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Eocene Wetzeliellaceous Dinoflagellate Cysts of Taiwan

Cheng-Long Shaw [1]

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ABSTRACT: Three genera *Apectodinium, Kisselovia* and *Wetzeliella,* the fossil dinoflagellate cysts of Wetzeliellaceae, obtained from Eocene sediments from offshore Keelung in northern Taiwan are reported. Two species of the genus *Apectodinium* (*A. homomorphum* (Deflandre & Coookson) Lentin & Williams emend. Harland and *A. raritubiformium sp. nov.*), three species of the genus *Kisselovia* (*K. pengchiahsuensis sp. nov.*, *K. coleothrypta* (Williams & Downie) Lentin & Williams and *K. taiwaniana sp. nov.*) and four new varieties of the genus *Wetzeliella* (*W. symmetrica* var. *taiwaniana var. nov.*, *W. symmetrica* var. *scabrata var. nov.*, *W. articulata* var. *taiwaniana var. nov.* and *W. articulata* var. *scabrata var. nov.*) are described. They are distributed sporadically in the Eocene formations, but have not been observed in Oligo-Miocene of Taiwan and may therefore have significance as marker species of Eocene.

KEY WORDS: Eocene, Wetzeliellaceous Dinophyceae, Taiwan area, Taxonomy.

INTRODUCTION

Cysts in *Wetzeliella* complex have a distinct endocyst and are typically circumcavate. The genera *Apectodinium, Kisselovia* and *Wetzeliella,* the fossil dinoflagellate cysts of Wetzeliellaceae, are some of the most characteristic and better known elements in Palaeogene dinoflagellate assemblages. Since *Wetzeliella* Eisenack was erected by Eisenack in 1938, this genus has received the attention of several investigators (Gocht, 1969; Williams and Downie 1966; Wilson 1967; Costa and Downie 1976), who considerably added to the knowledge on the morphology and taxonomy of the group. The relatively large number of works on Palaeogene microplankton assemblages published in the last forty years has yielded abundant addition of many species in this genus. The stratigraphical range of *Wetzeliella* is relatively restricted: no species properly referable to this genus is known from sediments older than the Upper Paleocene and it now seems certain that the genus becomes extinct in the Miocene. Of the thirty or so species of *Wetzeliella* described, the great majority occur in the Lower-Middle Eocene, the number decreases markedly towards the Oligocene and only one species (*W. symmetrica*) seems to occur in the Miocene. The picture offered by the group is that of a sudden and widespread first appearance in the late Upper Palaeocene, quickly followed by a rapid diversification which reached its maximum in the late Lower Eocene, and a progressive decline towards the Oligocene (Costa and Downie 1976). The stratigraphical range of *Apectodinium* is relatively restricted from Paleocene to Eocene. The stratigraphical range of *Kisselovia* is relatively restricted from Eocene to Early Oligocene (Wilson and Clowes, 1980).

1. Department of Research and Collection, National Museum of Prehistory Planning Bureau, Taitung 950, Taiwan, Republic of China.

Wetzeliella has an extensive geographical distribution comprising eastern and western Europe, central Asia, New Zealand, Australia, North America, and Taiwan. Only one species has so far been recorded in South America and no records are known from Africa, the remainder of Asia, or the Antarctic (Costa and Downie 1976).

The first reference to the importance of *Wetzeliella* in Paleogene biostratigraphy was made by Wilson (1967) who studied its distribution in the Paleocene-Eocene of New Zealand. Russian workers have included *Wetzeliella* in the analysis of Eocene and Oligocene deposits in Ukraine, Crimea, and Tadjikistan (Costa and Downie 1976). Downie *et al.* (1971) proposed the '*Wetzeliella* phase' to characterize the Oldhaven and Woolwich Beds in south-eastern England and to apply this to correlation with the Belgian Landenian. The first zonal scheme based on *Wetzeliella* was introduced by Caro (1973) for the Upper Paleocene-Lower Eocene of the southern Pyrenees in north-east Spain.

Dinoflagellate cysts were first reported from Taiwan Tertiary formations by Huang (1981) in *Taiwania* dealing with Miocene cysts. The dinoflagellate investigation of Eocene sedimentary rocks in Taiwan began in 1988. A total of thirty-three cores of Eocene from the offshore of the Keelung area in northern Taiwan were collected. These samples were brought to the Chinese Petroleum Corporation Micropaleontological Laboratory for the preparation of pollen slides. On examination, many fossil dinoflagellate were identified, the description of which began in 1997. The first part of the work on the Wetzeliellaceous dinoflagellate cysts is now being published, although the work is still continuing. When completed the author plans to report his taxonomic findings of the fossil dinoflagellate cysts in a subsequent publication. The last complete report will include a checklist of the Eocene fossil flora and biostratigraphy of the offshore of the Keelung area.

This paper is part of a more extensive discussion of the genera *Apectodinium, Kisselovia* and *Wetzeliella,* the fossil dinoflagellate cysts of Wetzeliellaceae, in which the morphology, taxonomy, and stratigraphic occurrence of this group have been found from the area offshore Keelung in northern Taiwan.

MATERIALS AND METHODS

Core samples from the OK-1, OK-2 and OK-3 wells from the area offshore Keelung in northern Taiwan were made available to the author (Fig. 1). A total of forty-nine side-wall cores were prepared by the Chinese Petroleum Corporation Micropaleontological Laboratory for a palynological study.

The extraction of fossil palynomorphs was made by using the method of the author (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 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, the standard references used by Eisenack (1967), Eisenack and Kjellstrom (1971), Williams, Sarjeant, and Kidson (1978), Wilson and Clowes (1980) were adopted. The fossil slides are catalogued and stored at the Micropaleontology Laboratory, Chinese Petroleum Corporation.

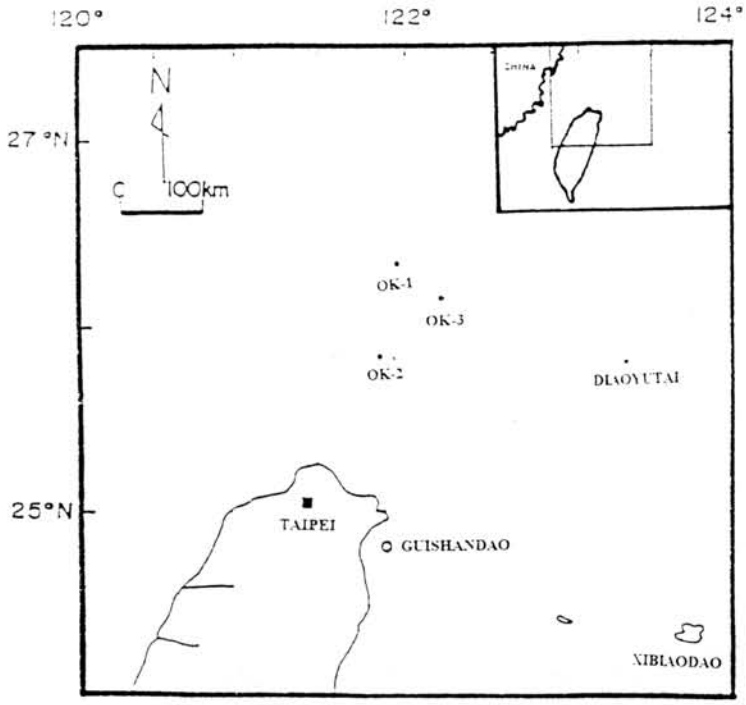


Fig. 1. Locality map of OK-1, OK-2 and OK-3 wells in the Keelung offshore of Taiwan area.

