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Crininicaminus giberti isp. nov.: Tubular trace fossil armored with crinoid stem plates from the Upper Permian Kamiyasse Formation, Northeastern Japan

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ABSTRACT

The tubular trace fossil *Crininicaminus giberti*, a horizontal tubular fossil burrow whose wall consists of numerous crinoid stem plates, occurs in the Upper Permian Kamiyasse Formation of northeastern Japan. The trace fossil described here measures 40-70 mm in length and 7-20 mm in diameter. The outer wall of the tube is characterized by numerous skeletal fragments, with most being crinoid stem plates (2 mm in diameter) and lesser fragments of brachiopods and other invertebrates. The inner wall of the tube is covered with a smooth lining devoid of crinoid skeletal elements. Because stalked crinoids mainly inhabited shallow water settings prior to the Cretaceous, it is possible that additional specimens of the ichnogenus *Crininicaminus* will be discovered from deposits of various ages and locations.

Keywords: Trace fossil, bioclast, crinoid, Capitanian, Permian.

RESUMEN

Se describe el icnofósil *Crininicaminus giberti* en el Pérmico Superior de la Formación Kamiyasse del noreste de Japón. Se trata de una madriguera horizontal y tubular cuya pared está compuesta por numerosas placas pedunculares de crinoideo, con unas dimensiones de 40-70 mm de longitud y 7-20 mm de diámetro. La pared externa de dicha madriguera se caracteriza por presentar gran cantidad de fragmentos esqueléticos, principalmente placas pedunculares de crinoideo (2 mm de diámetro) y en menor medida fragmentos de braquiópodos y otros invertebrados. La pared interna está cubierta por un revestimiento liso carente de elementos esqueléticos. Puesto que los crinoideos pedunculados habitaban principalmente ambientes marinos someros antes del Cretácico, es posible que en el futuro se describan nuevos ejemplares del icnogénero *Crininicaminus* en diferentes localidades y periodos geológicos.

Palabras clave: Pista fósil, bioclastos, crinoideos, Capitaniense, Pérmico.

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1. INTRODUCTION

Bioclasts are utilized in tube construction and/or as camouflage materials by certain species. Typical examples are the shell-armored vertical tube produced by the marine polychaete *Diopatra* (Myers, 1972; Bromley, 1996), and freshwater larval caddisfly cases armored with shell and/or lithic fragments (e.g., Boucot, 1990). These shell-armored structures are preserved as trace fossils in the geological record (Kern, 1978; Ettensohn, 1981; Jarzembowski, 1995; Bromley, 1996; Ivanov & Sukatsheva, 2002; Monaco *et al*., 2005; Jach *et al*., 2011; Zaton *et al*., 2012); hence, studies on trace fossils ornamented with bioclasts enable us to understand the nature of ancient animal-bioclast relationships.

We have previously documented the macrofauna and stratigraphy of the Upper Permian Kamiyasse Formation in northeastern Japan, which was deposited in a shallow-marine setting (e.g., Shiino & Suzuki, 2007; Shiino *et al*., 2008, 2011; Kobayashi *et al*., 2009). During the course of additional fieldwork, a shell-armored trace fossil was discovered within the formation. The present paper describes the morphology of this trace fossil in detail, and proposes a new ichnospecies: *Crininicaminus giberti*. The report of this new ichnospecies from the Permian shallow-marine deposits provides important paleoecological information on the relationships between benthic animals and skeletal fragments (bioclasts) during the Paleozoic and pre-Cretaceous Mesozoic. All specimens described and illustrated herein are housed at the University Museum, University of Tokyo (UMUT), Japan.

2. LOCATION AND STRATIGRAPHY

All the specimens described herein were collected from the Kamiyasse region of the Southern Kitakami Massif, northeast Japan, where a fossiliferous Middle Permian sequence is exposed (Fig. 1; Tazawa, 1973; Misaki & Ehiro, 2004; Shiino & Suzuki, 2007; Shiino *et al*., 2008, 2011; Kobayashi *et al*., 2009).

