970. ORDOVICIAN (LLANVIRNIAN) STROMATOPOROIDS FROM THE YOUNGWOL AREA, SOUTHERN KOREA*

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Abstract. The Ordovician stromatoporoid Labachiella regularis (Yabe and Sugiyama) has been recovered from the shallow ramp facies of the Yeongheung Formation (Llanvirnian) of the Ogcheon Fold Belt in southern Korea. The skeletal characteristics of this species have been altered by diagenesis. It represents the first discovery of a stromatoporoid from the southern part of the Korean peninsula. This Middle Ordovician stromatoporoid occurrence extends the geographical range of the species, previously reported from other parts of Asia.

Key words. Llanvirnian, Ordovician, stromatoporoids, Ogcheon Belt, southern Korea.

Introduction

Ordovician stromatoporoids of the North China-Korea Platform, inclusive of North China, Manchuria and the Korean peninsula, are poorly documented. The first study of stromatoporoids from the North China-Korea Platform was by Yabe and Sugiyama (1930a, b), followed by Endo (1932), Ozaki (1938), Yang and Dong (1962), Dong (1982), Dong and Wang (1984) and Lin and Webby (1988, 1989). However, these publications have mostly focused on the North China region, except that of Yabe and Sugiyama (1930a, b), which included two northern Korean localities. Stromatoporoids have not previously been recognized from southern Korea.

This study describes stromatoporoids from the Yeongheung Formation of southern Korea, to which is assigned a Middle Ordovician (Llanvirnian) age.

During recent sampling, 45 specimens were collected from the Yeongheung Formation in Youngwol County, Kangwon Province of southern Korea. All the well preserved specimens proved to represent the labachiid stromatoporoid Labachiella regularis (Yabe and Sugiyama, 1930a). This species, as well

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as most other labecchiid stromatoporoids of the same age reported previously from other areas of the North China-Korea Platform, is older than, or contemporaneous with those from the Chazy Group of North America that, prior to the 1980s, were mainly regarded as the oldest stromatoporoids (Stock, 1983).

**Geologic and stratigraphic settings**

The Cambro-Ordovician sedimentary rocks distributed both in the southern and northern parts of the Korean peninsula constitute the Joseon Supergroup. In southern Korea it is extensively exposed as widely scattered localities within the Ogcheon Fold Belt (Figure 1a), presumably a continental margin depression trending northeast to southwest, but most sections are in the Taebaeksan Limestone Plateau of Kangwon Province, southern Korea.

The Yeongheung Formation represents the uppermost part of the Joseon Supergroup occurring in Youngwol County and its vicinity. The formation consists of dark grey dolomitic limestone and grey to bluish grey limestone intercalated in places with several thin beds of shale and argillite, and was probably deposited in the axial zone of the extended Ogcheon Basin (Chang, 1985).

Yoo (1991) recognized four repetitions of a shallowing-upward cycle, each composed of a shallow ramp facies migrating upward into peritidal facies. Thickening upward of the peritidal facies in each grand cycle indicates that the Yeongheung Formation was deposited during the four regressive phases.

The detailed stratigraphic correlation and age determination of the formation have been hampered by scattered exposures, lack of distinctive marker horizons and lack of age-diagnostic megafossils. Based on the trilobite genus *Basilicella* and some poorly preserved cephalopods, Kobayashi (1966) previously correlated the Yeongheung Formation with the Middle Ordovician Tufanglian Series in Liaoning and Shandong Provinces of North China.

In recent attempts to provide a more refined biostratigraphy based on conodonts, Lee (1989) has dated the middle part of the Yeongheung Formation as late Llanvirnian (Middle Ordovician) in age. He reported some conodont species including *Plectodina onychodonta* from the middle part of the Yeongheung Formation, from which the stromatoporoids described herein were collected, and correlated this part of the sequence with the Upper Majiagou Formation of North China. *Plectodina ony-

![Figure 1. Localities of stromatoporoids of the middle part of Yeongheung Formation (b), Youngwol County, southern Korea (a). Crosses point to stromatoporoid localities 1 and 2 dealt with herein.](image-url)
Figure 2. Measured section at Namgyo near Mungog-ri (Figure 1b), showing stratigraphic positions of localities of *Laboechiella regularis* with relationship of relative sea level fluctuations inferred from the vertical changes in sedimentary facies. Vertical lithologic changes represent a threefold repetition of a shallowing-upward cycle. Arrow 1 indicates lower stromatoporoid bed at locality 1, Arrow 2 indicates upper stromatoporoid bed at locality 2, respectively. SR: Shallow Ramp Facies; P: Peritidal Facies (modified from Yoo, 1991).
chondonta is a biostratigraphic indicator of the late Llanvirnian, e.g., the Upper Majiagou Formation in North China (An, 1981), a unit which also contains some of the earliest stromatoporoids in the North China-Korea Platform (Yabe and Sugiyama, 1930a, b; Dong, 1982).