RESULTS

Apectodinium, Kisselovia and *Wetzeliella* are distributed sporadically in the Eocene formations, but have not been observed in Oligo-Miocene formatios of Taiwan and may therefore have significance as marker species of Eocene. Three genera *Apectodinium, Kisselovia* and *Wetzeliella,* the fossil dinoflagellate cysts of Wetzeliellaceae, obtained from Eocene sediments from offshore of the Keelung area in northern Taiwan are reported. Two species of the genus *Apectodinium* (*Apectodinium homomorphum* (Deflandre & Coookson) Lentin & Williams emend. Harland and *Apectodinium raritubiformium* sp. nov.), three species of the genus *Kisselovia* (*Kisselovia pengchiahsuensis* sp. nov., *Kisselovia coleothrypta* (Williams & Downie) Lentin & Williams and *Kisselovia taiwaniana* sp. nov.) and four new varieties of the genus *Wetzeliella* (*Wetzeliella symmetrica* var. *taiwaniana* var. nov., *Wetzeliella symmetrica* var. *scabrata* var. nov., *Wetzeliella articulata* var. *taiwaniana* var. nov. and *Wetzeliella articulata* var. *scabrata* var. nov.) are described from the OK-1, OK-2 and OK-3 wells drilled.

TAXONOMIC TREATMENT

Class Dinophyceae Fritsch, 1929
Order Peridiniales, 1894
Suborder Deflandreineae Eisenak emend. Norris, 1974
Family Wetzeliellaceae Vozzhennikova, 1961

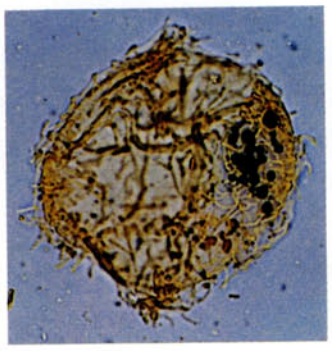
Genus **Apectodinium** Costa & Downie, 1976 *ex* Lentin & Williams, 1977

Type species: *Apectodinium homomorphum* (Deflandre & Cookson, 1955) Lentin & Williams, 1977 emend. Harland, 1979

Remarks: The genus differs from *Wetzeliella* in having nontabular processes and an endophragm which is always in very close contact with the perophragm. Forms with developed lateral horns are rare (Wilson and Clowes, 1980). A modified generic description is given by Stover and Evitt (1978, p. 95).

Stratigraphic range: Late Paleocene – Eocene (Wilson and Clowes, 1980).

1. **Apectodinium homomorphum** (Deflandre & Coookson, 1955) Lentin & Williams, 1977 emend. Harland, 1979 Figs. 2-4



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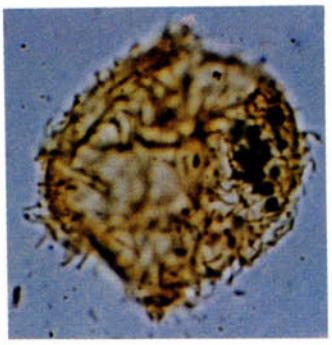

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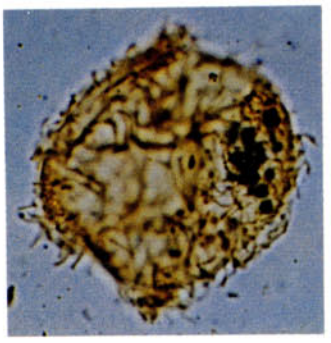

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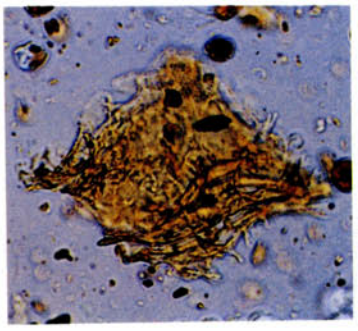

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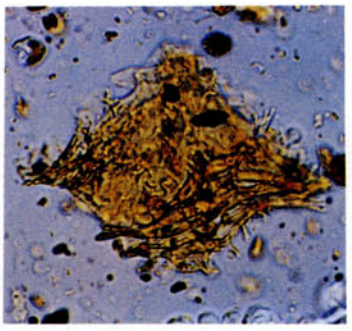

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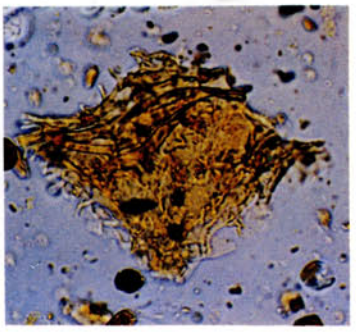

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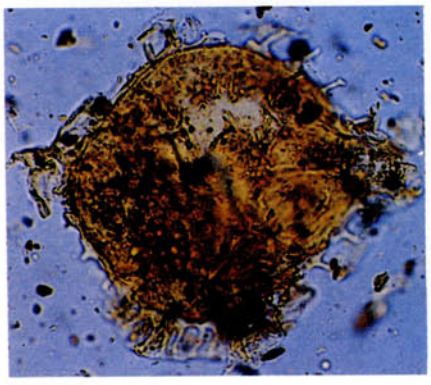

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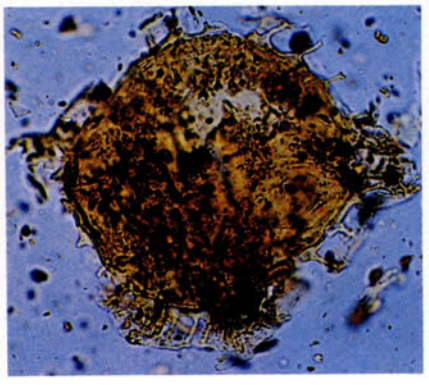

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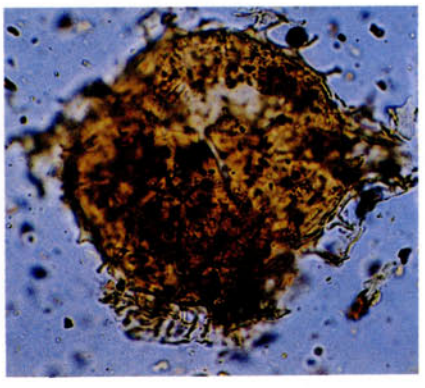

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Figs. 2-4. *Apectodinium homomorphum* (Deflandre & Coookson) Lentin & Williams emend. Harland (Film PF50-34, PF50-35, PF50-36). Figs. 5-7 *Kisselovia pengchiahsuensis* C. L. Shaw *sp. nov.* (Film WA70-4, WA70-5, WA70-6). Figs. 8-10 *Kisselovia taiwaniana* C. L. Shaw *sp. nov.*(Film WA70-17, WA70-18, WA70-19) (All figures x 400)

1948 *Hystrichosphaeridium geometricum* Pastiels (pars): 41,pl.4, fig.3,5,6,7,9,10.
1955 *Wetzeliella homomorpha* Defiandre & Cookson: 254, pl. 5, fig. 7, text-fig. 19.
1977 *Apectodinium homomorphum* (Deflandre & Cookson) Lentin & Williams: 8.
1979 *Wetzeliella* (*Apectodinium*) *homomorpha* (Deflandre & Cookson) Harland: 63, 0pl. 1, figs. 1-8.

