

Pseudofrenelopsis cf. *parceramosa* and its reproductive organs from the Lower Cretaceous Youngdong Group of Korea

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ABSTRACT: A large number of cheirolepidiaceae shoots and some associated male and female cones collected from the Lower Cretaceous Youngdong Group in the Youngdong area of Chungcheongbug-do, Korea, are described as *Pseudofrenelopsis* cf. *parceramosa* (Fontaine) Watson, its male cone of *Classostrobus comptonensis* Alvin et al. and female cone based on their external morphology respectively. The abundant presence of *Pseudofrenelopsis* shoots in the Youngdong Group indicates that it was a dominant group flourished during the Early Cretaceous in Korea.

Key words: plant fossils, Cheirolepidiaceae, *Pseudofrenelopsis*, *Classostrobus*, Youngdong Group

1. INTRODUCTION

The extinct family Cheirolepidiaceae is a large family and one of the important Mesozoic conifers. It is well represented in the Lower Cretaceous fossil floras of Europe, North America, Africa, and Asia by vegetative and reproductive remains (e.g., Watson, 1977; 1988; Srinivasan, 1995; Zhou, 1995; Saiki, 1997, 1999; Gomez et al., 2002; Axsmith, 2006; Rothwell et al., 2007; Yang et al., 2009). The members of this family such as *Frenelopsis*, *Pseudofrenelopsis*, *Pagiophyllum*, and *Brachyllum* are characterized by their smooth and cylindrical segmented shoots with minute leaves. The vegetative remains are fairly various and rich in number of species in contrast to the reproductive remains (Watson, 1988; Srinivasan, 1995). According to Watson (1988), vegetative remains are classified as ten genera. So far sixteen male cone species of this family have been described as *Classostrobus* from the Mesozoic floras. These male cones are attached or associated with several cheirolepidiaceae shoots described and bearing unique type of *Classopollis* type pollen (Watson, 1988; Srinivasan, 1995; Talor et al., 2009). The latter is the only unifying character of this family as mentioned by Watson (1988) and Talor et al. (2009). However, the female cones of most genera assigned to this family are poorly known (Watson, 1988; Srinivasan, 1995).

Several species of the cheirolepidiaceae fossils such as *Pseudofrenelopsis* and *Brachyllum* have been known in the

Korean Early Cretaceous floras (Shimamura, 1926, 1927, 1929; Tateiwa, 1929; Oishi, 1940). Tateiwa (1976) made a general review on the Korean Cretaceous floras. According to Tateiwa (1976), the cheirolepidiaceae fossils have been known in the Youngdong, Jinan, Hayang Groups of South Korea and Ponamri and Hanbongsan Formations in North Korea, respectively. However, reliable generic or specific determinations are few because early workers ignored details of descriptions, associated cones, and cuticular features. It is needed to have the systematically critical re-examination of the cheirolepidiaceae fossils including other fossil plants. Unfortunately all of the cheirolepidiaceae specimens of early workers kept in Korea were lost during the Korean War (1950–1953). Accordingly, the status of cheirolepidiaceae fossils of Korea is poorly understood.

Since the Tateiwa's study (1976), some paleobotanical studies have been carried out in the Cretaceous sedimentary basins scattered in and near the Ogcheon Belt (Chun et al., 1993, 1994; Choi et al., 1996; Seo and Kim, 2009).

Recently a large number of cheirolepidiaceae fossils have been collected from new fossil localities of Youngdong Group. They are preserved as impression state in shale and show typical cheirolepidiaceae characters with cylindrical segmented shoots with minute leaves. Particularly, eight male cones and three female cones are newly obtained. All male cones are associated with shoots of *Pseudofrenelopsis* on the single rock slab. However, any pollen grains could not be found in the male cones.

The Lower Cretaceous Youngdong Group is of non-marine origin and distributed near Youngdong-eup in Chungbuk Province. It has been known to yield a few plant fossils until now. The first record of plant fossils from the Youngdong Group was documented by Shimamura (1927). Subsequently additional paleobotanical studies have been made (Chun et al., 1993, 1994; Choi et al., 1996; Seo and Kim, 2009). However, the fossil plants mentioned above are lack of detailed descriptions.

This paper deals with descriptions of *Pseudofrenelopsis* cf. *parceramosa* (Fontaine) Watson, its male cone of *Classostrobus comptonensis* Alvin et al. and female cone of

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Hirmeriella muensteri type. They were compared with well known species of Euramerica.

