MIOCENE PALYNOMORPHS OF TAIWAN (IV)
—Gymnospermous grains[2]

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Abstract: Four orders, 11 families, 18 genera and 34 species of gymnospermous grains are reported. In addition, one genus, *Schizosporis* of a botanically unknown affinity is also described. In order to facilitate the identification of the Miocene gymnospermous palynomorphs, thus far found in Taiwan, a key to the genera is provided.

Order I-II Cycadales—Ginkgoales (蘇鐵目—銀杏目)
Family 1-2 CYCADACEAE—GINKGOACEAE (蘇鐵科—銀杏科)
Genus 1 **Cycadopites** Wodehouse 1933 蘇鐵狀粉屬

Grains monosulcate; ellipsoidal; 24-74 μ long, 12-20 μ wide; furrow rounded on both ends; exine psilate, less than 2 μ thick; sexine smooth.

KEY TO THE SPECIES

1. Exine 2 μ thick; grains 74×20 μ.....3. *C. longiformis*
1. Exine 1 μ thick; grains less than 60×20 μ.
   2. Grains less than 30 μ long.....1. *C. ellipticus*
   2. Grains more than 30 μ long.....2. *C. gracilis*

1. Cycadopites ellipticus *sp. nov.* 橢圓形蘇鐵狀粉 Pl. 1, Figs. 1-5.
Grains 24-30 μ long, 12-16 μ wide; exine 1 μ or less than 1 μ thick.
Locality: Shuliufen Shale Member, Miaoli County.
Slide: 54-2L, (holotype); 27-1L, 22-15L, Mm 3-2R, 1-3R, (paratypes).
Film: 37:1 (holotype); 14:12, 45:21, 23:34, 6:10 (paratypes).
Taxonomic affinity: This species is closely related to the extant species of either *Cycas* or *Ginkgo*.

2. Cycadopites gracilis W. Krutzsch Atlas der mittel-und jungtertiären dispersen Sporen-und Pollen-sowie der Mikroplanktonformen des nördlichen Mitteleuropas. Lieferung VII: 94, *Tafel 18: 1-3.* 1970. 常見蘇鐵狀粉 Pl. 1, Figs. 6-9.
Grains 35-55 μ long, 10-17 μ wide; exine 1 μ thick.
Locality: Shuliufen Shale Member, Miaoli County.
Slide: 54-2L (holotype); 10-21L, 35-1L (paratypes).
Film: 37:2L (holotype); 37:19, 43:10, 51:24 (paratypes).
Taxonomic affinity: This species is possibly related to an extant species of *Cycas*.

3. Cycadopites longiformis *sp. nov.* 長蘇鐵狀粉 Pl. 1, Fig. 10.
Grains 74 μ long, 20 μ wide; exine 2 μ thick.
Locality: Kuanyinshan Sandstone, Miaoli County.
Slide: 39-14L.
Film: 53:29.
Taxonomic affinity: Unknown.

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Order III Coniferales 松柏目
Family 1-2 CUPRESSACEAE—TAXODIACEAE 柏科—杉科

KEY TO THE GENERA

1. Grains inaperturate.
   2. Grains less than 40 μ wide, with ligula ..... *4. Sequeiapollenites*
   2. Grains more than 50 μ wide, without ligula ..... *3. Psophosphaera*
1. Grains opening bilobately or monoporate.
   3. Grains obscurely monoporate ..... *2. Inaperturopollenites*
   3. Grains opening bilobately.
      4. Grains smooth; exine psilate ..... *5. Taxodiaceaepollenites*
      4. Grains granulate; exine with verrucate processes ..... *6. Taxodiacites*

Genus 2 **Inaperturopollenites** Pflug & Thomoson in Thomoson & Pflug 1953 無溝孔類粉屬

Grains usually obscurely monoporate; spheroidal or subspheroidal; 15–35 μ wide; pores circular to elliptic, 2–4 wide; exine psilate or subpsilate, 1 μ thick.

KEY TO THE SPECIES

1. Grains 33–35 μ wide; sexine granulate ..... *4. I. concedipites*
1. Grains 15–34 μ wide; sexine wrinkled ..... *5. I. microforatus*

4. Inaperturopollenites concedipites (Wodehouse) Krutzsch, *loc. cit.* VI: 204. *Tafel 65.* 1971. 微點壁無溝孔類粉 Pl. 2, Figs. 1–3.

Grains spheroidal; 33–35 μ wide; pores 2 μ wide; exine subpsilate, 1 μ thick; sexine finely granulate.

Locality: Peliao Sandstone, Miaoli County.
Slide: 27–6L (holotype); 31–2R (paratype).
Film: 47:7 (holotype); 48:6 (isotype); 49:23 (paratype).
Taxonomic affinity: Perhaps, this species is related to the extant *Glyptostrobus* and *Cunninghamia* of the Taxodiaceae, or *Calcedrus* and *Juniperus* of the Cupressaceae.

5. Inaperturopollenties microforatus Krutzsch, *loc. cit.* VI: 220. *Tafel 63: 20–36.* 1971. 皺壁無溝孔類粉 Pl. 2, Figs. 4–7.

Grains subspheroidal; 15–34 μ wide; pores 2–4 μ wide; exine psilate, 1 μ thick; sexine wrinkled.

Locality: Talu Shale, Miaoli County.
Slide: 1–2L (holotype); 1–1L, 37–1L, 29–2R (paratypes).
Film: 3:2 (holotype), 2:2, 7:17, 1:9 (paratypes).
Taxonomic affinity: This species is closely related to the extant species of *Cunninghamia* or *Taiwania* of the Taxodiaceae.

Genus 3 **Psophosphaera** Naumova 1939 *ex* Ishchenko 1952 皺球粉屬

Grains speroidal, 56–71 μ wide, with crumpled exine, the sexine granulate.

6. Psophosphaera taiwaniana *sp. nov.* 臺灣皺球粉 Pl. 1, Figs. 11–12.

Locality: Peliao Sandstone, Miaoli County.
Slide: 34–1L (holotype), 54–3L (paratype).
Film: 50:27 (holotype), 36:14 (paratype).

Plate 1. CYCADACEAE (GINKGOACEAE), EPHEDRACEAE, ARAUCARIACEAE, ×1000. **1-5.** *Cycadopites ellipticus* Huang; **6-9.** *Cycadopites gracilis* Krutzsch; **10.** *Cycadopites longiformis* Huang; **11-12.** *Psophosphaera taiwaniana* Huang; **13-14.** *Ephedripites ellipticus* Huang; **15-18.** *Ephedripites taiwanensis* Huang.

Taxonomic affinity: It has been considered to be a member of the Araucariaceae, Cupressaceae or Taxodiaceae.