The fossil localities and occurrences

Megafossils are rare and in general very poorly preserved in the Yeongheung Formation. The stromatoporoid specimens were collected from a measured section in the middle part of the formation near the village of Mungog-ri, about 13 km NNE from Youngwol (Figure 1b). In this section two stromatoporoid-bearing horizons were recognized: each from a lithofacies of prominent burrow-mottling, suggesting deposition during deeper subtidal intervals (Figure 2). The fact that scattered crinoid ossicles and orthid cephalopod fragments are occasionally found in these horizons also suggests as open shelf with of comparatively high energy environment (shallow ramp facies of Yoo, 1991).

Some stromatoporoid skeletons found in upper horizons were in growth position with a laminar to domed shape (Figure 3), and in larger skeletons well developed mamelons were observed. Latilaminae are in many cases clearly observed in outcrops, showing that earlier generations of skeletons expanded outwards on the muddy bottom. According to Kano's (1990) definition of the ecomorphotypes of the laminar-domed stromatoporoids, such a growth habit indicates that the species is ambitopic.

Some specimens, however, were not analyzed due to their poor preservation. Although the external form of the skeletons is preserved, dolomitization and silicification often obscure the internal structures of the skeletons. However, a number of better preserved specimens were available to allow the description, diagnosis and an estimate of variation in the species.

Systematic description

Taxonomic procedures.—The problem of the present species is the diagenetic alteration (dolomitization and/or silicification). Skeletal microstructures of most specimens are poorly preserved and the original structure of some important elements (e.g., wall microstructure, thickness of original walls and pillars) is difficult to recognize. For this reason certain measurements (thickness of laminae and pillars) should be given limited

![Figure 3. External growth modes of Labachiella regularis. (a) A laminar specimen resting on a muddy substrate in growth position (Locality 2). (b) A toppled domed specimen (Locality 1). Scale in centimeters and inches.](image-url)
emphasis in taxonomic subdivision. The silicification seriously destroys the skeletal structures, and some silicified specimens do not even preserve their gross structure (Figure 4f). The dolomitization is a less serious problem. Therefore, the description is restricted to specimens which are not silicified.

Classification of the extinct group of the Palaeozoic stromatoporoids at the higher taxonomic level has been in debate. Affinity to the Phylum Porifera is the opinion of the majority (e.g., Stearn, 1972, 1975, 1982; Webby, 1986) because some of the stromatoporoids exhibits an internal structure which is similar to that of the recent calcareous demosponges. However, because no spicules have been found to confirm their affinities within the sponges, other possible affinities (Mori, 1982; Kazmierczak, 1976; Kazmierczak and Kempe, 1990) cannot be refuted.

In this study suprageneric assignments were used following Webby (1979, 1993). Terminology of external forms refers to Kershaw and Riding (1978).

Class Stomatoporidea Nicholson and Murie, 1878
Order Labachiida Kühn, 1927
Family Labachiidae Nicholson, 1879
Genus Labachiella Yabe and Sugiyama, 1930a
Type species: Labachiella serotina
(Nicholson, 1886)

Labachiella regularis
(Yabe and Sugiyama)

Figures 3 and 4a–e

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

Labachiella regularis var. tenuis Yabe and Sugiyama, 1930a, p. 57, pl. 21, figs. 9–10, Yabe and Sugiyama, 1930b, p. 9, pl. 3, fig. 1, pl. 4, figs. 1–2.

Labechia tuvensis Yavorsky, 1968, p. 48, pl. 1, figs. 3–4.

Material.—Eleven specimens from Locality 1 and one from Locality 2 (Figures 1 and 2). All specimens are in the collection of the Department of Geology, Andong National University, Andong, Korea.

Description.—The species exhibits a low domed to laminar form and commonly shows ragged margins with sediment layers within the skeletons (Figure 4c). Skeletons are small, mostly less than 10 cm in width and 5 cm in height, although the largest specimen reaches 60 cm in width and 25 cm in height (Figure 3a). Mamelons are recognized on the upper surfaces of some specimens and are spaced from 2 to 5 cm apart. Latilaminae are commonly found from 8 to 15 mm in width.

Skeletons consist of thin laminae intersected by thick recrystallized pillars in vertical section (Figure 4a). Laminae are parallel, flat, or slightly concave, and continuous between pillars over a few centimeters. Spacing of laminae is regular and the distance between two laminae mostly ranges from 0.20–0.60 mm (Figure 4e). Pillars seem to be thick (0.2–0.4 mm), persistent, and often extending through more than five laminae, however the pillars are selectively altered by diagenesis. The dolomitized pillars commonly consist of large blocky dolomite crystals with fringes of smaller crystals (Figure 4e). The pillars may have been once dissolved and later filled by dolomite. In tangential section, the pillars are spaced from 0.7–0.12 mm apart (Figures 4b and d).

