

## Permian Plants from Maiya, Japan, 3. Pteridophylls

By

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**Abstract** This is the third paper of the serial works on Permian plants from Maiya, northeast Japan. Taxa described and discussed herein are *Pecopteris toyomaensis*, *P. yabei*, *P. sp. A*, *P. sp. B*, *P. sp. C*, *Pecopteris (Asterotheca) sp.*, *Sphenopteris tenuis*, *S. sp.*, *Odontopteris subcrenulata*, *O. yongwolensis*, *Cyclopteris sp.*, *Callipteridium koraiense* and *Aphlebia sp.* *Pecopteris toyomaensis* is described as new.

### Introduction

The Maiya flora is the best recorded Permian flora in Japan. ASAMA (1967, 1970, 1981) discriminated 22 species and varieties from the Nishikori Formation of the Maiya Group from the Maiya area, northeast Japan. This is the third paper documenting a diverse fossil flora from the Maiya area. Locality, lithology, and stratigraphic details are given in the previous papers. This paper discriminated 13 species of pteridophylls and described one new species.

### Description

Genus *Pecopteris* BRONGNIART

*Pecopteris toyomaensis*, n. sp.

(Pl. 1, fig. 2; Pl. 2, fig. 8; Pl. 4, fig. 6; Pl. 5, fig. 3)

*Description:* Frond at least bipinnate; penultimate pinnae probably linear, 7 cm in half breadth; length unknown; rachis very thick, attaining 7 mm in breadth; ultimate pinnae being contact each other laterally or slightly separated, attaining 7–11 cm in length, 1.7 cm in maximum breadth, linear to lanceolate in form, becoming gradually narrower toward subacute apex; pinnae having about 25 pinnules in half side; pinnules forming an angle of 70°–80° with pinna-rachis, very slightly falcate or almost straight, attaining 7 mm in length, and 2 mm in breadth; apex of pinnules obtuse or subacute; midrib very slender, persisting almost to the apex; secondary veins arising with an angle of 40°–50°, bifurcating once.

*Remarks:* Most specimens are poorly preserved. Figured specimens are relatively well-preserved among them. *Pecopteris toyomaensis*, n. sp. resembles *Pecopteris hirta*, *P. lepidorachis* and *P. liuiana* in pinnule shape and in having once forked venation. However, the new species differs from these species in their venation and in

having more numerous pinnules.

*Occurrence*: Plant bed A (*Parafusulina* Zone).

*Material*: Holotype, NSM-PP5688, Paratypes, NSM-PP5690–5692

***Pecopteris yabei* KAWASAKI, 1931**

(Pl. 1, fig. 4; Pl. 2, figs. 6–7; Pl. 3, fig. 2)

*Pecopteris yabei* KAWASAKI, 1931, pl. 36, figs. 80–84.

*Pecopteris yabei*; KAWASAKI, 1934, p. 119.

*Pecopteris yabei*; KON'NO, 1968, p. 182; pl. 13, fig. 3; pl. 15, figs. 3–4; text-fig. 4-D, E.

*Pecopteris yabei*; HUANG, 1980, p. 539; pl. 233, figs. 1–4, la.

*Description*: Frond unknown; pinnae linear lanceolate, long, attaining more than 8 cm in length and 1.8 cm in width; terminal pinnules unknown; pinnules oblique, almost contact or slightly apart, alternate, oblong pararell-sided, contracted to apex and in posterior part of pinnae somewhat contracted at the base; midrib decurrent; secondary veins slightly arching and forked once.

*Remarks*: This species is referable to *Pecopteris yabei* KAWASAKI, 1931, from the Jido Series of South Korea, because it has a similar form, size and venation of the pinnules.

*Occurrence*: Plant bed A (*Parafusulina* Zone).

*Material*: NSM-PP5695–5698.

***Pecopteris* sp. A**

(Pl. 1, fig. 1)

*Description*: Frond at least bipinnate; penultimate pinnae attaining 5 cm in breadth; more than 10 cm in length; ultimate pinnae giving off with an angle of 50°–60° from pinna-rachis, touching each other or slightly separated, short lanceolate, attaining 1 cm in width and 3 cm in length, gradually narrowing into a terminal pinule; pinnules slightly apart from one another, oblong, round-apexed, attaining 5 mm in length and 2 mm in width; venation indistinct.

*Remarks*: Only single specimen resembles those of *Pecopteris hirta* HALLE, 1927, from the lower part of the Lower Shihhotse Series in Taiyuan coal-field, China. The latter species was also reported from the Jido Series of South Korea (KAWASAKI, 1934). *Pecopteris* sp. A differs from *Pecopteris hirta* in having distinct pinnules.

*Occurrence*: Plant bed B (*Parafusulina* Zone).

*Material*: NSM-PP5023.

