PALYNOLOGICAL STUDY OF THE KUJI GROUP IN NORTHEASTERN HONSHU, JAPAN

by

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(with 3 Tables, 3 Text-figures and 11 plates)

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Contents

Introduction

In Japan palynological study of the Cretaceous sediments has been not yet developed. It seems mainly to be attributed to the fact that most of the Cretaceous are largely of marine origin, and that Cretaceous pollen and spores are ill-preserved, due mainly to considerable crustal movements after their deposition. Only a few palynological investigations of the Hokobuchi group (Latest Cretaceous) in Hokkaido have been published by SATO (1961) and TAKAHASHI (1964, 1965). No palynological study on the sediments older than the Hakobuchi group has been published.

The Upper Cretaceous sediments, except igneous rock complex, are widely developed along the outer side of southwestern Japan and the meridional zone of Hokkaido, and are also limitedly scattered in northeastern Honshu. Most of these sediments are of marine origin. Upper Cretaceous non-marine sediments are poorly developed; they are known partly in the Kuji group of Iwate

Prefecture, the Hakobuchi group of Hokkaido and the Futaba group of Fukushima Prefecture.

The Kuji group is distributed in the vicinity of Kuji City (40°N, 142°E) in Iwate Prefecture, northern Honshu. It is composed of three formations: the Tamagawa, the Kunitan and the Sawayama formations. The Tamagawa and the Sawayama formations composed mainly of non-marine sediments, occasionally contain thin coal seams and abundant fossil leaves. The author can find a number of well-preserved spores and pollen from these two formations through the detailed investigation during these five years.

The Kuji group plays an important role for establishment of Late Cretaceous microfloral sequence in Japan, which has been little known up to the present. Recently, TOKUNAGA and TAKASE (1968) published a preliminary report on the spores and pollen from the Sawayama formation at a locality, but they gave no discussion of floral composition and no description of fossils. In this paper the author describes the fossil pollen and spores from the Kuji group, and further makes a discussion on the microfloral composition and geologic age.

Acknowledgement

The author is greatly indebted to Dr. Toshimasa TANAI and Dr. Seiji SATO, Depertment of Geology and Mineralogy, Hokkaido University, who first introduced the author to the study of Cretaceous palynology, for their suggestions to investigate the work as well as for constant guidance in the course of it. Dr. TANAI has also devoted much time to give many helpful criticism and to read this manuscript. Acknowledge is also to thank Mrs. T. WATANABE for her help in preparing the manuscript.

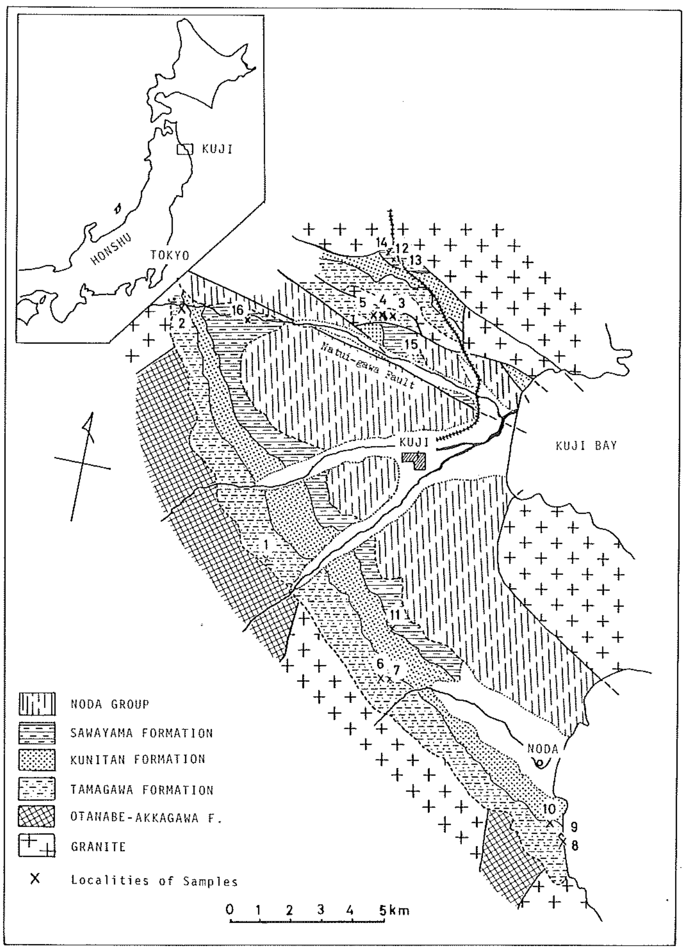
Stratigraphy of the Kuji Group

The Kuji group was first named by SASA (1932) for the Upper Cretaceous sediments in the Kuji coal field, and was subdivided into three formations: the Tamagawa, the Kunitan and the Sawayama (formerly the Kadonosawa) formations in ascending order. The Kuji group covers unconformably the Paleozoic sediments and post-Miyakoan (Albian to Aptian) granitic rocks, and is overlaid by the Paleogene Noda group. The Kuji group consists of neritic to terrestrial sediments with 400 to 500 meters thickness. These three formations represent one sedimentary cycle.

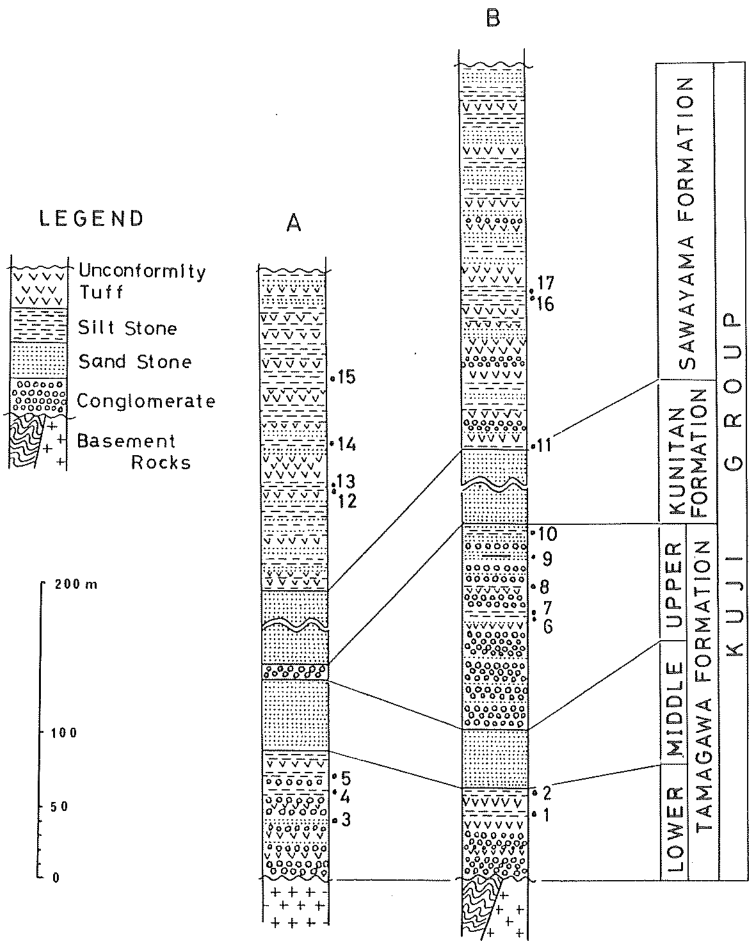
The Tamagawa formation is of brackish origin, and consists of coarse grained sediments such as conglomerate and sandstone with interstratified shale and tuff. Thin coal seams are lenticularly interbedded. The formation can be divided into three parts by lithology: the lower conglomerate, the middle sandstone and the upper conglomerate members. Several tuff beds are good "key beds" for the subdivision (SAWARA, 1967 MS.). From the formation molluscan fossils and plant fossils have been occurred.

The Kunitan formation is of marine origin, and is composed of rather monotonous neritic sediments consisting almost of medium- to fine-grained sandstone. This is approximately 160 meters in thickness. The formation yields several species of *Inoceramus* and ammonites.

The Sawayama formation lying above the Kunitan formation consists of alternation of sandstone, siltstone and tuff beds, sometimes with thin coal or coaly shale. This is 70 to 200 meters thick. The geological map of the Kuji basin and the schematic columnar sections of the Kuji group are shown in Text-figures 1 and 2.



