Bulletin of the Mizunami Fossil Museum, no. 37 (2011), p. 115–121, 3 figs.

Chariocrinus japonicus, a new species of isocrinid crinoid (Articulata) from the Lower Cretaceous of Takayama City, central Japan

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Abstract

A specimen, originally described as '*Pentacrinus*' from the Middle–Upper Jurassic of central Japan, is re-analysed and now recognised to be a new species of the genus *Chariocrinus* Hess, 1972, from the Lower Cretaceous. *Chariocrinus japonicus* sp. nov. has nine columnals per noditaxis, low columnal height, a pentalobate to sub-pentagonal articular facet and an impersistent median ridge on the latera. *Chariocrinus* was originally described from the Middle Jurassic of Switzerland, and has also been recognised from elsewhere in Europe, Antarctica and North America. The Japanese specimen represents the first report of *Chariocrinus* in the Cretaceous of Asia, thereby significantly extending both its temporal and eastern geographical range. This specimen suggests *Chariocrinus* had a global distribution and, as such, conforms with the distribution of other Mesozoic and modern isocrinine genera.

Key words: Crinoids, Lower Cretaceous, Mitarai Formation, Tetori Group, Takayama City, Gifu Prefecture, Japan

Introduction

The crinoid genus *Chariocrinus* Hess, 1972, has only previously been described from Lower to Middle Jurassic strata of Europe (Hess 1972, 1975; Simms, 1989; Hunter and Underwood, 2009), Antarctica (Eagle and Hikuroa, 2003) and North America (Hunter and Zonnerveld, 2008). Until now, there have been no reports of *Chariocrinus* from the Lower Cretaceous of eastern Asia.

The specimen here studied was originally described as '*Baikaseki*' (or in Japanese, apricot blossom stone) by Hamada (in Ōe and Ōe, 1972) who, on the basis of the star-shaped columnals, suggested affinities with *Isocrinus*, but did not attempt a more detailed taxonomic assignment. The last 30 years has seen significant advances in crinoid taxonomy (Hess, 1975; Simms, 1989). These advances have enabled the confident identification to generic and specific level of disarticulated Mesozoic crinoid remains in various states of preservation, including specimens lacking cups or brachials (Hess, 1975), consisting only of isolated columnals (Simms, 1989) and columnals in thin section (Hunter and Clark, 2009).

Mesozoic crinoids are not uncommon in Japan. Notable Jurassic examples include: *Pseudosaccocoma japonica* Kobayashi, 1935, from the Upper Jurassic Torinosu Group in Kochi Prefecture; *Seirocrinus* sp. from the Toarcian of the Kuruma Group of central Japan (Goto, 1994); *Pentacrinus* sp. (= *Isocrinus* sp. of Hunter *et al*. research in progress) from the basal part of the Higashinagano Formation of the Toyora Group of Western Honshu (Hayami, 1961); and *Pentacrinites dichotomus* (M'Coy, 1849), *Pentacrinites* cf. *doreckae* Simms, 1989, and *Seirocrinus* sp. (= *S* '*alaska*'), also from the Toyora group (Hunter *et al*. research in-progress). Cretaceous crinoid records from Japan include the exceptionally well-preserved isocrinids *Isocrinus hanaii* Oji, 1995, and *Isocrinus* sp. from the upper Aptian Tanohata and Hiraiga formations of the Miyago Group, northeast Japan, and *Nielsenicrinus japonicus* Oji *et al*., 1996, from the Campanian of western Kyushu. Whilst most described Mesozoic crinoids are from Europe and North America, the Japanese records outlined above and the new species described herein suggest that the geographical range of many Mesozoic taxa is much wider than has been previously assumed (Hess, 1972, 1975; Simms, 1989; Hunter and Zonnerveld, 2008), extending the occurrence of these genera well into eastern Asia.

Geological setting

The specimen described in this paper was collected from the Mitarai Formation in the Kuzuryu Subgroup, Tetori Group, from a quarry located in the northernmost part of Gifu Prefecture, 100 m southwest of Mitarai bus stop, Shokawa, Takayama City, Gifu

Fig. 1. Map of Japan showing the location of Shokawa and Takayama City.

