

## Eocene Palynomorphs of Taiwan-Pteridophytic Spores

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(Manuscript received 13 April, 1999; accepted 15 May, 1999)

**ABSTRACT:** Forty-three taxa of Eocene fossil pteridophytic palynomorphs were reported as an ongoing effort to increase our knowledges of the Eocene microflora of Taiwan. They belong to two classes and twenty-one form genera; namely four form genera and six taxa for the class Monolete, and seventeen form genera and thirty-seven taxa for the class Trilete. Twenty new species (*Gemmatosporis pengchiahsuensis* sp. nov.; *Polypodiidites thunbergiensis* sp. nov.; *Camarozonosporites taiwanensis* sp. nov.; *Gemmatriletes pengchiahsuensis* sp. nov.; *Leiotriletes pengchiahsuensis* sp. nov.; *Lophotriletes pengchiahsuensis* Shaw sp. nov.; *Punctatisporites taiwanensis* sp. nov.; *Retitriletes pengchiahsuensis* sp. nov.; *Sphagnumsporites pengchiahsuensis* sp. nov.; *Torofoveolatisporis pengchiahsuensis* sp. nov.; *T. taiwanensis* sp. nov.; *Triplanosporites pengchiahsuensis* sp. nov.; *T. granulatus* sp. nov.; *Verrucingulatisporites pengchiahsuensis* sp. nov.; *V. chinaensis* sp. nov.; *V. minor* sp. nov.; *V. creticus* sp. nov.; *Verrucosisporites pengchiahsuensis* sp. nov.; *V. wartus* sp. nov.; *V. minutus* sp. nov. ), one new combination (*Verrucingulatisporites fatangularis* (Liu) comb. nov.) were described from offshore Keelung in northern Taiwan.

**KEY WORDS:** Eocene, Pteridophytic spores, Taxonomy, Taiwan aera.

### INTRODUCTION

This paper is the fifth installment reporting the palynological observation from wells drilled in offshore Keelung in northern Taiwan. A total of fifty-five cores and one cutting samples were collected. The previous installments includes reporting Tiliaeous palynomorphs (Shaw, 1997), Ephedraceous (Shaw, 1998), Wetzeliellaceous dinoflagellate (Shaw, 1999a), and fossil dinocysts (Shaw, 1999b). More reports which deal with the taxonomy and complete checklist will come in the immediate future.

In this paper, artificial form genera names for nomenclature the taxonomic treatment was adapted.

### MATERIALS AND METHODS

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

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The palynomorph extraction method followed Shaw (1990), including treatment of 10% KOH for dissolution of humic material, heavy liquid of ZnCl<sub>2</sub> for flotation (S. G. 1.8-2.2), and 30% of HCl, as well as 52% of HF for maceration of the laterite pebble samples, collected from the exploration well.

Photomicrographs were taken with a Zeiss Axiophot microscope equipped with an automatic camera using Kodacolor Gold (ASA 100) film. For fossil identification, Huang (1978a, 1978b, 1981), Jansonius and Hills (1976), Krutzsch (1971), and Shaw (1980, 1984, 1990) were used for reference. The fossil slides were catalogued and stored at the Micropaleontology Laboratory, Chinese Petroleum Corporation.

## 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, the author here reports forty-three taxa of the Eocene fossil pteridophytic palynomorphs. They belong to two classes and twenty-one form genera; namely four form genera and six taxa for the class Monolete; and seventeen form genera and thirty-seven taxa for the class Trilete. Twenty new species, one new combination are described from the well drilled by CPC in offshore Keelung in northern Taiwan. They are listed as below:

### Class 1. Monolete

- Gemmamonoletes formosensis* Huang
- Gemmatosporis pengchiahsuensis* sp. nov.
- Laevigatosporites gracilis* Wilson & Webster
- Laevigatosporites medius* Kosanke
- Polypodiidites formosensis* Shaw
- Polypodiidites thunbergiensis* sp. nov.

### Class 2. Trilete

- Camarozonosporites taiwanensis* sp. nov.
- Cicatricosisporites tersus* (Kara-Muursa) Pocock
- Crassoretitriletes vanraadshooveni* G.H.M.
- Cyathidites formosus* Shaw & Huang
- Cyathidites parvus* Shaw & Huang
- Gemmatriletes pengchiahsuensis* sp. nov.
- Gleicheniidites peikangensis* Shaw
- Gleicheniidites taiwanensis* Huang
- Gleicheniidites rasilis* Krutzsch
- Leiotriletes pengchiahsuensis* sp. nov.
- Leiotriletes sphaerotriangulus* (Loose) Potonie & Kremp
- Leiotriletes wolffi* Kr. subsp. *brevis* Kr.
- Lophotriletes pengchiahsuensis* sp. nov.
- Osmundacidites taiwanensis* Huang
- Polypodiaceoisporites scabristiptus* Shaw

*Punctatisporites taiwanensis sp. nov.*  
*Retitriteles pengchiahsuensis sp. nov.*  
*Sphagnumsporites pengchiahsuensis sp. nov.*  
*Torofoveolatisporis pengchiahsuensis sp. nov.*  
*Torofoveolatisporis taiwanensis sp. nov.*  
*Triplanosporites figuratus* Shaw & Huang  
*Triplanosporites pengchiahsuensis sp. nov.*  
*Triplanosporites formosus* Shaw & Huang  
*Triplanosporites cretaceous* Shaw & Huang  
*Triplanosporites minor* Shaw & Huang  
*Triplanosporites granulatus sp. nov.*  
*Verrucingulatisporites excelsanus* Shaw  
*Verrucingulatisporites ssuhuensis* Shaw  
*Verrucingulatisporites pengchiahsuensis sp. nov.*  
*Verrucingulatisporites fatangularis* (Liu) comb. nov.  
*Verrucingulatisporites vittatus* Shaw & Huang  
*Verrucingulatisporites chinaensis sp. nov.*  
*Verrucingulatisporites minor. sp. nov.*  
*Verrucingulatisporites creticus sp. nov.*  
*Verrucosisporites pengchiahsuensis sp. nov.*  
*Verrucosisporites wartus sp. nov.*  
*Verrucosisporites minutus sp. nov.*

## SYSTEMATIC TAXONOMIC TREATMENT

### Class 1. Monolete

Six taxa Eocene fossil spores were described here.

**Genus 1. Gemmamonoletes** Pierce 1961 Univ. Minnesota, Minn. Geol. Surv. Bull. 42, p. 21

Generotype: *Gemmamonoletes gemmatus* Pierce

Diagnosis: Gemmate monolete spores.

1. ***Gemmamonoletes formosensis*** Huang in *Taiwania* 23: 9, Pl. 2; figs: 1-9. 1978

Figs. 1-3

Slide: YKL-1 1190-1225-(4); Figs. 1-3; film W49-17, W49-18, W49-19; CPC Micro-paleontology Lab.

Description: Spores monolete; amb elliptic on proximal view; 27-29 x 36-38  $\mu\text{m}$ ; furrow 19-20  $\mu\text{m}$  long, with line-like margo, the margo 1  $\mu\text{m}$  wide. Exine 1-1.5  $\mu\text{m}$  thick, with gemmate processes, the gemmae 2 x 2  $\mu\text{m}$ ; sexine tuberculate, the tuberculae 1-2  $\mu\text{m}$  wide.

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

Taxonomic affinity: This species is similar to extant *Crypsinus tosaensis* (Makino) H. Ito of Polypodiaceae.

**Genus 2. Gemmatosporis** Krutzsch 1959 *Geologie, Beih.* 21-22. p. 203

Generotype: *Gemmatosporis gemmatoides* Krtz.

Diagnosis: Azonomonolete microspores, with a loosely verrucate sculpture elements consist of verrucae, clavae, gemmae or in part even echinae.

1. **Gemmatosporis pengchiahsuensis** sp. nov.

Figs. 4, 5.

Holotype: Slide OK-3 1750-(2); Figs. 4, 5; film PF21-1, 2; CPC Micro-paleontology Lab.

Description: Spores monolete; lateral view convex-hemispherical, size 23-25 x 32-34  $\mu\text{m}$ , surface view irregularly granulate, usually less than 1.5  $\mu\text{m}$  wide; lateral view loosely verrucate to psilate; exine about 1  $\mu\text{m}$  thick; laesurae 19  $\mu\text{m}$  long.

Stratigraphic occurrence: Eocene (OK-3 well, 1750m)

Taxonomic affinity: This species is possibly related to extant *Loxogramme* species.

Note: This species is named after the Pengchiahsu basin of the type locality.

**Genus 3. Laevigatosporites** Ibrahim 1933

Dissertation 1933, p. 39

Type species: *Laevigatosporites vulgaris* (Ibr.) Ibrahim

Diagnosis: Spores monolete; amb bean-shaped with a more or less straightened elongate dehiscent mark. Exine psilate, smooth.

1. **Laevigatosporites gracilis** Wilson & Webster 273/4 fig. 4. *Fort. Union Kohle*, Montana, U.S.A. 1964. Figs. 6, 7

Slide: OK-3 1750-(2); Figs. 6, 7; film PF11-8, 9; CPC Micropaleontology Lab.

Description: Spores monolete; amb lunate, proximal face straight to concave, distal face convex; 16-20 x 27-31  $\mu\text{m}$ . Surface view of exine smooth; lateral view of exine psilate; exine 0.5-1  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-3 well, 1750m)

Taxonomic affinity: This species may be related to extant species of *Asplenium* or *Parathelypteris*.

2. **Laevigatosporites medius** Kosanke, *Catalog of fossil spores and pollen* 5: 44, Fig. 2.

Figs. 8, 9.

Slide: OK-3 1760-(5); Figs. 8, 9; film PF46-20, 21; CPC Micropaleontology Lab.

Description: Spores monolete, equatorial view lunate, proximal face flat, distal face convex; 23-32 x 35-51  $\mu\text{m}$ ; surface view smooth; lateral view psilate; exine 0.8-1.2  $\mu\text{m}$  thick.

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

Taxonomic affinity: This species is possibly related to extant Polypodiaceae spore.

**Genus 4. Polypodiidites** Ross 1949 Bull. ol. Inst. Univ. Upsala, v. 34, p. 33.

Generotype: *Polypodiidites senonicus* Ross

Diagnosis: Spores monolete; amb lunate; exine sculptured with flat, more or less polygonal plates to rather high, partly irregular warts and conical hillocks; lateral view with scabrate or verrucate process.

1. **Polypodiidites formosensis** Shaw in Journ. Taiwan. Museum 37 (1): 131-166 Pl. 4; fig. 3-7. Figs. 12, 13

Slide: OK-2 1901-(2); Figs. 12, 13; film W38-31, 32; CPC Micropaleontology Lab.

Description: Spores monolete; proximal view elliptic; lateral view hemispherical; size 20-26 x 27-35  $\mu\text{m}$ ; laesurae 12-18  $\mu\text{m}$  long, with margo; surface view irregular warts to conical hillocks; lateral view with irregularly verrucate to coniculate process; exine 1-2.2  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-2 well, 1901m)

Taxonomic affinity: This species is possibly related to extant *Lepisorus* of Polypodiaceae.