Text-figure 1. Geological Map of Kuji Area (after Sawara, 1967) with the Location of Samples. Numbers correspond with those in Text-Figure 2.



Text-figure 2. Shcematic Columnar Sections of the Kuji Group. Number shows aproximate stratigraphical positions of Samples.
A: Northern part of the Natsui-gawa fault in the Kuji basin.
B: Southern part of the fault.

Procedure of Study

Sampling and preparation

About 70 smaples composed of coal, coally shale, siltstone and sandy siltstone were collected from the Kuji group, and were macerated. Of them 17 samples contain well-preserved spores and pollen, which show common occurrence suitable for the present study. Of these 17 samples ten were from the Tamagawa, and seven were from the Sawayama formation. Few spores and pollen are found from the Kunitan formation.

Crushed samples were macerated by the following procedure.

1. Maceration by $KC10_3$ and concentrated HNO_3 for about 40 hours to oxidate humic matter.
2. Treatment by 10% KOH for about one hour in a hot water bath (under 60°C) to dissolve humic acide.
3. Maceration by cold, commercial graded HF to remove mineral matters.
4. Treatment by mixed solution of conc. HCl., conc. HNO_3 and water (HCl : HNO_3 : $H_2 0$ = 1 : 1 : 1) to remove CaF_2 and sulphide minerals for about 5 minutes in a hot water bath (70-80°C).

Residue were mounted in glycerine jelly stained with gentiana violet.

Examination of Samples

A minimum of two preparats were prepared for each sample. Tow hundreds of pollen and spores were counted for each sample, and then the relative abundance of each species was calculated. After counting, at least two preparats were completely scanned to record the presence of any rare species. Through this scanning were found many species which appear to represent characteristics of the Kuji microflora, though they are very rare in occurrence.

The Kuji Microflora

Floral composition

One hundred and six species of pollen and spores were found through this investigation as listed in Table 1. Their occurrence were shown in Table 2.

The relative abundance of species distributed among the major plant taxa in the Kuji group was calculated as shown in Table 3*.

Table 3 shows that the Kuji microflora is composed mainly of pteridophytes, with subordinate gymnosperms and angiosperms. Bryophytes and pteridophytes contain the following common species: *Stereisporites antiquasporites, Lycopodiacidites hamulatis, Gleicheniidites senonicus, G. laetus, Cardioangulina diaphana, Deltoidospora cascadensis, D. nodaense, Laevigato-*

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* For a reference the species composition of the Hakobuchi microflora by Takahashi (1964) was also shown together, calculated by the author.

Table 1. List of Sporomorphs from the Kuji Group

Division Bryophyta
- Class Music
  - Family Sphagnaceae
    - Genus *Stereisporites* PFLUG 1953
      - *Stereisporites antiquasporites* (WIL. & WEB.) POTONIÉ
      - *Stereisporites apolaris* (REINHARDT) n. comb.
      - *Stereisporites grossus* TAKAHASHI
      - *Stereisporites* sp.

Division Trachophyta
- Class Lycopodinae
  - Family Lycopodiaceae (Provisional assignment)
    - Genus *Lycopodiacidites* (COUPER) POTONIÉ 1956
      - *Lycopodiacidites hamulatis* (KRUTZSCH) KLAUS
      - *Lycopodiacidites amplus* (STANLEY) n. comb.
- Class Filicinae
  - Family Osmundaceae (Provisional assignment)
    - Genus *Osmundacidites* COUPER 1953
      - *Osmundacidites wellmanii* COUPER
      - *Osmundacidites alpinus* KLAUS
    - Genus *Todisporites* COUPER 1958
      - *Todisporites major* COUPER
  - Family Gleicheniaceae (Provisional assignment)
    - Genus *Gleicheniidites* ROSS 1949
      - *Gleicheniidites senonicus* ROSS
      - *Gleicheniidites laetus* (BOLKH.) KRUTZSCH
      - *Gleicheniidites circinidites* (COOKSON) KRUTZSCH
      - *Gleicheniidites marginatus* TAKAHASHI
      - *Gleicheniidites* cf. *delicatus* (BOLKH.) KRUTZSCH
      - *Gleicheniidites* cf. *echinatus* (BOLKH.) KRUTZSCH
  - Family Schizaeaceae (Provisional assignment)
    - Genus *Appendicisporites* WEYLAND & KRIEGER 1953
      - *Appendicisporites tricornitatus* WEYLAND & GREIFELD
      - *Appendicisporites ethmos* DELCOURT & SPRUMONT
      - *Appendicisporites* cf. *potomacensis* BRENNER
      - *Appendicisporites* sp. A
      - *Appendicisporites* sp. B
    - Genus *Cicatricosisporites* POTONIÉ & GELLETICH 1932
      - *Cicatricosisporites australiensis* (COOKSON) POTONIÉ
      - *Cicatricosisporites mediostriatus* (BOLKH.) POCOCK
      - *Cicatricosisporites* cf. *dorogensis* POTONIÉ & GELLETICH
      - *Cicatricosisporites* sp.
    - Genus *Ischyosporites* BALME 1957
      - *Ischyosporites* sp.
    - Genus *Reitculosporis* KRUTZSCH 1959
      - *Reticulosporis* sp.
  - Family Dicksoniaceae (Provisional assignment)
    - Genus *Trilites* ERDTMAN ex COUPER emend. DETTMAN 1963
      - *Trilites* sp. A
      - *Trilites* sp. B

Trilites sp. C
Family *Cyatheaceae* (Provisional assignment)
Genus *Cyathidites* COUPER 1953
Cyathidites australis COUPER
Family Matoniaceae (Provisional assignment)
Genus *Matonisporites* COUPER 1958
Matonisporites ? sp.
Family Polypodiaceae (Provisional assignment)
Genus *Laevigatosporites* (IBRAHIM) emend. SCHOPF, WILSON & BENTALL 1944
Laevigatosporites ovatus WILSON & WEBSTER
Laevigatosporites haardti (POT. & VEN.) THOMSON & PFLUG
Genus *Polypodiidites* ROSS 1949
Polypodiidites sp. A
Polypodiidites sp. B
Genus *Reticuloidosporites* THOMSON and PFLUG 1953
Reticuloidosporites sp.
Spores-Incertae Sedis
Genus *Balmeisporites* COOKSON & DETTMAN 1958
Balmeisporites minutus BRENNER
Genus *Biretisporites* DELC. & SPRUM. emend. DELCOURT, DETTMAN & HUGHES 1963
cf. *Biretisporites Potoniaei* DELCOURT & SPRUMONT
Genus *Cardioangulina* (Malawkina) POTONIÉ 1960
Cardioangulina diaphana (WIL. & WEB.) STANLEY
Genus *Ceratosporites* COOKSON & DETTMAN 1958
Ceratosporites ? sp.
Genus *Cingulatisporites* THOMSON emend. POTONIÉ 1956
Cingulatisporites distaverrucosus BRENNER
Genus *Deltoidospora* MINER emend. POTONIÉ 1956
Deltoidospora cascadensis MINER
Deltoidospora psilotoma ROUSE
Deltoidospora nodaense n. sp.
Deltoidospora cf. *rhytisma* ROUSE
Genus *Foveosporites* BALME 1957
Foveosporites sawayamaensis n. sp.
Foveosporites sp.
Genus *Granulatisporites* (IBRAHIM) POTONIÉ & KREMP 1954
Granulatisporites sp.
Genus *Jimboisporites* SOHMA 1969
Jimboisporites kujiensis SOHMA
Jimboisporites senonicus n. sp.
Genus *Leiotriletes* NAUMOVA ex POTONIÉ & KREMP 1954
Leiotriletes sphaerotriangulus (LOOSE) POTONIÉ & KREMP
Leiotriletes minutus (KNOX) POTONIÉ & KREMP
Leiotriletes sp.
Genus *Punctatisporites* (IBRAHIM) POTONIE & KREMP 1955
Punctatisporites punctulatus TAKAHASHI
Punctatisporites sp. A
Punctatisporites sp. B
Genus *Regulatisporites* THOMSON & PFLUG 1953
Rugulatisporites sp.