Prefecture, Japan (Fig. 1). The Mitarai Formation was previously assigned to the Middle Jurassic on the basis of a single ammonite species, *Lilloetia* sp. (Sato and Kanie, 1963), or to the Upper Jurassic by Komatsu *et al*. (2001) based on bivalves. However, the discovery of new ammonites (berriasellids) and a revision of the formerly described species suggest that the formation is, in fact, Tithonian–Berriasian (Sato *et al*., 2003). Radiometric U-Pb dating of zircons within tuff beds from the Mitarai Formation give an absolute date of 129.8 $\pm$ 1.0 Ma, that is, Hauterivian–Barremian (Kusuhsahi *et al*., 2006). This data and the recent discovery of a single ammonite, *Neocosmoceras* sp., that was likely to have been collected from the Mitarai quarry suggests a Berriasian age (Sato *et al*., 2008), although further evidence is needed to corroborate this determination.

The section containing the crinoid dips 18° to the west and displays prominent ripple-marks covering an area of approximately 20 m^2. The ripples are interpreted as slightly disturbed, single ridge, parallel types of deltaic origin (Takahashi *in* Nomura, 1969). The crinoid remains are from the uppermost layer within a black sandy shale and occur with a rich associated fauna of bivalves (*Inoceramus* sp., *Modiolus* sp.), gastropods, belemnites and plant remains (Nomura, 1969). A wood fragment occurs in close association with the crinoid specimen, but a physical connection between the two could not be determined. This sedimentological interpretation suggests that these crinoids were most likely to have been living in or adjacent to marginal marine conditions as defined by Hunter and Underwood (2009).

Systematic palaeontology

Terminology of the crinoid endoskeleton used herein follows that of Donovan (1984) and Simms (1989).

Order Isocrinida Sieverts-Doreck, 1952
Suborder Isocrinina Gislén, 1924
Family Isocrinidae Gray, 1842
Genus *Chariocrinus* Hess, 1972

Type species: *Isocrinus andrae* Désor, 1845, by original designation; Middle Jurassic, northern Switzerland.

Diagnosis: (Translated and adapted from Hess, 1972, pp. 200–201, with his assistance, and from Rasmussen and Sieverts-Doreck, 1978, pp. 855-857). Small to medium sized crinoids. Column pentagonal to sub-pentagonal, commonly with fewer than 10 internodals per noditaxis. Columnals high with smooth latera and sharp to slightly rounded interradii. Nodals slightly larger than internodals, with 5 small, oval, cirral scars each displaying a cupule and lower lip. Internodal articular facets small, pentalobate to pentastellate in outline, with large marginal and adradial crenulae that diminish rapidly in size towards the centre. Petals small, drop-like. Symplectial areolae broad, elliptical, with adradial crenulae of adjacent areolae fused. Nodal/infranodal articulations synostosial or planar cryptosymplectial (see Remarks below), typically on the distal surface only (Fig. 3B); all other intercolumnal articulations are either proximally cryptosymplectial (Fig. 3C) or distally symplectial (Fig. 3A, D). Cirri directed laterally and slightly upwards. Basals large with broad contact. Arms moderately slender.