Note: This palynomorph is very similar to that of *Equisetum* except for thin crumple exine.

Genus 4 **Sequoiapollenites** Thiergart 1937 世界爺粉屬

Grains inaperturate with apiculate tip; subspheroidal; 25×35 μ; apical tip (ligula) 5×7 μ; exine psilate, 1 μ thick; sexine granulate.

7. Sequoiapollenites taiwanensis *sp. nov.* 臺灣世界爺粉 Pl. 2, Fig. 8.

Locality: Shuliufen Shale Member, Miaoli County.
Slide: 54-2L.
Film: 36:18.
Taxonomic affinity: This species is related to the extant species of *Cryptomeria*.

Genus 5 **Taxodiaceaepollenites** Kremp 1949 *ex* Potonie 1958 杉科粉屬

Grains inaperturate but bilobately open; subspheroidal; 30-40 μ wide; exine psilate, 1 μ thick; sexine smooth.

8. Taxodiaceaepollenties taiwanensis *sp. nov.* 臺灣杉科粉 Pl. 2, Figs 9-10.

Locality: Chuhuankeng Formation, Miaoli County.
Slide: 19-2R (holotype); Mw4-2L (paratype).
Film: 12:23 (holotype); 18:15 (paratype).
Taxonomic affinity: Dr. J. E. Canright (1972, 1974) considered these as pollen grains of *Metasequoia*.

Genus 6 **Taxodiacites** Botsch. 1960 in Pokrovskaya & Stelmak 杉粉屬

Grains inaperturate, but bilobately open; subspheroidal; 30-40 μ wide; exine verrucate, 1 μ thick; sexine finely granulate.

9. Taxodiacites verrucosus Botsch. in Porovskaya & Stelmak, Atlas 1960 瘤壁杉粉 Pl. 2, Figs. 11-12.

Locality: Chuhuankeng Formation, Miaoli County.
Slide: 19-2R (holotype); 27-1L (paratype).
Film: 12:31 (holotype); 13:19 (paratype).
Taxonomic affinity: This species is closely related to the extant species of *Cunninghamia* of Taxodiaceae, and fossil species of *Inaperturopollenites verrupapillatus* Trevisan (Krutzsch, *loc. cit.* VI: 206, *Tafel 66: 1-31*. 1971).

Family 3-5 AMENTOTAXACEAE—CEPHALOTAXACEAE —TAXACEAE 穗花杉科—粗榧科—紅豆杉科

Genus 7 **Monosulcites** Cookson *ex* Couper 1953 單裂溝粉屬

Grains monocolpate; subspheroidal; 25-36×21-28 μ; furrow 21-28 μ long; exine psilate, 1 μ thick; sexine granulate.

10. Monosulcites taiwanensis *sp. nov.* 臺灣單裂溝粉 Pl. 2, Figs. 13-15.

Locality: Shuliufen Shale Member, Miaoli County.
Slide: 54-2L (holotype); 37-2R (paratype).

Film: 36:29 (holotype); 37:30, 9:20 (paratypes).

Taxonomic affinity: This species is related to the extant species of *Taxus* of the Taxaceae, *Amentotaxus* of the Amentotaxaceae or *Cephalotaxus* of the Cephalotaxaceae.

Family 6 CHEIROLEPIDACEAE 手掌形鱗盾科

Genus 8 **Classopollis** Pflug 1953 emend De Jerry & Paten 1964 內環粉屬

Grains monad or tetrad; 3-colpo(ro)late.

This genus is related to the organ genus, namely to the seed cone genera of *Hermerella* and *Frenelopsis*, and to the leaves genera of *Brachyphyllum* and *Pagrophyllum* (oral communication with Dr. Bruce Cornet during 11th annual meeting, AASP at Phoenix in 1978).

KEY TO THE SPECIES

1. Grains single, free, 3-colporate.....11. *C. miaoliensis*
1. Grains grouping into tetrads, 3-colpate.....12. *C. taiwanensis*

11. Classopollis miaoliensis *sp. nov.* 苗栗內環粉 Pl. 2, Figs. 16–17.

Grains 3-colpo(ro)late; subprolate; 25–26×19–20 μ; colpi very long; ora obscure or transversally parallel; exine psilate, 1 μ thick; sexine smooth.

Locality: Kuanyinshan Sandstone, Miaoli County.

Slide: 35–3L (holotype), 40–1L (paratype).

Film: 52:14 (holotype), 53:30 (paratype).

Taxonomic affinity: An extinct member of Coniferales.

12. Classopollis taiwanensis Huang in Bot. Bull. Academia Sinica **19**: 77. 1978. 臺灣內環粉 Pl. 2, Fig. 18.

Family 7 PINACEAE 松科

KEY TO THE GENERA

1. Bladder rudimentary, circular.....15. *Zonalapollenites*
1. Bladder bisaccate.
2. Body usually less than 70 μ long or wide; shoulder pad with prominent marginal ridges.....14. *Pityosporites*
2. Body usually larger than than 70 μ long or wide; shoulder pad without marginal ridges.
3. Body longitudinally oblong-ellipitic, extending over bladders on both poles.....12. *Longicorpuspollenites*
3. Body usually transversally elliptic or subspheroidal, not longer than bladders on both poles.
4. Cap 5 μ thick.
5. Body transversally elliptic, granulate.....9. *Abiespollenites*
5. Body subspheroidal, smooth.....11. *Keteleeriaepollenites*
4. Cap 2–3 μ thick
6. Bladders acute at ends.....13. *Piceapollis*
6. Bladders rounded or flat at ends.
7. Body punctate or granulate; bladders closely attached each other on cappula.....10. *Hesperopeucepollenites*
7. Body smooth; bladders distantly attached each other on cappula.....11. *Keteleeriaepollenites*

Genus 9 **Abiespollenites** Thiergart in Raatz (1937) 1938 冷杉粉屬

Grains vesiculate; body transversally elliptic or oblong-elliptic; 34–46×70–85 μ, the cap

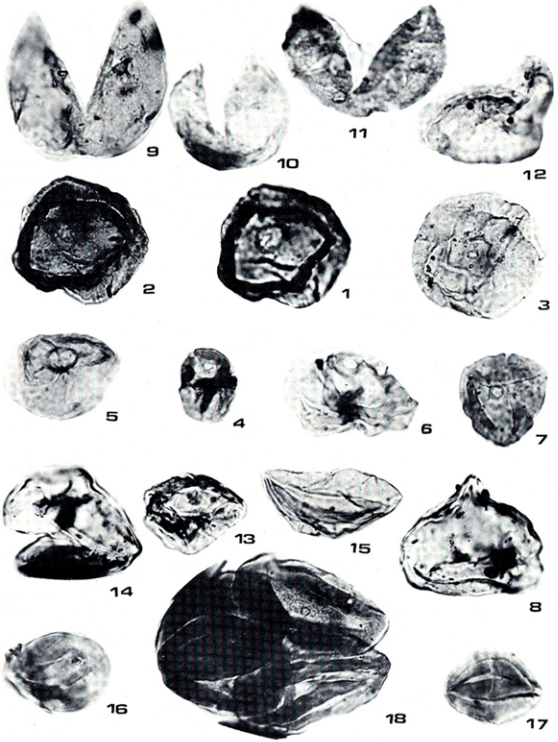


Plate 2. TAXACEAE, CUPRESSACEAE, TAXODIACEAE, CHEIROLEPIDACEAE, ×1000.

