

# Fungal and Algal Palynomorphs from the Tokotan and Kiritappu Formations of the Nemuro Group, Eastern Hokkaido

Kiyoshi TAKAHASHI

*Department of Geology, Faculty of Liberal Arts,  
Nagasaki University, Nagasaki 852  
(Received July 18, 1991)*

Thirty-three forms of fungal and algal palynomorphs were recovered from the Tokotan Formation (Maastrichtian) at Konbumori and from the Kiritappu Formation (Danian) at Kiritappu and in Yururi Island. Thirty fungal spores and three acritarchs are described and illustrated in this paper.

On a classification of fossil fungal spores, the author adopts a nomenclatural system followed by Van der Hammen (1954), Rouse (1959, 1962), Clarke (1965), Elsie (1968), Sheffy & Dilcher (1971) etc. in this paper. On the acritarchs, he introduces a nomenclatural treatment proposed by Downie & Sarjeant (1963) and Downie, Evitt & Sarjeant (1963) in this paper.

**Key words:** Tokotan Formation, Kiritappu Formation, Fungal spore, Acritarchs.

## Introduction

Thirty-three forms of fungal and algal palynomorphs were recovered together with fern spores and pollen grains on the slides made by a standard palynological technique employed in the processing of marine mudstone sediments of the Tokotan at Konbumori<sup>(21)</sup> and the Kiritappu Formation at Kiritappu and in Yururi Island<sup>(22)</sup>, eastern Hokkaido. The characteristic fungal and algal elements are described and illustrated in this paper.

On the fungal spores, the author adopts the nomenclatural system followed by Van der Hammen (1954)<sup>(1)</sup>, Rouse (1959<sup>(2)</sup>, 1962<sup>(3)</sup>), Clarke (1965)<sup>(4)</sup>, Elsie (1968)<sup>(5)</sup>, Srivastava (1968)<sup>(6)</sup>, Sheffy & Dilcher (1971)<sup>(7)</sup> etc. in this paper. An artificial system for the classification of fossil fungal spores facilitates to assign generic and specific names and to aid biostratigraphy.

On the phytomicroplankton of acritarchs, the author conforms to the nomenclatural treatment proposed by Downie & Sarjeant (1963)<sup>(8)</sup> and Downie, Evitt & Sarjeant (1963)<sup>(9)</sup> in this paper.

## Materials and Treatment

The fungal and phytomicroplanktonic palynomorphs described and illustrated in this paper have been obtained from the Tokotan Formation outcropping along the western cliff of Konbumori fishing port<sup>(21)</sup> and the Kiritappu Formation at Kiritappu and in Yururi Island<sup>(22)</sup>.

The samples of the Tokotan Formation at Konbumori yielded the fungal and algal remains are as follows:

- KON-01: black shale (two fungal remains)
- KON-02: black shale (five fungal and algal remains)
- KON-03: black shale (five fungal and algal remains)

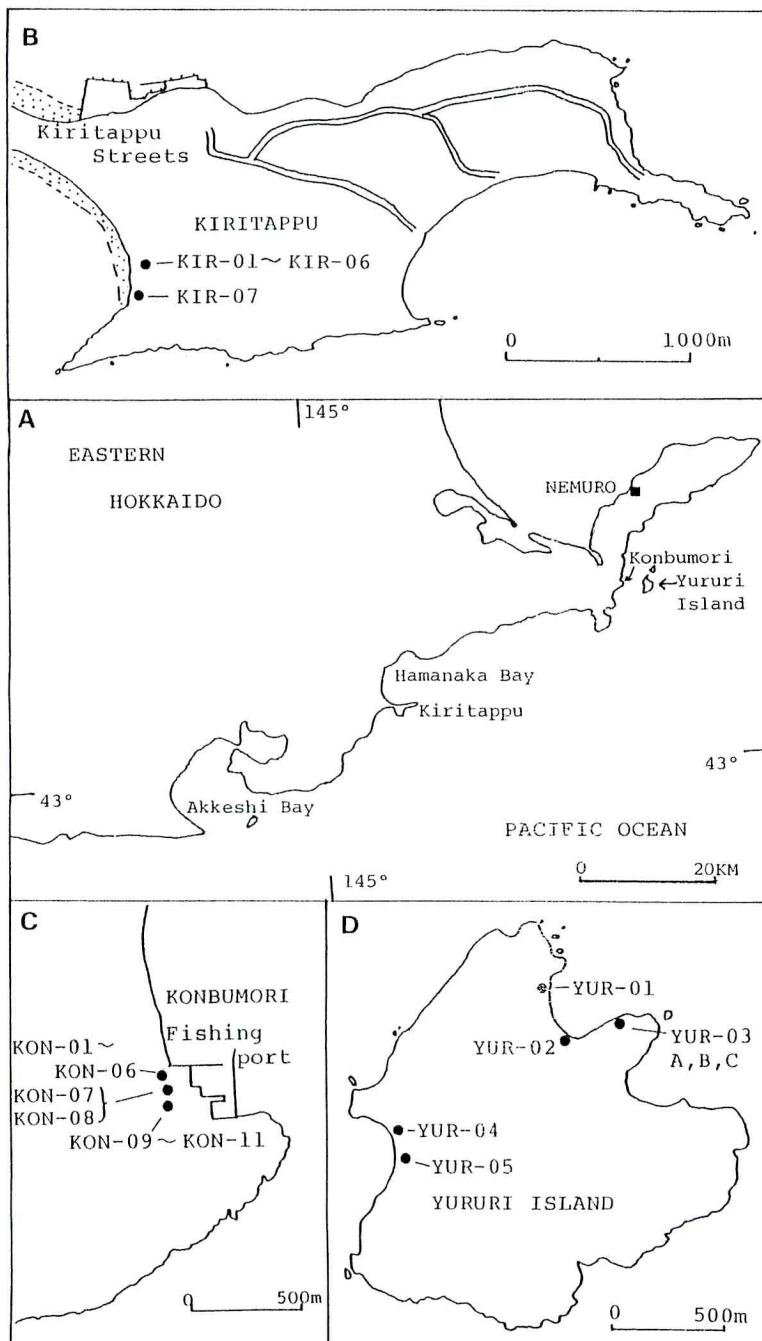


Fig. 1. Location maps of Konbumori, Kiritappu, and Yururi Island in eastern Hokkaido. (A)

B : Localities and numbers of the samples collected at Kiritappu.

C : Localities and numbers of the samples collected near Konbumori fishing port.

D : Localities and numbers of the samples collected in Yururi Island.

KON-04 : black shale (three fungal and algal remains)

KON-05 : black shale (two fungal remains)

KON-06 : black shale (five fungal remains)

KON-08 : black shale (a fungal remain)

KON-09 : black shale (a fungal remain)

The shales of the Kiritappu Formation at Kiritappu, from which the fungal and algal remains were recovered, are as follows :

KIP-01 : gray shale (an algal remain)

KIR-04 : weakly ocherous shale (four fungal and algal remains)

KIR-05 : weakly ocherous shale (a fungal remain)

The sample shales yielded the fungal and algal remains of the Kiritappu Formation in Yururi Island are as follows :

YUR-01 : black shale (three fungal remains)

YUR-02 : black shale (a fungal remain)

YUR-05 : gray shale (ten fungal and algal remains)

The sample crushed in an iron mortar were macerated by the following procedure.