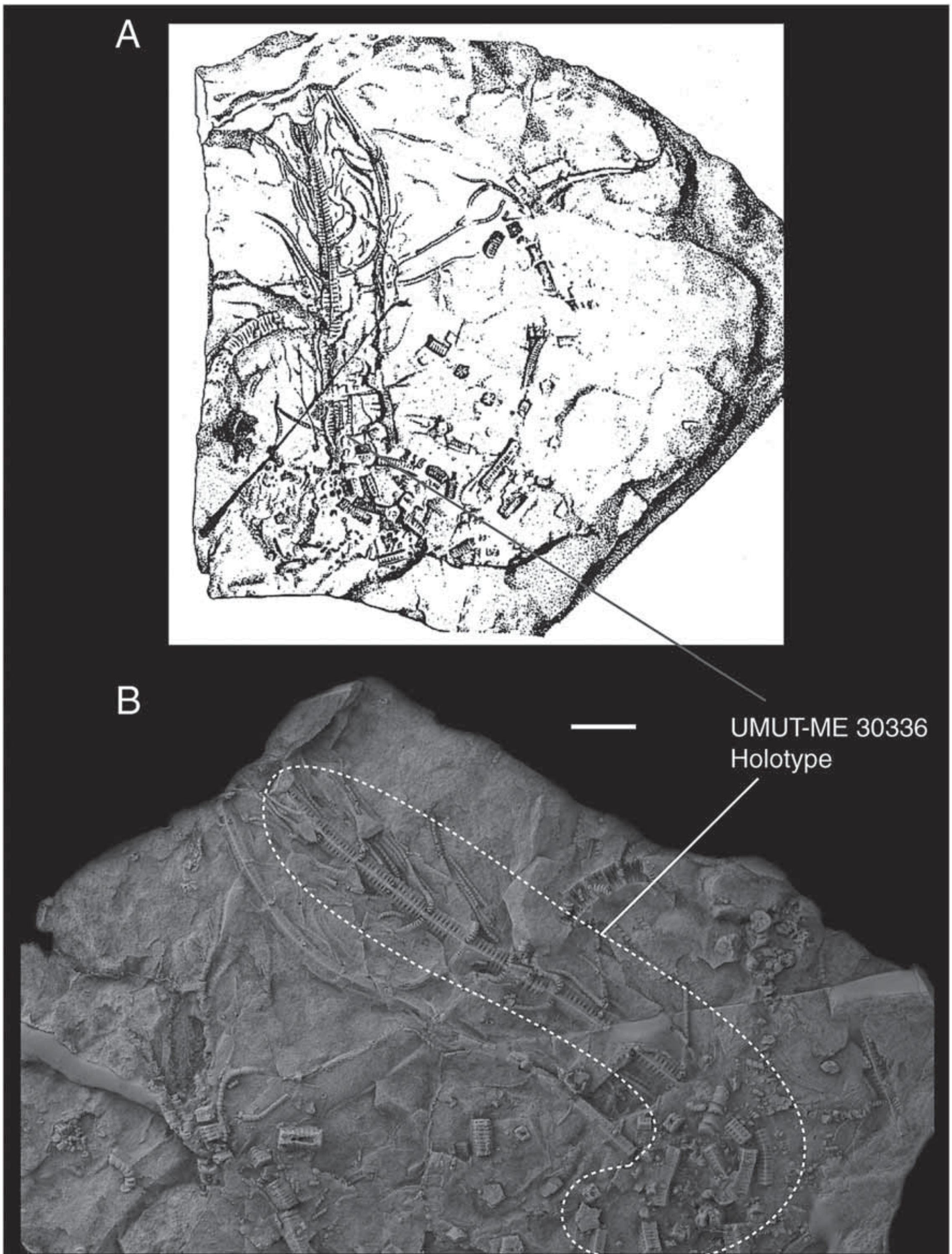
Remarks: Hess (1972; also see Eagle and Hikuroa, 2003) included the type species along with *Pentacrinus schlumbergeri* de Loriol, 1886), *P. cristagalli* Quenstedt, 1852, *P. wuerttembergicus* Oppel, 1856, *Balanocrinus bathonicus* de Loriol, 1887, and *Balanocrinus mosensis* de Loriol, 1888, in the genus *Chariocrinus. Hispidocrinus* Simms is differentiated from *Chariocrinus* by having large spine bases on the axillaries, much wider and flatter columnals, and crenulae of adjacent areolae that are separated by a furrow and not fused. The stem of both *Isocrinus* and *Chariocrinus* are typically pentalobate to pentastellate, but are differentiated on several features. The key differences between *Isocrinus* and *Chariocrinus* relate to the morphology of the articula surface. In *Isocrinus*, the symplectial areolae are elliptical. The crenulae of adjacent areolae separated at right angles to one another, except near the lumen. In *Chariocrinus* the symplectial areolae are broadly elliptical, with the crenulae of adjacent areolae generally fused (Simms, 1989). The stem of *Isocrinus* is more robust than that of *Chariocrinus* and displays cirral scars of moderate size that are directed outwards and slightly upwards (Simms, 1989). The stem of *Chariocrinus* is usually more pentagonal and gracile, with a small cupule above and an aboral lip below each cirrus scar (Eagle and Hikuroa, 2003). *Chariocrinus* is further distinguished from *Isocrinus* by the presence of unornamented articulations (i.e., no visible evidence of crenulae on the facet although remnants of groves may be apparent) between the distal surface of the nodals and internodals, whereas they are distinctly cryptosymplectial with relict crenulae throughout in *Isocrinus* (Eagle and Hikuroa, 2003). Eagle and Hikuroa (2003) and earlier Simms (1989), used the term synostosial to describe these unornamented articulations. This is not strictly correct because synostosial articulations, as defined by Donovan (1984; 1990), are unornamented from their initial formation below the cup and throughout the stem. It is not possible to say whether the smooth facet ornament in *Chariocrinus* was formed in this way in any published fossil example; instead, it is more likely that it was formed by particularly heavy secondary calcification of the facet and is thus an extreme form of cryptosymplexy. Simms (1989) and Eagel and Hikuroa (2003) used the term synostosial in a purely descriptive sense contrary the dynamic sense of Donovan (1990). However, we follow the use of synostosial *sensu* Simms (1989) and Eagel and Hikuroa (2003).