Genus *Toroisporis* sp.
Toroisporis sp.
Genus *Uveaesporites* DÖRING 1965
Uveaesporites simplex (MULLER) n. comb.
Uveaesporites margaritatus (MULLER) n. comb.
Genus *Schizosporis* COOKSON & DÖRING 1959
Schizosporis scabratus STANLEY
Spore Type A
Spore Type B

Class Gymnospermae
Order Cycadales
Family Cycadaceae (Provisional assignment)
Genus *Cycadopites* (WODEHOUSE) WILSON & WEBSTER 1946
Cycadopites cf. *follicularis* WILSON & WEBSTER
Order Ginkgoales
Family Ginkgoaceae (Provisional assignment)
Genus *Monosulcites* COOKSON ex COUPER 1953
Monosulcites epakros BRENNER
Order Caytoniales
Family Caytoniaceae
Genus *Vitreisporites* LESCHIK emend. JANSONIUS 1962
Vitreisporites pallidus (REISINGER) NILLSON
Order Coniferales
Family araucariaceae
Genus *Araucariacites* COOKSON ex COUPER 1953
Araucariacites australis COOKSON
Araucariacites limbatus (BALME) HABIB
Family Pinaceae
Genus *Pityosporites* SEWARD emend. MANUM 1960
Pityosporites constrictus (PIERCE) n. comb.
Genus *Abietineaepollenites* POTONIÉ 1959
Abietineaepollenites sp.
Genus *Piceaepollenites* POTONIÉ 1931
Piceaepollenites saccellus TAKAHASHI
Genus *Cedripites* WODEHOUSE 1933
Cedripites sp.
Family Podocarpaceae
Genus *Podocarpidites* COOKSON emend. POTONIE 1958
Podocarpidites ezoensis (SATO) n. comb.
Coniferales – Incertae Sedis
Genus *Inaperturopollenites* PFLUG & THOMSON 1953
Inaperturopollenites sp.
Genus *Classopollis* PFLUG emend. POCOCK & JANSONIUS 1961
Classopollis sp.
Genus *Rugubivesiculites* PIERCE 1961
Rugubivesiculites fluens PIERCE
Order Gnetales
Family Ephedraceae
Genus *Ephedripites* BOLKHOVITINA 1953
Ephedripites sp.
Class Angiospermae

Subclass Monocotyldones (Provisional assignment)
- Genus *Monocolpopollenites* PFLUG & THOMSON 1953
  - *Monocolpopollenites kyushuensis* TAKAHASHI
  - *Monocolpopollenites* cf. *universalis* TAKAHASHI
  - *Monocolpopollenites pflugii* TAKAHASHI
- Genus *Spinizonocolpites* MULLER 1968
  - *Spinizonocolpites echinatus* MULLER

Subclass Dicotyldones

Family-Incertae Sedis
- Genus *Retitricolpites* VAN DER HAMMEN ex PIERCE 1961
  - *Retitricolpites vulgaris* PIERCE
  - *Retitricolpites* cf. *prosimilis* NORRIS
  - *Retitricolpites* sp. A
  - *Retitricolpites* ? sp.
- Genus *Tricolpopollenites* PFLUG & THOMSON 1953
  - *Tricolpopollenites minutiretiformis* TAKAHASHI
  - *Tricolpopollenites vulgaris* TAKAHASHI
  - *Tricolpopollenites micromunus* GROOT & PENNY
  - *Tricolpopollenites* cf. *simplicissimus* GROOT, PENNY & GROOT
  - *Tricolpopollenites* cf. *meinohamensis rotundus* TAKAHASHI
  - *Tricolpopollenites* sp. A
  - *Tricolpopollenites* sp. B
  - *Tricolpopollenites* sp. C
  - *Tricolpopollenites* sp. D
- Genus *Tricolpites* COOKSON ex COUPER 1953
  - *Tricolpites* sp. A
  - *Tricolpites* sp. B
  - *Tricolpites* sp. C
- Genus *Tricolporopollenites* PFLUG & THOMSON 1953
  - *Tricolporopollenites* sp.
- Genus *Triporopollenites* PFLUG & THOMSON 1953
  - *Triporopollenites shimensis* TAKAHASHI
  - *Triporopollenites* sp.

Pollen-Incertae Sedis
- Genus *Accuratipollis* CHLONOVA 1961
  - *Accuratipollis evanidus* CHLONOVA
- Genus *Ocellipollis* CHLONOVA 1961
  - *Ocellipollis obliquus* CHLONOVA
- Genus *Tricolpites* COOKSON ex COUPER 1953
  - *Tricolpites* ? sp.
- Pollen Type A
- Pollen Type B

sporites ovatus, L. haardti, Matonisporites ? sp., *Leiotriletes sphaerotriangulus*. A number of species probably referred to the Schizaeaceae were also found, though most of them have few specimens respectively. Four species of *Cicatricosisporites* (*C. australiensis, C. dorogensis, C. mediostriatus* and *Cicatricosisporites* sp.), five species of *Appendicisporites* (*A. tricornitatus, A. ethmos, A.* cf. *potomacensis, Appendicisporites* sp. A and *Appendicisporites* sp.

Table 2. Distribution and Frequency of Sporomorphs from the Kuji Group

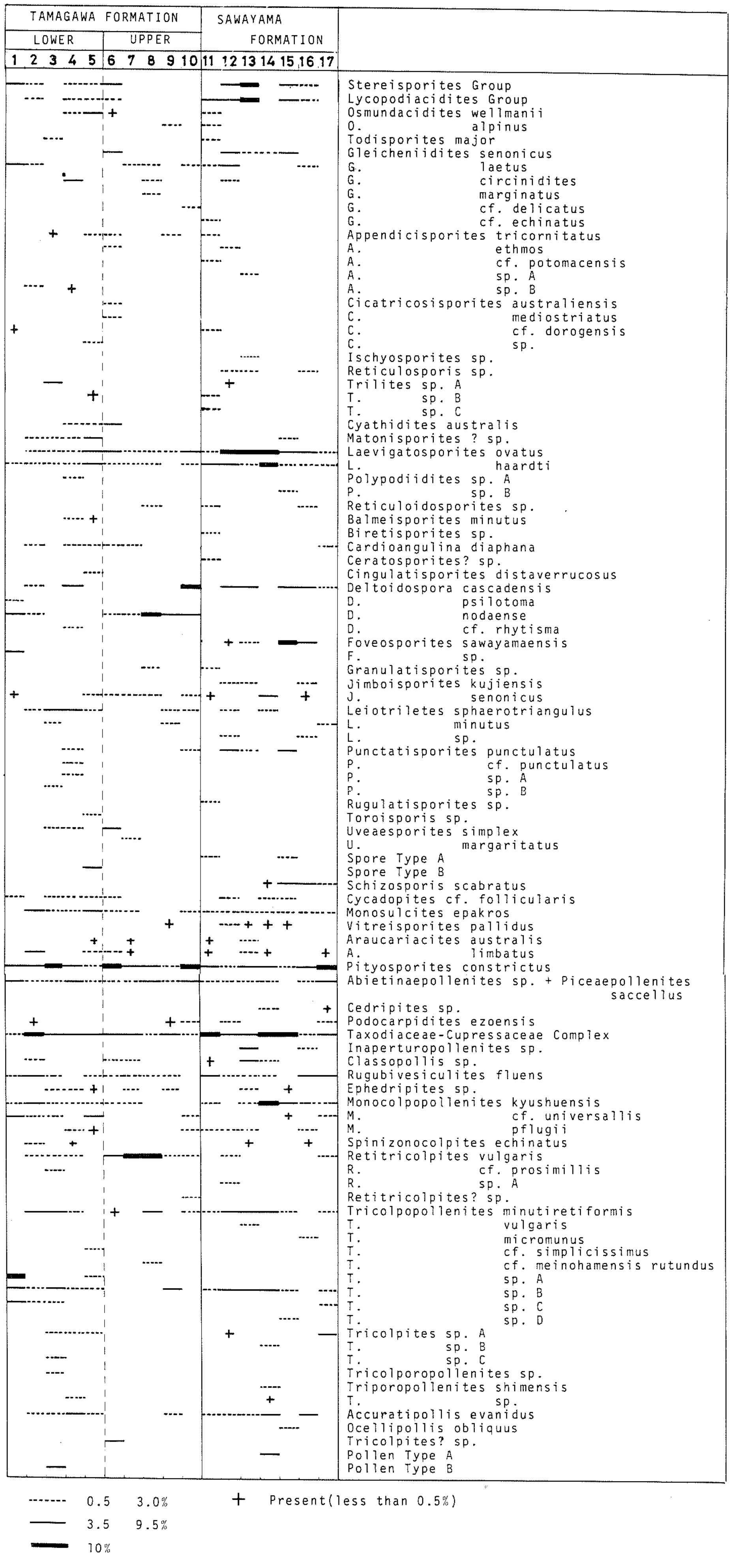


Table 3. Species composition in the microfloras from the Kuji and the Hakobuchi Group