Slide: OK-3 1808-(2); film PF50-34, PF50-35, PF50-36; Figs. 2-4; CPC Micropaleontology Lab.

Description: Cysts intermediate; outline polygonal or more or less rounded; the wall of cyst thin and well-covered with appendages; processes numerous, tubiformed, with bifid or entire tips, up to 8.5 μm long, the surface view smooth. The endophragm is always very closely contact with the perophragm. Intercalary archeopyle, sometimes indistinct.

Stratigraphic occurrence: Eocene (OK-3 well, 1808m)

Dimensions: Overall length 99 μm long, breadth 98 μm wide; length of the endocyst 81 μm long, breadth 79 μm wide (n=1).

Remarks: The species Specimen is somewhat variable, especially in the degree of development of the horns, which are sometimes not developed, and shorter tubiformed appendages. The species was recorded from the Waipawa Section (Wilson 1967) and it was used as a zone index for the New Zealand Late Teurian and early Waipawan (Wilson 1984; 1988).

Previous records: The species has a world-wide distribution in the Late Paleocene and Early Eocene.

2. **Apectodinium raritubiformium** C. L. Shaw *sp. nov.* Figs. 11-13

Holotype: Sample slide, OK-2 1875- (1); film WA68-31, WA68-32, WA68-33 (Holotype at three focus levels); Figs. 11-13; CPC Micropaleontology Lab.

Description: Cysts intermediate, outline polygonal or more or less rounded; the wall of cyst thin and sparsed with appendages; processes tubiformed, with bifid or entire tips, fairly long (up to 18 μm long), surface view smooth. The endophragm is always very close contact with the perophragm. Intercalary archeopyle, sometimes indistinct.

Stratigraphic occurrence: Eocene (OK-2 well, 1875m)

Dimensions: Overall length 95 μm long, the breadth 72 μm wide, length of endocyst 85 μm long, breadth 68 μm wide, surface features with tubiform processes, the tubiforms about 10-18 μm long (n=1).

Derivation of name: The specific epithet, **raritubiformium** means the sparsed and tubiformed appendages.

Remarks: The new species resembles *Apectodinium homomorphum* in having a roughly similar outline. However it differs from that in having sparsed and longer tubiformed appendages.

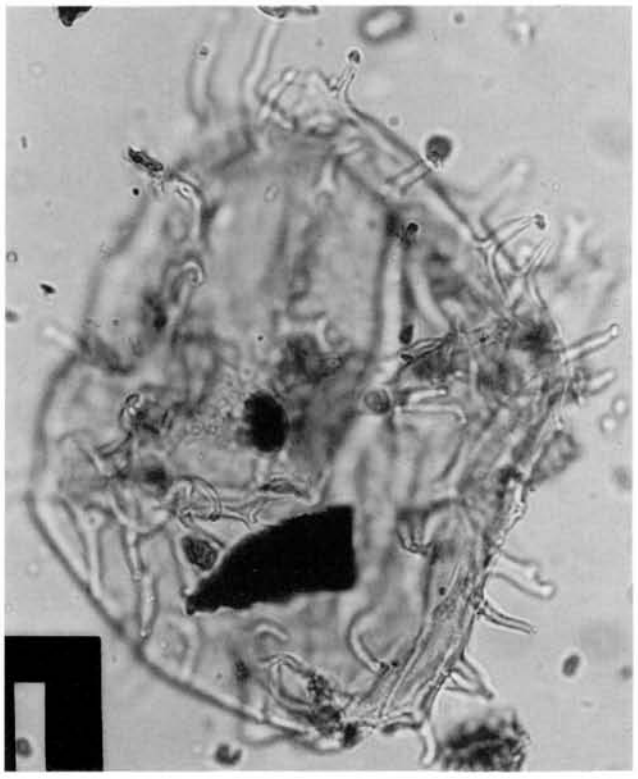
Genus **Kisselovia** Vozzhennikova, 1963

Type species: *Kisselovia ornata* Vozzhennikova, 1967

Remarks: The genus differs from *Wetzeliella* in having all or some of the intratabular groups of processes covered by pieces of ectophragm whose outlines approximate the shapes

of paraplates (Wilson and Clowes, 1980). A modified generic description is given by Stover and Evitt (1978, p.111).

Stratigraphic range: Eocene –Early Oligocene (Wilson and Clowes, 1980).



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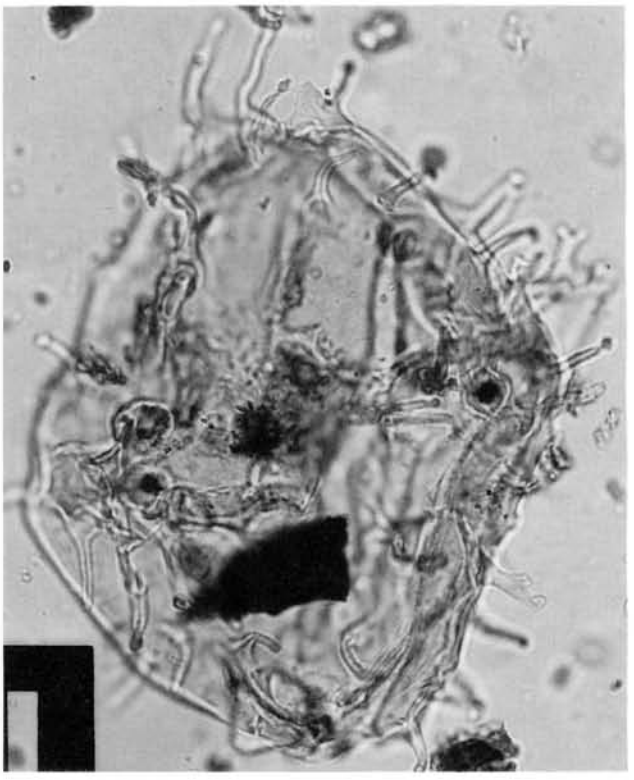

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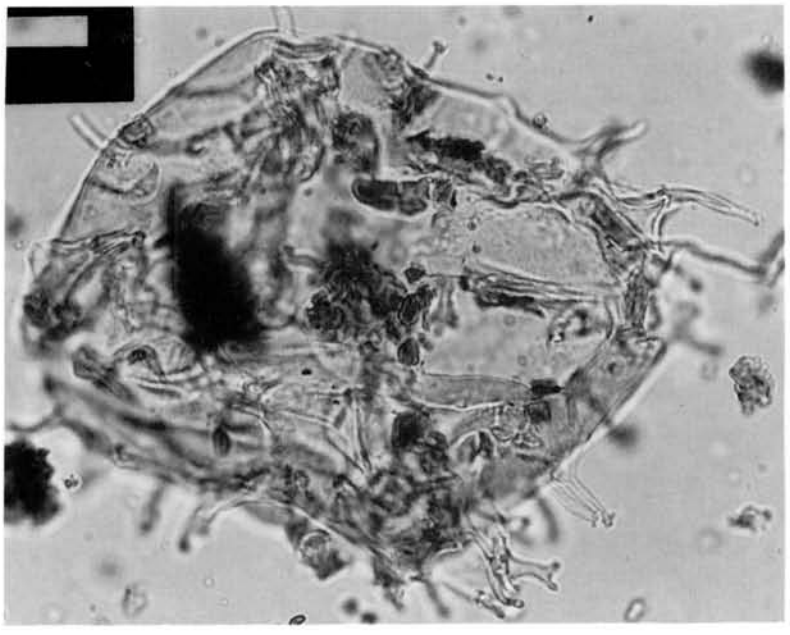