***Pecopteris* sp. B**

(Pl. 1, fig. 3; Pl. 2, figs. 4–5)

*Description*: Frond unknown; unimate pinnae linear to linear-lanceolate; at least 8 cm in length, 1.3 cm in width, becoming gradually narrower toward acute

apex; pinnules being just contact each other, forming an angle of generally  $70^\circ$  to  $80^\circ$  with pinna-rachis, oblong to oblong-lanceolate with rounded apex, attaining 8 mm in maximum length; length generally 2.0 to 2.5 times greater than breadth; midrib distinct; secondary veins dividing once generally at a short distance from midrib.

*Remarks:* The specimens are similar to those of *Pecopteris orientalis* (SCHENK) POTONIE known from the Upper Shihhotse Series of Taiyuan, Shansi (HALLE, 1927) in form and arrangement of venation. However, the assignment of the Maiya specimens to *P. orientalis* is in doubt because the characteristics of frond and penultimate pinnae are not known.

*Occurrence:* Plant bed A (*Parafusulina* Zone).

*Material:* NSM-PP5700–5702.

### *Pecopteris* sp. C

(Pl. 2, fig. 9)

*Remarks:* Only single specimen is probably referable to the genus *Pecopteris*, but poor preservation of the material precludes its specific comparison.

*Occurrence:* Plant bed A (*Parafusulina* Zone).

*Material:* NSM-PP5705.

### *Pecopteris (Asterotheca)* sp.

(Pl. 5, fig. 2)

*Remarks:* Only one fertile specimen is available for study. The pinna is oblong, more than 2.7 cm in maximum breadth, and has a very thick rachis. The pinnules are distinctly separated from one another, oblong linear in form, parallel sided, have length 3 to 4 times greater than breadth and a broadly rounded apex. They are giving off from the rachis with an angle of  $60^\circ$  to  $80^\circ$  and possess a row of *Asterotheca*-type synangia on both sides of the midrib.

*Occurrence:* Plant bed A (*Parafusulina* Zone).

*Material:* NSM-PP5704.

### *Sphenopteris tenuis* HALLE, 1927

(Pl. 1, fig. 8a)

*Sphenopteris tenuis* HALLE, 1927, p. 58–59; pl. 15, figs. 15–17.

*Sphenopteris tenuis*; KAWASAKI, 1934, p. 91–92, pl. 20, figs. 21–22.

*Sphenopteris tenuis*; STOCKMANS and MATHIEU, 1939, p. 57–58, pl. 6, figs. 1–3.

*Sphenopteris tenuis*; GU and ZHI, 1974, p. 76, pl. 46, figs. 5–6; pl. 47, figs. 1–7.

*Remarks:* This species is represented by single fragment any sterile penultimate pinna, which is 11 cm long and probably 1.5 cm wide, becomes gradually narrower toward the pointed apex, and has a slender axis. The ultimate pinnae are delicate, approximate 3 mm in maximum width and 1.5 cm in maximum length, deltoid-

lanceolate in form, and contracted below into a very narrow base.

The characteristics described above suggest that the *Maiya* specimen can safely be assigned to *Sphenopteris tenuis* HALLE, 1927, described from the Lower Shihhotse Series of Taiyuan, Shansi and also recorded by KAWASAKI (1934) from the Jido Series of South Korea.

*Occurrence*: Plant bed A (*Parafusulina* Zone).

*Material*: NSM-PP5707.

***Sphenopteris* sp.**

(Pl. 1, fig. 7a)

*Remarks*: Only one incomplete specimen is referable to the genus *Sphenopteris*, but confident comparison is limited by the lack of additional and well-preserved specimens.

*Occurrence*: Plant bed A (*Parafusulina* Zone).

*Material*: NSM-PP5708.

***Odontopteris subcrenulata* (ROST) ZEILLER, 1890**

(Pl. 2, figs. 1–3; Pl. 3, fig. 1; Pl. 5, fig. 4)

*Odontopteris subcrenulata*; HALLE, 1927, p. 114–115, pl. 34, figs. 1–5.

*Odontopteris subcrenulata*; KAWASAKI, 1931, pl. 42, fig. 106A; pl. 48, figs. 121–124; pl. 49, fig. 125; pl. 50, figs. 126–127.

*Odontopteris subcrenulata*; KAWASAKI, 1934, p. 135–137.

*Odontopteris subcrenulata*; GU and ZHI, 1974, p. 117, pl. 84, figs. 1–2.

*Description*: Penultimate pinnae approximating to 15 cm in breadth, reaching more than 25 cm in length; ultimate pinnae linear lanceolate in form, giving off with a wide angle from rachis, becoming gradually into a long ligulate terminal pinnule of 8 cm long and 2.5 cm wide; pinnules alternate, oblong, giving off with an angle of about 50°, being almost touching one another or slightly separated, contracted to a rounded apex; venation indistinct.

