Palynomorph Assemblage of the Tokotan Formation at Konbumori, Nemuro City, Eastern Hokkaido

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The author collected eleven black shale samples of the Tokotan Formation outcropping along the southern cliff of Konbumori fishing port, analyzed them palynologically, and discriminated 746 palynomorphs of pteridophytes, bryophytes, gymnosperms, angiosperms, fungi and phytomicroplankton from nine samples of them. He examined total 176 species consisting of 62 spores, 54 gymnospermous pollen, and 60 angiospermous pollen excepting fungal spores and phytomicroplankton. This palynomorph assemblage is evidently compared with that of the Tokotan Formation at Ochiishi which is of Maastrichtian age. Furthermore, six new species of spores, a new form-genus and three new species of gymnospermous pollen are described, and then additionally two new combinations are proposed.

Key words : Palynomorph, Pollen, Spores, Tokotan Formation.

Introduction

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Already the author examined many palynomorphs from the Oborogawa, Hamanaka, Akkeshi and Tokotan Formations in Akkeshi and Ochiishi districts of eastern Hokkaido and published two papers with the result of palynostratigraphic investigation and descriptions of 311 species of palynomorphs which are of Maastrichtian age.

In 1990, he took aim at an elucidation of microfloral assemblages of the Tokotan and Kirittappu Formations. In this study, he collected eleven black shale samples from the Tokotan Formation outcropping along the western cliff near Konbumori fishing port and detected 746 palynomorphs of pteridophytes, bryophytes, gymnosperms, angiosperms, fungi and phytomicroplankton from nine samples of them. This time, excepting fungal spores and phytomicroplankton, 176 species consisting of 62 spores, 54 gymnospermous pollen and 60 angiospermous pollen were examined palynostratigraphically. As a result of the study, it was proved that the palynofloral assemblage of the Tokotan Formation at Konbumori can be compared with the Tokotan Formation at Ochiishi, whereas some new species have been found from Konbumori. Furthermore, six new species of spores and a new form-genus and three new species of gymnospermous pollen are described and two new combinations are proposed.

Collection of materials

Eleven black shale samples were collected from lower and middle horizons of the Tokotan Formation outcropping along the western cliff of Konbumori fishing port (Fig. 1).

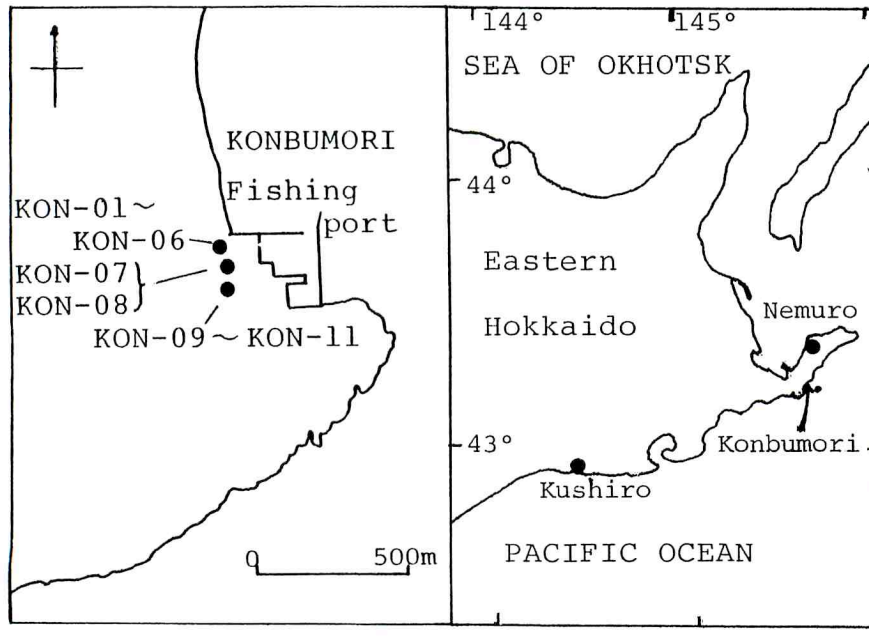

Fig. 1. Localities and numbers of the samples collected near Konbumori fishing port.

Lower Tokotan Formation (from lower to upper)

KON-01 : black shale (139 palynomorphs were found)*

KON-02 : black shale (102 palynomorphs were found)

KON-03 : black shale (51 palynomorphs were found)

KON-04 : black shale (104 palynomorphs were found)

KON-05 : black shale (100 palynomorphs were found)

KON-06 : black shale (100 palynomorphs were found)

Middle Tokotan Formation (from lower to upper)

KON-07 : black shale (under fine sandstone beds ; 50 palynomorphs were found)

KON-08 : black shale (intercalated part between fine sandstone beds ; 50 palynomorphs were found)

KON-09 : hard black shale (50 palynomorphs were found)

KON-10 : hard black shale (no slide was made in spite of occurrence of only a few grains)

KON-11 : hard black shale (under massive sandstone bed ; no slide was made notwithstanding occurrence of some grains)

Although pollen and spores are not well preserved, the author could distinguish to a certain degree their morphologic characteristics.

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* On an analytical technique of the samples, see Takahashi's paper (1991). [3]

Characteristics of pollen-spores assemblage

Pollen and spores examined consist of 62 pteridophyte-bryophyte spores, 54 gymnosperm pollen and 60 angiosperm pollen.

