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Early labechiid stromatoporoids of the Yeongheung Formation (Middle Ordovician), Yeongwol Group, mideastern Korean Peninsula: Part II. Systematic paleontology and paleogeographic implications

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ABSTRACT: Three species belonging to two genera of labechiid stromatoporoids are described from the Yeongheung Formation (Darriwilian, Middle Ordovician), Yeongwol Group of the Taebaeksan Basin, mid-eastern Korean Peninsula. Sixteen stromatoporoid-bearing stratigraphic intervals have been recognized in the Namgyo section. All stromatoporoids occur in the peloidal and bioclastic packstone to grainstone facies. *Labechia yeongwolense* sp. nov. is the dominant species, occurring throughout the lower and middle parts of the section. In contrast, *Labechiella mingshankouensis* is restricted to the lower-middle part and *Labechiella regularis* occurs mostly in the upper part of the section. The occurrence of the early labechiids in the Yeongwol Group is suggestive of a close biogeographic affinity with the Liaoning and Shandong provinces of northeastern China.

Key words: stromatoporoid, *Labechiella*, *Labechia*, Middle Ordovician, Yeongheung Formation, North China Block

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1. INTRODUCTION

This paper is the second part of an investigation of the early labechiid stromatoporoids in the Yeongheung Formation in the mideastern Korean Peninsula (Park et al., 2017). It focuses mainly on the systematic description of the stromatoporoids and their paleogeographic implications. Stromatoporoids are a group of extinct invertebrates consisting of a massive calcareous skeleton with a variety of structural elements (Stearn et al., 1999). They have a certain resemblance to some tabulate corals and were previously regarded as the hydrozoan cnidarians, but are now generally placed in the Phylum Porifera, mainly because of the similarities in their skeletal growth pattern and astrorhizal canal system to those of sclerosponges (Boardman et al., 1987). Stromatoporoids generally inhabited warm, shallow carbonate platforms and shelves with good circulation in low paleolatitudes during the Paleozoic (Kershaw, 1998, 2015; Kershaw and Brunton, 1999; Webby, 2015a; Webby and Kershaw, 2015) and Mesozoic (Leinfelder et al., 2005). They were especially abundant in the Siluro-Devonian and often built reefs as a primary constructor associated with corals (Copper, 2002; James and Wood, 2010).

East Asia, including the Korean Peninsula and Northeast China, is one of a few main areas worldwide where the labechiids, the first 'indisputable' stromatoporoids, are recorded in upper Middle Ordovician (middle to upper Darriwilian) successions (Webby, 2004, 2015a; Stock et al., 2015). The stromatoporoids of the region have been the subject of research since the early studies nearly a century ago (Yabe and Sugiyama, 1930; Ozaki, 1938; Sugiyama, 1941); a few subsequent studies examined stromatoporoid species in Anhui, southeastern China (Dong, 1982) and the Korean Peninsula (Lee and Yu, 1993; Kano et al., 1994; Kano and Lee, 1997).

The stromatoporoids in the Korean Peninsula documented to date include *Labechiella variabilis* (Yabe and Sugiyama, 1930), *Lblla. regularis* (Yabe and Sugiyama, 1930), *Labechia coreanica* (Yabe and Sugiyama, 1930), and *Lblla. ohsei* (Sugiyama, 1941) in the Middle Ordovician Mandal Series of the Pyeongnam Basin, and *Lblla. regularis* in the upper Middle Ordovician

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Yeongheung Formation of the Yeongwol Group, Taebaeksan Basin (Lee and Yu, 1993; Kano et al., 1994; Kano and Lee, 1997). The presence of another labechiid, *Cystostroma*, has recently been recognized in the Duwibong Formation (upper Middle Ordovician) of the Taebaek Group, Taebaeksan Basin (Oh et al., 2015).

This study complements the previous work by Lee and Yu (1993) and Kano et al. (1994) on the stromatoporoids in the Yeongheung Formation. In this paper, we re-evaluate the previous reports of *Lblla. regularis* and describe two additional species, *Lblla. mingshankouensis* (Ozaki, 1938) and *Lb. yeongwolense* sp. nov., from the formation. The findings will enhance our understanding of the origin, dispersal, and paleogeography of early stromatoporoids in East Asia.