- 1) macerated by mixed solution of conc. HCl and conc. HNO<sub>3</sub>.
- 2) washed with distilled water.
- 3) macerated by HF to remove mineral matters.
- 4) washed with distilled water.
- 5) agitated and separated with 70% solution of ZnCl<sub>2</sub> (specific gravity 1.6-1.8).
- 6) transferred organic matters floated or suspended in the upper parts of the solution to other centrifugal tubes.
- 7) washed with distilled water.
- 8) dehydrated with ethyl alcohol.
- 9) organic residues without stain were mounted in glycerine jelly on the slides.

The Nikon Apophot microscope with Apo and Plan objectives was used to examine and identify several strewn palynomorphs on the slides. Some fungal and algal remains keep sufficiently their morphological characters together with fern spores and pollen grains.

All the slides containing specimens studied in this paper are kept in the Department of Geology, Faculty of Liberal Arts, Nagasaki University.

### Descriptions of Fungal and Algal Palynomorphs

#### A) Fungal spores :

**Form-genus :** *Inapertisporites* Van der Hammen 1954 emend. Elsik 1968.

**Type species :** *Inapertisporites variabilis* Van der Hammen 1955<sup>(10)</sup>.

*Inapertisporites laevigatus* Rouse

Pl. 2, figs. 1-3.

1959 *Inapertisporites laevigatus* Rouse, Micropaleontology, vol. 5, no. 3, pp. 312-313, pl. 2, fig. 30.

**Diagnosis :** See Rouse (1959)<sup>(2)</sup>.

**Dimensions :** 19-23  $\mu\text{m}$  in diameter ; wall 2-2.5  $\mu\text{m}$  thick.

**Occurrence** : Kiritappu Formation, KIR-04 (GN 5970), KIR-05 (GN 5980), and YUR-01 (GN 5893).

**Remarks** : The present fungal spores are similar to *Inapertisporites circularis* Sheffy & Dilcher (1971)<sup>(7)</sup> resembling the conidiospore *Peltcothallos villous*, Order Microthyriales, Family Trichopelteae, Dilcher (1965)<sup>(41)</sup>, but differ in having a thicker wall and in being larger in size.

*Inapertisporites major* Ke & Shi

Pl. 2, figs. 15 a, b.

1978 *Inapertisporites major* Ke & Shi, Song et al., p. 31, pl. 1, fig. 6, Sci. Publishing House.

1985 *Inapertisporites major* Ke & Shi, Zhu et al., p. 42, pl. 2, fig. 16, Petrol. Indust. Press.

**Description** : See Ke et Shi in Song et al. (1978)<sup>(12)</sup> and in Zhu et al. (1985)<sup>(13)</sup>.

**Dimensions** : 52 X 51  $\mu\text{m}$  in diameter; wall 5  $\mu\text{m}$  thick.

**Occurrence** : Kiritappu Formation, KIR-04 (GN 5972).

**Remarks** : The single specimen is assigned to *Inapertisporites major* Ke et Shi from Oligocene Shahejie Formation of the coastal region of Bohai (China) and from the upper Miocene lower Youshashan Formation of the Qaidam Basin, Qinghai Province (China). This is somewhat smaller in size and thinner in wall thickness than those of the Bohai specimen and corresponds very well with the Qaidam specimen in morphological characteristics.

**Form-genus** : *Basidiosporites* Elsik 1968.

**Type species** : *Basidiosporites fournierii* Elsik 1968.

*Basidiosporites* cf. *fournierii* Elsik

Pl. 2, fig. 13.

1968 *Basidiosporites fournierii* Elsik, Pollen et spores, vol. 10, no. 2, p. 237, pl. 2, figs. 8, 19.

**Description** : See Elsik (1968).

**Dimensions** : 17.5  $\mu\text{m}$  long and 11  $\mu\text{m}$  wide; wall 0.5  $\mu\text{m}$  thick, smooth, folded.

**Occurrence** : Kiritappu Formation, YUR-05 (GN 5945).

**Remarks** : Only one specimen was observed. Morphologically this resembles *Basidiosporites fournierii* Elsik from the Paleocene Rockdale Formation, Texas (U. S. A.). However, this is somewhat larger in size.

**Affinity** : Elsik (1968) indicated Basidiomycetes?

**Form-genus** : *Dicellaesporites* Elsik 1968 emend. Sheffy & Dilcher 1971.

**Type species** : *Dicellaesporites popovii* Elsik 1968.

*Dicellaesporites popovii* Elsik

Pl. 1, fig. 14.

1968 *Dicellaesporites popovii* Elsik, Pollen et spores, vol. 10, no. 2, p. 269, pl. 2, fig. 9.

1978 *Dicellaesporites popovii* Elsik, Sci. Publ. House, pp. 33-34, pl. 1, figs. 14-16.

1985 *Dicellaesporites popovii* Elsik, Petrol. Indust. Press, p. 45, pl. 1, figs. 15, 17.

1989 *Dicellaesporites popovii* Elsik, Petrol. Indust. Press, p. 33, pl. 1, figs. 17-19.

**Description** : See Elsik (1968).

**Dimensions** : 29  $\mu\text{m}$  long and 14  $\mu\text{m}$  wide; wall 0.5  $\mu\text{m}$  thick, smooth; septum 1  $\mu\text{m}$  thick; width/length ratio = 0.48.

**Occurrence** : Tokotan Formation, KON-09 (GN 5872).

**Remarks** : The Konbumori specimen is somewhat narrower than the Rockdale holotype specimen illustrated by Elsik (1968). The Chinese specimens from the coastal region of Bohai, the Qaidam Basin, and the Dongpu region<sup>(1)</sup> are measured to prove a large variety in size of the spores.

**Form-genus** : *Multicellaesporites* Elsik 1968 emend. Sheffy & Dilcher 1971.

**Type species** : *Multicellaesporites nortonii* Elsik 1968.

*Multicellaesporites* cf. *cingulatus* Ke & Shi

Pl. 1, fig. 2.

1978 *Multicellaesporites cingulatus* Ke & Shi, Sci. Publ. House, p. 35, pl. 2, fig. 14.

**Description** : Ke et Shi in Song et al. (1978).

**Dimensions** : 60  $\mu\text{m}$  long and 19  $\mu\text{m}$  wide; wall 0.5-1  $\mu\text{m}$  thick, septa 1.5-2  $\mu\text{m}$  thick; width/length ratio = 0.317.

**Occurrence** : Tokotan Formation, KON-01 (GN 5770).

**Remarks** : A single specimen with partially broken wall and a bubble in the inside of a spore body was observed. The Konbumori specimen possesses five cells and more or less thinner wall, whereas the Bohai specimen has six cells and somewhat thicker wall.