2. MATERIALS

All of the fossil plants described in this paper were collected from the three fossil localities of the Youngdong Group during this study (Fig. 1). Despite the cheirolepidiaceae fossils are abundant in the Youngdong Group, they are all impressions because of the Bulguksa orogeny with the intrusion of the Bulguksa granite. Consequently, no cuticles and pollen grains of cheirolepidiaceae fossils are preserved. Accordingly, it is difficult to determine their exact specific determinations. Because of the mentioned condition above, some plant taxa are identified with "cf". All

specimens used in this study are deposited in the Department of Earth Science, College of Education, Kongju National University.

3. GEOLOGICAL SETTING AND FOSSIL LOCALITY

The Youngdong Group is distributed in the eastern margin of the Okcheon Orogenic Belt in the central part of southern Korea (Fig. 1). The geologic map of the Youngdong area was first made by Shimamura (1927), and later the geologic map was published by Kim and Hwang (1986).

According to Kim and Hwang (1986), the Youngdong Group consists of five formations; Mangyeri, Saniri, Dongjeongri, Paekmasan, and Wonchonri Formations in ascending order. Fossil plants mainly occurred in the Saniri and Dong-

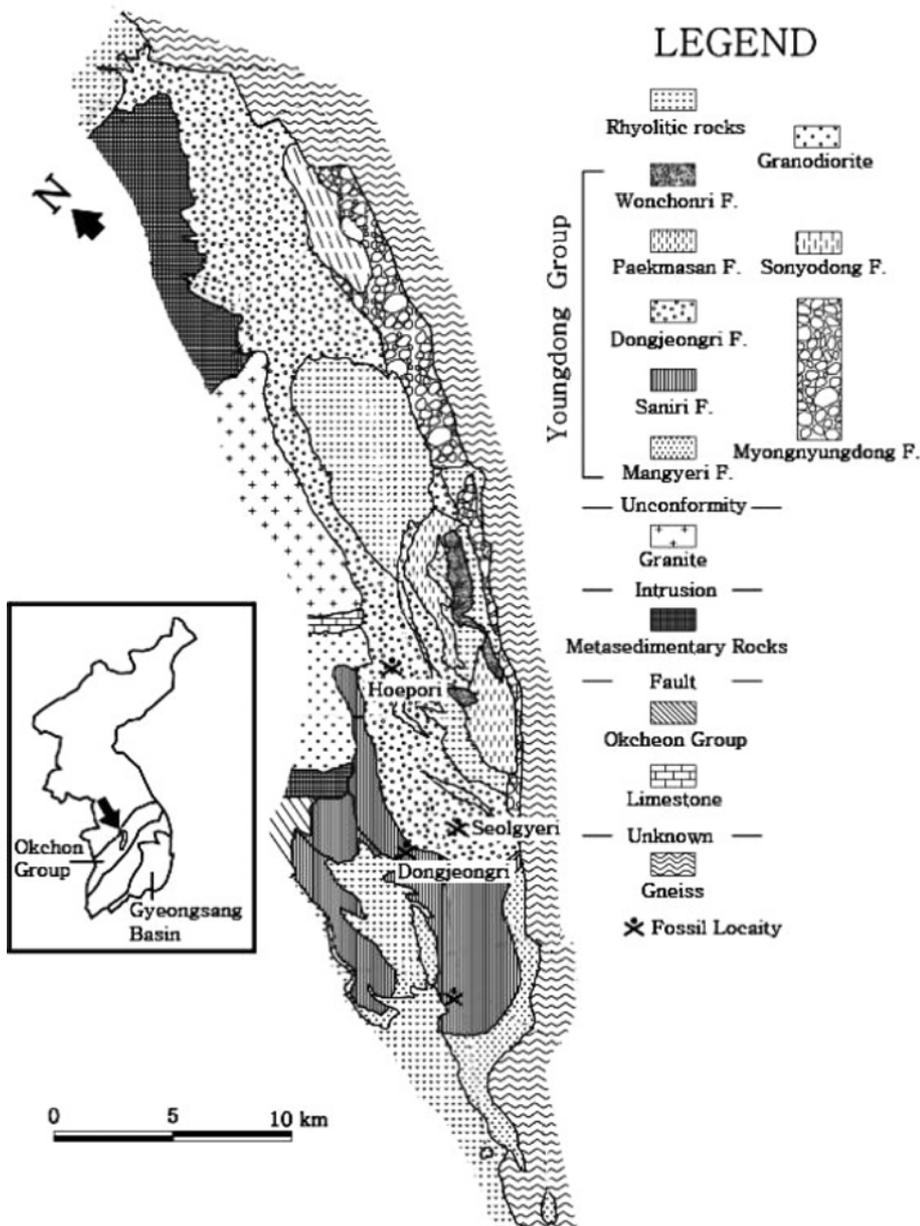


Fig. 1. Geological map of Youngdong area (redrawn after Chun et al., 1993) and fossil locality.

jongri Formations. The Saniri Formation, formerly named Sigeumri Formation by Shimamura (1927), is mainly composed of various coloured shales with sandstones and conglomerate layers. The Dongjeongri Formation is wholly composed of variable conglomerates with purple matrixes and contains partially some purple sandstones and shale beds.

