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Gondwanan nautiloid cephalopods from the Ordovician of Myanmar

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Abstract. Two species of Darriwilian (late Middle Ordovician) nautiloid cephalopods are described from the Wunbye Formation and its equivalent strata in the Shan Plateau of Myanmar (Sibumasu Block). They are the orthocerid *Sibumasuoceras langkawiense* (Kobayashi) and the discosorid *Tasmanoceras* sp. First, *Sibumasuoceras* is proposed for a new genus of the cayutoceratin pseudorthoceratids. *Sibumasuoceras langkawiense* [originally *Ormoceras langkawiense*, the type species of the genus] was previously assigned either to the Actinocerida or the Discosorida. However, the present investigations reveal that it possesses thin connecting rings and differentiated endosiphuncular deposits and lacks a detailed endosiphuncular canal system, all suggestive of a relationship to the Orthocerida. *Sibumasuoceras* is known to occur so far from Malaysia and Myanmar of the Sibumasu Block, which was part of northern Gondwana during the early Palaeozoic. Second, the rare genus *Tasmanoceras,* which was previously known only in Tasmania, is confirmed in Southeast Asia for the first time; this implies an Ordovician marine biotic linkage between Sibumasu and Tasmania over northern Gondwana.

Key words: Darriwilian (Middle Ordovician), northern Gondwana, Sibumasu Block, *Sibumasuoceras* gen. nov., *Tasmanoceras*

Introduction

As the second installment of our series of taxonomic works concerning the Ordovician cephalopods of the Sibumasu Block in Southeast Asia, the present study describes one new genus and two species of the subclass Nautiloidea from Myanmar, namely, *Sibumasuoceras langkawiense* (Kobayashi, 1959) and *Tasmanoceras* sp. This is on the basis of the specimens kept in the Geology Museum, Department of Geology, Dagon University in Yangon, Myanmar with the abbreviation of DUGM. The examined nautiloids occur in the Darriwilian (upper Middle Ordovician) limestones of the Wunbye Formation and its equivalent strata of the Pindaya Group (Thein, 1973; Aye Ko Aung, 2012) in the western part of the Shan Plateau, the detailed geologic settings of which sample areas are referable in our preceding paper (Niko and Sone, 2014).

Systematic paleontology

Subclass Nautiloidea Agassiz, 1847
Order Orthocerida Kuhn, 1940
Superfamily Pseudorthoceratoidea Flower and Caster, 1935
Family Pseudorthoceratidae Flower and Caster, 1935
Subfamily Cayutoceratinae Flower, 1939

Genus ***Sibumasuoceras*** gen. nov.

Type species.—*Ormoceras langkawiense* Kobayashi, 1959.

Diagnosis.—Longiconic orthocones with gradual conch expansion and circular cross sections; sutures essentially straight; camerae very short; siphuncle central to slightly eccentric, consists of cyrtochoanitic septal necks and undifferentiated connecting rings, the latter of which are thin and broadly expanded; ratio of maximum diameter per length in siphuncular segments reaches 2.3; cameral deposits well developed; annulosiphonate

deposits differentiated into inner transparent layer and outer darker one; inner layer fuses to form continuous lining in apical shell.

Etymology.—The generic name is derived from the Sibumasu Block.

Discussion.—The thin connecting rings and the differentiated endosiphuncular deposits of *Sibumasuoceras* gen. nov. warrant its subfamilial taxonomic placement to the Cayutoceratinae belonging to the Order Orthocerida.

Among members of cayutoceratines, *Sibumasuoceras* resembles more or less *Dnestroceras* Zhuravleva (1961; type species, *D. incertum* Zhuravleva, 1961, p. 57, pl. 6, figs. 5a, b, v from the upper Silurian of Podolia, Ukraine), *Eostromatoceras* Chen (1976; type species, *E. meditubulum* Chen, 1976, p. 68, pl. 3, fig. 5 from the Middle Ordovician of Shangdong, Northeast China), *Metastromatoceras* Zhuravleva (1957; type species, *M. formosum* Zhuravleva, 1957, p. 679, fig. 1 from the lower Silurian of Tunguska, Northeast Russia), and *Xorkoloceras* Lai and Wang (1986; type species, *X. xinjiangense* Lai and Wang, 1986, p. 253, pl. 2, figs. 11a, b, text-fig. 4 from the Lower Ordovician of Xinjiang, Northwest China). However, its morphologic combination of a nearly central siphuncular position, the broadly expanded connecting rings with values of up to 2.3 in the ratio of maximum diameter per length in the siphuncular segments and the well developed cameral deposits can separate *Sibumasuoceras* from these previously known genera.