2. GEOLOGICAL SETTING AND MATERIALS

The lower Paleozoic sedimentary rocks of the Korean Peninsula crop out in the Taebaeksan and Pyeongnam basins, which are located in the southeastern and northcentral parts of the Peninsula, respectively (Choi and Chough, 2005; Chough, 2013; Fig. 1a). The Taebaeksan Basin contains mixed clastic-carbonate deposits of the Joseon Supergroup, which is subdivided into the Taebaek, Yeongwol, Yongtan, Pyeongchang, and Mungyeong groups, based mainly on their geographic distributions and lithology (Choi, 1998; Choi and Chough, 2005; Chough, 2013). The Taebaeksan Basin has traditionally been regarded as an extension of the North China Block supported by paleontological and sedimentary studies (Chough, 2013). Ordovician trilobites and stromatoporoids from the Yeongwol Group implies that the group belongs to same biogeographic province with the North China Block (Kano et al., 1994; Choi et al., 2001).

The Yeongheung Formation is the topmost lithostratigraphic unit of the Yeongwol Group. The formation overlies the Mungok Formation and is unconformably overlain by the Upper Paleozoic Pyeongan Supergroup (Choi, 1998; Choi and Chough, 2005). It consists of lime mudstone to wackestone, peloidal and bioclastic packstone to grainstone, laminated dolomitic lime mudstone, and algal laminite (Park et al., 2017). Based on the occurrence of the trilobite *Basiliella*, actinoceratoid cephalopods (Kobayashi, 1966), and conodonts (Lee, 1979), the formation has been estimated to be middle to late Darriwilian in age. All stromatoporoids in the Yeongheung Formation occur in packstone to grainstone facies (Fig. 2), with mollusks, crinoid ossicles, brachiopods, siliceous sponge spicules, ostracods, trilobites, bryozoans (*Dianulites* sp.), and *Ortonella*-like calcimicrobes, which are indicative of deposition under moderate to high energy, well-oxygenated open marine conditions (Park et al., 2017).

Most specimens described and illustrated in this study were collected from the Namgyo section, in which 16 stromatoporoid-bearing units (S1 to S16) are recognized (Figs. 1b and 2). Most stromatoporoids in the studied interval are not distinctly identified in the field except for *Lblla. regularis* mostly occurring in the upper part of the interval (e.g., S14~S16), with domical external morphology and a massive or irregular growth pattern. Other stromatoporoid species, *Lblla. mingshankouensis* and *Lb. yeongwolense* sp. nov. with laminar growth forms are present throughout the lower to middle parts of the section. A few

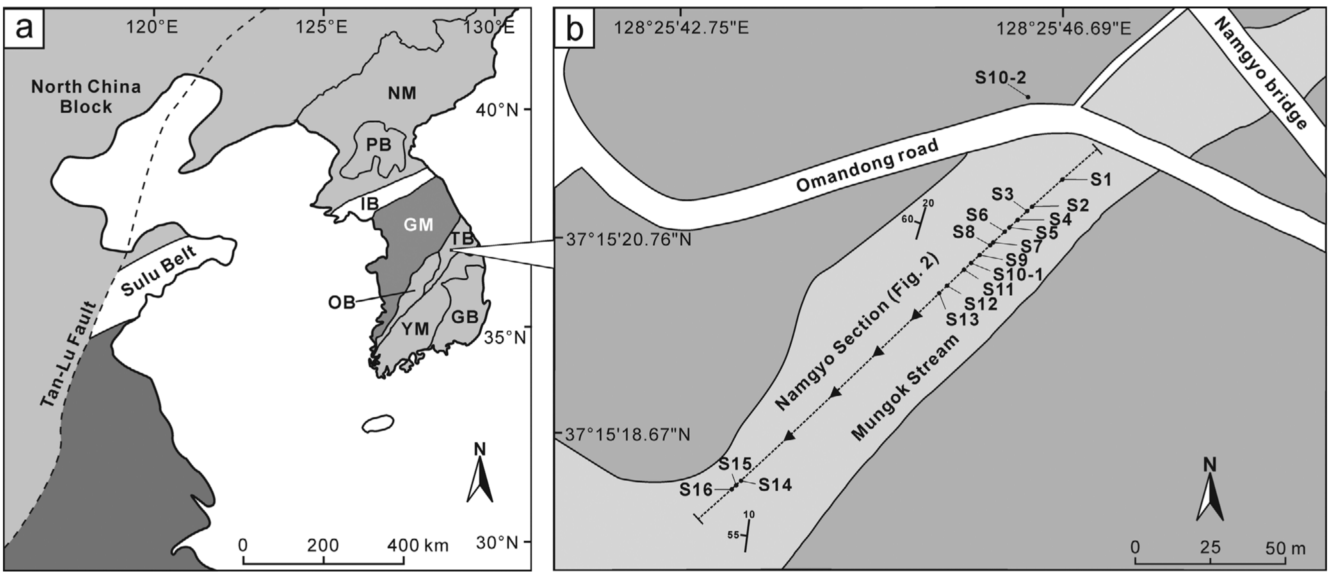

Fig. 1. (a) Simplified tectonic map of East Asia and the study area in mid-eastern Korea (black dot), modified after Chough (2013). (b) Sample locations in the Namgyo section, Yeongwol. NM = Nangrim Massif, PB = Pyeongnam Basin, IB = Imjingang Belt, GM = Gyeonggi Massif, TB = Taebaeksan Basin, OB = Okcheon Basin, YM = Yeongnam Massif, GB = Gyeongsang Basin.