The depositional environment of the Youngdong Group is fluvial associated with floodplain and pond (Kim, 1974).

Systematic description

Order Coniferales

Family Cheirolepidiaceae Takhtajan, 1963

Genus *Pseudofrenelopsis* Nathorst, 1893

Type species *Pseudofrenelopsis varians* (Fontaine) Watson, 1977

Pseudofrenelopsis cf. *parceramosa* (Fontaine) Watson

Comparable specimens

Pseudofrenelopsis parceramosa (Fontaine) Watson, 1977, pl. 85, figs. 1, 7; pl. 86, fig. 112; pl. 87, figs. 1, 10

Synonymy for Korean only

Frenelopsis cf. *parceramosa* Fontaine, Tateiwa 1929, figs. 26a–c.

Frenelopsis parceramosa Fontaine, Oishi, 1940, pl. 40, figs. 1, 5–8.

Pseudofrenelopsis cf. *parceramosa* (Fontaine) Watson, Chun et al., 1993, pl. 1, fig. 1, pl. 4, fig. 4, pl. 6, fig. 5, pl. 11, figs. 3, 4 (figures only).

Pseudofrenelopsis cf. *parceramosa* (Fontaine) Watson, Seo and Kim, 2009, figs. 2A–D (figures only).

Material: KNU-050113223 and other thirty rock specimens.

Locality: The fossils of this species are abundant in the fossil localities of Saniri and Dongjongri Formations.

Description: Full size and extent of shoot are unknown. The obtained specimens are all segmented cylindrical shoots and mostly unbranched shoots exception of a few specimens (Fig. 2b). Most of these shoots consist of three to at least thirteen internodes (Figs. 2a–j). The longest one shows more than 85 mm long and 4 mm wide, with more than ten internodes (Fig. 2a). The internode is variable in size and typically 7–10 mm long and 3–5 mm wide. The surface of shoots has fine numerous longitudinal striations. The leaves are mostly missing; the leaves are one per node and normally have the base of the free part joined a cylindrical sheath with smooth internode below (Fig. 2d). In some small shoots with short internodes the leaf does not join into a cylindrical and has a short suture of open type

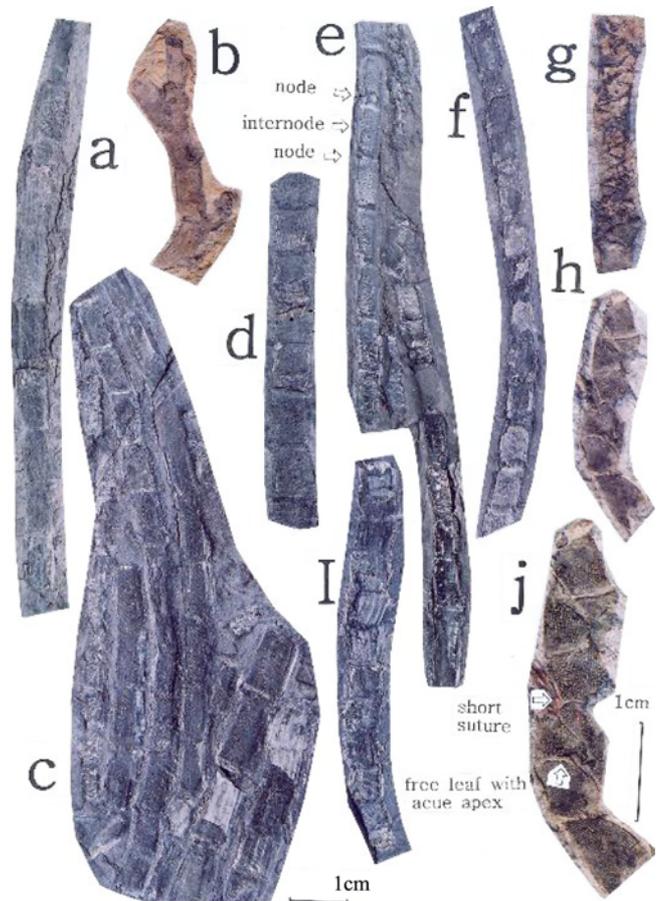


Fig. 2. *Pseudofrenelopsis* cf. *parceramosa* shoots. All scales = 1 cm unless otherwise indicated. a, c, d, e, f, I: shoots showing cylindrical internodes of variable sizes, b: showing sparse branching, g, h: shoots with short suture, open-type of leaf sheaths, j: enlarged twice of h.

