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Palynologic study of the Akkeshi and Tokotan Formations of the Nemuro Group, eastern Hokkaido

Kiyoshi TAKAHASHI

(Received October 15, 1990)

Abstract

The author has carried out the palynological study of the Akkeshi and Tokotan Formations of the Nemuro Group which is distributed in the coastal regions between Kushiro and Nemuro and consists of Campanian, Maastrichtian, and Danian marine sediments. He has collected 48 samples from the Hamanaka-Oborogawa, Akkeshi, and Tokotan Formations and discriminated 311 palynomorphs which are composed of 121 spores, 55 gymnospermous pollen, and 135 angiospermous pollen, excepting phytomicroplankton. He describes and illustrates minutely these spores and pollen grains in this paper and discusses on the Cretaceous/Tertiary boundary problem from the palynologic angle.


Moreover, new combinations are proposed: Baculatisporites cf. dubius Burger n. comb., B. wellmanii Couper n. comb., Cicatricosisporites minutaestriatus Bolkhovitina n. comb., and Murospora circulata Weyland & Krieger n. comb.

Among the trilete spores, Baculatisporites (Osmundaceae), Biretisporites, Deltoidospora, Leiotriletes (Schizaeaceae etc.), Monoleiotriletes, Pterisispores (Pteridaceae), Retitriletes (Lycopodiaceae), Stereisporites (Sphagnaceae), and Triplanosporites (Schizaeaceae) appear predominantly. Among the monolete spores, Extrapunctatosporis (Athyriaceae) and Laevigatosporites (Polypodiaceae) occur abundantly. Of the gymnospermous pollen
grains the following grains occur frequently: *Cupressacites* (Cupressaceae), *Cycadopites* (Cycadaceae), *Ephedripites* (Ephedraceae), *Inaperturopollenites* (Taxodiaceae etc.), *Phyllocladidites* (*Phyllocladus*), *Pityosporites* (Pinaceae), and *Psophosphaera* (*Larix* or *Pseudotsuga*). The angiospermous pollen assemblages include the *Aquilapollenites* (Triprojectacites) pollen group, oculata pollen grains, and some other pollen grains which are very important for age determination.

In conclusion these pollen grains and a number of spores from the Akkeshi and Tokotan Formations indicate consistently Maastrichtian time, notwithstanding in the Tokotan Formation angiospermous pollen grains increase more in number and kind than in the Akkeshi Formation and the grains of the *Aquilapollenites* (Triprojectacites) pollen group decrease conversely. After all, the author could find no evidence supporting Danian time from the palynologic standpoint, whereas nannofossils of the uppermost Akkeshi Formation and the Tokotan Formation indicate the middle to late Danian time.

**Contents**

Abstract .......................................................................................................................... 169
Introduction ...................................................................................................................... 170
Acknowledgements ......................................................................................................... 171
Geologic and palaeontologic notes of the Nemuro Group .............................................. 172
Materials and treatment ................................................................................................ 177
Palynomorphs of the Nemuro Group .............................................................................. 182
A) Spores ......................................................................................................................... 182
   a) Trilete spores ........................................................................................................ 182
   b) Monolete spores .................................................................................................... 185
   c) Alete spore ............................................................................................................ 186
B) Gymnospermous pollen grains .................................................................................. 186
C) Angiospermous pollen grains .................................................................................... 188
Systematic description .................................................................................................... 192
A) Spores ......................................................................................................................... 193
   a) Trilete spores ........................................................................................................ 193
   b) Monolete spores .................................................................................................... 245
   c) Alete spore ............................................................................................................ 261
B) Gymnospermous pollen grains .................................................................................. 262
C) Angiospermous pollen grains .................................................................................... 300
Palynologic assemblages ............................................................................................... 385
Discussion on the Cretaceous/Tertiary boundary ............................................................ 395
References ...................................................................................................................... 407

**Introduction**

The Nemuro Group which consists of Campanian to Palaeocene (Danian)
marine sediments is widely distributed along the coastal areas from the eastern region of Kushiro to Nemuro in eastern Hokkaido. The Group yields many ammonoids, inoceramids, foraminifera, nannofossils etc. Centering around these fossils the Cretaceous/Tertiary boundary problem was recently discussed. According to a number of recent investigations, some planktonic foraminifera and nannofossils indicating the Danian occurred from the upper part of the lower Tokotan Formation along Ochiishi Bay and it was stated that the Cretaceous/Tertiary boundary should be drawn somewhere in the lower part of the Tokotan Formation on the basis of these fossils. However, on the other hand, foraminifera indicating the Palaeocene were found from the middle part of the Akkeshi Formation in the eastern area along Akkeshi Bay. Recently Okada et al. (1987) examined the occurrence of nannofossils and biostratigraphic correlation of the Nemuro Group exposed along the coastal areas of eastern Hokkaido, detected the nannofossils indicating the middle to late Danian from the upper member of the Akkeshi Formation and from the Tokotan and Kiritappu Formations, and therefore concluded that the Cretaceous/Tertiary boundary should be placed within the lower to middle member of the Akkeshi Formation.

Formerly pollen grains and spores from the Nemuro Group only were given by Okazaki (1966) on the list in the “Geology of Kushiro”, so that the palynologic assemblage has not been studied sufficiently.

The author has collected 48 samples in the coastal areas along Akkeshi Bay, in the coast near Honhoroto, in the area around Ochiishi Bay, and in the coastal area of Choboshi in eastern Hokkaido, and distinguished 311 kinds of palynomorphs which consist of 121 spores, 55 gymnospermous pollen, and 135 angiospermous pollen excepting phytoplankton. He has picked up and examined biostratigraphically the *Aquilapollenites* (Triprojectacites) pollen grains, the oculata pollen grains, and a number of spores and other pollen grains which are useful for age determination. In conclusion, these palynomorphs from both the Akkeshi and Tokotan Formations indicate the Maastrichtian and after all no evidence was found that genuinely the Tokotan Formation is the Danian, whereas the nannofossils from the upper member of the Akkeshi Formation and from the Tokotan Formation indicate the middle to late Danian.

**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 (1989).
The author expresses sincere thanks to the Educational authorities. Many thanks are also due to Prof. Dr. N. Suzuki, Kushiro Branch, Hokkaido University of Education, for his kind arrangement of hotel by the field survey and Mr. Y. Yoshimoto for his able field guidance. Special thanks are extended to Prof. Dr. Y. Ueda, Department of Geology, Nagasaki University, for collecting samples in the fields together with the author.

Geologic and palaeontologic notes of the Nemuro Group

The Nemuro Group, a continuous marine sedimentary sequence spanning the Cretaceous / Tertiary boundary, has been studied and discussed stratigraphically and palaeontologically. Of course, there are many scientific papers on stratigraphy, palaeontology, geochronology, palaeomagnetism, geological maps (1/50,000) with explanation etc.
Above all, Matsumoto (1970) divided the Nemuro Group with ca. 3000 m thickness into the following six units and summarized them.

Tab. 1. Stratigraphy and correlation of the Nemuro Group (adopted from among recent papers).

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<td>Nokkamappu F.</td>
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<td>Upper Cretaceous</td>
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N1 (lower Nemuro Formation in a narrow sense; Otamura Formation in Akkeshi district): Mainly shales and including often tuffaceous sandstones. Occurring *Inoceramus shikotanensis*. Uppermost Companian or lowest Maastrichtian.

N2 (middle Nemuro Formation; Monshizu Formation in Akkeshi district): Characteristic tuffaceous sandstones and siliceous shales including *Inoceramus kushiroensis* and *Pachydiscus cf. subcompressus*. Maastrichtian.


N4 (Choboshi Formation; Akkeshi Formation in Akkeshi district; Shiomi Formation disconformably overlying N3 in the west of Akkeshi Bay): Alternation of sandstone and shale with many slumping structures. Sedimentary formation with questionable determination of geologic age, because the foraminifera, *Globorotalia pseudobulloides, Globigerina triloculinoides, Globigerinoides* etc., indicating the Danian, and inoceramids and ammonoids indicating the Maastrichtian, occur.

N5 (Ochiishi and Yururi Formations in Nemuro Peninsula; Chinbe Formation in Akkeshi district; Oshamappu, Chippomanai, and Sarukiushi Formations in the west of Akkeshi Bay): Conglomerate, conglomeratic sandstone, muddy sandstone. Remarkable variation of rock facies. Occurring bivalves, gastropods, brachipods etc. which have never appeared in the Cretaceous and rarely the planktonic foraminifer *Globorotalia pseudomenardii* indicating the middle and upper Palaeocene.

Furthermore, Matsumoto (1970) stated that “the above-mentioned N4 is the Danian and ammonoids were mixed from N3 by slumping, if so, the Cretaceous / Tertiary boundary will be drawn between N3 and N4 and as another possibility, the relatively upper part of N4 is distributed in the coast of Ochiishi where the planktonic foraminifera were collected, the lower part of N4 originally is the uppermost Maastrichtian in age and the upper is the Danian in age, and an existence of horizon in which both mixed by the slumping will be conceived. In such a case, the boundary will be somewhere in N4. This remains to be proved in the future.”

Kiminami (1978) made a stratigraphic division of the Nemuro Group fundamentally based on lithostratigraphy, reexamined a correlation by key-beds of the acidic tuff of the uppermost Monshizu Formation and dolerite-sheet and tuff of the Hamanaka Formation, divided it into 8 formations, i.e. Nokka-
mappu, Otamura, Monshizu, Oborogawa, Hamanaka, Akkeshi, Tokotan and Kiritappu Formations and correlated as shown on the table 1.

Moreover, he stated that "a contradiction between the former stratigraphy and the observed fossils in the N4 age indicated by Matsumoto has resulted from an imperfection of establishment of stratigraphy and correlation through the whole district, and presumed that the Maastrichtian/Danian boundary will be drawn nearly in the middle part of the Akkeshi Formation. Each sandstone of the lower, middle, and upper Akkeshi Formation is different in petrographic characters and it is hard to accept that sedimentary materials have been brought secondarily from the lower horizons by the slumping.

The research of foraminiferal fossils of the Nemuro Group was made first by Yoshida (1957), and Asano (1960) found the Tertiary planktonic foraminifer Globigerina (Globorotalia pseudomenardii ) from the Choboshi Formation in the coast of Choboshi in Nemuro City. Yoshida and Kiminami (1980) surveyed preponderantly the Nemuro Group in the Ochiishi area and obtained the following results: 1) Pachydiscus (Neodesmoceras) cf. gracilis Matsumoto occurs from the upper Akkeshi Formation, 2) Angaudryceras occurs nearby in the lowest of the Tokotan Formation, 3) Subbotina triculinoides (Plummer) occurs from the upper half part of the lower Tokotan Formation, 4) Okada found a number of nannofossils being equivalent to the Cruciplancolithus tenui Zone (early Danian, 63.5-64.0 Ma) from almost the same horizon as the type Danian planktonic foraminifera occurred, 5) Foraminiferal fossils of the Yururi Formation are closely similar to those of the Kiritappu Formation, and the Cretaceous/Tertiary boundary in this area must be placed somewhere in the lower member of the Tokotan Formation. Besides, they reported Palaeocene foraminiferal fossils which are not well in preservation, from the sandy shale of the middle Akkeshi Formation in the eastern coast of Akkeshi Bay. Yoshida (1981) stated on characteristics of foraminiferal fossils of the Nemuro Group along the coast of Ochiishi Bay: 1) Akkeshi Formation yields a too small kind and number of foraminifera which are only benthonic and species almost common to those of the upper formation, excepting only an individual of Rzehakina epigonalata . In the uppermost horizon Pachydiscus (Neodesmoceras) cf. gracilis Matsumoto and Inoceramus sp. were discovered, 2) Tokotan Formation yields many foraminiferal fossils: the planktonic foraminifera Subbotina triloculinoides indicates the middle to late Danian and S. pseudobulloides occurs in the Danian, and also coccolith fossils indicating the upper part of the lower Danian were found, whereas ammonoids and shark teeth indeterminable genera and species were found from the upper half part of the lower Tokotan
Formation, 3) no foraminifer was found in the Ochiishi Formation, 4) Yururi Formation yields only benthonic foraminifera. Furthermore, he concluded that 26 species of the foraminiferal fossils of the Tokotan Formation are common to those of the Kiritappu Formation, and consequently the Akkeshi Formation corresponds to the uppermost Cretaceous and the Tokotan Formation is the Palaeocene in age.

Okada et al. (1987) examined minutely the nannofossils of the Nemuro Group and concluded as follows: The Nokkamappu Formation can be assigned to the middle and upper Campanian Zones CC19 to CC22b of the nannofloras. The upper part of the Akkeshi Formation, the Tokotan Formation, and the Kiritappu Formation respectively yield the late early and late Danian nannofloras (Zones CP2 and CP3). The Shiomi Formation yielding a middle Palaeocene nannoflora unconformably overlies the Senposhi Formation belonging to the uppermost Maastrichtian Zone CC26 of the nannoflora. The Cretaceous/Tertiary boundary was lost by the unconformity in the western area, whereas it should be placed within the lower or middle member of the Akkeshi Formation in eastern area.