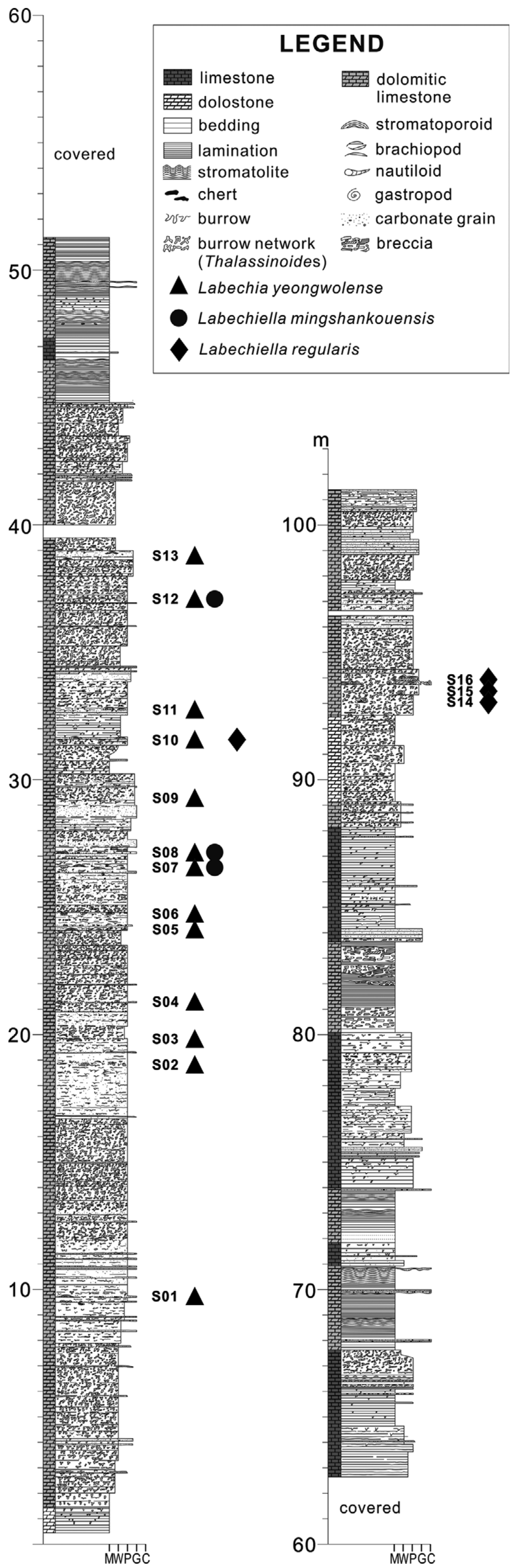

Fig. 2. Sedimentary log of the Namgyo section with stromatoporoid-bearing horizons (S1 to S16). M = lime mudstone, W = wackestone, P = packstone, G = grainstone, C = conglomerate.

specimens obtained from the same section in the course of previous studies (Lee and Yu, 1993; Kano et al., 1994) are also included, though those specimens are not used in figures. Materials from localities 1 and 2 of Lee and Yu (1993) and Kano et al. (1994) are correlated with present stromatoporoid-bearing units S10-2 and S16. Polished slabs and more than 120 large-format thin sections were prepared for the measurements and descriptions of the internal morphology of stromatoporoids. Suprageneric assignments and terminology of the internal and external morphology of stromatoporoids follow those of Webby (2015b, 2015c). Type and figured specimens are deposited in the Geological Collections, Natural Heritage Center (NHCG) of the Cultural Heritage Administration in Daejeon, Korea.

3. IMPLICATIONS OF THE NORTH CHINA LABECHIIDS FOR EARLY DISPERSAL OF STROMATOPOROIDS

The record of early stromatoporoids is not fully understood. The sudden emergence of labechiid stromatoporoids during the late Middle Ordovician coincided with ongoing major biodiversification during that time (Webby, 2004, 2015a; Stearn, 2015). Although their origin is still unclear, it has been suggested that a simple, non-calcifying sponge acquired the ability to secrete a mineralized skeleton more or less simultaneously with the major diversification event (Nestor and Webby, 2013). The present study and a recent report of *Cystostroma* from the Duwibong Formation, Taebaek Group (Oh et al., 2015) conform to the recent conclusion of Nestor and Webby (2013) that both the North China Block and Laurentia were the centers of diversification of the earliest labechiids.