1-3. *Inaperturopollenites concedipites* (Wodehouse) Krutzsch; **4-7.** *Inaperturopollenites microforatus* Krutzsch; **8.** *Sequoiapollenites taiwanensis* Huang; **9-10.** *Taxodiaceaepollenites taiwanensis* Huang; **11-12.** *Taxodiacites verrucosus* Botsch.; **13-15.** *Monosulcites taiwanensis* Huang; **16-17.** *Classopollis miaoliensis* Huang; **18.** *Classopollis taiwanensis* Huang.

psilate or subpsilate, 1–5 μ thick, the sexine granulate; bladders 2, granulate or reticulate-granulate; 30–45 × 45–70 μ.

KEY TO THE SPECIES

1. Body elliptic; bladders vertically pendent ..... 13. *A. formosensis*
1. Body oblong-elliptic; bladders divergent ..... 14. *A. oblongus*

13. Abiespollenites formosensis *sp. nov.* 臺灣冷杉粉 Pl. 3, Figs. 1–2.

Grains transversally elliptic, 34–46 × 70–73 μ, the cap psilate, 1–3 μ thick; bladder pendent vertically from body on ventral surface, obtuse at ends.

Locality: Mushan Formation, Keelung.

Slide: Mm1–2R (holotype); Mm1–1L (paratype).

Film: 21:23 (holotype); 20:22 (paratype).

Taxonomic affinity: This palynomorph is very similar to that of *Abiespollenites* cf. *sibiriciformis* (Zaklinskaja) Krutzsch (Krutzsch 1971: 90, *Tafel 17*).

14. Abiespollenites oblongus *sp. nov.* 橫長體冷杉 Pl. 4, Figs. 1–3.

Grains transversally oblong-elliptic; 43–53 × 85–88 μ, the cap subpsilate, 2–5 μ thick; bladders widely divergent, granulate or reticulate, flately at root, broadly obtuse or rounded at ends, 30–45 × 45–72 μ.

Locality: Yutengping Sandstone Member, Miaoli County.

Slide: 58–1R (holotype); Mm1–1L, Mm1–2L (paratypes).

Film: 39:33 (holotype); 20:21, 69:4 (paratypes).

Taxonomic affinity: This species is perhaps related to *Abies mariesii* Masters. (Ueno, 1978: 170, *Pl. 26*, *Fig. Ea*).

Genus 10. **Hesperopeucepollenites** *gen. nov.* 翼鐵杉粉屬

Grains vesiculate; body elliptic, 67–69 × 83–90 μ, the exine with scabrate processes, 1 μ thick, the sexine punctate or granulate; bladders 2, closely attached to each other on cappula, 1 μ thick, 34–39 × 60–66 μ, finely reticulate.

15. Hesperopeucepollenites pattoniana *sp. nov.* 柏特翼鐵杉粉 Pl. 5, Figs. 1–2.

Locality: Mushan Formation, Keelung.

Slide: 59–1L (holotype); Mn3–2L (paratype).

Film: 79:14 (holotype), 79:15–16 (paratypes).

Taxonomic affinity: This species is related to the extant *Tsuga pattoniana* Engelm. (Ueno, 1978: 170, *Pl. 26*, *Fig. D*).

Genus 11. **Keteleeriaepollenites** Nagy 1969 油彩粉屬

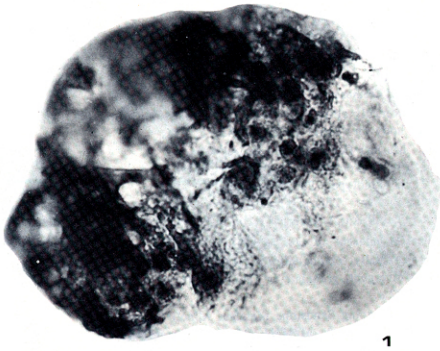
Grains vesiculate; body spheroidal or subspheroidal, 70–92 × 75–100 μ, the cap psilate or subpsilate, 3 μ thick, the sexine reticulate-granulate; bladders 2, widely attached from each other on cappula, obscurely reticulate, slightly concave at root, and convex at ends, 30–75 × 48–61 μ; furrow obscure.

16. Keteleeriaepollenites taiwanensis *sp. nov.* 臺灣油杉粉 Pl. 6, Figs. 1–2.

Locality: Mushan Formation, Keelung.

Slide: Mm1–2L (holotype); 55–1R (paratype).

Taxonomic affinity: This species is closly related to *Keteleeria davidiana* (Franchet) Boissner var. *formosana* Hayata.



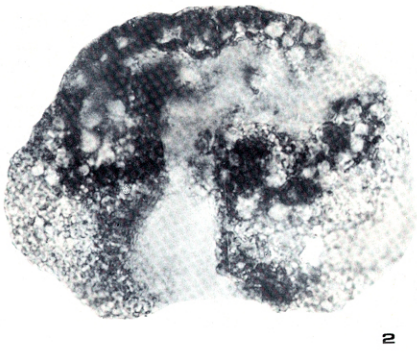


Plate 3. PINACEAE, ×1000.
1-2. *Abiespollenites formosensis* Huang.