*Remarks*: The best preserved specimen (Pl. 2, Fig. 1) shows a characteristic ultimate pinna of this species, which attains 12 cm long and 3 cm wide. It also shows characteristic alternate and elongate tongue-shaped ultimate pinnules, which give off from the rachis with a wide angle, come into contact with each other, and have fine and dense venation. The veins are all markedly decurrent and forked repeatedly.

*Occurrence*: Plant bed A (*Parafusulina* Zone) and B (*Parafusulina* Zone).

*Material*: NSM-PP5025, PP5711, PP5714, PP5716.

***Cyclopteris* sp.**

(Pl. 5, fig. 1)

*Remarks*: The *Maiya* specimen seems to be assignable to the genus *Cyclopteris*,

because the specimen has a lateral pinnule which is borne on the main rachis of *Odontopteris subcrenulata* described above as modified pinnule. It is a well known fact that *Cyclopteris* is the name adopted to the modified pinule found on the main rachis of *Odontopteris* or *Neuropteris*. In Maiya *Neuropteris* has not been found, therefore the present specimen may be the lateral pinnule of *Odontopteris subcrenulata*.

*Occurrence*: Plant bed A (*Parafusulina* Zone).

*Material*: NSM-PP5721.

***Odontopteris yongwolensis* (KAWASAKI, 1931) n. comb.**

(Pl. 4, figs. 1–4)

*Neuropteridium?* *yongwolensis* KAWASAKI, 1931, pl. 50, fig. 129.

*Neuropteridium?* *yongwolensis*; KAWASAKI, 1934, p. 148.

*Cladophlebis* sp. aff. *C. yongwolensis*; STOCKMANS and MATHIEU, 1939, p. 84, pl. 11, fig. 5.

*Cladophlebis?* *yongwolensis*; GU and ZHI, 1974, p. 103, pl. 71, figs. 5–8; pl. 72, figs. 1–2.

KAWASAKI'S (1934) *description*: Froud simple? pinnate, linear, 20 mm wide, very slowly narrowing anteriorly, base and apex unknown, axis moderately stout, about 2 mm across. Pinnules nearly round or roundly rhomboidal, attaining 10 mm across in size, attached to the rachis with the whole wide base in anterior pinnules and with the contracted narrow base in posterior ones. Venation distinct; midrib not marked but slightly thicker than lateral veins, except near the base, markedly decurrent, not straight, but somewhat zigzag-shaped; lateral vein few, given off at a very acute angle from the midrib, the basal lateral veins originating from the markedly decurrent base of the midrib; the catadromous one often from slightly below it, repeatedly bifurcated, five times at most, strongly curved outwards and the lower branches of the anadromous one running nearly parallel to the rachis and the upper branches parallel to the other veins; the other lateral veins, usually two on each side, forked thrice at most.

*Remarks*: This species was described by KAWASAKI (1931) from the Jido Series of South Korea. The Maiya specimens are similar to that described by KAWASAKI (1931) in general form and venation arrangement of pinnae. Similar forms are recorded from the Lower Shansi Series of China, which were described by STOCKMANS and MATHIEU (1939) as *Cladophlebis* sp. aff. *C. yongwolensis*, and by GU and ZHI as *Cladophlebis?* *yongwolensis*, respectively. I do not agree with their assignment because *Cladophlebis* does not have secondary veins originating from the rachis and KAWASAKI'S species has evidently *Odontopteris*-type venation.

KAWASAKI (1931) referred this species to the genus *Neuropteridium* with query, but *Neuropteridium* possesses a simple pinnate frond and a very stout axis.

*Occurrence*: Plant bed A (*Parafusulina* Zone).

*Material*: NSM-PP5718–5720.

*Callipteridium koraiense* (TOKUNAGA, 1915) KAWASAKI, 1941

(Pl. 1, figs. 5, 6, 7b; Pl. 4, fig. 5)

*Alethopteris koraiensis* TOKUNAGA, 1915, p. 52, unnumbered text-figures.*Callipteridium koraiense*; KAWASAKI, 1931, pl. 26, fig. 44A; pl. 43, fig. 108; pl. 44, figs. 109–112; pl. 45, figs. 113–114; pl. 46, figs. 116–119; pl. 47, fig. 120A.*Callipteridium koraiense*; KAWASAKI, 1934, p. 129–134.*Callipteridium koraiense*; STOCKMANS and MATHIEU, 1939, p. 73–75, pl. 14, figs. 1, 1a, 2, 2a.*Callipteridium koraiense*; GU and ZHI, 1974, p. 122, pl. 89, figs. 1–4; pl. 90, fig. 1.*Callipteridium koraiense*; HUANG, 1976, p. 376, pl. 221, figs. 1–2.