Of the five early labechiid stromatoporoid families, the distribution of Rosenellidae and Labechiidae clearly demonstrates that their near-simultaneous initiation centered on the Korean Peninsula and North China, and eastern North America (Table 1). In the Rosenellidae, *Pseudostylodictyon* was one of the first cosmopolitan genera, being concurrently recorded in the Darriwilian of the North China Block, Laurentia, Baltica, and Kazakhstan. *Cystostroma* was also present during the Darriwilian in both the eastern part of the North China Block and Laurentia, and later, during the Sandbian, in Baltica, Australia, and Siberia. After the first occurrence of *Rosenella* in the Darriwilian of the North China Block and Malaysia, the genus later appeared in Australia, Laurentia, and Siberia during the Sandbian and Katian. *Priscastroma* was the only Darriwilian form endemic to Siberia.

Similar to the Rosenellidae, the Labechiidae, *Labechia* was present in the Darriwilian of Yeongwol (Lee and Yu, 1993; Kano et al., 1994) and Pyongyang (Yabe and Sugiyama, 1930) of the Korean Peninsula, the eastern North China Block (Yabe

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Table 1. Paleogeographic distribution of 12 genera of labechiid stromatoporoids in the Middle Ordovician (Darriwilian), with the number of species recognized from each region

Family	Genus	NCB	Malaysia	Laurentia	Baltica	Siberia	Kazakhstan	Distribution	Remarks
Rosenellidae	*Pseudostylodictyon*	1		1	2		2	Common genus in several regions during the Darriwilian	Most widespread cosmopolitan labechiid in the Darriwilian
	Cystostroma	1	1	4				Common genus in both the NCB and Laurentia during the Darriwilian	Oh et al. (2015) extended the Darriwilian occurrence to the NCB
	Rosenella	2	1					First appeared in peri-Gondwana during the Darriwilian, subsequently in other regions	
	Priscastroma					1		Limited to the Darriwilian of Siberia	
Labechiidae	*Labechia*	5		4				Common genus in both the NCB and Laurentia during the Darriwilian	Second most widespread labechiid in the Darriwilian after *Pseudostylodictyon*
	Labechiella	4	1					First appeared in the NCB during the Darriwilian, subsequently in other regions	
Stylostromatidae	*Pachystylostroma*			5				First appeared in Laurentia during the Darriwilian, subsequently in other regions	Likely to have originated from Laurentia
Aulaceratidae	*Aulacera*	2						First appeared in the NCB during the Darriwilian, subsequently in other regions	The Aulaceratidae are likely to have a NCB origin
	Ludictyon	1						Originated in the NCB, limited to peri-Gondwana (Mongolia and South China Block)	
	Thamnobeatricea	3						Originated in the NCB, limited to peri-Gondwana (Mongolia and South China Platform)	
	Sinodictyon	1						Limited to the Darriwilian of the NCB	
Lophiostromatidae	*Lophiostroma*	2						Limited to the Darriwilian of the NCB	

Based on Galloway and St. Jean (1961), Kapp and Stearn (1975), Webby et al. (1985), Bogoyavlenskaya and Lobanov (1990), Dong (2001), Nestor and Webby (2013), Stock et al. (2015), and this study.
NCB = North China Block.

and Sugiyama, 1930; Ozaki, 1938; Sugiyama, 1941), and Laurentia (Kapp and Stearn, 1975; Webby, 1979a; Table 1). *Labechia* has been subsequently recorded in the Sandbian of Tarim, Australia, and Russia. The earliest record of *Labechiella* is from the Darriwilian of the North China Block and Malaysia, with other reports from the Sandbian of Tarim and Australia, and the Katian of Siberia and Kazakhstan. Similarly, for the Stylostromatidae, *Pachystylostroma* initially appears in the Darriwilian succession in Laurentia, and is also known from the Sandbian of Tarim and the Katian of Siberia, Mongolia, and Australia.

In contrast, other early labechiids, the families Aulaceratidae and Lophiostromatidae display mostly limited distributions which first occurred in the Darriwilian of the North China Block and has also been recorded from the Sandbian of Laurentia and the Katian of Laurentia, Siberia, and Australia. The remaining Aulaceratidae, the genera *Ludictyon*, *Thamnobeatricea*, and *Sinodictyon*, all have their first appearance in the Darriwilian in the North China Block, but remained restricted to the block and the adjacent region: *Ludictyon* is sporadically known from the Katian rocks of Mongolia and *Thamnobeatricea* occurs in the Sandbian and Katian successions of Australia. *Sinodictyon* is known only from the Darriwilian of the North China Block. Similarly, *Lophiostroma*, first recorded in the Darriwilian of the North China Block, only occurs in Mongolia and Siberia in Katian strata.