**Affinity** : Ascomycetes.

*Multicellaesporites* cf. *evidens* Ke & Shi

Pl. 1, fig. 4.

1978 *Multicellaesporites evidens* Ke & Shi, Sci. Publ. House, p. 37, pl. 2, fig. 10.

**Description** : See Ke et Shi in Song et al. (1978).

**Dimensions** : 41  $\mu\text{m}$  long and 16  $\mu\text{m}$  wide; wall 1.5  $\mu\text{m}$  thick, smooth; septa 2.5-3  $\mu\text{m}$  thick; four cells or more (?).

**Occurrence** : Tokotan Formation, KON-03 (GN 5791).

**Remarks** : Only one specimen was found. This is compared to *Multicellaesporites evidens* Ke et Shi from the late Oligocene Dongying Formation in the coastal region of Bohai (China), whereas this has three thicker septa.

**Affinity** : Ascomycetes.

*Multicellaesporites* cf. *leptaleus* Ke & Shi

Pl. 1, fig. 3.

1978 *Multicellaesporites leptaleus* Ke et Shi, Sci. Publ. House, p. 37, pl. 2, fig. 4.

1989 *Multicellaesporites leptaleus* Ke et Shi, Petrol. Indust. Press, p. 35, pl. 1, fig. 33.

**Description** : See Ke et Shi in Song et al. (1978, 1989).

**Dimensions** : 48  $\mu\text{m}$  long and 20  $\mu\text{m}$  wide; wall 0.5  $\mu\text{m}$  thick, septa 1-1.5  $\mu\text{m}$  thick; five cells; width/length ratio = 0.417.

**Occurrence** : Tokotan Formation, KON-03 (GN 5792).

**Remarks** : Only one specimen was observed. This is identified with *Multicellaesporites leptaleus* Ke et Shi from the Oligocene Shahejie Formation in the coastal region of Bohai (China) and in the Dongpu region (China).

**Affinity** : Ascomycetes.

*Multicellaesporites* cf. *ovatus* Sheffy & Dilcher

Pl. 2, fig. 7.

1971 *Multicellaesporites ovatus* Sheffy & Dilcher, Palaeontographica, B, 133, Lfg. 1-3, p. 44, pl. 14, fig. 44; pl. 16, fig. 44.

1978 *Multicellaesporites ovatus* Sheffy & Dilcher, Sci. Publ. House, p. 39, pl. 2, figs. 7-9.

1989 *Multicellaesporites ovatus* Sheffy & Dilcher, Petrol. Indust. Press, p. 36, pl. 1, fig. 22.

**Description** : See Sheffy & Dilcher (1971).

**Dimensions** : 26  $\mu\text{m}$  long and 15-17  $\mu\text{m}$  wide; wall 1  $\mu\text{m}$  thick, smooth; septa 1.5  $\mu\text{m}$  thick; 4 cells; width/length ratio = 0.577-0.654.

**Occurrence** : Kiritappu Formation, YUR-01 (GN 5893).

**Remarks** : Only one specimen was observed. This is larger than the original specimen described by Sheffy & Dilcher (1971) from middle Eocene Claiborne Formation, Tennessee (U. S. A.). The Chinese specimens from the Oligocene Shahejie and Dongying Formations in the coastal region of Bohai (China) and from the Dongying Formations in the Dongpu region (China) indicate some varieties in size and in thickness of wall and septa.

*Multicellaesporites* sp. a

Pl. 2, fig. 6.

**Description** : Inaperturate, ovate, tetracellate (?) spore with a slightly tapered one end. Wall 1  $\mu\text{m}$  thick, smooth. There opaque septa; each septum thick (?). A bubble is confined in the inside of the spore body.

**Dimensions** : 26  $\mu\text{m}$  long and 15  $\mu\text{m}$  wide; width/length ratio = 0.577.

**Occurrence** : Kiritappu Formation, YUR-05 (GN 5953).

**Remarks** : Only a single grain was recovered and the details are not sufficient for closer comparison.

*Multicellaesporites* sp. b

Pl. 1, fig. 5.

**Description** : Very long, stringy, inaperturate spore with ten or more cells. Wall 0.5  $\mu\text{m}$  thick,

finely punctate. Septa very thin.

**Dimensions** : More than 48  $\mu\text{m}$  long and 5  $\mu\text{m}$  wide in the middle, tapered gradually towards the ends.

**Occurrence** : Tokotan Formation, KON-6 (GN 5835).

**Remarks** : Only one specimen was found. Morphologically this is closely similar to the specimens illustrated by Van Geel<sup>(15)</sup> (1978, pl. 15, figs. 77 Aa, b and 77 B), especially to the ascospore of *Trichoglossum* cf. *hirsutum* (Pers. ex Fr.) Boud. (pl. 15, fig. 77 B), but differs by its much smaller size.

**Affinity** : Ascospore of Ascomycetes.

**Form-genus** : *Pluricellaesporites* Van der Hammen 1954 emend. Sheffy & Dilcher 1971.

**Type species** : *Pluricellaesporites typicus* Van der Hammen 1954.

*Pluricellaesporites* sp. a

P1. 1, fig. 9.

**Description** : Monoporate fungal spore of six cells with five septa. Wall very thin, psilate. Septa 1-1.5  $\mu\text{m}$  thick. A pore situated at one end of the spore and cell at opposite end is rounded.

**Dimensions** : 33  $\mu\text{m}$  long and 9  $\mu\text{m}$  wide; width/length ratio = 0.273.

**Occurrence** : Tokotan Formation, KON-03 (GN 5790).

**Remarks** : This specimen resembles *Pluricellaesporites serratus* Sheffy & Dilcher (1971) from the middle Eocene Claiborne Formation, Tennessee (U. S. A.), but differs by its thinner wall and septa.

*Pluricellaesporites* sp. b

P1. 1, fig. 12.

**Description** : Monoporate fungal spore of four cells with three septa. Wall 0.5  $\mu\text{m}$  thick, smooth. Septa smooth, 0.5-1  $\mu\text{m}$  thick. Two middle cells of the spore include a bubble in each cell. A cell at one end makes a bottle-neck like shape with a very small pore at the top and one at opposite end is flat or somewhat concave.

**Dimensions** : 22  $\mu\text{m}$  long and 9  $\mu\text{m}$  wide; width/length ratio = 0.409.

**Occurrence** : Tokotan Formation, KON-02 (GN 5777).

**Remarks** : Only a single spore was observed. The author cannot find a species of *Pluricellaesporites* identifiable with this specimen in morphological feature.

*Pluricellaesporites* sp. c

P1. 2, fig. 14.

**Description** : Monoporate fungal spore of four cells with three septa. Wall 1  $\mu\text{m}$  thick, smooth. Septa 0.5  $\mu\text{m}$  thick, smooth. Each cell confines respectively a small bubble. A cell at one end shaped distortedly and possesses a very small pore near the top, and one at opposite end is flat or somewhat concave.