(Figs. 2g, h, j). In Figure 2j, the small shoot bearing leaves in phyllotactic spiral. Free leaf is triangular with acute apex in shape and up to 2 mm high, sheathing base up to 8 mm wide. The abaxial surface is ornamented by alternating fine longitudinal furrow and ridges, converging to the apex. Some shoots are associated with male cones (see Fig. 3).

Remarks: The present specimens are characterized by their cylindrical shoots with closed-type and open-type of leaves. The shoots are often thickly massed and appressed. Although no details of cuticle have been known in the present specimens, it is no doubt that their gross morphology clearly belongs to the genus of *Pseudofrenelopsis* emended by Srinivasan (1995) based on his new data. According to Watson (1977), the internodes of *Pseudofrenelopsis* consist of both the closed and open sheaths, and leaf is one or occasionally two per internode in a spiral arrangement (Srinivasan, 1995).

So far eight species of *Pseudofrenelopsis* have been

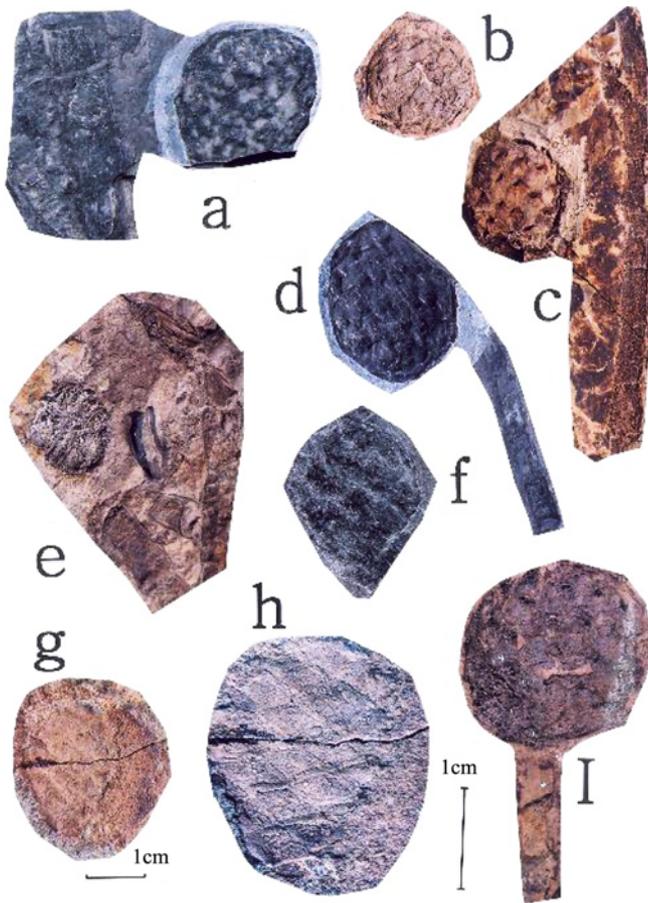


Fig. 3. Male cones (*Crassostrobis*) associated with shoots of *Pseudofrenelopsis* cf. *parceramosa*. All scales = 1 cm unless otherwise indicated. a, c, e, d, i: spherical cones associated with shoots, b, f, g: separated spherical cones, h: enlarged twice of g, showing helically arranged rhomboidal sporophylls.

described from the Lower Cretaceous strata of the world (Table 1). The specific identification of these species was made mainly based on their external morphology and ana-

tomical features. Of these *P. parceramosa* (Fontaine) Watson are the most similar in external morphology to the present *Pseudofrenelopsis* cf. *parceramosa* (Fontaine) Watson. Unfortunately the Youngdong specimens are represented by only their external morphology, the exact comparison between the present specimens and Euramerican species of *P. parceramosa* (Fontaine) Watson is difficult. Thus the Youngdong shoots observed here treated as *P. cf. parceramosa* (Fontaine) Watson.

In external morphology, *Pseudofrenelopsis* cf. *parceramosa* (Fontaine) Watson was often confused with the Euramerican species of *P. varians* (Fontaine) Watson to which emended diagnosis was given by Watson (1977), but the free leaves of latter species are smaller in size than those of the former species. The shoot of *P. varians* (Fontaine) Watson is known to have the closed type of leaf sheaths, but according to Watson (1988, Figs. 919c and d), some shoots with short internodes have clearly the open type of leaf sheaths that do not completely encircle the stem as those with short internodes in the present specimens (Figs. 2g, h, j).