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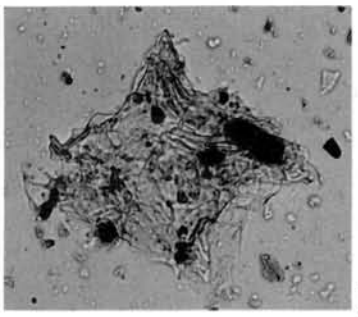

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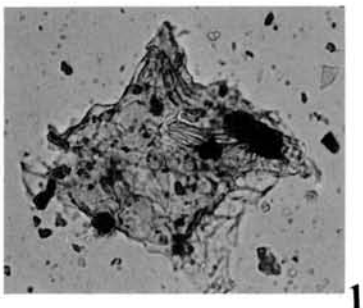

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Figs. 11-13 *Apectodinium raritubiformium* C. L. Shaw *sp. nov.* (Film WA68-31, WA68-31, WA68-33). Figs. 14-15 *Kisselovia pengchiahsuensis* C. L. Shaw *sp. nov.* (Film WA70-23, WA70-24) (Figs. 11-13, x1000; Figs. 14,15 x400)

1. **Kisselovia coleothrypta** (Williams & Downie, 1966) Lentin & Williams 1976. Figs. 16-18

1966 *Wetzeliella* (*Wetzeliella*) *coleothrypta* Williams & Downie: 185-186, pl. 18, fig. 8-9; text-fig. 47.
1976 *Kisselovia coleothrypta* (Williams & Downie) Lentin & Williams: 136.

Description: Cysts pentagonal with apical, two lateral and two normal to well-developed antapical horns and with endophragm, periphragm and ectophragm; intercalary archeopyle; about 142 μm wide. Pericoel totally enclosing endophragm. Ectocoel between periphragm and ectophragm. Parasuture with gonal tubiform processes. Processes arising from periphragm, hollow, connnecting with pericole., surface features with tubiform processes, the tubiforms about 7.5-11 μm long.

Slide: OK-2 1700- (4); Figs. 16-18; film: WA70-25, WA70-26, WA70-27; Figs. 16-18; CPC Micropaleontology Lab.

Dimensions: Overall length 163 μm long, breadth 142 μm wide; length of endocyst 93 μm long, breadth 101 μm wide, length of processes 7.5 μm -11 μm long (n=1).

Stratigraphic occurrence: Eocene (OK-2 well, 1700m)

Remarks: Recorded from upper Mangaorapan Stage and lower Heretaungan Stage. The species is the index for the Early Eocene *K. coleothrypta* Zone of Wilson (1984).

Previous records: Eocene, England (Williams & Downie 1966); Eocene, Canada (Eilliams 1975); Abbotsford Mudstone, Dunedin, New Zealand (Mangaorapan and Heretaungan Stages) as outlined by Wilson (1967, 1984).

2. **Kisselovia taiwaniana** C. L. Shaw *sp. nov.* Figs. 8-10 and Figs. 19-21

Holotype slide: OK-2 1700- (4); Figs. 8-10; film WA70-17, WA70-18, WA70-19 (Holotype at three focus levels); CPC Micropaleontology Lab.

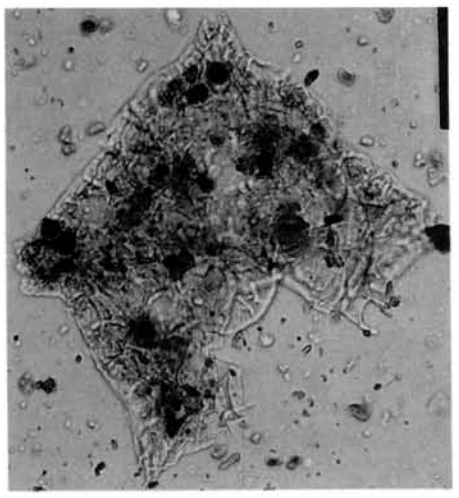
Description: Cysts pentagonal with apical, two lateral and two relative reduced antapical horns and with endophragm, periphragm and ectophragm; intercalary archeopyle; about 105-143 μm wide. Pericoel totally enclosing endophragm. Ectocoel between periphragm and ectophragm. Parasuture with gonal tubiform processes. Processes arising from periphragm, hollow, connnecting with pericole., surface features with tubiform processes, the tubiforms about 9-19 μm long.

Dimensions Holotype: Overall length 112 μm long, breadth 125 μm wide, length of endocyst 88 μm long , breadth 94 μm wide, surface features with tubiform processes, the tubiforms about 10-13 μm long

Dimensions: Overall length 92-112 μm long, breadth 105-143 μm long, length of endocyst 65-93 μm long, breadth 76-101 μm wide, length of processes 9-19 μm long (n=6).
Stratigraphic occurrence: Eocene (OK-2 well, 1700m)

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

Remarks: The new species most closely resembles *Kisselovia coleothrypta* (Williams & Downie) Lentin & Williams in having a roughly similar outline. However it differs from that in having two relative-reduced antapical horns, and in having a smaller size and longer tubiformed appendages.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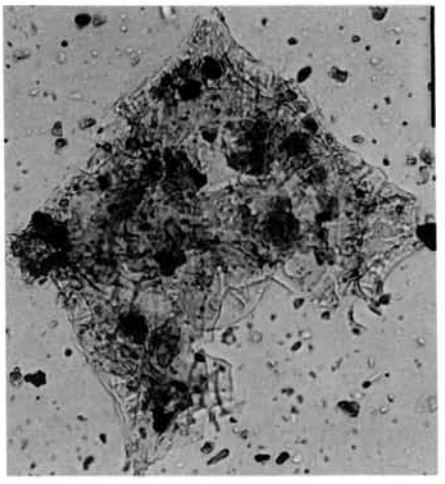
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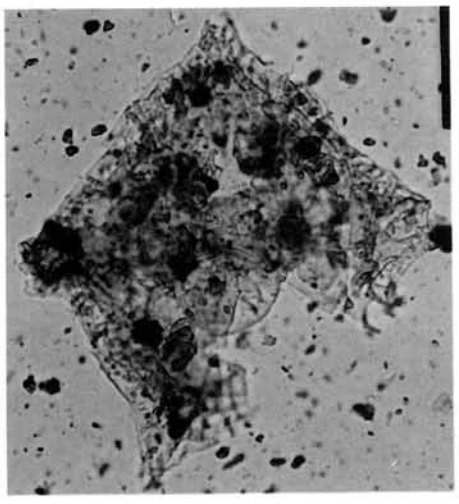
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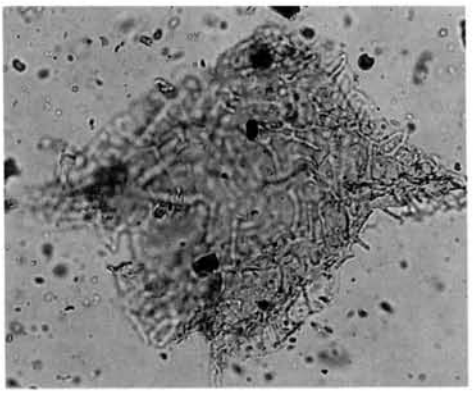
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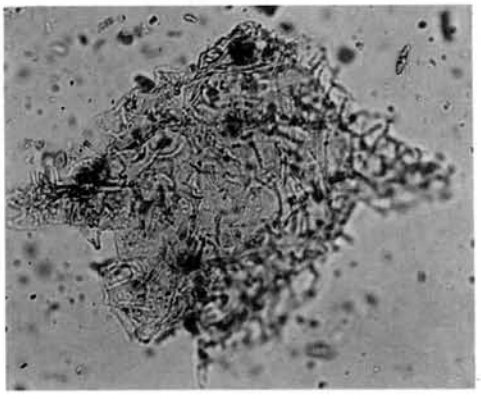
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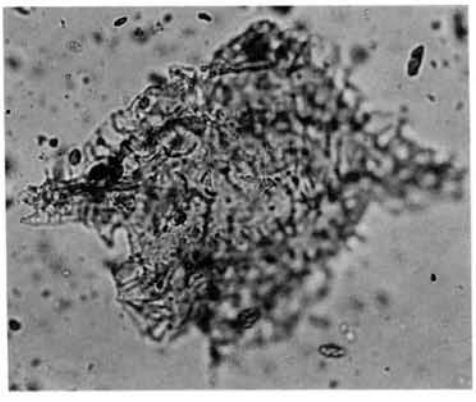
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Figs. 16-18 *Kisselovia coleothrypta* (Williams & Downie) Lentin & Williams (Film WA70-25, WA70-26, WA70-27); Figs. 19-21 *Kisselovia taiwaniana* C. L. Shaw *sp. nov.* (Film WA70-8, WA70-9, WA70-10) (All figures x400)