**Dimensions** : 22  $\mu\text{m}$  long and 11  $\mu\text{m}$  wide; width/length ratio = 0.5.

**Occurrence :** Tokotan Formation, KON-03 (GN 5789).

**Remarks :** The present specimen is very closely similar to *Pluricellaesporites* sp. b (pl. 1, fig. 12), but differs in form of the cell with a very small pore at one end.

? *Pluricellaesporites* sp.

P1. 1, fig. 15.

**Description :** Monoporate (?) fungal spore of four or more cells with three or more septa. Wall 1  $\mu\text{m}$  thick, psilate. Septa are split open and 6  $\mu\text{m}$  thick in the thickest part. Both the end cells are broken.

**Dimensions :** 30  $\mu\text{m}$  long and 17  $\mu\text{m}$  wide; width/length ratio = 0.567.

**Occurrence :** Tokotan Formation, KON-04 (GN 5802).

**Remarks :** Only one specimen was found. Whether this belongs to the genus *Pluricellaesporites* or not is uncertain due to its bad preservation.

**Form-genus :** *Diporicellaesporites* Elsik 1968.

**Type-species :** *Diporicellaesporites stacyi* Elsik 1968.

? *Diporicellaesporites* sp.

P1. 1, fig. 1.

**Description :** Diporate (?) fungal spore of six cells (?) with five septa. Wall thin, smooth. Septa generally all split open in one direction and 9-10  $\mu\text{m}$  thick in the thickest part.

**Dimensions :** More than 60  $\mu\text{m}$  long and 33  $\mu\text{m}$  wide in middle part of the spore body.

**Occurrence :** Tokotan Formation, KON-08 (GN 5857).

**Remarks :** Only one specimen with both the broken end cells was recovered. Whether this is the genus *Diporicellaesporites* or not, is not clear, because both the end cells are broken.

**Form-genus :** *Fractisporonites* Clarke 1965.

**Type species :** *Fractisporonites canalis* Clarke 1965.

*Fractisporonites* sp. a

P1. 1, figs. 7, 8.

**Description :** Hyphal fragments consists of seven or more rectangular cells with no indentation. Wall less than 0.5  $\mu\text{m}$  thick, smooth. Septa have small single pore, 1-2  $\mu\text{m}$  thick, and perpendicular to hyphae walls.

**Dimensions :** More than 40-49  $\mu\text{m}$  long and 7-10  $\mu\text{m}$  wide.

**Occurrence :** Tokotan Formation, KON-06 (GN 5832 and GN 5834).

**Remarks :** Two hyphal fragments were observed.

*Fractisporonites* sp. b

P1. 2, fig. 5.

**Description :** Hyphal fragments consists of eight or more rectangular cells. Outer walls up to



1  $\mu\text{m}$  thick, smooth, and running parallel. Septa 2.5  $\mu\text{m}$  thick, with small single pore, and perpendicular to hyphae walls. Each cell confines respectively a bubble.

**Dimensions:** More than 67  $\mu\text{m}$  long and 12  $\mu\text{m}$  wide.

**Occurrence:** Kiritappu Formation, YUR-01 (GN 5903).

**Remarks:** A large hyphal fragment was recovered. However, the author cannot find a species of *Fractisporonites* identifiable to this one.

? *Fractisporonites* sp.

Pl. 1, fig. 6.

**Description:** Hyphal fragment (?). Wall 1  $\mu\text{m}$  thick, psilate. Septa oblique, 1-2  $\mu\text{m}$  thick. Eleven or more cells arranging along a long axis and separated by oblique or spiral-like septa.

**Dimensions:** More than 35  $\mu\text{m}$  long and 4.5-9  $\mu\text{m}$  wide.

**Occurrence:** Tokotan Formation, KON-06 (GN 5834).

**Remarks:** Only a single specimen was observed. It is uncertain that this belongs to the genus *Fractisporonites*, because this is not well in its preservation.

**Form-genus:** *Granatisporites* Elsik & Jansonius 1974<sup>(16)</sup>.

**Type species:** *Granatisporites cotalis* Elsik & Jansonius 1974<sup>(16)</sup>.

*Granatisporites* sp.

Pl. 2, fig. 8.

**Description:** Monoporate, oval fungal spore of four cells with three septa. A small cell at one end has a small pore on the top and one at aporate end is much larger. Wall 0.5-1  $\mu\text{m}$  thick, smooth. Septa have a single pore and are 3-5  $\mu\text{m}$  thick.

**Dimensions:** 28  $\mu\text{m}$  long and 20  $\mu\text{m}$  wide.

**Occurrence:** Kiritappu Formation, YUR-05 (GN 5941).

**Remarks:** Only one specimen was encountered. This is not so well in preservation.

**Form-genus:** *Staphlosporonites* Sheffy & Dilcher 1971.

**Type species:** *Staphlosporonites conoideus* Sheffy & Dilcher 1971.

*Staphlosporonites* sp.

Pl. 1, figs. 10, 11.

**Description:** Inaperturate fungal spores. Eight irregular cells arranged in long-ellipsoidal spore body. A long single cell tapering to the one end, 12-29  $\mu\text{m}$  long X 2-9  $\mu\text{m}$  wide, and with smooth wall. Wall of main body excepting the long single cell at one end finely punctate, 0.5  $\mu\text{m}$  thick. Septa 0.5  $\mu\text{m}$  or less thick, smooth, continuous with wall; second and third cells of the short end cell separated by longitudinal thinner septum into two small cells. Some cells confine respectively a bubble.

**Dimensions:** 42-56  $\mu\text{m}$  long and 9-12  $\mu\text{m}$  wide.

**Occurrence:** Tokotan Formation, KON-01 (GN 5770) and KON-02 (GN 5777).

**Remarks:** Two specimens were observed. The author cannot give its specific epithet, because

only two specimens were found.

**Affinity** : Genus *Alternaria*-type.

**Form-geuns** : *Frasnacritetrus* Taugourdeau 1968 emend. Saxena & Sarkar 1986<sup>(17)</sup>.

**Type species** : *Frasnacritetrus josettae* Taugourdeau 1968.

*Frasnacritetrus* sp.

P1. 1, figs. 13 a-c.

**Description** : Fungal conidium with four processes. Main body biconvex, subrectangular in shape, dark brown in colour, multicellular due to presence of longitudinal and transverse septa ; surface punctate. Wall of the main body thin, 0.5  $\mu\text{m}$  thick. Four processes arise from one end of the main body, slightly wider at the base and gradually narrower towards the apex, unicellular, tubular, nonseptate ; wall of the processes very thin, smooth.

**Dimensions** : Overall length : 55  $\mu\text{m}$ .

Length of the main body : 27  $\mu\text{m}$ .

Width of the main body : 15  $\mu\text{m}$ .

Length of the processes : 30  $\mu\text{m}$ .

Width of the processes : 3-3.5  $\mu\text{m}$ .

**Occurrence** : Tokotan Formation, KON-02 (GN 5777).

**Remarks** : Only a single specimen was observed. This is closely similar to *Tetraploa* Berkeley & Broome described and illustrated by Sharme (1976, p. 79, pl. 1, fig. 2)<sup>(18)</sup> from Quaternary deposits of Malvan, Gujarat (India).