Armenocerina Chen *in* Chen *et al*. (1981; type species, *A. guizhouensis* Chen *in* Chen *et al*., 1981, p. 56, pl. 22, figs. 8, 11, text-fig. 10 from the lower Silurian of Guizhou, Southwest China) is comparable with *Sibumasuoceras* in having broadly expanded connecting rings. However, the siphuncle of *Armenocerina* is exceptionally large for the Orthocerida and occupies approximately 1/3 of the corresponding conch diameter, unlike the new genus.

Sibumasuoceras is known to occur from the Langkawi Islands and Perlis, Malaysia and the Shan Plateau of Myanmar. These areas belong to the Sibumasu Block, and were located in northern Gondwana during the early Palaeozoic.

Sibumasuoceras langkawiense (Kobayashi, 1959)

Figure 1

Stereoplasmoceras (?) sp. indet., Kobayashi, 1958, p. 227.

Ormoceras langkawiense Kobayashi, 1959, p. 401, pl. 27, figs. 3a, b, 4a, b [not 5a, b].

Pseudowutinoceratidae n. g. *langkawiense* (Kobayashi, 1959), Stait *et al*., 1987, p. 387–389, figs. 7.1–7.3.

Nautiloid, Aye Ko Aung, 2012, fig. 4 [the leftmost specimen of three presented as "Nautiloids (Early Middle Ordovician)"].

Diagnosis.—As for the genus.

Description.—Longiconic orthocones indicate gradual conch expansion and smooth surface; cross sections of conch are circular; the largest specimen of a fragmentary phragmocone (DUGM 3106) attains approximately 43 mm in diameter. Sutures are essentially straight; septal curvatures gentle in apical and moderate in adoral shells; camerae are very short in length having cameral form ratios (maximum width in dorsoventral section per length) of 7.9–12.0; siphuncle is central to slightly eccentric in position; ratios of siphuncular diameter per corresponding conch dorsoventral diameter are approximately 0.2; siphuncular wall consists of cyrtochoanitic septal necks and undifferentiated connecting rings; length of necks 0.39–0.42 mm; width of septal brims 0.31–0.46 mm; width of adnation area nearly equal to slightly wider than brims; connecting rings are thin, 0.03–0.04 mm in thickness and broadly expanded; ratio of maximum diameter per length of siphuncular segments 1.4–1.6 in apical and 2.0–2.3 in adoral shells. Cameral deposits are well developed and consist of episeptal-mural and hyposeptal deposits; annulosiphonate deposits are also well developed in endosiphuncle, and differentiated into inner transparent layer and outer darker one; inner layer fuses to form continuous lining in apical shell, where endosiphuncular deposits make a central canal.

Material.—DUGM 3103, 3105–3107. In addition, the type series of *Ormoceras langkawiense* Kobayashi, 1959 (the holotype, UMUT PM2344, and the two paratypes, UMUT PM2345, 2346) from Malaysia were also examined; the type specimens are housed in the University Museum of the University of Tokyo, Japan.

Occurrence.—Wunbye Hill (DUGM 3103) about 70 km northwest of Taunggyi city, Shan State, and near the village of Tha Yauk Myaung (DUGM 3105–3107) approximately 18 km south of Pyin U Lwin city, Mandalay Division, in the western part of the Shan Plateau, Myanmar.

The type specimens of this species were collected from the Whiterockian (=uppermost Dapingian to lower Darriwilian, Middle Ordovician) strata of the Lower Setul Limestone at Tanjung Dendan Island (UMUT PM2344), one of the Langkawi Islands, and in Perlis (UMUT PM2345, 2346), northwestern Peninsular Malaysia (Kobayashi, 1958, 1959; Jones, 1981; Stait *et al*., 1987).

Discussion.—In the four specimens available from Myanmar, thin sections were prepared from the best preserved specimen, DUGM 3107 (Figure 1.4, 1.6), whose approximate conch diameter is 27 mm. Thus, observations of the connecting ring structure and measurements of septal necks, septal brims, adnation area and connecting rings in the above description are based on this specimen.