*Description:* Ultimate pinnae are poorly known, long lanceolate in form, slightly contracted towards base, gradually narrowing into an acutely pointed, long terminal pinnule; pinnules alternate or subopposite, attached to rachis with a wide angle, more or less confluent at base, long or short triangular, more or less falcate, variable in size, usually 6–13 mm in length and 5 mm in breadth across base; nervation distinct not decurrent, having a stout midrib, giving off with a wide angle; secondary veins arising from midrib with an acute angle, forked at or near base.

*Remarks:* Four poorly preserved specimens are available for study. The characteristics described above suggest that the *Maiya* specimens are referable to *Callipteridium koraiense* (TOKUNAGA, 1915) from the Jido Series of North and South Korea.

*Occurrence:* Plant bed A (*Parafusulina* Zone).*Material:* NSM-PP5708–5710.*Aphlebia* sp.

(Pl. 3, figs. 3–4)

*Remarks:* The generic name *Aphlebia* has been used as a descriptive name for modified pinnules or stipular structures that cannot be applied to any known species described based on fronds. Two specimens are referable to the genus *Aphlebia*.

*Occurrence:* Plant bed A (*Parafusulina* Zone).*Material:* NSM-PP5722, 5723.

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### Explanation of Plates

*Locality*: Furudate, Maiya, Towa-cho, Tome-gun, Miyagi Prefecture.

*Horizon*: Plant beds A and B of Nishikori Formation, *Parafusulina* Zone, Lower Permian.

*Depository*: National Science Museum, Tokyo (NSM).

#### Plate 1

(All figures in natural size)

- Fig. 1. *Pecopteris* sp. A. NSM-PP5023 from Plant bed B.
- Fig. 2. *Pecopteris toyomaensis*, n. sp. Holotype, NSM-PP5688 from Plant bed A.
- Fig. 3. *Pecopteris* sp. B. NSM-PP5700 from Plant bed A.
- Fig. 4. *Pecopteris yabei* KAWASAKI, NSM-PP5695 from Plant bed A.
- Figs. 5–6. *Callipteridium koraiense* (TOKUNAGA) KAWASAKI. 5, NSM-PP5708d from Plant bed A. 6, NSM-PP5709 from Plant bed A.
- Fig. 7. a, *Sphenopteris* sp. b, *Callipteridium koraiense* (TOKUNAGA) KAWASAKI. c, *Asterophyllites?* sp. NSM-PP5708 from Plant bed A.
- Fig. 8. a, *Sphenopteris tenuis* SCHENK. b, *Taeniopteris oishi* ASAMA. NSM-PP5707 from Plant bed A.

#### Plate 2

(All figures in natural size)

- Figs. 1–3. *Odontopteris subcrenulata* (ROST) ZEILLER. 1a, *Odontopteris subcrenulata* (ROST) ZEILLER. 1b, *Taeniopteris* sp. NSM-PP5025 from Plant bed B. 3, NSM-PP5711 from Plant bed B.
- Figs. 4–5. *Pecopteris* sp. B. 4, NSM-PP5701. 5, NSM-PP5702 from Plant bed A.
- Figs. 6–7. *Pecopteris yabei* KAWASAKI. 6, NSM-PP5696. 7, NSM-PP5697 from Plant bed A.
- Fig. 8. *Pecopteris toyomaensis*, n. sp. Paratype, NSM-PP5690 from Plant bed A.
- Fig. 9. *Pecopteris* sp. NSM-PP5705 from Plant bed A.

**Plate 3**

(All figures in natural size)

- Fig. 1. *Odontopteris subcrenulata* (ROST) ZEILLER. NSM-PP5714 from Plant bed A.  
Fig. 2. *Pecopteris yabei* KAWASAKI. NSM-PP5698 from Plant bed A.  
Figs. 3–4. *Aphlebia* sp. 3, NSM-PP5722. 4, NSM-PP5723 from Plant bed A.

**Plate 4**

(All figures in natural size, except otherwise stated.)