Given the scarcity of studies of early labechiids from the North China Block (Table 1), it is remarkable that the North China labechiids were more diverse than their Laurentian counterparts, as noted by Nestor and Webby (2013). Of twelve

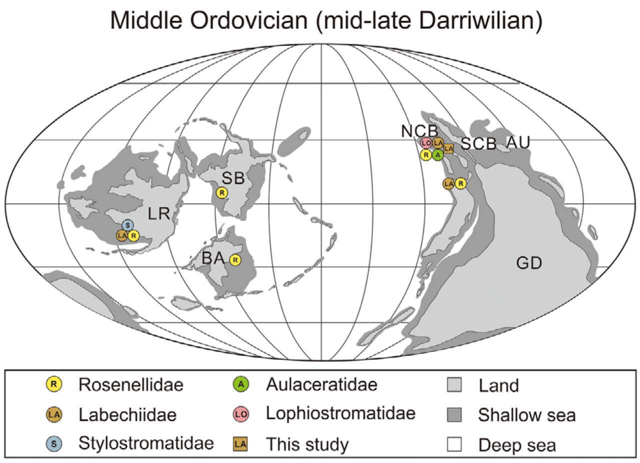

Fig. 3. Paleogeographical distribution of labechiids during the Middle Ordovician based on Nestor and Webby (2013), and Stock et al. (2015). Paleogeographic map modified after Scotese (2001), Webby (2002), Blakey (2008), Golonka and Gawęda (2012), and Burrett et al. (2014); locations of the North China, South China, and Tarim blocks based on Metcalfe (2013) and Burrett et al. (2014). LR = Laurentia, SB = Siberia, BA = Baltica, NCB = North China Block, SCB = South China Block, AU = Australia, GD = Gondwana.

Darriwilian labechiid genera, the only ones that did not continue into the Late Ordovician were *Priscastroma* and *Sinodictyon*, which were endemic to Siberia and the North China Block, respectively. Nine of the other ten genera appeared in the North China Block, whereas the other four occurred in Laurentia (Table 1; Fig. 3; Webby, 2004). It suggests that the North China Block was the center for diversification during the rise of the stromatoporoid root stock, which might have provided the foundation for further diversification in the Late Ordovician.

4. SYSTEMATIC PALEONTOLOGY

Phylum Porifera Grant, 1836
Class Stromatoporoidea Nicholson and Murie, 1878
Order Labechiida Kühn, 1927
Family Labechiidae Nicholson, 1879
Genus *Labechiella* Yabe and Sugiyama, 1930

Labechiella regularis (Yabe and Sugiyama, 1930)
Figures 4a–c

Labechia regularis Yabe and Sugiyama, 1930, p. 56, pl. 18, figs. 5 and 6, pl. 21, fig. 8; Ozaki, 1938, p. 210, pl. 26, figs. 2a, b, c and d; Yavorsky, 1955, p. 59, pl. 24, figs. 4 and 5; Yavorsky, 1957, p. 29, pl. 13, figs. 1 and 2, Webby, 1969, p. 649, pl. 120, fig. 1, pl. 121, figs. 3, 4, 5 and 6, pl. 124, figs. 1 and 2.

Labechia regularis var. *tenuis* Yabe and Sugiyama, 1930, p. 57, pl. 3, fig. 1, pl. 4, figs. 1 and 2; Yavorsky, 1957, p. 30, pl. 43, figs. 1, 2 and 3.

Tuvaechia regularis (Yabe and Sugiyama) Bogoyavlenskaya, 1971, p. 35, pl. 2, fig. 1.

Labechiella regularis (Yabe and Sugiyama) Webby, 1991, p. 200, fig. 3g; Kano et al., 1994, p. 453, figs. 3, and 4a, b, c, d and e.

Material: Five specimens from the units of S10, S14, S15, and S16 (Figs. 1 and 2), middle to upper part of the Yeongheung Formation (Middle Ordovician, Darriwilian), Namgyo, Yeongwol County, Gangwon-do, mid-eastern Korea (Figs. 1 and 2).

Diagnosis: A species of *Labechiella* with well-developed continuous pillars 0.50–8.40 mm in length and 0.10–0.33 mm in diameter. Low, long, and flattened cyst plates are 0.20–0.36 mm in height.

Description: The specimens of this species are domical with a massive or irregular growth pattern and commonly show ragged margins containing sediment layers. The largest specimen measures 61 cm across and 60 cm high (height estimated from preserved portion).