Remarks.—Gross skeletal structures, such as spacing of laminae and pillars, indicate that the present specimens resemble Labechiella regularis. Pillars of the present specimens display lighter center and darker mar-
Figure 4. Internal skeletal structures of the stromatoporoids collected from the Yeongheung Formation at Namgyo. (a)-(e) *Labechiella regularis* Yabe and Sugiyama. (a-b) Vertical and tangential sections of a specimen from Locality 1 (NAM 25). Laminae are parallel to each other and intersected by 'hollow' pillars. The scale bar is 1 cm long. (c) Vertical section of a specimen from Locality 1 (NAM 40). Micritic sediment fills a space between the latilaminae. The scale bar is 1 cm long. (d) Tangential section of a specimen from Locality 1 (NAM 44). A concentric arrangement of laminae represents a mamelon-like structure. The scale bar is 1 cm long. (e) Magnified view of vertical section of a specimen from Locality 1 (NAM 16) showing that pillars consist of blocky dolomite crystals fringed by finer-grained crystals. The scale bar is 1 mm long. (f) A specimen seriously altered by diagenesis (NAM 8). The upper part of the skeleton is replaced by fine-grained dolomite crystals and exhibits a micritic microstructure. The lower part of the skeleton is silicified, thus obliterating the gross structure. The scale bar is 1 cm long.
gins which look like the 'hollow' pillars that may characterize the genus *Stromatocerium* (Nestor, 1976). However, the 'hollow' structure of the present specimens is diagenetic. Furthermore, Webby (1969, 1979) described *Labechiella regularis* with the pillars exhibiting light colored centers, and he also considered them to be secondary structures.

*Labechiella mingshankouensis* (Ozaki) from the Ordovician of the Northern China also exhibits regular laminae, however they are more widely spaced. *L. variabilis* (Yabe and Sugiyama) is also similar to *L. regularis*, however it exhibits wider and less regular spacing of laminae.

*L. regularis* was first reported as a species of *Labechia* by Yabe and Sugiyama (1930a), although it has the parallel and regular horizontal skeletal elements of typical members of *Labechiella*. Bogoyavlenskaya (1971) proposed a new genus *Tuvaechia* with *L. regularis* as the type species. According to Bogoyavlenskaya (1971), *Tuvaechia* was differentiated from the forms of *Labechiella serotina* type by having an isolated distribution of pillars in tangential sections. At the time of proposal of *Tuvaechia*, Bogoyavlenskaya (1971) had only investigated the plates of Yabe and Sugiyama (1930a) using additional drawings to repair poorly preserved skeletal parts. Furthermore, there is another problem in the proposal. Mori (1971) had already showed that both isolated and fused distributions of pillars can be seen in single specimens of some labechiid stromatoporoids (e.g., *Labechia conferta*) and that they cannot have a taxonomic importance, such as differentiating characteristics between *Tuvaechia* and *Labechiella*.

**Occurrence.**—*L. regularis* has been reported from the Middle to Late Ordovician of China (Yabe and Sugiyama, 1930a; Ozaki, 1938), northern Korea (Yabe and Sugiyama, 1930b), Siberia (Yavorsky, 1955, 1968; Bogoyavlenskaya, 1971) and Australia (Webby, 1969, 1991).

It is widely accepted that the stromatoporoids originated in the Llanvirnian (Webby, 1969, 1980, 1984, 1987; Stock, 1983) with the globally distributed stromatoporoid assemblage dominated by labechiids (Webby, 1993). Stromatoporoid faunas of the Llanvirnian have a low diversity but a wide distribution, suggesting their rapid dispersal. They became more diverse in the Caradocian and replaced the algal-sponge associations in the reef environment (Webby, 1984; Copper, 1988).

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**References**


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Macha-ri 磯崎里，Mungog-ri 文谷里，Namkyo 南橋，Youngwol 寧越。

韓国 Youngwol からのオルドビス紀 (Llanvirnian) 層孔虫: 韓国北東部の Youngwol 付近に分布する Llanvirnian (中部オルドビス系) の浅海性石灰岩層から層孔虫化石 Labe-
chiella regularis (Yabe and Sugiyama) を報告した。試料はドロマイト化や珪化作用を受け、骨格の微細構造の保存は必ずしも良好ではないが、laminae と pillars の特徴から上記の
種と同定が可能である。本試料は韓国からの最初の層孔虫化石の報告であるとともに、世
界的に見て最も古い層孔虫化石の 1 つであると言える。中部オルドビス系の層孔虫化石
群集の多様性は低いが、本種を含めて、多くの種が広い地理的分布を示しており、層孔虫
は進化の初期段階で急速に拡散していったと考えられる。

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