The white scales on the fossil indicate 1 cm)

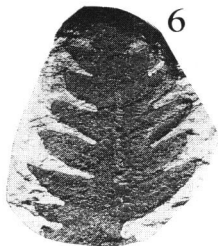
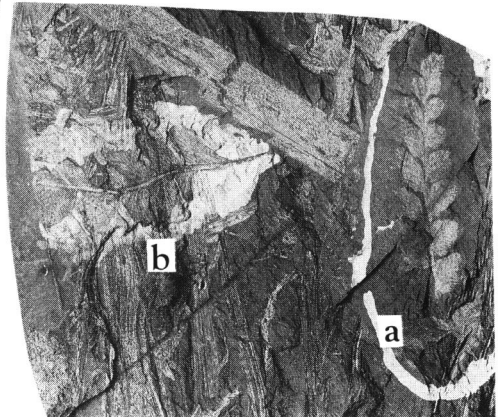
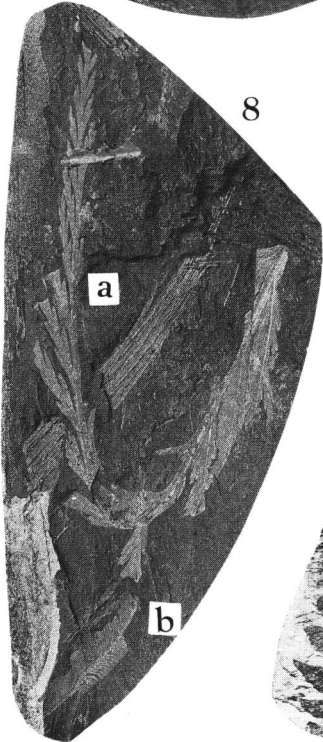
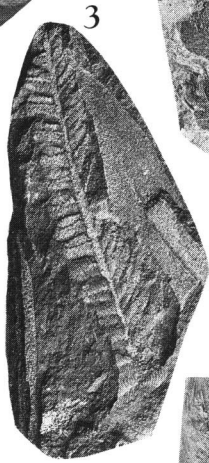
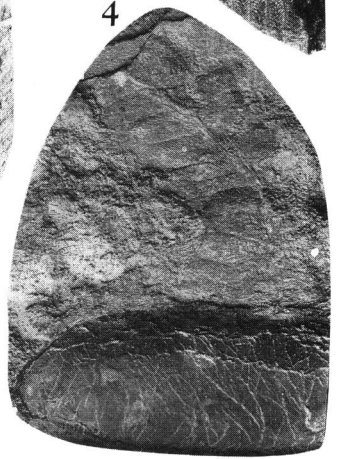
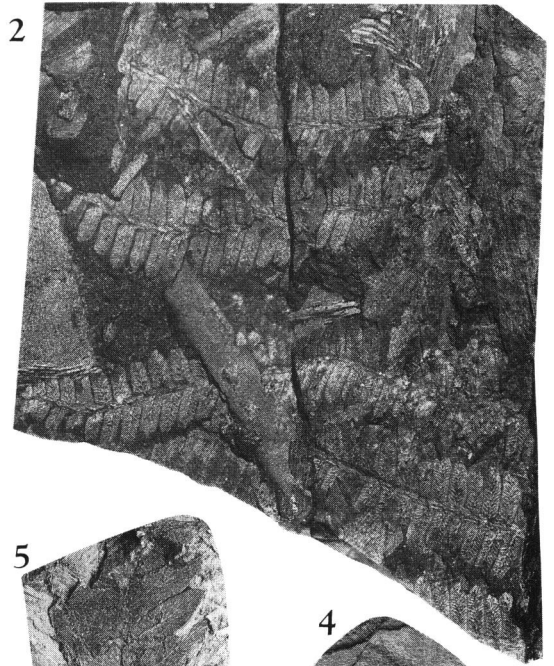
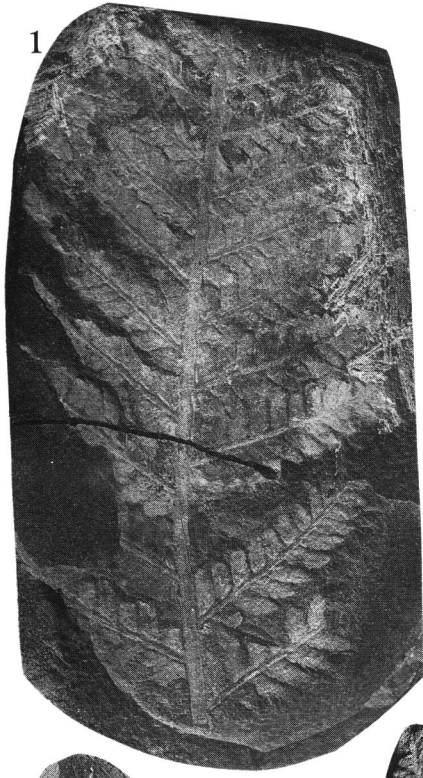
- Figs. 1–4. *Odontopteris yongwolensis* (KAWASAKI). 1, NSM-PP5718. 2, NSM-PP5718b (counterpart of Fig. 1). 3, NSM-PP5719. 4, NSM-PP5720 from Plant bed A.  
Fig. 5. *Callipteridium koraiense* (TOKUNAGA) KAWASAKI. NSM-PP5710 from Plant bed A.  
Fig. 6. *Pecopteris toyomaensis*, n. sp. Paratype, NSM-PP5691 from Plant bed A. Fig. 6a shows a part of Fig. 6.