3. **Kisselovia pengchiahsuensis** C. L. Shaw *sp. nov.* Figs. 5-7 and Figs. 14-15.

Holotype slide: OK-2 1700- (4); Figs. 5-7; film WA70-4, WA70-5, WA70-6 (Holotype at three focus levels); CPC Micropaleontology Lab.

Description: Cysts quardragonal with apical, two lateral and antapical horns and with endophragm, periphragm and ectophragm; intercalary archeopyle; about 93-100 μm wide. Pericoel totally enclosing endophragm. Ectocoel between periphragm and ectophragm. Parasuture with gonal tubiform processes. Processes arising from periphragm, hollow, connnecting with pericole., surface features with tubiform processes, the tubiforms about 6-11 μm long.

Dimensions Holotype: Overall length 72 μm long , breadth 100 μm wide, length of endocyst 52 μm long, breadth 62 μm wide, surface features with tubiform processes, the tubiforms about 6-10 μm long

Dimensions: Overall length 72-89 μm long, breadth 93-100 μm wide, length of endocyst 52-53 μm long, breadth 60-62 μm wide, length of processes 6-11 μm (n=3).

Stratigraphic occurrence: Eocene (OK-2 well, 1700m)

Derivation of name: The specific epithet, **pengchiahsuensis** is derived from the Pengchiahsu Basin of the type locality.

Remarks: The new species most closely resembles *Kisselovia coleothrypta* (Williams & Downie) Lentin & Williams in having a roughly similar outline. However it differs from that in having four horns, and in having a smaller size and shorter tubiformed appendages.

Genus **Wetzeliella** Eisenack ,1938 emend, Lentin & Williams, 1976

Type species *Wetzeliella articulata* Eisenack, 1938

Remarks: The genus differs from *Apectodinium* in having clearer indication of paratabulation and generally a more distinct endocyst, and from *Wilsonnidium* in having intratabular rather than parassutural features (Wilson and Clowes, 1980). A modified generic description is given by Stover and Evitt (1978, p. 131).

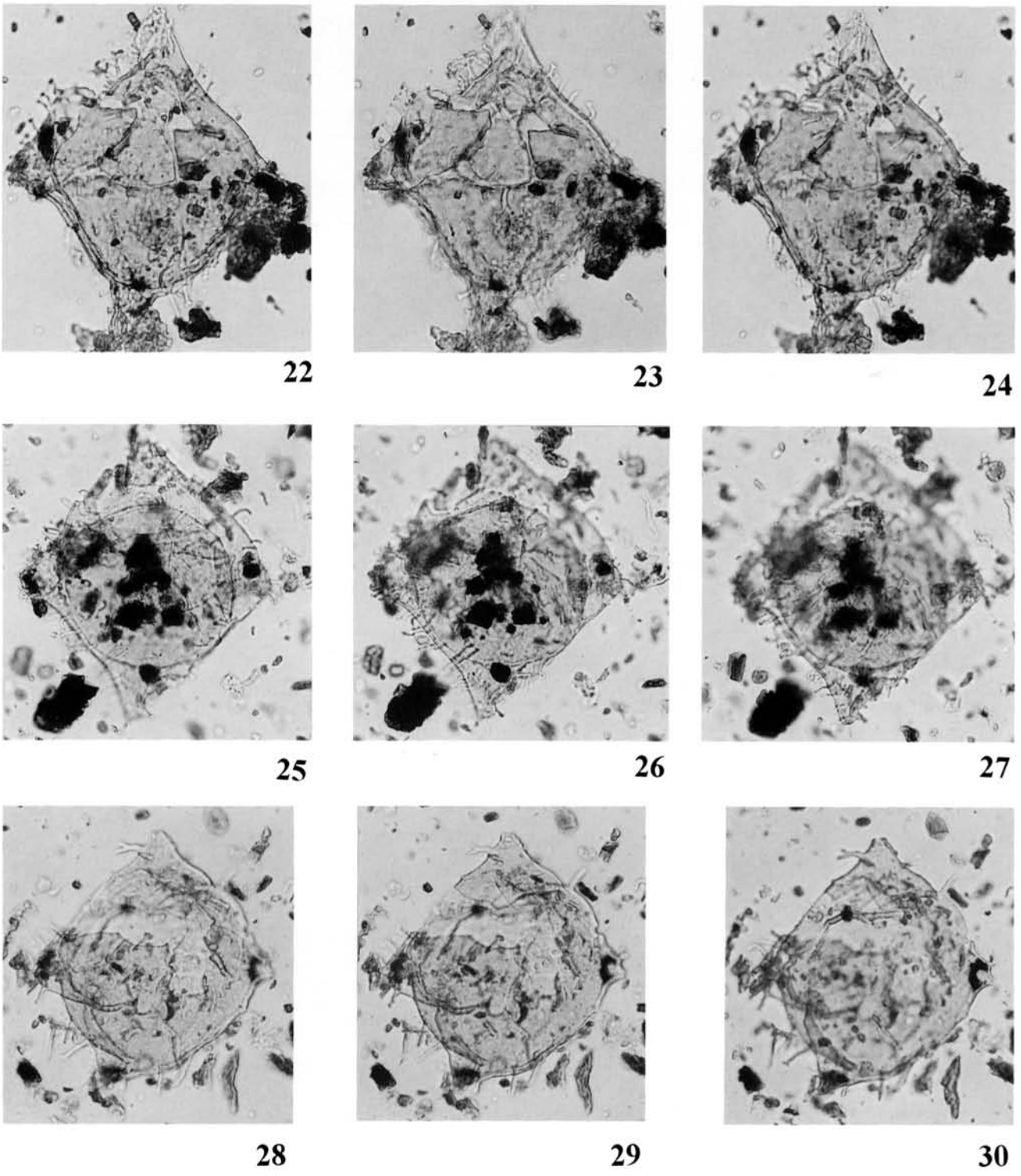
Stratigraphic range: Paleocene – Oligocene (Wilson and Clowes, 1980).