Only one study on palynology of the Nemuro Group was made first by Okazaki (1966) with the list of palynomorphs of the Nemuro Group and a photo-plate in the "Geology of Kushiro". Pollen grains and spores were derived from the Otamura, Senposhi, Shiomi, and Chippomanai Formations and showed by families and genera. *Aquilapollenites* was found in three formations excepting the Chippomanai Formation. Recently, Saito et al. (1986) examined a continuous stratigraphic section spanning the Cretaceous/Tertiary boundary, based on planktonic foraminiferal analyses and concurrently observed palynomorphs from this section. At this time, they recognized three distinct palynomorph assemblages in this section: 1) fern-angiosperm-rich floras of the latest Cretaceous interval, 2) impoverished palynomorph assemblages, dominated by fern spores, in the boundary claystone, and 3) pine-dominated gymnosperm pollen in the earliest Tertiary interval. Referring to *Aquilapollenites*, *Aquilapollenites* pollen group continues to the Palaeocene and is not age-diagnostic in Asia.

Lately, Krassilov et al. (1988) reported and described the Cretaceous-Palaeogene plant fossils, wood fossils, pollen grains, spores, and foraminiferal fossils of the Kuril Islands. In the paper, 19 spores, 10 gymnospermous pollen, and 34 angiospermous pollen were described and many of them are closely similar to those of the Nemuro Group.
Materials and treatment

All the samples were collected mainly in the Akkeshi and Tokotan Formations, and partially in the Hamanaka and Oborogawa Formations. Localities and numbers of the collected samples are referred on the map inserted in every district.

(A) District around Akkeshi Bay.

1) Coast from Tokotan to Horomanbetsu in Akkeshi town.
TOK—01: black shale (△)* (lower Tokotan Formation)
TOK—02: black shale (×) * with many calcareous nodules (middle Tokotan Formation)

* (×): Sample undiscoverable palynomorph.
(△): Sample of which no slide was made, although some palynomorphs were discovered.
TOK-03: dark gray shale (×) with many calcareous nodules (middle Tokotan Formation)
TOK-04: black shale (△) (upper Tokotan Formation)
TOK-05: dark gray shale (△) (middle Kiritappu Formation?)

2) Western coast of Akkeshi Bay (Tomata–Okimanbetsu).
AKK-01: dark gray shale (×) (Oborogawa Formation-Hamanaka Formation), cliff along old road in south of school
AKK-02: somewhat greenish dark gray shale (×) (Oborogawa Formation-Hamanaka Formation), cliff along old road in south of school

![Map of Tomata and Okimanbetsu in the western coast of Akkeshi Bay.](image)

Fig. 3. Localities and numbers of the samples collected between Tomata and Okimanbetsu in the western coast of Akkeshi Bay.

AKK-03: hard dark gray shale (△) (Oborogawa Formashon-Hamanaka Formation), cliff along old road in south of school
AKK-04: hard somewhat greenish shale (△) (Oborogawa Formation-Hamanaka Formation), cliff along old road in south of school
AKK-05: dark gray shale (○)* (lower Akkeshi Formation), Okimanbetsu

3) Senposhi.
AKK-06: dark gray shale (×) (Senposhi mudstone Formation, Kawai, 1956)
AKK-07: black shale (○) (Senposhi mudstone Formation, Kawai, 1956), west of Senposhi harbor

*(○): Sample of which slides were made.
Fig. 4. Localities and numbers of the samples collected near Senposhi in the western coast of Akkeshi Bay.

Fig. 5. Locality and numbers of the samples collected in Urayakotan of Hamanaka town.

4) Eastern coast of Akkeshi Bay (Chikushigoi—Ariake-machi).
AKK-08: black muddy fine sandstone (×) (upper Akkeshi Formation), bluff in the southeast of Chikushigoi
AKK-09: black shale (○) (middle Akkeshi Formation), Chikushigoi
AKK-10: black sandy mudstone (○) (middle Akkeshi Formation), Chikushigoi
AKK-11: black shale (○) (middle Akkeshi Formation), cliff along dump yard of snow in the east of Ariake-machi
AKK-12: black shale (○) (middle Akkeshi Formation), cliff along dump yard of snow in the east of Ariake-machi

(B) Urayakotan in Hamanaka town.
URA-01: ocherous shale (weathered?) (×) (Oborogawa Formation), bluff in the south 225 m of Urayakotan
URA-02: yellowish gray shale (weathered?) (×) (Oborogawa Formation), bluff in the south 225 m of Urayakotan

(C) District around Ochiishi Bay in Nemuro city.
1) Southern bluff along Ochiishi harbor.
OCH-01: dark gray shale (△) (lower Tokotan Formation)
OCH-02: dark gray shale (○) (lower Tokotan Formation)
OCH-03: somewhat greenish muddy fine sandstone including carbonized plant fragments (○) (middle Tokotan Formation)
OCH-04: hard dark gray shale (○) (upper Tokotan Formation)
OCH-05: hard dark gray shale (○) (upper Tokotan Formation)

Fig. 6. Localities and numbers of the samples collected around Ochiishi Bay.

2) Western bluff of Ochiishi harbor.
OCH-06: dark gray shale (○) (upper Akkeshi Formation), slumping structure
OCH-07: ocherous shale (weathered?) (△) (upper Akkeshi Formation)
OCH-08: black shale (○) (upper Akkeshi Formation)
OCH-09: dark shale (○) (upper Akkeshi Formation)

3) Northern bluff of Ochiishi Bay (under Ochiishi loran station).
OCH-10: hard dark gray shale (○) (upper Tokotan Formation)
OCH-11: black mudstone (△) (upper Tokotan Formation)
OCH-12: muddy fine sandstone including plant fragments (×) (middle Tokotan Formation)
OCH-13: hard dark gray shale including molluscan fossils (○) (middle Toko-
OCH-14: dark gray shale (△) (lower Tokotan Formation)

Southern coast of Choboshi in Nemuro city.
CHO-01: hard black shale (○) (lower Akkeshi Formation), quarry in the east of Choboshi lake
CHO-02: dark gray tuffaceous mudstone (△) (lower Akkeshi Formation), quarry in the east of Choboshi lake
CHO-03: hard black shale (△) (lower Akkeshi Formation), quarry in the east of Choboshi lake

Fig. 7. Localities and numbers of the samples collected in the southern coast of Choboshi in Nemuro city.

CHO-04: hard black shale (△) (lower Akkeshi Formation)
CHO-05: hard black shale (△) (lower Akkeshi Formation)
CHO-06: dark gray shale (×) (lower Akkeshi Formation)
CHO-07: hard dark gray shale (×) (lower Akkeshi Formation)
CHO-08: black shale (×) (lower Akkeshi Formation)
CHO-09: hard black shale (×) (lower Akkeshi Formation)
CHO-10: dark gray shale (△) (lower Akkeshi Formation)
CHO-11: hard black shale (△) (lower Akkeshi Formation)
CHO-12: hard dark gray shale (△) (lower Akkeshi Formation)
CHO-13: dark gray shale (×) (lower Akkeshi Formation)
CHO-14: black shale (△) (lower Akkeshi Formation)
CHO-15: black shale (△) (lower Akkeshi Formation)

Sixteen samples with a circle mark among the above-mentioned samples are useful. The author has found 1369 palynomorphs from these samples and examined 121 spores, 55 gymnospermous pollen, and 135 angiospermous pollen, excepting phytomicroplankton.

The samples crushed in a iron mortar were macerated by the following procedure.
1) macerated by mixed solution of conc. HCl (2) and conc. HNO₃ (1).
2) washed with distilled water.
3) macerated by HF to remove mineral matters.
4) washed with distilled water.
5) dehydrated with alcohol.
6) residues without stain were mounted in glycerine jelly on the slides.

The Apophot microscope with Apo and Plan objectives was used to examine and identify several strewn palynomorphs on the slides. Many spores and pollen grains keep sufficiently their morphological characters and identification for genera and species was made almost without hindrance, although they are not well in preservation. Among them some old recycled ones are found.

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

**Palynomorphs of the Nemuro Group**

A) Spores:

a) Trilete spores:

(1) *Baculatisporites comaumensis* (Cookson) Potonié (pl. 7, fig. 7; pl. 8, figs. 1–3)

(2) *Baculatisporites cf. dubius* Burger n. comb. (pl. 6, figs. 10a–b)

(3) *Baculatisporites wellmanii* Conper n. comb. (pl. 6, figs. 18, 19; pl. 7, figs. 1–6; pl. 29, fig. 14)

(4) *Baculatisporites* sp. (pl. 8, figs. 7, 8)

(5) *Baculatisporites* sp. (pl. 1, figs. 1a–b)

(6) *Biretisporites cf. incrassatus* Takahashi & Shimono (pl. 5, fig. 3; pl. 10, fig. 11; pl. 20, fig. 5)
(7) ? *Biretisporites minus* Takahashi (pl. 5, fig. 5)
(8) *Biretisporites potoniaei* Delcourt & Sprumont (pl. 13, fig. 11)
(9) *Biretisporites triangulatus* n. sp. (pl. 5, figs. 7, 9–11; pl. 6, figs. 5–6)
(10) *Biretisporites yoshimotoi* n. sp. (pl. 6, figs. 1–4)
(11) *Biretisporites* sp. a (pl. 5, fig. 2)
(12) *Biretisporites* sp. b (pl. 5, fig. 4)
(13) *Biretisporites* sp. c (pl. 5, fig. 8)
(14) *Biretisporites* sp. d (pl. 29, fig. 10)
(15) *Camarozonosporites* (*Camarozonosporites*) *semilevis* Krutzsch (pl. 8, figs. 12a–b)
(16) *Camarozonosporites* (*Hamulatisporis*) *hamulatis* Krutzsch (pl. 8, figs. 11a–b)
(17) *Camarozonosporites* (*Hamulatisporis*) *insignis* Norris (pl. 8, fig. 10)
(18) *Cardioangulina cardioliformis* Maljavkina (pl. 1, figs. 2a–b)
(19) *Cibotiidites* cf. *zonatus* Ross (pl. 12, figs. 1a–b)
(20) *Cicatricosisporites* cf. *hallei* Delcourt & Sprumont (pl. 9, figs. 1a–b)
(21) *Cicatricosisporites* *minor* (Bolkhovitina) Takahashi (pl. 9, figs. 5, 6)
(22) *Cicatricosisporites* *minutaestriatus* Bolkhovitina n. comb. (pl. 9, figs. 8a–b)
(23) *Cicatricosisporites* sp. a (pl. 9, fig. 4)
(24) *Cicatricosisporites* sp. b (pl. 9, fig. 7a–b)
(25) *Cicatricosisporites* cf. *levispeciosus* Pflug (pl. 5, fig. 16)
(26) *Concavissimisporites* cf. *variwerrucatus* (Couper) Brenner (pl. 11, fig. 11)
(27) *Converrucosisporites* *triquetrus* (Ibrahim) Potonié & Kremp (pl. 13, fig. 9)
(28) *Corrugatisporites* *solidus* (Potonié) Thomson & Pflug (pl. 13, figs. 10 a–c; pl. 14, figs. 6a–c)
(29) *Cyathidites* *minor* Couper (pl. 1, figs. 3a–b; pl. 2, fig. 7)
(30) *Deltoidospora* *cascadensis* Miner (pl. 2, figs. 4–6; pl. 29, figs. 7)
(31) *Deltoidospora* *diaphana* Wilson & Webster (pl. 2, figs. 1–3; pl. 3, fig. 13 (cf.); pl. 4, figs. 10a–b)
(32) *Deltoidospora* *microlepioides* (Krutzsch) Wang (pl. 1, figs. 4, 5; pl. 2, figs. 8, 9, 12–15; pl. 19, fig. 13)
(33) *Deltoidospora* *seidewitzensis* (Krutzsch) Hu (pl. 2, figs. 10, 11a–b; pl. 3, figs. 8, 9)
(34) ? *Deltoidospora* sp. (pl. 2, fig. 16)
(35) *Divisisperites* sp. (pl. 3, fig. 7; pl. 8, fig. 5; pl. 20, fig. 3)
(36) *Duplosporis* sp. (pl. 29, fig. 13a–b)
(37) ? *Foveolatisporites* sp. (pl. 5, fig. 14)
(38) *Foveotriletes scrobiculatus* (Ross ex Weyland & Krieger) Potonié (pl. 6, figs. 7a–b)
(39) *Gleicheniidites marginatus* Takahashi (pl. 3, fig. 2)
(40) *Gleicheniidites senonicus* Ross (pl. 3, figs. 1; pl. 5, figs. 12a–b)
(41) *Granulatisporites* sp. (pl. 8, figs. 9a–b)
(42) *Ischyosporites cf. crateris* Balme (pl. 12, figs. 2a–b)
(43) *Leiotriletes maxoides* Krutzsch *minoris* Krutzsch (pl. 3, figs. 6a–b; pl. 4, fig. 2)
(44) *Leiotriletes wolffi* Krutzsch *brevis* Krutzsch (pl. 2, figs. 17a–b)
(45) *Leiotriletes wolffi* Krutzsch (pl. 3, figs. 10–12; pl. 4, fig. 8)
(46) *Monoleiotriletes gracilis* Krutzsch (pl. 2, figs. 18, 19; pl. 3, figs. 3–5; pl. 16, figs. 15a–b (cf.); pl. 29, fig. 8)
(47) *Monoleiotriletes minimus* Krutzsch (pl. 3, fig. 14; pl. 18, fig. 27)
(48) *Monoleiotriletes* sp. (pl. 29, fig. 9)
(49) *Multinodisporites taihouensis* Liu (pl. 14, figs. 8a–b)
(50) *Murospora circulata* Weyland & Krieger n. comb. (pl. 5, fig. 15)
(51) *Pterisisporites cf. bellus* Song, Li & Zhong (pl. 13, figs. 1a–b; pl. 14, figs. 2a–b)
(52) *Pterisisporites hokkaidoensis* n. sp. (pl. 13, figs. 2a–b, 4, 6a–b; pl. 19, fig. 14)
(53) *Pterisisporites ochiishiensis* n. sp. (pl. 14, figs. 3–4)
(54) *Pterisisporites rotundus* n. sp. (pl. 13, figs. 5, 7a–b, 8a–b; pl. 14, figs. 1a–b, 5a–b)
(55) *Pterisisporites trizonatus* Song, Li & Zhong (pl. 13, fig. 3)
(56) *Pterisisporites verrucatus* n. sp. (pl. 12, figs. 6a–c, 7)
(57) *Pterisisporites* sp. (pl. 12, fig. 5; pl. 14, fig. 7)
(58) *Punctatisporites minor* n. sp. (pl. 20, figs. 4–6)
(59) *Punctatisporites punctus* Pflug (pl. 8, fig. 13; pl. 20, fig. 2)
(60) *Radialisporis radiatus* (Krutzh) Krutzsch (pl. 9, figs. 2, 3)
(61) *Retitriletes borealis* n. sp. (pl. 11, figs. 4–9)
(62) *Retitriletes nemuroensis* n. sp. (pl. 10, figs. 2–5)
(63) *Retitriletes triangulatus* n. sp. (pl. 10, figs. 6–9; pl. 11, figs. 1–3)
(64) *Retitriletes* sp. (pl. 15, fig. 1)
(65) ? *Retitriletes* sp. (pl. 10, fig. 10)
(66) *Saxosporis gracilis* Krutzsch & Pacltova (pl. 7, figs. 8a–b)
(67) *Saxosporis minor* n. sp. (pl. 8, figs. 4, 6a–b)
(68) ? *Stenozonotriletes* sp. (pl. 6, fig. 8)
(69) *Stereisporites antiquaspores* (Wilson & Webster) Dettmann (pl. 6, figs. 14–16)
(70) *Stereisporites* cf. *limbus* Takahashi (pl. 6, fig. 12)
(71) *Stereisporites minor* (Raatz) Krutzsch (pl. 6, fig. 13 (?); pl. 29, fig. 12)
(72) *Stereisporites* sp. a (pl. 6, fig. 17)
(73) *Stereisporites* sp. b (pl. 20, figs. 7, 8)
(74) *Toroisporis* (*Duplotoroisporis*) *triangulus* Takahashi & Sugiyama (pl. 5, figs. 13a–b)
(75) *Triletes* sp. (megaspore?) (pl. 20, figs. 1a–c)
(76) *Trilites pustulosus* Takahashi & Sugiyama (pl. 12, figs. 3a–b)
(77) *Trilites* sp. (pl. 11, figs. 10a–c)
(78) ? *Trilites* sp. (pl. 14, fig. 11)
(79) *Triplanosporites inornatus* Takahashi (pl. 4, figs. 6, 7)
(80) *Triplanosporites quadrangulatus* n. sp. (pl. 4, fig. 3)
(81) *Triplanosporites* cf. *sinomaxoides* Krutzsch (pl. 4, figs. 1a–b)
(82) *Triplanosporites sinuosus* Pflug (pl. 4, figs. 4, 5, 9)
(83) *Triplanosporites* sp. a (pl. 3, fig. 15)
(84) *Triplanosporites* sp. b (pl. 5, fig. 6)
(85) ? *Triplanosporites* sp. (pl. 5, fig. 1)
(86) *Undulatisporis* cf. *rotundus* Takahashi (pl. 6, fig. 10; pl. 29, fig. 11)
(87) *Undulatisporis subtriangulatus* n. sp. (pl. 14, figs. 9, 10a–b)
(88) *Undulatisporis* sp. (pl. 6, figs. 9, 11)
(89) *Varirugosisporites* sp. (pl. 12, figs. 4a–c)
(90) *Verrucosisporites* sp. (pl. 7, fig. 9)
(91) *Zlivisporis* sp. (pl. 10, fig. 1)
(92) ? *Zlivisporis* sp. (pl. 20, fig. 10)