The Middle Permian sequence in the Kamiyasse area consists of the following three formations (in ascending order): the Hoso-o, Kamiyasse, and Kurosawa formations (Misaki & Ehiro, 2004). Based on previous biostratigraphic studies, the formations have been assigned in ages of Upper Cisuralian to Lower Guadalupian, Middle Guadalupian, and Upper Guadalupian, respectively (e.g., Morikawa, 1960; Choi, 1973; Misaki & Ehiro, 2004). Recent studies have revealed that the upper parts of the Hoso-o and Kamiyasse formations can be correlated with the Midian Stage (Shiino *et al*., 2008; Kobayashi *et al*., 2009; Shiino *et al*., 2011). Figure 2 shows lithostratigraphic columns for the five routes considered in the present study and correlations among them.

The Hoso-o Formation consists mainly of alternating beds of mudstone and sandstone/fossiliferous pavement beds in a coarsening and thickening-upward sequence. The beds of clast-supported conglomerate are lenticular in shape and occur locally. The lower part of the Kamiyasse Formation is characterized by skeletal packstone and grainstone with medium- to coarse-grained sandstone beds in the basal part. These beds are overlain by matrix-supported conglomerate bed, followed by poorly sorted fine-grained sandstone beds rest on the skeletal packstone and grainstone. The Kurosawa Formation comprises alternating beds of black mudstone and sandstone beds in a fining- and thinning-upward sequence, locally intercalated with lenticular beds of matrix-supported conglomerate.

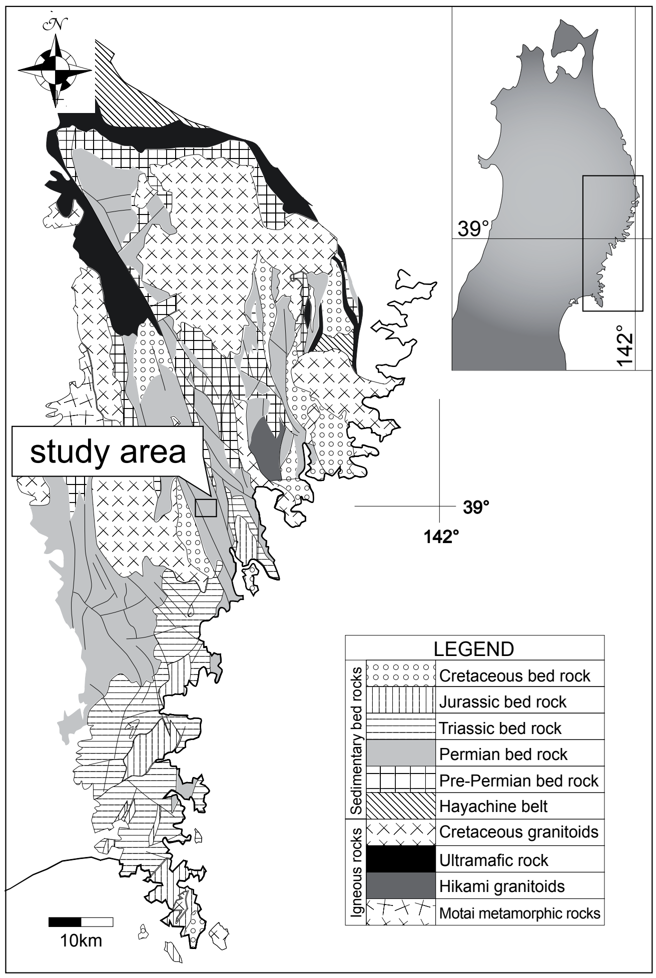

Figure 1. Geological map of the Kitakami Massif, northeastern Japan showing the location of the study area.

The upper part of the Kamiyasse Formation, which yielded the present specimens of *Crininicaminus* (Fig. 2), is alternating beds of fossil pavement (including numerous crinoid stem plates, brachiopods, and trilobites) and fine-grained sandstone. The *Crininicaminus*-bearing horizon consists of fine-grained sandstone.

