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RAPID COMMUNICATION

The first Furongian (late Cambrian) echinoderm from the British Isles

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Abstract

Furongian (late Cambrian) echinoderms are extremely rare in the fossil record and only two previous reports have been described from the Paibian Stage worldwide. Here, the third occurrence of an echinoderm from the Paibian, and the first ever reported in the Furongian of Britain is presented. It is a primitive pelmatozoan which shows intermediate characteristics between eocrinoids with columnal-bearing stems and primitive glyptocystitid rhombiferans. The palaeobiogeographic affinities of Cambrian echinoderm faunas from Britain, eastern Avalonia, are shown to be with Gondwana.

Keywords: Cambrian, Glyptocystitida, Britain, Gondwana, palaeogeography

1. Introduction

Throughout Europe, Furongian (late Cambrian) echinoderms are extremely poorly known, with only two localities where very rare complete specimens have been recorded (Zamora *et al*. in press). These are: (i) Montagne Noire (France) where a fauna including rhombiferans, rare stylophorans and a questionable edrioasteroid have been reported (Ubaghs, 1999) and, (ii) Holy Cross Mountains (Poland) where only the primitive eocrinoid *Cambrocrinus* has been described (Orłowski, 1968; Dzik & Orłowski, 1993).

Different causes have been proposed to understand why Furongian echinoderms are rare, including global sea level regression (Smith, 1988), which resulted in a scarcity of rocks from this time interval, reducing potential preservation of echinoderm-Lagerstätte. Taphonomy, sampling bias and anoxia are also important causes that affect the rarity of echinoderms described from this time interval (Zamora *et al*. in press).

Here I report an assemblage of echinoderms from the Furongian of Britain coming from the Maentwrog Formation in central Wales (see Allen, Jackson & Rushton, 1981 for more details on stratigraphy). This find is noteworthy because, after decades of sampling in Britain, these are the first articulated echinoderms ever reported from the Furongian. It is a primitive pelmatozoan and has a thecal and stem organization that places it between Cambrian eocrinoids with columnals in the stem and more derived glyptocystitid rhombiferans. This is also remarkable because the age of these levels is Paibian and only two other localities in the world, one in North America (Laurentia) and the other in Poland (Baltica), have yielded echinoderms from this time interval (Zamora *et al*. in press).

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2. Palaeobiogeographic implications of British Cambrian echinoderms

The inclusion of Avalonia in the supercontinent Gondwana (McKerrow, Scotese & Brasier, 1992; Cocks & Fortey, 2009) or as an independent terrane (Landing, 1996, 2005) in the Cambrian is controversial. Echinoderms easily disarticulate after death and are thus a good indicator of endemicity, suffering little or no post-mortem transport.

Only a few localities in Britain have reported Cambrian echinoderms. The oldest remains are isolated plates with calcite composition and a distinct stereom structure from the lower Cambrian (Cambrian Series 2) Fucoid beds in Scotland (McKie & Donovan, 1992) and from the Comley Limestone of England (Donovan & Paul, 1982). In both cases these records are of disarticulated ossicles assigned to an eocrinoid of uncertain affinities, and thus provide no useful information.

The classic middle Cambrian (Cambrian Series 3) from Wales provides a more diverse and richer fauna that includes cinctans, stylophorans and ctenocystoids. Cinctans are represented by two species, *Davidocinctus pembrokensis* and *Elliptocinctus barrandei* (Friedrich, 1993, 1995). Stylophorans are represented by the single armoured stylophoran *Protocystites meneviensis* (Jefferies, Lewis & Donovan, 1987) and ctenocystoids by *Pembrocystis gallica* (Domínguez-Alonso, 1999). The latter, although included in a different genus, is very similar to *Ctenocystis* from France, Australia and North America and to *Etoctenocystis* from Bohemia, all three belonging to the family Ctenocystidae (Domínguez-Alonso, 1999). These middle Cambrian (Series 3) echinoderm faunas show clear Gondwanan affinities as was previously noted (Cocks & Fortey, 2009). Armoured stylophorans are endemic to Gondwanan margin assemblages (Lefebvre, 2007; Rahman, Zamora & Geyer, 2010), and cinctans are largely confined to Gondwana, although there are rare occurrences from Siberia (Friedrich, 1993; Rozhnov, 2006; Smith & Zamora, 2009; Zamora & Álvaro, 2010). Ctenocystoids are biogeographically widespread, being present in Laurentia (North America and Canada), Baltica (Poland) and Gondwana (Spain, Bohemia and Australia) (Robison & Sprinkle, 1969; Jell, Burrett & Banks, 1985; Ubaghs, 1987).