**Affinity** : Hyphomycetes, *Tetraploa*.

**Form-genus** : *Involutisporonites* Clarke 1965 emend. Elsik 1968.

**Type species** : *Involutisporonites foraminus* Clarke 1965.

*Involutisporonites* sp.

P1. 1, fig. 20.

**Description** : Coiled fungal spore of nine cells. Wall thin, 0.5  $\mu\text{m}$  thick, psilate. Septa simple, 1  $\mu\text{m}$  thick ; each cell connected by a 0.5  $\mu\text{m}$  diameter opening through each septum, whereas the opening is often invisible.

**Dimensions** : 23 X 20  $\mu\text{m}$  in diameter.

**Occurrence** : Tokotan Formation, KON-04 (GN 5803).

**Remarks** : Only a single specimen was recovered. This is different from *Involutisporonites foraminus* Clarke (1965) from the Upper Cretaceous of Colorado (U.S.A.) in having much smaller size.

? *Involutisporonites* sp. a

P1. 1, fig. 19.

**Description** : Coiled (?) fungal spore. Wall 1  $\mu\text{m}$  thick, darkly pigmented in color, and smooth. Thirteen to fourteen cells small, with a small pore. Septa 2.5  $\mu\text{m}$  thick and small.

**Dimensions** : Overall diameter : 27 X 23  $\mu\text{m}$ .

**Occurrence** : Tokotan Formation, KON-05 (GN 5816).

**Remarks** : This specimen resembles *Involutisporonites* sp. (pl. 1, fig. 20) in this paper, but

differs in having more numerous cells and larger size.

? *Involutisporonites* sp. b

P1. 2, fig. 9.

**Description:** Fungal spore (?). Darkly pigmented central body is obscure in structure, but has, maybe, an opening (?) at one end. Sixteen small cells arranged around the central body and no cell at opening (?) end. Wall thin, 0.5  $\mu\text{m}$  thick, smooth and septa 0.5  $\mu\text{m}$  thick.

**Dimensions:** Overall diameter: 23 X 21  $\mu\text{m}$ .

Central body: 17  $\mu\text{m}$  long and 10  $\mu\text{m}$  wide.

Cell size: 4-7  $\mu\text{m}$  long and 2-4  $\mu\text{m}$  wide.

**Occurrence:** Kiritappu Formation, YUR-02 (GN 5909).

**Remarks:** Only one specimen was recovered. The author cannot find a specimen identifiable specifically.

**Form-genus:** *Monoporisporites* Van der Hammen 1954 emend. Sheffy & Dilcher 1971.

**Type species:** *Monoporisporites minutus* Van der Hammen 1954.

*Monoporisporites* sp.

P1. 1, fig. 17.

**Description:** Monoporate fungal spores. An aggregation of five spherical cells; each cell monoporate, variant in size; pore with annulus 1-2  $\mu\text{m}$  in diameter. Wall thin, 0.5  $\mu\text{m}$  thick, and smooth.

**Dimensions:** Overall diameter: 23 X 22  $\mu\text{m}$ .

Cell diameter: 17 X 17  $\mu\text{m}$ , 16 X 15.5  $\mu\text{m}$ , 13 X 11  $\mu\text{m}$ , 13 X 9  $\mu\text{m}$  and 10 X 7  $\mu\text{m}$ .

**Occurrence:** Tokotan Formation, KON-02 (GN 5772).

**Remarks:** A single cell of the aggregation resembles *Monoporisporites singularis* Sheffy & Dilcher (1971) and *Monoporisporites annularis* Van der Hammen (1954), but differs in having much thinner wall.

? *Monoporisporites* sp.

P1. 2, fig. 11.

**Description:** Aggregation of five spherical cells. Wall thin, 0.5  $\mu\text{m}$  thick; pore invisible. Each cells variant in size.

**Dimensions:** Overall diameter: 17.5 X 17  $\mu\text{m}$ .

Cell diameter: 12 X 10  $\mu\text{m}$ , 11 X 8  $\mu\text{m}$ , 10 X 10  $\mu\text{m}$ , 10 X 9  $\mu\text{m}$  and 8 X 7  $\mu\text{m}$ .

**Occurrence:** Kiritappu Formation, YUR-05 (GN 5947).

**Remarks:** Only a single specimen was found. It is uncertain, whether this belongs to the genus *Monoporisporites* or not.

**Form-genus:** *Polyadosporites* Van der Hammen 1954.

**Type species:** *Polyadosporites suescae* Van der Hammen 1954.

*Polyadosporites* sp. a

P1. 1, figs. 18 a-b; p1. 2, fig. 10.

**Description:** Fungal spore colonies composed of numerous individual subspherical cells. Cells

inaperturate, 5-15  $\mu\text{m}$  in diameter, and psilate. Cell wall 0.5-1  $\mu\text{m}$  thick.

**Dimensions:** Diameter of colonies: 27-30  $\mu\text{m}$  X 26-27  $\mu\text{m}$ .

**Occurrence:** Tokotan Formation, KON-05 (GN 5816); Kiritappu Formation, YUR-05 (GN 5942).

**Remarks:** The fungal spore colonies with numerous cells display a variety of overall shape, size, and number of cells.

*Polyadosporites* sp. b

P1. 2, fig. 12.

**Description:** Fungal spore colony consisting of numerous individual subspherical cells. Cells inaperturate, 5-10  $\mu\text{m}$  in diameter, and smooth. Wall thin. Septa connecting two or more cells 1-2  $\mu\text{m}$  thick.

**Dimensions:** 36 X 23  $\mu\text{m}$  in diameter.

**Occurrence:** Kiritappu Formation, YUR-05 (GN 5948).

**Remarks:** Only one fungal spore colony was recovered.

#### B) Phytomicroplankton:

**Group:** Acritarcha Evitt 1963.

**Subgroup:** Acanthomorphytae Downie, Evitt & Sarjeant 1963.

**Form-genus:** *Micrhystridium* Deflandre 1937<sup>(19)</sup> emend. Downie & Sarjeant 1963.

**Type species:** *Micrhystridium inconspicuum* (Deflandre 1935) Deflandre 1937.

*Micrhystridium minutum* n. sp.

P1. 2, figs. 17-19.

**Description:** This form possesses an ovoidal to spherical thin-walled shell and bears a large number of very fine spines. The spines are very fine, straight and densely distributed. The shell is smooth excepting the spines and less than 0.5  $\mu\text{m}$  thick.

**Dimensions:** Diameter of shell: 12-13  $\mu\text{m}$  X 9-11  $\mu\text{m}$ .

Length of spines: 0.5  $\mu\text{m}$  or less

**Occurrence:** Kiritappu Formation, YUR-05 (GN 5941 and GN 5943).

**Holotype:** P1. 2, fig. 19; 12 X 11  $\mu\text{m}$  in diameter; spines very fine, less than 0.5  $\mu\text{m}$  long; shell thin, less than 0.5  $\mu\text{m}$  thick; Kiritappu Formation in Yururi Island; YUR-5 (GN 5943).