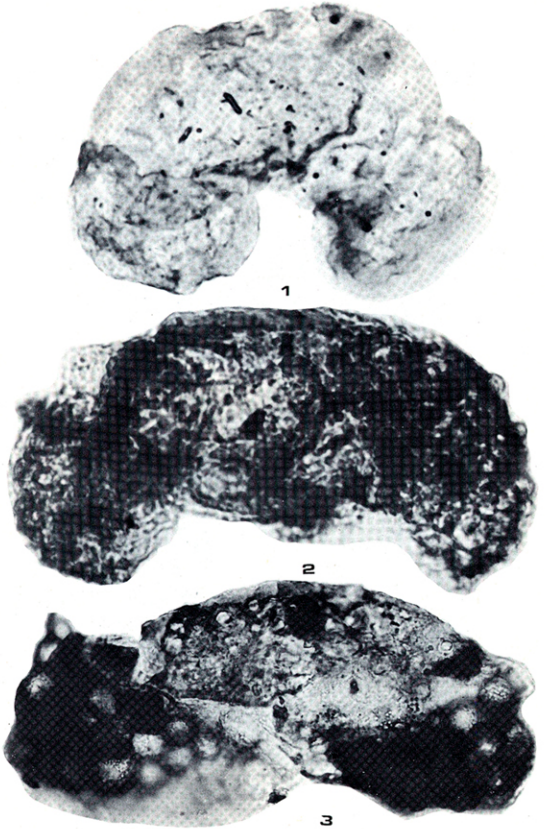
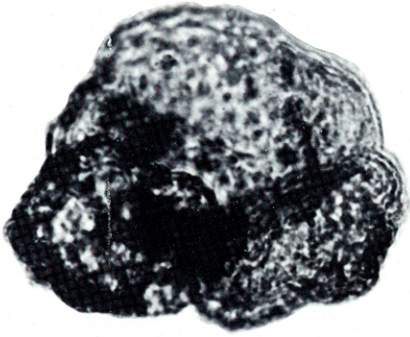


Plate 4. PINACE. ×1000.
1-3. *Ablespollenites oblongus* Huang.



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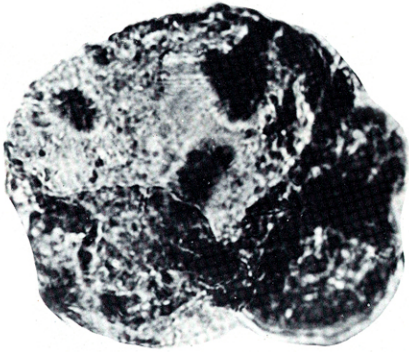

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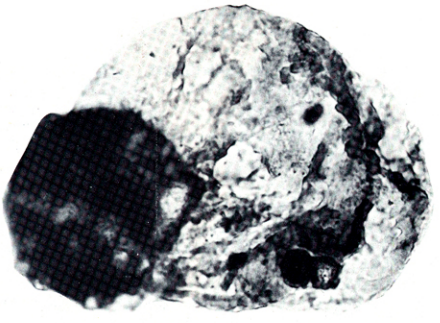
Plate 5. PINACEAE, ×1000.
1-2. *Hesperopeucepollenites pattoniana* Huang.



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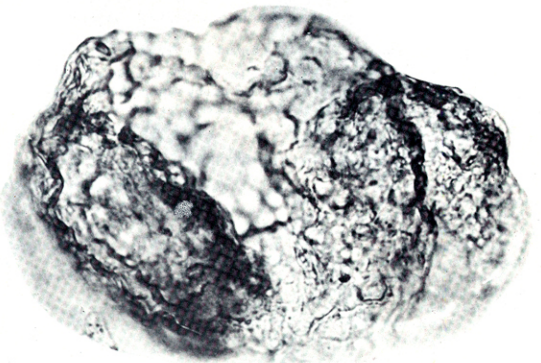

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Plate 6. PINACEAE, ×1000.
1-2. *Keteleeriaepollenites taiwanensis* Huang.

Genus 12. **Longicorpuspollenteis** *gen. nov.* 縱長體杉粉屬

Grains vesiculate; body longitudinally oblong, 102×44 μ, the cap subpsilate, 5 μ thick, the sexine granulate; bladders 2, longitudinally oblong-elliptic, 30-38×78-80 μ, the sexine granulate; furrow unknown.

17. Longicorpuspollenites taiwanensis *sp. nov.* 臺灣縱長體杉粉 Pl. 7, Fig. 1.

Locality: Kuanyinshan Sandstone, Miaoli County.

Slide: 6-10L.

Film: 53:8.

Taxonomic affinity: This species is perhaps related to *Cedripites oligocaenicus* Krutzsch, (Krutzsch, 1971: 114, *figs. 8-9*), or *Pityosporites paclovae* Krutzsch (Krutzsch 1971: 54, *figs. 1-9*).

Genus 13. **Piceapollis** Krutzsch 1971 雲杉粉屬

Grains vesiculate; body spheroidal or ellipsoidal, 70-83×83-85 μ, the cap psilate, 1-2 μ thick, the sexine granulate; bladders 2, widely divergent, reticulate-granulate, slightly rounded but not constricted at root, and acute at end, 62-70×70-72 μ.

18. Piceapollis acutosaccatus *sp. nov.* 尖囊雲杉粉 Pl. 7, Figs. 2-3.

Dacrydiumites florinii sensu Canright, Special Publication 3. Sani Institute of Paleobotany. Lucknow. India. *Pl. 1. fig. 2.* 1974, *non* Cookson & Pike.

Locality: Taliao Formation, Keelung.

Slide: TR3-3R (holotype); 51-6R (paratype).

Film: 25:29 (holotype); 35:10 (paratype).

Taxonomic affinity: This species is related to the extant *Picea morrisonicola* Hayata.

Genus 14. **Pityosporites** Seward 1914 松粉屬

Grains vesiculate; body shapes various, usually less than 60×60 μ, the cap 1-2(-3) μ thick, with scabrate or verrucate processes, the shoulder pad usually with prominent marginal ridges, the sexine usually reticulate or reticulate-granulate; bladders 2, as large as or smaller than the body, the sexine usually reticulate.

KEY TO THE SPECIES

1. Bladders enclosing whole body .....26. *P. zonalalatus*
1. Bladders as long as or shorter than the body.
   2. Body longitudinally elliptic or triangular.
      3. Body longitudinally elliptic, 44-50×35-45 μ.....19. *P. acutus*
      3. Body triangular, 20×32 μ.....24. *P. triangulatus*
   2. Body transversally elliptic, transversally oblong or spheroidal.
      4. Grains usually smaller than 30×40 μ.....21. *P. morrisonicola*
      4. Grains usually larger than 30×40 μ.
         5. Cap 2-3 μ thick
            6. Cap 2 μ thick, with scabrate processes; grains 42×45 μ.....20. *P. massoniana*
            6. Cap 2.5-3 μ thick, with verrucate processes; grains 43-48×52-60 μ.....25. *P. verrucatus*
         5. Cap 1 μ thick
            7. Grains oblong-elliptic, 20-22×48-70 μ.....22. *P. oblongus*
            7. Grains elliptic, 45-55×60-63 μ.....23. *P. scabratus*

19. Pityosporites acutus *sp. nov.* 銳體松粉 Pl. 8, Figs. 1-2.

Grains longitudinally elliptic, acute at least on one pole, with scabrate processes, 44-50×

Plate 7. PINACEAE, ×1000.
1. *Longicorpuspollenites taiwanensis* Huang. **2-3.** *Piceapollis acutosaccus* Huang.

35–45 μ, the cap 2.5–3 μ thick, the sexine reticulate; bladder elliptic, obscurely reticulate, 23–34 × 39–50 μ.

