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Two new species of orthocerid cephalopods from the Carboniferous Panching Limestone, West Malaysia

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Abstract. Two new species of orthocerid cephalopods from the Bashkirian (Late Carboniferous) Panching Limestone in Pahang, West Malaysia are described. They are an orthoceratid *Kionoceras panchingense* and a pseudorthoceratid *Dolorthoceras malaysiense*. The detailed internal structure of *K. panchingense* is documented, this being the first time that the internal structure of a Carboniferous species of *Kionoceras* is revealed. A species which was previously reported as *Hesperoceras* cf. *laudoni* is reexamined, and is revised as *D. malaysiense* sp. nov. It shows the closest affinity with *D. circulare* Miller, 1931 of northern Kashmir. Species of *Kionoceras* and *Dolorthoceras* are recorded in the Carboniferous of Southeast Asia for the first time.

Key words: Bashkirian (Upper Carboniferous), *Dolorthoceras malaysiense* sp. nov., *Kionoceras panchingense* sp. nov., Malaysia, Orthoceratidae, Panching Limestone, Pseudorthoceratidae

Introduction

The Carboniferous Panching Limestone, from which the present orthocerid specimens were recovered, is a 600 m sequence and crops out as a narrow, north-northeast to south-southwest trending zone in Pahang, West Malaysia (Figure 1; Metcalfe *et al*., 1980). It was deposited in a shallow marine environment of the East Malaya Terrane. Among the highly diverse and rich fossil faunas (e.g., Muir-Wood, 1948; Metcalfe *et al*., 1980; Fontaine *et al*., 2003), conodonts provide the most reliable age determination for the limestone. The index conodont *Declinognathodus noduliferus* (Ellison and Graves, 1941) is present in the Panching Limestone (see Igo and Koike, 1968; Metcalfe, 1980); this species' first appearance defines the base of the Bashkirian (lowest Upper Carboniferous), that is, the Mid-Carboniferous Boundary, in the Global Boundary Stratotype Section and Point (GSSP; Lane *et al*., 1999). On the basis of the specimens examined, we propose the two new species, *Kionoceras panchingense* and *Dolorthoceras malaysiense* as the first described cephalopods from the Panching Limestone, and the first Carboniferous representatives of these genera in Southeast Asia.

Systematic paleontology

Order Orthocerida Kuhn, 1940
Superfamily Orthoceratoidea M'Coy, 1844
Family Orthoceratidae M'Coy, 1844
Subfamily Kionoceratinae Hyatt *in* Zittel, 1900
Genus ***Kionoceras*** Hyatt, 1884

Type species.—*Orthoceras doricum* Barrande, 1868.

Kionoceras panchingense sp. nov.

Figure 2

Diagnosis.—Large species of *Kionoceras* with gradual shell expansion and probably circular cross section; longitudinal ridges of surface ornament are weak and numerous, 0.5 to 0.8 mm in their shallowly concave interspace width; siphuncular position is nearly central; septal necks long, 2.0–2.6 mm in length, usually orthochoanitic.