Such an open type of leaf is also recognized both in *Pseudofrenelopsis intermedia* (Chow et Tsao) Watson and *P. nathorstiana* Srinivasan as shown in Table 1. *Pseudofrenelopsis intermedia* (Chow et Tsao) Watson was originally described by Chow et Tsao (1977) from the Lower Cretaceous of East China, and later transferred by Watson (1988) to the present genus. *P. nathorstiana* Srinivasan was established by Srinivasan (1995) from the Lower Cretaceous of eastern North America. It is considered that the presence of the open type of leaf is not prominent characters. It may be attributed to the immature shoots with short internodes.

Tateiwa (1929) figured three impressions of *Pseudofrenelopsis*-like shoots assigned as *Frenelopsis* cf. *parceramosa* Fontaine without description from the Daegu Formation of Hayang Group. Later Oishi (1940) described Tateiwa's specimens as *F. parceramosa* Fontaine. They probably belong

Table 1. Comparison of *Pseudofrenelopsis* cf. *parceramosa* and related species

Taxa	Branching	Internode length×width (mm)	Suture or gap	Leaf number	Maximum length of free leaf (mm)	Authors
<i>Pseudofrenelopsis</i> cf. <i>parceramosa</i>	sparce	7–10×3–5	in some open forms	1	2	This study
<i>Pseudofrenelopsis parceramosa</i>	sparce	1–11×1 15×15	in some open forms	1	2	Watson (1977); Axsmith (2006)
<i>P. varians</i>	sparce	1.5–17×3–7	in some open forms	1	1.5	Watson (1988)
<i>P. intermedia</i>	–	–	yes	1	–	Zhou (1983); Watson (1988)
<i>P. nathorstiana</i>	–	1–2.9×1–2	yes	1–2	1	Srinivasan (1995)
<i>P. glabra</i>	–	6–8×4	no	1	1.5	Saiki (1999)
<i>p. papillosa</i>	sparce	5–11×3–7.5	no	1	1.5	Zhou (1995)
<i>p. dalatzensis</i>	presumed to be sparce	5.5–10×3–6.5	no	1	2	Zhou (1995)
<i>P. heishanensis</i>	presumed to be sparce	5–6×2.5×4	no	1	2	Zhou (1995)

to the *Pseudofrenelopsis* cf. *parceramosa* (Fontaine) Watson.

The leafy shoots of *Brachyllum* cf. *vulgare* (Stopes and Fujii) Jeffrey reported without description by Chun et al. (1993) from the Youngdong Group, Korea are closely similar in external features and phyllotaxy to the present open type of leaves (Pl. 1, Figs. 2g, h, j) of the *Pseudofrenelopsis* cf. *parceramosa* (Fontaine) Watson. The former species probably belongs to the present *Pseudofrenelopsis* cf. *parceramosa* (Fontaine) Watson. Moreover the former species does not agree with *Brachyllum vulgare* (Stopes and Fujii) Jeffrey originally described by Stopes and Fujii (1910) and Ohana and Kimura (1993) from the Upper Cretaceous Yezo Group of Hokkaido, Japan based on their permineralized leafy branches. The leafy branches of Japan are characterized by their frequent branching and close helicals of adnate leaves, and the phyllotaxy of leaves clearly show the contact parastichy of a compressed fossil (Watson et al., 1986). While in *Brachyllum* cf. *vulgare* (Stopes and Fujii) Jeffrey, the phyllotaxy of leaves are loose spiral.

Form-genus *Classostrobus* Alvin, Spicer and Watson, 1978

Type species *Classostrobus comptonensis* Alvin, Spicer and Watson, 1978

Classostrobus comptonensis Alvin, Spicer and Watson

Comparable specimen

Classostrobus comptonensis Alvin, Spicer and Watson, 1978, pl. 96, figs. 7–9; pl. 97, figs. 1–7; pl. 98, figs. 1–6, text-figs. 1A–D

Classostrobus comptonensis Alvin, Watson, and Spice, 1994, text-figs. 1A–C

Synonymy for Korean only

Female cone, Seo and Kim, 2009, figs. 2L, D (figures only).

Material: KNU-050113338 and other seven male cones collected from the Dongjongri Formation.

Description: Male cones are usually spherical to elliptical in shape, variable in size, and mostly associated with shoots of *Pseudofrenelopsis* cf. *parceramosa* (Fontaine) described above. The male cones in Figures 3a, b, c, d are 16×17, 15×14, 14×12, 12×10 mm respectively. The male cones in Figures 3e, f, g, i are 11×10, 20×17, 20×17, 14×14 mm respectively. Sporophylls are mostly unknown. The cone of Figure 3g shows partly preserved sporophylls. As shown in Figure 3h, the sporophyll is helical in arrangement, peltate, with an acute apex, 5 mm long and 3 mm height. The surfaces of cones show helically arranged small holes instead of sporophyll head. Unfortunately pollen grains could not be found in the male cones.