b) Monolete spores:
(93) *Echinosporis* sp. (pl. 18, fig. 26)
(94) *Extrapunctatosporis* cf. *alveolatus* (Couper) Krutzsch (pl. 19, fig. 3; pl. 30, fig. 1)
(95) *Extrapunctatosporis microsporocyst* n. sp. (pl. 18, figs. 24, 25)
(96) *Extrapunctatosporis* sp. (pl. 19, fig. 4)
(97) *Gemmatosporis* sp. a (pl. 19, figs. 5a–b)
(98) *Gemmatosporis* sp. b (pl. 19, fig. 6)
(99) *Gemmatosporis* sp. c (pl. 19, figs. 7a–b)
(100) *Laevigatosporites bellulus* n. sp. (pl. 17, figs. 18, 22a–b; pl. 18, figs.
2–5, 9, 11)

(101) *Laevigatosporites* cf. *bisulcatoides* Krutzsch (pl. 17, fig. 1)
(102) *Laevigatosporites convexus* n. sp. (pl. 15, figs. 2–4, 7, 8a–b, 11, 12)
(103) *Laevigatosporites dehiscens* Takahashi (pl. 15, figs. 9, 10, 13; pl. 16, figs. 1–6, 9–14; pl. 17, figs. 3, 4, 6–8)
(104) *Laevigatosporites gracilis* Wilson & Webster (pl. 17, figs. 2, 20, 21)
(105) *Laevigatosporites haardti* (Potoniè & Venitz) Thomson & Pflug *haardtioides* Krutzsch (pl. 16, fig. 8)
(106) *Laevigatosporites ovoideus* Takahashi (pl. 17, fig. 9)
(107) *Laevigatosporites probatus* Takahashi (pl. 19, figs. 1, 2)
(108) *Laevigatosporites prominens* Takahashi (pl. 15, figs. 5, 6)
(109) *Laevigatosporites senonicus* Takahashi (pl. 16, fig. 7; pl. 17, figs. 5, 10–16; pl. 18, figs. 7, 8, 10, 12–16; pl. 20, fig. 11)
(110) *Laevigatosporites tenuis* n. sp. (pl. 15, figs. 14, 15; pl. 18, figs. 1, 6)
(111) *Laevigatosporites uedae* n. sp. (pl. 18, figs. 18–23)
(112) *Laevigatosporites* sp. (pl. 17, figs. 17a–b)
(113) ? *Laevigatosporites* sp. (pl. 17, fig. 19)
(114) *Latosporites subrotundus* n. sp. (pl. 20, figs. 12, 13)
(115) ? *Perinomonoletes* sp. (pl. 24, figs. 3a–b)
(116) *Polypodiidites repandus* (Takahashi) Krutzsch (pl. 19, figs. 9a–b)
(117) *Punctatosporis* sp. (pl. 18, fig. 17)
(118) *Verrucatosporites* cf. *favus* (Potoniè) Thomson & Pflug *gracilis* Krutzsch (pl. 19, fig. 12)
(119) *Verrucatosporites* cf. *tenellis* (Krutzsch) Krutzsch (pl. 19, figs. 10, 11)
(120) *Verrucatosporites* sp. (pl. 19, fig. 8)

c) Alete spore:
(121) *Corrusporis globoverrucatus* Krutzsch (pl. 20, figs. 14a–b)

B) Gymnospermous pollen grains:
(122) *Alisporites hokkaidoensis* n. sp. (pl. 25, figs. 3–6)
(123) *Araucariacites australis* Cookson ex Couper (pl. 21, fig. 26)
(124) ? *Classopollis* sp. (pl. 21, fig. 23)
(125) *Cupressacites cuspidataeformis* (Zaklinshaja) Krutzsch (pl. 20, figs. 15–17)
(126) *Cupressacites ochiiishiwanensis* n. sp. (pl. 21, figs. 1–8)
(127) *Cycadopites* cf. *follicularis* Wilson & Webster (pl. 23, fig. 1)
(128) *Cycadopites laevis* n. sp. (pl. 23, figs. 7–10; pl. 30, fig. 2)
(129) *Cycadopites microfollicularis* Krutzsch (pl. 23, figs. 4, 5, 12, 13)
(130) *Cycadopites cf. minimus* (Cookson) Krutzsch (pl. 23, fig. 14)
(131) *?Cycadopites minutus* Krutzsch (pl. 23, fig. 6)
(132) *Cycadopites cf. sculptigracilis* Krutzsch (pl. 23, fig. 3)
(133) *Ephedripites* (*Distachyapites*) *cf. fusiformis* (Shakmundes) Krutzsch (pl. 23, fig. 2)
(134) *Ephedripites* (*Ephedripites*) *angustus* n. sp. (pl. 23, figs. 20–24)
(135) *Ephedripites* (*Ephedripites*) *cf. dafengshanensis* Zhu & Wu (pl. 23, figs. 18, 19)
(136) *Ephedripites* (*Ephedripites*) *robustus* n. sp. (pl. 23, figs. 15, 16)
(137) *Ephedripites* (*Ephedripites*) *viesenensis* Krutzsch (pl. 23, fig. 17)
(138) *Ephedripites* (*Ephedripites*) sp. (pl. 30, fig. 3)
(139) *Ephedripites* (*Spiralipites*) *ellipsoideus* (Takahashi) Takahashi (pl. 23, figs. 25–29; pl. 24, fig. 1)
(140) *Ephedripites* (*Spiralipites*) *kulandyensis* Bolkhovitina n. comb. (pl. 24, fig. 2)
(141) *Ephedripites* (*Spiralipites*) sp. (pl. 23, fig. 30)
(142) *Inaperturopollenites dubius* (Potonié & Venitz) Thomson & Pflug (pl. 21, figs. 14–16, 22)
(143) *Inaperturopollenites laevigatus* Takahashi (pl. 21, figs. 9–13; pl. 30, fig. 5)
(144) *Inaperturopollenites parviundulatus* Takahashi (pl. 30, fig. 4)
(145) *Inaperturopollenites parvus* Takahashi (pl. 21, figs. 18–21; pl. 30, fig. 6)
(146) *Monosulcites* sp. (pl. 23, fig. 11)
(147) *Phyllocladidites mawsonii* Cookson (pl. 29, figs. 1, 2)
(148) *Phyllocladidites ovatus* Takahashi (pl. 28, fig. 6 (cf.), 10a–b (cf.); pl. 29, figs. 3, 4)
(149) *Phyllocladidites* sp. (pl. 28, figs. 9a–b)
(150) *? Phyllocladidites* sp. (pl. 29, figs. 6a–b)
(151) *Piceapollis minutus* n. sp. (pl. 27, figs. 2–5; pl. 28, figs. 3a–b)
(152) *Piceapollis cf. sacculiferoides* Krutzsch (pl. 27, fig. 8; pl. 28, fig. 2)
(153) *Piceapollis* sp. (pl. 27, figs. 6, 7)
(154) *Pityosporites alatipollenites* (Rouse) Takahashi & Sugiyama (pl. 24, figs. 6–10)
(155) *Pityosporites aliformis* Takahashi (pl. 25, figs. 1, 2)
(156) *Pityosporites cretaceus* Takahashi & Sugiyama (pl. 25, fig. 7)
(157) *Pityosporites cf. insignis* (Naumova ex Bolkhovitina) Krutzsch (pl. 28, fig. 5)
(158) *Pityosporites* cf. *labdacus* (Potonie) Thomson & Pflug (pl. 27, fig. 1)
(159) *Pityosporites minutus* (Zaklinskaja) Krutzsch (pl. 25, figs. 8, 9)
(160) *Pityosporites pristinipolliniius* (Traverse) Krutzsch (pl. 24, fig. 11)
(161) *Pityosporites scopulipites* (Wodehouse) Krutzsch (pl. 26, figs. 3, 12)
(162) *Pityosporites siegburgensis* Takahashi & Jux (pl. 26, figs. 1 (cf.), 5–9; pl. 28, fig. 4)
(163) *Pityosporites* sp. a (pl. 26, fig. 2)
(164) *Pityosporites* sp. b (pl. 26, fig. 11)
(165) *Pityosporites* sp. c (pl. 26, figs. 4, 10, 13)
(166) *Pristinuspollenites microsaccus* (Couper) B. D. Tschudy (pl. 28, figs. 7 a–b; pl. 29, figs. 5a–b)
(167) *Psophosphaera aggereloides* (Maljavkina) Chlonova (pl. 21, figs. 24, 25; pl. 22, figs. 2, 3, 5–7)
(168) *Psophosphaera pseudotsugoides* Krutzsch (pl. 22, figs. 1a–b, 4, 9)
(169) *Psophosphaera* sp. (pl. 22, fig. 8)
(170) *Rossipollis minor* n. sp. (pl. 25, figs. 10, 11)
(171) *Rossipollis* sp. (pl. 25, figs. 12a–b)
(172) *Sciadopityspollenites* sp. (pl. 21, fig. 17)
(173) *Vitreisporites pallidus* (Reissinger) Nilsson (pl. 24, fig. 4)
(174) Bisaccate pollen (? *Phyllocladidites*) (pl. 28, fig. 8)
(175) Indeterminable bisaccate pollen (pl. 28, fig. 1)
(176) Indeterminable coniferous pollen? (pl. 24, figs. 5a–b)