Kobayashi (1958) assigned two poorly preserved specimens of this species from Perlis questionably to the

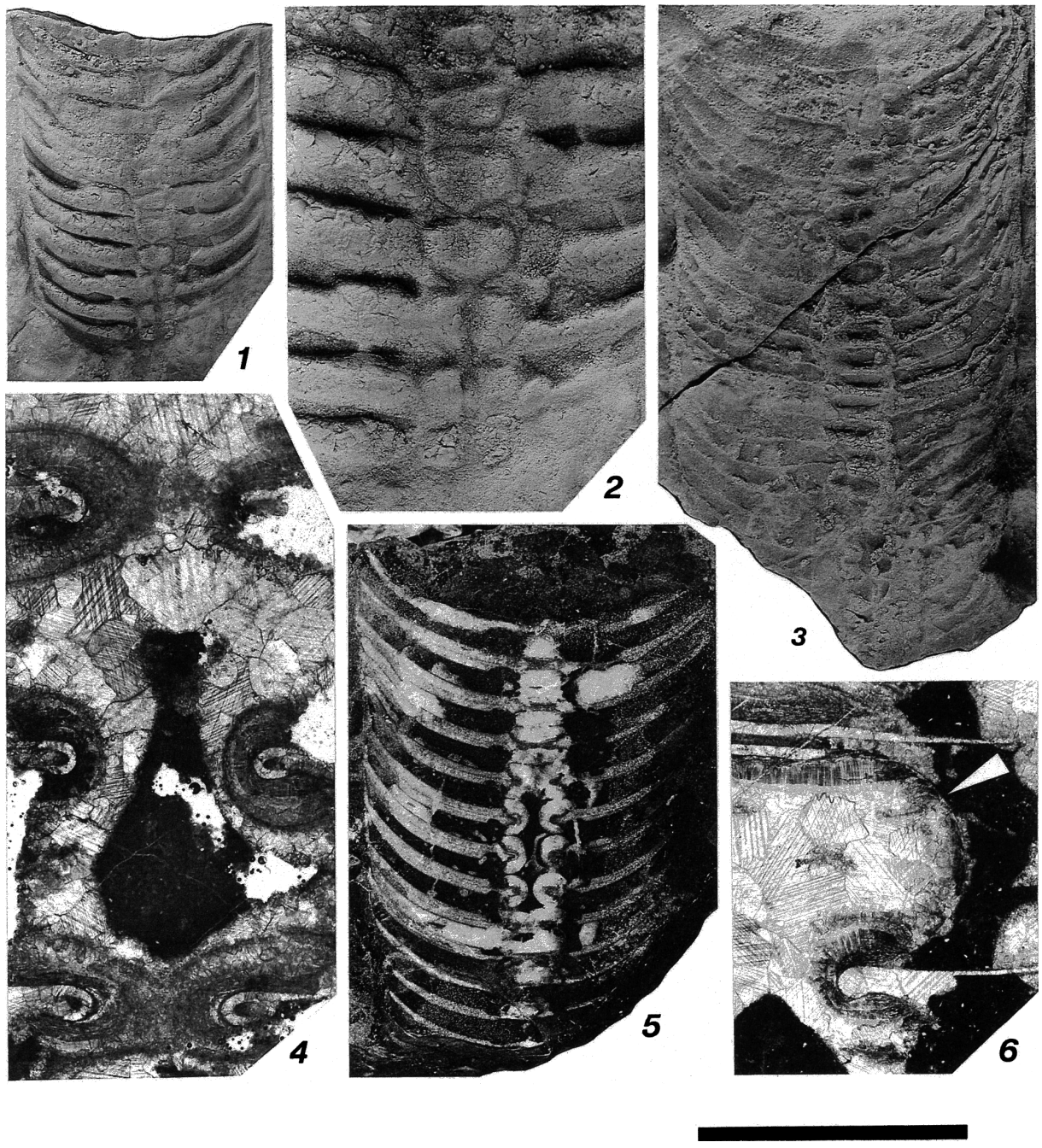

Figure 1. *Sibumasuoceras langkawiense* (Kobayashi, 1959). **1, 2,** DUGM3105; 1, longitudinal section, weathered surface; 2, partial enlargement of Figure 1.1 to show details of siphuncle; **3,** DUGM3106, longitudinal section, weathered surface; **4, 6,** DUGM3107, longitudinal thin sections; 4, partial enlargement to show details of septal necks and endosiphuncular deposits; 6, partial enlargement to show details of connecting ring (arrow); **5,** DUGM3103, longitudinal polished section. Scale bar is 22.5 mm in Figure 1.1; 9 mm in Figure 1.2; 30 mm in Figure 1.3, 1.5; 3.2 mm in Figure 1.4, 1.6.