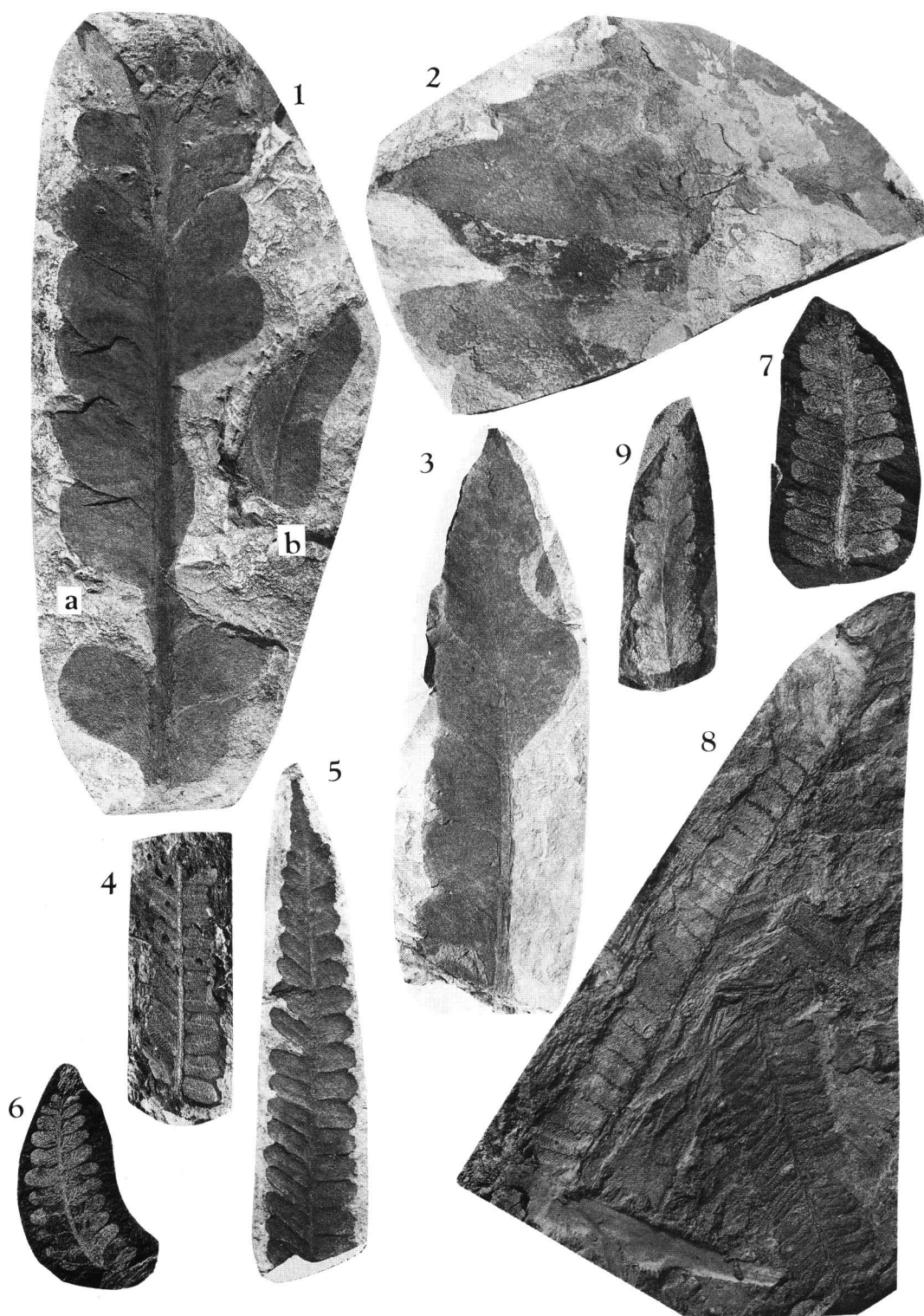
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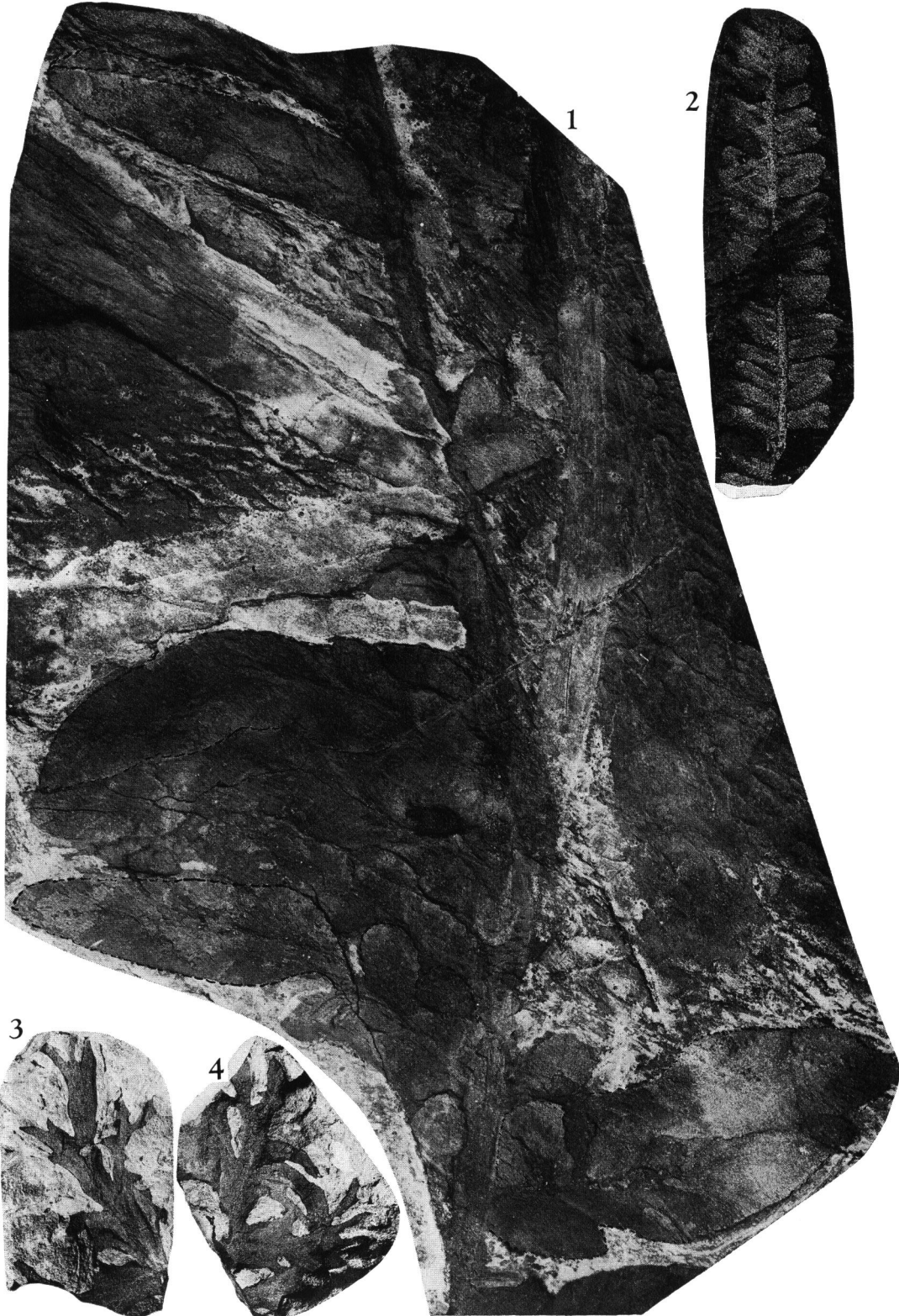
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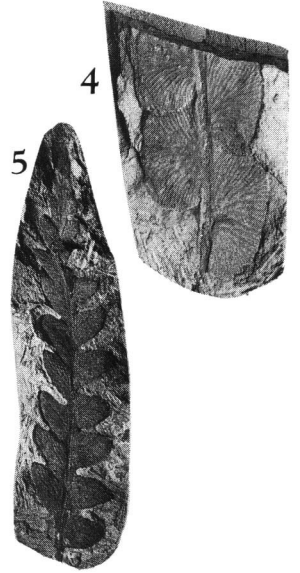
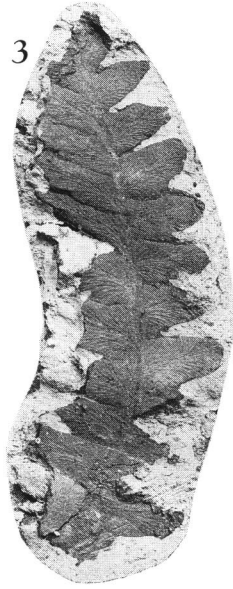
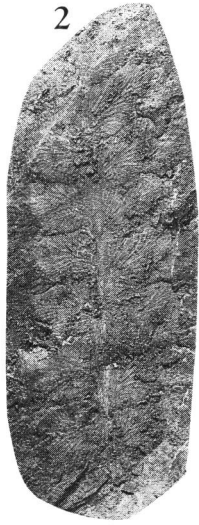
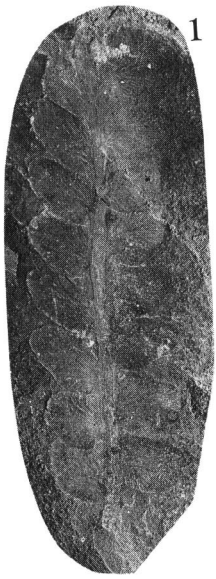
- Fig. 1. *Cyclopteris* sp. NSM-PP5721 from Plant bed A.  
Fig. 2. *Pecopteris (Asterotheca)* sp. NSM-PP5704 from Plant bed A.  
Fig. 3. *Pecopteris toyomaensis*, n. sp. Paratype, NSM-PP5692 from Plant bed A.  
Fig. 4. *Odontopteris subcrenulata* (ROST) ZEILLER. NSM-PP5716 from Plant bed A.