2. **Polypodiidites thunbergiensis** sp. nov. Figs. 10, 11

Holotype: Slide OK-3 1750-(2); Figs. 10, 11; film PF12-10, 11; CPC Micropaleontology Lab.

Description: Spores monolete; proximal view elliptic; lateral view hemispherical; size 36 x 51  $\mu\text{m}$ ; laesurae 31-33  $\mu\text{m}$  long; surface view irregular warts to conical hillocks; lateral view with irregularly verrucate to coniculate process; exine 1-2  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-3 well, 1750m)

Taxonomic affinity: This species is possibly related to extant *Lepisorus thunbergianus* of Polypodaceae

### Class 2. Trilete

Thirty-eight taxa fossil spores were described here.

#### Genus 1. Camarozonosporites Pant ex Potonie 1956

Synopsis I, p. 65

Type species: *Camarozonosporites cretaceus* (Weyl. & Kr.) Pot., ibid.

Diagnosis: Type species ca. 25  $\mu\text{m}$ , trilete, amb nearly circular with a narrow cingulum that is much narrower again in those parts of the equatorial region where ends of the trilete rays extend almost to the equator. In the type species there seems to be an indication of kytomes; exine smooth, equatorial outline of the cingulum faintly wavy. The type species lacks the wide cingulum of *Rotaspora* which has a flat base and peripheral thickening.

1. **Camarozonosporites taiwanensis** sp. nov.

Figs. 86-89

Holotype: Slide OK-1 1588-bl-(3); Figs. 86, 87; film P9-21-23; P9-22-24; CPC Micropaleontology Lab.

Description: Spores zonotrilete, amb rounded triangular; size about 20-25  $\mu\text{m}$  wide; equatorial ridge 2-3  $\mu\text{m}$  thick, annulate, margin with scabrate process; distal face rugulate; laesurae about 6-10  $\mu\text{m}$  long; proximal face rugulate.

Stratigraphic occurrence: Eocene (OK-1 well, 1435m, 1588m)

Derivation of name: The specific epithet *taiwanensis* is derived from the name of the island where the specimens were found.

Taxonomic affinity: This species is closely related to extant *Pteris cretica* spores of Pteridaceae.

**Genus 2. Cicatricosisporites** Potonie & Gelletich 1933

Sitz-ber. Ges. Naturf. Freunde, Berlin, Jahrg. 1931 (1932, but 1933 in Pot. 1956)

Type species: *Cicatricosisporites dorogensis* Pot. & Gell

Diagnosis: (Pocock 1965) Trilete spores with two-layered exine; nexine smooth and thinner than or as thin as the sexine, showing little tendency to thicken at the apices, ornamented with ribs of more or less regular width and height, canaliculate to cicatricose.

1. **Cicatricosisporites tersus** (Kara-Mursa) Pocock

Figs. 32, 33

Slide: YKL-6 1128-(3); Figs. 32, 33; film WA75-10, 11; CPC Micropaleontology Lab.

Description: Spores trilete; about 36-46  $\mu\text{m}$  wide; tetrahedral, radially symmetrical; polar view rounded triangular, equatorial view triplanal shape. Laesural arms straight 18-22  $\mu\text{m}$  long, margo 0.1-1  $\mu\text{m}$  wide. Surface view striate, jointed at angles and forming 6-7 concentric ribs on proximal face, about 18 subparallel ribs on distal face; the grooves between ribs 0.5-0.7  $\mu\text{m}$  wide. Exine with verrucate processes.

Stratigraphic occurrence: Eocene (YKL-6 well, 1128m; OK-1 well, 1894m)

Taxonomic affinity: This species may be related to extant species of *Anemia*.

Note: This species is reworked from the Cretaceous sediments.

**Genus 3 Crassoretitriletes** Germeraad, Hopping & Muller 1968.

Diagnosis: Spores trilete, entirely and coarsely reticulate with undulating muri, thick-walled; laesurae indistinct.

There was one species in Taiwan, with muri varying in shape and size.

1. **Crassoretitriletes vanraadshooveni** G.H.M. in Rev. Palaeobot. Palynol. 5: 286. 1968.

Figs. 52, 53

Slide: OK-1 1588-(5); Figs. 52, 53; film S7-17, S7-18.; CPC Micropaleontology Lab.

Description: Spores trilete; amb semi-circular or semi-angular; 46-70 x 68-75  $\mu\text{m}$ . Laesural arms nearly straight, without margo, extending toward exine, 22-40  $\mu\text{m}$  long, 1-2

$\mu\text{m}$  wide. Exine 2-5  $\mu\text{m}$  thick, with scabrate processes; sexine vermiculate or reticulato-vermiculate, the vermiculae irregularly elongated elliptic, 2-15 x 2-6  $\mu\text{m}$ , the muri 2  $\mu\text{m}$  wide.

Stratigraphic occurrence: Eocene (OK-1 well, 1588m; OK-3 well, 1800m)

Taxonomic affinity: This species may be related to the extant species of *Lygodium microphyllum* (Cav.) R. Br. The species is known from Africa, S. E. Asia, Australia and Taiwan.

#### Genus 4. *Cyathidites* Couper 1953

New Zealand Geol. Surv., Paleont. Bull. 22, p. 27

Type species: *Cyathidites australis* Coup.

Diagnosis: Trilete miospores; amb triangular, corners broadly rounded, sides slightly concave; rays Y mark clearly defined, at least 2/3 radius; proximal and especially distal side convex; exine smooth.

Remarks: *Concavitriletes* is a junior synonym (G. von der Brölie, 1964)

1. ***Cyathidites formosus*** Shaw & Huang in *Taiwania* 39(3-4): 81-198, Pl. 10; figs: 3-6 1994  
Figs. 34-37

Slide: OK-3 1800-(2); YKL-1 well, 1190-1225-(4); Figs. 34-37; film WA76-23, 24; W49-23, 24; CPC Micropaleontology Lab.

Description: Spores trilete; amb triquetate, sides slightly concave, the angle broadly rounded, about 34-45  $\mu\text{m}$  wide. Laesural arms 12-15  $\mu\text{m}$  long, straight, simple. Exine psilate, 0.5-1  $\mu\text{m}$  thick; sexine smooth.

Stratigraphic occurrence: Eocene (YKL-1 well, 1190-1225m; OK-3 well, 1800m).

Taxonomic affinity: Unknown.

2. ***Cyathidites parvus*** Shaw & Huang in *Taiwania* 39(3-4): 81-198, Pl. 10; figs: 3-6 1994  
Figs. 40, 41

Slide: OK-3 1760-(5); Figs. 40,41; film PF47-10, 11; CPC Micropaleontology Lab.

Description: Spores trilete; about 21-28  $\mu\text{m}$  wide; amb triquetate with sides slightly concave. Laesural arms simple type to line-like margo; 8-12  $\mu\text{m}$  long. Surface view of exine obscure pattern; lateral view of exine subpsilate; exine 0.5-1  $\mu\text{m}$  thick.

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

Taxonomic affinity: Unknown.

#### Genus 5 *Gemmatriletes* Pierce 1961.

Univ. Minnesota, Minn. Geol. Surv., Bull. 42, p. 20

Genotype: *Gemmatriletes morulus* Pierce

Diagnosis: Gemmate trilete spores.

1. ***Gemmatriletes pengchiahsuensis*** sp. nov. Figs. 58-61

Holotype: Slide OK-1 1545-(1); Figs. 58,59; film P12-1-3, P12-2-4; CPC Micropaleontology Lab.

Description: Spores trilete; amb circular to round-triangular, size about 24-27  $\mu\text{m}$  wide; laesural arms 6-11  $\mu\text{m}$  long; surface views tuberculae, 2-5  $\mu\text{m}$  wide; lateral view gemmate to verrucate process; exine 1-1.5  $\mu\text{m}$  thick (not contained the ornamentation).

Stratigraphic occurrence: Eocene (OK-1 well, 1545m, 1669m)

Taxonomic affinity: This species is possibly related to extant species of *Selaginella*.

### Genus 6 *Gleicheniidites* Ross 1949, Krutzsch 1959

1959: *Ggeologie*, Beiheft 21-22, p. 111

Diagnosis: *Gleicheniidites* with only weak thickened equatorial sides and also mostly only weak proximal tori; no sculpture and usually no significant structure of the spore wall.

#### 1. *Gleicheniidites taiwanensis* Huang in *Taiwania* 23: 40, Pl. 18; figs: 4-6. 1978

Figs. 20, 21

Slide: OK-1 1545-(2); Figs. 20, 21; film P12-25-26, P12-26-27; CPC Micropaleontology Lab.

Description: Spores trilete; polar view subtriangular to triquetate; about 32-39  $\mu\text{m}$  wide. Laesural arms 15-16  $\mu\text{m}$  long, with narrow-band proximal ridges, the ridge 2.5 – 4.5  $\mu\text{m}$  wide. Lateral view of the exine psilate. Exine about 1  $\mu\text{m}$  thick.

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

Taxonomic affinity: This species possibly related to extant species of *Gleicheniaceae*.

#### 2. *Gleicheniidites peikangensis* Shaw in *Taiwania* 39(3-4): 81-198, Pl. 53; figs: 7, 8. 1994

Figs. 14-19

Slide: OK-1 1669-(2); OK-1 1719-(1); OK-1 1669-bl-(1); Figs. 14-19; film W53-10, 11; P14-26-27, P14-27-28; P5-19-21, P5-20-22; CPC Micro-paleontology Lab.

Description: Spores trilete; polar view subtriangular to triquetate; 26-36  $\mu\text{m}$  wide. Laesural arms 13-15  $\mu\text{m}$  long, with narrow-band proximal ridges, the ridge 1-4  $\mu\text{m}$  wide. Lateral view of the exine psilate. Exine about 1  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1719m, 1669m)

Taxonomic affinity: This species is possibly related to extant species of *Gleicheniaceae*.

#### 3. *Gleicheniidites rasilis* Krutzsch *Ggeologie*, Beiheft 21-22, p. 113. 1959.

Figs. 22, 23

Slide: OK-1 1719-(1); Figs. 22, 23; film P14-28-29, P12-29-30; CPC Micropaleontology Lab.

Description: Spores trilete; polar view subtriangular; about 28-36 x 33-42  $\mu\text{m}$  wide. Laesural arms 15-20  $\mu\text{m}$  long, with plane field proximal ridges, the ridge 4-5  $\mu\text{m}$  wide. Lateral view of the exine psilate. Exine about 1  $\mu\text{m}$  thick.

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

Taxonomic affinity: This species is possibly related to extant species of *Gleicheniaceae*.



**Genus 7. *Leiotriletes*** Naumova 1939 ex Ishchenko 1952

1939 Rept. Intern. Geol. Congr., 17 sess, Moscow 1937; v. 1, p. 355. 1952 Akad. Nauk SSSR; Inst. Geol. Nauk; Atlas; p. 9

Generotype: *Leiotriletes sphaerotriangulus* (Loose) Potonie & Kremp

Diagnosis: Spores azonotrilete; amb rounded triangular, sides usually convexly. Angle rounded; laesural arms simple, exine smooth, rarely infrapunctate.

1. ***Leiotriletes pengchiahsuensis*** sp. nov.

Figs. 26, 27

Holotype: Slide OK-1 1545-(2); Figs. 26, 27; film P12-13-14, P12-14-15; CPC Micropaleontology Lab.