A) Spores :

The spores which are most significant palynostratigraphically are as follows :

1) *Biretisporites incrassatus* Takahashi & Shimono (Santonian-Maastrichtian ; Hamanaka-Oborogawa, Akkeshi, and Tokotan Formations)
2) *Biretisporites triangulatus* Takahashi (Akkeshi and Tokotan Formations)
3) *Biretisporites yoshimotoi* Takahashi (Akkeshi and Tokotan Formations)
4) *Gleicheniidites senonicus* Ross (Uppermost Jurassic-Early Tertiary ; Akkeshi and Tokotan Formations)
5) *Laevigatosporites probatus* Takahashi (Santonian-Maastrichtian ; Akkeshi Formation)
6) *Laevigatosporites prominens* Takahashi (coniacian-Maastrichtian ; Akkeshi and Tokotan Formations)
7) *Laevigatosporites senonicus* Takahashi (Coniacian-Maastrichtian ; Hamanaka-Oborogawa, Akkeshi and Tokotan Formations)
8) *Monoleiotriletes gracilis* Krutzsch (Japan : Coniacian-Maastrichtian ; Akkeshi and Tokotan Formations)
9) *Stereisporites antiquasporites* (Wilson & Webster) Dettmann (Santonian-Paleocene ; Akkeshi and Tokotan Formations)

Except the above-mentioned palynomorphs, the spores in common with those of the Tokotan Formation at Ochiishi are as follows : *Deltoidospora diaphana* Wilson & Webster, *Ischyosporites* cf. *crateris* Balme, *Laevigatosporites convexus* Takahashi, *Laevigatosporites dehiscens* Takahashi, *Laevigatosporites ovoideus* Takahashi, *Leiotriletes maxoides* Krutzsch *minoris* Krutzsch, *Monoleiotriletes minimus* Takahashi, *Retitriletes nemuroensis* Takahashi, *Triplanosporites inornatus* Takahashi and *Verrucatosporites tenellis* (Krutzsch) Krutzsch.

Due to not well preservation of palynomorphs, among many spores which were not determined their specific epithets 19 species appeared in common with the Tokotan Formation at Ochiishi. This fact relates that the Tokotan Formation at Konbumori is equivalent to that at Ochiishi.

Regarding the occurrence of spores, vide table 1.

B) Gymnospermous pollen :

As many species of gymnospermous pollen show their comparatively long appearance, only very restricted species of them are useful for palynostratigraphy. The following species occur in the Upper Cretaceous.

1) *Phyllocladidites mawsonii* Cookson (Japan : Santonian-Maastrichtian ; Akkeshi and Tokotan Formations)
2) *Pityosporites aliformis* Takahashi (Coniacian-Maastrichtian ; Tokotan Formation)
3) *Pityosporites siegburgensis* Takahashi & Jux (Japan : Coniacian-Maastrichtian ; Akkeshi and Tokotan Formations)
4) *Araucariacites australis* Cookson ex Couper (Japan : Coniacian-Maastrichtian ; Tokotan Formation)

Excepting the above-mentioned palynomorphs, the common species between both the Tokotan Formations at Konbumori and Ochiishi are as follows : *Cupressacites cuspidataeformis* (Zaklinskaja) Krutzsch, *Cycadopites microfollicularis* Krutzsch, *Inaperturopollenites dubius* (Pot. & Ven.) Thomson

& Pflug, *Inaperturopollenites laevigatus* Takahashi, *Inaperturopollenites parvus* Takahashi, *Pityosporites* cf. *labdacus* (Pot.) Thomson & Pflug, *Psophosphaera aggereloides* (Maljavkina) Chlonova, and *Psophosphaera pseudotsugoides* Krutzsch.

The occurrence of gymnospermous pollen is shown on table 1.

C) Angiospermous pollen :

The following species are important in the Upper Cretaceous.

1) *Betulaepollenites minutulus* Takahashi (Coniacian–Maastrichtian ; Hamanaka–Oborogawa and Tokotan Formations)
2) *Betulaepollenites normalis* Takahashi (Campanian–Maastrichtian ; Akkeshi and Tokotan Formations)
3) *Callistopollenites comis* Srivastava (Maastrichatian ; Akkeshi Formation)
4) *Fibulapollis hamulatus* Takahashi (Maastrichtian)
5) *Orbiculapollis globosus* (Chlonova) Chlonova (Maastrichtian–Danian ; Akkeshi Formation)
6) *Paraalnipollenites confusus* (Zaklinskaja) Hills & Wallace (Maastrichtian–Paleocene ; Akkeshi and Tokotan Formations)
7) *Pentapollenites manifestus* Takahashi & Shimono (Maastrichtian ; Akkeshi Formation)
8) *Tricolpites minutiretiformis* (Takahashi) Takahashi (Senonian–Maastrichtian ; Akkeshi and Tokotan Formations)
9) *Tricolpites sphaericus* Takahashi (Coniacian–Maastrichtian ; Akkeshi and Tokotan Formations).
10) *Ulmipollenites undulipunctatus* Takahashi (Maastrichtian ; Tokotan Formation)
11) *Ulmoideipites fornicatus* Takahashi (Maastrichtian)

The above–mentioned species appear in comparatively short term and are useful for palynostratigraphic correlation. Excepting those aforementioned, the following palynomorphs occur in common with the Tokotan Formation at Ochiishi : *Cupuliferoidaepollenites facetus* (Takahashi) Takahashi, *Cupuliferoidaepollenites fallax* (Pot.) Potonié, *Cupuliferoidaepollenites weylandii* (Takahashi) Takahashi, *Cyrillaceaepollenites megaexactus* (Pot.) Potonié, *Polyvestibulopollenites eminens* Takahashi, *Potamogetonacidites difficilis* Takahashi, *Striatocolporites striatulus* (Takahashi & Jux) Takahashi & Jux, *Subtriporopollenites kyushuensis* Takahashi, *Subtriporopollenites minor* Takahashi, *Triatriopollenites mirabilis* Takahashi, *Tricolpites ellipticus* Takahashi & Jux, *Tricolpites hokkaidoanus* Takahashi & Jux, *Triporopollenites shimensis* Takahashi and *Triporopollenites suzukii* Takahashi.

