Taiwania, **45**(1): 13-29, 2000

Eocene Gymnospermous Palynomorphs of Taiwan

Cheng-Long Shaw[1]

(Manuscript received 22 October, 1999; accepted 30 November, 1999)

ABSTRACT: Thirty-two fossil gymnospermous taxa from Eocene of offshore Keelung area, northern Taiwan are described. They belong to two oders, four families and five form genera. Two new species (*Taxodiaceaepollenites pengchiahsuensis* C. L. Shaw *sp. nov.; Pityosporites pengchiahsuensis* C. L. Shaw *sp. nov.*) and one new variety (*Taxodiacites verrucosus* Botsch *minor* C. L. Shaw *var. nov.*) are described.

KEY WORDS: Eocene, Gymnospermous palynomorphs, Taxonomy.

INTRODUCTION

This paper is the seven installment of the palynological report describing the gymnospermous flora from wells drilled in offshore Keelung in northern Taiwan. The previous installments includes reporting Tiliaceous palynomorphs (Shaw, 1997), Ephedraceous (Shaw, 1998), Wetzeliellaceous dinoflagellate (Shaw, 1999a), fossil dinocysts (Shaw, 1999b), pteridophytic palynomorphs (Shaw, 1999c), and angiospermous palynomorphs (Shaw, 1999d). More reports which deal with the taxonomy and complete checklist will come in the immediate future. Palynomorphic nomenclature in this paper, the artificial form genera system was adopted.

MATERIALS AND METHODS

Cores samples from the OK-1, OK-2, OK-3, (Shaw, 1999a) YKL-6, YKL-3 and YKL-1 (Shaw, 1996) wells from offshore Keelung in northern Taiwan were made available. A total of fifty-five cores and one cutting sample were prepared by the Chinese Petroleum Corporation Micropaleontological Laboratory for a palynological study.

The palynomorph extraction method followed Shaw (1990), including the treatment of 10% KOH for the dissolution of humic material. Heavy solution of $ZnCl_2$ for floatation (S. G. 1.8-2.2) and also 30% of HCl, 52% of HF were used for maceration of the laterite pebble samples, which were collected from six exploration wells.

Photomicrographs were taken with a Zeiss universal microscope equipped with an automatic camera using Kodak Panatomic X (16 DIN) film. For fossil identification, the standard references used by Krutzsch (1971), Jansonius and Hills (1976), Huang (1976, 1979, 1981), Chaw (1980), Sung and Tsao (1978), Zhu, *et al.* (1985), were adopted. The fossil slides are catalogued and stored at the Micropaleontology Laboratory, Chinese Petroleum Corporation.

1. National Museum of Prehistory Planning Bureau, Taitung 950, Taiwan, R.O.C.

RESULTS AND DISCUSSION

Accurate taxonomic treatment is important for biostratigraphy. As an on-going effort building up our knowledges of the Eocene microflora of Taiwan, this paper deals with the gymnospermous palynomorphs. Thirty-two taxa are described. They belong to two oders, four families and five form genera. Two new species (*Taxodiaceaepollenites pengchiahsuensis* C. L. Shaw *sp. nov.*; *Pityosporites pengchiahsuensis* C. L. Shaw *sp. nov.*) and one new variety (*Taxodiacites verrucosus* Botsch *minor* C. L. Shaw *var. nov.*) are described. They are listed as below:

Order I Coniferales

Family 1 Taxodiaceae

1. *Taxodiaceaepollenites taiwanensis* T. C. Huang 1979
2. *Taxodiaceaepollenites pengchiahsuensis* C. L. Shaw *sp. nov.*
3. *Taxodiacites verrucosus* Botsch *minor* C. L. Shaw *var. nov.*

Family 2 Pinaceae

1. *Pityosporites verrucatus* T. C. Huang 1979
2. *Pityosporites massoniana* T. C. Huang 1979
3. *Pityosporites morrisonicola* T. C. Huang 1979
4. *Pityosporites pengchiahsuensis* C. L. Shaw *sp. nov.*
5. *Pityosporites scabratus* T. C. Huang 1979
6. *Pityosporites triangulatus* T. C. Huang 1979

Family 3 Podocarpaceae

1. *Podocarpidites taiwanensis* T. C. Huang 1979

Order II Gnetales

Family 1. Ephedraceae

1. *Ephedripites* (*D.*) *eocenipites var. formosensis* C. L. Shaw 1998
2. *Ephedripites* (*D.*) *parafusiformis*. Z. Zhu & L. Wu 1985 *var. taiwanensis* C. L. Shaw 1998
3. *Ephedripites* (*D.*) *scabridus* Z. C. Song & Y. Zheng 1981
4. *Ephedripites* (*D.*) *formosanus* C. L. Shaw 1998
5. *Ephedripites* (*D.*) *fushunensis* T. Sung & L. Tsao 1978
6. *Ephedripites* (*D.*) *fushunensis* T. Sung & L. Tsao 1978 *var. minimus* C. L. Shaw 1998
7. *Ephedripites* (*D.*) *baculatus* Z. Zhu et L. Wu 1985
8. *Ephedripites* (*D.*) *miocenus* T. C. Huang & S. M. Chaw 1981
9. *Ephedripites* (*D.*) *quadriplicatus* C. L. Shaw 1984
10. *Ephedripites* (*D.*) *membranus* C. L. Shaw 1998
11. *Ephedripites* (*D.*) *nanlingensis* X. Sun & J. M. He 1980
12. *Ephedripites* (*E.*) *gracilis* C. L. Shaw 1998
13. *Ephedripites* (*E.*) *taiwanensis* T. C. Huang 1976
14. *Ephedripites* (*E.*) *angularis* C. L. Shaw 1998
15. *Ephedripites* (*E.*) *scabratus* C. L. Shaw 1998
16. *Ephedripites* (*E.*) *minor* C. L. Shaw 1998
17. *Ephedripites* (*E.*) *olivaeformis* C. L. Shaw 1998
18. *Ephedripites* (*E.*) *polyplicatus* C. L. Shaw 1998
19. *Ephedripites* (*S.*) *perprolatus* C. L. Shaw 1998
20. *Ephedripites* (*S.*) *pengchiahsuensis* C. L. Shaw 1998

21. *Ephedripites* (*S.*) *densistriatus* C. L. Shaw 1998
22. *Ephedripites* (*S.*) *tenuissimus* C. L. Shaw 1998

SYSTEMATIC TAXONOMIC TREATMENT

Order I Coniferales
Family1 Taxodiaceae
Genus 1. Taxodiaceaepollenites Kremp 1949 ex Potonie 1958

1. Taxodiaceaepollenites taiwanensis T. C. Huang 1979 Figs. 7-16

Selected slide: Figs. 7-8. OK-1, 1501m-1, P12-3-5, P12-4-6, 25 x 28 μm. Figs. 9-10. OK-1, 1545m-2, P12-17-18, P12-18-19, 27 x 33 μm, Figs. 11-12. OK-1, 1348m-1, P12-33-34, P12-34-35, 25 x 29 μm, Figs. 13-14. OK-1, 1669m BL-2, P6-14-16, P6-13-15, 21 x 28 μm. Figs. 15-16. OK-1, 1719m-2, P15-35-37, P15-34-36, 36 x 37 μm; CPC Micropaleontology Lab.

Description: Grains inaperturate but bilobately open; subspheroidal; 25-40 μm wide; exine psilate to subpsilate, 1 μm thick; sexine smooth to obscure pattern.

Stratigraphic occurrence: Eocene (OK-1 well, 1348m, 1501m, 1545m, 1669m, 1719m).