Description: Spores trilete; amb rounded triangular to subtriangular, 59-64  $\mu\text{m}$  wide; laesural arms with narrow band-laesural ridges, 19-26  $\mu\text{m}$  long; surface view smooth; lateral view psilate; exine 2.0-2.5  $\mu\text{m}$  thick.

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

Taxonomic affinity: This species is possibly related to extant *Lygodium* species.

2. ***Leiotriletes wolffi*** Kr. subsp. ***brevis*** Kr. *Atlas der mittelund jungtertiären dispersion sporen und pollensowie der Mikroplanktonformen des nordlichen Mitteleuropas 1: 28, Tafel 17, fig. 1-20.*

Figs. 38, 39

Slide: OK-1 1435-(1); Figs. 38, 39; film P13-17-18, P13-16-17; CPC Micropaleontology Lab.

Description: Spores triletes; amb rounded triangular to subtriangular, 25-34  $\mu\text{m}$  wide; angle broadly obtuse; laesural arms simple, 11-16  $\mu\text{m}$  long; surface view smooth; lateral view psilate; exine 0.5-1  $\mu\text{m}$  thick.

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

Taxonomic affinity: Unknown.

3. ***Leiotriletes sphaerotriangulus*** (Loose) Potonie & Kremp 1954

Figs. 28-31

Slide: OK-2 1936-(4); OK-3 1800-(1); Figs. 28-31; film WA77-28, 29; W47-26, 27; CPC Micropaleontology Lab.

Description: Spores trilete; amb rounded triangular, the sides slightly convex; 33-55  $\mu\text{m}$  wide. Laesural arms simple, 16-24  $\mu\text{m}$  long. Surface view of exine smooth; lateral view of exine psilate; exine 1-1.5  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-2 well, 1936m; OK-3 well, 1800m)

Taxonomic affinity: Unknown.

**Genus 8. *Lophotriletes*** Naumova 1939 ex Ishchenko 1952

1939 Rept. intern. Geol. Congr., 17 sess., Moscow 1937; v.1, p. 355

1952 Akad. Nauk SSSR; Inst. Geol. Nauk; Atlas; p.30

Type species: *Lophotriletes gibbosus* (Ibr.) Potonie & Kremp

Diagnosis (1939): azonotrilete spores, tubercular.

1. ***Lophotriletes pengchiahsuensis*** sp. nov.

Figs. 90-93

Holotype: Slide OK-1 1719-(1); Figs. 92, 93; film P14-33, 34; P14-34, 35; CPC Micropaleontology Lab.

Description: Spores azonotrilete; amb rounded triangular with concave sides; size 21-27  $\mu\text{m}$  wide (holotype 25  $\mu\text{m}$ ); line-like laesural arms 9-11  $\mu\text{m}$  long; surface views tuberculae, 2-6  $\mu\text{m}$  wide; lateral view gemmate to verrucate process; exine 1  $\mu\text{m}$  thick (not including ornamentation).

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

Note: This species is named after the Pengchiahsu basin of the type locality.

Taxonomic affinity: Unknown.

**Genus 9. *Osmundacidites*** Couper 1953

New Zealand Geol. Surv., Paleontol. Bull. 22, p. 20

Type species: *Osmundacidites wellmanii* Coup.

Diagnosis: Trilete spores, amb circular to subcircular; laesural arms moderately long; exine thin, granular to papillate, sculpture somewhat reduced on proximal face.

1. ***Osmundacidites taiwanensis*** Huang in *Taiwania* 23: 44, Pl. 19; figs: 3, 4. 1978

Figs. 101, 102

Slide: YKL-1 1190-1225-(4); Figs. 101, 102; film W49-20, 21; CPC Micropaleontology Lab.

Description: Spores trilete, 35-60  $\mu\text{m}$  wide; amb circular to ellipsoidal. Laesural arms simple or indistinct, about 13-16  $\mu\text{m}$  long. Surface view of exine finely granulate; lateral view of exine finely verrucate; exine 1  $\mu\text{m}$  thick.

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

Taxonomic affinity: This species is may be related to extant species of Osmundaceae.

**Genus 10. *Polypodiaceoisporites*** Potonie' 1951 ex Potonie' 1956

Palaeontographica, 13d. 91, Abt. B, P. 136

Generotype: *Polypodiaceoisporites speciosus* (Pot.) ex Pot. 1956, *ibid.*

Diagnosis: Trilete cingulate spores; amb triangular with round corners; Y mark reaching cingulum; cingulum smooth; central body distally reticulate, with thin muri, proximally the reticulum is reduced to individual isolated rugae.

1. ***Polypodiaceoisporites scabristiptus*** Shaw in *Journ. Taiwan. Museum* 37 (1): 131-166 Pl.8.; Figs.1, 2.

Figs. 48, 49

Slide: OK-3 1760-(5); Figs. 48, 49; film PF46-36, 5; CPC Micropaleontology Lab.

Description: Spores zonotrilete; amb round triangular; size 33-44  $\mu\text{m}$  wide; equatorial ridge annulotrilete; margin smooth, sometimes interrupted on radial position, 3-4.5  $\mu\text{m}$  thick. Laesurae 16-18.5  $\mu\text{m}$  long; distal face convolute to ornate, with verrucate or cuneate process; proximal face somewhat extravermiculate, not very clear.

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

Taxonomic affinity: This species is closely related to extant *Pteris scabristipes* of Pteridaceae.

### Genus 11. *Punctatisporites* Ibrahlm 1933

Dissertation T. H. Beriin (1932); K. Triltsch, Wdozburg, p. 21

Type species: *Punctatisporites punctatus* (Ibr.) Ibr. 1933, Ibid., pl. 2, fig. 18

Diagnosis: "Trilete spores; exine surface appears to have fine sandy texture." Schopf, Wilson & Bentall 1944 gave this emended diagnosis: Spores radial, trilete; shape originally nearly spherical or possibly broadly rounded triangular with slight shortening of the axial dimension; when compressed the spores show no proximo-distal orientation preference.

#### 1. *Punctatisporites taiwanensis* sp. nov.

Figs. 24, 25

Holotype: Slide OK-1 1435-(3); Figs. 24, 25; film S9-7, 8; CPC Micropaleontology Lab.

Description: Spores trilete, 35  $\mu\text{m}$  wide; amb round triangular. Laesural arms simple, about 11  $\mu\text{m}$  long. Surface view of exine finely granulate; lateral view of exine scabrate; exine 0.5  $\mu\text{m}$  thick.

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

Derivation of name: The specific epithet **taiwanensis** is derived from the name of Taiwan Island of type locality.

Taxonomic affinity: Unknown

### Genus 12. *Retitriletes* Pierce 1961

Univ. Minnesota, Minn. Geol. Surv., Bull. 42, p.21

Type species: *Retitriletes glogosus* Pierce

Diagnosis: Spores azonotrilete; amb circular or rounded triangular; laesural arms usually long; exine with scabrate to echinate processes; sexine reticulate.

#### 1. *Retitriletes pengchiahsuensis* sp. nov.

Figs. 97-100

Holotype: Slide OK-3 1770-(2); Figs. 97, 98.; film WA79-1, 2.; CPC Micropaleontology Lab.

Description: Spores trilete; amb subtriangular; 40-49  $\mu\text{m}$  wide. Laesural arms simple type, 16-21  $\mu\text{m}$  long. Surface view of exine reticulate, lumina 2-5  $\mu\text{m}$  wide, muri about 1  $\mu\text{m}$  thick; lateral view of exine slightly echinate; exine about 1  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-3 well, 1770m)

Note: This species is named after the Pengchiahsu basin of the type locality.  
Taxonomic affinity: It may be related to the extant species of *Lycopodium*.

### **Genus 13. *Sphagnumsporites* Raatz (1937) 1938 ex Potonie 1956**

Type species: *Sphagnumsporites stereoides* (Pot. & Ven) Raatz.

Diagnosis: Trilete microspores; amb convexly triangular; Y-mark 3/5-4/5 radius, consisting of simple slits or flanked by narrow raised lips; exine proportionally thick and strong, smooth or with scabrate processes in surface view.

#### **1. *Sphagnumsporites pengchiahsuensis* sp. nov.**

Figs. 42, 43

Holotype: Slide OK-1 1788-(1); Figs. 42, 43; film P1-23-25; P1-24-26; CPC Micropaleontology Lab.

Description: Trilete spores; amb convexly triangular to circular, 18-22 x 18-22  $\mu\text{m}$ ; laesural arms 8-10  $\mu\text{m}$  long; exine 1.5  $\mu\text{m}$  thick, lateral view psilate or with scabrate sculpture, surface view smooth to obscure pattern.

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

Note: This species is named after the Pengchiahsu basin of the type locality.

Taxonomic affinity: This species is similar to extant species of *Sphagnum* (Boros, & Jarai-Komlodi, 1975. p. 86-99)

### **Genus 14. *Torofoveolatisporis* Shaw gen. nov.**

Generotype: *Torofoveolatisporis taiwanensis* Shaw, this paper.

Diagnosis: *Torofoveolatisporis* with distinct trilete mark and proximal simple tori or di-tori (two rows may be connected together). Distally without any significant differentiation. Surface view foveolate.

#### **1. *Torofoveolatisporis pengchiahsuensis* sp. nov.**

Figs. 103-107

Holotype: Slide OK-1 1768-(1); Figs. 103-104; film W38-23, 24; CPC Micropaleontology Lab.

Description: Spores trilete; size 35-53  $\mu\text{m}$  wide; radius 22-28  $\mu\text{m}$  long, subtriangular with sides straight and angle rounded; laesurae 11-25  $\mu\text{m}$  long; proximal face with plane field ridges 3-7  $\mu\text{m}$  thick; surface view foveolate; lateral view scabrate; exine 1-1.5  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1588m, 1768m)

Note: This species is named after the Pengchiahsu basin of the type locality.

Taxonomic affinity: Unknown.

#### **2. *Torofoveolatisporis taiwanensis* sp. nov.**

Figs. 108-111

Holotype: Slide OK-1 1669-(1); Figs. 108-109; film PF41-18, 19; CPC Micropaleontology Lab.

Description: Spores trilete; size 33-46  $\mu\text{m}$  wide; radius 19-24  $\mu\text{m}$  long, round-triangular to subtriangular; laesurae 14-23  $\mu\text{m}$  long; proximal face with two rows plane field ridges and usually connected together, tori about 3-5  $\mu\text{m}$  thick; surface view foveolate; lateral view scabrate; exine 1-1.5  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1638m, 1669m)

Note: This species is named after the Taiwan island of the type locality.

Taxonomic affinity: Unknown.

**Genus 15. *Triplanosporites*** Pflug (in Thomson & Pflug 1952) ex Thomson & Pflug 1953

1953 *Palaeontographica*, Bd. 94, Abt. B, p. 58

Type species: *Triplanosporites sinuosus* Pflug

Diagnosis: Spores with often indistinct Y mark, and extremely concave amb, with a polar axis that is longer than the equatorial axis.

1. ***Triplanosporites figuratus*** Shaw & Huang in *Taiwania* 39(3-4): 81-198, Pl. 12; fig. 4. 1994 Figs. 112, 113

Slide: OK-1 1788-bl-(1); Figs. 112,113; film P15-19-21; P15-20-22; CPC Micro-paleontology Lab.