Only two species of *Aquilapollenites* occurred. The grain which the author has named *Aquilapollenites* aff. *spinulosus* Funkhouser is small in form and a distinct species from *A. spinulosus* which occurs in Maastrichtian–Danian age of Rocky Mountains districts (U. S. A.) (Tschudy & Leopold, 1970),[1] although this grain is similar to *A. spinulosus* in morphological features.

The pollen and spores from each sample of the Tokotan Formation at Konbumori are divided into three classifications, i. e., spores, gymnospermous pollen, and angiospermous pollen and each of them is shown with percentage on table 2.

As a whole, gymnospermous pollen are most numerous, that is, more than 40%. Angiospermous pollen appear more than 23% and fluctate considerably between 23.3 and 40.0%. As compared percentage of them with one of pollen and spores from the Tokotan Formation at Ochiishi (Takahashi & Ueda, 1990[2]; Takahashi, 1991[3]), the fluctation of figures is remarkably recognized. Gymnospermous pollen show a higher percentage and contrariwise angiospermous ones are lower.

Table 1. Occurrence (×) of palynomorphs of the Tokotan Formation at Konbumori

Spores and pollen \ Samples	KON 01	KON 02	KON 03	KON 04	KON 05	KON 06	KON 07	KON 08	KON 09
Acanthotriletes sp. a						×			
A. sp. b	×								
Biretisporites incrassatus	×								
B. minor		×	×						
B. triangulatus				×					
B. yoshimotoi								×	
? B. sp. a					×				
? B. sp. b			×						
? Cibotiidites sp.						×			
Cicatricosisporites sp.					×				
Deltoidospora konbumoriensis	×	×							
D. diaphana			×		×			×	×
D. microforma						×			
D. nodaensis						×			
D. taenia		×	×						
D. triangula	×					×		×	
Duplosporis sp.								×	
Echinatisporis embryonalis				×					
Faviosporis sp.			×				×		×
Gleicheniidites senonicus	×			×					
Granulatisporites sp. a	×								
G. sp. b	×								
Ischyosporites cf. crateris						×			
I. sp.		×							
Leiotriletes maxoides minoris				×					
L. sp.		×							
Lygodiidites minimus	×		×						
Monoleiotriletes gracilis									×
M. cf. minimus									×
Retitriletes nemuroensis		×						×	×
R. sp. a					×				
R. sp. b	×					×			
R. sp. c	×								
Stereisporites antiquasporites				×					
S. nemuroensis		×			×				
S. pseudostereoides	×			×					
S. sp.	×						×		×
? Todisporites major						×			
Trilites sp. a		×							
T. sp. b	×								
Triplanosporites cf. inornatus				×	×				
T. cf. microsinuosus				×					
T. rikuchuensis					×				
T. sp. a								×	
T. sp. b				×					

T. sp. c	×								
Undulatisporites sp.					×				
? Verrucatisporites sp.	×								
Verrucatitriletes sp.				×					
? V. sp.						×			
Megaspore (indeterminable)					×				
Inderminable trilete spores				×	(×)				
Laevigatosporites convexus					×				
L. dehiscens	×	×	×	×	×	×	×	×	×
L. nitidulus		×		×		×			
L. ovoideus		×	×						
L. probatus					×				
L. prominens	×	×	×		×	×	×	×	
L. semicircularis	×	×				×	×		
L. senonicus	×	×		×	×	×	×	×	
L. tener	×	×		×	×	×	×		×
Verrucatosporites tenellis				×	×	×			
Gymnospermous pollen :									
? Alisporites bisaccus				×					
Cedripites sp.					×				
? C. sp. a	×								
? C. sp. b						×			
Phyllocladidites mawsonii				×	×?				
P. sp.						×			
Piceapollis planoides						×			
P. sacculiferoides									×
? P. sp.			×						
Pityosporites aliformis				×		×		×	×
P. insignis					×				×
P. cf. labdacus						×			
P. cf. microalatus	×								
P. cf. microinsignis						×			
P. minutus	×		×		×	×			
P. cf. pristinipollinius						×			
P. cf. scopulipites						×		×	
P. siegburgensis	×			×	×	×	×		
P. sp. a				×					
P. sp. b	×								×
P. sp. c	×			×					
P. sp. d	×			×					×
P. sp. e	×	×							
P. sp. f	×								
? P. sp.								×	
P. (abnormal form)					×				
Cunninghamicites hokkaidoensis	×	×	×		×		×		×
Cupressacites bockwitzensis	×						×		
C. cuspidataeformis	×	×			×			×	
C. insulipapillatus					×				

C. microrugulatus	×		×	×	×	×	×	×	×
Inaperturopollenites dubius	×	×	×	×	×	×	×	×	×
I. globulosus	×		×			×			
I. hiatus			×		×	×			×
I. laevigatus	×	×	×	×	×	×			×
I. parvus	×	×		×	×		×	×	
Psophosphaera aggereloides	×	×	×	×	×		×	×	×
P. pseudotsugoides				×		×		×	×
Sequoiapollenites gracilis		×		×					
S. polyformosus					×	×			
S. sp.	×								
Cycadaceaelagella sp.	×								
Cycadopites gracilis				×					×
C. cf. microfollicularis						×			
C. sp. a	×								
C. sp. b									×
C. sp. c		×							
C. sp. d									×
C. sp. e	×								
? C. sp.				×		×			
? Classopollis sp.	×								
Araucariacites australis	×								
Ephedripites (Distachyapites) sp.						×	×		
E. (Spiralipites) sp.				×		×			
Angiospermous pollen :									
Aquilapollenites aff. spinulosus						×			
A. sp.		×							
Arecipites sp.							×		
Betulaepollenites cf. minutulus				×	×		×		
B. normalis	×	×	×	×	×	×	×	×	
Callistopollenites comis				×	×				
Caryapollenites viridi-fluminipites						×	×		
Chenopodipollis sp.				×					
Cupuliferoidaepollenites cf. facetus							×		
C. fallax				×			×		×
C. vulgaris	×	×	×	×			×		
C. weylandii	×								
? C. sp.			×						
Cupuliferoipollenites fusus		×						×	
C. pusillus	×	×							
Cyrillaceaepollenites cf. megaexactus							×		
Ericipites sp.	×								
Fibulapollis cf. hamulatus	×								
Foveoinaperturites sp.	×								
? Gothanipollis sp.					×				
Graminidites sp. a					×				
G. sp. b		×	×		×		×	×	
G. sp. c									×