Key to Species

1. Cysts with four horns.
   2. The wall of cyst covered with tubiformed appendages, surface view smooth ..... (1)*Wetzeliella symmetrica taiwaniana*
   2. The wall of cyst covered with tubiformed appendages, surface view scabrate .....(2) *Wetzeliella symmetrica scabrata*
1. Cysts with five horns.
   3. The wall of cyst covered with tubiformed appendages, surface view smooth ..... (3) *Wetzeliella articulata taiwaniana*
   3. The wall of cyst covered with tubiformed appendages, surface view scarbrate ..... (4) *Wetzeliella articulata scabrata*

1. **Wetzeliella symmetrica** Weiler **taiwaniana** C. L. Shaw *var. nov.* Figs. 22-30

Holotype: Sample slide: OK-1 1788BL- (2); film W52-9, W52-10, W52-11 (Holotype at three focus levels); Figs. 22-24; CPC Micropaleontology Lab.



Figs. 22-30. *Wetzeliella symmetrica* var. *taiwaniana* C. L. Shaw *var. nov.* (Film W52-9, W52-10, W52-11, W54-31, W54-32, W54-33, W56-16, W56-17, W56-18) (All figures x400)

Description: Cyst intermediate to large, compressed peridinioid, with four prominent horns (one apical, two lateral and one antapical). The wall of cyst thin and well-covered with appendages; processes numerous, tubiformed, with bifid or entire tips, fairly long (up to 15 μm), relative small and closely clustered on distal part of horns (2-5 μm), surface view smooth; endocyst smooth, thin-walled and broadly elliptical in outline. Intercalary archeopyle, operculum sometimes attached along anterior margin, generally free.
Stratigraphic occurrence: Eocene (OK-1 well, 1788m)

Dimensions: Holotype: Overall length 120 μm long, breadth 95 μm wide, length of endocyst 80 μm long, breadth 75 μm wide, length of processes 2 μm -15 μm .

Dimensions: Overall length 103-120 μm long, breadth 95-103 μm wide, length of the tubiformed processes may up to 15 μm long (n=4).

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

Remarks: The new variety resembles *Wetzeliella symmetrica* Weiler in having a roughly similar outline. However it differs from that in having a smaller size and shorter tubiformed appendages.

2. **Wetzeliella symmetrica** Weiler **scabrata** C. L. Shaw *var. nov.* Figs. 31-36

Holotype: Sample slide: OK-1 1788- (1); film PF36-37, PF36-38, PF36-39 (Holotype at three focus levels); Figs. 31-33; CPC Micropaleontology Lab.

Description: Cyst intermediate to large, compressed peridinioid, with four prominent horns (one apical, two lateral and one antapical). The wall of cyst thin and well-covered with appendages, processes numerous, tubiformed, with bifid or entire tips, fairly long (up to 16 μm), relative small and closely clustered on distal part of horns (2-5 μm), surface view with scabrate ornamentation; endocyst smooth, thin-walled and broadly elliptical in outline. Intercalary archeopyle, operculum sometimes attached along anterior margin, generally free.

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

Dimensions Holotype: Overall length 147 μm long, breadth 125 μm wide, length of endocyst 85 μm , breadth 80 μm ,length of processes 3 μm -16 μm.

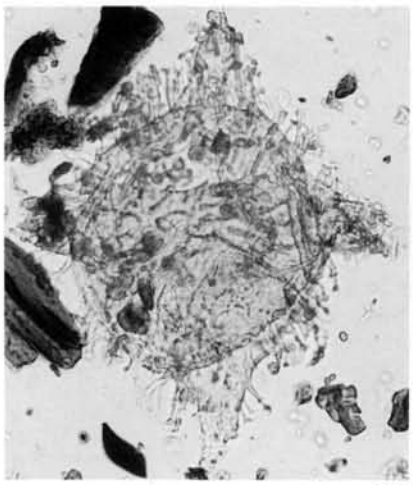
Dimensions: Overall length 112-147 μm,breadth 66-125 μm, length of endocyst 75-85 μm long, breadth 70-80 μm wide, surface features with tubiformed processes, the tubiformed processes may up to 16 μm long (n=3).

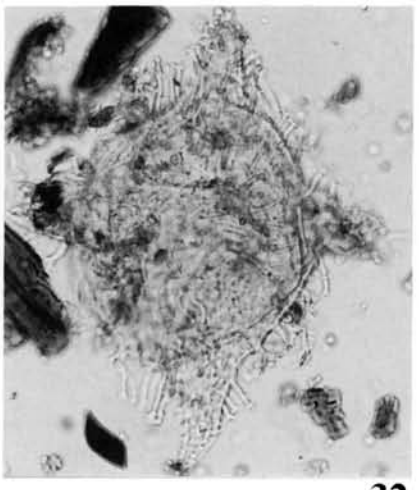
Derivation of name: Latin, **scabrata** is named after the scabrate ornamentation of the cyst.

Remarks: The new variety resembles *Wetzeliella symmetrica* Weiler in having a roughly similar outline. However it differs from both in having a smaller size and the surface view with scabrate ornamentation.

3. **Wetzeliella articulata** Eisenack **taiwaniana** C. L. Shaw *var. nov.* Figs. 37-48

Holotype: Sample slide: OK-2 1875- (4); film WA69-17, WA69-18, WA69-19 (Holotype at three focus levels); Figs. 37-39; CPC Micropaleontology Lab.