Description: Spores trilete; amb extremely concave; 41-46 x 43-48  $\mu\text{m}$  wide. Laesural arms 20-22  $\mu\text{m}$  long. Surface view of exine smooth; lateral view of exine psilate; exine 1-1.5  $\mu\text{m}$  thick.

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

Taxonomic affinity: The species is similar to extant species Cyatheaceae

2. ***Triplanosporites minor*** Shaw & Huang in *Taiwania* 39(3-4): 81-198, Pl. 36; figs: 10-12. 1994 Figs. 122-125

Slide: OK-1 1435-(1), OK-1 1768-bl-(2); Figs. 122-125; film P13-20-21; P13-21-22; P5-11-13; P5-12-14; CPC Micro-paleontology Lab.

Description: Spores trilete; amb extremely concave; 21-25 x 17-23  $\mu\text{m}$  wide. Laesural arms 8-10  $\mu\text{m}$  long. Surface view of exine smooth to somewhat finely granulate; lateral view of exine psilate; exine 0.5  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1435m, 1768m)

Taxonomic affinity: It may be related to extant species of Cyatheaceae.

3. ***Triplanosporites granulatus*** sp. nov. Figs. 44, 45

Holotype: Slide OK-1 1545-(1); Figs. 44, 45; film P10-25-24, P10-26-25; CPC Micro-paleontology Lab.

Description: Spores trilete; 32-35  $\mu\text{m}$  wide. Laesural arms 15-25  $\mu\text{m}$  long. Surface view of exine granulate, about 2-3  $\mu\text{m}$  wide. Lateral view of exine verrucate. Exine 2-3  $\mu\text{m}$  thick.

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

Taxonomic affinity: Unknown.

4. **Triplanosporites formosus** Shaw & Huang in *Taiwania* 39(3-4): 81-198, Pl. 12; Figs. 1-3. 1994 Figs. 116, 117

Slide: OK-1 1588-(1); Figs. 116, 117; film P15-28-30; P15-29-31; CPC Micropaleontology Lab.

Description: Spores trilete; amb extremely concave; 32-39 x 32-39 x 28-33  $\mu\text{m}$  wide. Laesural arms 9-11  $\mu\text{m}$  long. Surface view of exine smooth; lateral view of exine psilate; exine 0.5-1  $\mu\text{m}$  thick.

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

Taxonomic affinity: It may be related to extant species of Cyatheaceae.

5. **Triplanosporites pengchiahsuensis** sp. nov. Figs. 114, 115

Holotype: Slide OK-3 1770-(3); Figs. 114, 115; film WA79-3, 4; CPC Micropaleontology Lab.

Description: Spores trilete; amb extremely concave; 48-53 x 51-55  $\mu\text{m}$  wide. Laesural arms 15-21  $\mu\text{m}$  long. Surface view of exine smooth; lateral view of exine psilate; exine 2  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-3 well, 1770m)

Note: This species is named after the Pengchiahsu basin of the type locality.

Taxonomic affinity: This species is similar to extant species of Cyatheaceae.

6. **Triplanosporites cretaceous** Shaw & Huang in *Taiwania* 39(3-4): 81-198, Pl. 11; figs: 10-12. 1994 Figs. 118-121

Slide: OK-3 1750-(1); OK-1 1788-bl-(1); Figs. 118-121; film PF9-5, 6; P15-21-23, P15-22-24; CPC Micropaleontology Lab.

Description: Spores trilete; amb extremely concave; 22-30 x 25-28  $\mu\text{m}$  wide. Laesural arms 8-10  $\mu\text{m}$  long. Surface view of exine smooth; lateral view of exine psilate; exine 0.5-1  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-3 well, 1750m; OK-1 well, 1788m)

Taxonomic affinity: It may be related to extant species of Cyatheaceae.

#### **Genus 16. Verrucingulatisporites** Kedves 1961, *Pollen et Spores*, v. 3, p. 140.

Generotype: *Verrucingulatisporites verrucatus* Kdv.

Diagnosis: Zonotrilete spores; both sides of central body and zona are ornamented with remarkable sculpture with relative large elements; sculpture corrugate or verrucose.

1. **Verrucingulatisporites vittatus** Shaw & Huang in *Taiwania* 28: 19-41, Pl. 2; figs: 3, 4, 1983  
Figs. 94-96

Slide: OK-1 1669-(1); Figs.94-96; film W54-10, 11, 12; CPC Micropaleontology Lab.

Description: Spores zonotrilete, amb subtriangular to round triangular; size 46-54  $\mu\text{m}$  wide; equatorial ridge 4-6.5  $\mu\text{m}$  thick, annulate, margin with coarse verrucate process; distal face lophate, muri 2-4  $\mu\text{m}$  thick, lumina polygonal, 4-11  $\mu\text{m}$  wide with rounded granulated processes of most of the lumina; laesurae up to the equatorial ridge, about 19  $\mu\text{m}$  long; proximal face ornamentation inconspicuous.

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

Taxonomic affinity: This species is closely related with extant *Pteris* spores of Pteridaceae.

2. **Verrucingulatisporites excelsanus** Shaw in *Journ. Taiwan. Museum* 37 (1): 131-166 Pl. 9; fig.3, 4.  
Figs. 46, 47

Slide: YKL-6 1200-(1); Figs. 46, 47; film W31-13, 14; CPC Micropaleontology Lab.

Description: Spores zonotrilete, amb subtriangular with side straight and angle round; 38-45  $\mu\text{m}$  wide; equatorial ridge 4-6.5  $\mu\text{m}$  thick, annulate, margin with coarse verrucate process; distal face lophate, muri 2.5-4  $\mu\text{m}$  thick, lumina small like pore 1.5-2.5  $\mu\text{m}$  wide; laesurae up to the equatorial ridge, about 16  $\mu\text{m}$  long; proximal face with circumfluent field proximal ridge, away from the laesurae.

Stratigraphic occurrence: Eocene (YKL-6 well, 1200m)

Taxonomic affinity: This species is closely related with extant *Pteris excelsa* spores of Pteridaceae.

3. **Verrucingulatisporites ssuhuensis** Shaw in *Journ. Taiwan. Museum* 37 (1): 131-166 Pl. 9; fig. 5-6.  
Figs. 50, 51

Slide: OK-1 1588-(2); Figs. 50, 51; film WA63-7, 8; CPC Micropaleontology Lab.

Description: Spores zonotrilete, amb round triangular with sides convex; size 30-39  $\mu\text{m}$  wide; equatorial ridge annulotriletes, margin coarsely verrucate 3-5  $\mu\text{m}$  thick, verrucae 0.8-1.3  $\mu\text{m}$  high; distal face ornate 4-7  $\mu\text{m}$  thick, with margin large verrucate to round verrucate process; proximal face with circumfluent laesural ridge, about 1.5-2  $\mu\text{m}$  thick; laesurae about 12  $\mu\text{m}$  long.

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

Taxonomic affinity: This species is closely related with extant *Pteris* spores of Pteridaceae.

4. **Verrucingulatisporites creticus** sp. nov. Figs. 70-73

Holotype: Slide OK-1 1545-(1); Figs. 70, 71; film P11-13-15; P11-14-16; CPC Micropaleontology Lab.

Description: Spores zonotrilete, amb rounded triangular; 19-31  $\mu\text{m}$  wide; equatorial ridge 2-4  $\mu\text{m}$  thick, annulate, margin with verrucate process; distal face convolute or extervermiculate; laesurae 6.5-10  $\mu\text{m}$  long; proximal face indistinct.

Stratigraphic occurrence: Eocene (OK-1 well, 1545m, 1588m)

Taxonomic affinity: This species is closely related with extant *Pteris cretica* spores of Pteridaceae.

#### 5. *Verrucingulatisporites pengchiahsuensis* sp. nov.

Figs. 62-69

Holotype: Slide OK-1 1669-bl(1); Figs. 68-69; film P8-18-21; P8-19-22; CPC Micropaleontology Lab.

Description: Spores zonotrilete, amb subtriangular to round triangular; 21-34  $\mu\text{m}$  wide; equatorial ridge 2-3  $\mu\text{m}$  thick, annulate, margin with coarse verrucate process; distal coarse granulate, 3-6  $\mu\text{m}$  wide; laesurae about 9  $\mu\text{m}$  long.

Stratigraphic occurrence: Eocene (OK-1 well, 1669m, 1719m; OK-3 well, 1800m)

Note: This species is named after the Pengchiahsu basin of the type locality.

Taxonomic affinity: This species is closely related with extant *Pteris* spores of Pteridaceae.

#### 6. *Verrucingulatisporites fatangularis* (Liu) comb. nov.

Figs. 84-85

*Pterisporites fatangularis* Liu a Song *et. al.*, 1981

Slide: OK-1 1588-bl(3); Figs. 84-85; film P9-28-30; P9-29-31; CPC Micropaleontology Lab.

Description: Spores zonotrilete, amb sub-triangular to slightly concave; 20-27  $\mu\text{m}$  wide; equatorial ridge 3-5  $\mu\text{m}$  thick, margin with verrucate process, the angle protrudent and thick (about 5  $\mu\text{m}$ ); distal face tuberculate to large granulate; laesurae 6.5-9  $\mu\text{m}$  long; proximal face indistinct.

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

Taxonomic affinity: This species is closely related with extant *Pteris* spores.

#### 7. *Verrucingulatisporites minor*. sp. nov.

Figs. 80, 81

Holotype: Slide OK-2 1936-(3); Figs. 80, 81; film W47-15, 16; CPC Micropaleontology Lab.

Description: Spores zonotrilete, amb sub-triangular; 21-24  $\mu\text{m}$  wide; equatorial ridge 1.5-2.5  $\mu\text{m}$  thick, margin with verrucate process; surface view granulate, 2-3.5  $\mu\text{m}$  wide; laesurae 6-8  $\mu\text{m}$  long.

Stratigraphic occurrence: Eocene (OK-2 well, 1936m)

Taxonomic affinity: This species is closely related with extant *Pteris* spores.



8. **Verrucingulatisporites chinaensis** sp. nov.

Figs. 78, 79

Holotype: Slide OK-1 1588-(1); Figs. 78, 79; film S8-25, 26; CPC Micropaleontology Lab.

Description: Spores zonotrilete, amb subtriangular to round triangular; 20-25  $\mu\text{m}$  wide; equatorial ridge 1.5-3  $\mu\text{m}$  thick, annulate, margin with coarse verrucate process; distal coarse granulate, 1-3  $\mu\text{m}$  wide; laesurae 7-9  $\mu\text{m}$  long.

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

Taxonomic affinity: This species is related with extant *Pteris* spores.

**Genus 17. Verrucosisporites** Ibrahim 1933

Dissertation, p. 24

Type species: *Verrucosisporites verrucosus* Ibr.

Diagnosis: Spores trilete; sexine covered with warts or wrinkles (verrucate process).

1. **Verrucosisporites pengchiahsuensis** sp. nov.

Figs. 54-57 and Figs. 74, 75

Holotype: Slide OK-1 1788-(5); Figs. 56-57; film S4-12, 13; CPC Micropaleontology Lab.