C) Angiospermous pollen grains:
(177) *Aquilapollenites latialatus* Takahashi (pl. 34, figs. 1a–b)
(178) *Aquilapollenites melior* Takahashi & Shimono (pl. 31, figs. 2a–b; pl. 35, figs. 3a–c)
(179) *Aquilapollenites melioratus* Takahasshi (pl. 32, figs. 1a–c)
(180) *Aquilapollenites nemuroensis* n. sp. (pl. 31, figs. 4, 5)
(181) *Aquilapollenites parvus* Takahashi (pl. 30, figs. 18a–b (cf.); pl. 32, figs. 5, 7; pl. 35, figs. 8a–c)
(182) *Aquilapollenites pseudoaucellatus* Takahashi & Shimono (pl. 30, figs. 19a–c (cf.); pl. 31, figs. 1a–b)
(183) *Aquilapollenites quadrinus* Takahashi (pl. 33, figs. 1, 2)
(184) *Aquilapollenites* sp. (pl. 32, fig. 2)
(185) ? *Aquilapollenites* sp. a (pl. 31, figs. 3a–b)
(186) ? *Aquilapollenites* sp. b (pl. 31, figs. 2a–b)
(187) *Arecipites monosulcoides* Krutzsch (pl. 30, figs. 13, 15 (cf.))
(188) *Arecipites pflugii* (Takahashi) Krutzsch (pl. 30, figs. 14a–b)
(189) *Betulaepollenites minutulus* Takahashi (pl. 45, figs. 10, 25–27)
(190) *Betulaepollenites normalis* Takahashi (pl. 45, figs. 21–24, 28a–b)
(191) *Callistopollenites comis* Srivastava (pl. 38, figs. 2, 9, 10)
(192) *Callistopollenites radiatostriatus* (Mtchedlishvili) Srivastava (pl. 38, figs. 3–8, 11, 12)
(193) *Cranwellia striata* (Couper) Srivastava (pl. 37, figs. 8, 9)
(194) *Cranwellia* sp. (pl. 36, fig. 12)
(195) *Cupuliferoidaepollenites* cf. *ditis* (Takahashi) Takahashi (pl. 39, figs. 6, 7)
(196) *Cupuliferoidaepollenites facetus* (Takahashi) Takahashi (pl. 39, figs. 11, 12, 15 (cf.), 16; pl. 40, figs. 10, 11)
(197) *Cupuliferoidaepollenites fallax* (Potonié) Potonié (pl. 39, figs. 13, 14)
(198) *Cupuliferoidaepollenites weylandii* (Takahashi) Takahashi (pl. 39, figs. 8–10)
(199) *Cupuliferoidapollenites* cf. *fusus* (Potonié) Takahashi & Jux (pl. 42, figs. 16, 18a–b)
(200) *Cupuliferoidapollenites pusillus* (Potonié) Potonié (pl. 42, sigs. 21, 29)
(201) *Cupuliferoidapollenites* sp. (pl. 42, fig. 20)
(202) *Cyrillaceaepollenites exactus* (Potonié) Potonié (pl. 42, figs. 24–27)
(203) *? Cyrillaceaepollenites megaexactus* (Potonié) Potonié (pl. 42, figs. 22 a–b)
(204) *Echitricolpites* sp. a (pl. 39, fig. 20)
(205) *Echitricolpites* sp. b (pl. 39, fig. 21)
(206) *Engelhardtioioides microcoryphaeus* (Potonié) Potonié, Thomson & Thiergart ex Potonié (pl. 45, figs. 6–9 (cf.))
(207) *Erdtmanipollis procumbentiformis* (Samoilovitch) Krutzsch (pl. 39, figs. 2a–c)
(208) *Fibulapollis pusillus* Takahashi (pl. 35, figs. 13a–b; pl. 36, fig. 9)
(209) *Fibulapollis* sp. a (pl. 35, figs. 7a–b)
(210) *Fibulapollis* sp. b (pl. 36, figs. 6a–b)
(211) *Fibulapollis* sp. c (pl. 36, fig. 11)
(212) *? Fibulapollis* sp. (pl. 35, fig. 2)
(213) *Graminidites* sp. a (pl. 46, figs. 7a–b)
(214) *Graminidites* sp. b (pl. 46, figs. 8, 9)
(215) *? Graminidites* sp. (pl. 46, fig. 10)
(216) *Hemicorpus trapeziforme* (Mtchedlishvili) Krutzsch (pl. 32, figs. 3a–c; pl. 33, figs. 4a–b)
(217) ? *Hemicorpus* sp. (pl. 33, figs. 5a–b)
(218) *Integricorpus* cf. *bertillonites* (Funkhouser) Stanley (pl. 33, figs. 6a–b; pl. 34, figs. 6a–b)
(219) *Integricorpus machedlishvili* (Srivastava) Takahashi (pl. 32, figs. 8a–c; pl. 35, figs. 1a–b (cf.))
(220) *Integricorpus* cf. *striatum* (Mtechedlishvili) Stanley (pl. 34, figs. 3a–b)
(221) *Integricorpus* sp. a (pl. 34, figs. 5a–c)
(222) *Integricorpus* sp. b (pl. 35, fig. 5)
(223) *Intrabaculitricolporites* cf. *consularis* (Takahashi) Takahashi & Jux consularis (pl. 42, fig. 19)
(224) *Kurtzipites* cf. *mirificus* (Chlonova) Srivastava (pl. 36, figs. 7a–c, 10)
(225) ? *Kurtzipites* sp. a (pl. 39, figs. 3a–b)
(226) ? *Kurtzipites* sp. b (pl. 39, figs. 19a–b)
(227) *Liliacidites* cf. *variegatus* Couper (pl. 30, fig. 12)
(228) *Momipites* constatus (Takahashi) Takahashi (pl. 44, fig. 1; pl. 45, fig. 1 (?))
(229) *Monocolpopollenites intrabaculatus* Takahashi (pl. 30, fig. 7)
(230) *Monocolpopollenites kyushuensis* Takahashi (pl. 30, figs. 8–11)
(231) *Orbiculapollis globosus* (Chlonova) Chlonova (pl. 37, figs. 1, 2)
(232) *Orbiculapollis minutus* (Mtechedlishvili) Krutzsch (pl. 36, figs. 14a–b; pl. 37, fig. 3)
(233) *Paraalnipollenites confusus* (Zaklinskaja) Hills & Wallace (pl. 45, figs. 14a–b; pl. 46, figs. 2 (cf.)–5)
(234) *Pentapollenites manifestus* Takahashi & Shimono (pl. 35, fig. 6)
(235) *Pentapollenites minus* n. sp. (pl. 34, fig. 7 (cf.); pl. 36, figs. 4, 5)
(236) *Pentapollenites miser* Takahashi (pl. 36, figs. 3a–b)
(237) *Pentapollenites normalis* Takahashi & Shimono (pl. 32, figs. 4a–b, 6; pl. 33, figs. 3a–c; pl. 35, figs. 8a–b; pl. 36, figs. 1, 2)
(238) *Pentapollenites* sp. (pl. 30, figs. 17a–b)
(239) ? *Pentapollenites* sp. a (pl. 35, figs. 11a–b)
(240) ? *Pentapollenites* sp. b (pl. 35, figs. 12a–c)
(241) ? *Pentapollenites* sp. c (pl. 35, fig. 4)
(242) ? *Pentapollenites* sp. d (pl. 36, figs. 8a–b)
(243) *Periscarioipollis rarus* n. sp. (pl. 38, figs. 13a–b; pl. 39, figs. 1a–b)
(244) *Polyatriopollenites polyceras* (Takahashi) Takahashi (pl. 43, fig. 10)
(245) *Polyvestibulopollenites eminus* Takahashi (pl. 43, figs. 11–15)
(246) *Potamogetonacidites difficilis* Takahashi (pl. 30, fig. 16)
(247) *Proteacidites tumidiporus* Samoilovitch var. *ecollariatus* Samoilovitch
(pl. 46, figs. 6a–b)

(248) ? *Pseudointegricorpus* sp. (pl. 34, figs. 4a–b)

(249) *Quercoidites umiensis* (Takahashi) Takahashi (pl. 39, figs. 4, 5)

(250) *Retitrescolpites* sp. (pl. 41, figs. 2a–b)

(251) *Rhoipites* cf. *minus* Takahashi & Jux (pl. 43, fig. 3)

(252) *Rhoipites* sp. a (pl. 42, fig. 23)

(253) *Rhoipites* sp. b (pl. 42, fig. 32)

(254) *Rhoipites* sp. c (pl. 43, figs. 1a–b)

(255) *Rousea* sp. (pl. 40, figs. 32a–b)

(256) *Satishia* sp. (pl. 41, figs. 1a–b, 3a–b)

(257) *Scollardia nortoni* Srivastava (pl. 37, figs. 10a–b)

(258) *Smilacipites* sp. (pl. 46, fig. 11)

(259) *Spinainaperturites* sp. (pl. 46, figs. 13a–b)

(260) *Striatocolporites* cf. *striatulus* Takahashi & Jux (pl. 42, fig. 30)

(261) *Striatocolporites* sp. a (pl. 42, fig. 33)

(262) *Striatocolporites* sp. b (pl. 43, figs. 2a–b)

(263) *Striatopollis striatellus* (Takahashi) Takahashi (pl. 40, figs. 27–29)

(264) *Striatopollis* sp. a (pl. 40, fig. 2)

(265) *Striatopollis* sp. b (pl. 40, fig. 25)

(266) *Striatopollis* sp. c (pl. 40, fig. 26)

(267) *Subtriporopollenites kyushuensis* Takahashi (pl. 45, figs. 13a–b, 19)

(268) *Subtriporopollenites minor* n. sp. (pl. 45, figs. 15–18)

(269) *Subtriporopollenites* sp. (pl. 45, fig. 20)

(270) ? *Symplocoipollenites* sp. (pl. 38, figs. 1a–c)

(271) *Triatriopollenites mirabilis* Takahashi (pl. 44, fig. 2)

(272) *Triatriopollenites* sp. a (pl. 44, fig. 3)

(273) *Triatriopollenites* sp. b (pl. 44, fig. 4)

(274) *Triatriopollenites* sp. c (pl. 44, figs. 5a–b)

(275) *Tricolpites ellipticus* Takahashi & Jux (pl. 42, figs. 2, 4)

(276) *Tricolpites hokkaidoanus* n. sp. (pl. 40, figs. 9, 31; pl. 41, figs. 4, 14)

(277) *Tricolpites intrabaculatus* n. sp. (pl. 41, figs. 19a–b, 25–27)

(278) *Tricolpites minutiretiformis* (Takahashi) Takahashi (pl. 41, figs. 7 (cf.), 10–13, 15–17, 22; pl. 42, figs. 1, 3)

(279) *Tricolpites retiformis* (Pflug & Thomson) Takahashi & Jux (pl. 41, figs. 5, 6, 8, 9, 23, 24; pl. 42, figs. 6–15)

(280) *Tricolpites sphaericus* Takahashi (pl. 41, figs. 18, 20, 21; pl. 42, figs. 5a–b)

(281) *Tricolpopollenites akkeshiensis* n. sp. (pl. 40, figs. 15–18)
Systematic description

The genera and species described here are arranged alphabetically under
the broad heading of spores (trilete spores, monolete spores and alte spore), gymnospermous pollen grains and angiospermous pollen grains.

A) Spores:
   a) Trilete spores:
   Genus: *Baculatisporites* Pflug & Thomson 1953.
   Type species: *Baculatisporites primarius* (Wolff 1934) Thomson & Pflug 1953.

   Remarks: Pflug & Thomson in Thomson & Pflug (1953) instituted a genus *Baculatisporites* and Couper (1953) described newly another genus *Osmundacidites*. According to Krutzsch (1967), the genus *Osmundacidites* Couper (autumn, 1953) is a junior synonym of the genus *Baculatisporites* Pflug & Thomson (March, 1953) which was published earlier in spite of publications in the same year.

   (1) *Baculatisporites comaumensis* (Cookson) Ponië
   Pl. 7, fig. 7; pl. 8, figs. 1-3.

   1980 *Baculatisporites comaumensis* (Cookson) Ponië, Burger, BMR Bull., 189, p. 50, pl. 4, figs. 6, 8, 9.

   Description: See Cookson (1953).
   Dimensions: 29-59 μm in diameter, blunt rod-like processes about 1.2 μm long (Cookson, 1953); present specimens: 25-32 μm X 25-37 μm in diameter, exine up to 1.5 μm thick, ornamentations (echini, bacula, verrucae or clavae) 0.5-2 μm long.
   Occurrence: Akkeshi and Tokotan Formations in Ochiishi area (OHC-02, OCH-03, OHC-05 and OHC-09).
   Previous records: Pre-Tertiary, South Australia (Cookson, 1953); Common in the Jurassic and Early Cretaceous of Western and southeastern Australia (Balme, 1957; Dettmann, 1963); Lower Cretaceous in the Surat Basin, Queensland (Australia) (Burger, 1980).
   Botanical affinity: Osmundaceae.