31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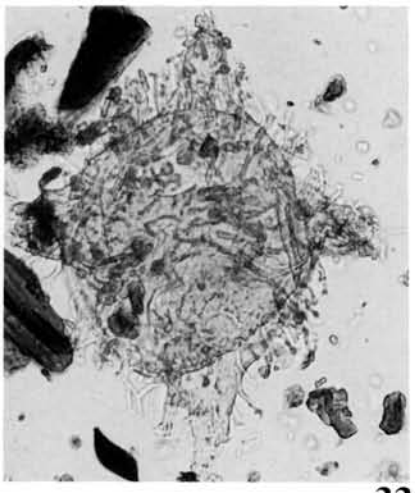
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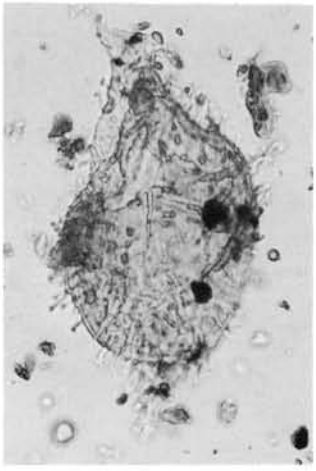
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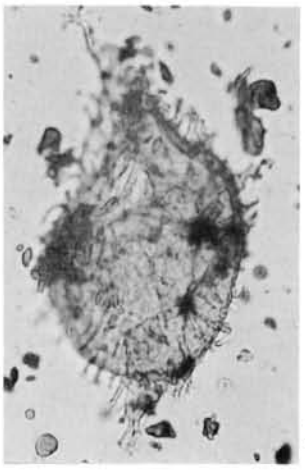
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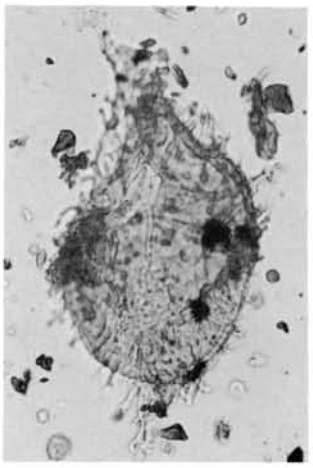
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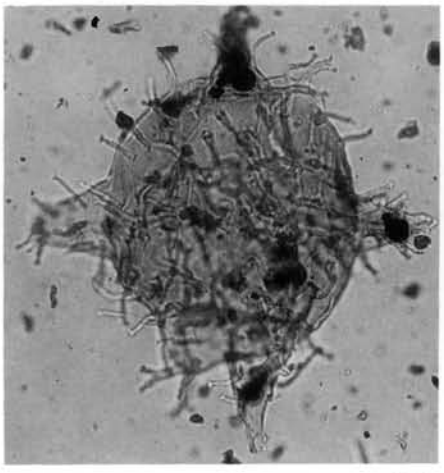
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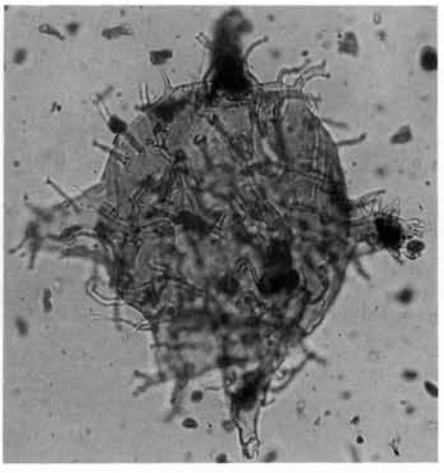
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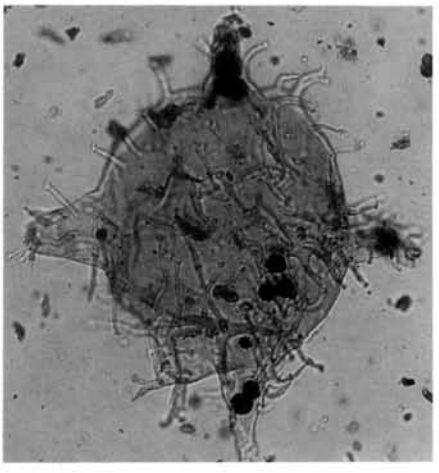
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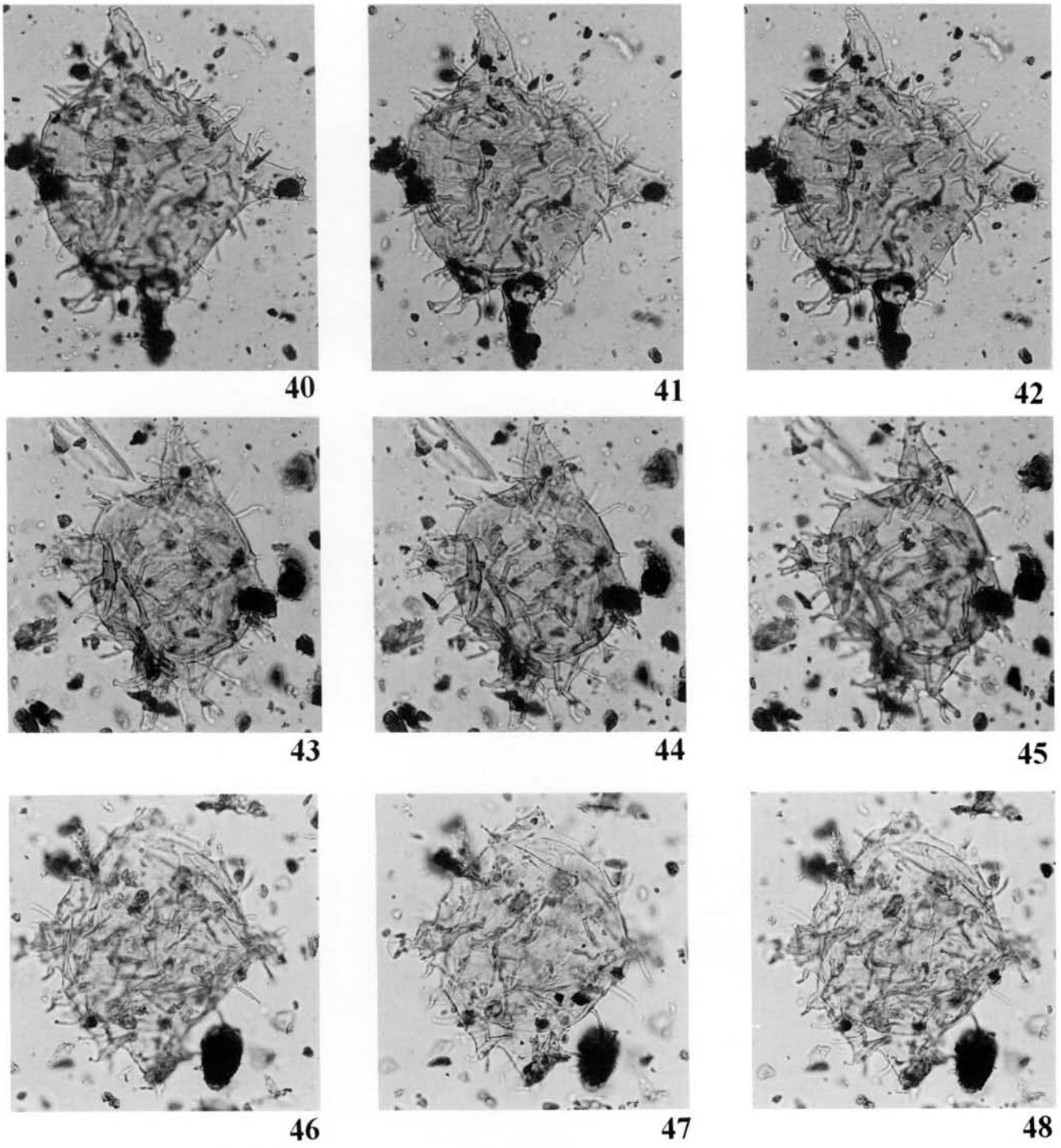
Figs. 31-36. *Wetzeliella symmetrica* var. *scabrata* C. L. Shaw var. nov.(Film PF36-37, PF36-38, PF36-39, W57-36, W57-37, W57-38), Figs. 37-39 *Wetzeliella articulata* var. *taiwaniana* C. L. Shaw var. nov. (WA69-17, WA69-18, WA69-19) (All figures x400)



Figs. 40-48 *Wetzeliella articulata* var. *taiwaniana* C. L. Shaw *var. nov.* (Film WA69-26, WA69-27, WA69-28, W54-34, W54-35, W54-36) (All figures x400)

Descriptions: Cyst intermediate to large, compressed peridinioid, with apical, two lateral and two well-developed to relative reduced antapical horns. The wall of cyst thin and well-covered with appendages; processes numerous, tubiformed, with bifid or entire tips, fairly long (up to 15 μm), relative small and closely clustered on distal part of horns (2-4 μm),

surface view smooth; endocyst smooth, thin-walled and broadly elliptical in outline. Intercalary archeopyle, operculum sometimes attached along anterior margin, generally free.

Dimensions Holotype: Overall length 145 μm long, breadth 127.5 μm wide, length of endocyst 93 μm long, breadth 80 μm wide, length of processes 5 -21 μm long.