? G. sp.	×					×			
Monocolpopollenites kyushuensis	×								
Orbiculapollis globosus	×			×					
Paraalnipollenites confusus		×		×	×	×		×	×
Pentapollenites cf. manifestus							×		
Polyporopollenites sp.					×				
Polyvestibulopollenites eminens	×	×	×	×		×			×
P. sp.					×				
Potamogetonacidites difficilis	×	×		×	×	×		×	
Proteacidites sp.								×	
? Smilacipites sp.						×			
Striatocolporites striatulus						×			
Subtriporopollenites kyushuensis	×	×	×	×	×	×	×	×	
S. minor	×						×		
Tetracolporopollenites sp.		×							
Tiliaepollenites sp.	×								
Triatriopollenites mirabilis		×							
T. cf. ongaensis	×	×							
T. sp. a			×				×		×
T. sp. b	×								
Tricolpites ellipticus									×
T. hokkaidoanus		×	×	×	×	×	×		
T. cf. interangulus	×								
T. marginatus					×				
T. cf. microretiformis			×						
T. minutiretiformis	×	×			×				
T. retiformis		×							
T. sphaericus	×	×			×				
T. sp.					×				
Tricolpopollenites subasper								×	
T. sp. a				×					
T. sp. b					×				
T. sp. c								×	
Triporopollenites shimensis	×	×		×					
T. suzukii	×	×	×	×				×	×
Ulmipollenites undulipunctatus	×			×			×		
Ulmoideipites fornicatus	×	×							

Table 2. Percentage of spore and pollen detected from the Tokotan Formation at Konbumori (%)

Sample number	KON 01	KON 02	KON 03	KON 04	KON 05	KON 06	KON 07	KON 08	KON 09
Spores	26.7	26.8	28.3	27.0	29.6	27.8	20.0	30.6	22.4
Gymnospermous pollen	50.3	41.2	41.3	47.0	40.8	49.9	40.0	40.8	49.0
Angiospermous pollen	23.0	32.0	30.4	26.0	29.6	23.3	40.0	28.6	28.6

Description of new palynomorphs

A) Trilete spores :

Form-geuns : *Biretisporites* Delcourt & Sprumont 1955 emend. Delcourt, Dettmann & Hughes 1963.[4]

Type species : *Biretisporites potoniei* Delcourt & Sprumont 1955.[5]

Biretisporites minor n. sp.
Pl. 1, figs. 1, 2.

Description : Trilete spores. Amb triangular with slightly convex sides and rounded corners in polar view. Trilete laesurae straight or slightly wound, with wide, elevated lips on both their sides, 1.5-2.2μm thick or less, chagrenate to laevigate.

Dimensions : 16-17μm × 12-15μm in equatorial diameter.

Occurrence : Tokotan Formation at Konbumori (KON-02 and KON-03).

Holotype : Pl. 1, fig. 1 ; 17×12μm in equatorial diameter ; exine thin, chagrenate ; trilete rays 2.2 μm wide ; slide GN 5773 ; Tokotan Formation at Konbumori (KON-02).

Name derivation : *minor* (lat.)=less, smaller.

Comparisons : The present spores are superficially similar to ? *Biretisporites minus* Takahashi (1964) [6] and *B. triangulus* Takahashi (1991),[3] but can be distinguished by the smallest size of spore.

Botanical affinity : Unknown.

Form-genus : *Deltoidospora* Miner 1935 ex Potonié 1956.[7]

Type species : *Deltoidospora hallii* Miner 1935.[8]

Deltoidospora konbumoriensis n. sp.
Pl. 1, fig. 3.

Description : Trilete spores. Outline triangular with convex sides and rounded corners in polar view. Trilete laesurae straight, narrow, and reaching equator. Exine two-layered, 0.5μm thick, smooth.

Dimensions : 27-28μm×18-20μm in equatorial diameter.

Occurrence : Tokotan Formation at Konbumori (KON-01 and KON-02).

Holotype : Pl. 1, fig. 3 ; 28×18μm in equatorial diameter ; exine two-layered, 0.5μm thick, smooth ; trilete laesurae straight, narrow, reaching the equator ; slide GN 5762 ; Tokotan Formation at Konbumori (KON-01).

Name derivation : From Konbumori of Nemuro city.

Comparison : In general shape this new species is similar to *Deltoidospora microlepioides* (Krutzsch) Wang in Song et al. (1981) [9] from the Akkeshi Formation in Akkeshi and Ochiishi areas and from the Tokotan Formation in Ochiishi area, but the former has the convex sides of spore and the latter possesses the conspicuously concave sides.

Botanical affinity : Unknown.

Form-genus : *Lygodiidites* Pocock 1964.

Type species : *Lygodiidites laevigatus* Pocock 1964.[10]

Lygodiidites minimus n. sp.
Pl. 1, figs. 6a-b.