Range: Lower to Upper Jurassic (Toarcian-Oxfordian), England, Switzerland and southwest Germany (Hess, 1972, 1975; Simms, 1989); Middle Jurassic (Bajocian-Callovian), western United States (Wyoming) (Hunter and Zonnerveld, 2008) and Antarctica (Eagle and Hikuroa, 2003); Lower Cretaceous, Japan.

Chariocrinus japonicus sp. nov.

(Figs. 2, 3)

Material: External mould and artificial latex cast of two articulated stem sections with articulated cirri. There are also additional disarticulated ossicles, including 14–15 pluricolumnals,



Figs. 2. *Chariocrinus japonicus* sp. nov., UMUT-ME 30336, Holotype. A: Sketch refigured from Ōe and Ōe (1972, fig. 1). B: Latex cast of two preserved stems and disarticulated pluricolumnals. Scale bar = 20 mm.

five brachials and some isolated cirri (UMUT-ME 30336).

Holotype: UMUT-ME 30336, the uppermost of the three articulated specimens (including disarticulated lower portion shown in Fig. 2B), type collection of the University Museum, University of Tokyo.

Type locality: 100 m southwest of Mitarai bus stop, Shokawa, Gifu Prefecture, Japan, Mitarai Formation (Lower Cretaceous, ?Berriasian), Kuzuryu Subgroup, Tetori Group.

Derivation of name: From the Latin for Japan.

Diagnosis: *Chariocrinus* with nine columnals per noditaxis, low columnal height, articular facet pentalobate to sub-pentagonal, latera displaying a median ridge that disappears over the interradii.

Description: Column slender with low columnals. Columnal outline pentastellate proximally to weakly pentagonal distally. Proximal internodals display sharp interradii, but are more rounded distally. Columnal latera possess a median ridge that is absent over the interradii, but are otherwise unornamented and smooth. Articulation between the nodal and internodal is synostosial (Fig. 3B), with all other columnal articulations symplectial (Figs. 3A, D). or cryptosymplectial (Fig. 3C). The areola is depressed with adradial crenulae have various stages of fusion while the marginal crenulae are slightly enlarged (Fig. 3A).

Cirri: are long (10–25 mm), slender, rounded and unornamented. Cirral scars large compared to columnal height, elliptical, subrounded or teardrop-shaped in outline with the facet directed outwards and slightly upwards. Articulation between adjacent cirral ossicles is 0.4 mm in height and 0.2 mm in width.

Dorsal cup: unknown.

Arms: Only a handful of brachial elements (probably secundibrachs) are known and are poorly preserved.

Columnal measurements: nodal diameter: 3 mm, internodal diameter: 2.3 mm; nodal height 0.6–0.7 mm; internodal height= 0.5 mm; preserved noditaxis ranges between 5.5–5.7 mm.

Remarks: 'Synostosial' articulations between the nodals and internodals, and the arrangement of the crenulae on the internodal articular facets confirms assignment of this species to *Chariocrinus*. Like the other members of the genus, *Chariocrinus japonicus* is small. Based on comparisons of columnal measurements with other species of *Chariocrinus*, a height of 150–200 mm for the entire crinoid is suggested. *Chariocrinus japonicus* is most similar to *Chariocrinus andreae* Hess, 1972, and *Chariocrinus lutadiensis* Eagle and Hikuroa, 2003, in its small size and low columnals. However, both of these species have columnals that are more pentalobate in section, with less fusion between adjacent adradial crenulae, and neither species has a weakly developed epifacet over the radii. *Chariocrinus japonicus* is reminiscent of *Chariocrinus wuerttembergicus* Oppel, 1856, in that both display subpentagonal distal columnals and adradial and marginal crenulae. However, *C. wuerttembergicus* has higher columnals than *C. japonicus* with smooth latera lacking epifacets on the radii and a far greater number of columnals (7–18) per nodataxis. *Chariocrinus wuerttembergicus* is restricted to the Lower Jurassic (Toarcian) of England and Germany, and as such is older than other members of this genus. *Chariocrinus* morphotypes were recorded by Hunter and Underwood (2009) and Hunter and Zonnerveld (2008) from the Middle Jurassic (Bathonian) of Dorset and Wyoming, respectively, but again these are significantly older than *C. japonicus*.