Locality: Mushan Formation, Keelung.

Slide: Mm1–1R (holotype); Mm1–2L (paratype).

Film: 21:11 (holotype); 20:30 (paratype).

Taxonomic affinity: This species is related to the extant *Pinus*.

Note: In this species the shape of the body is acute.

20. Pityosporites massoniana *sp. nov.* 馬尾松粉 Pl. 8, Figs. 3–4.

Pinuspollenites sp. Canright, *loc. cit. Pl.* 1, *fig.* 4, 1974.

Grains subspheroidal, 42 × 45 μ, the cap with scabrate processes, 2 μ thick. the sexine reticulate-granulate; bladders subspheroidal, flat at root, round at ends, finely reticulate, 28–31 × 38–42 μ; furrow granulate.

Locality: Sangfuchi Sandstone,Miaoli County.

Slide: 47–7L.

Film: 30: 24–26.

Taxonomic affinity: This species is closely related to the extant *Pinus massoniana* Lambert.

21. Pityosporites morrisonicola *sp. nov.* 玉山松粉 Pl. 8, Figs. 5–7.

Grains transversally elliptic, 24–28 × 35–38 μ, the cap with scabrate or verrucate processes, 1–5 μ thick, with marginal ridges on the shoulder pads, the sexine reticulate; bladders subspheroidal, 24–29 × 24–32 μ, reticulate.

Locality: Mushan Formation, Keelung.

Slides: Mm1–1R (holotype); 59–1L, Mm1–2L (paratypes).

Film: 21:5 (holotype); 42:1, 21:37 (paratypes).

Taxonomic affinity: This species is closely related to the extant *Pinus morrisonicola* Hayata and *Pinus thunbergii* Parl. (Ueno, 1978: 169, *fig.* **23**: *A–F*), and also to the fossil species of *Pityosporites scopuliptes* (Wodehouse) Krutzsch (Krutzsch, 1971:72, *Tafel 10*).

22. Pityosporites oblongus *sp. nov.* 橫長體粉 Pl. 9, Figs. 1–2.

Grains transversally oblong-elliptic, 20–22 × 48–70 μ, the cap with verrucate-scabrate processes, 1 μ thick, the sexine reticulate; bladders 2, subspheroidal, reticulate, 24–35 × 27–36 μ.

Locality: Kuanyinshan Sandstone, Miaoli County.

Slide: 35–2L (holotype); 38–5R (paratype).

Film: 52:4 (holotype); 53:7 (paratype).

Taxonomic affinity: This species is related to the extant *Pinus* species.

23. Pityosporites scabratus *sp. nov.* 波緣體松粉 Pl. 9, Figs. 3–4.

Grains transversally elliptic, 45–55 × 60–63 μ, the cap with scabrate or verrucate processes, 1 μ thick, the sexine finely reticulate; bladders subspheroidal, concave at root, convex at end, reticulate, 29–52 × 40–52 μ; furrow granulate.

Locality: Shuliufen Shale Member, Miaoli County.

Slide: 55–3R (holotype); 55–5R (paratype).

Film: 39:12 (holotype); 29:1 (paratype).

Taxonomic affinity: This species is closely related to the extant *Pinus taiwanensis* Hayata.

24. Pityosporites triangulatus *sp. nov.* 三角體松粉 Pl. 10, Figs. 1–2.

Grains triangular, 20 × 32 μ, the cap subpsilate or with scabrate processes, 1 μ thick, the sexine granulate; bladder oblong, rounded on both roots and ends, granulate, 24–25 × 21–24 μ.

Locality: Chuhuankeng Formation, Miaoli County.

Slide: 19–9L.

Film: 44: 32–33.

Taxonomic affinity: This species is related to the extant *Pinus* species.

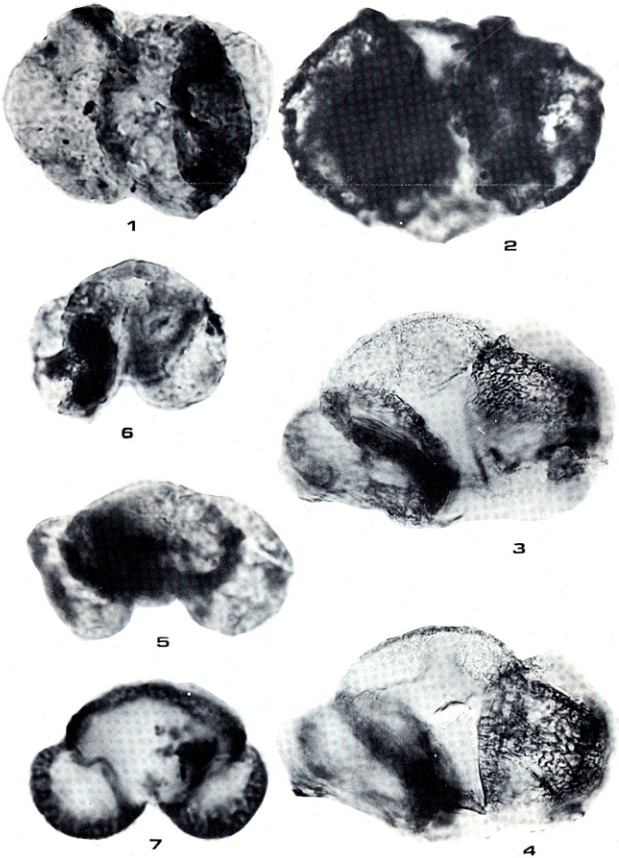


Plate 8. PINACEAE, ×1000.
1-2. *Pityosporites acutus* Huang; 3-4. *Pityosporites massoniana* Huang;
5-7. *Pityosporites morrisonicola* Huang.

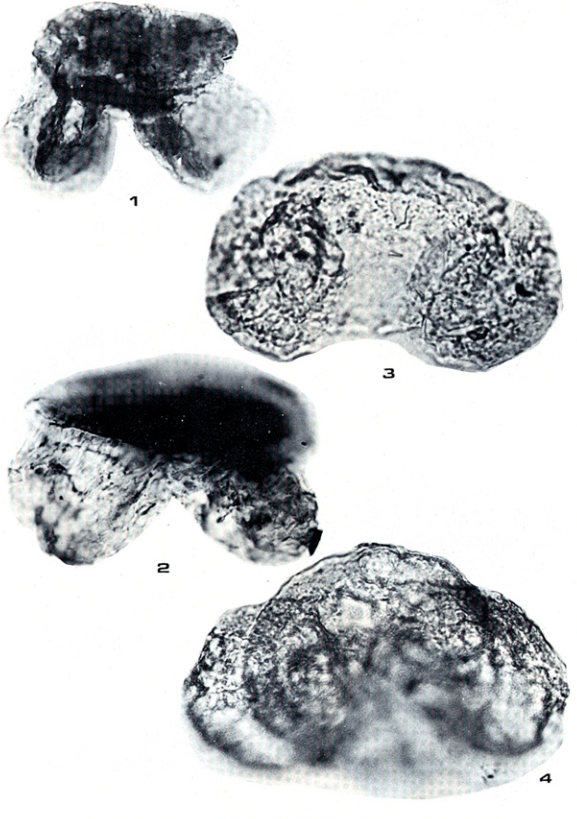


Plate 9. PINACEAE. ×1000.
1-2. *Pityosporites oblongus* Huang; 3-4. *Pityosporites scabratus* Huang.