In longitudinal section, the skeleton consists of vertically well-developed, closely placed, mostly persistent, and rarely branching pillars, although the pillars are selectively preserved as flanged and hollow, or without any outlines; pillars extend

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through at least four cysts and are 0.50 to 8.40 mm in length (species average 2.60 mm; n = 152). In transverse view, pillars mainly exhibit flanged circular to ellipsoidal forms, 0.15 to 0.37 mm in diameter (species average 0.24 mm; n = 47). Cyst plates are long, low, and moderately parallel to other cyst plates, or slightly concave; their height ranges from 0.20 to 0.36 mm (species average 0.28 mm; n = 34).

Occurrence: Middle Ordovician: common in the Yeongheung Formation at Yeongwol, Taebaeksan Basin, Korea (Fig. 2; Lee and Yu, 1993; Kano et al., 1994); Pyongyang, Pyeongnam Basin, Korea (Yabe and Sugiyama, 1930); and the upper Majiagou Formation, Shandong Province and the Tofangkou Formation, Liaoning Province, China (Yabe and Sugiyama, 1930). Upper Ordovician: Siberian Platform (Yavorsky, 1955; Bogoyavlenskaya, 1971), New South Wales (Webby, 1969), and the Den Formation of Mole Creek, Tasmania, Australia (Webby, 1991).

Remarks: *Labechiella regularis* (Yabe and Sugiyama, 1930) has been reported from the Middle Ordovician of the Korean Peninsula (Yeongwol and Pyongyang), Shandong and Liaoning provinces of northeastern China, and from the Upper Ordovician of New South Wales and Tasmania, Australia, and the Siberian Platform and Tuva, Russia. Yabe and Sugiyama (1930) originally erected *Labechiella regularis* as a species of *Labechia*, although the specimens from Liaoning show regularly spaced, parallel cyst plates and straight, persistent pillars, all of which are considered diagnostic of *Labechiella* (Webby, 1979a, p. 92). The material of *Lblla. regularis* described from Liaoning by Yabe and Sugiyama (1930) is very similar to the Yeongwol specimens except for the smaller pillar diameter (0.12–0.25 mm) than in the present specimens (0.15–0.37 mm, species average 0.24 mm).

The Yeongwol material closely resembles that described and illustrated by Ozaki (1938) from the upper Majiagou Formation in Shandong and the Tofangkou Formation in Liaoning, on the basis of the persistent, regularly spaced, straight vertical pillars and flattened cyst plates, although Ozaki's material has slightly smaller pillar diameter (0.15–0.21 mm). The specimens described in this study are identical to *Lblla. regularis* of Kano et al. (1994) from the Namgyo section in most respects, although the latter possesses well-developed mamelons and common latilaminae.

The specimens of *Lblla. regularis* reported from the Upper Ordovician of Stony Tunguska River and a tributary of the Kotuy River, Siberian Platform (Yavorsky, 1955) and from New South Wales (Webby, 1969) are considered to be conspecific with the present material, although both the Siberian and Australian specimens have updomed cysts, which are rare in the Middle Ordovician forms of the North China Platform (cf. Webby, 1969).

Labechiella mingshankouensis (Ozaki, 1938)
Figures 4d and e

Actinostroma mingshankouensis Ozaki, 1938, p. 207, pl. 23, figs. 1a, b, c, d and e.

Material: Three specimens from the units of S7, S8, and S12 (Figs. 1 and 2), lower part of the Yeongheung Formation (Middle Ordovician, Darriwilian), Namgyo, Yeongwol County, Gangwon-do, mid-eastern Korea (Figs. 1 and 2).

Diagnosis: *Labechiella* with hollow unflanged persistent pillars (length 1.15–3.90 mm and diameter 0.16–0.37 mm) extending through flattened and widely spaced cyst plates 0.47–1.72 mm in height.

Description: The skeleton consists of conspicuous, continuous, unflanged, stout, erect, structureless, aligned, and widely spaced pillars. In vertical view, the pillars are persistent, stout, and straight with lengths of 1.15–3.90 mm (species average 2.90 mm, n = 13) and diameters of 0.16–0.37 mm (exceptionally 0.48 mm, species average 0.26 mm, n = 30). The entire pillar is hollow without outline. In longitudinal view, the cyst plates are characteristically long, low, and parallel to other plates, and form slightly concave, lamina-like features filled with sediments or peloids; cyst height is 0.47–1.72 mm (species average 1.02 mm, n = 22). In transverse section, pillars are preserved as unflanged ellipsoidal to circular shapes. An obvious astrorhiza can be recognized in one specimen (Fig. 4d).