**Name derivation:** *minutus* (lat.) = minute.

**Comparison:** Morphologically the present specimens are closely comparable with *Micrhystridium deflandrei* Valensi (1953)<sup>(20)</sup> from the Middle Jurassic (Bathonian) of France, but differ in possessing much finer and smaller spines distributed densely.

*Micrhystridium nemuroense* n. sp.

P1. 2, figs. 16 a-b, 20-23.

**Description:** Shell subspherical; shell wall thin, smooth, with a large number of spines, and always secondarily folded. Spines small, 1-2  $\mu\text{m}$  long, straight, and distributed densely.

**Dimensions:** 16-20  $\mu\text{m}$  X 12.5-18.5  $\mu\text{m}$  in diameter.

**Occurrence:** Tokotan Formation, KON-03 (GN 5791) and KON-04 (GN 5803); Kiritappu Formation, KIR-01 (GN 5881), KIR-04 (GN 5975), and YUR-05 (GN 5949).

**Holotype:** P1. 2, figs. 16 a-b; 19 X 16  $\mu\text{m}$  in diameter; spines fine, straight, 1-2  $\mu\text{m}$   $\pm$  long; wall thin, smooth, secondarily folded; Kiritappu Formation, YUR-05 (GN 5949).

**Derivation of name :** From Nemuro city.

**Comparison :** *Micrhystridium nemuroense* is closely similar to *Micrhystridium deflandrei* Valensi, but differs in possessing larger shell and longer spines.

*Micrhystridium* sp.

P1. 2, fig. 24.

**Description :** This form has an ovoidal thin walled shell and bears a large number of spines. The spines are small, straight, and 2-2.5  $\mu\text{m}$  long. Wall thin, 1  $\mu\text{m}$  thick, smooth, and more or less crumpled.

**Dimensions :** 20 X 17  $\mu\text{m}$  in diameter.

**Occurrence :** Tokotan Formation, KON-02 (GN 5778).

**Remarks :** This specimen is alike *Micrhystridium nemuroense* n. sp., but differs in having somewhat longer spines and a small number of spines.

#### C) *Incertae sedis* :

Fungal type A

P1. 1, fig. 16.

This fungal form resembles *Polyadosporites*-type. This fungal colony consists of ten to eleven small cells. Wall thin, smooth. Septa between two or more adjoined cells ca. 1  $\mu\text{m}$  thick. Each cell inaperturate.

**Dimensions :** 19 X 15  $\mu\text{m}$  in diameter.

**Occurrence :** Tokotan Formation, KON-06 (GN 5834).

Fungal type B

P1. 2, fig. 4.

This fungal spore is superficially similar to *Staphlosporonites*, but differs in morphological characters, because this one has probably two pores at both the ends of the spore. The spore body is divided into seven chambers by six transversal septa and excepting the both the single cells at both the ends five chambers are, moreover, divided into two or more small cells by longitudinal septa.

**Dimensions :** 29  $\mu\text{m}$  long and 12  $\mu\text{m}$  wide.

Seven chambers : 4 X 4  $\mu\text{m}$ , 6 X 12  $\mu\text{m}$ , 5 X 11  $\mu\text{m}$ , 4 X 10  $\mu\text{m}$ , 4 X 8  $\mu\text{m}$ , 3 X 5.5  $\mu\text{m}$ , and 2 X 3  $\mu\text{m}$ .

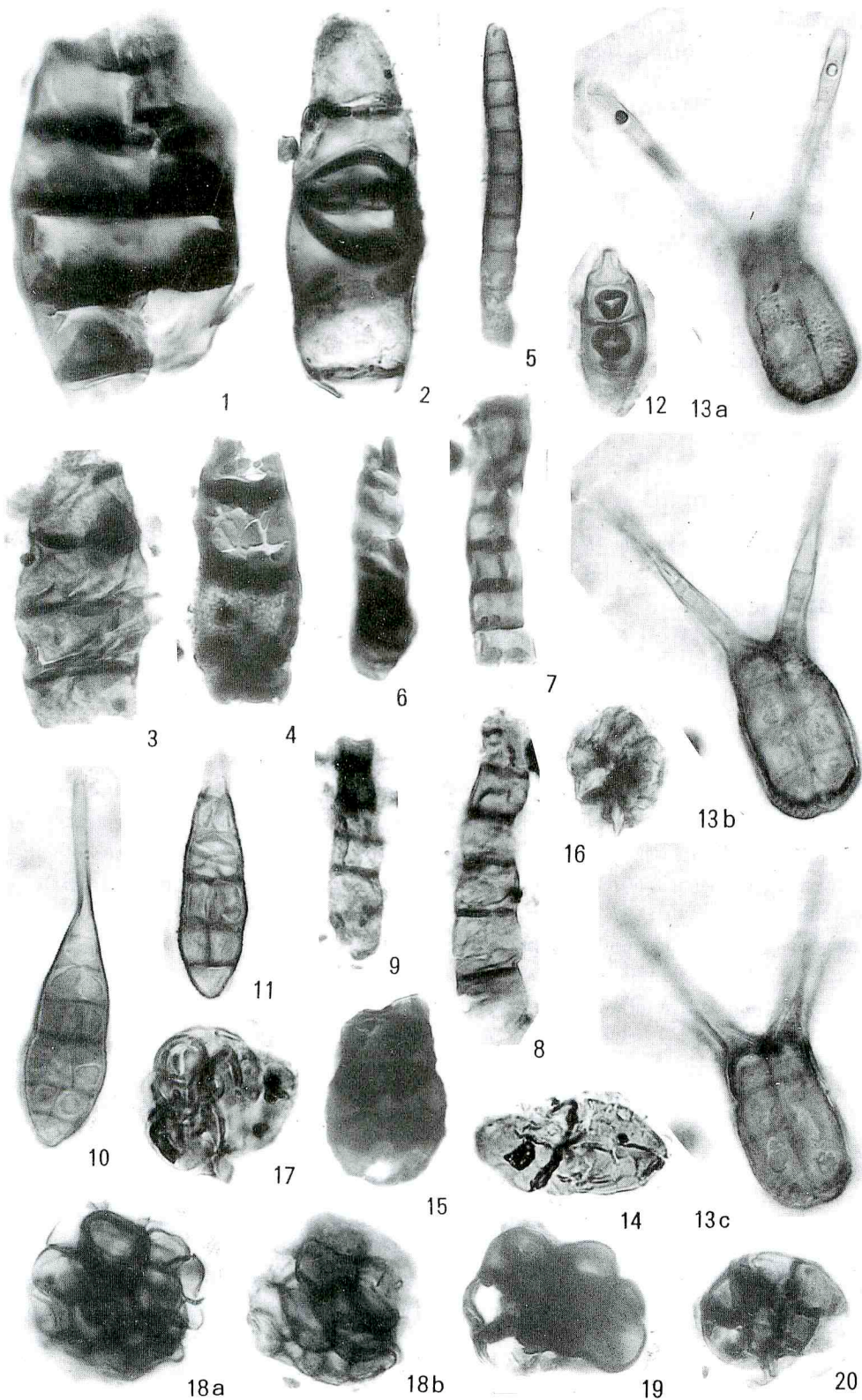
Wall 0.5-1  $\mu\text{m}$  thick and transversal septa 1  $\mu\text{m}$  thick.

