Available online at www.sciencedirect.com

ScienceDirect

Palaeoworld 24 (2015) 438–444

Palaeoworld

www.elsevier.com/locate/palwor

New discoveries of Cambrian pelmatozoan echinoderm ossicles from North China

Tin-Wai Ng [a,b], Joseph P. Botting [a,c], Jin-Liang Yuan [a], Jih-Pai Lin [d,e,*]

[a] *Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China*
[b] *Department of Earth Sciences, National Taiwan Normal University, Taipei 11677, Taiwan, China*
[c] *Chatsworth, Spa Road, Llandrindod Wells LD1 5EY, UK*
[d] *State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China*
[e] *Department of Geosciences, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, Taipei 106, Taiwan, China*

Received 14 November 2014; received in revised form 1 February 2015; accepted 21 May 2015
Available online 30 May 2015

Abstract

A variety of echinoderm ossicles have been discovered in the middle to upper Cambrian rocks of the North China Craton. Material was collected from two localities: Shuangqiao (SQ) section (Paibian) in Hebei Province and Linyi (LY) (Guzhangian?–Paibian?) in Shandong Province. Six types of ossicles can be recognized, including rounded thecal plates, and columnals with a narrow lumen and ridged articulating facets. The combination of characters suggests an unknown stalked echinoderm, probably an eocrinoid, with relatively advanced columnal morphology.

Keywords: Echinoderm; Pelmatozoan; Ossicles; Guzhangian; Paibian; North China

1. Introduction

Furongian (upper Cambrian) records of complete pelmatozoan echinoderms are rare (Zamora, 2012; Zamora et al., 2013a). There are examples from South China (Han and Chen, 2008; Zamora et al., 2013b), Australia (Jell et al., 1985), Poland (Dzik and Orłowski, 1993), France (Ubaghs, 1999), Spain (Zamora et al., 2009), and Wales (Zamora, 2012), but there are no formal reports from the North China Craton. Studies of isolated echinoderm ossicles are increasingly providing useful information on the Cambrian faunas, and several important papers on disarticulated material provide essential background in understanding Cambrian echinoderms (e.g., Sumrall et al., 1997; Clausen and Smith, 2008; Clausen et al., 2009; Zamora et al., 2010, 2013a; Clausen and Peel, 2012). Detailed examination of isolated ossicles and disarticulated remains can reveal unexpected insights, such as alpha diversity, phylogeny, and paleobiogeography (Clausen and Smith, 2008; Zamora et al., 2013a), so records of even fragmentary material from poorly known intervals and regions can add significantly to wider knowledge of echinoderm evolution.

In this paper we present a small suite of newly collected echinoderm ossicles from the Guzhangian and Paibian stages of the North China Craton, representing the first late Cambrian records from this palaeocontinent. Two localities yielded these ossicles: the first is located in the previously described Shuangqiao (SQ) section in Tangshan City, Hebei Province (Ng et al., 2014), and the second is located in Linyi (LY), near Linyi City, Shandong Province (Fig. 1).

2. Geological settings

During middle to upper Cambrian times, the North China Craton was situated near the equator. The geology is represented primarily by shallow-water carbonate platform deposits. These limestone deposits are widely exposed on the North China Craton, although there are numerous small-scale differences in

* Corresponding author. Current address: Department of Geosciences, National Taiwan University, No. 1, Sec. 4, Roosevelt Road, P.O. Box 13-318, 106 Taipei, Taiwan, China. Tel.: +886 2 33669475; fax: +886 2 23636095.
E-mail addresses: twngpaleo@hotmail.com (T.W. Ng), acutipuerilis@yahoo.co.uk (J.P. Botting), jlyuan@nigpas.ac.cn (J.L. Yuan), jplin@hotmail.com (J.P. Lin).