The new Furongian pelmatozoan is thus important, as pelmatozoans of this age are strongly differentiated palaeobiogeographically. In Laurentia, the assemblages are dominated by trachelocrinids, a group endemic to this area

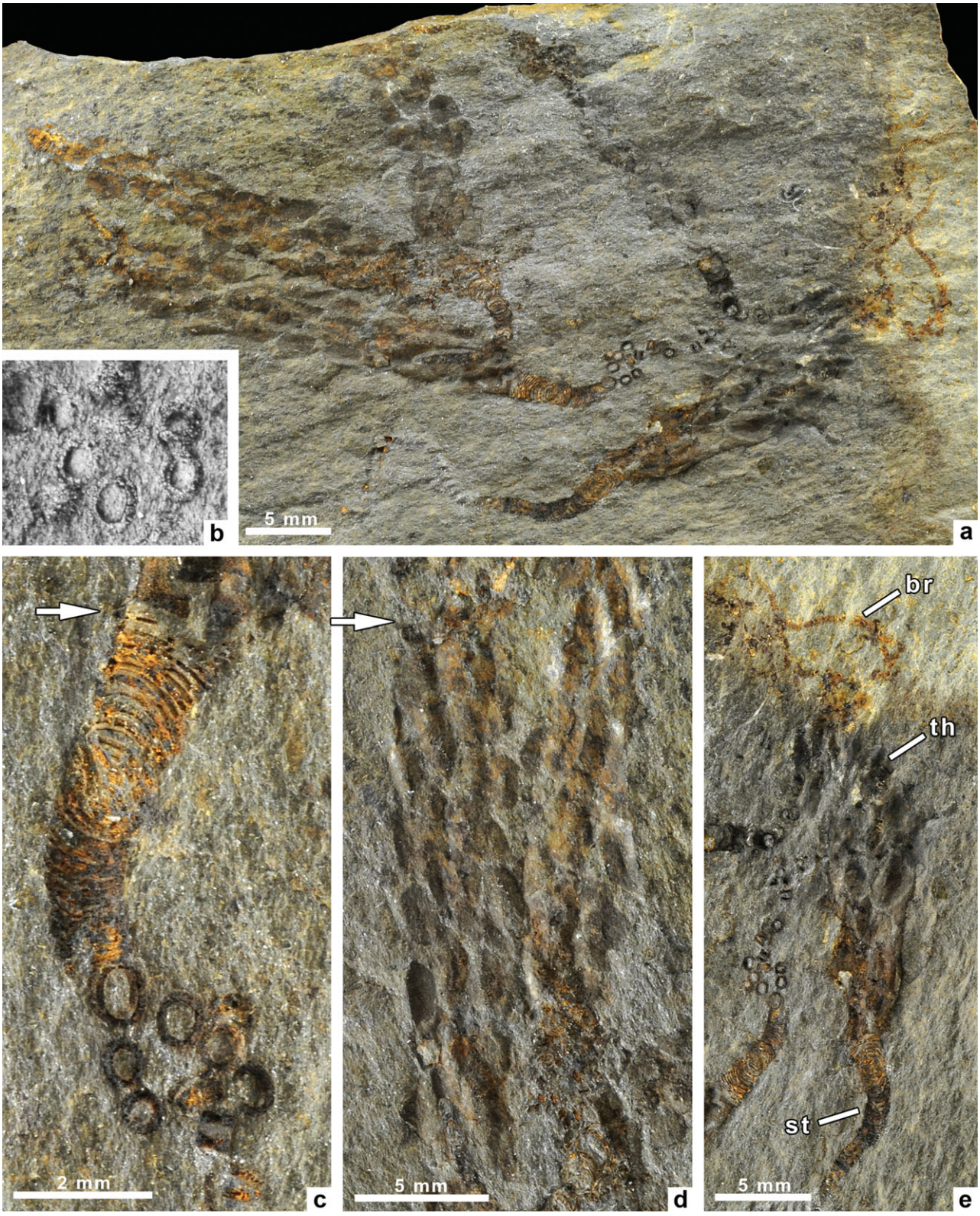

Figure 1. (Colour online) ?*Cambrocrinus* sp. from the Maentwrog Formation, Paibian (Furongian Series, Cambrian) 7 km north of Bronaber, near Trawsfyndd, in North Wales. (a) General view showing five specimens preserved as natural moulds. (b) Latex cast of proximal columnals showing large lumen and wide external flange. (c) Detail of proximal stem; arrow indicates the transition from the theca to the stem. (d) Detail of thecal plating in two specimens; arrow indicates the summit from where brachioles arise. (e) Complete specimen preserving stem (st), theca (th) and brachioles (br). All photographs were taken directly from the natural fossil with the exception of (b), which is a latex cast whitened with NH_4Cl sublimate.