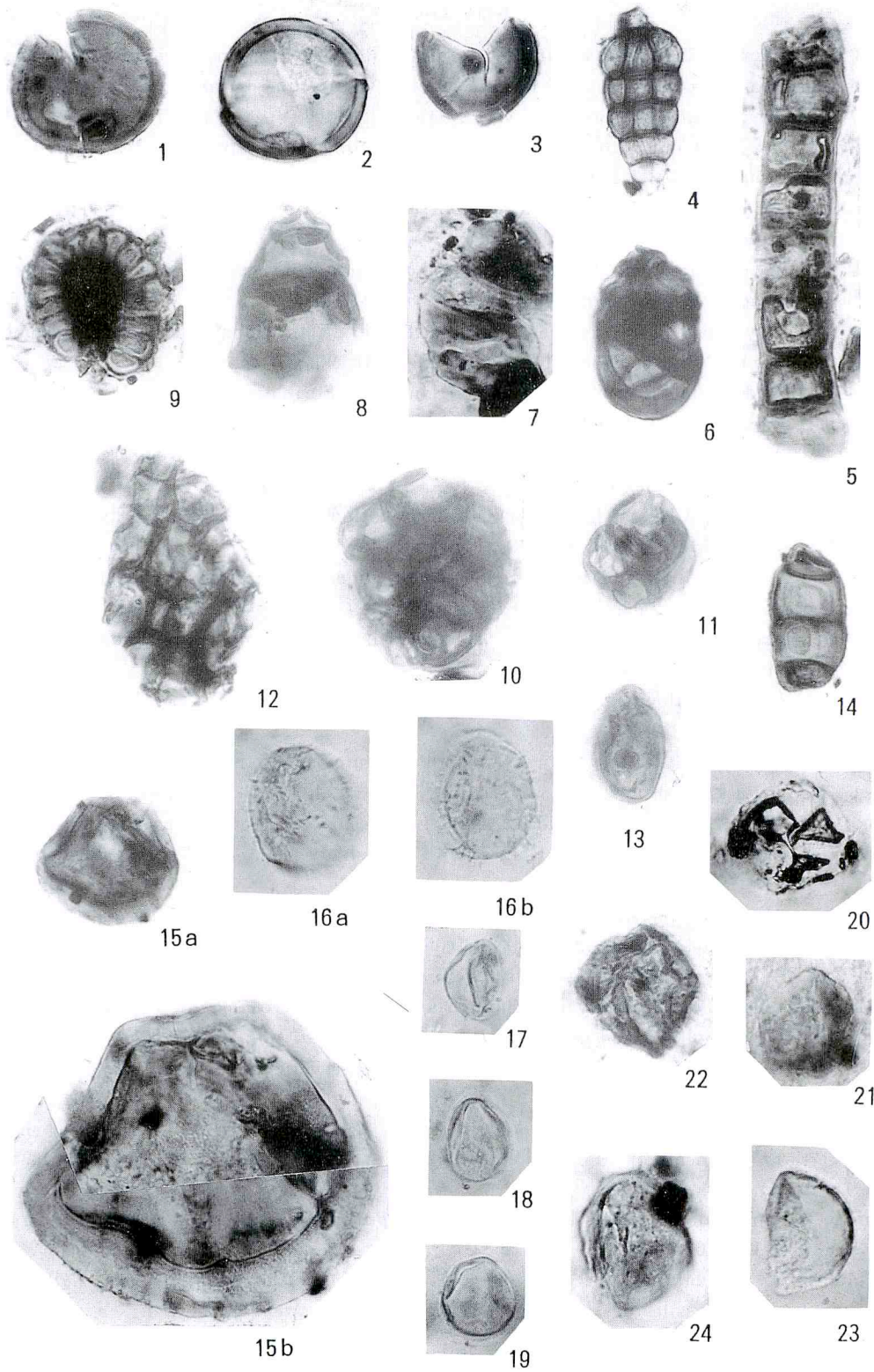
**Occurrence :** Kiritappu Formation, KIR-04 (GN 5970).

### Acknowledgements

This study was supported by the Ministry of Education, Science and Culture of Japan, Grant-in-Aid for Scientific Research (C), Grant No. 01540645 in 1989 and 1990. The author expresses his sincere thanks to the Educational authorities. Many thanks are also due to Mr. Y. Yoshimoto, a geologist in Nemuro city, for his able field guidance and collecting the samples in Yururi Island.

Plate 1





## References

- (1) Van der Hammen, T.: El desarrollo de la flora Colombiana en los periodos geologicos I: Maestrichtiano hasta terciario mas inferior (Una investigación palinológica de la formación de Guaduas y equivalentes) *Boletin Geol. Bogota* **2**, 49-106. pls. I-VII y 1-21 (1954).
- (2) Rouse, G. E.: Plant microfossils from Kootenay coal-measures strata of British Columbia. *Micropaleontology* **5**, 303-324, pls. 1-2 (1959).
- (3) Rouse, G. E.: Plant microfossils from the Burrard Formation of western British Columbia. *Micropaleontology* **8**, 187-218, pls. 1-5 (1962).
- (4) Clarke, R. T.: Fungal spores from Vermejo Formation coal beds (Upper Cretaceous) of Central Colorado. *The Mountain Geologist* **2**, 85-93 (1965).
- (5) Elsik, W.: Palynology of a Paleocene Rockdale lignite, Milam County, Texas. I. Morphology and Taxonomy. *Pollen et spores* **10**, 263-314, pls. 1-15 (1968).
- (6) Srivastava, S. K.: Fungal elements from the Edmonton Formation (Maestrichtian), Alberta, Canada. *Canad. Jour. Bot.* **46**, 1115-1118, pl. 1 (1968).
- (7) Sheffy, M. V. and D. L. Dilcher: Morphology and taxonomy of fungal spores. *Palaeontographica*, B **133**, 34-51, pls. 13-16 (1971).
- (8) Downie, C. and W. A. S. Sarjeant: On the interpretation and status of some hystrichosphere genera. *Palaeontology* **6**, 83-96 (1963).
- (9) Downie, C., W. R. Evitt and W. A. S. Sarjeant: Dinoflagellates, hystrichosphere, and the classification of the acritachs. *Stanford Univ. Publ., Geol. Sci.* **7**, 3-16 (1963).
- (10) Van der Hammen, T.: Principios para la nomenclatura palinologica sistematica. *Bolet. Geol. Bogota* **2**, 3-24 (1955).
- (11) Dilcher, D. L.: Epiphyllous fungi from Eocene deposits in Western Tennessee, U. S. A. *Palaeontographica*, B **116**, 1-54 (1963).
- (12) Song, Z. et al: Early Tertiary spores and pollen grains from the coastal region of Bohai (in Chinese with English abstract). 1-177, pls. 1-62, Sci. Publ. House (1978).
- (13) Zhu, Z., L. Wu, P. Xi, Z. Song and Y. Zhang: A research on Tertiary palynology from the Qaidam Basin, Qinghai Province (in Chinese with English abstract). 1-297, pls. 1-62, Petroleum Industry Press (1985).
- (14) Song, Z. et al: Early Tertiary sporo-pollen assemblages from the Dongqu region (in Chinese with English abstract). 1-192, pls. 1-52, Petroleum Industry Press (1989).
- (15) Van Geel, B.: A palaeoecological study of Holocene peat bog sections in Germany and the Netherlands, based on the analysis of pollen, spores and macro and microscopic remains of fungi, algae, cormophytes and animals. *Rev. Palaeobot. Palynol.* **25**, 1-120, pls. 1-18 (1978).
- (16) Elsik, W. C. and J. Jansonius: New genera of Paleogene fungal spores. *Can. Jour. Bot.* **52**, 953-958, pl. 1 (1974).
- (17) Saxena, R. K. and S. Sarker: Morphological study of *Frasnacritetrus* Taugourdeau emend. from Tertiary sediments of Himachal Pradesh, India. *Rev. Palaeobot. Palynol.* **46**, 209-225, pls. 1-2 (1986).
- (18) Sharma, C.: Some fungal spores from Quaternary deposits of Malvan, Gujarat. *Palaeobotanist* **23**, 79-81, pl. 1 (1976).
- (19) Deflandre, G.: Microfossiles des silex crétacés. II. *Ann. Paléont.* **26**, 51-103, pls. 11-18 (1937).
- (20) Valensi, L.: Microfossiles des silex du Jurassique moyen. *Mém. Soc. Géol. Fr., N. S.*, **32**, Mém. **68**, 11-100, pls. 1-16 (1953).