orthocerid genus *Stereoplasmoceras*. Subsequently he altered this assignment, placing it in the actinocerid genus *Ormoceras*, and erected *O. langkawiense* Kobayashi, 1959 on the basis of newly obtained material from the Langkawi Islands. Our investigations of Kobayashi's Malaysian type series and the new Myanmar specimens clarify that both collections belong to the same species, which lacks diagnostic characters for the

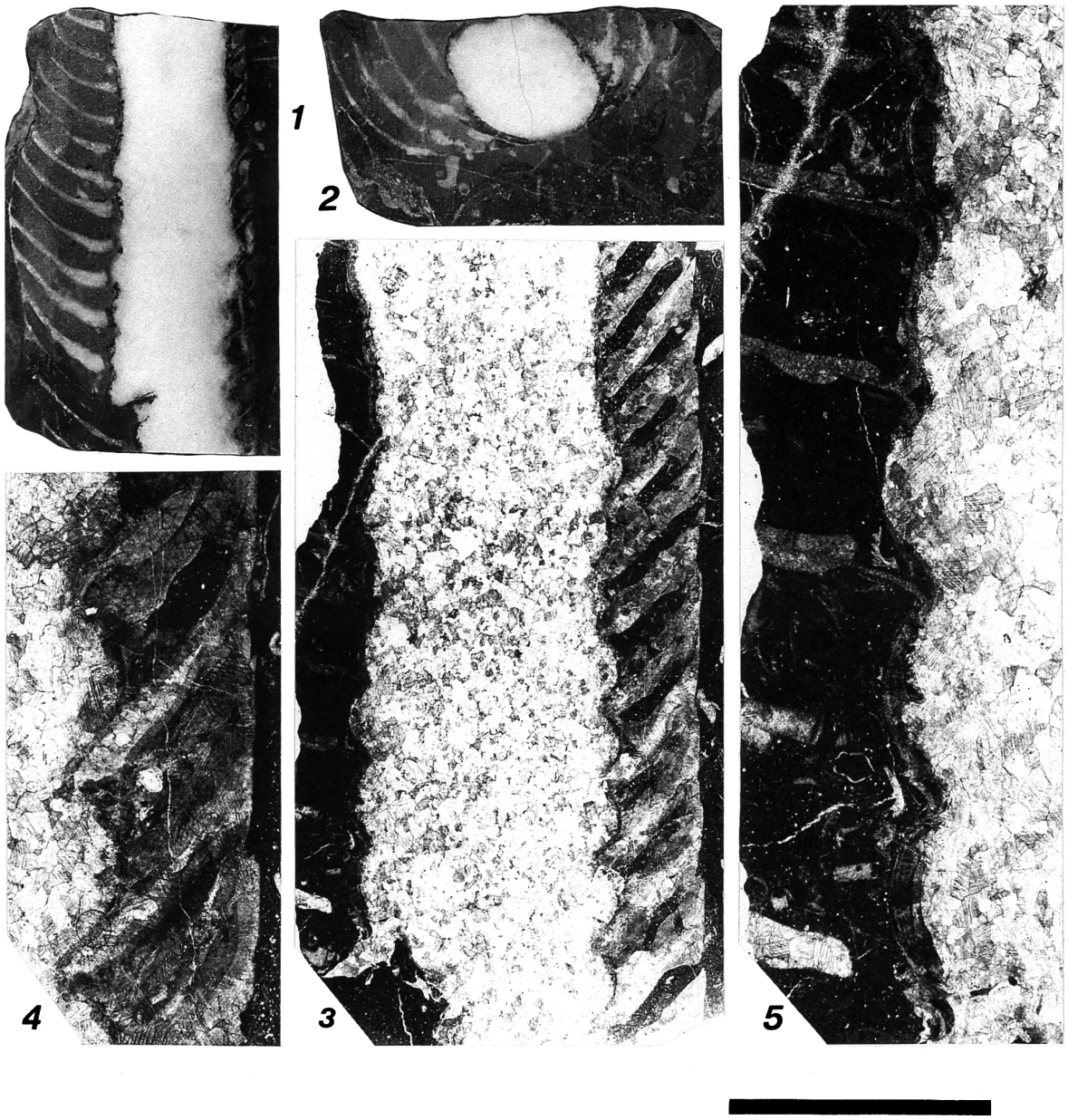

Figure 2. *Tasmanoceras* sp., DUGM3110. **1,** dorsoventral polished section, venter on right; **2,** cross polished section of adoral end, venter down; **3,** dorsoventral thin section, venter on right; **4,** partial enlargement to show details of ventral siphuncular wall and cameral deposits; **5,** partial enlargement of Figure 2.3 to show details of dorsal siphuncular wall. Scale bar is 20 mm in Figure 2.1, 2.2; 10 mm in Figure 2.3; 4 mm in Figure 2.4, 2.5.

Actinocerida, such as a detailed endosiphuncular canal system and perispatial deposits.

Except for the structure of the connecting rings, the gross siphuncular shape of *Sibumasuoceras langkawiense* closely resembles those of some Ordovician discosorids found in mainland Australia and the island of Tasmania. These species are *Hecatoceras longinquum* Teichert and Glenister (1952, p. 740, 741, pl. 104, fig. 10, pl. 105, fig. 7; 1953, pl. 225–228, pl. 6, fig. 11, text-fig. 3B; also in Stait, 1980, p. 1116, pl. 1, figs. 1–8), *H. obliquum* Teichert and Glenister (1953, p. 228, 229, pl. 6, figs. 5–10, text-fig. 3A) and *Madiganella magna* Teichert and Glenister (1952, p. 744, pl. 105, figs. 1, 2). Stait *et al.* (1987) previously assigned the current species to the family Pseudowutinoceratidae Chen *in* Chen and Zou, 1984, and placed the family in the order Discosorida. This view is