Taxonomic affinity: Dr. J. E. Canright (1971, 1974) considered these as pollen grains of *Metasequoia*.

2. Taxodiaceaepollenites pengchiahsuensis C. L. Shaw sp. nov. Figs. 24-25

Holotype: Slide YKL-3, 1360m-8, KD23-12, 13, 21-23 μm; CPC Micropaleontology Lab.

Description: Grains inaperturate but bilobately open; subspheroidal; 18-24 μm wide; exine psilate, 1μm thick; sexine smooth.

Stratigraphic occurrence: Eocene (YKL-3 well, 1360m).

Taxonomic affinity: This species is closely related to the extant species of *Metasequoia*.

Genus 2. Taxodiacites Botsch. 1960 in Pokrovskaya & Stelmak

1. Taxodiacites verrucosus Botsch **minor** C. L. Shaw var. nov. Figs. 1-6

Holotype: Figs. 1-2. Slide OK-1, 1501m-1, P12-8-9, P12-9-10, 19-23 μm. Paratype: Figs. 3-4. OK-1, 1348m-1, P13-9-11, P13-10-12, 18-25 μm. Figs. 5-6. OK-1, 1365m-1, P14-3-4, P14-4-5, 22-27 μm; CPC Micropaleontology Lab.

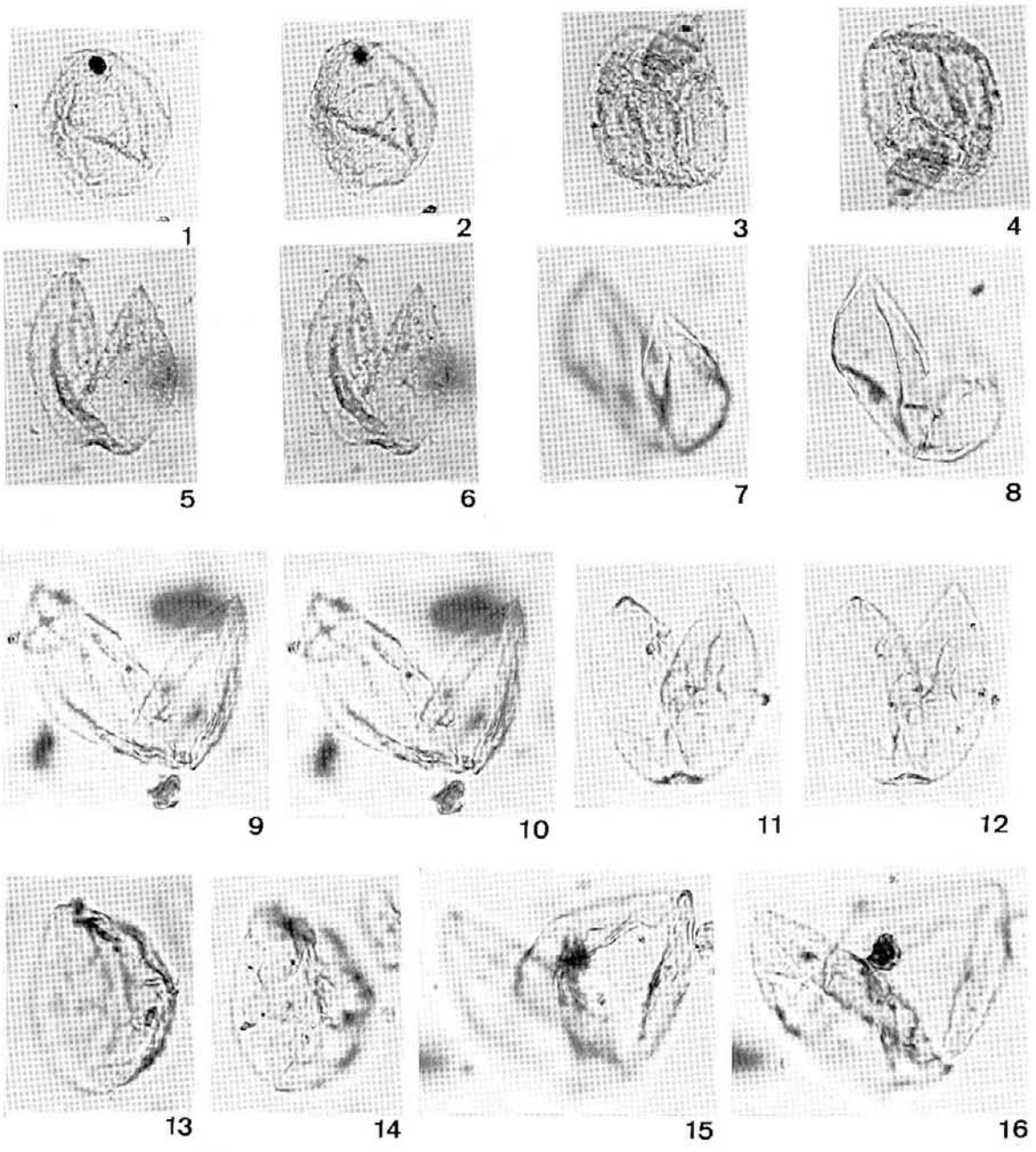
Description: Grains inaperturate, but bilobately open; subspheroidal; 18-27 μm wide; surface view finely granulate; lateral view scabrate; exine thin about 0.5 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1348m, 1365m, 1501m).

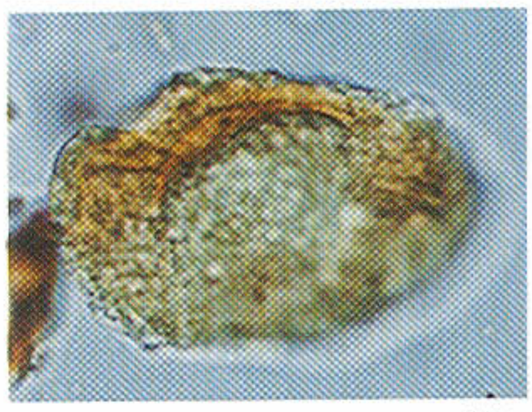
Family 2 Pinaceae
Genus 1. Pityosporites Seward 1914

Grains vesiculate; body shapes various, usually less than 60 x 60μm, the cap 1-2(-3) μm thick, with scabrate or verrucate processes, shoulder pad usually with prominent marginal

ridges, sexine usually reticulate or reticulate-granulate; bladders two, as large as or smaller than the body, sexine usually reticulate.



Figs. 1-6. *Taxodiacites verrucosus* Botsch *minor* C. L. Shaw *var. nov.* Figs. 1-2: OK-1, 1501m-1, P12-8-9, P12-9-10. Figs. 3-4: OK-1, 1348m-1, P13-9-11, P13-10-12. Figs. 5-6: OK-1, 1365m-1, P14-3-4, P14-4-5. Figs. 7-16. *Taxodiaceaepollenites taiwanensis* T. C. Huang. Figs. 7-8: OK-1, 1501m-1, P12-3-5, P12-4-6. Figs. 9-10: OK-1, 1545m-2, P12-17-18, P12-18-19. Figs. 11-12: OK-1, 1348m-1, P12-33-34, P12-34-35. Figs. 13-14: OK-1, 1669mbl-2, P6-14-16, P6-13-15. Figs. 15-16: OK-1, 1719m-2, P15-35-37, P15-34-36. All figures x1150.