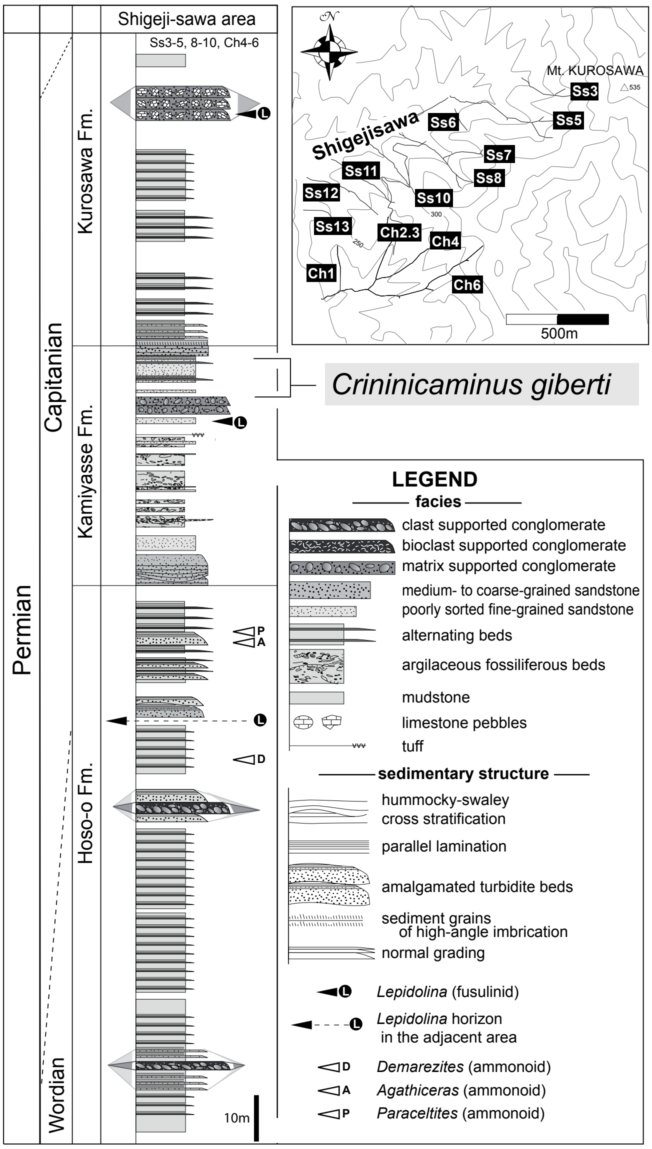

Figure 2. Generalized columnar section of the Kamiyasse area. The trace fossil *Crininicaminus giberti* occurs within the upper part of the Kamiyasse Formation. Modified after Shiino & Suzuki (2007).

3. SYSTEMATIC ICHNOLOGY

Ichnogenus *Crininicaminus* Ettensohn, 1981

Ichnospecies *Crininicaminus giberti* isp. nov.
(Fig. 3)

Derivatio nominis. In honor of Dr. Jordi Maria de Gibert.

Holotype. UMUT-PW30072 (Figs 3a-b).

Paratypes. UMUT-PW30073 (Figs 3c-d) and UMUT-PW30074.

Diagnosis. A slightly tapered, unbranched cylindrical agglutinated tube composed of numerous well-sorted crinoid stem plates added to externally to the tube in a series of adjacent columns vertical to the long axis of the tube. The inner wall is covered with a smooth lining. The lumen of the tube is composed of sediment particles similar to those of surrounding strata.

Description. The tubular trace fossil described herein measures 40-70 mm in length 7-20 mm in diameter, and is preferentially oriented parallel to bedding. The bioclasts adhered to the outer wall are mainly of crinoid stem plates of 2 mm in diameter. Fragments of brachiopods and other invertebrates are also attached to the wall. The tube base is planar and is covered with well-sorted crinoid stem plates (Figs 3a-b). The top and sides of the tube are covered by skeletal fragments of varying type and size, showing a coarsening-centrifugal distribution (Figs 3c-d), convex shape, and thicker ornamentation than the tube base. The side edge of the tube consists of relatively large bioclasts such as brachiopod shells (Figs 3a-b).