Description: Spores trilete; rounded triangular to subcircular; 26-32  $\mu\text{m}$  wide. Laesural arms 12-15  $\mu\text{m}$  long. Surface view of exine granulate, granules 1-3  $\mu\text{m}$  wide; lateral view of exine verrucate processes; exine 1  $\mu\text{m}$  thick.

Stratigraphic occurrence: Eocene (OK-1 well, 1788m; YKL-6 well, 1128m)

Note: This species is named after the Pengchiahsu basin of the type locality.

Taxonomic affinity: It is possibly related to extant species of *Selaginella*.

2. **Verrucosisporites minutus** sp. nov.

Figs. 82, 83

Holotype: Slide OK-1 1768-bl-(1); Figs. 82, 83; film P4-12-15; P4-13-16; CPC Micropaleontology Lab.

Description: Spores trilete; sub-triangular; 18-20  $\mu\text{m}$  wide. Laesural arms 6-7  $\mu\text{m}$  long. Surface view of exine granulate, granules 1-2  $\mu\text{m}$  wide; lateral view of exine verrucate processes; exine 0.5-1  $\mu\text{m}$  thick.

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

Taxonomic affinity: It is possibly related to extant species of *Selaginella*.

3. **Verrucosisporites wartus** sp. nov.

Figs. 76, 77

Holotype: Slide OK-3 1760-(4); Figs. 76, 77; film PF45-7, 8; CPC Micropaleontology Lab.

Description: Spores trilete; sub-triangular; 26-29  $\mu\text{m}$  wide. Laesural arms 6-7  $\mu\text{m}$  long. Surface view of exine granulate, granules 1.5-3.5  $\mu\text{m}$  wide; lateral view of exine verrucate processes; exine 1  $\mu\text{m}$  thick.

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

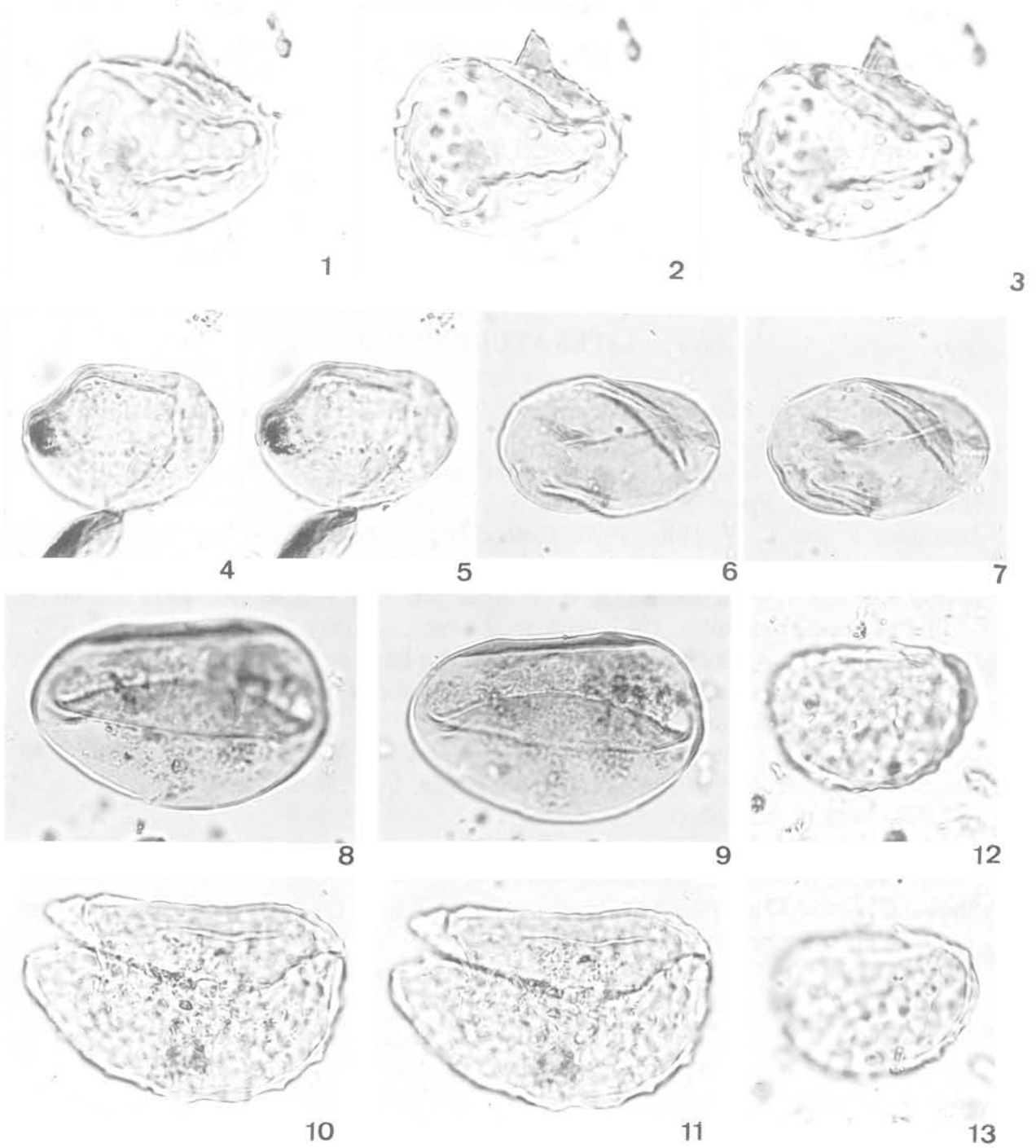
Taxonomic affinity: It is possibly related to extant species of *Selaginella*.

## ACKNOWLEDGMENTS

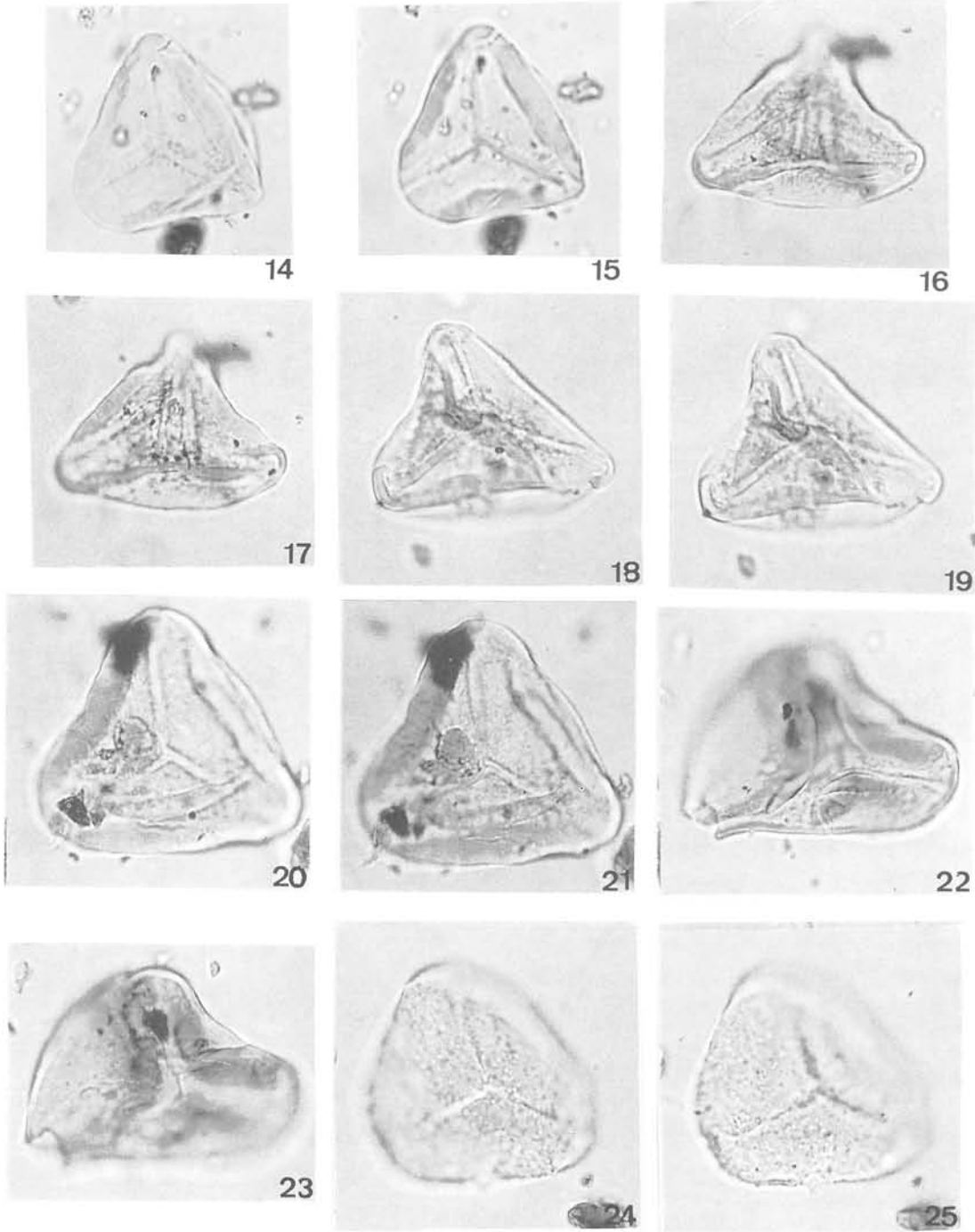
I would like to express my deep appreciation to the Exploration Development and Research Institute, CPC for providing facilities to conduct this study, the Offshore and Oversea Petroleum Division, CPC for providing subsurface rock samples. This work was supported by National Science Council of the Republic of China under contract NSC87-2116-M-326-001.