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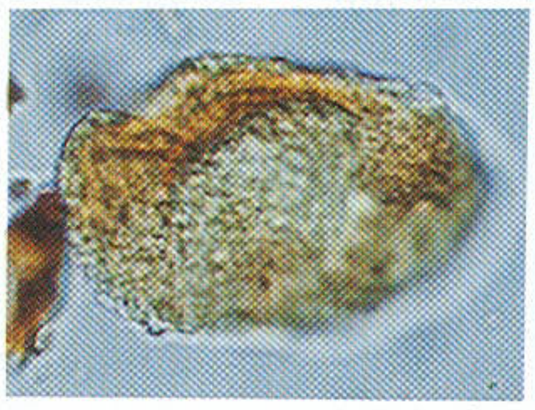

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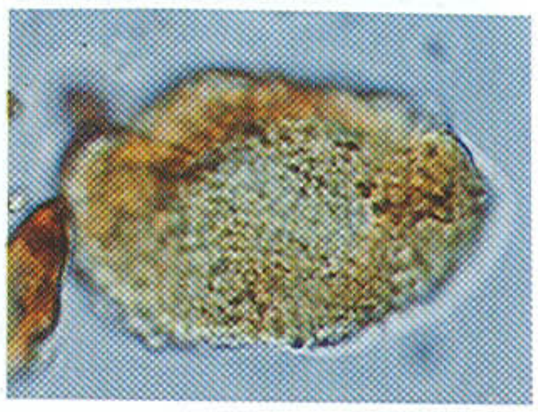

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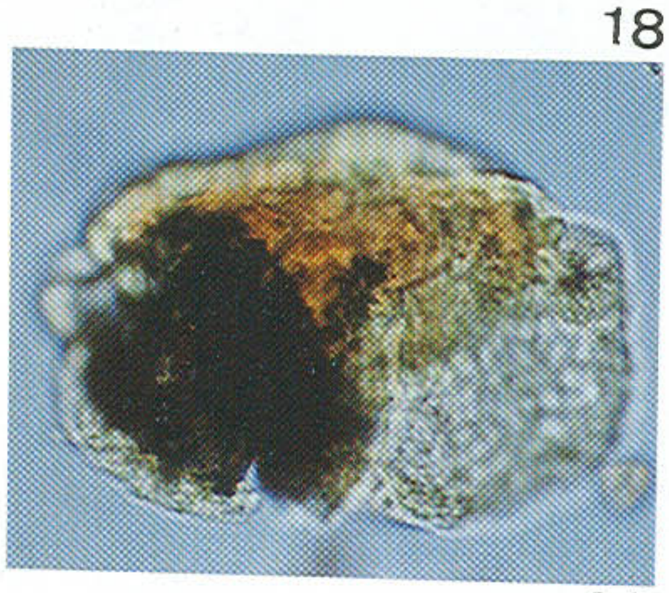

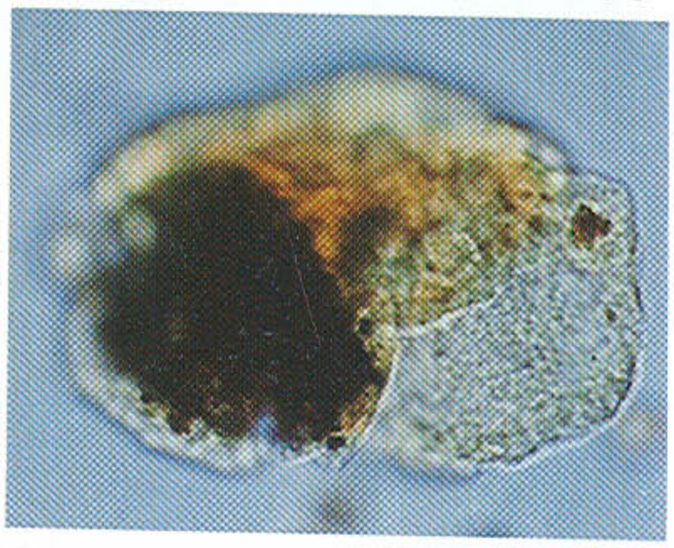

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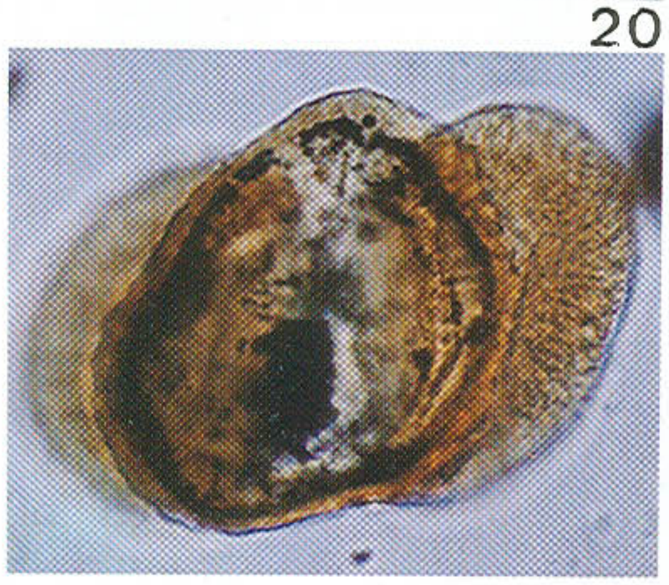

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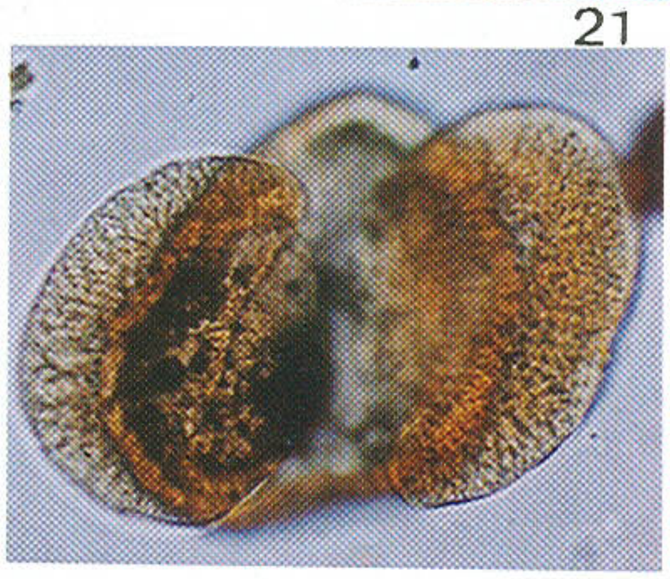

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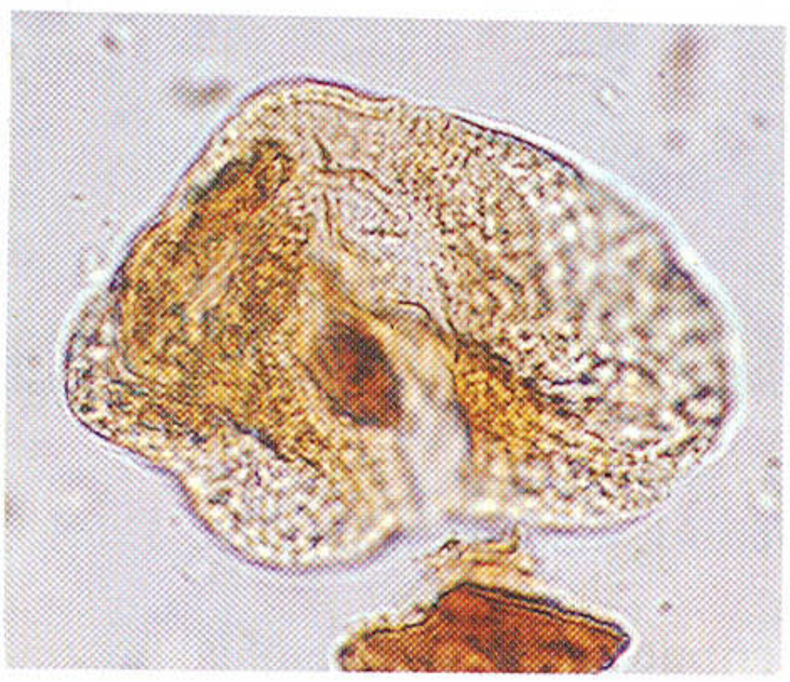