Dimensions: Overall length 107-145 μm long, breadth 87-131 μm wide, length of endocyst 75-93 μm long, breadth 70-82.5 μm wide, surface features with tubiformed processes, the tubiformed processes may up to 21 μm long (n=11).

Stratigraphic occurrence: Eocene (OK-2 well, 1875m; OK-1 well, 1788m)

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

Remarks: The new variety resembles *Wetzeliella articulata* Eisenack in having a roughly similar outline and virtually no development of a right antapical horn. However it differs from that in having a smaller size and shorter tubiformed appendages.

4. **Wetzeliella articulata** Eisenack **scabrata** C. L. Shaw *var. nov.* Figs. 49-57

Holotype: Sample slide OK-1 1788- (1); film PF34-6, PF34-7, PF34-8 (Holotype at three focus levels); Figs. 49-51; CPC Micropaleontology Lab.

Description: Cyst intermediate to large, compressed peridinioid, with apical, two lateral and two normal to relative reduced antapical horns. The wall of cyst thin and well-covered with appendages; processes numerous, tubiformed, with bifid or entire tips, fairly long (up to 15 μm), relative small and closely clustered on distal part of horns (2-4 μm), surface view with scabrate ornamentation; endocyst smooth, thin-walled and broadly elliptical in outline. Intercalary archeopyle, operculum sometimes attached along anterior margin, generally free.

Dimensions Holotype: Overall length 127 μm long, breadth 113 μm wide, length of cyst 78 μm long, breadth 80 μm wide, surface features with tubiformed processes, the tubiformed processes may up to 11 μm long.

Dimensions: Overall length 85-162 μm long ,breadth 90-113 μm wide, length of endocyst 78-92 μm long, breadth 78-95 μm wide, surface features with tubiformed processes, the tubiformed processes may up to 12 μm long (n=6).

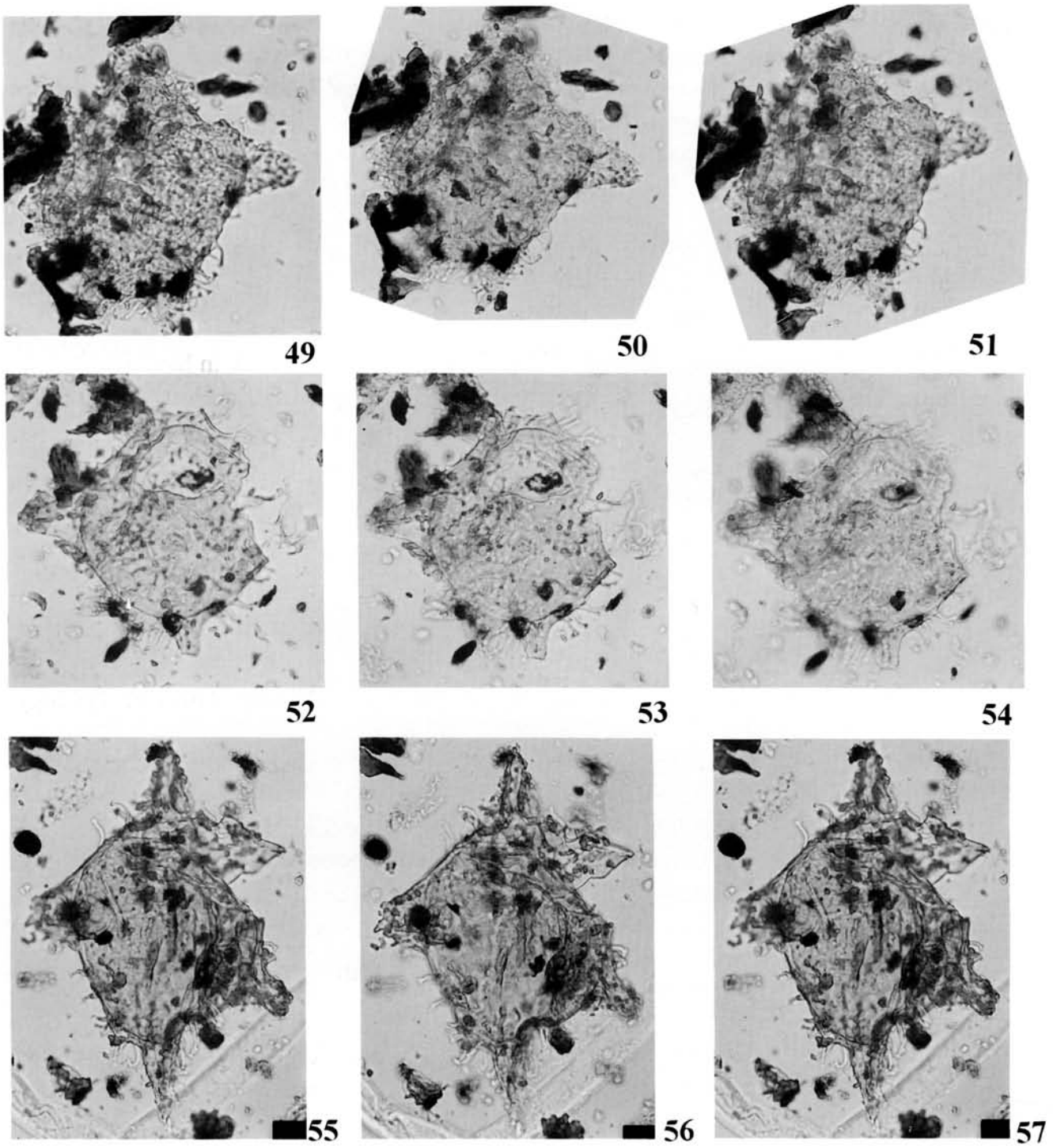
Stratigraphic occurrence: Eocene (OK-1 well, 1788m)

Derivation of name: Latin, **scabrata** is named after the scabrate ornamentation of the cyst.

Remarks: The new variety resembles to *Wetzeliella articulata* Eisenack in having a roughly similar outline. However it differs from that in having a smaller size and the surface view with granulate ornamentation.

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 NSC87-2116-M-326-001.



Figs. 49-57 *Wetzeliella articulata* var. *scabrata* C. L. Shaw *var. nov.* (Film PF34-6, PF34-7, PF34-8, PF33-28, PF33-29, PF33-30, KD-29, KD-30, KD-31). (All figures x400)

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台灣始新統之威茲氏化石藻

蕭承龍[1]

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摘　　要

本文描述發現於台灣基隆北方海域始新世地層中，甲藻類威茲氏化石藻科 *Apectodinium* 屬共計兩種 (*A. homomorphum* (Deflandre & Coookson) Lentin & Williams emend. Harland; *A. raritubiformium* sp. nov.)，*Kisselovia* 屬共計三種(*K. pengchiahsuensis* sp. nov.; *K. taiwaniana* sp. nov.; *K. coleothrypta* (Williams & Downie) Lentin & Williams)，*Wetzeliella* 屬共計四變種(*W. symmetrica* var. *taiwaniana* var. nov.; *W. symmetrica* var. *scabrata* var. nov.; *W. articulata* var. *taiwaniana* var. nov.; *W.* var. *articulata scabrata* var. nov.)。這三屬的化石於台灣僅出現於始新世地層，在漸新世中新世地層皆未發現，或可以做為生物地層的指標。

關鍵詞: 始新世地層、威茲氏化石藻科、台灣、分類。

1. 國立台灣史前文化博物館籌備處，研究典藏組，台東 950，台灣，中華民國。