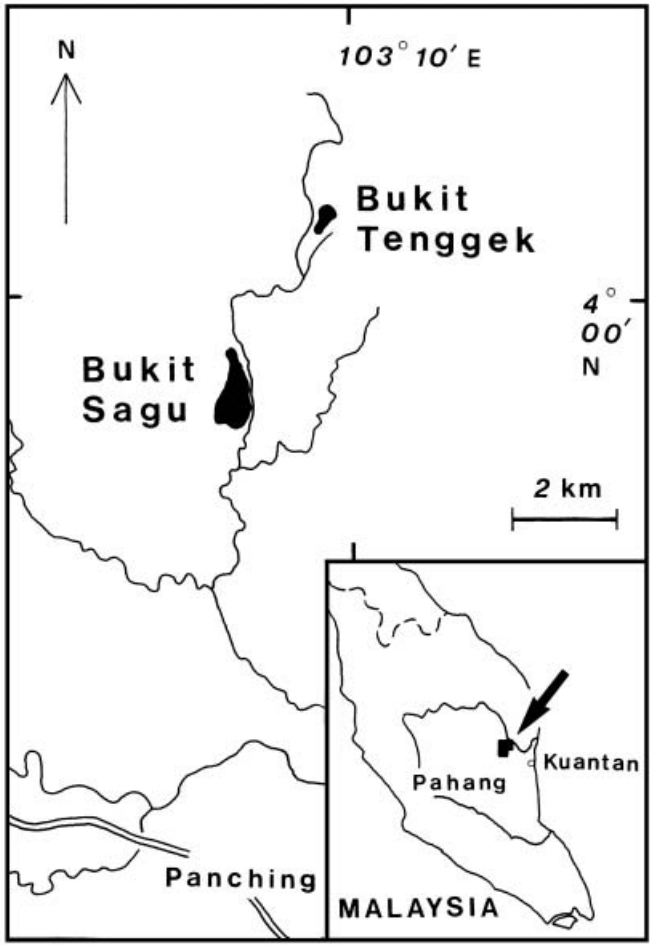

Figure 1. Locality map of the study area in West Malaysia showing limestone hills, Bukit Tenggek and Bukit Sagu, that have yielded orthocerid cephalopods.

Description.—An imperfect and weakly deformed specimen available for study has a large-sized, non-annulated orthoconic phragmocone with gradual shell expansion; approximate angle of shell expansion is 4°; cross section of the available shell is probably circular, reconstructed shell diameter near apical end attains approximately 40 mm. Shell surface ornamented by longitudinal ridges and transverse lirae; longitudinal ridges are weak for *Kionoceras*, numerous and separated by shallowly concave interspaces, that range from 0.5 to 0.8 mm in width; a very weak longitudinal ridge commonly occurs in each interspace; transverse lirae rarely form narrow but relatively deep salients; no hyponomic sinus detected; constriction not developed in internal mold. Sutures straight and transverse; septa relatively deep, slightly thickening towards ventral(?) side, attaining a thickness of 0.8 mm; cameral length moderate for the genus; width/length ratios of camerae are approximately 2.5. Siphuncle nearly central in position, empty; septal necks usually orthochoanitic, but indicate faintly suborthochoanitic appearance in dorsal(?) side, long, 2.0–2.6 mm in length; connecting rings cylindrical with narrow adnation area on dorsal(?) surface of septa; diameters of connecting rings range from 3.0 to 3.1 mm. Cameral deposits absent in preserved portion.

Material examined.—The holotype, UMUT PM29436, is approximately 110 mm in length. Repository of the specimen is in the paleontological collections of the University Museum of the University of Tokyo, Japan.

Occurrence.—The specimen was collected from an isolated limestone hill named Bukit Tenggek, located approximately 30 km north-west of Kuantan. Detailed geologic information concerning this locality is given by Metcalfe *et al.* (1980).

Etymology.—The specific name is derived from the Panching Limestone.

Discussion.—Late Paleozoic records of *Kionoceras* are relatively few. About ten Carboniferous species of the genus have been documented from Western Europe (Fleming, 1828; Haughton, 1859; Koninck, 1880; Foord, 1897; Demanet, 1941; Histon, 1998), the Urals (Shimanskiy, 1968), and North America (Miller and Garner, 1953; Gordon, 1957). Internal structure of these species is essentially unknown, thus direct comparisons with *Kionoceras panchingense* sp. nov. are difficult. However, this new species can be diagnosed by the combination of its external morphology, including gross shell shape, shell size, and character of surface ornamentation.

Superfamily Pseudorthoceratoidea Flower and Caster, 1935
Family Pseudorthoceratidae Flower and Caster, 1935
Subfamily Spyroceratinae Shimizu and Obata, 1935
Genus ***Dolorthoceras*** Miller, 1931

Type species.—*Dolorthoceras circulare* Miller, 1931.

Dolorthoceras malaysiense sp. nov.