Description : Trilete spores. Amb rounded-triangular with convex sides in polar or somewhat oblique views. Exine two-layered ; ectexine ornamented by a large flange with undulate margin ; flange 4μm wide on the sides and 5-6μm wide on the corners ; endexine thin, smooth. Proximal surface smooth and distal one more or less irregularly uneven. Trilete laesurae conspicuous, slightly wound, mostly with lips (ca. 2μm wide).
Dimensions : 38-42μm×35-36μm in outer diameter ; 28-37μm×26.5-29μm in inner diameter (without flange).
Occurrence : Tokotan Formation at Konbumori (KON-01 and KON-03).
Holotype : Pl. 1, figs. 6a-b ; 38×36μm in outer diameter ; 28×26.5μm in inner diameter (without flange) ; flange 4μm wide on the sides and 5-6μm wide on the corners ; proximal surface smooth and distal one irregularly uneven ; slide GN 5768 ; Tokotan Formation (KON-01).
Name derivation : *minimus* (lat.)=little, small.
Comparison : *Lygodiidites minimus* differs from the other species of *Lygodiidites* in having the smallest size of spore.
Botanical affinity : Schizaeaceae, *Lygodium*.

Form-genus : *Stereisporites* Thomson & Pflug 1953.
Type species : *Stereisporites stereoides* (Potonié & Venitz 1934) [11] Thomson & Pflug 1953.[12]

Stereisporites nemuroensis n. sp.
Pl. 1, figs. 4a-b, 5.

Description : Trilete spores. Amb subcircular with slightly undulate sides in polar siew. Trilete rays small, narrow, with length of a half to two-thirds spore radius. Exine thin, 1-2μm thick, smooth to chagrenate.
Dimensions : 24-25μm×17-18μm in equatorial diameter.
Occurrence : Tokotan Formation at Konbumori (KON-02 and KON-05).
Holotype : Pl. 1, figs. 4a-b ; 25×18μm in equatorial diameter ; exine 1μm thich, smooth ; Y-mark small and narrow ; slide GN 5820 ; Tokotan Formation at Konbumori (KON-05).
Name derivation : From Nemuro city.
Comparisons : *Stereisporites nemuroensis* can be distinguished from *S. stereoides* (Potonié & Venitz, 1934) Thomson & Pflug (1953) in its subcircular shape and a slender Y-mark, and from *S. pseudostereoides* Takahashi (1964,[6] 1982[13]) in its smaller size and subcircular shape.
Botanical affinity : Sphagnaceae, *Sphagnum*.

B) Monolete spores :
Form-Genus : *Laevigatosporites* Ibrahim 1933.
Type species : *Laevigatosporites vulgaris* (Ibrahim 1932) Ibrahim 1933.

Laevigatosporites semicircularis n. sp.

Pl. 1, figs. 7-9.

Description : Monolete spores. Figura semicircular or reniform in lateral view. Dehiscence side concave ; monolete furrow concave and expressed in thicker exine. Exospore thin, smooth, up to 1μm thick on distal side and 2.5-3μm thick on dehiscence side,

Dimensions : 21-25μm in equatorial axis and 14-18μm in polar axis ; polar axis / equatorial axis ratio=0.636-0.773.

Occurrence : Tokotan Formation at Konbumori (KON-01, KON-02, KON-06 and KON-07).

Holotype : Pl. 1, fig. 7 ; 22×17μm in size ; exine 1μm thick on distal side and 3μm thick on dehiscence side ; polar axis / equatorial axis ration=0.773 ; slide GN 5837 ; Tokotan Formation at Konbumori (KON-06).

Name derivation : *semi-* (lat.)=half ; *circularis* (lat.)=circular.

Comparisons : The present specimens are closely similar to *Laevigatosporites gracilis* wilson & Webster (1964) [14] from the Paleocene Fort Union Formation of Montana (U. S. A.), but differ in being smaller in size and thinner in exine.

Botanical affinity : Polypodiaceae.

Laevigatosporites tener n. sp.

Pl. 1, figs. 10-13.

Description : Monolete spores. Outline narrow bean-shaped in lateral view. Dehiscence side concave or slightly convex. Monolete furrow simple and running parallel to the dehiscence side. Exine thin, smooth, 0.5-1μm thick on distal side and 1-1.3μm thick on dehiscence side.

Dimensions : 23-30μm in equatorial axis and 10-15μm in polar axis ; polar axis / equatorial axis ration=0.37-0.565.

Occurrence : Tokotan Formation at Konbumori (KON-01, KON-02, KON-04, KON-05, KON-06, KON-07 and KON-09).

Holotype : Pl. 1, fig. 11 ; 28×12μm in size ; exine 1μm thick, smooth ; dehiscence side concave ; polar sxis / equatorial axis ration=0.428 ; slide GN 5776 ; Tokotan Formation at Konbumori (KON-02).

Name derivation : *tener* (lat.)=tender, delicate.

Comparison : Morphologically *Laevigatosporites tener* shows considerable resemblance to *L. bellulus* Takahashi (1991) [3], but differs in being much narrower in shape. The figure 1 of plate 18 illustrated as *Laevigatosporites tenuis* by Takahashi (1991) [3] must be transferred to *Laevigatosporites tener.*

Botanical affinity : Polypodiaceae.

C) Gymnospermous pollen :

Form-genus : *Cunninghamicites* n. gen.

Type species : *Cunninghamicites hokkaidoensis* n. gen. et sp.

Cunninghamicites n. gen.

Description : Monoporate pollen grains with dense sculpture of exine and a circular or elliptical pore which is often invisible. Figura spherical or subspherical in any sight. Exine two-layered,

often secondarily folded or cracked ; exine surface covered densely with small granules, papillae or verrucae.