   (2) *Baculatisporites cf. dubius* Burger n. comb.
   Pl. 7, figs. 10a-b.
1980 *Osmundacidites dubius* Burger, BMR Bull., 189, p. 50, pl. 4, figs. 3–5.

**Description**: See Burger (1980).

**Dimensions**: Equatorial diameter 35–(44)–54 μm, exine 1–2 μm thick (Burger, 1980); present specimen: 30 × 30 μm in diameter, ornamentations (clavae, bacula, verrucae) 0.5–1 μm long.

**Occurrence**: Tokotan Formation in Ochiishi area (OCH–05).

**Previous record**: Lower Cretaceous in the Surat Basin, Queensland (Australia) (Burger, 1980).

**Remark**: Only one specimen was observed. The specimen is more or less smaller than the Burger's original specimens.

**Botanical affinity**: Osmundaceae.

(3) *Baculatisporites wellmanii* Couper n. comb.

Pl. 6, figs. 18, 19; pl. 7, figs. 1–6; pl. 29, fig. 14.


1958 *Osmundacidites wellmanii* Couper, Palaeontographica, B, 103, Lfg. 4–6, p. 134, pl. 4, figs. 4, 5.


1970 *Osmundacidites wellmanii* Couper, Pocock, Palaeontographica, B, 130, Lfg. 1–2, p. 47, pl. 8, figs. 3, 6.


1975 *Osmundacidites wellmanii* Couper, Serivastava, Palaeont. Continent., vol. 6, no. 2, p. 54, pl. 25, figs. 13, 14.


1980 *Osmundacidites wellmanii* Couper, Burger, BMR Bull., 189, p. 50, pl. 4, figs. 1, 2.


**Description**: See Couper (1953).

**Dimensions**: 40–(60)–63 μm in equatorial diameter, exine ca. 1.5 μm thick, with granular-papillate sculpture (Couper, 1953); 40–55 μm in equatorial dia-


meter (Couper, 1958); 30 – (43) – 54 μm in equatorial diameter, exine about 1 μm thick (Pocock, 1962); 41.0 μm in equatorial diameter, length of laesurae 17.5 μm, exine about 1.0 μm thick, verrucae 0.5 – 2.0 μm in diameter (Pocock, 1970); 35 – 42 – 50 μm in equatorial diameter, exine ca. 0.5 μm thick (Miki, 1972); 39 – 42.5 μm in diameter, exine ca. 1 μm (Song et al., 1978); 45 μm in diameter (Song et al., 1981); 46 – 57 μm in equatorial diameter, exine thin, granula and papillae 0.9 – 2.4 μm high (Takahashi & Shimono, 1982); 50 – 51.6 μm in equatorial diameter, exine 1.5 μm thick (Takahashi, 1988); present specimens: 35.5 – 47 μm X 42 – 63 μm in diameter, exine less than 2.5 μm thick, bacula-echini-verrucae 0.5 – 2 μm high.

**Occurrence:** Hamanaka-Oborogawa and Akkeshi Formations in Akkeshi area (AKK-05, AKK-07, AKK-09, AKK-10 and AKK-11); Akkeshi and Tokotan Formations in Ochiishi area (OCH-03, OCH-04, OCH-06, OCH-08, and OCH-10).

**Previous records:** Jurassic-Lower Cretaceous (Couper, 1953); Liassic to middle Senonian (Couper, 1960); Upper Jurassic and Lower Cretaceous (very abundant in the Lower Cretaceous) (Pocock, 1962); Santonian to lower Campanian, Kuji (Miki, 1972); Albian, Oklahoma (U.S.A.) (Srivastava, 1975); Eocene-Oligocene, Bohai region (China) (Song et al., 1978); Lower Cretaceous, Surat Basin (Queensland) and Early Cretaceous of southeastern Australia (Burger, 1980); Oligocene, Jiangsu (China) (Song et al., 1981); Maestrichtian, Hida (Japan) (Takahashi & Shimono, 1982); Coniacian, Futaba (Japan) (Takahashi, 1988).

**Remarks:** Srivastava (1975) distinguished the genus *Osmundacidites* Couper with granulose exine from the genus *Baculatisporites* Pflug & Thomson with the predominantly baculate exine. However, the Couper's original specimen (delineated picture) shows clearly ornamentation with bacula, verrucae and echini. Accordingly, as Krutzsch (1967) stated, the genus *Osmundacidites* Couper (1953) must be replaced with the genus *Baculatisporites* Pflug & Thomson (1953).

**Botanical affinity:** Osmundaceae.

(4) *Baculatisporites* sp.

Pl. 8, figs. 7a–b, 8a–b.

**Description:** Trilete spores. Amb circular to triangular with straight or convex sides and rounded corners in polar view. Trilete laesurae indistinct, narrow, long, reaching equatorial periphery. Exine with baculate sculpture densely distributed, about 2–3.5 μm high.
Dimensions: 21–28 \( \mu m \) X 32–33 \( \mu m \) in diameter.

Occurrence: Akkeshi Formation (AKK-11).

Remarks: Two specimens were observed. They are preserved not well.

Botanical affinity: Unknown.


Type species: Balmeisporites holodictyus Cookson & Dettmann 1958.

(5) Balmeisporites sp.

Pl. 1, figs. 1a–b.

Description: Trilete megaspore; spore-body elliptical to subcircular in outline, covered by double-layered exospore (?). Trilete laesurae are indistinct. Inner layer of exospore formed by ribbon-shaped structures criss-crossing on several levels to form complex reticulate network, connecting and anastomosing at places to produce large conical protrusions which place at intervals of 25–30 \( \mu m \) on equatorial margin of the spore-body. Acrolamella is not preserved.

Dimensions: 170 X 147 \( \mu m \) in diameter.

Occurrence: Akkeshi Formation in Ochiishi area (OCH-09).

Remarks: Only one specimen which is preserved not well was found. This is similar to Balmeisporites bellus Kondinskaya, but the author cannot compare with the formerly described species due to its bad preservation.

Botanical affinity: Unknown.


Type species: Biretisporites potoniaei Delcourt & Sprumont 1955.

(6) Biretisporites cf. incrassatus Takahashi & Shimono

Pl. 5, fig. 3; pl. 10, fig. 11; pl. 20, fig. 9.


Description: See Takahashi & Shimono (1982).
Dimensions: 26.5–30 µm in equatorial diameter (Takahashi & Shimono, 1982); 24 X 32 µm in equatorial diameter, width of trilete laesurae 2.5–3 µm (Takahashi & Sugiyama, 1990); present specimens: 16.5–21 µm in diameter, exine less than 1.5 µm thick, width of trilete laesurae 2–3 µm.

Occurrence: Hamanaka-Oborogawa and Akkeshi Formations in Akkeshi area (AKK-07 and AKK-12); Tokotan Formation in Ochiishi area (OCH-03).

Previous records: Maastrichtian, Hida (Japan) (Takahashi & Shimono, 1982); Santonian, Taneichi (Japan) (Takahashi & Sugiyama, 1990).

Remarks: The present specimens are compared with Biretisporites incrassatus Takahashi & Shimono.

Botanical affinity: Unknown.

(7) ? Biretisporites minus Takahashi
Pl. 5, fig. 5.


Description: See Takahashi (1964).

Dimensions: Ca. 23–27 µm in size, trilete laesurae 1.4–1.6 µm wide (Takahashi, 1964); present specimen: 25 µm in diameter, width of trilete laesurae 3 µm, margin of spore more or less undulate.

Occurrence: Akkeshi Formation in Akkeshi area (AKK-11).

Previous record: Maastrichtian-Campanian, Yubari coal-field (Hokkaido, Japan) (Takahashi, 1964).

Remarks: The present specimen is closely similar to Biretisporites? minus Takahashi (especially, 1964, pl. 26, fig. 9).

Botanical affinity: Unknown.

(8) Biretisporites potoniaei Delcourt & Sprumont
Pl. 13, fig. 11.


1962 Biretisporites potoniaei Delcourt & Sprumont, Pocock, Palaeontographica, B, 111, Lfg.1–3, p. 36, pl. 1, fig. 17.

1963 Biretisporites potoniaei Delcourt & Sprumont, Delcourt Dettmann & Hughes, Palaeoentology, vol. 6, pt. 2, p. 284, pl. 42, figs. 12–14; pl. 44, fig. 11.

1987 Biretisporites potoniaei Delcourt & Sprumont, Srivastava, Geobios, no 20, fas. 1, p. 15, pl. 1, fig. 3.
Description: See Delcourt & Sprumont, (1955) and Delcourt, Dettmann & Hughes, (1963).

Dimensions: 50–60 µm in size (Delcourt & Sprumont, 1955); ±45 µm in equatorial diameter (Pocock, 1962); 48 µm in diameter; laesurae 23 µm long; lips narrow (1–2 µm wide), elevated (2–3 µm high); exine 2.5 µm thick (Delcourt, Dettmann & Hughes, 1963); 38 µm in equatorial diameter (Srivastava, 1987); present specimen: 43 X 47 µm in diameter, exine 3 µm thick, trilete laesurae 3 µm wide.


Previous records: Wealden, Hainaut (Belgium) (Delcourt & Sprumont, 1955); Neocomian, western Canada (Pocock, 1962); Wealden, Belgium (Delcourt, Dettmann & Hughes, 1963); Upper Hettangian, Germany (Srivastava, 1987).

Remarks: Srivastava (1987) treated the species name potoniaei as an orthographic error and named potoniei. However, the author uses here the original species name potoniaei.

Botanical affinity: Unknown.

(9) Biretisporites triangulatus n. sp.

Pl. 5, figs. 7, 9–11; pl. 6, figs. 5, 6.

Description: Trilete spores. Amb triangular with slightly convex or concave sides and rounded corners in polar view and rather four-cornered in lateral view. Trilete laesurae with the wide, elevated lips on both sides, 2.5–3 µm in width, reaching equator. Exine thin, less than 2 µm thick, smooth.

Dimensions: 21–27 µm X 22.5–28 µm in diameter.

23 µm in width and 18 µm in height (pl. 5, fig. 7).

Occurrence: Akkeshi Formation in Akkeshi area (AKK–10), and Akkeshi and Tokotan Formations in Ochiishi area (OCH–02, OCH–04, OCH–05 and OCH–09).

Holotype: Pl. 5, fig. 11; 25 X 26 µm in equatorial diameter; exine thin, smooth; trilete rays 3 µm wide; slide No. GN 5544; Akkeshi Formation in Akkeshi area (AKK–10).

Name derivation: triangulatus (lat.)=triangular.

Remarks: The present specimens are similar to Biretisporites incrassatus Takahashi & Shimono (1982) and Biretisporites sp. A & B (Takahashi, 1974) and differ from B. incrassatus in from and from B. sp. A & B in size.

Botanical affinity: Unknown.
(10) *Biretisporites yoshimotoi* n. sp.
Pl. 6, figs. 1–4.

**Description:** Trilete spores. Outline subtriangular to subcircular in polar view. Trilete laesurae straight or curved, with wide, elevated lips on both their sides, 3−4 μm in width, reaching equator. Exine thin, less than 2 μm thick, smooth or somewhat chagrenate.

**Dimensions:** 23−33.5 μm X 30−37.5 μm in equatorial diameter.

**Occurrence:** Akkeshi Formation in Akkeshi area (AKK−05 and AKK−09), and Akkeshi and Tokotan Formations in Ochiishi area (OCH−03, OCH−06, and OCR−08).

**Holotype:** Pl. 6, fig. 3; 23 X 34 μm in equatorial diameter; exine thin, more or less chagrenate; trilete laesurae 4 μm wide; slide No. 5535; Akkeshi Formation in Akkeshi area (AKK−09).

**Name derivation:** After Mr. Y. Yoshimoto, geologist at Nemuro.

**Remarks:** This new species is compared with *Biretisporites potoniaei* Delcourt & Sprumont (1955), but differs from the latter in having smaller size and in form.

**Botanical affinity:** Unknown.

(11) *Biretisporites* sp. a
Pl. 5, fig. 2.

**Description:** Trilete spore. Amb subtriangular to subcircular with convex sides in polar view. Trilete rays straight, short, with the wide lips (4−6 μm wide), not reaching equator. Exine thin, chagrenate.

**Dimensions:** 43 X 48 μm in diameter.

**Occurrence:** Akkeshi Formation in Akkeshi area (AKK−05).

**Remarks:** The single specimen is similar to *Biretisporites potoniaei* Delcourt & Sprumont (Delcourt, Dettmann & Hughes, 1963, p. 284, pl. 42. figs. 12−14), but differs in having wider and shorter trilete laesurae.

**Botanical affinity:** Unknown.

(12) *Biretisporites* sp. b
Pl. 5, fig. 4.

**Description:** Trilete spore. Amb subtriangular with convex sides in polar view. Trilete rays more or less curved, with the wide lips (2 μm wide), reach-
ing equator. Exine thin, smooth.

**Dimensions:** 14 X 18 μm in equatorial diameter.

**Occurrence:** Akkeshi Formation in Akkeshi area (AKK-05).

**Remarks:** Only one specimen was observed. This is compared with *Biretisporites incrassatus* Takahashi & Shimono (1982), but differs in being smaller in size and in having narrower trilete rays.

**Botanical affinity:** Unknown.

(13) *Biretisporites* sp. c
    Pl. 5, fig. 8.

**Description:** Trilete spore. Outline subcircular in polar view. Trilete rays with wide lips (4.5 μm wide), straight, reaching equator. Exine thin, smooth.