Figure 3

Hesperoceras cf. *laudoni* Miller and Youngquist, 1947; Metcalfe *et al*., 1980, pl. 3, figs. 19, 20.

Diagnosis.—Species of *Dolorthoceras* with circular cross section of shell and smooth shell surface; usual camerae relatively short; siphuncle subcentral with siphuncular position ratio (see the description for its determination) of approximately 0.4.

Description.—An imperfect specimen consisting of

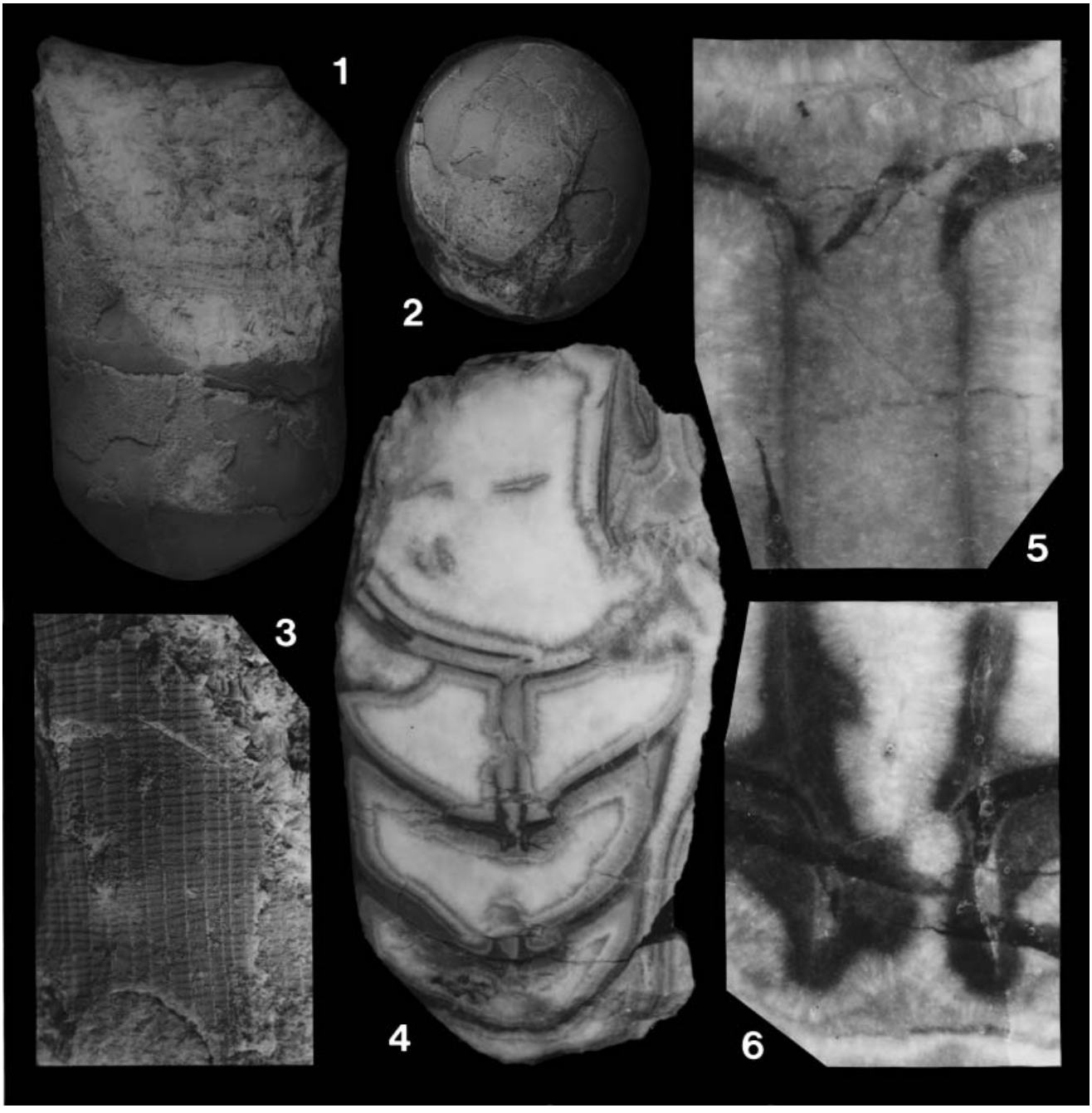

Figure 2. *Kionoceras panchingense* sp. nov., holotype, UMUT PM29436. **1**. Dorsal(?) view, ×1. **2**. Septal view, venter down(?), weakly deformed, ×1. **3**. Partial enlargement to show surface ornamentation, ×5. **4**. Longitudinal polished section, venter on right(?), ×1.2. **5**, **6**. Partial enlargements to show siphuncular structure, ×10.

phragmocone and apical position of body chamber available for study, nonannulated, orthoconic with gradual expansion indicating an approximately 4° angle; cross section is circular, diameter attains 16 mm at body chamber; no apical shell preserved. Shell surface smooth, lacks distinct ornamentation. Sutures straight and faintly oblique, toward apex on dorsum with an approximately 3° angle from rectangular plane to shell axis; septal curvature moderate; usual cameral length relatively short for the genus, indicating 6.2–6.5 in width/length ratio; the last camera very short with width/length ratio of 11.2. Siphuncle subcentral, shifting ventrally in position; siphuncular position ratio (distance of central axis of septal foramen from ventral