Discussion

The discovery in Japan of *Chariocrinus* along with *Isocrinus, Pentacrinites* and *Seirocrinus* (Hunter *et al*., research in progress) greatly increases the geographical range of certain Mesozoic crinoid genera into eastern Eurasia. Along with recent published records of these genera from North America (Hunter and Zonnerveld, 2008) and Antarctica (Eagle and Hikuroa, 2003), the Japanese material suggests that Mesozoic isocrinid genera probably had pandemic distributions similar to those observed in modern isocrinids.

Chariocrinus japonicus represents the first record of a crinoid from the Neocomian (?Berriasian) of the eastern Tethys. Previously, Neocomian crinoids have been described from England, Germany, Russia, Greenland (Rasmussen, 1961, Rasmussen and Sieverts-Doreck, 1978), the United States (Texas) (Peck, 1943) and the Caribbean (Donovan *et al*., 1996). In comparison with the rich crinoid faunas from the Jurassic and the middle to late Cretaceous (Rasmussen, 1961; Hess, 1972, 1975; Simms, 1989; Mitchell and Langner, 1995; Jagt, 1999; Hunter and Underwood, 2009), Neocomian crinoids are relatively rare.

The discovery of the present species represents the first Cretaceous record of *Chariocrinus*. Therefore, either *Chariocrinus*, like the coeval *Apiocrinites* and *Isocrinus* (Rasmussen, 1961), existed globally in the Early Cretaceous, and its fossils have yet to be discovered in Europe and North America, or *Chariocrinus* only survived into the Early Cretaceous in the eastern Tethys as a relict. Further investigations of the global distribution of Upper Jurassic and Lower Cretaceous isocrinids are needed to test these alternatives.

Only a handful of localities in the Middle/Upper Jurassic and uppermost Cretaceous have yielded fossil crinoids with articulated stems (Rasmussen, 1961; Hess, 1975; Hunter and Underwood, 2009). Thus, the articulated preservation of the Japanese specimen is significant. Despite the limited number of specimens and lack of extensive sedimentological and palaeontological information (Nomura, 1969; Ōe and Ōe, 1972), available evidence suggests that the crinoids were exceptionally preserved (at least beneath the basal plates and arms) as a result of rapid burial and experienced minimal transport from their original habitat (taphofacies 1 of Hunter and Zonnerveld, 2008). The recent isocrinid *Metacrinus rotundus* (sampled from Suraga Bay, Japan) detaches its crown from the stem under stress (Amemiya, and Oji, 1992). *Chariocrinus japonicus* may also have experienced such a trauma, resulting in the articulated preservation of the stem after most of