## LITERATURE CITED

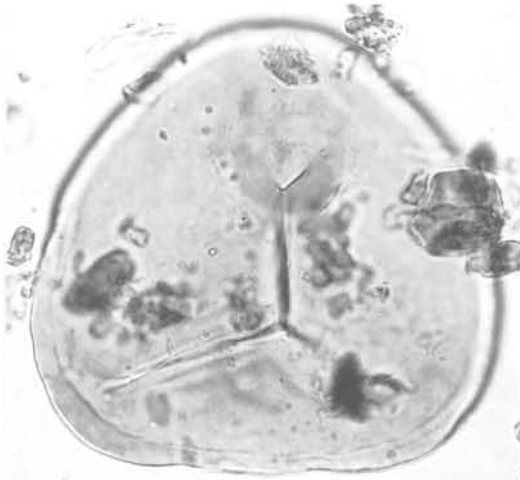
- Huang, T.-C. 1978a. Miocene Palynomorphs of Taiwan (1). Pteridaceae and Schizaeaceae. Bot. Bull. Academia Sinica. **19**: 13-31.
- Huang, T.-C. 1978b. Miocene Palynomorphs of Taiwan (3). Spores. *Taiwania*. **23**: 7-55.
- Huang, T.-C. 1981. Spore Flora of Taiwan. figs. 12. pls. 120, p.112, Taipei Taiwan, R.O.C.
- Jansonius, J. and L. V. Hills. 1976, Genera File of Fossil Spore and Pollen. Special Publication, Department of Geology, University of Calgary, Canada.
- Kremp, G. O., W. W. Spackman, B. H. T. Ames and A. J. Kovar. 1957-1972. Catalog of Fossil Spores and Pollen. The Pennsylvania State University. Vol. 34.
- Krutzsch, W. 1971. Atlas der Mittel-und Jungtertiären Dispersen Spore-und Pollen-sowie der Mikroplanktonformen des Nördlichen Mitteleuropas. Veb. Deutscher Verlag der Wissenschaften Berlin. Lieferung VII: 154-171.
- Song, Z.-C., Y.-H. Zheng, J.-L. Liu, P.-Y. Ye, C.-F. Wang and S.-F. Zhou. 1981. Cretaceous-Tertiary palynological assemblages from Jiansu area. The Geological Publishing House, 268pp.
- Shaw, C.-L. 1980. Miocene Sporomorphs (Pteridophytic Spore), Biostratigraphy, Taiwan. MS. thesis of National Taiwan University, 92pp.
- Shaw, C.-L. 1984, Oligo-Miocene Palynomorphs of Taiwan (1) Pteridophytic Spores. *Journ. Taiwan. Museum* **37**: 131-166.
- Shaw, C.-L., 1990. Pollen Analysis on Cretaceous Sediments in Taiwan. Ph. D. Dissertation of National Taiwan University, 506pp.
- Shaw, C.-L. and T.-C. Huang. 1994. Cretaceous Palynomorphs of Taiwan (2)— Taxonomic Treatment. *Taiwania* **39**: 81-198.
- Shaw, C.-L. 1996. Strigraphic Correlation and Isopach Maps of the Western Taiwan Basin. *TAO* **7**: 333-360.
- Shaw, C.-L. 1997, Eocene Tiliaceous Palynomorphs of Taiwan. *Taiwania* **42**: 267-273.
- Shaw, C.-L. 1998, Eocene Ephedraceous Palynomorphs of Taiwan. Bot. Bull. Acad. Sin. **38**: 69-80.
- Shaw, C.-L. 1999a. Eocene Wetzeliellaceous cysts of Taiwan. *Taiwania* **44**: 31-48.
- Shaw, C.-L. 1999b. Eocene dinoflagellate cysts of Taiwan. *Taiwania* **44**: 155-201.



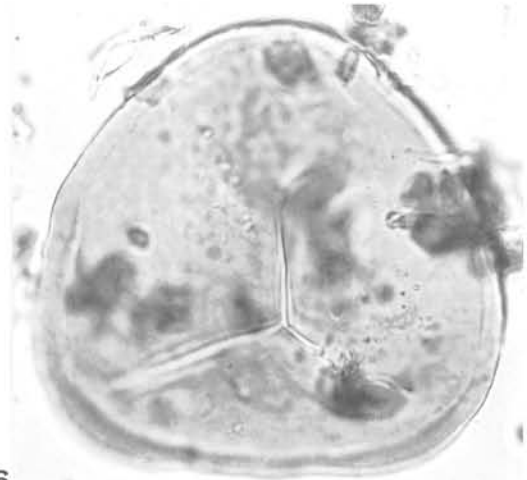
Figs. 1-3. *Gemmamonoletes formosensis* Huang; Figs. 4, 5. *Gemmatosporis pengchiahsuensis* sp. nov.; Figs. 6, 7. *Laevigatosporites gracilis* Wilson & Webster; Figs. 8, 9. *Laevigatosporites medius* Kosanke; Figs. 10, 11 *Polypodiidites thunbergiensis* sp. nov.; Figs. 12, 13. *Polypodiidites formosensis* Shaw (All figures x1000)



Figs. 14-19. *Gleicheniidites peikangensis* Shaw; Figs. 20, 21. *Gleicheniidites taiwanensis* Huang; Figs. 22, 23. *Gleicheniidites rasilis* Krutzsch; Figs. 24, 25. *Punctatisporites taiwanensis* sp. nov. (All figures x1000)



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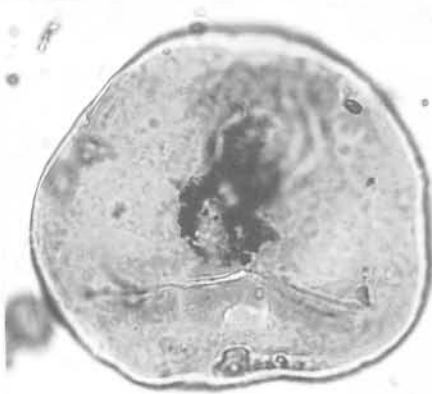
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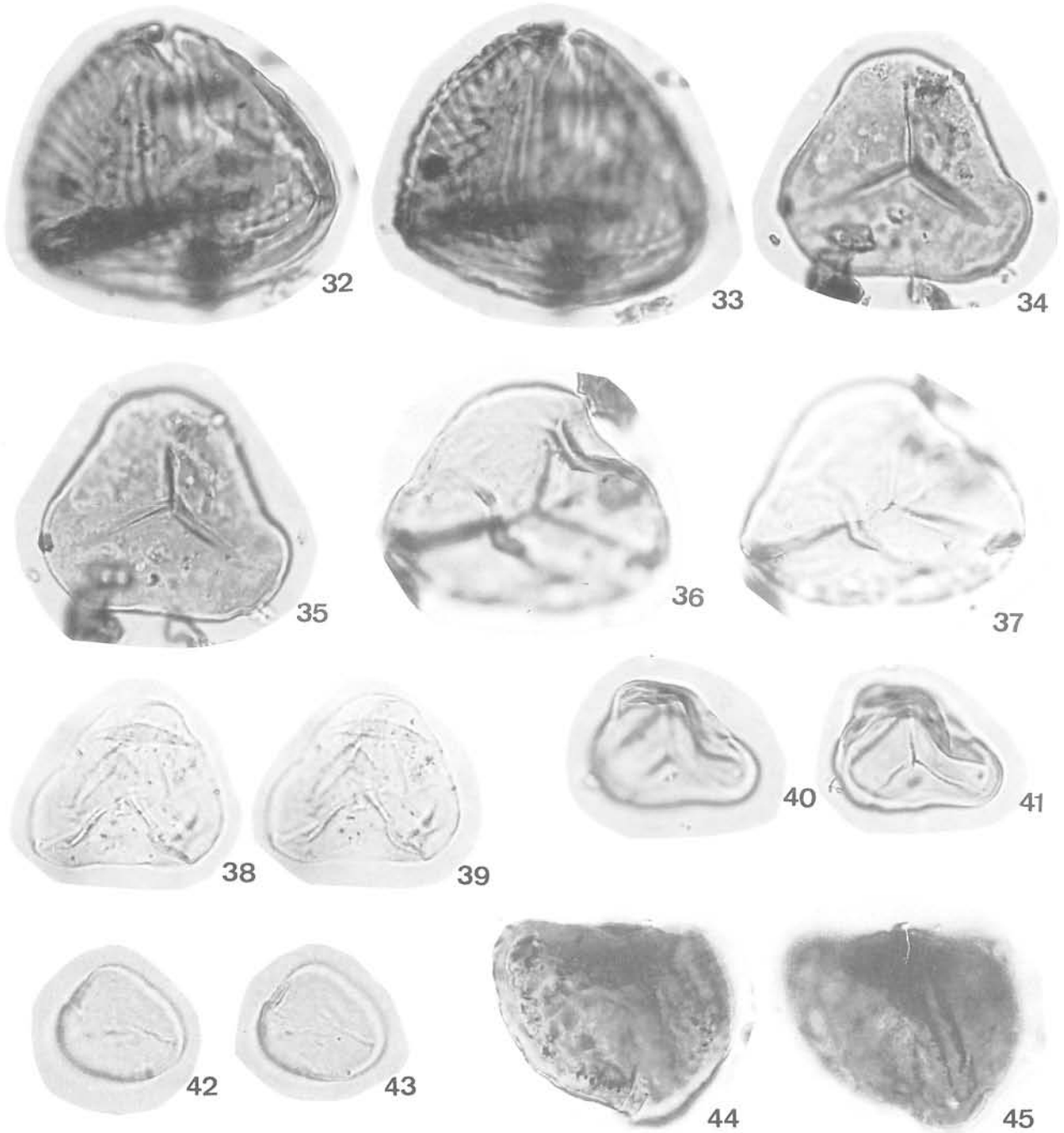


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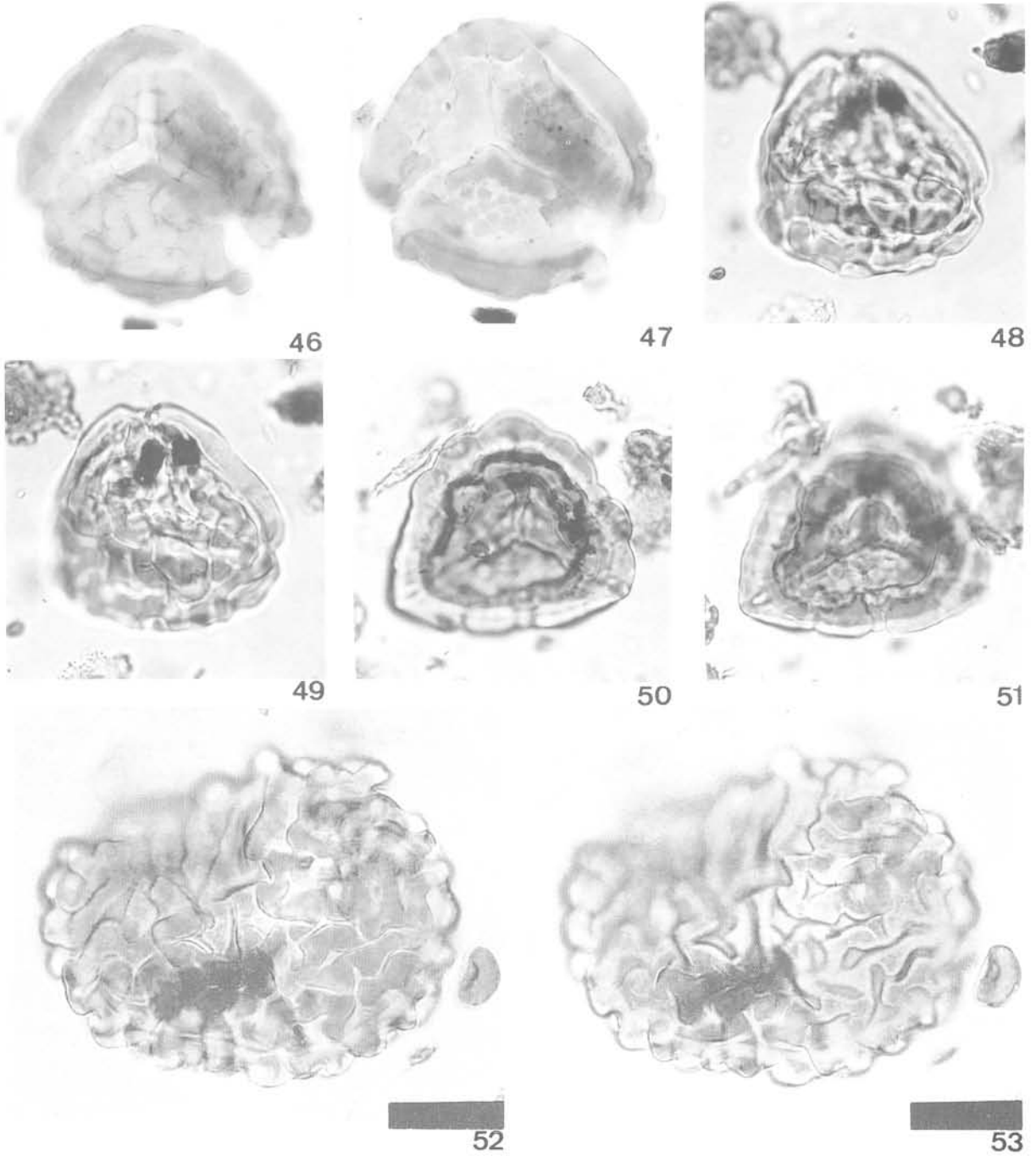