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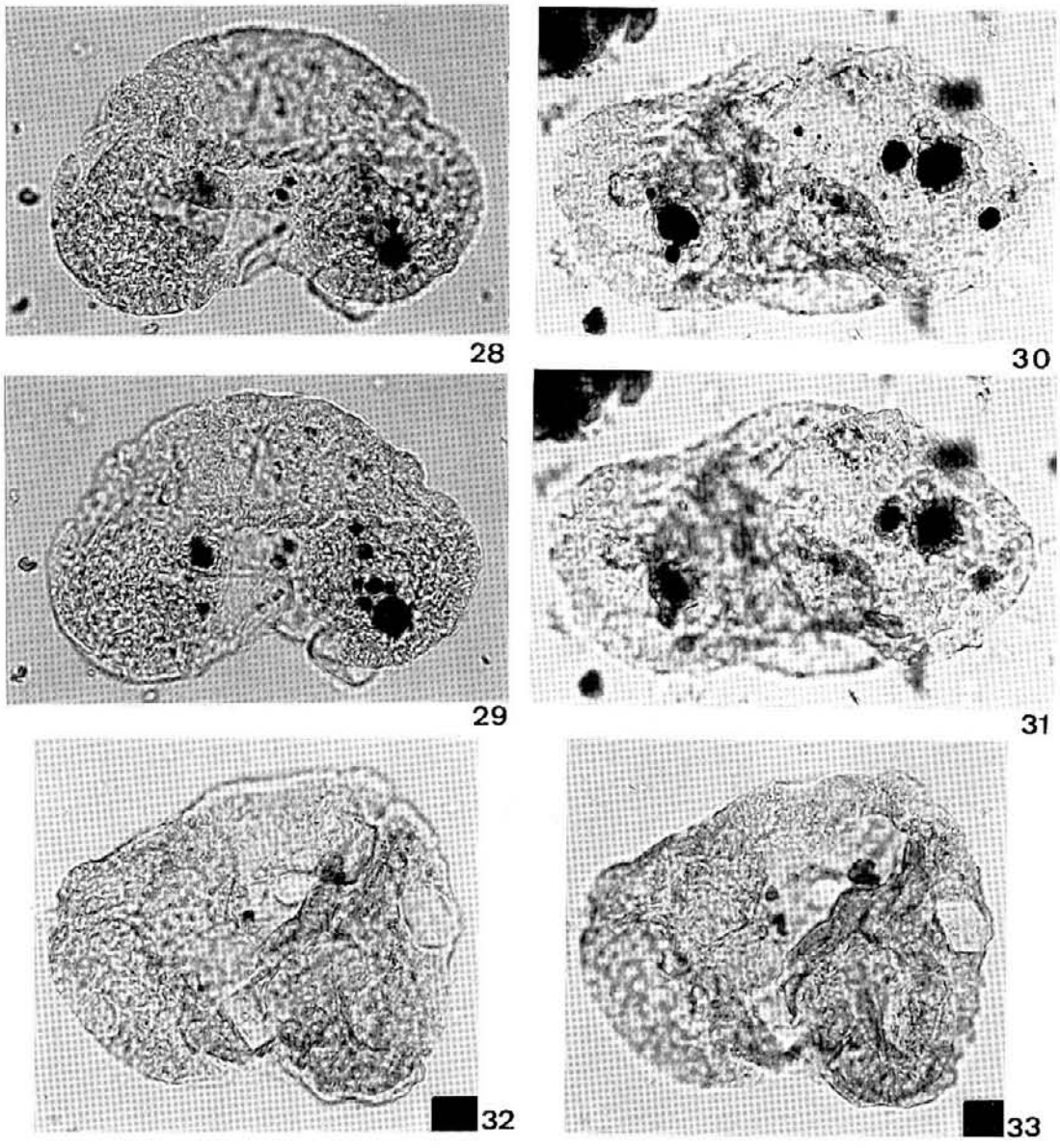
Figs. 17-19. *Pityosporites pengchiahsuensis* C. L. Shaw *sp. nov.* (OK-1, 1545m-1, P11-21-23, P11-22-24, P11-23-25); Figs. 20-23. *Pityosporites morrisonicola* T. C. Huang. Figs. 20-21: OK-1, 1699 mbl-2, P7-1-3, P7-2-4. Figs. 22-23. OK-1, 1435m-5, S9-23, 24. Figs. 24-25. *Taxodiaceaepollenites pengchiahsuensis* C. L. Shaw *sp. nov.* (YKL-3, 1360m-8, KD23-12, 13); Figs. 26-27. *Pityosporites triangulatus* Huang (YKL-1, 1190-1225m-3, W48-30, 31). All figures x1000.

1. Pityosporites verrucatus T. C. Huang 1979 Figs. 40-43

Selected slide: Figs. 40-41. OK-3, 1720m-2, W97-18, 19, 56 x 89 μm. Figs. 42-43. OK-1, 1348m-1, P13-00-1, P13-0-2, 44 x 83 μm; CPC Micropaleontology Lab.



Figs. 28-33. *Pityosporites scabratus* T. C. Huang. Figs. 28-29: OK-3, 1730m-2, TL11-17, 18. Figs. 30-31: OK-3, 1760m-3, WA67-10, 11. Figs. 32 –33: OK-3, 1720m-1, W97-9, 10. All figures x1000.

