. The inner circlet is composed of small, pentagonal plates surrounding a central depression with a radius of 0.5 mm in size. The marginal circlet is composed of bigger and thicker, polygonal, tessellate plates arranged in two or three rows. The marginal frame exhibits up to five orders of plates following the classic rosette pattern blooming from the first order plates (those plates present in juvenile stages) and subsequent orders intercalate in between previous ones (see Fig. 4A). At least 1/4 of the radius of the animal is occupied by this circlet. A concave depression with the biggest, elongate, pentagonal plates appears between the inner circlet and the marginal circlet, but this region is not well preserved. Punctuate ornamentation is present in all plates.

Remarks: The Spanish material resembles *C. tastudorum* (Figs. 4C and D) in the arrangement of the three main circlets, the ornamentation, and size (see Jell et al., 1985: Figs. 3A and F). However, a peripheral skirt of spinose plates is not observed in *C. cf. tastudorum*. The lack of the oral surface makes it difficult to determinate whether *C. cf. tastudorum* belongs to the same species as the Australian one, or to a new species.

Jell et al. (1985) indicate that *C. tastudorum* is readily distinguished from *C. cannati* by the plate arrangement of the central portion of the aboral surface. This feature, which is well-observed in the Murero specimen, suggests closer affinities with the Australian *Cambraster* than with the French one.

Consequently, in the wait for additional material, the Spanish specimen is tentatively determined as *Cambraster cf. tastudorum*.

Occurrence: Cadenas Ibéricas (NE Spain), river Isuela valley, Murero Formation. *Solenopleuropsis verdiagana* + *S. riberoi* biozone of Liñán and Gozalo (1986), Upper Caesaraugustan (Middle Cambrian).

5. Biostratigraphy and palaeobiogeography

All taxa included in the genus *Cambraster* occur in Middle Cambrian rocks. *Cambraster cannati* has been recorded in the “association caractéristique” E of Courtessole (1973: Table 13). The trilobites recorded in this biostratigraphical unit have been considered as Middle Languedocian in age (see Álvaro and Vizcaíno, 1998).

The age of the Australian *Cambraster* is not well constrained. Jell et al. (1985) commented that the locality, where they found it, was similar in age to locality 5 of Jago (1973). Recently, Brock et al. (2000) considered that the stratigraphic range of *Cambraster tastudorum* and *Cambraster*

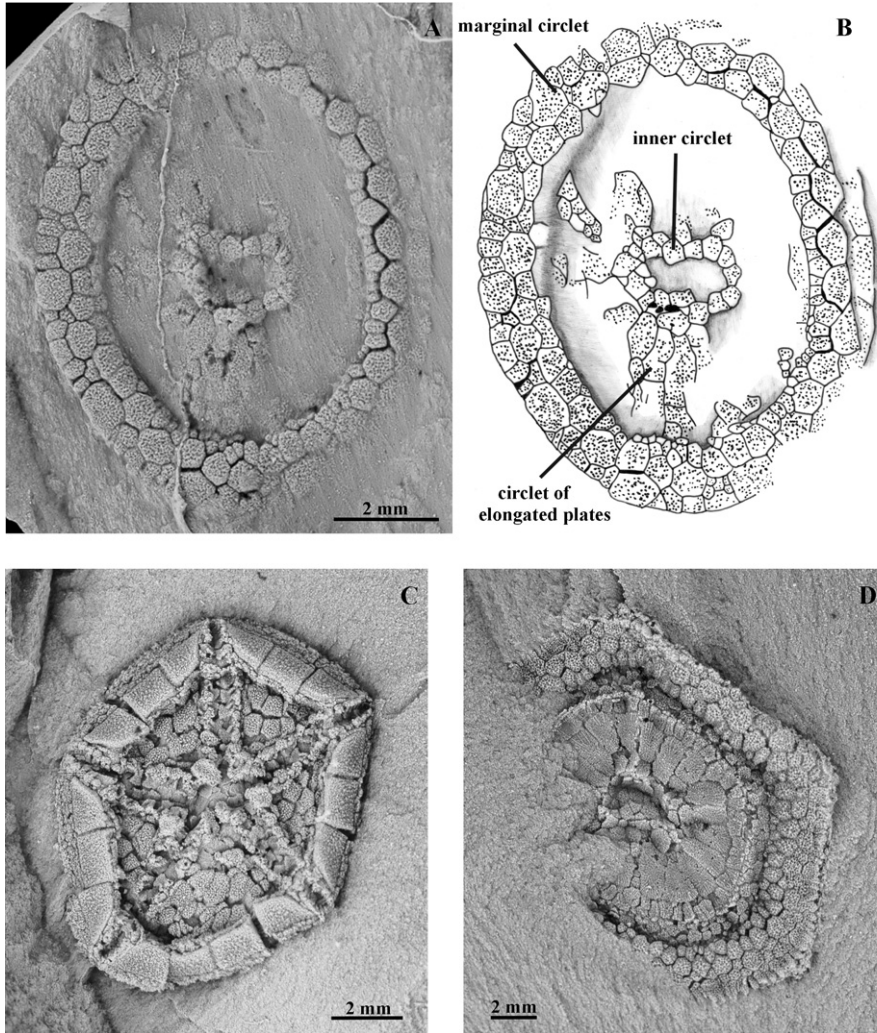


Fig. 4. **A, B.** *Cambraster cf. tastudorum* (Middle Cambrian of Cadenas Ibéricas, NE Spain). **A.** Aboral surface of the single found specimen. Repository: MPZ 2006/85. **B.** Camera lucida drawing of the aboral surface figured in **A.**, showing plate arrangement in three main circlets. **C, D.** *Cambraster tastudorum* (Middle Cambrian of Tasmania, Australia). **C.** Oral view showing the marginal ossicles and the ambulacra. Specimen NMVP107061. **D.** Aboral view of an incomplete specimen showing the plate organization in circlets. Specimen NMVP107067. All figures are latex casts.