(Sprinkle, 1973; Sumrall, Sprinkle & Guensburg, 1997), and are accompanied by other endemic forms with a much-reduced stem, such as *Eustipocystis* (Sprinkle, 1973). The assemblages of Gondwana and Baltica are composed of columnal-bearing pelmatozoans, including primitive glypt-ocystitids (*Velieuxicystis* and *Barroubiocystis*) from France

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(Ubaghs, 1999) and eocrinoids, such as *Cambrocrinus*, from Poland (Dzik & Orłowski, 1993) and *Ridersia* from Australia (Jell, Burrett & Banks, 1985). The eocrinoid *Pareocrinus* is the only pelmatozoan described from the Furongian of Siberia (Yakovlev, 1956) but its morphology is poorly known. There are also unpublished occurrences of glyptocystitids in Spain, Korea and China. The presence of ?*Cambrocrinus* in Wales thus indicates Baltic affinities in the Furongian, as indeed do many trilobites (Olenids) from this area (Rushton, 1982; Álvaro *et al*. 2003).

Cambrian echinoderm faunas therefore support a Gondwanan placement for Avalonia rather than as an independent terrane with its own endemic fauna, as proposed among others, by Cocks & Fortey (2009).

3. Systematic palaeontology

Specimens are housed in Lapworth Museum of Geology in Birmingham, England, under repository number Bu 5247.

Phylum ECHINODERMATA Bruguière, 1791
(ex Klein, 1734)
Class EOCRINOIDEA
Order and Family uncertain
?*Cambrocrinus* sp.
Figure 1

Material. A single slab with five partially complete specimens showing brachioles, theca and stem (Fig. 1a). They are preserved in dark shales as natural moulds and occur with the trilobites *Olenus micrurus* Salter and the agnostoid *Homagnostus obesus* (Belt).

Locality. Furongian, *O. cataractes* Zone, Maentwrog Formation, Mawdach Group, at Ffrid Dol y Moch, 7 km north of Bronaber, near Trawsfyndd, in North Wales. See locality details in Allen, Jackson & Rushton (1981, fig. 4). These levels correlate with the Paibian Stage (Rushton, 2011).

Description. The theca is elongate (up to 24 mm in height) with an expanded summit and a narrow base (Fig. 1e). It is composed of multiple circlets (between eight to ten circlets) of polygonal, roughly hexagonal plates that are smooth, slightly raised towards their centre and lack epispires or any other respiratory structure (Fig. 1d). The majority of the plates are similar in size (2 mm in length/1 mm in width) but they become slightly smaller towards the base where they articulate with the stem.

The transition between the stem and the theca is abrupt (Fig. 1c). The stem is differentiated into proximal and distal parts but is missing its distalmost part. Proximal columnals are wider that tall, have a large circular lumen (Fig. 1b, c) and are alternately flanged and probably non-flanged, although sutures are difficult to indentify in the specimens. The external flange on the columnals is very wide and very sharp compared with the inner one (Fig. 1b). Distal columnals are more cylindrical and lack any obvious flange. They are slightly wider than tall and have a small lumen.

The feeding appendages are partially preserved in several specimens (Fig. 1e). They are very thin, non-spiralated and at least as long as the theca. Brachiolars are as wide as tall and have a rectangular outline.

The oral area and apertures of the theca (anal pyramid, hydropore, gonopore) cannot be observed in the studied specimens. However, the periproct probably opens in the oral surface because thecal plates are not modified (i.e. showing invaginated borders) to house this structure.

Discussion. This specimen is tentatively assigned to *Cambrocrinus* based on the arrangement of thecal plates into more than four circlets, lack of epispires or any other respiratory structures, and construction of the stem. *Cambrocrinus regularis* Orłowski, 1968 has thecal plates that are ornamented with ridges, but the absence of such ornamentation in ?*Cambrocrinus* sp. could be due to the poor state of preservation in the available material.

Primitive glyptocystitid rhombiferans (i.e. *Velieuxicystis* and *Barroubiocystis*) have a similar stem to ?*Cambrocrinus* and also lack rhombs. However, these taxa can easily be distinguished as they have a more derived thecal plating composed of just four circlets. In addition, *Velieuxicystis* has its periproct opening in a lateral position and framed by thecal plates.

The primitive eocrinoids *Ubaghsicystis* and *Akadocrinus* are also easy to distinguish as they have an undifferentiated stem with columnals and have epispires in the theca.

The comparison of ?*Cambrocrinus* with other pelmatozoans shows that it retains the primitive multiplated thecal arrangement of primitive eocrinoids (i.e. *Akadocrinus*) but has the derived stem differentiated into proximal and distal parts that characterize glyptocystitids. In having a large number of organized circlets of thecal plates, ?*Cambrocrinus* is intermediate between primitive eocrinoids (which have only irregular thecal plating) and glyptocystitids (which have just four circlets).

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