<table>
<tr><th></th><th></th><th colspan="2">Bryophyta & Pteridophyta</th><th colspan="2">Gymnospermae</th><th colspan="2">Angiospermae</th><th colspan="2">Total number of species</th></tr>
<tr><td rowspan="2">Kuji Group</td><td>Sawayama F.</td><td rowspan="2">60%</td><td>57%</td><td rowspan="2">13%</td><td>18%</td><td rowspan="2">22%</td><td>21%</td><td rowspan="2">106</td><td>76</td></tr>
<tr><td>Tamagawa F.</td><td>58%</td><td>16%</td><td>22%</td><td>77</td></tr>
<tr><td rowspan="2">Hakobuchi Group</td><td>Upper Group</td><td colspan="2">40%</td><td colspan="2">12%</td><td colspan="2">48%</td><td colspan="2">50</td></tr>
<tr><td>Lower Group</td><td colspan="2">44%</td><td colspan="2">16%</td><td colspan="2">40%</td><td colspan="2">93</td></tr>
</table>

B), one species of *Reticulosporis* and one species of *Ischyosporites* were found out. In *Gleicheniidites* five species were found. *Cyathidites australis, Balmeisporites minutus, Granulatisporites* sp. *Schizosporis scabratus* were found out, though their occurrence is rare or restricted to a few samples.

Gymnosperms contain abundantly the following characteristic species: *Cycadopites* cf. *follicularis* and *Monosulcites epakros* referred to the Cycadaceae or Ginkgoaceae; *Pityosporites constrictus, Abietineaepollenites* sp. and *Piceaepollenites saccellus* belonging to the Pinaceae, and small inaperturate pollen of the Taxodiaceae or Cupressaceae. Such species as *Rugubivesiculites fluens, Classopollis* sp., *Araucariacites australis* and *A. limbatus,* characterize the Kuji microflora. They are some of the representative Mesozoic conifers, and flourished from Jurassic to Middle Cretaceous time, extinct during the Late Cretaceous in the Northern Hemisphere. *Vitreisporites* (al. *Caytonipollenites) pallidus* was found, though very rare.

Angiosperms are composed almost of tricolpate and monocolpate pollen, and rarely of tricolporate and triporate forms. Principal species are *Retitricolpites vulgaris, Tricolpopollenites minutiretiformis, Tricolpopollenites* sp. A, *Tricolpopollenites* sp. B and *Tricolpites* sp. A. Such species probably referred to monocotyledon as *Monocolpopollenites kyushuensis* and *M. pflugii* were also commonly found.

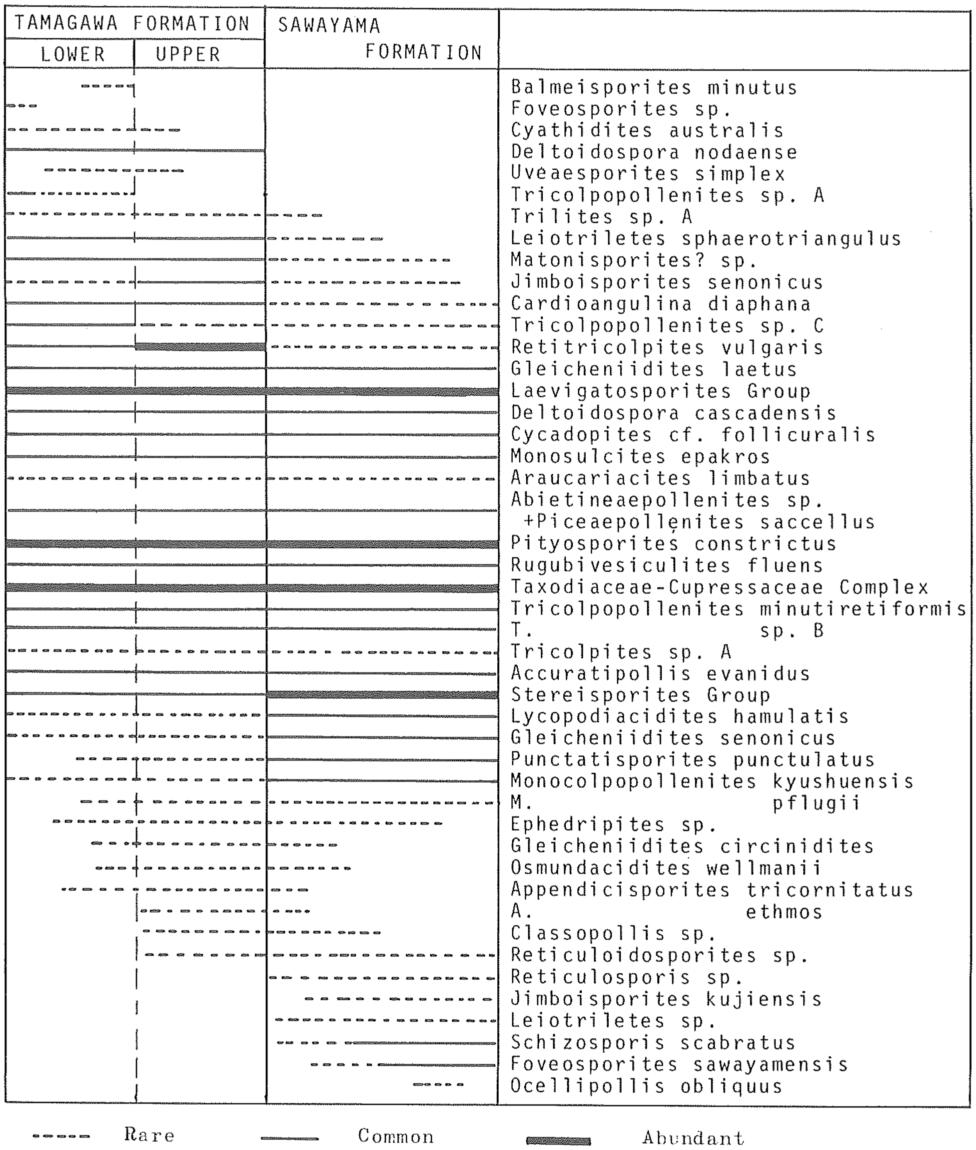
Accuratipollis evanidus is found in many samples, though its taxonomical relationship is uncertain. The genus *Accuratipollis* is represented by morphorogical type as "Unica" group defined by CHLONOVA (1961, 1962) together with the genus *Aquilapollenites.* It is noteworthy that the Kuji microflora has no pollen referred to the genus *Aquillapollenites,* which is usually found from Latest Cretaceous sediments of East Asia and western North America. In the samples from the Sawayama formation *Ocellipollis obliquus* was also found.

Stratigraphical Distribution of the Kuji Sporomorphae

Of 106 sporomorphae making up the Kuji microflora, 48 species are common between the Tamagawa and the Sawayama formations. Thirty-one are restricted to the Tamagawa, while 27 are restricted to the Sawayama formation. Considering the limited occurrence and relative abundance of all species determined, 46 species listed in Text-figure 3 seem important for stratigraphic consideration, and some are useful to characterize the Sawayama and the Tamagawa formations respectively. Most of species limited in occurrence to either of these two formations, are very few in number of specimens, but several species are useful for discriminating the spores and pollen assemblage. For instance, they are *Cyathidites australis, Balmeisporites minutus, Deltoidospora nodaense, Foveosporites* sp., *Uveaesporites simplex, Tricolpopollenites* sp. A in the Tamagawa, while *Reticulosporis* sp., *Jimboisporites kujiensis, Foveosporites sawayamaensis, Leiotriletes* sp., *Schizosporis scabratus, Ocellipollis obliquus* in the Sawayama formation. Of 48 species common between these two formations, there are several useful species, which are abundantly found only in either of these two. They are *Appendicisporites tricornitatus, Leiotriletes sphaerotriangulus, Jimboisporites senonicus, Cardioangulina diaphana, Araucariacites limbatus, Retitricolpites vulgaris* in the Tamagawa, while *Stereisporites* group, *Lycopodiacidites hamulatis, Gleicheniidites senonicus, Punctatisporites punctulatus, Monocolpopollenites kyushuensis* in the Sawayama formation.