Comparisons : According to this feature and character, the form-genus *Cunninghamicites* belongs to the recent genus *Cunnighamia* of the family Taxodiaceae.

Nagy (1969) [15] instituted the form-genus *Cunninghamiaepollenites* with the type-species *C. lignitus* Nagy which is a roundish pollen grain of 36μm size with a minute pore aperture in its intragranulate exine and radial, fold-like lines issuing from the pore towards the border of the grain from the Miocene (Tortonian) of Hungary, notwithstanding Krutzsch (1971) [16] indicated as a foraminate form of the genus *Inaperturopollenites*.

Cunninghamicites hokkaidoensis n gen. et sp.
Pl. 2, figs. 1-5.

Description : Spherical or subspherical, monoporate pollen grains with dense sculpture of exine and a circular or elliptical pore. The pore is not always apparent and often hardly visible. Exine two-layered, with secondary folds and cracks due to fossilization ; granulate, papillate or verrucate ornamentations distributed densely, 1-2μm wide and 1-2.5μm high.

Dimensions : 28-46μm×22-44μm in diameter.

Occurrence : Tokotan Formation at Konbumori (KON-01, KON-02, KON-03, KON-05, KON-07 and KON-09).

Holotype : Pl. 2, figs. 1a-b ; 35×30μm in diameter ; exine 1.5μm thick ; sculptures verrucate, granulate or papillate, distributed densely ; slide GN 5846 ; Tokotan Formation at Konbumori (KON-07).

Name derivation : From Hokkaido district.

Comparisons : The present specimens are similar to *Sciadopityspollenites tubulus* Krutzsch (1971) [16] and *S. quintus* Krutzsch (1971) [16] from the middle Miocene of Germany, but differ from the two latters in having much smaller ornamentation.

Botanical affinity : Taxodiaceae, *Cunninghamia*.

From-genus : *Cupressacites* Bolkhovitina 1956.

Type species : *Cupressacites russeus* Bolkhovitina 1956.

Cupressacites microrugulatus n. sp.
Pl. 2, figs. 8a-b, 9.

Description : Pollen grains rather small, more or less rounded, without an aperture. Exine thin, 0.5-1μm thick, with punctate or very finely granulate sculpture which arranged often rugulately, secondarily folded or cracked ; muri baculate-partially tectate, 0.5-1μm high.

Dimensions : 22-35μm in diameter.

Occurrence : Tokotan Formation at Konbumori (KON-01, KON-03, KON-04, KON-05, KON-06, KON-07, KON-08 and KON-09).

Holotype : Pl. 2, figs. 8a-b ; 35μm in diameter ; exine 1μm thick, with punctate and granulate sculpture ; muri baculate-partially tectate, 0.5-1μm high ; slide GN 5847 ; Tokotan Formation at Konbumori (KON-07).

Name derivation : *mikros* (gr.)=small ; *rugulatus* (lat.)=rugulate.

Comparisons : *Cupressacites microrugulatus* can be distinguished from *C. ochiishiwanensis* Takahashi (1991) from both the Akkeshi and Tokotan Formations in Ochiishi area by its thicker exine and finely rugulated sculpture and from *C. insulipapillatus* (Trevisan) Krutzsch (1971) by its densely punctate and rugulate ornamentations.
Botanical affinity : Cupressaceae.

Form-genus : *Inaperturopollenites* Pflug & Thomson 1953 emend. Potonié 1958 [17] emend. Potonié 1960 [18].
Type species : *Inaperturopollenites dubius* (Potonié & Venitz 1934) Thomson & Pflung 1953.

Inaperturopollenites globulosus n. sp.
Pl. 1, figs. 14–17.

Description : Inaperturate pollen grains. Figura spherical or subspherical in any sight. Exine thin, less than 0.5μm thick, laevigate, often secondarily folded due to fossilization.
Dimensions : 10.5–14μm×9–11μm in diameter.
Occurrence : Tokotan Formation at Konbumori (KON-01, KON-03 and KON-06).
Holotype : Pl. 1, fig. 17 ; 12×11μm in diameter ; erine 0.5μm thick, laevigate ; without an aperture ; slide GN 5762 ; Tokotan Formation at Konbumori (KON-01).
Name derivation : *globulosus* (lat.)=globulous, globulose.
Comparison : This new species can be distinguished from the other species of *Inaperturopollenites* by its the smallest size.
Bothanical affinity : Probably conifer.

Finally two new combinations are proposed :

1) *Deltoidospora* (al. *Leiotriletes*) *triangula* (Mürringer & Pflug ex Krutzsch) n. comb.
2) *Caryapollenites* (al. *Hicoria*) *viridi-fluminipites* (Wodehouse) n. comb.