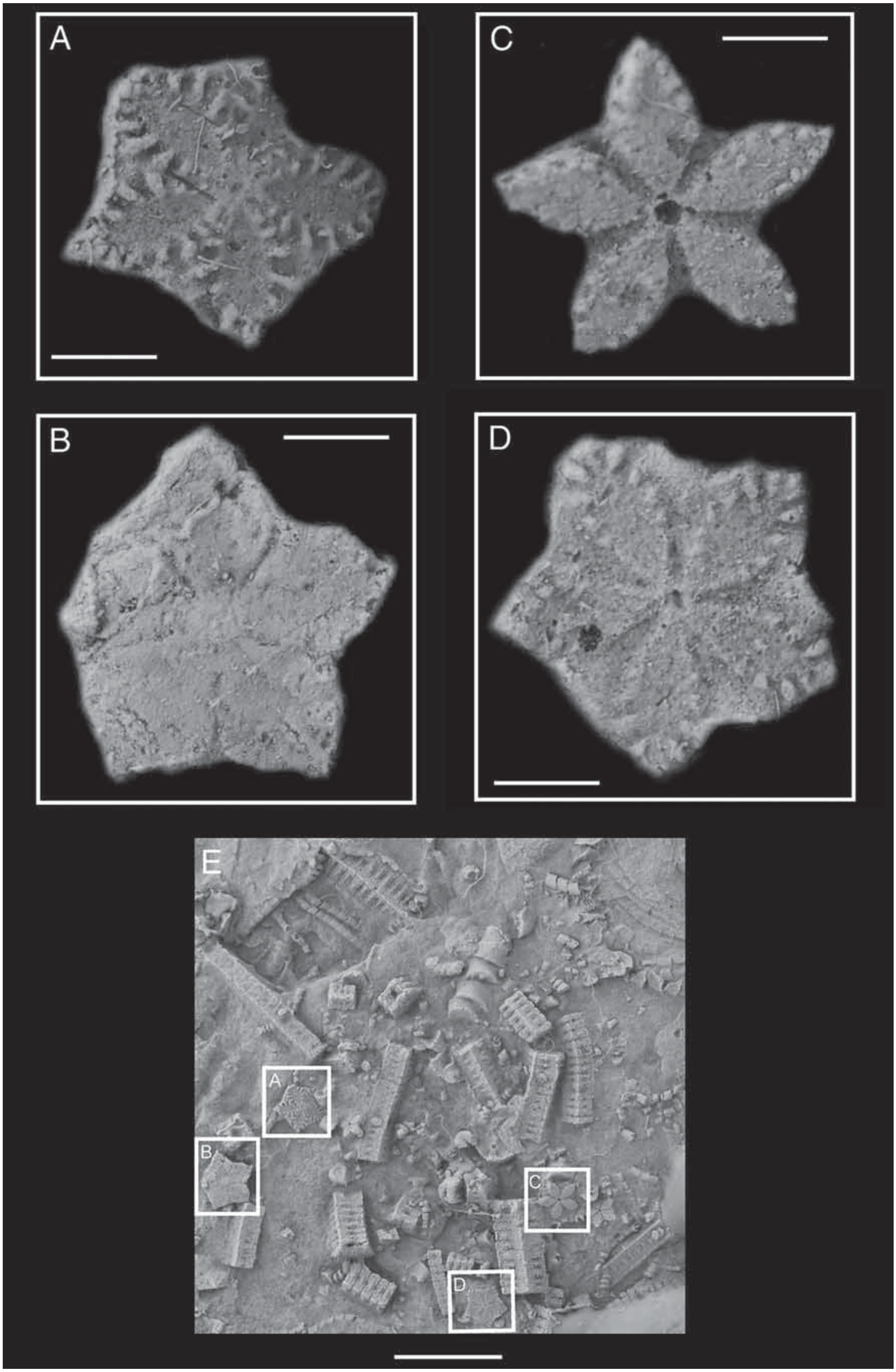


Fig. 3. *Chariocrinus japonicus* sp. nov., UMUT-ME 30336, Holotype A: Symplectial articular face of a distal intermodal. B: Synostosial articular face of a nodal. C: Cryptosymplectial articular face of a proximal internodal. D: Weakly symplectial articular face of a medium distal internodal. E: Pluricolumnals, columnals, cirri and brachials (magnified lower section). Scale bars: A–D, = 2 mm; E = 5 mm.

the upper part of the crown had been detached.

The interpretation of the ripple marks as deltaic in origin and the presence of plant remains within the facies suggests that these crinoids lived in or adjacent to a marginal marine setting, and it is tempting to suggest that the Japanese crinoids were buried by deltaic sediments. The occurrence of shallow, nearshore or lagoonal crinoids in the Middle Jurassic of England has previously been noted by Hunter and Underwood (2009). It is therefore suggested that the crinoids were inundated by a sediment influx that induced autotomy of most of the cup and the arms. Leaving mainly the articulated stems to be buried and fossilised.

Acknowledgments

The original specimen was donated from Takashi Hamada to one of the authors (T.O.). We thank these people for giving an opportunity to study this crinoids. Thanks go to Stephen K. Donovan (Naturalis, Lieden) and David N. Lewis (Natural History Museum, London) for their thoughtful reviews, and Paul D. Taylor for his useful comments on the final version of this paper.

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Manuscript accepted on August 28, 2010