Deltoidospora nodaense seems an useful indicator of the Tamagawa formation. *Cyathdites australis, Balmeisporites minutus* and *Retitricolpites vulgaris* restricted to or common in the Tamagawa, have been usually known from the Lower and Middle Cretaceous of the world. *Balmeisporites minutus* was reported from the Middle Cretaceous of Peru (BRENNER, 1968). *Retitricolpites vulgaris* originally described from the Cenomanian of Minnesota (PIERCE, 1961), was reported from the Middle Cretaceous of Alberta (NORRIS, 1967), and was recently reported from the Cretaceous to Tertiary sediments in Sarawak, Malaysia (MULLER, 1968). According to MULLER, it is especially abundant from the Cenomanian to the Turonian in Sarawak, but is rare from the younger sediments.

No spores similar to *Jimboisporites kujiensis* and *Foveosporites sawayamaensis* are known from the Cretaceous of the Northern Hemisphere. *Schizosporis scabratus* was reported from the Hell Creek formation (Maestrichtian) of South Dakota, the United States (STANLEY, 1965). *Lycopodiacidites hamulatis, Punctatisporites punctulatus, Monocolpopollenites kyushuensis* and *Ocellipollis obliquus* have been known from the Latest Cretaceous to the Tertiary. Though *Lycopodiacidites hamulatis* was at first



Text-figure 3. Occurrence of representative Sporomorphs in the Kuji Group.

reported from Tertiary sediments in Germany (KRUTSZCH, 1959), it was later reported from the Maestrichtian of South Dakota (STANLEY, 1965). The genus *Ocellipollis* belongs to a morphological type, "Oculata" group (CHLONOVA, 1961, 1962). "Oculata" group along with "Unica" group, has been known from Late Senonian to Paleocene sediments in East Asia and in western North America. *Ocellipollis obliquus* was reported from the Upper Cretaceous sediments in Vilyuisk depression, eastern Siberia (CHLONOVA, 1966).

It appears possible to distinguish these two formations on the basis of the age distribution of the characteristic species discussed above: the Tamagawa formation contains Early to Middle Cretaceous sporomorphae, while the Sawayama contains Latest Cretaceous to Early Tertiary sporomorphae. However, these two assemblages show a gradual floral change with a number of common species as shown in Text-figure 3.

Comparison of the Kuji microflora with Cretaceous microfloras of East Asia

Only a few palynological studies on the Upper Cretaceous have been published in Japan. But Late Cretaceous palynology of East Asia, especially of eastern Siberia, has been done by many Russian investigators. In North America many contributions have been also published, but no studies on the Turonian and the Senonian have been published as far as the writer concerns.

TAKAHASHI (1964) studied on the Hakobuchi group (Campanian to Maestrichtian) in Hokkaido and revealed two assemblages; the Lower Hakobuchi and the Upper Hakobuchi spores and pollen assemblages. In the Lower Hakobuchi assemblage angiosperms are abundantly contained as much as pteridophytes in number of species. Spore belonging to the Schizaeaceae such as *Appendicisporites* or *Cicatricosisporites* is almost absent, and diverse species of the Osmundaceae are found. *Apiculatisporites inouei, Baculaisporites papillosus* and *B. validus* occur commonly. The Lower Hakobuchi assemblage contains no gymnosperm pollen such genera as *Araucariacites, Rugubivesiculites* and *Classopollis,* which are found commonly in the Kuji assemblage. On the one hand, it has commonly angiosperm pollen of porate form such as *Alnipollenites eminesis, Betulaepollenites normalis, Momipites constatus* and others. Diverse species of *Aquilapollenites* are also commonly found.

The Lower Hakobuchi assemblage may represent a younger vegetation than the Kuji assemblage in abundant occurrence and taxonomic diversity of angiosperm pollen. On the other hand, older ferns and conifers such as *Araucariacites, Rugubivesiculites* are represented by sparse specimens. These facts show that the Kuji microflora is older than the Lower Hakobuchi assemblage which has been assigned to the Campanian.

The Cenomanian to Turonian spores and pollen assemblage was described from the lower part of the Zabitinsk formation of the Zeya-Bureya depression in eastern Russia (BRATZEVA, 1969), and it is characterized by diversity of the Schizaeaceous spores, by a few angiosperms, and by no pollen of "Unica" type. This assemblage is older than the Kuji microflora, comparing their floral composition. SUKURATENKO (1969) revealed three floristic types of Turonian spores and pollen assemblage latitudinally distributed in West Siberia Lowland.

The two assemblages excluding the northern type are similar to the Kuji microflora with sparse representation of angiosperms including the tricolpate forms. But they contain diverse spores belonging to the Schizaeaceae, especially to the genus *Lygodium*. *Stenozonotriletes radiatus*, *Taurocusporites reduncus* and *Cingulatisporites* (al. *Rouseisporites*) *euskirchensoides* are frequently found; these three spores were commonly known from the Middle or Lower Cretaceous. Pollen of "Unica" and "Oculata" types are almost absent. Accordingly the Kuji microflora is considered to be younger than the Turonian assemblage of West Siberia Lowland.

Spores and Pollen assemblage from the Upper Santonian sediments in Khatanga depression was reported by BONDARENKO (1958, in POKLROVSKAYA ed., 1966). BOLCHOVITINA (1959) reported the Lower Senonian spores and pollen assemblage in Vilyuisk depression. These two spores and pollen assemblages are generally similar to the Kuji in floral composition, but they are poorer in angiosperms pollen. Angiosperms from the Khatanga depression show only a few per cent of the total sporomorphae number, and those from the Vilyuisk depression attain 11 per cent in maximum, including rarely pollen of porate forms.

BRATZEVA (1965, 1969) and CHLONOVA (1969) reported several spores and pollen assemblages from the Cretaceous sediments in Zeya-Bureya depression in eastern Russia. According to CHLONOVA (1969) the assemblage from the upper part of the Zabitinsk formation has some characteristic features in composition as follows:

1) Spores belonging to the Schizaeaceae are always recognized; especially *Schizaea dorogensis* and the genus *Pelletieria* are common. Spores referred to *Lygodium* are nearly absent. The Lower Cretaceous spores such as *Rouseisporites* and *Aequitriradites* are rarely found.

2) Among gymnosperms, pollen of the Taxodiaceae and Cupressaceae, and bivesiculate pollen of the Pinaceae are dominant. The genera such as *Caytonia* and *Classopollis* are rarely recognized.

3) Angiosperm pollen grains make 5 to 28 per cent of the total spores and pollen. No pollen grains are referred to the modern genera. Tricolpate pollen with smooth or reticulate exine and the genus *Gothanipollis* are commonly contained.

4) Pollen of "Unica" type such genera as *Aquilapollenites* and *Fibulapolli* is found.

The "Upper Zabitinsk assemblage" has common features in floral composition with the Kuji: Early and Latest Cretaceous (especially Late Senonian) sporomorphase are contained; angiosperm pollen is not abundant, and pollen of porate forms are especially of rare occurrence. Accordingly, the Kuji microflora is closely similar in floral composition to the "Upper Zabitinsk assemblage", which has been assigned to Early Senonian in age.