Acknowledgements

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Plate 1

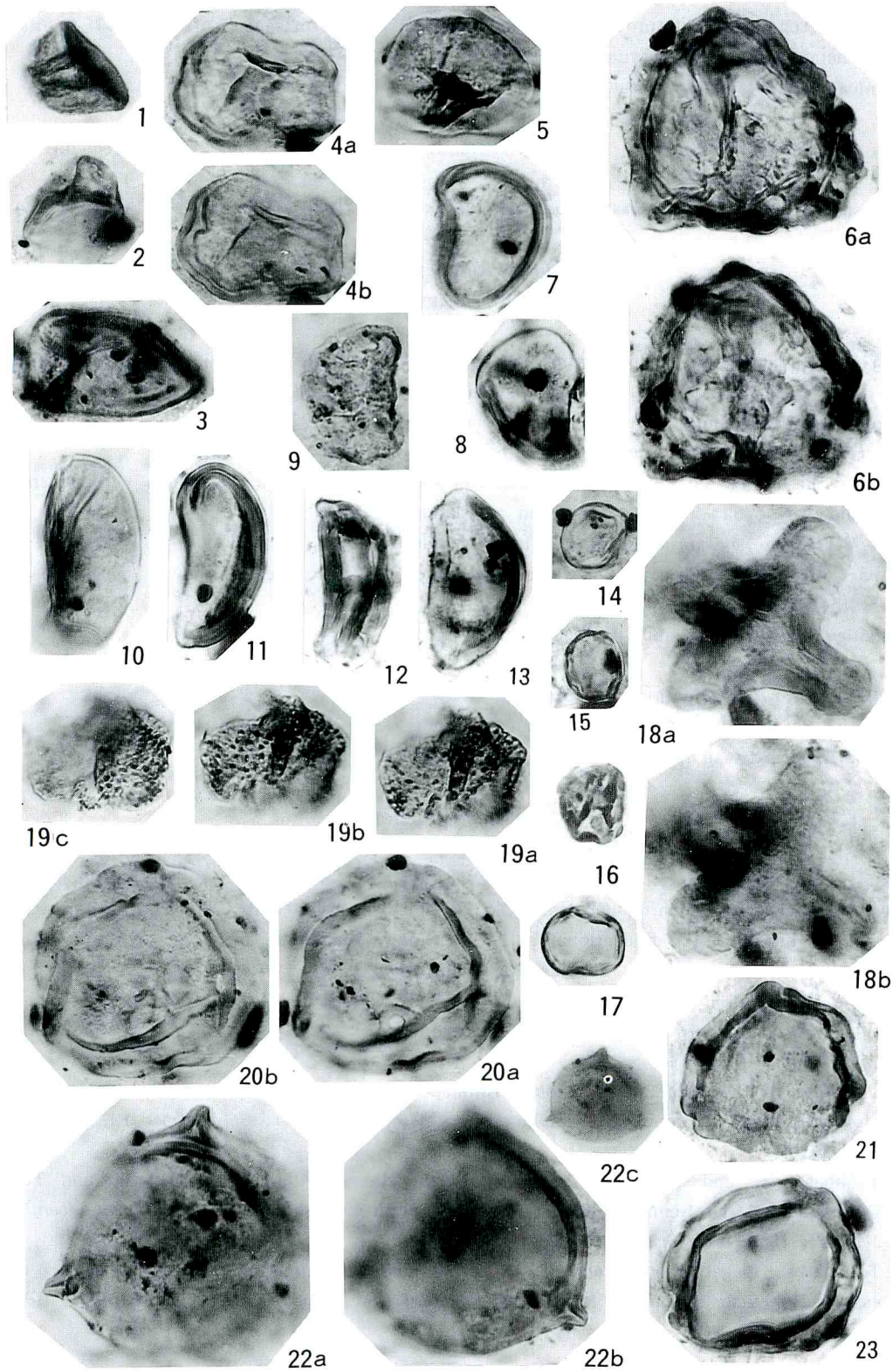
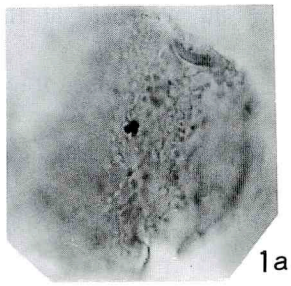

1
4a
5
6a
2
4b
7
3
9
8
6b
10
11
12
13
14
18a
15
19c
19b
19a
16
18b
17
20b
20a
21
22c
22a
22b
23

Plate 2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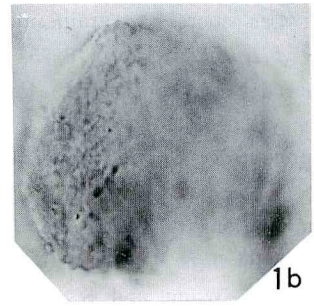
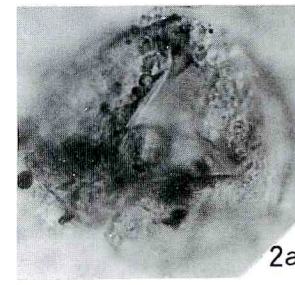