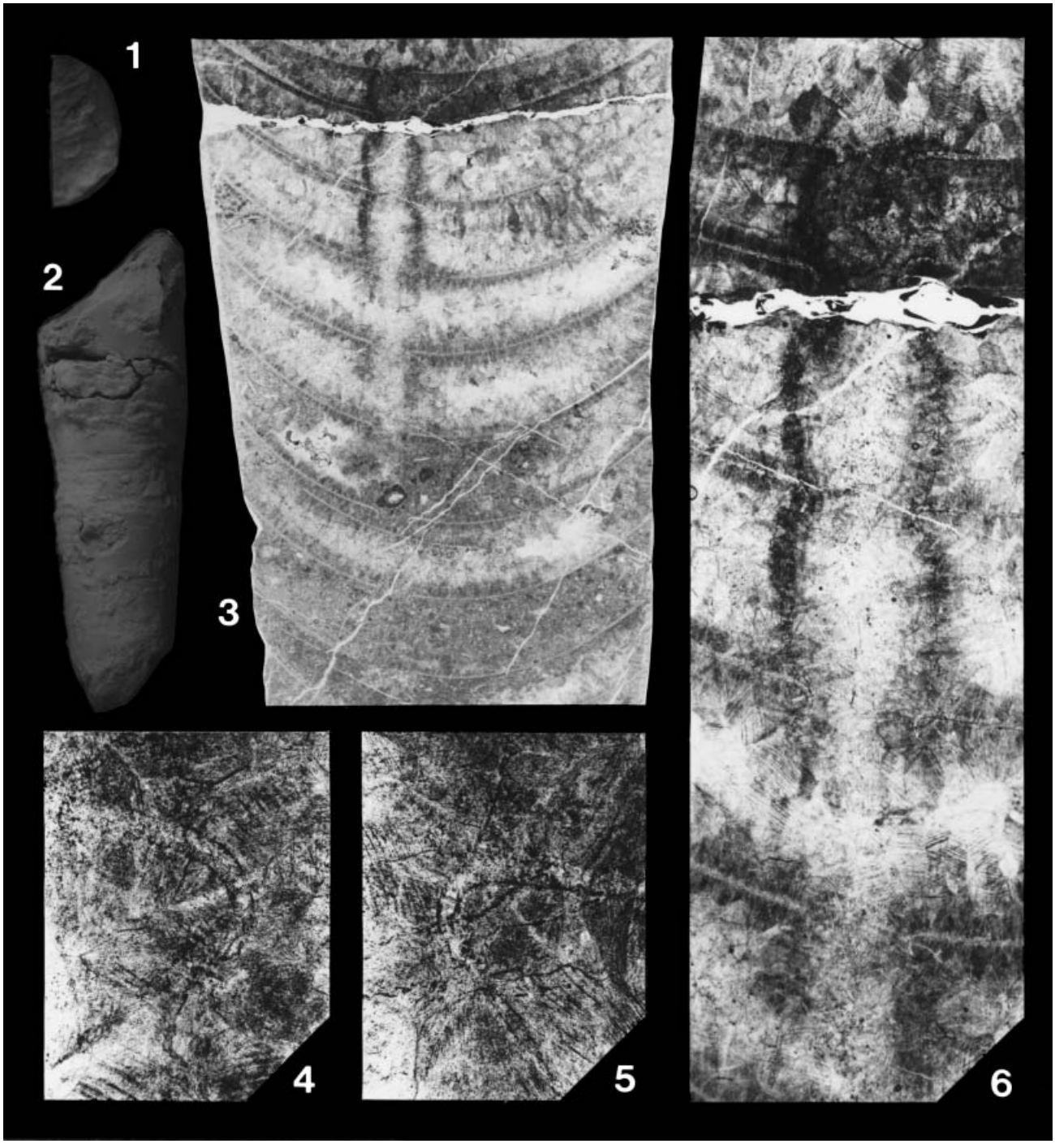

Figure 3. *Dolorthoceras malaysiense* sp. nov., holotype, A420. **1**. Cross sectional view of adoral end, venter down, ×1.5. **2**. Lateral view, venter on right, ×1.5. **3**. Longitudinal thin section, venter on left, ×5. **4**. Partial enlargements to show ventral septal neck, ×50. **5**. Partial enlargements to show dorsal septal neck, ×50. **6**. Partial enlargement to show siphuncular structure; note modifications of the last septum, camera and connecting ring, ×14.

shell per corresponding shell diameter) is approximately 0.4; except for dorsal septal neck of the last septum that has a cyrtochoanitic appearance, septal necks are usually suborthochoanitic; length of septal necks ranges from 0.33 to 0.40 mm; except for the last connecting ring which has a nearly circular profile,

usually they are fusiform with weak inflation; maximum diameter/length ratios of usual siphuncular segments are approximately 0.7; adnation area very narrow on ventral surface of septa and narrow on dorsal counterpart. Cameral deposits not preserved; endosiphuncular deposits not well preserved, but may be parietal.

Material examined.—The holotype, A420, is approximately 53 mm in length. Repository of the specimen is in the Department of Geology, University of Malaya, Kuala Lumpur, Malaysia.

Occurrence.—The specimen was collected from an isolated limestone hill named Bukit Sagu, located approximately 3 km south-southwest of Bukit Tenggek (see the occurrence of the preceding species).