**Dimensions:** 24 X 27 μm in equatorial diameter.

**Occurrence:** Tokotan Formation in Ochiishi area (OCH-10).

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

**Botanical affinity:** Unknown.

(14) *Biretisporites* sp. d
    Pl. 29, fig. 10.

**Description:** Trilete spore. Amb subcircular in polar view. Trilete laesurae short, with wide lips (2 μm wide), not reaching equator. Exine thin, chagrenate.

**Dimensions:** 20 X 21 μm in diameter.

**Occurrence:** Akkeshi Formation in Akkeshi area (AKK-12).

**Remarks:** Only one specimen which is not well in preservation was observed. The author cannot find a comparable species.

**Botanical affinity:** Unknown.

**Subgenus:** *Camarozonosporites (Camarozonosporites)* Krutzsch 1963.  
**Type species:** *Camarozonosporites (Camarozonosporites) cretaceous* (Weyland & Krieger, 1953) Potonié 1956.

(15) *Camarozonosporites (Camarozonosporites) semilevis* Krutzsch
    Pl. 8, figs. 12a–b.
Camarozonosporites (Camarozonosporites) semilevis Krutzsch, Atlas, Lfg. II, p. 124, pl. 43, figs. 1–11.


Description: See Krutzsch (1963).

Dimensions: Ca. 23–38 μm in size (Krutzsch, 1963); 33–38 μm in equatorial diameter, exine 1–1.5 μm thick on corner, cinguli on side 1.7–3 μm thick (Takahashi & Jux, 1986); 38 X 38 μm in equatorial diameter, cingulum 4 μm wide (Takahashi & Sugiyama, 1990); present specimen: 32.5 μm in diameter, wall 2 μm thick, Y-rays with 6 μm wide lips, proximal face almost smooth.

Occurrence: Tokotan Formation in Ochiishi area (OCH-03).

Previous records: Late Eocene-Late Oligocene, Germany (Krutzsch, 1963); Late Oligocene, St. Augustin (Germany) (Takahashi & Jux, 1986); Santonian, Taneichi (Japan) (Takahashi & Sugiyama, 1990).

Remarks: Only one specimen was observed. This is identified with Camarozonosporites (C.) semilevis Krutzsch (1963) by its size, form and almost smooth proximal face.

Botanical affinity: Lycopodiaceae, Lycopodium.


Type species: Camarozonosporites (Hamulatisporis) hamulatis Krutzsch 1959.

(16) Camarozonosporites (Hamulatisporis) hamulatis Krutzsch

Pl. 8, figs. 11a–b.

1959 Hamulatisporis hamulatis Krutzsch, Geologie, Jrg. 8, Beih. 21/22, p. 157, pl. 29, figs. 326–328.


1986 Hamulatisporis hamulatis Krutzsch 1959, Farabee & Canright, Palaeontographica, B, 199, Lfg. 1–3, pp. 19–20, pl. 4, fig. 3.


**Description:** See Krutzsch (1959, 1963).

**Dimensions:** Ca. 30 μm in size (Krutzsch, 1959); 27–34 μm in equatorial diameter (Stanley, 1965) 24.2–(28.5)–35 μm in equatorial diameter (Farabee & Canright, 1986); 27–36 μm in equatorial diameter, exine 2–3 μm thick, hamulate sculpture 1.3 μm high and 3.7 μm wide (Takahashi, 1988); 27–30.5 μm X 22.4–27.6 μm in equatorial diameter (Takahashi & Sugiyama, 1990; present specimen: 25X 28 μm in equatorial diameter.

**Occurrence:** Akkeshi Formation in Akkeshi area (AKK-10).

**Previous records:** Middle Eocene, Geiseltal (Germany) (Krutzsch, 1959); Upper Cretaceous, northwestern South Dakota (U.S.A) (Stanley, 1965); Maastrichtian, Wyoming (U.S.A) (Farabee & Canright, 1986); Coniacian, Futaba (Japan) (Takahashi, 1988); Santonian, Teneichi (Japan) (Takahashi & Sugiyama, 1990).

**Remarks:** The single specimen which was found from the middle Akkeshi Formation in Akkeshi area is identical with *Camarozonosporites (Hamulatisporis) hamulatis* Krutzsch. This species described from Middle Eocene Geiseltal lower coal seam occurs in the Palaeogene in Europe and in the Upper Cretaceous in U.S.A and Japan.

**Botanical affinity:** Lycopodiaceae, Lycopodium.

(17) *Camarozonosporites (Hamulatisporis) insignis* Norris

Pl. 8, fig. 10.

1967 *Camarozonosporites insignis* Norris, Palaeontographica, B, 120, Lfg. 1–4, pp. 96–97, pl. 13, figs. 12–16.

1975 *Camarozonosporites insignis* Norris, Srivastava, Paleobi. Continent., 6, no. 2, pp. 21–22, pl. 10, figs. 5–14.


**Description:** See Norris (1967).

**Dimensions:** Equatorial diameter 30–55 μm (holotype 43 μm) (Norris, 1967); 24–33 μm in equatorial diameter (Srivastava, 1975); 43 μm in equatorial diameter (Takahashi & Sugiyama, 1990); present specimen: 39 μm in equatorial
diameter.

**Occurrence**: Akkeshi Formation in Akkeshi area (AKK-11).

**Previous records**: Albian, Maryland ([Brenner, 1963]-Norris, 1967); Cenomanian, Oklahoma ([Hedlund, 1965]-Norris, 1967); Late Albian, Alberta (Canada) (Norris, 1967); Albian, southern United States (Srivastava, 1975); Santonian, Taneichi (Japan: (Takahashi & Sugiyama, 1990).

**Remarks**: Only one specimen was found. This is identical with *Camarozonosporites* (Hamulatisporis) *insignis* Norris with indistinct rugulae on the proximal surface and closely spaced hamulate sculpture (rugulae) on the distal surface.

**Botanical affinity**: Lycopodiaceae, *Lycopodium*.


**Type species**: *Cardioangulina trichacantha* Maljavkina 1949 ex Potonié 1960.

1949 *Cardioangulina cardioliformis* Maljavkina, Trudy VNIGRI, N.S., no. 35, p. 33, pl. 2, figs. 9-10.

**Description**: See Maljavkina (1949).

**Dimensions**: 0.075 mm in diameter (Maljavkina, 1949); present specimen: 47 X 71 μm in diameter, exine 2.5 μm thick.

**Occurrence**: Akkeshi Formation in Ochiishi area (OCH-09).

**Previous record**: Lower Cretaceous, Nazyvaevsk (western Siberia, USSR) (Maljavkina, 1949).

**Remarks**: Only one specimen was observed. This is referred to *Cardioangulina cardioliformis* Maljavkina (1949) and smaller than *C. trichacantha* Maljavkina (1949).

**Botanical affinity**: Unknown.

**Genus**: *Cibotiidites* Ross 1949.

**Type species**: *Cibotiidites zonatus* Ross 1949.

1949 *Cibotiidites zonatus* Ross, Pl. 12, figs. 1a-b.

**Description:** See Ross (1949).

**Dimensions:** 26 X 48 μm in diameter (Ross, 1949); present specimen: 39 μm in diameter; verrucae on the proximal surface and verrucae (elongated) on the distal one, verrucae 1 μm high and 0.5–3 μm wide at base.

**Occurrence:** Hamanaka-Oborogawa Formation in Akkeshi area (AKK-07).

**Previous record:** Santonian-Campanian, Sweden (Ross, 1949).

**Remarks:** The present specimen is compared with *Cibotiidites zonatus* Ross.

**Botanical affinity:** Dicksoniaceae, *Cibotium*.

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

**Type species:** *Cicatricosisporites dorogensis* Potonie & Gelletich 1933.

(20) *Cicatricosisporites cf. hallei* Delcourt & Sprumont

Pl. 9, figs. 1a–b.


1967 *Cicatricosisporites hallei* Delcourt & Sprumont, Norris, Palaeontographica, B, 120, Lfg. 1–4, pp. 92–93, pl. 11, figs. 15–20.


1975 *Cicatricosisporites hallei* Delcourt & Sprumont, Srivastava, Paleobiol. Continent., vol. 6, no. 2, p. 27, pl. 11, figs. 5–6.

1985 *Cicatricosisporites hallei* Delcourt & Sprumont, Yu et al., p. 78, pl. 8, figs. 9–10.


**Description:** See Delcourt & Sprumont (1955).

**Dimensions:** 35–(40)–57 μm in equatorial diameter (Delcourt & Sprumont, 1955); 43.2 X 45.6 μm and 63.7 μm in diameter (Hedlund, 1967); 32–55 μm in diameter (Singh, 1971); 39 μm in equatorial diameter (Srivastava, 1975); 42–46.
Palynologic study of the Akkeshi and Tokotan Formations

\( \mu m \) in diameter (Yu et al., 1985); 65 \( X \) 51 \( \mu m \) in equatorial diameter, ribs 2–3.5 \( \mu m \) wide (Takahashi & Sugiyama, 1990); present specimen: 57 \( \mu m \) in width and 38 \( \mu m \) in height, ribs 2–3 \( \mu m \) wide.

**Occurrence:** Akkeshi Formation in Ochiishi area (OCH–09).

**Previous records:** Wealden, Hainaut (Belgium) (Delcourt & Sprumont, 1955); Albian, Alberta (Singh, 1964); Albian, Alberta (Canada) (Norris, 1967); Cenomanian, Oklahoma (U.S.A) (Hedlund, 1967); Albian, Oklahoma (U.S.A) (Hedlund & Norris, 1968); Albian, Saskatchewan and Manitoba (Canada) (Playford, 1971); Albian, southern U.S.A (Srivastava, 1975); Middle Cretaceous (Aptian-Albian), Jiangxi (China) (Yu et al., 1985); Santonian, Taneichi (Japan) (Takahashi & Sugiyama, 1990).

**Remarks:** The only one specimen observed is not well in preservation, but differs from *Cicatricosisporites dorogensis* Potonié & Gelletich (1933) in having larger and higher muri.

**Botanical affinity:** Schizaeaceae.

(21) *Cicatricosisporites minor* (Bolkhovitina) Takahashi

Pl. 9, figs. 5, 6.


1961 *Pelletieria minor* (Bolkhovitina) Bolkhovitina, Trudy Geol. Inst. Acad. Sci. USSR, no. 40, p. 68, pl. 19, fig. 8; pl. 12, figs. 3a–c.

1988 *Cicatricosisporites minor* (Bolkhovitina) Takahashi, Bull. Fac. Liberal Arts, Nagasaki Univ., Nat. Sci., vol. 28, no. 2, p. 95, pl. 7, fig. 5; pl. 8, fig. 5.

**Description:** See Bolkhovitina (1959, 1961).

**Dimensions:** 26–30 \( \mu m \) in size (Bolkhovitina, 1961); 21.6–25.8 \( \mu m \) in equatorial diameter, cicatricose ridges less than 1 \( \mu m \) in wide (Takahashi, 1988); present specimens: 25–26 \( \mu m \) in equatorial diameter.

**Occurrence:** Akkeshi Formation in Choboshi and Ochiishi areas (CHO–01 and OCH–06).

**Previous records:** Upper Cretaceous, Vilyuy (Yakutsukaya, Siberia) (Bolkhovitina, 1959, 1961); Coniacian, Futaba (Japan) (Takahashi, 1988).

**Remarks:** The present specimens are identical with the specimens from the Upper Cretaceous, Vilyuy River, Yakutsukaya (Siberia, USSR).

**Botanical affinity:** Schizaeaceae.

(22) *Cicatricosisporites minutaestriatus* Bolkhovitina n. comb.
Pl. 9, figs. 8a–b.

1961 *Pelletieria minutaestriata* Bolkhovitina, Trudy Geol. Inst., Acad. Sci. USSR, no. 40, p. 68, pl. 20, figs. 1a–f; pl. 21, figs. 3a–d.

Description: See Bolkhovitina (1961).

Dimensions: 34 – 38 μm in size (Bolkhovitina, 1961); present specimen: 36 μm in width and 26 μm in height.

Occurrence: Akkeshi Formation in Ochiishi area (OCH–06).

Previous records: Lower Cretaceous and Cenomanian, Vilyuysk (Yakustukaya, Siberia) and Lena-Hamtsi (Yakutsukaya, Siberia); Aptian, Millde Volga (USSR) (Bolkhovitina, 1961).

Remarks: The only specimen observed possesses many very finely cicatricose ribs. Accordingly, this is referable to *Cicatricosisporites (al. Pelletieria) minutaestriatus* (Bolkhovitina) n. comb.

Botanical affinity: Schizaeaceae.

(23) *Cicatricosisporites* sp. a

Pl. 9, fig. 4.

Description: Trilete spore. Amb triangular or subcircular with bow-shaped sides and rounded corners in polar view. Trilete rays strong, with wide lips, about 4 μm wide, not reaching the periphery. Exospore ornamented with very wide cicatricose ridges which are 2–3 in number on the proximal surface and run almost parallel the equatorial periphery.

Dimensions: 37 X 43 μm in diameter. Cicatricose ridge: 4 μm wide.

Occurrence: Akkeshi Formation in Ochiishi area (OCH–06).

Remarks: The only specimen observed is similar to *Cicatricosisporites subrotundus* Brenner (1963), but differs in having narrower ridges.