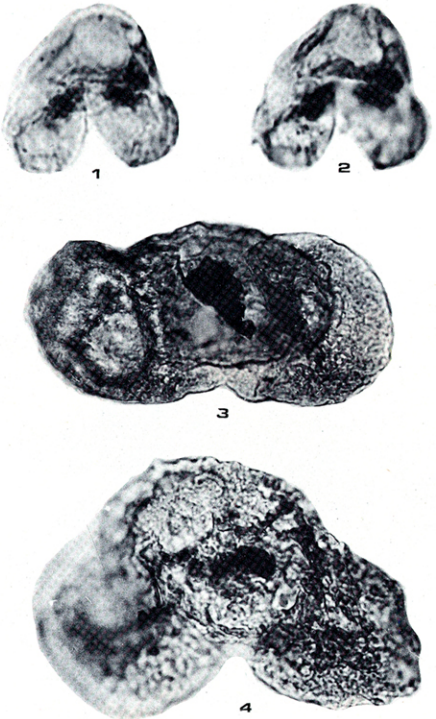


Plate 10. PINACEAE, ×1000.
1-2. *Pityosporites triangulatus* Huang; **3-4.** *Pityosporites verrucatus* Huang.

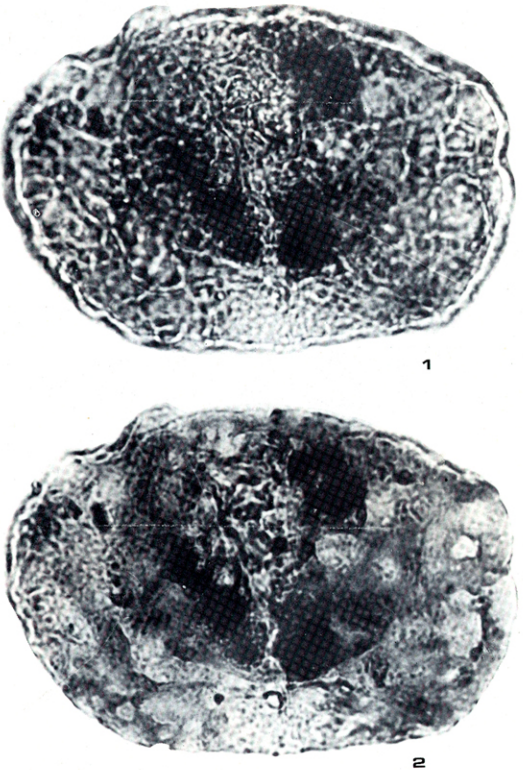


Plate 11. PINACEAE, ×1000.
1-2. *Pityosporites zonalalatus* Huang.

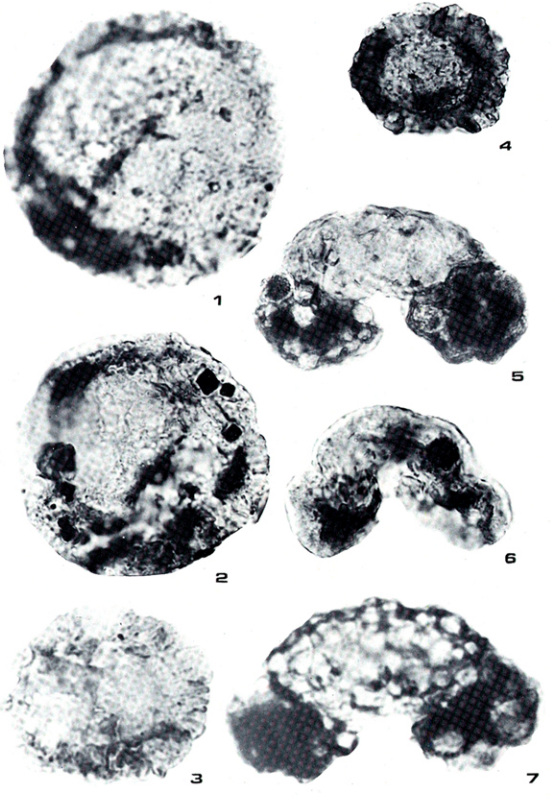


Plate 12. PINACEAE, PODOCARPACEAE, ×1000.
1-2. *Zonalapollenites chinensis* Huang; 3-4. *Zonalapollenites taiwanensis* Huang;
5-7. *Podocarpites beugii* Huang.

25. Pityosporites verrucatus *sp. nov.* 齒緣體松粉 Pl. 10, Figs. 3-4.

Grains spheroidal to transversally elliptic, 43-48 × 52-60 μ, the cap with verrucate processes, 2.5-3 μ thick, the sexine reticulate-granulate; bladders subspheroidal, concave at root, convex at end, reticulate, 29-42 × 40-52 μ; furrow granulate.

Locality: Shuliufen Shale Member, Miaoli County.

Slide: 55-2L (holotype); 55-5R (paratype).

Film: 38:14 (holotype); 39:1 (paratype).

Taxonomic affinity: This species is related with the extant species of *Pinus*.

26. Pityosporites zonalalatus *sp. nov.* 環翼松粉 Pl. 11, Figs. 1-2.

Grains vesiculate; body subspheroidal, 66 × 70 μ, the cap subpsilate or with scabrate processes, 2 μ thick, the sexine granulate; bladders 2, reticulate, 52-57 × 80 μ.

Locality: Mushan Formation, Keelung.

Slide: Mm1-2L.

Film: 79: 19-20.

Taxonomic affinity: This species is related to the fossil species of *Pityosporites alatus* (R. Pot.) Tu. & Pf. (Krutzsch 1971: 51, *Tafel 2*).

Genus 15. **Zonalapollenites** Pflug in Thomoson & Pflug 1953 環翼鐵杉粉屬

Grains spheroidal, with circular, rudimentary bladder.