1b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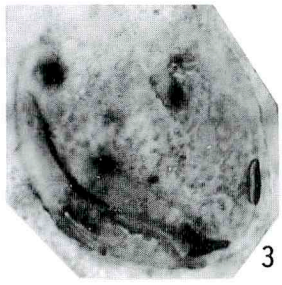
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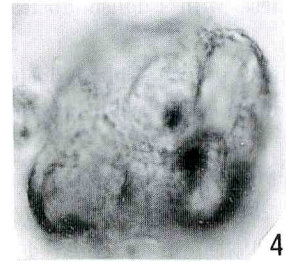
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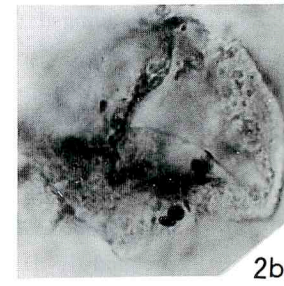
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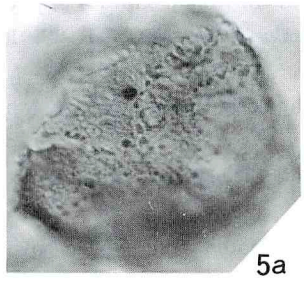
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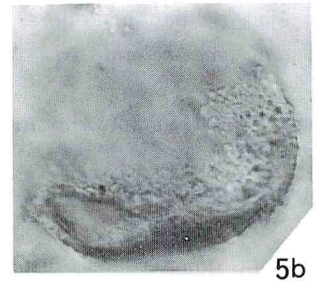
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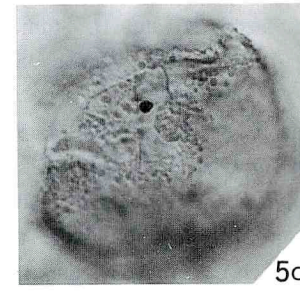
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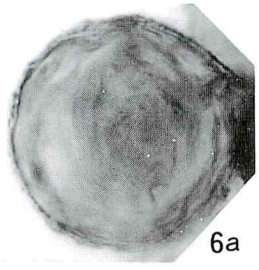
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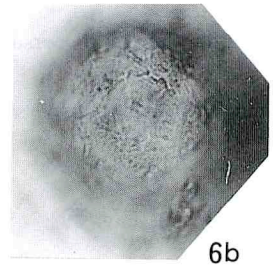
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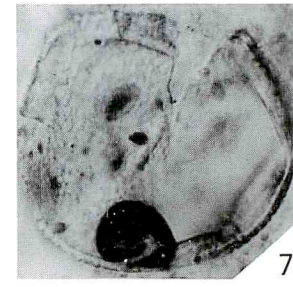
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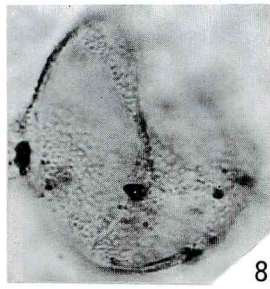
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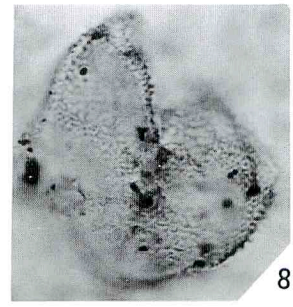
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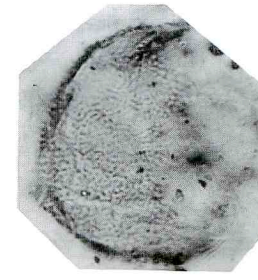
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要　　約

筆者は昆布盛魚港の西の崖に露出している床潭層の11の黒色頁岩の試料を採集し，それらを花粉学的に分析し，それの中9試料から羊歯植物，蘚苔植物，裸子植物，被子植物，菌類および植物性微プランクトンの微化石746個体を識別した．菌類胞子および植物性微プランクトンを除いて，62の胞子，54の裸子植物花粉および60の被子植物花粉の合計176種を検討した．この花粉—胞子群集はマーストリヒト期を示す落石の床潭層の群集に明らかに比較される．さらに，胞子の6新種，裸子植物花粉の1新属，3新種が記載され，その上，付加的に2つの種類の属の組合せを改めた．

Explanation of plate 1 (all figures magnified × 1000 unless otherwise mentioned)

Fig. 1, 2. ***Biretisporites minor*** **n. sp.**

Fig. 1 : holotype, GN 5773, KON-02; fig. 2 : GN 5774, KON-03.

Fig. 3. ***Deltoidospora konbumoriensis*** **n. sp.**

Holotype, GN 5762, KON-01.

Figs. 4a-b, 5. ***Stereisporites nemuroensis*** **n. sp.**

Figs. 4a-b : holotype,GN 5820, KON-05 ; fig. 5 : GN 5778, KON-02.

Figs. 6a-b. ***Lygodiidites minimus*** **n. sp.**

Holotype, GN 5768, KON-01.

Figs. 7-9. ***Laevigatosporites semicircularis*** **n. sp.**

Fig. 7 : holotype, GN 5837, KON-06 ; fig. 8 : GN 5771, KON-02 ; fig. 9 : GN 5769, KON-01.

Figs. 10-13. ***Laevigatosporites tener*** **n. sp.**

Fig. 10 : GN 5821, KON-05 ; fig. 11 : holotype, GN 5776, KON-02 ; fig. 12 : GN 5763, KON-01 ; fig. 13 : GN 5767, KON-01.

Figs. 14-17. ***Inaperturopollenites globulosus*** **n. sp.**

Fig. 14 : GN 5770, KON-01 ; fig. 15 : GN 5764, KON-01 ; fig. 16 : GN 5794, KON-03 ; fig. 17 : holotype, GN 5762, KON-01.

Figs. 18a-b. ***Aquilapollenites*** **aff.** ***spinulosus*** **Funkhouser**

GN 5832, KON-06.

Figs. 19a-c. ***Fibulapollis*** **cf.** ***hamulatus*** **Takahashi**

GN 5762, KON-01.

Figs. 20a-b. ***Caryapollenites viridi-fluminipites*** **Wodehouse n. comb.**

GN 5847, KON-07.

Figs. 21, 23. ***Paraalnipollenites confusus*** **(Zaklinskaja) Hills & Wallace**

Fig. 21 : GN 5814, KON-04 ; fig. 23 : GN 5832, KON-06.

Figs. 22a-c. ***Orbiculapollis globosus*** **(Chlonova) Chlonova**

GN 5770, KON-01 ; fig. 22c : × 400.

Explanation of plate 2 (all figures magnified × 1000)

Figs. 1-5. ***Cunninghamicites hokkaidoensis*** **n. gen. et sp.**

Figs. 1a-b : holotype, GN 5846, KON-07 ; figs. 2a-b : GN 5776, KON-02 ; fig. 3 : GN 5791, KON-03 ; fig. 4 : GN 5795, KON-03 ; figs. 5a-c : GN5822, KON-05.

Figs. 6a-b, 7. ***Cupressacites cuspidataeformis*** **(Zaklinskaja) Krutzsch**

Figs. 6a-b : GN 5777, KON-02 ; fig. 7 : GN 5861, KON-08.

Figs. 8a-b, 9. ***Cupressacites microrugulatus*** **n. sp.**

GN 5847, KON-07 ; figs. 8a-b : holotype.

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