Etymology.—The specific name is derived from Malaysia.

Discussion.—The available specimen was previously examined by Metcalfe *et al*. (1980) as *Hesperoceras* cf. *laudoni*. However, it is here designated as the holotype of *Dolorthoceras malaysiense* sp. nov. We consider it as belonging to *Dolorthoceras* rather than *Hesperoceras* (Miller and Youngquist, 1947), because of the circular shell cross section and the subcentral siphuncular position. *Hesperoceras laudoni* Miller and Youngquist (1947, p. 116, pl. 27, figs. 1–3), the type species of the genus, from the Lower Carboniferous of North America, is characterized by having a shell with a subrectangular cross section and a central siphuncular position, unlike the new species from West Malaysia. In addition, the new species possesses a nonannulated shell with suborthochoanitic septal necks, weakly inflated connecting rings, and very narrow to narrow adnation area. This justifies its generic assignment to *Dolorthoceras*.

Dolorthoceras malaysiense sp. nov. shows the closest affinity with *D. circulare* Miller (1931, p. 420–422, figs. 1, 2) from the Upper Carboniferous of northern Kashmir, Central Asia. However, the new species has a less eccentric siphuncle, that is, the siphuncular position ratio is approximately 0.4 in *D. malaysiense*, whereas it is approximately 0.3 in *D. circulare*.

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