http://dx.doi.org/10.1016/j.palwor.2015.05.008
1871-174X/

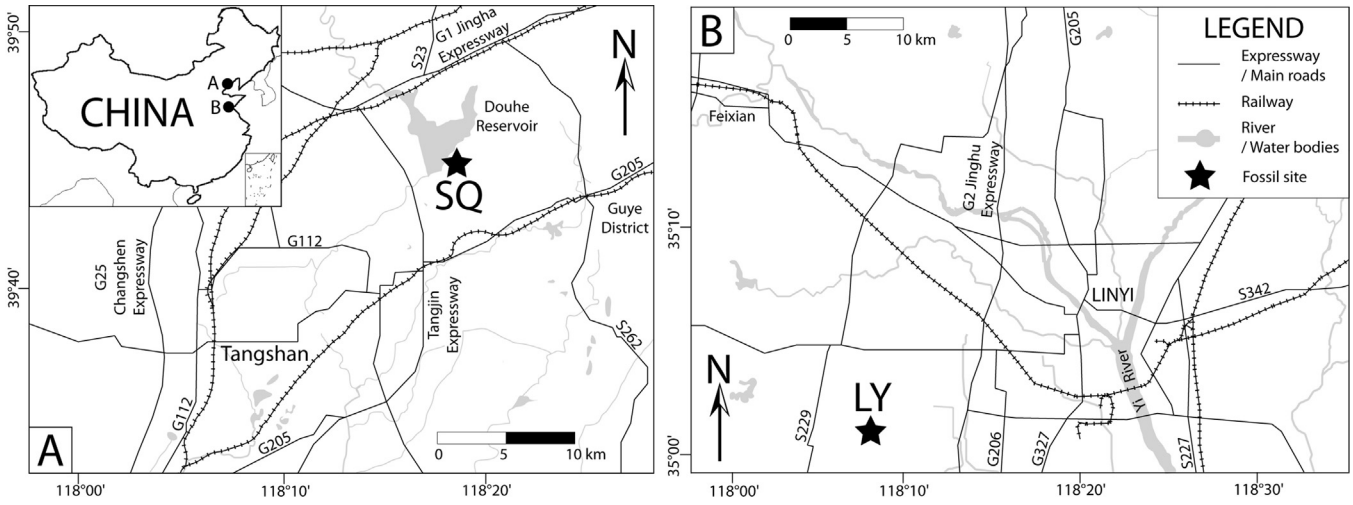

Fig. 1. Locality maps showing the sampling sites: (A) SQ section near Shuangqiao Village, Tangshan City, Hebei Province; and (B) LY, near Linyi City, Shandong Province.

lithology. Within the sampled areas (Fig. 1), intervals of wackestone, grainstone, packstone, rudstone, and lime mudstone are conspicuous components, with occasional thin-bedded siltstone, mudstone layers, and thin, small-scale stromatolite lenses. The presence of flat-pebble conglomerate (= edgewise limestone) indicates frequent storm influence typical for such a shallow-water depositional environment on an epeiric platforms (Chen et al., 2011, 2014; Zhou et al., 2011).

All the echinoderm ossicles were collected from two localities. The first site (SQ) is located adjacent to Shuangqiao Village, Tangshan City, Hebei Province, with a GPS location of N39°45.105′, E118°19.272′ (Fig. 1A); the second site (LY) is about 20 km southwest of Linyi City, Shandong Province, with a GPS location of N35°01′14.0″, E118°07′80.3″ (Fig. 1B). The SQ material was discovered at horizon 11.35 m (Figs. 2, 3, 4A) of the Changshan Formation; and based on the Steptoean Positive Carbon Isotope Excursion (SPICE) reported in Ng et al. (2014), this sampling horizon belongs to the upper part of the *Prochuangia-Paracoosia* Zone of the lowermost part of the Paibian Stage, Furongian Series (Figs. 2, 3). The LY material was collected from a loose boulder in a quarry (Fig. 4B), and its exact stratigraphic position is uncertain. Judging by the host sediment and field observations, these specimens most likely originated from the massive limestone cliffs of the lower part of the Chaumitien Formation and have a similar lithology to the SQ material. The limestone bed beneath this level yields the polymerid trilobite *Neodrepanura*, which could potentially act as a lower age constraint of these echinoderm ossicles. This implies that the LY ossicles originated in an interval ranging from the upper part of the Guzhangian Stage to the lower part of the Paibian Stage (Fig. 3).

3. Materials and methods

Densely packed echinoderm ossicles exposed on a few small areas of the weathered rock surface were obtained from the SQ 11.35 m horizon (Figs. 2, 4A). The rock is densely cemented, and individual ossicles cannot be isolated from the matrix. Specimens were washed with water before taking digital pictures under an optical microscope. The lithology of the LY samples is less densely cemented (Fig. 4B), and some ossicles on the surface could be isolated fairly easily. These individual ossicles from LY were soaked and rinsed only with water before gold coating and examined with a Scanning Electron Microscope (SEM). All optical microscopic digital images (Fig. 4C–F) were taken at the Nanjing Institute of Geology and Palaeontology (NIGPAS). SEM Fig. 5A–L and R were taken in NIGPAS, and SEM Fig. 5M–Q were photographed at the Department of Geosciences, National Taiwan University. Images were processed with Adobe Photoshop to enhance sharpness, contrast and brightness.

4. Results

In total, six ossicle morphotypes are recognized. At least four ossicle morphologies were present among the SQ specimens, probably representing a single species with a simple holdfast and multi-plated theca. A total of 24 ossicles were isolated from the LY material and include four distinct morphologies. Most of the recovered specimens are columnals or attachment disk plates, with thecal plates and brachiolar plates missing, which could suggest that the organisms were attached to hard substrates and that the crowns were separated and washed elsewhere during deposition. These ossicles were fragmented after the death of the organisms, and different parts of the animals were scattered by currents or storms in the shallow-water environment.

Type A. Domed thecal (and perhaps multi-plated column) plates from SQ with well-preserved stereom microstructure. The surfaces are strongly pitted, perhaps largely due to exaggeration of the stereom by weathering, with the largest cavities near the center of each plate (Fig. 4C, NIGP-161477). These depressions range from 50 to 100 μm. Plates are strongly convex in cross-section (Fig. 4D, upper middle, NIGP-161477), and no sign of sutural pores are present in the material. The overall shape ranges from sub-rectangular, sub-triangular, to sub-elliptical. The lengths and widths range from about 1 to 1.5 mm.