Remarks: Although the present cones are found at the same or different horizons, they are very similar to one another in size and shape. Due to their separate occurrences from their parent vegetative shoots, it is appropriate to regard the present male cones as a separate genus of *Classostrobus* bearing in situ *Classopollis* type pollen (Alvin et

Table 2. Comparison of *Classostrobus comptonensis* and related species

Taxa	Male cone		Sporophyll		Sporophyll head		Authors
	Shape	Dimension long×wide (mm)	Arrangement	Dimension long×wide (mm)	Dimension long×wide (mm)	Shape	
<i>Masculostrobus risbra</i> = <i>Classostrobus risbra</i>	ellipsoidal	14–16×9–10			1.52×1.2–1.6	rhomboidal	Barnard (1968); Barnard & Miller (1976)
<i>C. comptonensis</i>	spherical to elliptical	4–5 in diameter 14×12	spirally		24×1.5–3	rhomboidal	Alvin et al. (1978, 1994)
<i>C. cathayanus</i>	spherical	20×23	spirally		710×7–8	rhomboidal	Zhou (1983)
<i>C. sp. A</i>	oval	7.5–12×6–6.5	spirally		2×1.5	rhomboidal	Francis (1983)
<i>C. cloughtonensis</i>		6.5×5	helically		0.5–1×0.7–1	rhomboidal	Van Konijnenburg-Van Cittert (1987)
<i>C. lozerianus</i>	oval	12–20×8–16	spirally			rhomboidal	Thévenard (1993)
<i>C. ugaensis</i>	oval to elliptical	3.5×2.5	spirally	1.6×2.4		triangular to rhomboidal	Gomez et al. (2002)
<i>C. turolensis</i>	spherical to elliptical	5×4	spirally	2.5×2.5		triangular to rhomboidal	Gomez et al. (2002)
<i>C. arkansensis</i>	round to ovoid	9–20×6–14	helically	2–5 long	2×2, 5×3	rhomboidal	Axsmith et al. (2004)
<i>C. crossii</i>	subspheroidal	20×18	helically	11×4–5		cup-shape	Rothwell et al. (2007)
<i>C. dalatzensis</i>	ovoid	14×10	helically			rhomboidal	Yang (2008)
<i>C. pseudoexpansum</i>	ellipsoidal	10×7					Rothwell et al. (2007)
<i>C. comptonensis</i>	spherical to elliptical	10–20×11–17	helically		5×3	rhomboidal	This study

al., 1978). Although no organic connection with shoots was found, the present male cones are closely associated with shoots of *P. cf. parceramosa* (Fontaine) Watson as described above. Judging from their external morphology and associated with shoots, the present male cones probably belong to the *Classostrobus comptonensis* established by Alvin et al. (1978) from the Lower Cretaceous England Wealden (Barremian), and later emended by Alvin et al. (1994).

So far twelve species under the genus of *Classostrobus* have been described from the Mesozoic strata of the world as shown in Table 2. These species are mostly established based on their anatomical features. Of these *Classostrobus comptonensis* Alvin et al. have been known to associated with *Pseudofrenelopsis parceramosa* (Fontaine) Watson (1988), as in the present male cones.

Recently, Axsmith et al. (2004) described pollen cones from the Cretaceous of Arkansas as *Classostrobus arkansensis* Axsmith et al. based on its cuticular features and pollen grains. This pollen cone is also associated with *Pseudofrenelopsis parceramosa* (Fontaine) Watson, and some cones are still attached to the shoots. The Arkansas cone of *C. arkansensis* differs considerably from the English Wealden cone of *C. comptonensis* Alvin et al. The cone of *C. arkansensis* Axsmith et al. is round to ovoid and 920×614 mm in size. The cone size of *C. arkansensis* Axsmith et al. is similar to the present species, but its cone shape of *C. arkansensis* Axsmith et al. somewhat differs from the *Classostrobus comptonensis* Alvin, Spicer and Watson with spherical to elliptical in shape.

The following species such as *Classostrobus cathayanus* Zhou (1983), *C. cloughtonensis* Van Konijnenburg Van Cittert (1987), *C. ugnaensis* Gomez et al. (2002) and *C. turcolensis* Gomez et al. (2002), are also associated with leafy shoots of *Frenelopsis*, *Pseudofrenelopsis* or *Pagiophyllum*. Of these the male cone of *Classostrobus cathayanus* Zhou established by Zhou (1983) from the Lower Cretaceous of East China is similar in shape to those of *C. cf. comptonensis* Alvin et al., but the former is larger (more than 20×23 mm) than the latter.