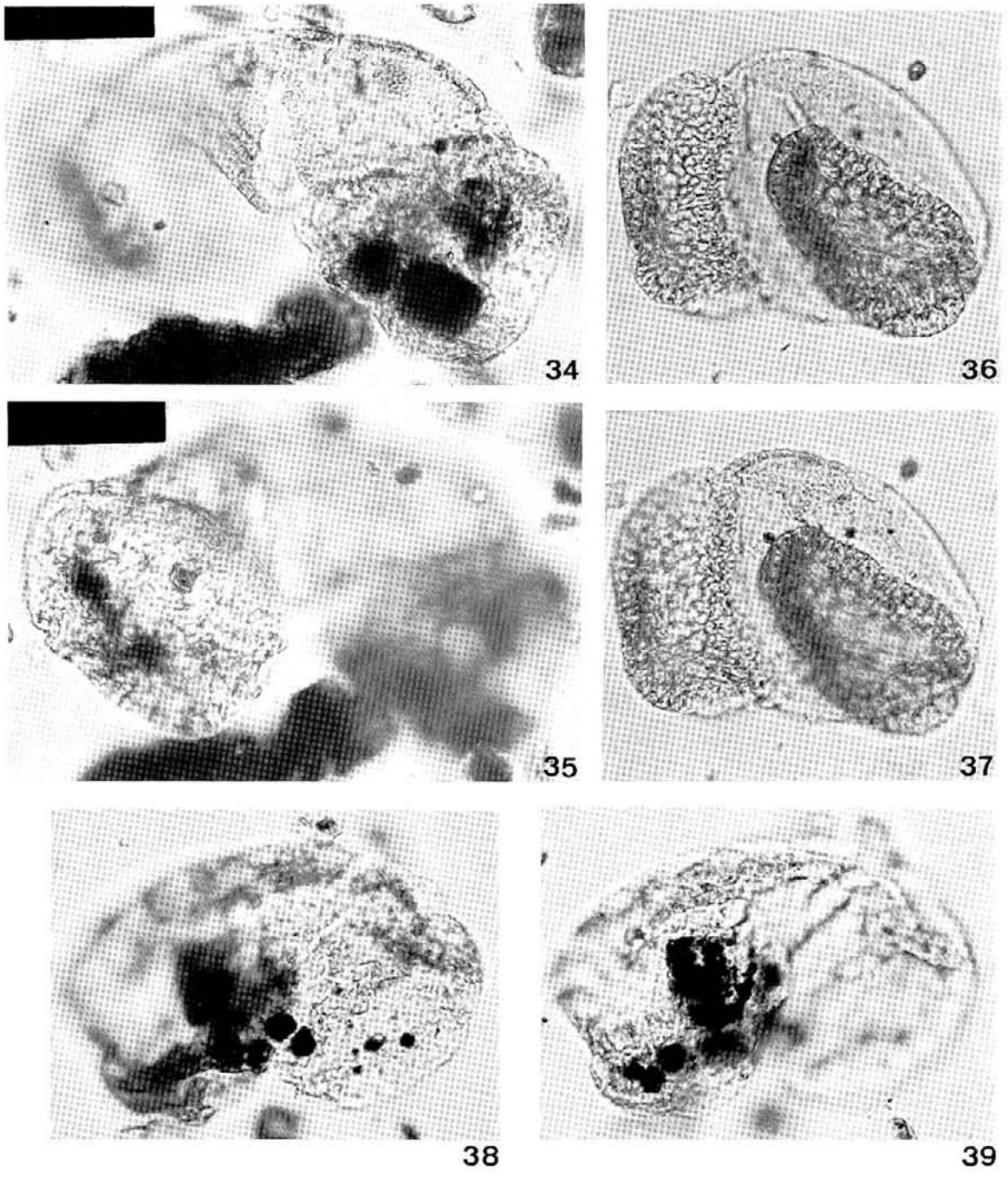
Description: Body spheroidal to transversally elliptic, 40-50 x 42-58 μm, cap with verrucate processes, 2.5-3 μm thick, sexine reticulate-granulate; bladders subspheroidal, concave at root, convex at end, reticulate, 32-38 x 36-41 μm; furrow granulate.

Stratigraphic occurrence: Eocene (OK-1 well, 1348m; OK-3 well, 1720m)

2. Pityosporites massoniana T. C. Huang 1979 Figs. 34-39

Pinuspollenites sp. Canright, loc. cit. Pl. 1, Fig. 4, 1974.

Selected slide: Figs. 34-35. OK-1, 1435m-1, W97-5, 7, 38 x 94.3 μm. Figs. 36-37. OK-1, 1365m-1, P14-10-11, P14-9-10, 36 x 62 μm. Figs. 38-39. OK-1, 1638m-4, S8-19, 20, 44 x 70 μm; CPC Micropaleontology Lab.



Figs. 34-39. *Pityosporites massoniana* T. C. Huang. Figs. 34-35: OK-1, 1435m-1, W97-5, 7. Figs. 36-37: OK-1, 1365m-1, P14-10-11, P14-9-10. Figs. 38-39. OK-1, 1638m-4, S8-19, 20. All figures x1000.

Description: Body subspheroidal, 35 x 62 μm, cap with scabrate processes, 2 μm thick, sexine reticulate-granulate; bladders subspheroidal, flat at root, round at ends, finely reticulate, 28-31 x 38-42 μm; furrow granulate.

Stratigraphic occurrence: Eocene (OK-1 well, 1365m, 1435m, 1638m)

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

3. Pityosporites morrisonicola T. C. Huang 1979 Figs. 20-23, 44-45

Selected slide: Figs. 20-21. OK-1, 1699m BL-2, P7-1-3, P7-2-4, 33 x 48 μm. Figs. 22-23. OK-1, 1435m-5, S9-23, 24, 35 x 50 μm. Figs. 44-45 OK-1, 1375m-1, P14-11-12, P14-12-13, 29 x 69μm; CPC Micropaleontology Lab.

Description: Body transversally elliptic, 22-29 x 38-42 μm, cap with scabrate or verrucate processes, 1.5-2.5 μm thick, with marginal ridges on the shoulder pads, sexine reticulate; bladders sub-spheroidal, 20-24 x 25-28 μm, reticulate.

Stratigraphic occurrence: Eocene (OK-1 well, 1375m, 1435m, 1669m).

Taxonomic affinity: This species is closely related to the extant *Pinus morrisonicola* Hayata and *Pinus thunbergii* Parl. (Wodehouse) Krutzsch (Krutzsch, 1971).

4. Pityosporites pengchiahsuensis C. L. Shaw sp. nov. Figs. 17-19

Holotype: Slide OK-1, 1545m-1, Figs. 17-19, P11-21-23, P11-22-24, P11-23-25, 21 x 32 μm; CPC Micropaleontology Lab.

Description: Body transversally elliptic, 17 x 22 μm, cap with verrucate-scabrate processes, 1.5-2 μm thick, sexine reticulate; bladders two, subspheroidal, reticulate, 9 x 16-17 μm.

Stratigraphic occurrence: Eocene (OK-1 well, 1545m).

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

5. Pityosporites scabratus T. C. Huang 1979 Figs. 28-33

Selected slide: Figs. 28-29, OK-3, 1730m-2, TL11-17, 18, 40 x 64 μm, Figs. 30-31. OK-3, 1760m-3, WA67-10, 11, 43 x 76 μm. Figs. 32 -33. OK-3, 1720m-1, W97-9, 10, 46 x 62 μm; CPC Micropaleontology Lab.

Description: Body transversally elliptic, 37-45 x 45-52 μm, cap with scabrate or verrucate processes, 1 μm thick, sexine finely reticulate; bladders subspheroidal, concave at root convex at end, reticulate, 26-32 x 30-41 μm.

Stratigraphic occurrence: Eocene (OK-3 well, 1720m, 1730m, 1760m).

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

6. Pityosporites triangulatus T. C. Huang 1979 Figs. 26-27

Selected slide: YKL-1 1190-1225-(3); Figs. 26-27; film W48-30, 31; CPC Micropaleontology Lab.

Description: Grains triangular, Body 34 x 30 μm, cap scabrate processes, 1 μm thick, sexine granulate; bladder oblong, rounded on both roots and ends, granulate, 18-21 x 30-31 μm.

Stratigraphic occurrence: Eocene (YKL-1 well, 1190-1225m).