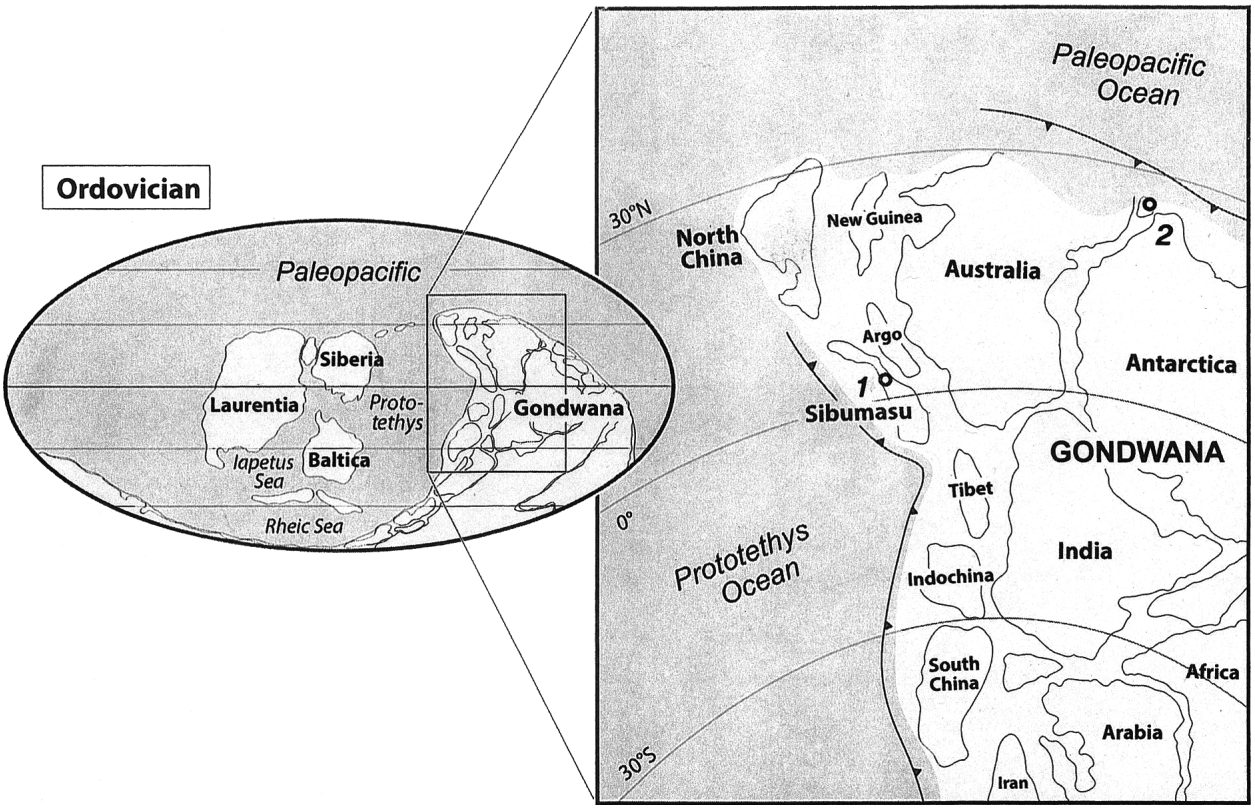

Figure 3. Distribution of *Tasmanoceras* plotted on an Arenigian (= Floian to Dapingian; late Early to early Middle Ordovician) paleogeographic reconstruction map (base map modified from Scotese and McKerrow, 1991). Abbreviations: *1*, Myanmar; *2*, Tasmania. Occurrence of *Tasmanoceras* in Tasmania is based on Teichert and Glenister (1952) and Stait (1984).

indeed difficult to understand. Pseudowutinoceratidae was originally and reasonably proposed as an orthocerid family, not discosorid. Diagnostic features of the Pseudowutinoceratidae are an annulated orthocone, submarginal siphuncular position and laminated endosiphuncular deposits; therefore, it is unlikely to include *S. langkawiense*. Stait *et al*. (1987)'s ordinal and familial classification of the current species must have been in error. Their inexplicable assignment might be due to overestimating superficial similarities of the above-mentioned Australian discosorid species to *S. langkawiense*.

Order Discosorida Flower *in* Flower and Kummel, 1950
Family Gouldoceratidae Stait, 1984

Genus ***Tasmanoceras*** Teichert and Glenister, 1952

Type species.—*Tasmanoceras zeehanense* Teichert and Glenister, 1952.

Discussion.—When Teichert and Glenister (1952) erected *Tasmanoceras*, they assigned the genus to the family Endoceratidae under the order Endocerida. Morphologic affinities of *Tasmanoceras* with genera of the endocerid family Narthecoceratidae were subsequently suggested by Flower (1968). Although these discussions were based only on isolated endocones, Stait (1984) clarified the siphuncular wall structure of *Tasmanoceras* for the first time and placed it in the newly erected family Gouldoceratidae under the order Discosorida. The preservation of the Myanmar material is inadequate and no reliable information is gained to add to discussions of the taxonomic placement, thus the latest view of Stait (1984) is followed herein.