It is noteworthy that angiosperms of the assemblages from Khatanga and Vilyuisk depressions are less in number of specimens and contain less diverse taxa than those of the assemblage from Zeya-Bureya depression, though the former two have been judged approximately contemporaneous with the latter. MARKOVA (1961) stated that the appearance and dispersion of angiosperms in northern Siberia was at later stage than in southern Siberia. POKROVSKAYA (1966) also pointed out that the spores and pollen assemblages of Cenomanian to Santonian show higher frequency of angiosperms in southern Siberia than in northern Siberia. In this connection she described that the assemblages representing nearly similar percentage of angiosperms pollen were distributed approximately parallel to the latitude during Late Cretaceous time. Some recent paleobotanical studies reveal that the latitudinal differences in floral composition should be taken into consideration when comparisons are made between floras for purposes of correlation. SAMOILOVICH (1967) proposed two floral provinces in Siberia during Late Senonian to Danian time: the Khatange-Lena and the Yenisey-Amur provinces. The former appears to have been under warm to temperate, and rather dry climate; the later province situated south of the former, tropical to subtropical in climate. VAKRAMEEV (1964, in SMILEY, 1967) demonstrated that macrofossil floras in Eurasia were distinguished into northern (cooler) and southern (warmer) types, during Jurassic to Middle Cretaceous time and that the boundary between two provinces in each age was approximately parallel to each other and migrated northwards. Based on investigation of Cretaceous macroplants in Alaska, SMILEY (1969) emphasized that the latitudinal differences of floral composition should considered when correlations were based on floral records. As already pointed out by many authors (AXELROD, 1959, and others), recent paleobotanical evidences favor the inference that angiosperms evolved at the lower latitudinal region during Middle Jurassic time, and then gradually dispersed northward with increasing number and diversity in the Northern Hemisphere.

Taking the latitudinal difference into account, it can be naturally accepted that the Kuji microflora is most closely similar in composition to the "Upper Zabitinsk assemblage" from Zeya-Bureya depression.

Discussion of Age of the Kuji Group

The definite age of the Kuji group has been still in question, because no marked macro-fossils have been known except from the marine Kunitan formation. The following leading fossils have been reported from the Kunitan formation by SASA (1932) and SHIMAZU and TERAOKA (1961): *Inoceramus japonicus* NAGAO et MATSUMOTO, *I. naumanni* YOKOYAMA, *Polyptychoceras subundulatum* YOKOYAMA, *Gaudryceras denseplicatum* (JIMBO) and *Texanites amakusense* (YABE). Several fossil plants from the Tamagawa and the Sawayama formations have been reported by SASA (1932), and they are recently reinvestigated by TANAI* on the basis of his additional collection. From the Tamagawa formation the following plants are noteworthy: *Osmunda asuwaensis* MATSUO, *Gleichenia lineariformis* KRYSHT., *G. sachalinensis* KRYSHT., *Cladophlebis acuta* FONTAINE, *Zamiophyllum* cf. *becheii* ETTINGS. and *Araucarites anadyrensis* KRYSHT. From the Sawayama formation there are also known many species: *Asplenium dicksonianum* Heer, *Cladophlebis frigida* (HEER) SEWARD, *Otozamites schenki* (HEER) TANAI, *Araucarites kujiensis* TANAI (MS), *Salix lancensis* BERRY, and many angiosperms.

Based on the fossil fauna and floras, SASA (1932) estimated the Kuji group to be Urakawan (Senonian) in age. He suggested that the Sawayama flora may be somewhat older though comparable with the Hakobuchi flora of Hokkaido. MATSUMOTO (1954) summarized Cretaceous biostratigraphy of Japan on the basis of his extensive investigation; the Kuji group including the Kunitan fauna was assigned to $K5\alpha-\gamma-K6\alpha$ (Santonian to Campanian) in his division of the Cretaceous.

As discussed in the preceding pages, the Kuji microflora is older than the Lower Hakobuchi assemblage, younger than Turonian assemblage from West Siberia Lowland. It is most similar to lower Senonian "Upper Zabitinsk assemblage" from the Zeya-Bureya depression and is dated as Lower Senonian. This age assignments by palynological evidence does not contradict with that of paleontological evidences once discussed.

Systematic Descriptions

From the Kuji microflora are described 106 sporomorphae. Regarding the nomenclature and taxonomy of fossil spores and pollen, the author considers to be ideally based on natural taxonomic system as similar as in the case of megafossil plants. However, our morphological informations of sporomorphae are usually too incomplete to apply the natural system in the case of pre-Quaternary sporomorphae. Especially, Cretaceous spores and pollen are very difficult to find the definite relationships with those of the modern plants;

* Oral comunication from Dr. T. Tanai

they are largely not assignable to the modern genera, and even to the modern families only by morphological characters. Until the taxonomic informations are sufficiently accumulated, it seems unavoidable to adopt the morphological system of nomenclature for Cretaceous spores and pollen, especially below the rank of the family.

In this paper the author used organ- and form-genera. The genera assignable to the families of natural system are grouped under each family as organ-genera, while the remaining genera are placed under the higher taxonomic ranks as form-genera. The assignment of the organ-genera to families of natural system followed the original description.

Dimensions of sporomorphae are given in a series of two or three numbers. When two numbers are given, the first shows the minimum value and the second shows the maximum value. When three numbers are given, the central number shows the arithmetic mean. In the case of subspheroidal pollen grains polar and equatorial diameters are given by multiplication formulas; the first number is polar diameter and the second is equatorial. The specimen frequency denotes the percentage for the 200 sporomorphae counted in a sample, and are shown by the following terms:

rare . . . . .less than 3 per cent
common . . . . 3.5 – 9.5 per cent
abundant . . . . .10 – 19.5 per cent
very abundant . . . . greater than 20 per cent

Sample numbers described in this chapter correspond with numbers shown in Figures 1, 2 and Table 2, as follows:

DIVISION BRYOPHYTA

Class MUSIC

Family SPHAGNACEAE

Genus *Stereisporites* PFLUG 1953

Stereisporites antiquasporites (WIL. & WEB.) DETTMAN

Pl. 1, Figs. 1-4.

1963 *Stereisporites antiquasporites* (WIL. & WEB.) DETTMAN, Proc. Roy. Soc. Victoria, vol. 77, p. 25, pl. 1, figs. 20-21.

1946 *Sphagnum antiquasporites* WILSON & WEBSTER, Am J. Botany, vol. 33, p. 273, fig. 2.

Size: 20-32-41 μ in equatorial diameter.

Remarks: The specimens from the Kuji group have slightly thinner exine, compared with those described by WILSON and WEBSTER (1946). *S.*

antiquasporites is similar to *Stereisporites pseudostereoides* TAKAHASHI from the Hakobuchi group (Campanian-Maestrichitian) in Hokkaido (TAKAHASHI, 1964) and *S. apsilatus* KRUTSZCH from the Tertiary of Germany (KRUTSZCH, 1959); but is smaller than the former and is larger than the latter.

Occurrence: Common both from the Tamagawa and the Sawayama formations.

Stereisporites apolaris (REINHARDT) n. comb.

Pl. 1, fig. 5.

1961 *Sphagnumsporites apolaris* REINHARDT, Monatsbers. Deut. Akad. Wiss. bd. 3, p. 705, pl. 1, fig. 13.

1953 cf. *Sphagnites australis* (COOKSON) f. *parva* COOKSON, Australian J. Botany, vol. 1, p. 469, pl. 2, figs. 25-26.
cf. *Sphagnites australis* (COOKSON) f. *crassa* COOKSON, Australian J. Botany, vol. 1, p. 464, pl. 1, fig. 24.

1959 *Sphagmum saflavum* BOLKHOVITINA, Tr. Inst. Geol., Akad. Nauk S.S.S.R., vol. 24, pl. 1, figs. 3a, 3c.

1963 *Stereisporites antiquasporites* (WIL. & WEB.) DETTMAN, Proc. Roy. Soc. Victoria, vol. 77, pl. 1, figs. 20, 21.

1963 *Sphagnumsporites antiquasporites* (WIL. & WEB.) POTONIÉ, Brenner, Dep. Geol. Min. Water resources Bull. 27, p. 41, pl. 4, fig. 1.

Size: 23-25-30 μ in equatorial diameter.

Remarks: Several specimens are referred to *Sphagnumsporites apolaris* originally described by REINHARDT (1961), though they have slightly thicker exine. BRENNER (1963) added distal polar thickenings to a morphorogical character of *Sphagnumsporites antiquasporites* (WIL. & WEB.) POTONIÉ, because he observed this feature on the figure of the holotype of *Sphagnum antiquasporites* WIL. & WEB. DETTMAN (1963) also did so but did not describe the reason. But the author can not agree with them, because such a feature is not found on the figure by WILSON and WEBSTER (1946). Before their works were done, REINHARDT (1961) established new species *Sphagnumsporites apolaris* which has distal polar thicknnings and is similar to *Stereisporites antiquasporites* (WIL. & WEB.) DETTMAN in the other features. The specimens of *S. antiquasporites* which has distal polar thickenings, should be assigned to *Stereisporites apolaris* (REINHARDT).