Remarks. Tubular trace fossils ornamented with bioclasts have previously been described based on the nature of conglutinated materials and/or tube orientation (Jach *et al*., 2011). For example, Kern (1978) reported *Diopatrichnus roederensis*, a vertical shaft armored largely with the shells of bivalve molluscs. Gibert (1996) also described another ichnospecies of *Diopatrichnus*, *D. odlingi* from the Middle Jurassic of Oxfordshire (UK). Ettensohn (1981) described a horizontal tube ornamented with tabular skeletal fragments (described as a biotaxon, but ichnotaxon in fact): its type ichnospecies *C. haneyensis* is characterized by ornamentation of the outer wall with tabular crinoid stem plates. Suhr (1988) summarized the ichnogenus *Lepidenteron*, and divided it to four ichnospecies based on the nature of adhered material: *L. lewesiensis* (composed of remains of fishes), *L. mantelii* (composed of plant detritus), *L. cancellata* (composed of sand or mud grains), and *L. variabilis* (composed of various building structures). Jarzembowski (1995) distinguished among case-shaped trace fossils from fluvial deposits based on the nature of adhered material, describing *Conchindusia rasnitsyni* (composed of conchostracan valves), *Pelindusia percealleni* (composed of bivalve fragments), and *Piscindusia sukachevae* (composed of fish bones). Monaco *et al.* (2005) described the trace fossil *Ereipichnus*, a horizontal tube ornamented with tabular skeletal fragments (mainly orbitolinid foraminifers). Jach *et al.* (2011) also reported *Nummipera eocenica*, which is built of *Discocyclina* and *Nummulities* (larger foraminifera) tests. Hence, the trace fossil described in this study undoubtedly represents a new