Occurrence: Middle Ordovician: rare in the middle part of the Yeongheung Formation, and in the upper Majiagou Formation of Liaoning and Shandong provinces, China (Ozaki, 1938).

Remarks: Closely set, vertically continuous, stout and hollow pillars that are radially aligned to form astrorhizae, widely spaced laminae, and laminae-like cyst plates are typical attributes of *Lblla. mingshankouensis* (Ozaki, 1938). The material described in this study from Yeongwol closely resembles that reported by Ozaki (1938, p. 207), who noted the difference between *Lblla. mingshankouensis* from the Shandong and Liaoning provinces as "…pillars which are somewhat slender in the specimen of South Manchuria than in the other; however, the two are tentatively regarded as conspecific". Because of the insufficient number of measurements available for the previously published material, direct comparison of the pillar diameters of specimens of Shandong, Liaoning, and Yeongwol is not possible at present.

Genus *Labechia* Milne-Edwards and Haime, 1851
Labechia yeongwolense sp. nov.
Figures 4f–h

Derivation of name: The new species is named for Yeongwol County, mid-eastern Korea.

Types: Holotype NHCG 10923 (Figs. 4f and g; specimen

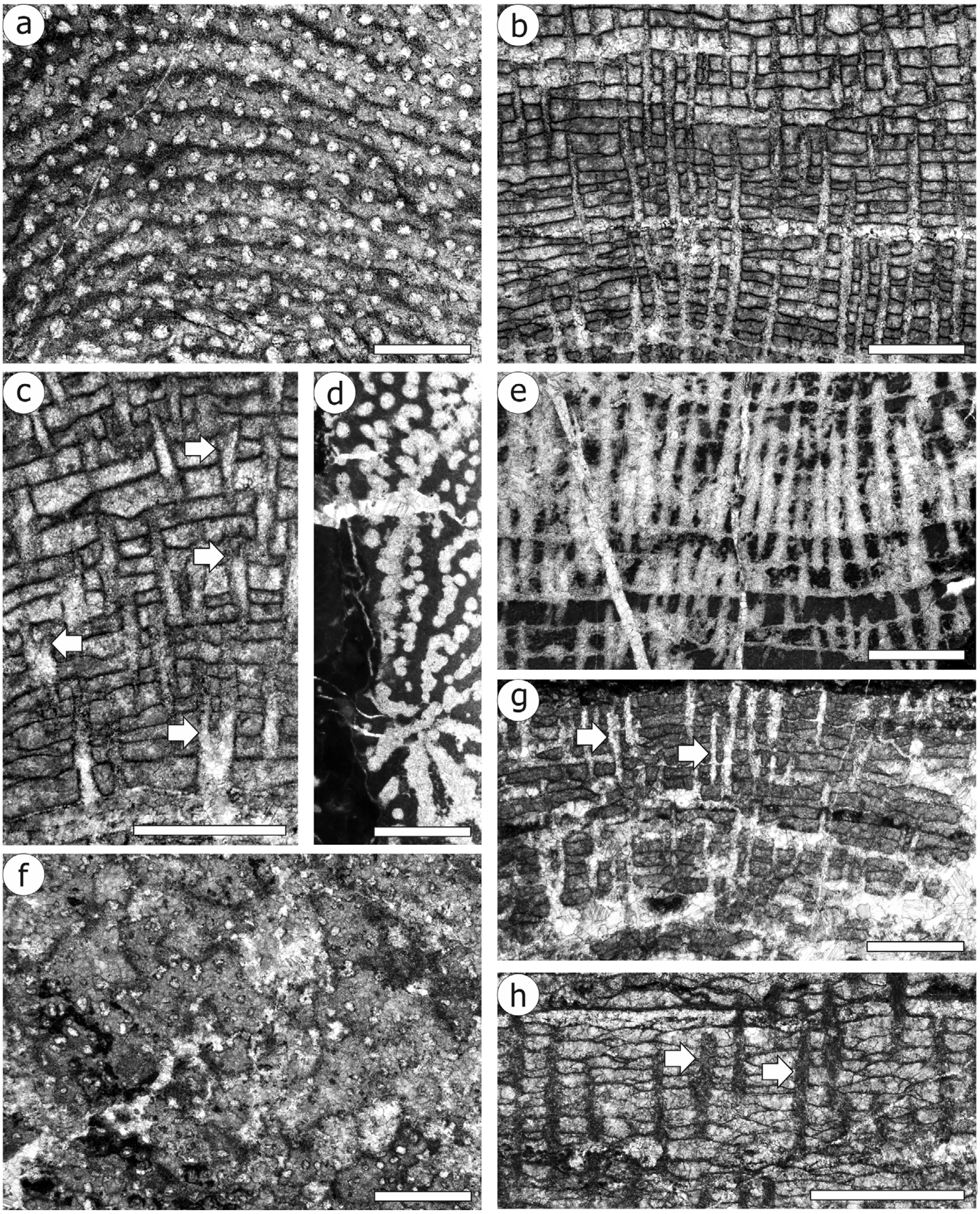

Fig. 4. (a)–(c) *Labechiella regularis* (Yabe and Sugiyama, 1930) from the upper part of the middle Yeongheung Formation, Namgyo section. (a) Transverse section of NHCG 10921 from stromatoporoid-bearing unit of S14. (b) Vertical section of NHCG 10920 from S14. (c) Branched pillars (white arrows) of *Labechiella regularis* in vertical section of NHCG 10920. (d), (e) *Labechiella mingshankouensis* (Ozaki, 1938) from the middle part of the middle Yeongheung Formation, Namgyo section. (d) Transverse section showing astrorhiza and radially arranged pillars of NHCG 10922 from S7. (e) Vertical section of NHCG140922. (f)–(h) *Labechia yeongwolense* sp. nov. from the lower to middle part of the Yeongheung Formation, Namgyo section. (f) Transverse section of holotype NHCG 10923 from S6. (g) Unflanged hollow pillars (white arrows) in vertical section of holotype NHCG 10923. (h) Solid pillars (white arrows) in vertical section of paratype NHCG 10924 from S10-2. Scale bars in all photomicrographs = 2 mm.

with one transverse (NHCG 10923-T) and one longitudinal section (NHCG 10923-L)), horizon S6 (Figs. 1 and 2), Namgyo, Yeongheung Formation (Middle Ordovician, Darriwilian), mid-eastern Korea. Paratype NHCG 10924 (Fig. 4h; specimen with one longitudinal section (NHCG 10924-L)), horizon S10-2 (Figs. 1 and 2), Namgyo, Yeongheung Formation (Middle Ordovician,