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Stereisporites grossus TAKAHASHI

Pl. 1, Figs. 6-8.

1964 *Stereisporites grossus* TAKAHASHI, Mem. Fac. Sci. Kyushu Univ., Ser. D, vol. 14, no. 3, p. 197, pl. 24, figs. 13-15.

Size: 40-50 μ in equatorial diameter.

Remarks: A number of specimens from the Sawayama formation are referred to *Stereisporites grossus* originally described by TAKAHASHI (1964) in their size and thick exine. Some specimens are raised in the commissures, and are rarely thickened in the exine at the distal polar area. This species is similar to *Sphagnum pedatiformis* BOLKHOVITINA from the Upper Cretaceous sediments in Vilyuisk basin, Siberia (BOLCHOVITINA, 1959), but is larger in size than the Siberian species (30-34 μ).

Occurrence: Abundant only in a sample (no. 68041604) from the Sawayama formation.

Stereisporites sp.

Pl. 1, Figs. 9, 10.

Description: Trilete spore; outline subcircular to subtriangular in polar view; exine psilate, trancelucent, very thin; trilete rays indistinct, simple, approximately 1/2-1/3 length of spore radius.

Size: 33-40 μ in equatorial diameter.

Remarks: The present species is different from other similar species assigned to the genus *Stereisporites* by its very thin exine and relatively larger size.

Occurrence: Very few from a sample (no. 68041604) of the Sawayama formation.

PHYLUM TRACHEOPHYTA

Class LYCOPODIACEAE

Family LYCOPODIACEAE (Provisional assignment)

Genus ***Lycopodiacidites*** (COUPER) POTONIÉ, 1956

Lycopodiacidites hamulatis (KRUTZSCH) KLAUS

Pl. 1, Figs. 11-13.

1960 *Lycopodiacidites hamulatis* (KR.) KLAUS, Jahrb. Geol. Bundesanstalt

(Austria), sonderber. vol. 5, p. 134.
1959 *Hamulatisporis hamulatis* KRUTSZCH, Geol. beih. 21, p. 157, pl. 29, figs. 326-328.

Size: 25-32-41 μ in equatorial diameter.

Remarks: Some specimens are thickened in flange-like equatorial exine of the interradial area, and may be assigned to the genus *Camarozonosporites* (POTONIÉ) KLAUS. The author is of opinion that *L. hamulatis* and *L. amplus* (STANLEY) n. comb. show a transitional form between *Lycopodiacidites* and *Camarozonosporites.*

Lycopodiacidites hamulatis is similar to *Camarozonosporites rudis* (LESCHIK) KLAUS from the Triassic of Switzerland (KLAUS, 1960) and *C. dakotaensis* AGASIE from the Cenomanian of Arizona, U.S.A. (AGASIE, 1969). But *L. hamulatis* has no flange-like thickenning of equatorial exine on interradial regions or is even weakly developed. It has no distinct lips bordering commissures.

Occurrence: Rare from the Tamagawa formation; common from the Sawayama formation.

Lycopodiacidites amplus (STANLEY) n. comb.
Pl. 1, Figs. 14, 15

1965 *Hamulatisporis amplus* STANLEY, Bull. Am. Paleontol., vol. 49, no. 222, p. 242, pl. 29, figs. 1-6.

Size: 40-50-63 μ in equatorial diameter.

Remarks: Genus *Hamulatisporis* KRUTZSCH is synonym of genus *Lycopodiacidites* (COUPER) POTONIÉ, The Kuji spores are slightly smaller than the American specimens. Some specimens have thickened distal exine on the interradial regions. This species is similar to *L. kupperi* KLAUS from the Triassic of Switzerland (KLAUS, 1960) but is distinguishable by absence of margo in laesurae, and also by more distinctly hamulated distal sculpture.

Occurrence: Abundant only in a sample (no. 68041604) from the Sawayama formation.

Class FILICINEAE
Family OSMUNDACEAE (Provisional assignment)
Genus ***Osmundacidites*** COUPER 1953
Osmundacidites wellmanii COUPER
Pl, 1, Figs. 16, 17

1953 *Osmundacidites wellmanii* COUPER, New Zealand Geol. Surv., Paleontol. Bull. 22, p. 20, pl. 1, fig. 5.

Size: 35-42-50 μ in equatorial diameter.

Remarks: A few specimens from the Kuji group refered to this species are thin (ca. 0.5 μ) and finely granulate in the exine. Some of them are similar to *Baculatisporites papillosus* TAKAHASHI described from the Lower Hakobuchi group (Campanian) of Hokkaido (TAKAHASHI, 1964).

Occurrence: Rare from the Tamagawa and the Sawayama formations.

Osmundacidites alpinus KLAUS
Pl. 1, Fig. 18

1960 *Osmundacidites alpinus* KLAUS, Jahrb. Geol. Bundesanstalt (Austria), Sonderber. 5, S. 127, Tf. 31, Fig. 26.

Size: 20-40 μ in equatorial diameter.

Remarks: This species was originally described from the Triassic of Eastern Alps. It is distinguishable from *Osmundacidites wellmanii* COUPER by its smaller size.

Occurrence: Very rare from the Sawayama formation.

Genus ***Todisporites*** COUPER 1958
Todisporites major COUPER
Pl. 1, Fig. 19.

1958 *Todisporites major* COUPER, Palaeontographica, Abt. B. bd. 103, p. 134, pl. 16, figs. 6-8.

Size: 50-68 μ in equatorial diameter.

Remarks: This species is somewhat similar to *Leiotriletes* sp. described in the following pages, but differs in its thinner exine, longer laesurae and slightly larger size.

Occurrence: Only a few from the Tamagawa and the Sawayama formations.

Family GLEICHENIACEAE (Provisional assignment)
Genus ***Gleicheniidites*** ROSS 1949
Gleicheniidites senonicus ROSS
Pl. 2, Fig. 1.

1949 *Gleicheniidites senonicus* ROSS, Bull. Geol. Inst. Upsala, vol. 34, p. 31, pl. 1, fig. 3.

Size: 26-35-41 μ in equatorial diameter.

Remarks: The specimens from the Kuji group are well consistent with specific diagnosis revised by SKARBY (1964).

Occurrence: Rare from the Tamagawa formation; frequent from the Sawayama formation.

Gleicheniidites laetsu (BOLKH.) KRUTZSCH
Pl. 2, Fig. 2.

1959 *Gleicheniidites laetus* (BOLKH.) KRUTZSCH, Geolgie, Beih., 21-22, p. 111.

1953 *Gleichenia laeta* BOLKHOVITINA, Tr. Inst. Geol. Sci., Akad. Nauk. S.S.S.R., Rel. 145, Geol. Ser. no. 61, p. 22, pl. 2, figs. 5-7.

Size: 20-27-35 μ in equatorial diameter.

Remarks: SKARBY (1964) suggested that *Gleichenia laeta* BOLKH. is synonymous with *Gleicheniidites senonicus* ROSS: *G. laeta* may be compared with small, thin-walled *G. senonicus* specimens. In the author's opinion *Gleichenia laeta* is distinguished from *Gleicheniidites senonicus* by the equatorial outline of apices, size and thickenes of exine. Equatorial outline at the apices appears to be angularly arched and somewhat pointed in *G. senonicus,* while it is well rounded in *G. laeta.*

Occurrence: Rare from both the Tamagawa and the Sawayama formations.

Gleicheniidites circinidites (COOKSON) KRUTZSCH
Pl. 2, Fig. 3.

1959 *Gleicheniidites circinidites* (COOKSON) KRUTZSCH, Geologie, Beih., 21-22, p. 113.

1953 *Gleichenia circinidites* COOKSON, Australian J. Botany, vol. 1, no. 3, p. 464, pl. 1, figs. 5, 6.

Size: 23 μ (two specimens) in equatorial diameter.

Remarks: This species is different from other five species of *Gleicheniidites* described in this paper. It is more or less sharply pointed in apices.

Occurrence: Rare from both the Tamagawa and the Sawayama formations.