The male cone of *Classostrobus crossii* Rothwell et al. originally described by Rothwell et al. (2007) differs from the present species by its larger cones (ca. 20 mm).

The female cone of *Pseudofrenelopsis varians* (Fontaine) Watson (1977) is very similar in shape and size to those of *P. parceramosa* (Fontaine) Watson. It is difficult to separate both the female cones from the male cones of *P. parceramosa* (Fontaine) Watson by only cone shape and size without cuticular features and shoots.

Female cone

Material: KNU-050409109, 050113143, 050113105. Three cones collected from the Dongjongri Formation.

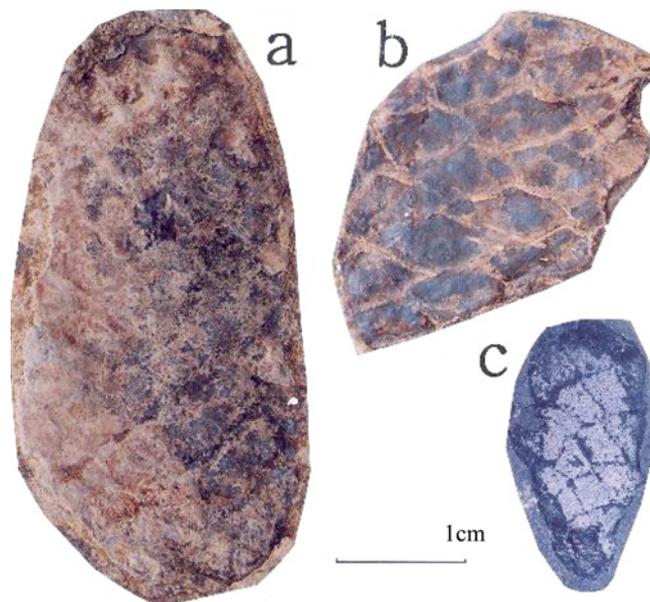


Fig. 4. Female cones associated with shoots of *Pseudofrenelopsis cf. parceramosa* (Fontaine) Watson. All scales = 1 cm unless otherwise indicated. a: ovoidal cone showing helically arranged rhomboidal ovuliferous scales, b: partly preserved female cone showing helically arranged rhomboidal ovuliferous scales, c: probably immature cone.

Description: The female cone of Figure 4a is a large cone, ovoid in shape, and 43×20 mm in size. Ovuliferous scales are helically arranged and elongated rhomboidal in shape, 6 mm long and 5 mm height. The female cone of Figure 4b is partly preserved, more than 30 mm long and 20 mm wide, and still bearing some ovuliferous scales. Ovuliferous scales are elongated rhomboidal in shape and arranged helically, typically 7 mm long and 4 mm high. The female cone of Figure 4c is probably ovoid or elliptical in shape, and more than 20 mm long and 14 mm wide in the middle part, with short stalk of 2 mm long and 1.5 mm wide. Ovuliferous scales are helically arranged, 5 mm long and 3 mm high.

Remarks: Isolated two cones mentioned above are found at the same rock slab (Figs. 4a and b), and similar to one another in cone shape and size. Although the female cone of Figure 4c is partly preserved small cone, it probably belongs to the same species mentioned above.

The present cones clearly differ in cone shape and size from the male cones of *Classostrobus comptonensis* Alvin et al. described herein. The present cones are also associated with *Pseudofrenelopsis cf. parceramosa* (Fontaine) Watson. Although the organic connection between the present cones and shoots has not been found, it is considered that they are the female cone of *P. cf. parceramosa* (Fontaine) Watson, because there is no other plant coexisted except for fragmental shoots of *Brachyllum* and male cones of *C. comp-*

tonensis Alvin et al. Accordingly, the present cones are safely referable to the female cone of *P.* cf. *parceramosa* (Fontaine) Watson.

In all species of *Pseudofrenelopsis* and *Frenelopsis*, such a large-sized female cone has not been recorded. A few species such as *Hirmeriella muensteri*, *Frenelopsis ramosissima* (Fontaine), *Pseudofrenelopsis varians* (Fontaine) are attached or associated with female cones. The present female cones are closely similar in shape to those of *Hirmeriella muensteri* reconstructed by Jung (1968) from the Rhaetoliasic, Bayreuth, Germany, but the latter is more ellipsoidal rather than ovoidal, and much smaller than the present cones. The present female cones is similar in shape to the female cone of *Frenelopsis ramosissima* (Fontaine) Watson described by Axsmith and Jacobs (2005) from the Lower Cretaceous of Texas, but the latter species is much larger than the present cones. The female cone of *Pseudofrenelopsis varians* (Fontaine) Watson (1977) is distinguished from the present female cones by its small sized and nearly rounded cone.