- ①) Takahashi, K.: Palynomorph assemblage of the Tokotan Formation at Konbumori, Nemuro city, eastern Hokkaido. *Jpn. J. Palynol.* **37**, 41-57, pls. 1-2 (1991).
- ②) Takahashi, K.: Playnostratigraphic study of the Kiritappu Formation at Kiritappu and in Yururi Island, eastern Hokkaido. (in Japanese with English abstract). *Jpn. J. Palynol.* **37**, 23-34, pls. 1-2 (1991).

Explanation of plate 1 (all figures magnified X 1000)

- Fig. 1. ? *Diporicellaesporites* sp. GN 5857, KON-08.
- Fig. 2. *Multicellaesporites* cf. *cingulatus* Ke & Shi GN 5770, KON-01.
- Fig. 3. *Multicellaesporites* cf. *leptaleus* Ke & Shi GN 5792, KON-03.
- Fig. 4. *Multicellaesporites* cf. *evidens* Ke & Shi GN 5791, KON-03.
- Fig. 5. *Multicellaesporites* sp. b GN 5835, KON-06.
- Fig. 6. ? *Fractisporonites* sp. GN 5834, KON-06.
- Figs. 7, 8. *Fractisporonites* sp. a Fig. 7: GN 5834, KON-06; fig. 8: GN 5832, KON-06.
- Fig. 9. *Pluricellaesporites* sp. a GN 5790, KON-03.
- Figs. 10, 11. *Staphlosporonites* sp. Fig. 10: GN 5777, KON-02; fig. 11: GN 5770, KON-01.
- Fig. 12. *Pluricellaesporites* sp. b GN 5775, KON-02.
- Figs. 13 a-c. *Frasnacritetrus* sp. GN 5777, KON-02.
- Fig. 14. *Dicellaesporites popovii* Elsik GN 5892, KON-09.
- Fig. 15. ? *Pluricellaesporites* sp. GN 5802, KON-04.
- Fig. 16. Fungal-type A (indeterminable), GN 5834, KON-06.
- Fig. 17. *Monoporisorites* sp. GN 5772, KON-02.
- Figs. 18 a-b. *Polyadosporites* sp. a GN 5816, KON-05.
- Fig. 19. ? *Involutisporonites* sp. a GN 5816, KON-05.
- Fig. 20. *Involutisporonites* sp. GN 5803, KON-04.

Explanation of plate 2 (all figures magnified X 1000 unless otherwise mentioned)

Figs. 1-3. *Inapertisporites laevigatus* Rouse

Fig. 1: GN 5893, YUR-01; fig. 2: GN 5970, KIR-04; fig. 3: GN 5980, KIR-05.

Fig. 4. Fungal-type B (indeterminable), GN 5970, KIR-04.

Fig. 5. *Fractisporites* sp. b GN 5903, YUR-01.

Fig. 6. *Multicellaesporites* sp. a GN 5953, YUR-05.

Fig. 7. *Multicellaesporites* cf. *ovatus* Sheffy & Dilcher GN 5893, YUR-01.

Fig. 8. *Granatisporites* sp. GN 5941, YUR-01.

Fig. 9. ? *Involutisporonites* sp. b GN 5909, YUR-02.

Fig. 10. *Polyadosporites* sp. a GN 5942, YUR-05.

Fig. 11. ? *Monoporisorites* sp. GN 5947, YUR-05.

Fig. 12. *Polyadosporites* sp. b GN 5948, YUR-05.

Fig. 13. *Basidiosporites* cf. *fournierii* Elsik GN 5945, YUR-05.

Fig. 14. *Pluricellaesporites* sp. c GN 5789, KON-03.

Figs. 15 a-b. *Inapertisporites major* Ke & Shi GN 5972, KIR-04; fig. 15a: X 400.

Figs. 16 a-b, 20-23. *Micrhystridium nemuroense* n. sp.

Figs. 16 a-b: GN 5949, YUR-05, holotype; fig. 20: GN 5975, KIR-04; fig. 21: GN 5881, KIR-01;

fig. 22: GN 5803, KON-04; fig. 23: GN 5791, KON-03.

**Figs. 17-19. *Micrhystridium minutum* n. sp.**

Figs. 17, 19: GN 5943, YUR-05; fig. 19: holotype; fig. 18: GN 5941, YUR-05.

**Fig. 24. *Micrhystridium* sp.** GN 5778, KON-02.

#### 北海道東部の根室層群の床潭層および霧多布層の菌類および藻類のパリノモルフ

高橋 清, 長崎大学教養部地学教室, 〒852 長崎市文教町1番14号.

菌類および藻類の微有機体33種類が昆布盛の床潭層（マーストリヒト期）と、霧多布とユルリ島の霧多布層（グリーンアン期）から発見された。この論文に30種の菌類胞子と3種のアクリタークスを記載し、図示した。

化石菌類胞子の分類に関して、筆者は、この論文で、Van der Hammen (1954), Rouse (1959, 1962), Clarke (1965), Elsik (1968), Sheffy & Dilcher (1971) などによって受けつがれた命名法を採用し、アクリタークスでは、Downie & Sarjeant (1963) と Downie, Evitt & Sarjeant (1963) により提案された命名法を用いた。