KEY TO THE SPECIES

1. Bladder with echinate processes ..... 27. *Z. chinensis*
1. Bladder with scabrate processes ..... 28. *Z. taiwanensis*

27. Zonalapollenites chinensis Huang *sp. nov.* 中國環翼鐵杉粉 Pl. 12, Figs. 1-2.

Tsugaepollenites enigmatus sensu Canright *loc. cit. Pl. 1, fig. 3.* 1974, *non* Singh & Kumar.

Grains 58-73 μ wide, irregularly granulate; bladder 5-12 μ thick, the margin irregularly undulate, with remotely and sparsely echinate processes, the echini about 1 μ long.

Locality: Mushan Formation, Keelung.

Slide: Mm1-L (holotype); 37-2R (paratype).

Film: 20:1 (holotype); 9:16 (paratype).

Taxonomic affinity: Perhaps, this is the same taxon as *Tsuga chinensis*, (Franchet) Pritzel *ex* Diels var. *formosana* (Hayata) Li & Keng (Huang: 1971: *Pl. 2, fig. 7*).

Note: The same palynomorphs are found abundantly through the range of Miocene, however the size of the grains vary greatly.

28. Zonalapollenites taiwanensis *sp. nov.* 臺灣環翼鐵杉粉 Pl. 12, Figs. 3-4.

Grains 30-50 μ; bladder 5-10 μ thick, the margin radiate-reticulate, with scabrate processes.

Locality: Mushan Formation, Keelung.

Slide: Mm3-2R (holotype); 28-1L (paratype).

Film: 23:29 (holotype); 1:26 (paratype).

Taxonomic note: These palynomorphs are similar to those of the species *Zonalapollenites igniculus* (R. Pot) Tu. & Pf. (Krutzsch 1971: 39, *Tafel 37*).

Family 8 PODOCARPACEAE 羅漢松科

KEY TO THE GENERA

1. Sexine radiate reticulate ..... 16. *Dacrydimites*
1. Sexine reticulate ..... 17. *Podocarpidites*,

Genus 16 **Dacrydimites** Cookson *ex* Harrir 1965 陸均松粉屬

Grains transversally elliptic, 32×38 μ, the cap with verrucate processes, 1 μ thick, the sexine reticulate; bladders rudimentary circularly verrucate; furrow 25 μ long.

29. Dacrydimites taiwanensis *sp. nov.* 臺灣陸均松粉 Pl. 13, Figs. 1-2.

Locality: Sangfuchi Sandstone, Miaoli County.

Slide: 47-1R.

Film: 30:14.

Taxonomic affinity: This species is closely related to the extant *Podocarpus elatus* R. Br. (Ueno, 1978: 173, *fig.* 45).

Note: This taxon was suggested by Dr. H. A. Martin during the 11th Annual Meeting of AASP in October, 1978 at Phoenix.

Genus 17 **Podocarpidites** Cookson *ex* Couper 1953 羅漢松粉屬

Grains bi- to tri-saccate; body usually angular shape, the cap 1-3 μ thick, with scabrate or verrucate processes, the sexine usually reticulate; bladders as large as or larger than body.

KEY TO THE SPECIES

1. Bladders 3 ..... 32. *P. trisaccatus*
1. Bladders 2
   2. Body transversally elongate, oblong-elliptic, the ratio between width and length of the body more than three times ..... 30. *P. beugii*
   2. Body subspheroidal, the ratio between width and length of the body less than one and half times ..... 31. *P. taiwanensis*

30. Podocarpidites beugii *sp. nov.* 波義羅漢松粉 Pl. 12, Figs. 5-7.

Grains transversally oblong-elliptic, 21×60 μ, the cap with remotely scabrate processes, 1-1.5 μ thick, the sexine granulate or reticulate; bladders 2, subspheroidal, pendent, reticulate, 22-25×30-32 μ.

Locality: Mushan Formation, Keelung.

Slide: Mm1-2L (holotype); Mn1-1L, 40-3R (paratypes).

Film: 22:9 (holotype); 20:6, 53:36 (paratypes).

Taxonomic affinity: This species is related with the extant *Podocarpus elongatus* (Arr.) L'Merit (Ueno, 1978: 173, *fig. 37*), and the fossil taxon of *Diplosacculiana semplissima* Maij. (Jansonius & Hills, 1976: 807).

Note: The preliminary observation of the Miocene palynomorphs of Taiwan was done at the laboratory of Prof. Dr. H. J. Beug, Abteilung für palynologie der Universität Göttingen, West Germany. This species is name after Prof. Dr. H. J. Beug for his kind help.

31. Podocarpidites taiwanensis *sp. nov.* 臺灣羅漢松粉 Pl. 13, Figs. 3-4.

Grains rhomboidal, or 6-angulate, acute at both ends or roots, 25×45 μ, the cap with verrucate processes, 1-3 μ thick, the sexine reticulate; bladders 2, subspheroidal, reticulate, 21-30×30-45 μ wide; furrow oblong-elliptic, granulate.

Locality: Mushan Formation, Keelung.

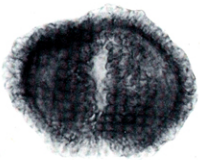
Slide: Mn1-2L (holotype); 27-1L (paratype).

Film: 20:16 (holotype); 13:22 (paratype).

Taxonomic affinity: This species is related with the extant *Podocarpus* species.

32. Podocarpidites trisaccatus *sp. nov.* 參翼羅漢松粉 Pl. 13, Figs. 5-6.

Grains spheroidal, 28-32 μ wide, the furrow obscure; bladders 3, reticulate, 20-25×29-32 μ.



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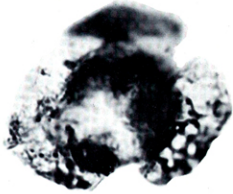

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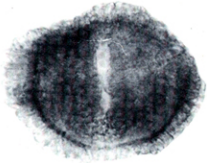

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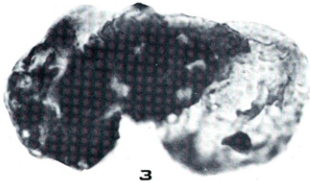

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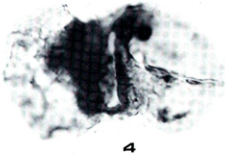

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Plate 13. PODOCARPACEAE, X1000.
1-2. *Dacrydimites taiwanensis* Huang; **3-4.** *Podocarpites taiwanensis* Huang; **5-6.** *Podocarpites trisaccatus* Huang.

Locality: Mushan Formation, Sanhsia, Taipei County.
Slide: Mm1-2R (holotype).
Film: 34:6-7.
Taxonomic affinity: This species is closely related with the *Podocarpus dacryoides* A. Richard (Ueno, 1978: 173, *fig. 21*) or *P. vieillardii* Parl. (Ueno, 1978: 173, *fig. 23*).