Fig. 4. **A, B.** *Cambraster cf. tastudorum* (Cambrien moyen des chaînes Ibériques, NE de l'Espagne). **A.** Surface aborale de l'unique spécimen récolté. Numéro d'inventaire de l'échantillon: MPZ 2006/85. **B.** Dessin à chambre claire de la surface aborale illustrée en **A.**, où l'on distingue la disposition des plaques selon trois cercles principaux. **C, D.** *Cambraster tastudorum* (Cambrien moyen de Tasmanie, Australie). **C.** Vue orale montrant les ossicles marginaux et les ambulacres. Spécimen NMVP107061. **D.** Vue aborale d'un spécimen incomplet, montrant la disposition des plaques selon plusieurs cercles concentriques. Spécimen NMVP107067. Toutes les figures sont des moulages en latex.

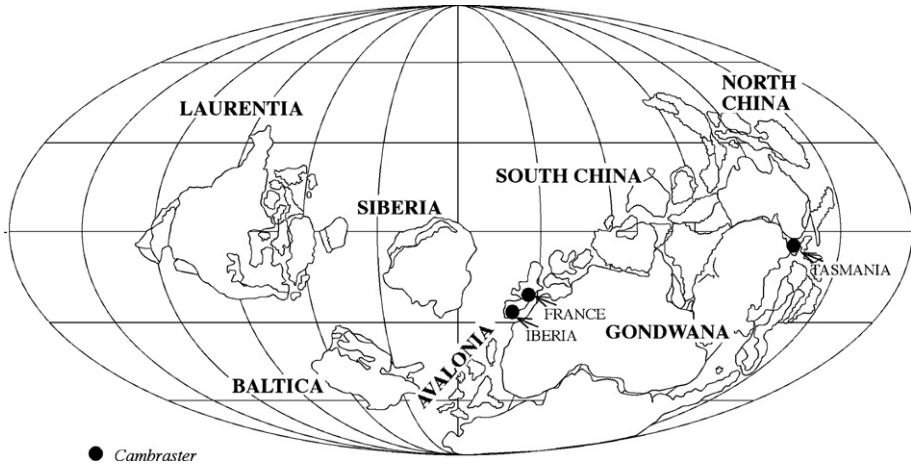


Fig. 5. Palaeobiogeographical distribution of the three known occurrences of *Cambraster*. Palaeogeographical restoration modified from McKerrow et al. (1992).

Fig. 5. Distribution paléobiogéographique des trois sites connus ayant livré *Cambraster*. La reconstitution paléogéographique est modifiée d'après McKerrow et al. (1992).

cf. tastudorum from the Cateona Group is from the *Acidusus atavus* to *Ptychagnostus punctuosus* zones. This biostratigraphical interval has been correlated with the Caesaraugustan Stage of the Mediterranean region (see Liñán et al., 2002). The age of *Cambraster cf. tastudorum* from the Cadenas Ibéricas (Spain) is late Caesaraugustian (i.e., of the same age as the Australian species). Thus, the Australian and Spanish specimens are both slightly older than the French ones (Fig. 3).

From a palaeobiogeographical point of view, the distribution of *Cambraster* in the Cambrian world consists in only two areas, both located in the periphery of Gondwana (Fig. 5): one is in modern Western Europe, and the second one, in Tasmania. It is difficult to explain such a scattered distribution, with two very distant areas in mid Cambrian times. However, similar palaeobiogeographical patterns have been documented for some trilobite genera. Two examples are the Lower Cambrian genus *Alanisia* (reported from Spain and Australia; see Jell, 1990) and the Lower–Middle Cambrian genus *Onaraspis* (from Australia, Jordan, Morocco, Poland, and Spain; Gozalo and Liñán, 1997; Geyer and Landing, 2004). Some genera of archaeocyatha-like *Porocoscinus* have been found in Spain and have Australian counterpart (Debrenne et al., 2002). These similar patterns of palaeogeographical distribution can possibly find a reasonable interpretation, but we cannot venture for the moment.

6. Conclusions

The conclusions of this study are as follows:

- the diversity of the echinoderm record in the late Lower through Middle Cambrian Murero biota (Cadenas Ibéricas, NE Spain) is documented.
- an edrioasteroid is described for the first time in the Cambrian of Spain;
- the Middle Cambrian edrioasteroid described here belongs to the genus *Cambraster*, a taxon which was previously known only from the Middle Cambrian of Australia and France;

- the new Spanish edrioasteroid shows stronger affinities with the Australian species (*C. tastudorum*) than with the French one (*C. cannati*);
- palaeobiogeographical relationships between Spain and Australia during Middle Cambrian times are, thus, evidenced here. It supports previous observations made on trilobite faunas.

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