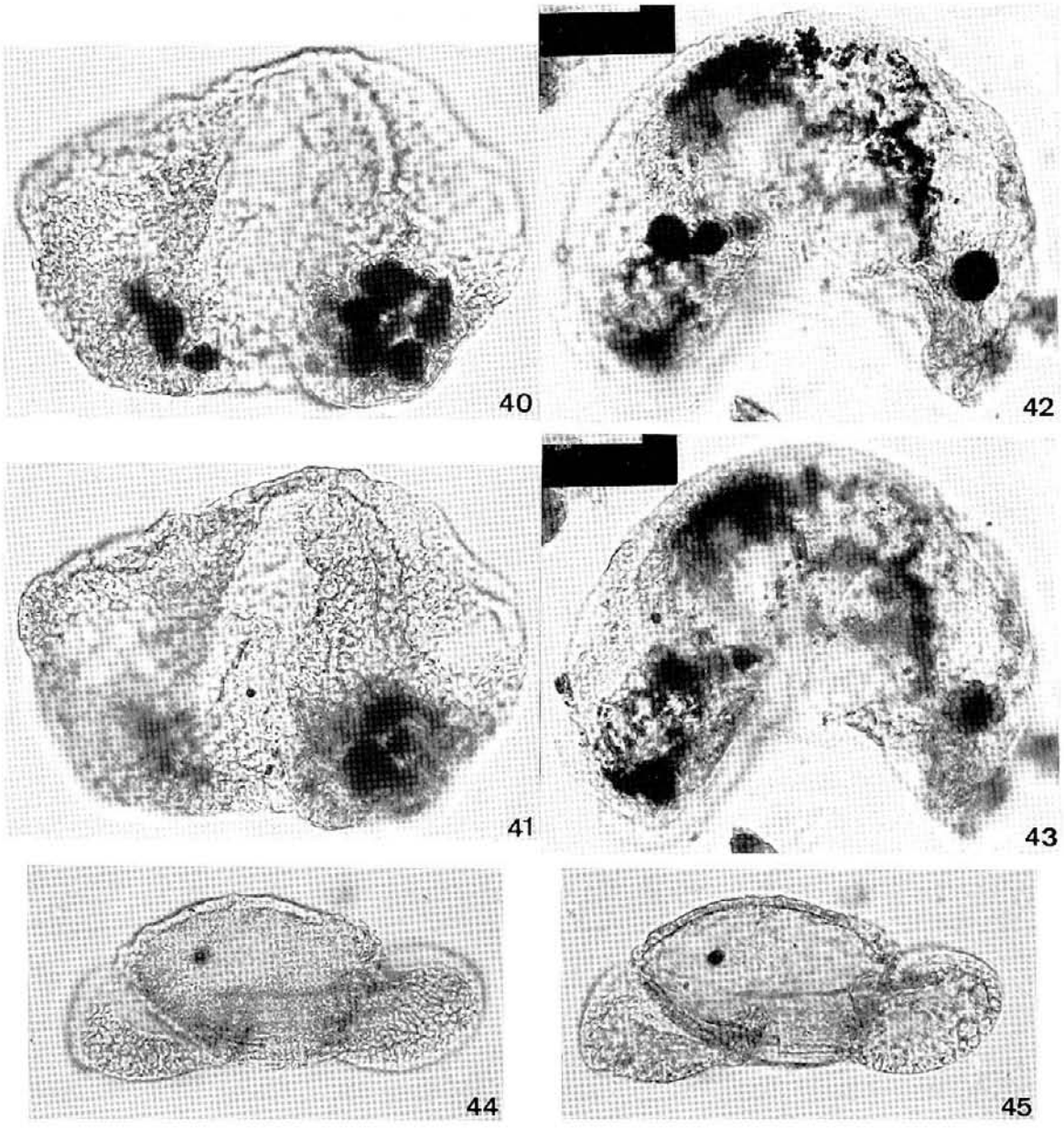
Taxonomic affinity: This species is related to the extant *Pinus* species.

Family 3 Podocarpaceae

Genus 1. Podocarpidites Cookson ex Couper 1953

1. Podocarpidites taiwanensis T. C. Huang 1979 Figs. 46-51

Selected slide: Figs. 46-47. OK-3, 1760m-5, PF46-31, 32, 44 x 71 μm. Figs. 48-49.



Figs. 40-43. *Pityosporites verrucatus* T. C. Huang. Figs. 40-41: OK-3, 1720m-2, W97-18, 19. Figs. 42-43: OK-1, 1348m-1, P13-00-1, P13-0-2. Figs. 44-45. *Pityosporites morrisonicola* T. C. Huang (OK-1, 1375m-1, P14-11-12, P14-12-13). All figures x1000.

OK-3, 1720m-2, W97-12, 13, 49 x 81 μm. Figs. 50-51. OK-3, 1800m-4, PF55- 21, 22, 49 x 81 μm; CPC Micropaleontology Lab.

Description: Grains bisaccate; body subspheroidal, 31-45 x 41-45 μm wide, cap 1-3 μm thick, with scabrate or verrucate processes, sexine usually reticulate; bladders as long as or longer than body, sexine finely reticulate 27-40 x 41-50 μm.

Stratigraphic occurrence: Eocene (OK-3 well, 1720m, 1760m, 1800m).

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

Order II Gnetales
Family 1. Ephedraceae
Genus 1. Ephedripites Bolkhovitina 1953 ex Potonie 1958

Type species: *Ephedripites* mediolobatus Bolkhovitina ex Potonie 1958
Diagnosis: Grains ellipsoidal to fusiform, with 3-12 longitudinal ridges.

Key to the subgenus (Compiled from Krutzsch 1961, 1971)

1. Grains encircled type; surface view striate ..... Subgenus *Spiralipites*
1. Grains plicate type; surface view ridges.
2. Cross-grid pattern between grooves present ..... Subgenus *Distachyapites*
2. Cross-grid pattern between grooves absent ..... Subgenus *Ephedripites*

1. Ephedripites subgen. Distachyapites Krutzsch 1961
Geologie, Beiheft 32, p. 20.

Type species: *Ephedripites* (*Distachyapites*) *eocenipites* (Wodehouse) Krutzsch., I. c., p. 27

Diagnosis: "Ephedroid pollen with a low number of ribs (approx. 3-8) and with a zig-zag line between the ribs; ribs are usually straight or slightly sinuous but strongly spiraling."

1. Ephedripites eocenipites (Wodehouse) Krutzsch 1961 **var. formosensis** C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 2A-F.

Holotype: Slide OK-1 , 1365-(1); Pl. 1; Fig. 1-2; film P13-35-36, P13-34-35; CPC Micropaleontology Lab.

Description: Grains with 4-5 ridges; prolate, pole rounded; fusiform; 46-55 x 26-28 μm, grooves as long as the P axes; grain length over width about 1.7-2; exine psilate; sexine with distinct cross-grid; ridges 1-1.5 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1365m).

Taxonomic affinity: This species and the other ten species described in this section are similar to the extant species of *Ephedra*.

2. Ephedripites parafusiformis Z. Zhu & L. Wu 1985 **var. taiwanensis** C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 2G-H and Figs. 3A-B.

Holotype: Slide OK-1 1768-(5); Pl. 2; Figure 1-2; film S5-22, S5-23; CPC Micropaleontology Lab.

Description: Grains with 4-ridges; prolate, pole rounded; fusiform; 50-67 x 17-21 μm, grooves as long as the P axes; grain length over width about 2.3-3.3; exine psilate; sexine with distinct cross-grid; ridges 1-1.5 μm thick.