4. DISCUSSION

Pseudofrenelopsis parceramosa (Fontaine) is characterized by ultimate shoots with a leaf at node. It is one of the best known frenelopsids from the Lower Cretaceous of the world. According to Watson (1977), there are two types of closed and open types of leaves in *P. parceramosa* (Fontaine). The closed type of leaf normally has a base of free part joined into a cylindrical sheath with smooth internode below, while the open type of leaf does not join into a cylindrical and thus has a suture, sometimes the edges of the open type of leaf does not meet, but has a gap filled by the base of the leaf above. Axsmith (2006) mentioned that all of the mature vegetative shoots show the closed type of leaf, and the absence of open or closed of leaf sheath may not be a significant characters. In the Yongdong conifer of *Pseudofrenelopsis* cf. *parceramosa* (Fontaine), there are two types of open and closed of leaf sheath as in Euramerican conifer. The shoots with long internodes have usually closed type of leaf sheath, but some shoots with short internodes have open type with short suture as illustrated by Watson (1977). The latter type is not so much. It probably appeared to be immature shoots. Accordingly, it is considered that the presence of the open type of leaf is not prominent characters as mentioned by Axsmith (2006).

As already pointed out by Axsmith (2006), Upchurch et al. (1994) mentioned that all claims of *P. parceramosa* (Fontaine) from Asia have been refuted. Nevertheless many species of *Pseudofrenelopsis* from the Lower Cretaceous strata of East Asia has been described (e.g., Zhou, 1995; Saiki, 1999; Deng et al., 2005; Yang, 2008).

The presence of *Pseudofrenelopsis* species in East Asia emphasized that it was floristically important taxa of Mesozoic conifers, and also flourished during the Early Cretaceous of East Asia.

Axsmith et al. (2004) described *Classostrobus arkansensis* Axsmith et al. from the Lower Cretaceous of North America Arkansas. This species is also associated with *P. parceramosa* (Fontaine) as well as in *C. comptonensis* Alvin et al. (1978). However, recently Axsmith (2006) discussed the relation between *P. parceramosa* (Fontaine) of North America Arkansas and that of England Wealden based on his new data, and mentioned that *P. parceramosa* (Fontaine) of North America Arkansas is not the same as the one reconstructed by Alvin (1982) from the England Wealden. From the anatomical point of view, the North America Arkansas and England Wealden conifers represent different biological species (Axsmith, 2006). Accordingly, it is appropriate that *P. parceramosa* (Fontaine) from the England Wealden is generally considered to be a parent vegetative shoots of *C. comptonensis* Alvin et al.

As reviewed by Watson (1988), the information concerning the female cones of *Pseudofrenelopsis* are very rare in contrast to those of male cones. Two lobed scales from the Lower Cretaceous of England are associated with *P. parceramosa* (Fontaine) (Watson, 1988, Figs. 9.16, H, I). The female cones attached to the shoots of *Pseudofrenelopsis varians* (Fontaine) Watson (Watson, 1977) are nearly round and similar in size to the present male cone of *C. comptonensis* Alvin et al. Now there is no direct evidence that three female cones from the Youngdong Group really belong to the *P. parceramosa* (Fontaine), but they are very similar in shape to the female cone of *Hirmeriella muensteri* (Schenk) Jung (1967, 1968). No similar cones to the present female cone have been yet recorded from the Lower Cretaceous strata of Euramerica.

Despite the widespread occurrence of non-marine sediments and a long history of paleontological investigation in Youngdong Group, so far the known fossil plants are scanty, and less than eight species. Of these abundant and dominant plants are cheirolepidiaceous fossils such as *Pseudofrenelopsis*, *Frenelopsis*, and *Brachyllum*. Accordingly, it is considered that cheirolepidiaceous plants had their own mixed community in the Youngdong area in the developmental stage of the sedimentary basin.

So far any palynofloras from the Youngdong Group have not been recorded. However, the Lower Cretaceous of Hayang Group distributed in the southern part of Korea yields diverse and abundant palynofloras. Of these dominant group is *Corollina* pollen belonging to Cheirolepidiaceae (Choi, 1985). According to (Choi, 1985), the genus *Corollina* is exceeding 70% of total palynomorphs. Despite abundant occurrence of cheirolepidiaceous shoots in the Lower Cretaceous strata of Korea, *Classopollis* pollen has not yet been recorded.

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