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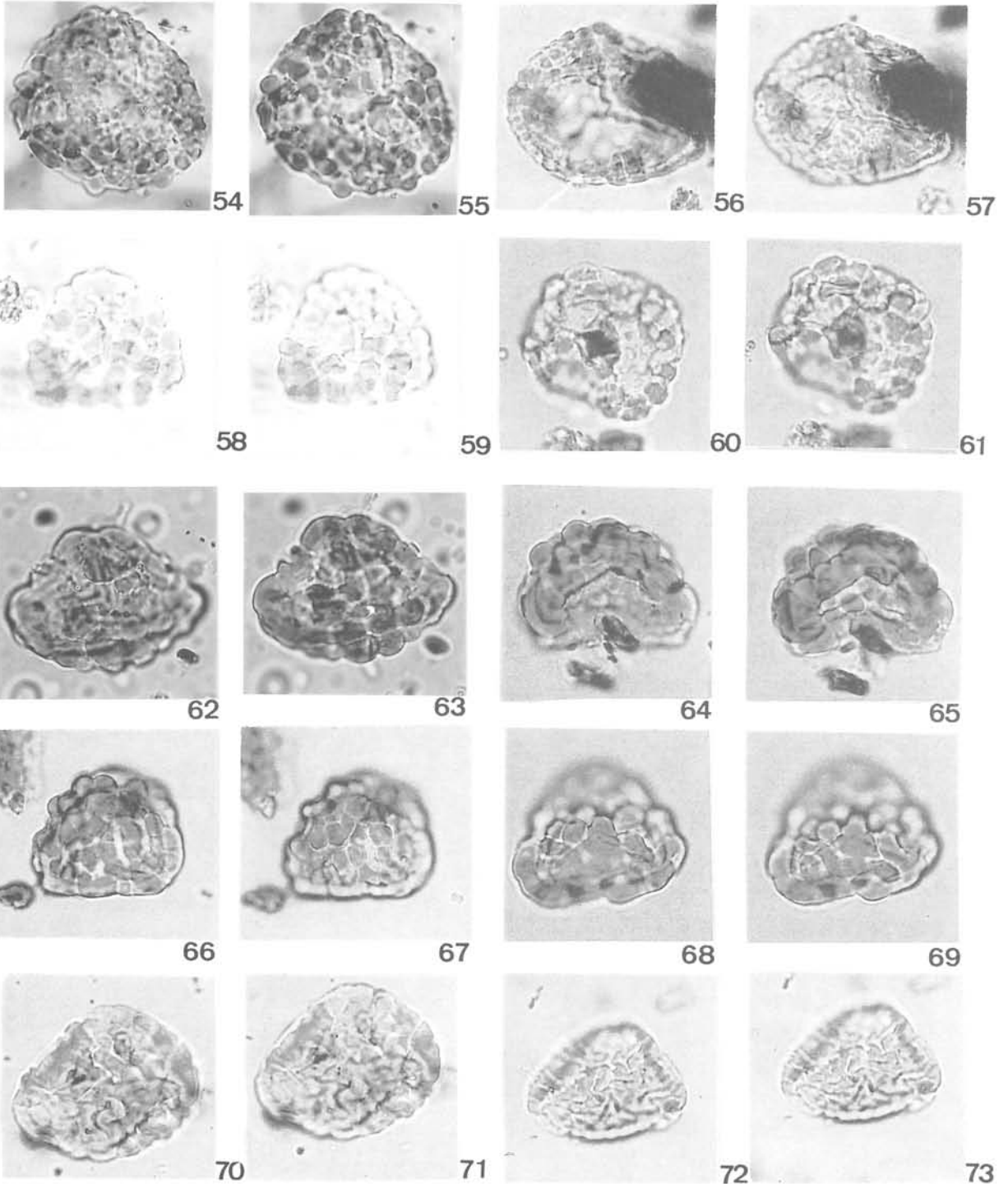
Figs. 26, 27. *Leiotriletes pengchiahsuensis* sp. nov; Figs. 28-31. *Leiotriletes sphaerotriangulus* (Loose) Potonie & Kremp. (All figures x1000)



Figs. 32, 33. *Cicatricosisporites tersus* (Kara-Muursa) Pocock; Figs. 34-37. *Cyathidites formosus* Shaw & Huang; Figs. 38, 39. *Leiotriletes wolffi* Kr. subsp. *brevis* Kr.; Figs. 40, 41. *Cyathidites parvus* Shaw & Huang; Figs. 42, 43. *Sphagnumsporites pengchiahsuensis* sp. nov; Figs 44, 45. *Triplanosporites granulatus* sp. nov. (All figures x1000)

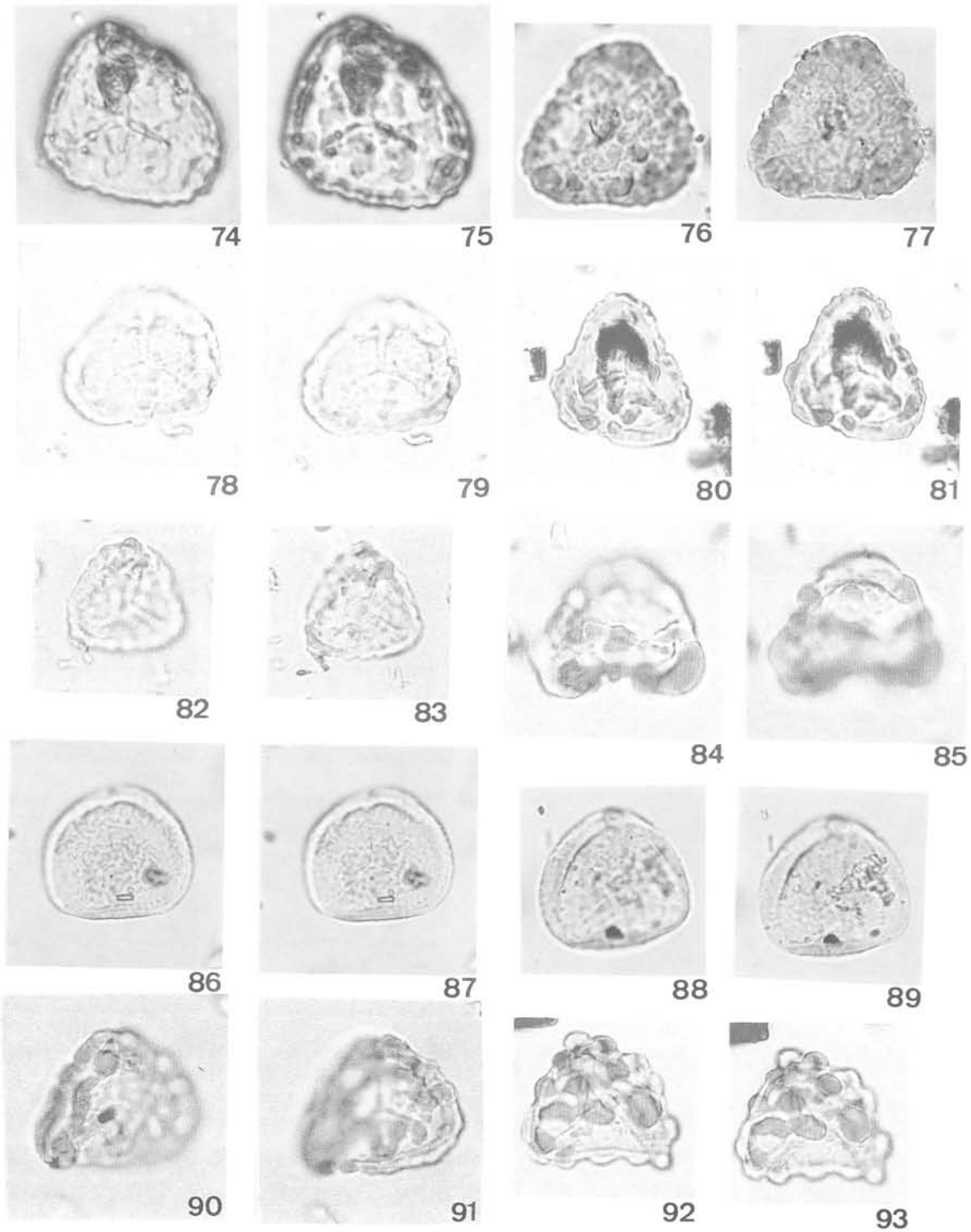


Figs. 46, 47. *Verrucingulatisporites excelsanus* Shaw; Figs. 48, 49. *Polypodiaceoisporites scabristiptus* Shaw; Figs. 50, 51. *Verrucingulatisporites ssuhuensis* Shaw; Figs. 52, 53. *Crassoretitriletes vanraad-shooveni* G.H.M. (All figures x1000)

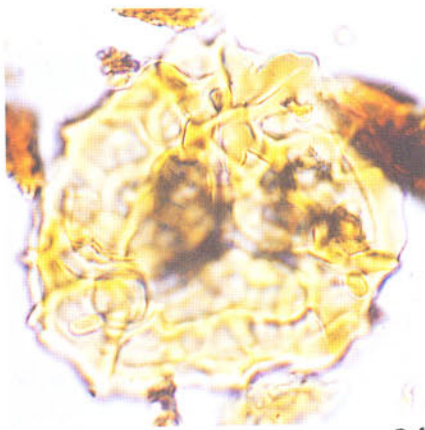


Figs. 54-57. *Verrucosporites pengchiahsuensis* sp. nov.; Figs. 58-61. *Gemmatriteles pengchiahsuensis* sp. nov.; Figs. 62-69. *Errucingulatisporites pengchiahsuensis* sp. nov.; Figs. 70-73. *Verrucingulatisporites creticus* sp. nov. (All figures x1000)