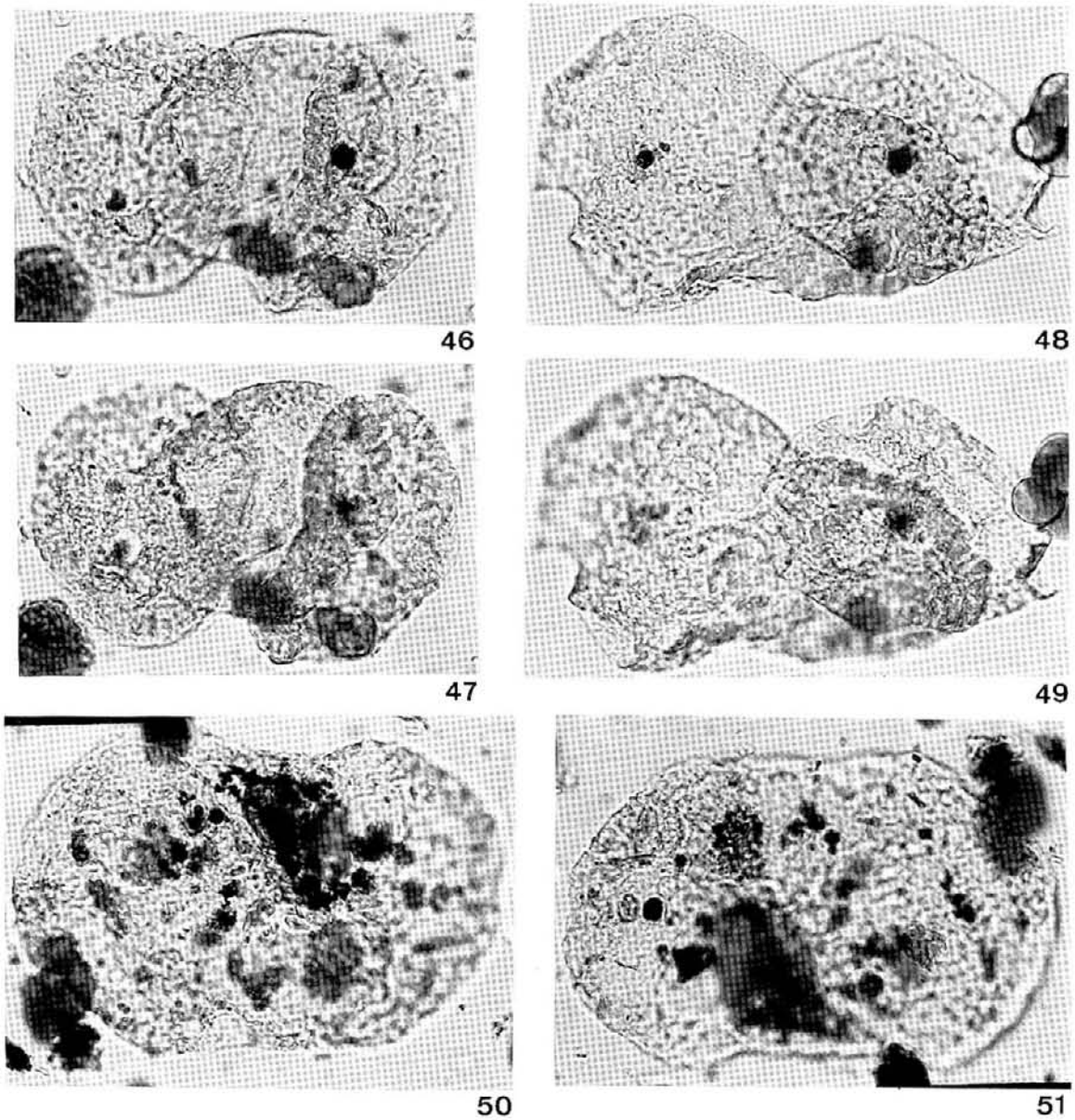
Stratigraphic occurrence: Eocene (OK-1 well, 1768m).

3. Ephedripites scabridus Z. C. Song & Y. Zheng 1981 in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 2I-J.

Slide: OK-1 1669- (1); film S7: 23, S7: 24; CPC Micropaleontology Lab.

Description: Grains with 4-5 ridges; prolate, pole rounded; fusiform; 38 x 22 μm, grooves as long as the P axes; grain length over width about 1.7-1.8; exine psilate; sexine with distinct cross-grid; ridges 1.5-2 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m).



Figs. 46-51. *Podocarpidites taiwanensis* T. C. Huang. Figs. 46-47: OK-3, 1760m-5, PF46-31, 32. Figs. 48-49. OK-3, 1720m-2, W97-12, 13. Figs. 50-51: OK-3, 1800m-4, PF55- 21, 22. All figures x1000.

4. Ephedripites formosanus C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 2K-L.

Holotype: Slide OK-1 1638-(2); Pl. 1; Figs. 11-12; film S8:1, S8:2; CPC Micropaleontology Lab.

Description: Grains with 4-5 ridges; subprolate, pole rounded; fusiform; 28-30 x 19-21 μm, grooves as long as the P axes; grain length over width about 1.4-1.5; exine psilate; sexine with distinct cross-grid; ridges 1.5-2 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1638m).

5. Ephedripites fushunensis T. Sung & L. Tsao 1978 in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 3E-J.

Slide: OK-1 1545-(1); film P10-29-28, P10-30-29; CPC Micropaleontology Lab.

Description: Grains with 4-ridges; prolate, pole rounded; fusiform; 28-33 x 16-20 μm, grooves as long as the P axes; grain length over width about 1.4-1.7; exine flatly verrucate; sexine with distinct cross-grid; ridges 3-4 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1545m).

6. Ephedripites fushunensis T. Sung & L. Tsao 1978 **var. minimus** C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 3K-L.

Holotype: Slide OK-1 1669-(4); film S6: 29, S6: 28; CPC Micropaleontology Lab.

Description: Grains with 4-ridges; subprolate-prolate, pole rounded; fusiform; 22-24 x 13-15 μm, grooves as long as the P axes; grain length over width about 1.4; exine flatly verrucate; sexine with distinct cross-grid; ridges 3 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m).

7. Ephedripites baculatus Z. Zhu et L. Wu 1985 in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 4A-F.

Slide: OK-1 1699-bl-(1); film P8-4-7, P8-5-8; CPC Micropaleontology Lab.

Description: Grains with 4-ridges; perprolate, pole acute; fusiform; 44-49 x 13-18 μm, grooves as long as the P axes; grains length over width about 2.7-3.5; exine psilate; sexine with distinct cross-grid; exine 1.5-2 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m).

8. Ephedripites miocenus T. C. Huang & S. M. Chaw 1981 in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 4I-L.

Slide: OK-1 1699-bl-(1); Pl. 3; Figs. 9-10; film P8-7-10, P8-8-11; CPC Micropaleontology Lab.

Description: Grains with 4 ridges; perprolate, pole acute; fusiform; 44-48 x 18-24 μm, grooves as long as the P axes; grain length over width about 1.9-2.5; exine psilate; sexine with distinct cross-grid; ridges 1.5-2 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m).

9. Ephedripites quadriplicatus C. L. Shaw 1984 in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 7A-B.

Slide: OK-1 1545-(1); film P10-18-17, P10-17-16; CPC Micropaleontology Lab.

Description: Grains with 4-ridges; perprolate, pole acute; fusiform; 58-62 x 19-22 μm, grooves as long as the P axes; grain length over width about 2.8; exine psilate; sexine with distinct cross-grid; ridges 1.5-2 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1545m).

10. Ephedripites membranus C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 3C-D.

Holotype: Slide OK-1, 1669- (4); film S6-18, S6-19; CPC Micropaleontology Lab.

Description: Grains with 4-ridges; prolate to perprolate, pole rounded; fusiform; 54 x 24 μm, grooves as long as the P axes; grain length over width about 2.3; exine psilate; sexine

with distinct cross-grid; ridge 1 μm thick or less.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m).

11. Ephedripites nanlingensis X. J. Sun & J. M. He 1980 in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 4G-H. and Figs. 7C-D.

Slide: OK-1 1669-(1); film S7: 25, S7: 26; CPC Micropaleontology Lab.