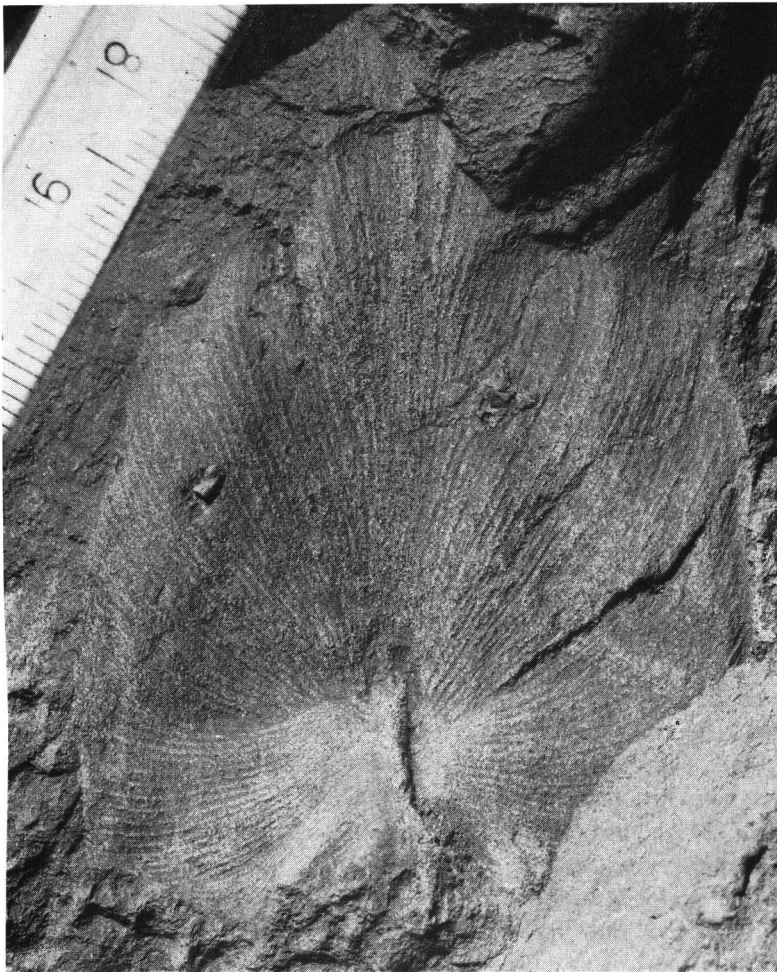










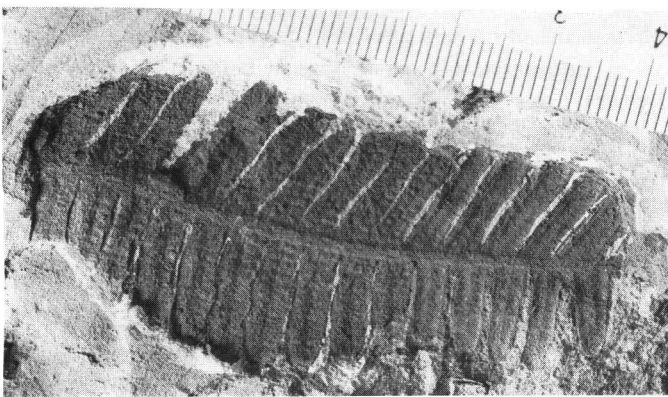
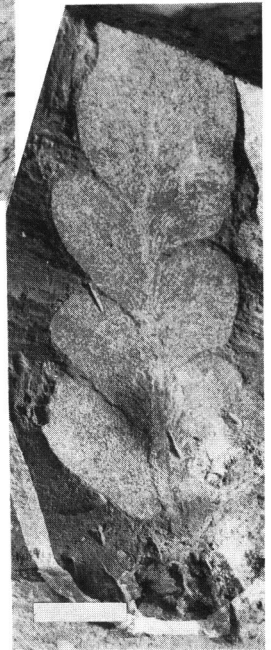


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