Tasmanoceras sp.

Figure 2

Description.—A fragmentary and slightly deformed phragmocone is available for study; it is a longiconic orthocone approximately 34 mm in length and 27 mm in lateral diameter. Septa deeply concaved and form short camerae; siphuncle subventral in position, large with dorsoventrally depressed cross section, whose lateral diameter is 12 mm at adoral end; siphuncular wall structure is

not well preserved, but it may consist of hemichoanitic septal necks and thickened connecting rings; siphuncular segments weakly inflated. Cameral deposits well developed; endosiphuncular deposits are not preserved due to recrystallization.

Material.—DUGM 3110.

Occurrence.—Near the village of Tha Yauk Myaung in the Mandalay-Pyin U Lwin area, Mandalay Division, Myanmar.

Discussion.—Two established species of *Tasmanoceras* are known, namely, *T. zeehanense* Teichert and Glenister, 1952 (p. 739, 740, pl. 104, figs 3–9) and *T. pagei* Stait, 1984 (p. 202, 205, figs. 18A–E, 19), both from the Middle Ordovician of Tasmania. The Myanmar form, *Tasmanoceras* sp., can be separated from the Tasmanian species in having well developed cameral deposits. The present specimen probably belongs to a new species, but due to its inadequate preservation the specific identification is left open. This occurrence from Myanmar marks the first record of this rare genus outside Tasmania, and implies a marine biotic linkage between Sibumasu and Tasmania over northern Gondwana in Middle Ordovician time (Figure 3).

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