Description: Grains with 4-5 ridges; prolate, pole acute; fusiform; 50-57 x 22-25 μm, grooves as long as the P axes; grain length over width about 2.1-2.3; exine psilate; sexine with distinct cross-grid; ridge 1-1.5 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m)

2. Ephedripites subgen. **Ephedripites** Krutzsch 1961
Geologie, Beiheft 32, p. 20

Type species: *Ephedripites* (*Ephedripites*) *mediolobatus* Bolkhovitina ex Potonie' 1958.

Diagnosis: "'Ephedroid' pollen with numerous ribs, in part spiraling along the longest axis; without characteristic Z-line, never with side branches; dehiscene slit very rare."

1. Ephedripites gracilis C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 5A-D.

Holotype: Slide OK-1 1669-(3); Pl. 4; Figs. 1, 2; film S5-26, S5-27; CPC Micropaleontology Lab.

Description: Grains with 6-9 ridges; perprolate, pole rounded to acute; 55-60 x 14-16 μm grooves as long as the P axes; grain length over width about 3.6-3.9; cross-grid absent; ridges 1.5 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m).

Taxonomic affinity: This species and the other six species described in this section are similar to the extant species of *Ephedra*.

2. Ephedripites taiwanensis T. C. Huang 1976 in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 5E-H.

Slide: OK-1, 1788-bl-(4); film P1-27-29, P1-28-30; CPC Micropaleontology Lab.

Description: Grains with 6-9 ridges; perprolate, pole rounded to acute; 43-46 x 13-14 μm; grooves as long as the P axes; grain length over width about 3.3; cross-grid absent; ridges 1.5 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1788m).

3. Ephedripites angularis C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 5K-L.

Holotype: Slide OK-1, 1699-bl-(2); Pl. 4; Figs. 11, 12; film P7-10-12, P7-11-13; CPC Micropaleontology Lab.

Description: Grains with 5-6 ridges; prolate , pole acute; 33 x 15 μm; grooves as long as the P axes; grain length over width about 2.2; exine psilate; ridges about 1.5 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m).

4. Ephedripites scabratus C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 6G-H.

Holotype: Slide OK-1, 1588-bl-(3); Pl. 5; Figs. 7, 8.; film P9-4-6, P9-3-5; CPC Micropaleontology Lab.

Description: Grains with 4 ridges; perprolate, pole acute; 47 x 14 μm; grooves as long as the P axes; grain length over width about 3.4; cross-grid absent; exine scabrate; ridges about 1 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1588m).

5. Ephedripites minor C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 5I-J and Figs. 7E-F.

Holotype: Slide OK-1, 1788-(5); Pl. 4; Figs. 9, 10; film S5-28, S5-29, S5-30; CPC Micropaleontology Lab.

Description: Grains with 5-6 ridges; perprolate, pole rounded to acute; 33-38 x 10-12 μm; grooves as long as the P axes; grain length over width about 3.0-3.8; cross-grid absent; ridge 1 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1788m).

6. Ephedripites olivaeformis C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 6I-L.

Holotype: Slide OK-1, 1768-(5); Pl. 5; Figs. 9, 10; film S7: 1, S7: 2; CPC Micropaleontology Lab.

Description: Grains with 7-9 ridges; prolate , pole acute, 28-33 x 17-19 μm; grooves as long as the P axes; grain length over width about 1.6-1.8; some of ridges dense unit undulate; exine psilate to scabrate; ridges 1.5 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1768m).

7. Ephedripites polyplicatus C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 7I-L.

Holotype: Slide OK-1, 1638-(5); Pl. 6; Figs. 9, 10.; film S8: 21, S8: 22; CPC Micropaleontology Lab.

Description: Grains with 12-15 ridges; prolate , pole acute, 33-38 x 17-22 μm; grooves as long as the P axes; grains length over width about 1.7-1.9; exine psilate; ridge 1 μm thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1638m).

3. **Ephedripites** subgen. **Spiralipites** Krutzsch 1970
Atlas, v. 7 p. 43

Type species: *Ephedripites* (*Spiralipites*) *praeciarus* (Khlonova) Krutzsch, ibid.

Diagnosis: A subgenus (of *Ephedripites*) with numerous rotated ribs and without zig-zag lines, and mostly found in the upper Cretaceous.

1. Ephedripites perprolatus C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 6A-B.

Holotype: Slide OK-1, 1699-bl-(2); film P7-5-7, P7-6-8; CPC Micropaleontology Lab.

Description: Grains encircled type, with 8-10 ridges; perprolate; 65 x 27 μm; pole rounded to obtuse; grain length over width about 2.4; surface view striate, striae 2-3 μm wide, the muri in line shape, about 3 μm wide.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m).

Taxonomic affinity: This species and the other three species described in this section are similar to the extant species of *Ephedra*. It belongs to the subgenus *Spiralipites*, which is mostly found in the Upper Cretaceous (Jansonius and Hill, 1976).

2. Ephedripites pengchiahsuensis C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 6E-F.

Holotype: Slide OK-1, 1719-(1); film P14-17-18, P14-18-19; CPC Micropaleontology Lab.

Description: Grains encircled type, with 7 ridges; prolate to perprolate; 34 x 17 μm; pole rounded; grain length over width about 2.0; surface view striate, striae 1-2 μm wide, muri linear, about 3-4 μm wide.

Stratigraphic occurrence: Eocene (OK-1 well, 1719m).

3. Ephedripites densistriatus C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 6C-D.

Holotype: Slide OK-1, 1788-bl-(1); film P15-15-17, P15-16-18; CPC Micropaleontology Lab.

Description: Grains encircled type, with 9-10 ridges; perprolate; 47 x 19 μm; pole rounded; grain length over width about 2.5; surface view striate, striae 2-3 μm wide, muri linear, about 0.5 μm wide.

Stratigraphic occurrence: Eocene (OK-1 well, 1788m).

4. Ephedripites tenuissimus C. L. Shaw in Bot. Bull. Academica Sinica 1998, 38: 69-80; Figs. 7G-H.

Holotype: Slide OK-1 1699-bl-(2); film P7-27-29, P7-28-30, P7-29-31,; CPC Micropaleontology Lab.

Description: Grains encircled type,with 6-8 ridges; perprolate; 47 x 19 μm; pole acute; grain length over width about 4.5; surface view striate, striae 2 μm wide, muri linear, about 0.5 μm wide.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m).

ACKNOWLEDGMENTS

I would like to express my deep appreciation to the Exploration and Research Institute, CPC for providing the facilities to conduct this study, the Offshore and Oversea Petroleum Division, CPC for providing subsurface rock samples. This work was supported by the National Science Council of the Republic of China under contract NSC89-2116-M-326-001.

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台灣始新統裸子植物化石花粉

蕭承龍[1]

（收稿日期：1999 年 10 月 22 日；接受日期：1999 年 11 月 30 日）

摘　　要

本文發現並描述台灣基隆北方海域始新世地層中，裸子植物花粉化石共計有三十二形態種，它們分別屬於貳綱，四科，五個形態屬，其中二種為新種 (*Taxodiaceaepollenites pengchiahsuensis* C. L. Shaw *sp. nov.*; *Pityosporites pengchiahsuensis* C. L. Shaw *sp. nov.*)，一種為變種 (*Taxodiacites verrucosus* Botsch *minor* C. L. Shaw *var. nov.*)。

關鍵詞: 始新統地層、裸子植物化石花粉、分類。

1. 國立臺灣史前文化博物館籌備處, 臺東 950, 中華民國。