Botanical affinity: Schizaeaceae.

(24) *Cicatricosisporites* sp. b

Pl. 9, figs. 7a–b.

Description: Trilete spore. Outline subcircular in oblique (near polar) view. Trilete mark strong, with 4 μm wide lips, extending to the equatorial periphery. Proximal face pyramidal, psilate (?); distal face convex, almost semicircular, occupying the most part of the store body. Exine 4 μm thick; sculpture of the
distal face roughly cicatricose; ribs 3 μm wide.

**Dimensions:** 31 X 31 μm in diameter.

**Occurrence:** Tokotan Formation in Ochiishi area (OCH -10).

**Remarks:** The present specimen differs from *Cicatricosisporites subrotundus* Brenner (1963) in being smaller in size and in having narrower cicatricose ridges, and from *C. sp. a* (this paper, pl. 9, fig. 4) in being smaller in size.

**Botanical affinity:** Schizaeaceae.


**Type species:** *Cingulatisporites levispeciosus* Pflug 1953.

(25) *Cingulatisporites cf. levispeciosus* Pflug

Pl. 5, fig. 16.

1953 *Cingulatisporites levispeciosus* Pflug, Thomson & Pflug, Palaeontographica, B, 94, p. 58, pl. 1, fig. 16.

**Description:** See Pflug in Thomson & Pflug (1953).

**Dimensions:** 30 – 60 μm in size (Pflug, 1953); present specimen: 27 μm in diameter, cingulum 3 μm wide.

**Occurrence:** Akkeshi Formation in Ochiishi area (OCH –06).

**Previous records:** Danian (?) – Palaeocene, Wehmingen near Sarstedt (Germany) (Thomson & Pflug 1953).

**Remarks:** The present specimen is more or less smaller than the Pflug's original specimens.

**Botanical affinity:** Unknown.

**Genus:** *Concauissimisporites* Delcourt & Sprumont 1955.

**Type species:** *Concauissimisporites verrucosus* Delcourt & Sprumont 1955.

(26) *Concauissimisporites cf. varierrucatus* (Couper) Brenner

Pl. 11, fig. 11.

1958 *Concauissimisporites varierrucatus* Couper, Palaeontographica, B, 103, Lfg. 1 – 4, p. 142, pl. 22, figs. 4 – 5.


1964 *Concauissimisporites varierrucatus* (Couper) Singh, Res. Coun. Alberta, 15, p. 78,
1969 *Converrucosisporites variverrucatus* (Couper) Norris, *Palaeontology*, vol. 12, pt. 4, p. 585, pl. 102, fig. 19.


**Description:** See Couper (1958).

**Dimensions:** $48-55-68 \mu m$ in equatorial diameter (Couper, 1958); $40-70 \mu m$ in diameter (Singh, 1964); $55-65 \mu m$ in equatorial diameter (Srivastava, 1975); present specimen: $38 \times 46 \mu m$ in equatorial diameter, exine $3 \mu m$ thick, verrucae $1.5-5 \mu m$ in diameter.

**Occurrence:** Akkeshi Formation in Choboshi area (CHO-01).

**Previous records:** Bajocian-Wealden, British Isles (Couper, 1958); Barremian-Albian, Maryland (U.S.A) (Brenner, 1963); Aptian-Albian, Alberta (Canada) (Singh, 1964, 1971); Upper Jurassic-Berriasian, southern England (Norris, 1969); Lower Albian, southern England (Kemp, 1970); Maestrichtian, Alberta (Canada) (Srivastava, 1972; Albian, Oklahoma (U.S.A) (Srivastava, 1975).

**Remarks:** The single specimen is distinct from *Concauissimisporites verrucosus* Delcourt & Sprumont (1955) emend. Delcourt, Dettmann & Hughes (1963) in being smaller in size and in having less concave sides of the amb, and from *C. crassatus* (Delcourt & Sprumont, 1955) Delcourt, Dettmann & Hughes (1963) in being smaller in size and in having more closely spaced verrucae.

**Botanical affinity:** Unknown, but possibly dicksoniaceous (Couper, 1958).

**Genus:** *Converrucosisporites* Potonié & Kremp 1954.

**Type species:** *Converrucosisporites triquetrus* (Ibrahim 1933) Potonié & Kremp 1954.

(27) *Converrucosisporites triquetrus* (Ibrahim) Potonié & Kremp
Pl. 13, fig. 9.

1933 *Verrucosi-sporites triquetrus* Ibrahim, K. Triltsch, Würzburg, p. 26, pl. 7, fig. 61.

**Description:** See Ibrahim (1933) and Döring (1964).
Dimensions: 38.5–42.5 μm X 42.5–58.0 μm in size, verrucae 3–4 μm in size (Ibrahim, 1933); ca. 44 μm in size, irregular warts 2–5 μm in diameter and up to 2 μm in height (Döring, 1964); present specimen: 41 μm in diameter, verrucae 2–5 μm in diameter.

Occurrence: Akkeshi Formation in Akkeshi area (AKK-12).

Previous records: Upper Carboniferous, Germany (Ibrahim, 1933; Potonié & Kremp, 1954).

Remarks: Only one specimen was observed. The Ibrahim’s original specimen occurred from the Upper Carboniferous seam Agir, Ruhr area (Germany), but the present specimen is identified with Converrucosisporites triquetrus (Ibrahim) Potonié & Kremp by its form, size and ornamentation.

Botanical affinity: Unknown.

Type species: Corrugatisporites solidus (Potonie 1934) Thomson & Pflug 1953.

(28) Corrugatisporites solidus (Potonie) Thomson & Pflug
Pl. 13, figs. 10a–c; pl. 14, figs. 6a–c.

1979 Corrugatisporites solidus (Potonie) Thomson & Pflug, Takahashi & Kim, Palaeontographica, B, 170, Lfg. 1–3, p. 22, pl. 1, fig. 6.

Description: See Thomson & Pflug (1953).

Dimensions: 36 μm in size (Potonie 1934); 36 μm in size (Potonie 1951); 30–60 μm in diameter, warts more than 1 μm high and more than 2 μm wide at base (Thomson & Pflug, 1953); 30–60 μm in size (Delcourt & Sprumont, 1955); 37 μm in equatorial diameter, verrucae 0.5–1 μm in height and 1.7–3 μm in width, verrucae along the sides of the Y-mark ca. 3 μm in width and 2.5 μm in height (Takahashi & Kim, 1979); present specimens: 29–35 μm X 35–42 μm in diameter, exine 2–3.5 μm thick.

Occurrence: Akkeshi Formation in Ochiishi area (OCH–09).

Previous records: Eocene, Geiseltal (Germany) (Potonie, 1934); Middle Tertiary, Germany (Thomson & Pflug, 1953); Wealden, Hainaut (Belgium) (Delcourt & Sprumont, 1955); Miocene, Yonil (Korea) (Takahashi & Kim, 1979).
Remarks: The present specimens are referable to *Corrugatisporites solidus* (Ptonie) Thomson & Pflug in spite of its imperfect preservation.

Botanical affinity: Schizaeaceae, *Lygodium*.

Genus: *Cyathidites* Couper 1953.

Type species: *Cyathidites australis* Couper 1953.

(29) *Cyathidites minor* Couper

Pl. 1, figs. 3a–b; pl. 2, fig. 7.


1962 *Cyathidites minor* Couper, Pocock, Palaeontographica, B, 111, Lfg. 1–3, p. 43, pl. 4, figs. 57–58.


1967 *Cyathidites minor* Couper, Norris, Palaeontographica, B, 120, Lfg. 1–4, p. 86, pl. 10, fig. 2.

1970 *Deltoidospora minor* (Couper) Pocock, Palaeontographica, B, 130, Lfg. 1–2, p. 28, pl. 5, fig. 3.

1970 *Cyathidites minor* Couper, Dutta & Sah, Palaeontographica, B, 131, Lfg. 1–4, p. 11, pl. 2, figs. 2, 5, 6.

1970 *Cyathidites minor* Couper, Kemp, Palaeontographica, B, 131, Lfg. 1–4, p. 84, pl. 10, figs. 2–3.


1985 *Cyathidites minor* Couper, Yu et al., p. 87, pl. 12, figs. 10, 12–15.


1990 *Cyathidites minor* Couper, Takahashi & Sugiyama, Bull. Fac. Liberal Arts, Nagasaki Univ., Nat. Sci., vol. 30, no. 2, pp. 185–186, pl. 8, figs. 8–10; pl. 9, figs. 3–4, 6.

Description: See Couper (1953).

Dimensions: 31–(35)–45 μm in equatorial diameter (Couper, 1953); 24–(35)–45 μm in equatorial diameter (Pocock, 1962); 25–55 μm in size (Burger, 1966); 30.0–(36.0)–45.0 μm in equatorial diameter (Pocock, 1970); 39–50 μm in size
Palynologic study of the Akkeshi and Tokotan Formations

(Dutta & Sah, 1970); 26–(37)–49 μm in equatorial diameter (Kemp, 1970); 25–45 μm in equatorial diameter (Singh, 1964, 1971); 25–56 μm in size (Srivastava, 1975); 31–42 μm in diameter (Yu et al., 1985); 31–39 μm in equatorial diameter (Takahashi, 1988); 32–46 μm X 30–46 μm in equatorial diameter (Takahashi & Sugiyama, 1990); present specimens: 27–29 μm X 33–34 μm in equatorial diameter, exine 0.5 μm thick.

Occurrence: Akkeshi Formation in Akkeshi rea (AKK-09 and AKK-10).

Previous records: Jurassic-Lower Cretaceous, New Zealand (Couper, 1953); Jurassic-Middle Valanginian, the eastern Netherlands (Burger, 1966); Albian, Alberta (Canada) (Norris, 1967); Tertiary (Lower Eocene), Assam (India) (Dutta & Sah, 1970); Aptian-Albian, southern England (Kemp, 1970); Coniacian, Futaba (Japan) (Miki, 1972); Cenomanian-Turonian, Saku (Hokkaido) (Miki, 1973); Coniacian-Santonian, Futaba (Japan) (Takahashi, 1973, 1988); Albian, southern U.S.A. (Srivastava, 1975); Cenomanian, Bathurst Island (Australia) (Norvick & Burger, 1976); Lower Cretaceous, Surat Basin (Australia) (Burger, 1980); Upper Triassic-Jurassic, Lancang (China) (Lei, 1981); Lower Cretaceous (Berriasian-Barremian), Jiangxi (China) (Yu et al., 1985); Paleocene-Early Eocene, Lingbao Basin (China) (Sun et al., 1985); Santonian, Taneichi (Japan) (Takahashi & Sugiyama, 1990).

Remarks: Hitherto, this species was reported from the Cenomanian to Santonian in Japan.

Botanical affinity: Cyatheaceae, Cyathea.

Type species: Deltoidospora hallii Miner 1935.

(30) Deltoidospora cascadensis Miner
Pl. 2, figs. 4–6; pl. 29, fig. 7.

1935 Deltoidospora cascadensis Miner, Am. Midland Naturalist, vol. 16, no. 4, p. 618, pl. 24, figs. 9–12.
Description: See Miner (1935).
Dimensions: 30–41 μm in equatorial diameter (Miner, 1935); 28–35 μm in equatorial diameter (Miki, 1972); 42 × 38 μm in equatorial diameter, exine 1.5 μm thick (Takahashi & Sugiyama, 1990); present specimens: 24–28 μm × 30–37 μm in equatorial diameter, exine 0.5 μm thick.
Occurrence: Hamanaka-Oborogawa and Akkeshi Formations in Akkeshi area (AKK-05, AKK-07, AKK-10 and AKK-11).
Previous records: Lower Cretaceous, Montana (U.S.A) (Miner, 1935); Santonian-(Campanian), Kuji (Japan) (Miki, 1972); Coniacian, Futaba (Japan) (Miki, 1972); Cenomanian-Turonian, Saku (Hokkaido) (Miki, 1973); Santonian, Taneichi (Japan) (Takahashi & Sugiyama, 1990).
Remarks: The present specimens are identified with Deltoidospora cascaden-sis Miner (1935) in form and size.
Botanical affinity: Unknown.

(31) Deltoidospora diaphana Wilson & Webster
Pl. 2, figs. 1–3; pl. 3, fig. 13 (cf.);
pl. 4, figs. 10a–b.

1946 Deltoidospora diaphana Wilson & Webster, Am. Jour. Bot., vol. 33, no. 4, p. 273, fig. 3.
1959 Deltoidospora diaphana Wilson & Webster, Rouse, Micropaleontol., vol. 5, no. 3, p. 311, pl. 1, figs. 31–32.
1990 Deltoidospora diaphana Wilson & Webster, Takahashi & Sugiyama, Bull. Fac. Liberal Arts, Nagasaki Univ., Nat. Sci., vol. 30, no. 2, p. 188, pl. 4, fig. 5 (?); pl. 7, fig. 3; pl. 10, figs. 2–3.