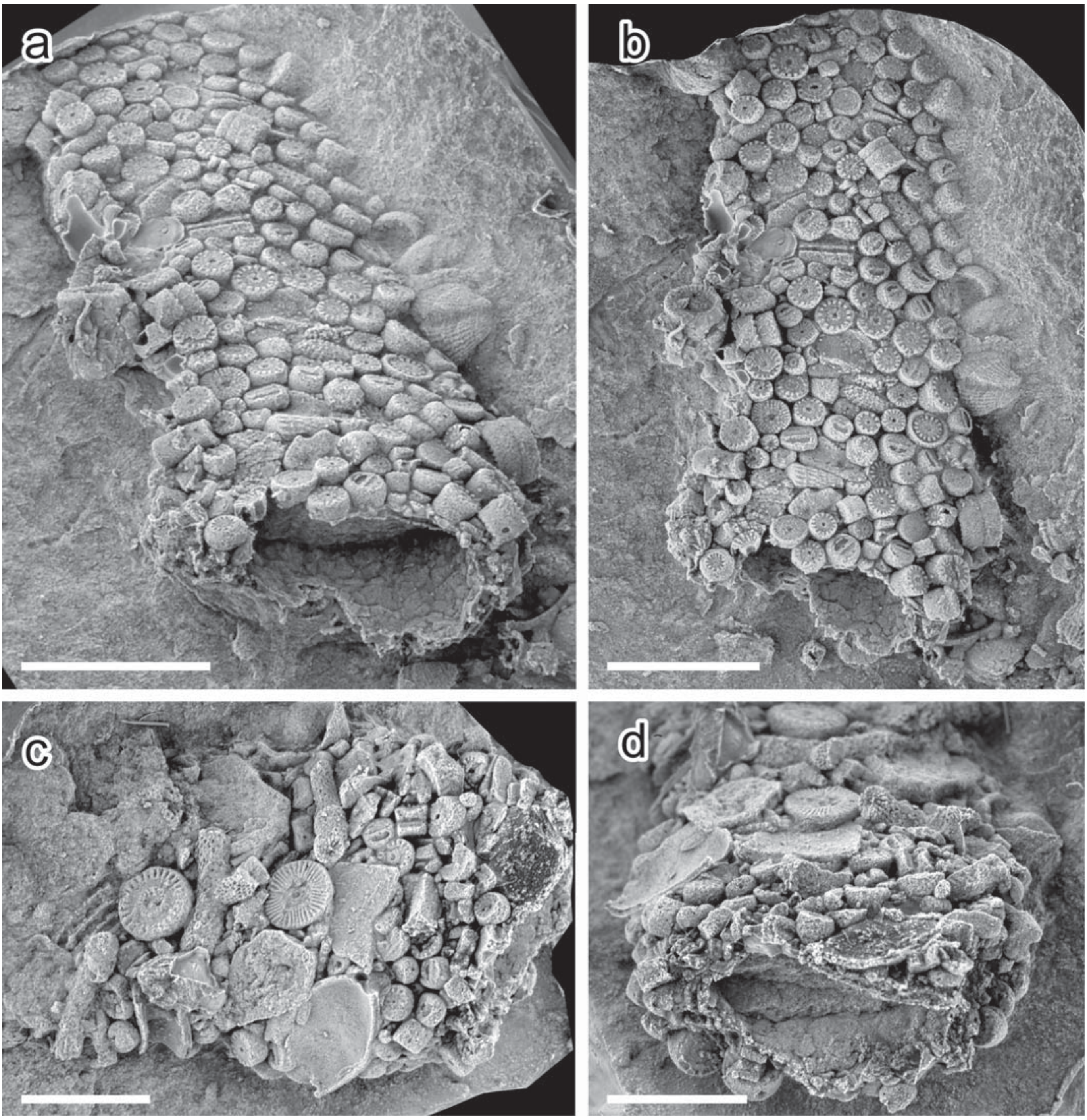

Figure 3. Referred specimens of *Crininicaminus giberti* isp nov. **a)** Oblique view of lower part (tube floor) of the trace fossil *C. giberti* (UMUT-PW30072). The outer wall is ornamented with numerous well-sorted crinoid stem plates, whereas the inner wall is covered with a smooth lining. **b)** Tube base of *C. giberti* (UMUT-PW30072), as viewed from below, showing ornamentation with numerous well-sorted crinoid stem plates. **c)** Tube top of *C. giberti* (UMUT-PW30073), as viewed from above. Note the difference in surface ornamentation between the lower (tube base: Figs 3a-b) and upper (tube top: Figs 3c-d) surfaces. The top (roof) of the tube is covered by various types of relatively large skeletal fragments. **d)** Oblique view of the upper part (tube top) of the trace fossil *C. giberti* (UMUT-PW30073). Scale bar = 10 mm.

ichnospecies of *Crininicaminus*, as the tube is horizontal and ornamented with numerous tabular crinoid stem plates. The new ichnospecies *C. giberti* is distinguishable from *C. haneyensis* by mode of crinoid' stem plate arrangement (vertical to the long axis of the tube).

Geographic and stratigraphical distribution. The type locality consists of a poorly sorted fine-grained sandstone bed within the upper part of the Kamiyasse Formation in the mountainside along the armlet of Shigeji-zawa creek (route Ss 3 in Fig. 2). The bed has been dated to the Upper Midian of the Tethyan stage and to the Middle–Upper Capitanian of the Standard stage (Shiino *et al.*, 2008, 2011; Kobayashi *et al.*, 2009).

Discussion. *Crininicaminus giberti* described herein occurs within fine-grained sandstone layers, thereby demonstrating that the tubular structure is biogenic in origin and autochthonous (i.e., trace fossils are rarely transported from the site of origin).

Stalked crinoids are today restricted to the deep sea, but during the Paleozoic and pre-Cretaceous Mesozoic (i.e., until the Mesozoic Marine Revolution) were important constituents of shallow-water bottom communities (e.g., Vermeij, 1977; Bottjer & Jablonski, 1988; Oji, 1996). Consequently, crinoid stem plates would have been abundant as bioclasts on the seafloor at this time, available for use in tube construction and/or as camouflage material. In fact, the type species of *Crininicaminus*, *C. haneyensis* is also described from the Carboniferous shaly limestone in east-central Kentucky, USA. Hence, it is possible that additional specimens of *Crininicaminus* will be discovered in future studies of shallow-marine deposits of various ages and locations.

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