Order IV Gnetales

Family 1 EPHEDRACEAE

Genus 18 **Ephedripites** Bolkh. 1953 *ex* R. Pot. 1958 emend. Krutzsch 1961 麻黃粉屬

Grains perprolate to prolate; ridges 6-8; exine psilate; sexine smooth.

KEY TO THE SPECIES

1. Grains prolate, 30×19 μ.....33. *E. ellipticus*
1. Grains perprolate, 42-48×12-16 μ.....34. *E. taiwanensis*

33. cf. **Ephedripites ellipticus** *sp. nov.* 橢圓麻黃粉 Pl. 1, Figs. 13-14.

Grains prolate; 30×19 μ; ridges 6-7, 2-5 μ wide; grooves 1 μ wide.
Locality: Shuliufen Shale Member, Miaoli County.
Slide: 54-2R.
Film: 37:37-38.
Taxonomic affinity: Possibly this species is a member of the *Ephedrus*.

34. cf. **Ephedripites taiwanensis** Huang Journ. Jap. Palynology 18:76. 1976. 臺灣麻黃粉 Pl. 1, Figs. 15-18.

Grains perprolate, 42-48×12-16 μ; ridges 6-8, 1-2.5 μ wide; grooves 0.5-1 μ wide.
Locality: Shuliufen Shale Member, Miaoli County.
Slide: 54-2R (holotype); 28-1L, 37-4R.
Film: 37:36 (holotype), 36:37 (isotype); 48:15, 14:37.
Taxonomic affinity: Possibly this species belongs to a member of the *Ephedrus*.

Order V Incertae 不定目

Genus 19 **Schizosporis** Cookson & Dettman 1959 半裂圓孢粉屬

Grains spheroidal, open bilobately, 96-120 μ; exine prominently two layered, psilate, 3-5 μ thick; sexine nearly smooth, or obscurely granulate.

35. **Schizosporis taiwanensis** *sp. nov.* 臺灣半裂圓孢粉 Pl. 14, Figs. 1-2.

Locality: Taliao Formation, Keelung.
Slide: TR4-1R (holotype); 51-6L (paratype).
Film: 25:39 (holotype); 35:8 (paratype).
Taxonomic affinity: Botanical affinity is unknown. However, these palynomorphs are similar to the extant megaspores of Selaginellaceae or homospores of Equisetaceae.
Note: Canright (1974: 122, *Pl. 1, Fig. 5*), reported the presence of *Schizospores cf. parvus* Cookson & Dettman. Only based on the pictures, the present species differs from the latter by their larger size and smooth exine.

36. **Schizosporis** cf. **parvus** Cookson & Dettman in Canright, *loc. cit. pl. 1. fig. 5. 1974.* 小半裂圓孢粉

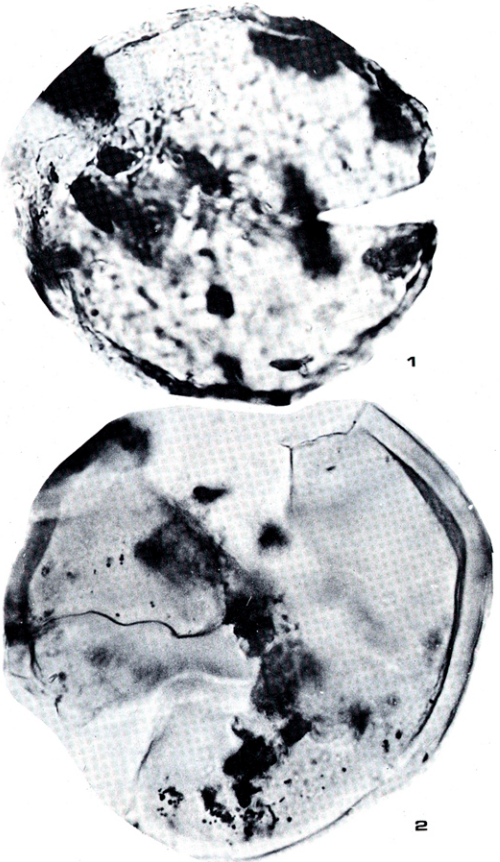

Plate 14. INCERTAE, ×1000.
1-2. *Schizosporis taiwanensis* Huang.

KEY TO THE GENERA OF GYMNOSPERMOUS GRAINS

1. Grains inaperturate, monosulcate, monoporate or 3-colporate
   2. Grains inaperturate
      3. Graina apiculate or ridged
         4. Grains apiculate.....4. *Sequoiapollenites*
         4. Grains ridged.....18. *Ephedripites*
      3. Grains neither apiculate nor ridged
         5. Grains usually with crumpled exine, more, more than 50 μ wide .....3. *Psophosphaera*
         5. Grains usually bilobately open
            6. Grains less than 50 μ wide
               7. Sexine smooth .....5. *Taxodiaceaepollenites*
               7. Sexine granulate .....6. *Taxodiacites*
            6. Grains morre than 50 μ wide.....19. *Schizosporis*
   2. Grains monosulcate, monoporate or 3-colporate
      8. Grains tetrad, or 3-colporate .....8. *Classopollis*
      8. Grains monad, monosulcate or monoporate
         9. Graina obscurely monoporate .....2. *Inaperturopollenites*
         9. Grains monosulcate
            10. Sexine smooth; furrow usually rounded on both ends.....1. *Cycadopites*
            10. Sexine granulate; furrow usually straight.....7. *Monosulcites*
1. Grains saccate
   11. Bladders rudimentary circular
      12. Sexine granulate .....15. *Zonalapollenites*
      12. Sexine radiate reticulate.....16. *Dacrydimites*
   11. Bladders prominently sacate
      13. Bladders 3 .....17. *Podocarpidites*
      13. Bladders 2
         14. Body usually less than 70 μ long or wide; shoulder pad with prominent marginal ridges
            15. Body usually larger than bladders .....14. *Pityosporites*
            15. Body usually smaller than bladders.....17. *Podocarpidites*
         14. Body usually larger than 70 μ long or wide; shoulder pad without marginal ridges
            16. Body longitudinally oblong-elliptic, extending over bladders on both poles.....
            .....12. *Longicorpuspollenites*
            16. Body usually transversally elliptic or subspheroidal, not longer than bladders on both poles
               17. Cap 5 μ thick
                  18. Body transversally elliptic, granulate.....9. *Abiespollenites*
                  18. Body subspheroidal, smooth.....11. *Keteleeriaepollenites*
               17. Cap 2-3 μ thick
                  19. Bladders acute at ends .....13. *Piceapollis*
                  19. Bladders rounded or flat at ends
                     20. Body punctate or granulate; closely attached to each other on cappula
                     .....10. *Hesperopeucepollenites*
                     20. Body smooth; bladders distantly attached from each other on cappula
                     .....11. *Keteleeriaepollenites*

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