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Darriwilian), mid-eastern Korea.

Material: Forty-two specimens from the units S1 to S11, lower to middle part of the middle Yeongheung Formation (Middle Ordovician, Darriwilian), Namgyo, Yeongwol County, Gangwon-do, mid-eastern Korea (Figs. 1 and 2).

Diagnosis: A species of *Labechia* with patchily developed, short, round, small pillars 0.40 to 2.65 mm in height, moderately convex cysts 0.13 to 0.44 mm high.

Description: Skeleton composed of less continuous and rather sporadically developed, short, round and slender pillars forming a cone-in-cone structure with upward low-convexity cyst plates. In longitudinal view, pillars variably and selectively preserved as hollow or solid forms; pillars range from 0.40 to 2.65 mm in length (species average 0.99 mm; n = 61) and 0.07 to 0.31 mm in diameter (species average 0.17 mm; n = 176). In transverse sections, pillars appear either as hollow or dark solid ellipsoidal to circular features. Cysts are moderately convex and vary in size, with heights ranging from 0.13 to 0.44 mm (species average 0.27 mm; n = 15). Latilaminae up to 1.38 mm high are common.

Remarks: *Labechia shanhsiensis* Yabe and Sugiyama (1930), *Lb. coreanica* Yabe and Sugiyama (1930), *Lb. changchiuensis* Ozaki (1938), and *Lb. chingchiachuangensis* Ozaki (1938) from the Middle Ordovician of Korea and northeast China all share the trait of possessing straight, regularly spaced, stout, persistent pillars (Yabe and Sugiyama, 1930; Ozaki, 1938). In contrast, *Lb. yeongwolense* sp. nov. displays notably patchy development of pillars. *Lb. yeongwolense* sp. nov. appears to show some resemblance to *Lb. banksi* Webby (1979c)) from the Cashions Creek Limestone (Upper Ordovician, Sandbian) of Tasmania, Australia. Both species have patchy development of pillars with similar cyst heights, but the cyst plates of *Lb. yeongwolense* sp. nov. are less convex, the pillars are smaller than those of *Lb. banksi* (up to 4.0 mm long; usually 0.1 to 0.2 mm in thickness; Webby, 1979c), and *Lb. banksi* has patchily developed denticles (Webby, 1979c).

Kano et al. (1994, Fig. 4f) illustrated an unidentified, poorly preserved specimen from the Namgyo section that possesses key characteristic features of *Lb. yeongwolense* sp. nov.; i.e., more convex cyst plates, rather sporadically developed solid pillars, and identical dimensions of pillars, and is thus herein regarded as being conspecific with *Lb. yeongwolense* sp. nov.

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