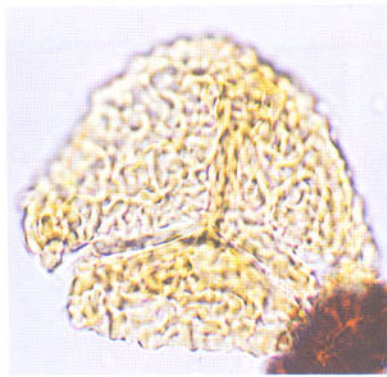




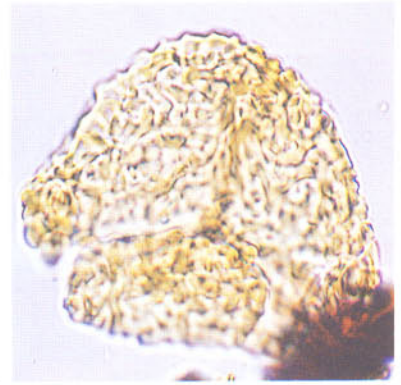
Figs. 74, 75. *Verrucosisporites pengchiahsuensis* sp. nov.; Figs. 76, 77. *Verrucosisporites wartus* sp. nov.; Figs. 78, 79. *Verrucingulatisporites chinaensis* sp. nov.; Figs. 80, 81. *Verrucingulatisporites minor* sp. nov.; Figs. 82, 83. *Verrucosisporites minutus* sp. nov.; Figs. 84, 85. *Verrucingulatisporites fatangularis* (Liu) comb. nov.; Figs. 86-89. *Camarozonosporites taiwanensis* sp. nov.; Figs. 90-93. *Lophotriletes pengchiahsuensis* sp. nov. (All figures x1000)



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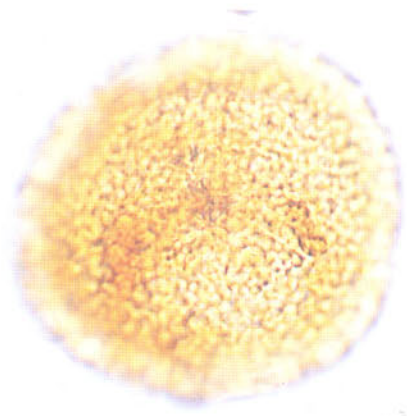
98



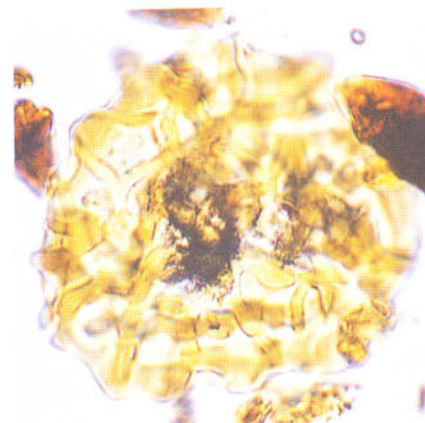
95



99



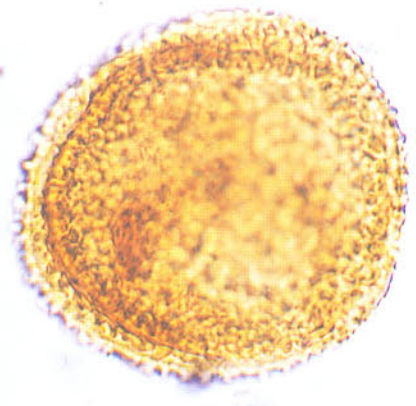
101



96

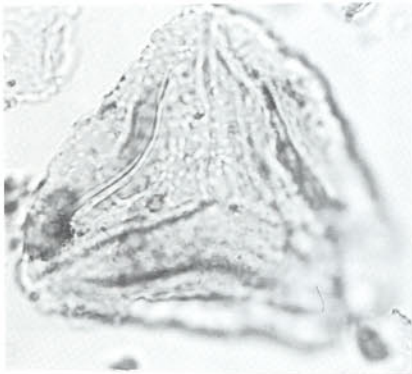


100

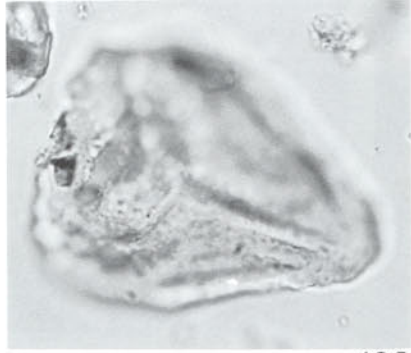


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Figs. 94-96. *Verrucingulatisporites vittatus* Shaw & Huang; Fig. 97-100. *Retitriletes pengchiahsuensis* sp. nov.; Figs. 101, 102. *Osmundacidites taiwanensis* Huang.



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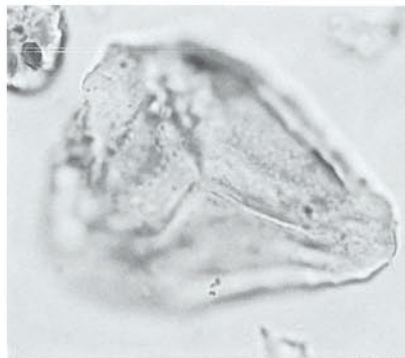
106



109



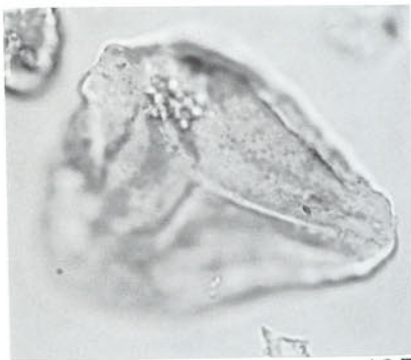
104



107



110



105

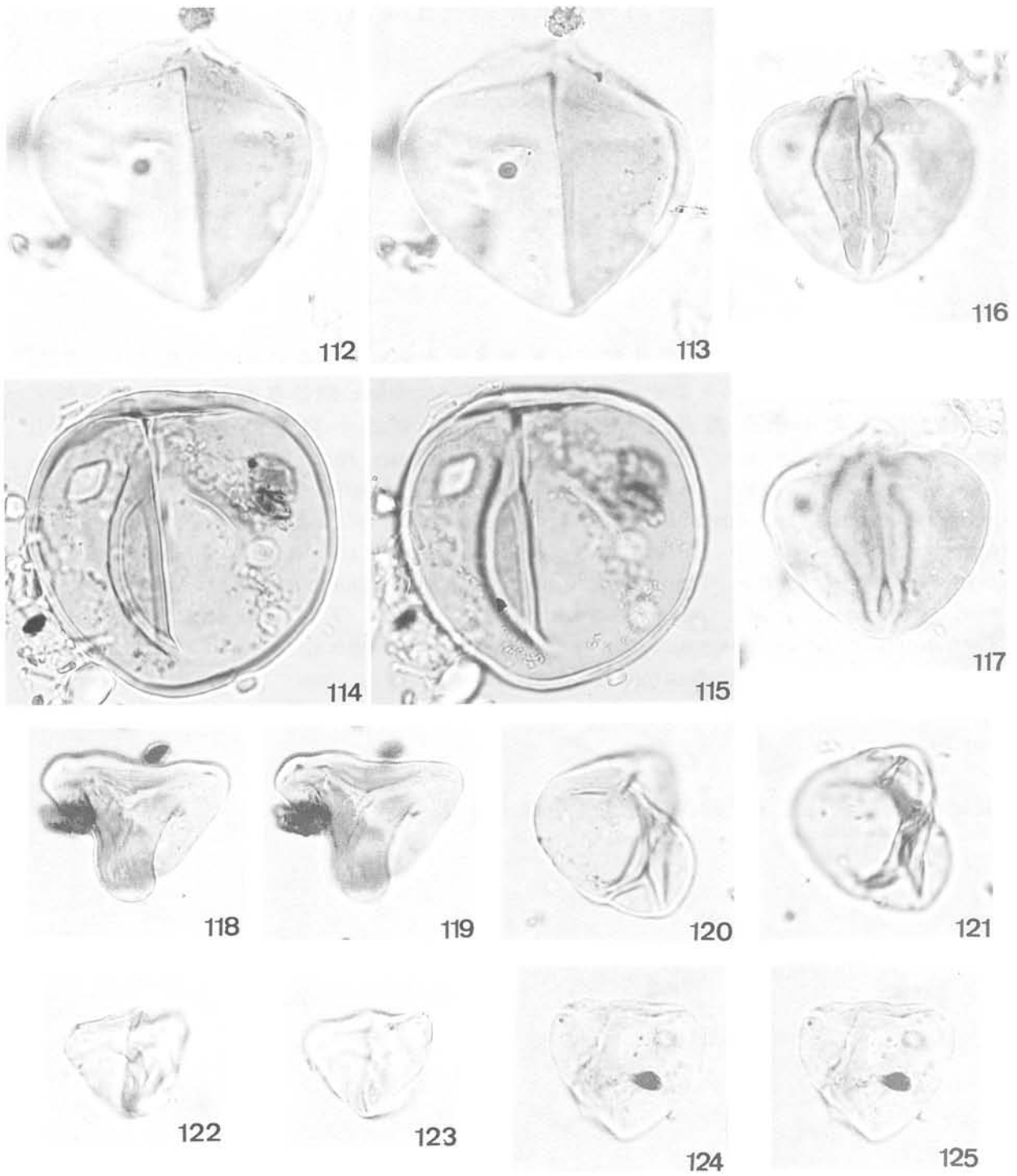


108



111

Figs. 103-107. *Torofoveolatisporis pengchiahsuensis* sp. nov.; Figs. 108-111. *Torofoveolatisporis taiwanensis* sp. nov. (All figures x1000)



Figs. 112, 113. *Triplanosporites figuratus* Shaw & Huang; Figs. 114, 115. *Triplanosporites pengchiahsuensis* sp. nov; Figs. 116, 117. *Triplanosporites formosus* Shaw & Huang; Figs. 118-121. *Triplanosporites cretaceous* Shaw & Huang; Figs. 122-125. *Triplanosporites minor* Shaw & Huang. (All figures x1000).

## 台灣始新世蕨類孢子化石

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(收稿日期：1999年4月13日；接受日期：1999年5月15日)

## 摘 要

本文報導發現於台灣基隆北方海域始新世地層中，蕨類孢子化石共計四十三個形態屬；它們分別屬於二綱，二十一形態屬，其中 *Monolete* 綱計有四形態屬六形態種，*Trilete* 綱計有十七形態屬三十七形態種，其中二十種為新種 (*Gemmatosporis pengchiahsuensis* sp. nov.; *Polypodiidites thunbergiensis* sp. nov.; *Camarozonosporites taiwanensis* sp. nov.; *Gemmatriletes pengchiahsuensis* sp. nov.; *Leiotriletes pengchiahsuensis* sp. nov.; *Lophotriletes pengchiahsuensis* sp. nov.; *Punctatisporites taiwanensis* sp. nov.; *Retitriletes pengchiahsuensis* sp. nov.; *Sphagnumsporites pengchiahsuensis* sp. nov.; *Torofoveolatisporis pengchiahsuensis* sp. nov.; *T. taiwanensis* sp. nov.; *Triplanosporites pengchiahsuensis* sp. nov.; *T. granulatus* sp. nov.; *Verrucingulatisporites pengchiahsuensis* sp. nov.; *V. chinaensis* sp. nov.; *V. minor* sp. nov.; *V. creticus* sp. nov.; *Verrucosisporites pengchiahsuensis* sp. nov.; *V. wartus* sp. nov.; *V. minutus* sp. nov.)，一種為新聚合種 (*Verrucingulatisporites fatangularis* (Liu) comb. nov.)。

關鍵辭：始新世地層、蕨類孢子化石、分類、台灣。

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