Description: See Wilson & Webster (1946).
Dimensions: 42–46 μm in diameter (Wilson & Webster, 1946); 42–44 μm in diameter (Rouse, 1957); 40–60 μm in diameter (Rouse, 1959); 41–48.5 μm × 25–41 μm in equatorial diameter, exine 3 μm thick (Takahashi & Sugiyama, 1990); present specimens: 35–37 μm × 38–48 μm in diameter; 41 μm in width and 30 μm in height; exine thin, up to 2 μm thick.
Occurrence: Akkeshi Formation in Akkeshi and Choboshi areas (AKK-09 and CHO-01) and Tokotan Formation in Ochiushi area (OCH-02).
Previous records: Paleocene, Montana (U.S.A) (Wilson & Webster, 1946); Santonian, southern Alberta (Canada) (Rouse, 1957); Upper Jurassic, British
Columbia (Canada) (Rouse, 1959); Santonian, Taneichi (Japan) (Takahashi & Sugiyama, 1990).

Remarks: The present specimens are identical with *Deltoidospora diaphana* Wilson & Webster (1946).

Botanical affinity: Unknown.

(32) *Deltoidospora microlepioides* (Krutzhc) Wang

Pl. 1, figs. 4, 5; pl. 2, figs. 8, 9, 12–15; pl. 19, fig. 13.


Description: See Krutzsch (1962).

Dimensions: Ca. 20–35 μm in diameter (Krutzhc, 1962); ca. 27 μm in size, exine 1–2 μm thick (Song et al., 1981); 23–26 μm in diameter, exine 1 μm thick (Yu et al., 1985); 28–31 μm in diameter, exine ca. 0.5–1.5 μm thick (Takahashi & Jux, 1986); 27.5 μm in diameter, (Song et al., 1986); 19.5–27 μm in diameter, exine 1–2 μm thick (Song et al., 1989); present specimens: 20–30 μm in diameter, exine 0.5–1.3 μm thick.


Previous records: Oligocene-Pliocene, Germany (Krutzhc, 1962); Upper Cretaceous, Jiangsu (China) (Song et al., 1981); Lower Cretaceous, Jiangxi (China) (Yu et al., 1985); Late Oligocene, St. Augustin (Germany) (Takahashi & Jux, 1986); Eocene-Oligocene, Sanshui Basin, Guangdong (China) (Song et al., 1986); Eocene-Oligocene, Dongpu region (China) (Song et al., 1989).

Remarks: *Deltoidospora microlepioides* (Krutzhc) Wang possesses a deltoid and relatively smaller form. Accordingly, the author considers, this species
should belong to the genus *Deltoidospora* rather than the genus *Leiotriletes*.

**Botanical affinity:** Unknown.

(33) *Deltoidospora seidewitzensis* (Krutzsch) Hu

Pl. 2, figs. 10, 11a–b; pl. 3, figs. 8, 9.

1989 *Deltoidospora seidewitzensis* (Krutzsch) Hu, Sun et al., Geol. Publ. House, Micro-paleobot. vol., p. 43, pl. 3, fig. 6; pl. 4, fig. 2.

**Description:** See Krutzsch (1962).

**Dimensions:** Ca. 23–30 μm in diameter, exine up to 1 μm thick (Krutzsch, 1962); 36 μm in diameter, exine ca. 2 μm thick (Song et al., 1985); present specimens: 24–29 μm in diameter, exine 0.5 μm thick.

**Occurrence:** Akkeshi Formation in Akkeshi and Ochiishi areas (AKK-10 and OCH-06) and Tokotan Formation in Ochiishi area (OCH-02 and OCH-05).

**Previous records:** Early Miocene, Germany (Krutzsch, 1962); Pliocene, Donghai (China) (Song et al., 1985); Paleocene, Pliocene, Donghai (China) (Sun et al., 1989).

**Remarks:** *Deltoidospora seidewitzensis* (Krutzsch) Hu furnishes with a deltoid form.

**Botanical affinity:** Unknown.

(34) ? *Deltoidospora* sp.

Pl. 2, fig. 16.

**Description:** Trilete spore. Amb subcircular to rounded triangular with a tapered corner in polar view. Trilete mark weak, reaching the periphery. Exine thin, 0.5 μm thick, psilate.

**Dimensions:** 18 X 28 μm in diameter.

**Occurrence:** Akkeshi Formation in Akkeshi area (AKK-10).

**Remarks:** It is not accurate due to imperfect preservation, whether the present specimen belongs to the genus *Deltoidospora* or not.

**Botanical affinity:** Unknown.

**Genus:** *Divisisporites* Pflug 1953.

**Type species:** *Divisisporites divisus* Pflug 1953.

(35) *Divisisporites* sp.

Pl. 3, fig. 7; pl. 8, fig. 5; pl. 20, fig. 3.
Description: Trilete spores with trilete ridges branched along an obtuse angle at their ends. The length of the branches is shorter than half that of each primary ray. Amb circular, subcircular or subtriangular in polar view. Exine thin, smooth.

Dimensions: 20 – 27 µm X 21 – 29 µm in diameter.

Occurrence: Akkeshi Formation in Akkeshi area (AKK–09) and Tokotan Formation in Ochiishi area (OCH–03).

Remarks: Three specimens with trilete laesurae branching at their ends were encountered. They are described here as *Divisisporites* sp. in the lump.

Botanical affinity: Unknown.

Genus: *Duplosporis* Pflug 1953.

Type species: *Duplosporis stipator* Pflug 1953.

(36) *Duplosporis* sp.

Pl. 29, figs. 13a – b.

Description: Spore with double Y marks on the proximal and distal surfaces. Amb triangular with convex or concave sides and rounded or pointed corners in polar view. Both Y marks narrow, straight, reaching the periphery. Exine thin, 1 µm thick, smooth.

Dimensions: 24 µm in equatorial diameter.

Occurrence: Akkeshi Formation in Ochiishi area (OCH–06).

Remarks: Only one specimen with double Y marks on the proximal and distal surfaces was observed. This is much smaller than *Duplosporis stipator* Pflug (1953) from the Middle Senonian in Aachen region, Germany.

Botanical affinity: Unknown.


Type species: *Foveolatisporites fenestratus* (Kosnake & Brokaw 1950) Bharadwaj 1956.

(37) ? *Foveolatisporites* sp.

Pl. 5, fig. 14.

Description: Trilete miospore. Amb subcircular in polar view. Trilete laesurae distinct, short and with wide lips (2 – 3 µm wide). Contact area circular in polar view. Exine densely baculate (3 µm long), visible foveolate on the first face.

Dimensions: 28 X 33 µm in equatorial diameter.

Occurrence: Akkeshi Formation in Akkeshi area (AKK–11).

Remarks: The single specimen which is probably a reworked spore was observed. This was more strongly carbonized than other Upper Cretaceous
palynomorphs. Whether this is *Foveolatisporites* is not clear. This is possibly a Palaeozoic spore.

**Botanical affinity:** Unknown.

**Genus:** *Foveotriletes* Potonié 1956.

**Type species:** *Foveotriletes scrobiculatus* (Ross 1949 ex Weyland & Krieger 1953) Potonié 1956.

(38) *Foveotriletes scrobiculatus* (Ross ex Weyland & Krieger) Potonié

Pl. 6, figs. 7a–b.


1953 *Microreticulatisporites scrobiculatus* (Ross) Weyland & Krieger, Palaeontographica, B, 95, Lfg. 1–3, pl. 11, pl. 4, fig. 23.

1956 *Foveotriletes scrobiculatus* (Ross) Potonié, Beih. Geol. Jb., 23, p. 43, pl. 5, fig. 49.


**Description:** See Potonié (1956).

**Dimensions:** 40–50 μm in diameter (Weyland & Krieger, 1953); ca. 38 μm in size (Potonié, 1956); 20–36 μm X 31–48 μm in size (Jansonius & Hills, 1976); 55 X 52 μm in equatorial diameter, exine 2 μm thick (Takahashi & Sugiyama, 1990); present specimen: 30 X 31 μm in equatorial diameter, exine 1.5 μm thick.

**Occurrence:** Akkeshi Formation in Ochiishi area (OCH–09).

**Previous records:** Late Santonian to Early Campanian, southern Sweden (Ross, 1949); Middle Senonian, Aachen (Germany) (Weyland & Krieger, 1953); Santonian, Taneichi (Japan) (Takahashi & Sugiyama, 1990).

**Remarks:** The present specimen is somewhat smaller than the specimens previously described of *Foveotriletes scrobiculatus*.

**Botanical affinity:** Unknown.

**Genus:** *Gleichenioidites* Ross 1949.

**Type species:** *Gleichenioidites senonicus* Ross 1949.

(39) *Gleichenioidites marginatus* Takahashi

Pl. 3, fig. 2.

Palynologic study of the Akkeshi and Tokotan Formations

Description: See Takahashi (1964).
Dimensions: Ca. 24–37 μm in size, exospore 2–3 μm thick (Takahashi, 1964); present specimen: 28 μm in diameter, exine 3 μm thick at side.
Occurrence: Akkeshi Formation in Ochiishi area (OCH–06).
Previous record: Campanian, Ooyubari (Hokkaido, Japan) (Takahashi, 1964).
Remarks: The single specimen was found. This is distinct from *Gleicheniidites senonicus* Ross (1949) in having more concave form and undulated trilete rays.
Botanical affinity: Gleicheniaceae.

(40) *Gleicheniidites senonicus* Ross
Pl. 3, fig. 1; pl. 5, figs. 12a–b.

1964 *Gleicheniidites senonicus* Ross, 1949, Skarby, Acta Univ. Stockholm, Stockholm Contrib. Geol. 11, no. 3, pp. 65–73, pl. 1, figs. 1–3; pl. 2, figs. 1–8; pl. 3, figs. 1–11; text–fig. 1: 1–11.
1966 *Gleicheniidites senonicus* Ross 1949, Burger, J, J. Groen & Zoon, p. 239, pl. 3, figs. 5a–c.
1967 *Gleicheniidites senonicus* Ross, Norris, Palaeontographica, B, 120, Lfg. 1–4, pp. 95–96, pl. 13, figs. 6–7.
1970 *Gleicheniidites senonicus* Ross, Kemp, Palaeontographica, B, 131, p. 103, pl. 18, figs. 3–7.
1981 *Gleicheniidites senonicus* Ross, Sung et al., p. 56, pl. 3, fig. 14.
**Description:** See Ross (1949) and Skarby (1964).

**Dimensions:** 16 X 26 (13–19 X 24–29) \( \mu \text{m} \) and 17 X 37 (15–19 X 34–39) \( \mu \text{m} \) in diameter, exine 1.5–2 \( \mu \text{m} \) thick (Ross, 1949); 10–30 \( \mu \text{m} \) in diameter (Delcourt & Sprumont, 1955); 24–(33.2)–41 \( \mu \text{m} \), 25–(31.9)–41 \( \mu \text{m} \), and 25–(31.3)–38 \( \mu \text{m} \) in length of side in polar view, 1.5–(2.6)–4.5 \( \mu \text{m} \) in width of equatorial thickening (Skarby, 1964); 21–30 \( \mu \text{m} \) in diameter (Chlonava, 1969); 26–(35)–41 \( \mu \text{m} \) in equatorial diameter (Miki, 1972); 23 \( \mu \text{m} \) in equatorial diameter (Miki, 1972); 20–30 \( \mu \text{m} \) in diameter (Srivastava, 1975); 20 \( \mu \text{m} \) in diameter (Sung et al., 1981); 22–(28.1)–40 \( \mu \text{m} \) in equatorial diameter (Farabee & Canright, 1986); 22.4–43 \( \mu \text{m} \) X 22.9–43 \( \mu \text{m} \) in equatorial diameter, exine 2.5–5 \( \mu \text{m} \) thick at the sides; present specimens; 28–31 \( \mu \text{m} \) X 30–43 \( \mu \text{m} \) in equatorial diameter, exine 2–5 \( \mu \text{m} \) at the sides.

**Occurrence:** Akkeshi Formation in Akkeshi area (AKK–12) and Tokotan Formation in Ochiishi area (OCH–05).

**Previous records:** Upper Cretaceous (Late Santonian), Lake Ivösjön (Sweden) (Ross, 1949); Wealden, Hainaut (Belgium) (Delcourt & Sprumont, 1955); Late Upper Cretaceous, western Siberian lowland (Chlonava, 1961); Uppermost Jurassic to Middle Valanginian, the eastern Netherlands (Burger, 1966); Albian, central Alberta (Canada) (Norris, 1967); Santonian to (Campanian), Kuji (Japan) (Miki, 1972); Cenomanian-Turonian, Saku (Hokkaido, Japan) (Miki, 1973); Albian, southern United States (Srivastava, 1975); Lower Cretaceous, Jiangsu (China) (Sung et al., 1981); Maastrichtian, Wyoming (U.S.A.) (Farabee & Canright, 1986); Santonian, Taneichi (Japan) (Takahashi & Sugiyama, 1990).

**Remarks:** This species was redefined by Skarby (1964) with the wide variety in morphology.

**Botanical affinity:** Gleicheniaceae, *Gleichenia* and *Dicranopteris* (Skarby, 1964).

**Genus:** *Granulatisporites* Ibrahim 1933.

**Type species:** *Granulatisporites granulatus* Ibrahim 1933.

(41) *Granulatisporites* sp.

Pl. 8, figs. 9a–b.

**Description:** Trilete spore. Amb triangular with convex sides and rounded corners in polar view. Trilete laesurae narrow, slightly curved, reaching the periphery. Exine thin with densely spaced verrucae; verrucae 1–2 \( \mu \text{m} \) wide, distributed on both the proximal and distal surfaces.

**Dimensions:** 39 X 43 \( \mu \text{m} \) in diameter.