Gleicheniidites marginatus TAKAHASHI
Pl. 2, Fig. 4.

1964 *Gleicheniidites marginatus* TAKAHASHI, Mem. Fac. Sci., Kyushu Univ., Ser. D, vol. 14, p. 191, pl. 23, figs. 4-17, pl. 40, fig. 1.

Size: 32 μ in equatorial diameter.

Remarks: Only one specimen from the Tamagawa formation, is referred to *G. marginatus* known commonly from the Lower Hakobuchi group (Campanian).

Occurrence: One specimen from the Tamagawa formation.

Gleicheniidites cf. ***delicatus*** (BOLKH.) KRUTZSCH
Pl. 2, Fig. 5.

1959 *Gleicheniidites delicatus* (BOLKH.) KRUTZSCH, Geologie, beih., 21-22, P. 111.

1953 *Gleichenia delicata* BOLKHOVITINA, Tr. Inst. Geol. Sci., Akad. Nauk S. S.S.R., Rel. 145, Geol. ser, no. 61, p. 22, pl. 2, figs. 1-4.

Size: 38, 40 μ (Two specimens) in equatorial diameter.

Remarks: The present specimens are similar to *G. delicatus* (BOLKH.) KR., but the equatorial contour of *G. delicatus* is triangular with slightly convex sides.

Occurrence: Two specimens from a sample (no. 67102901) of the Tamagawa formation.

Gleicheniidites cf. *echinatus* (BOLKH.) KRUTZSCH
Pl. 2, Fig. 6.

1959 *Gleicheniidites echinatus* (BOLKH.) KRUTZSCH, Geologie, Beih., 21-22, p. 114.

1953 *Gleichenia echinata* BOLKHOVITINA, Tr. Inst. Geol. Sci., Akad. Nauk S.S.S.R., Rel. 145, Geol. ser. no. 61, p. 55, pl. 8, fig. 17.

Size: 25-30-37 μ in equatorial diameter.

Remarks: *G. echinatus* (BOLKH.) KR. is more larger in size, and is more distinct in thickening of equatorial exine than Kuji's specimens.

Occurrence: A few from a sample (no. 66081502) of the Sawayama formation.

Family SCHIZAEACEAE (Provisional assignment)
Genus *Appendicisporites* WEYLAND & KRIEGER 1953
Appendicisporites tricornitatus WEYLAND & GREIFELD
Pl. 2, Figs. 7, 8.

1953 *Appendicisporites tricornitatus* WEYLAND & GREIFELD, Palaeontographica, Abt. B, bd. 95, p. 43, pl. 11, fig. 52.

Size: 40-47-52 μ in equatorial diameter.

Remarks: Original description by WEYLAND & GREIFELD (1953) was too unsatisfactory to establish the specific validity. The Kuji specimens are 40-52 μ in maximal diameter. The ribs are 2-3 μ wide, and form 5-6 sets of concentric triangles leaving a contact area free on the proximal face; while 6-7 sets are seen on the distal face. The appendices are 4-8 μ high and 4-7 μ wide in polar view; they are 10-12 μ wide at their bases in lateral view.

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Appendicisporites ethmos DELCOURT & SPRUMONT
Pl. 2, Figs. 9, 10.

1959 *Appendicisporites ethmos* DELCOURT & SPRUMONT, Revision in DELCOURT, DETTMAN & HUGHES, Palaeontology, vol. 6, p. 289, pl. 44, figs. 12, 13.

Size: 40-58 μ in equatorial diameter.

Remarks: These spores are closely similar to *A. tricornitatus* WEYL. & GREIF. excepting for pitted ribs. *A. ethmos* originally described from the Lower Cretaceous of Belgium, has been not yet known from the Upper Cretaceous of the world. The Kuji spores referred to *A. ethmos* may represent the corroded specimens of *A. tricornitatus.*

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Appendicisporites cf. ***potomacensis*** BRENNER
Pl. 2, Figs. 11, 12.

1963 *Appendicisporites potomacensis* BRENNER, Maryland Dep. Geol., Mines Water Resources, Bull. 27, p. 46, pl. 6, figs. 4,5.

Size: 45-51 μ in equatorial diameter.

Remarks: The spores from the Kuji group are closely similar to *A. potomacensis* BRENNER, but have no lip-like structure on the laesurae, which is observed in the original figures by BRENNER (1963).

Occurrence: Rare from the Sawayama formation.

Appendicisporites sp. A
Pl. 3, Figs. 1, 2.

Description: Trilete spore; outline in polar view triangular with straight or slightly convex sides and appendices; Appendices 10-15 μ high and ca. 12 μ wide at their bases; laesurae simple, length 3/4 spore radius, commissures 1-2 μ wide, raised 3 μ high; exine smooth, ornamentation on the distal face composed of ribs; ribs 8-10 μ wide, disposed parallel to the sides in an arrangement of 4-6 sets of concentric triangles, and spaced closely, canals indistinct; while on the proximal face contact area developing widely, only 2-4 sets of proximo-equatorial ribs disposed parallel to the sides in an same arrangement as distal face.

Size: 73-100 μ in equatorial diameter.

Remarks: These spores are different from the above described two species of *Appendicisporites* in their larger size and less developed ornamentation on the proximal face.

Occurrence: A few from a sample (no. 68041604) of the Sawayama formation.

Appendicisporites sp. B
Pl. 3, Fig. 3.

Description: Trilete spore; outline triangular in polar view with straight sides, rounded corners and appendices; appendices 3-8 μ high; laesurae extending over 3/4 radius of spore, commissure undulating; ornamentation composed of ribs; ribs disposed parallel to the sides in a pattern of 3-4 sets of concentric triangles on the distal face; on the proximal face no ornamentation seen, smooth, transparent; ribs 3-4 μ wide and spaced 2 μ apart.

Size: 46-60 μ in equatorial diameter.

Remarks: These spores are different from *Appendicisporites* sp. A in smaller size and no ornamentation on the proximal face.

Occurrence: A few from the Tamagawa formation.

Genus *Cicatricosisporites* POTONIÉ & GELLETICH 1933
Cicatricosisporites australiensis (COOKSON) POTONIÉ
Pl. 2, Figs. 13-14.

1956 *Cicatricosisporites australiensis* (COOKSON) POTONIÉ, Geol. Jahrb., beih., 23, p. 48.

1953 *Mohrioisporites australiensis* COOKSON, Australian J. Botany, vol. 1, p. 470, pl. 2, figs. 31-34.

Size: 55-63 μ in equatorial diameter.

Remarks: The Kuji specimens are fairly reffered to *Mohrioisporites australiensis* described by COOKSON (1953).

Occurrence: A few from a sample (no. 68041706) of the Tamagawa formation.

Cicatricosisporites mediostriatus (BOLKH.) POCOCK
Pl. 4, Fig. 1.

1964 *Cicatricosisporites mediostriatus* (BOLKH.) POCOCK, Grana Palynologica, vol. 5, p. 157, pl. 2, figs. 14-16.

1961 *Pelletieria mediostriata* BOLKHOVITINA, Tr. Geol. Inst., Akad. Nauk S.S.S.R., vol. 40, pl. 19, fig. 3, pl. 21, fig. 1.

Size: 50-60 μ in equatorial diameter.

Remarks: Two specimens from the Kuji group are identical with those from Siberia, U.S.S.R. (BOLKHOVITINA, 1961) and Saskatchewan, Canada (POCOCK, 1964) in their morphological features: especially in their raised (ca. 5 μ high) laesurae (Contact area) and pattern of striae crossing equator.

Occurrence: Rare in a sample (no. 68041706) from the Tamagawa formation.

Cicatricosisporites cf. ***dorogensis*** POTONIÉ & GELLETICH
Pl. 4, Figs. 2, 3.

1932 *Cicatricosisporites dorogensis* POTONIÉ & GELLETICH, Sitszungsber. Ges. Naturf. Freunde zu Berlin, Jhrg. 1932, S. 522, Tf. 1, Figs. 1-5.

Size: 50-55 μ in equatorial diameter.

Remarks: Only two spores are closely similar to *C. dorogensis* POT. & GELL., but they are too ill-preserved to assigne to it.

Occurrence: Rare from the Tamagawa and the Sawayama formations.

Cicatricosisporites sp.
Pl. 4, Fig. 4.

Description: Trilete spore; outline subtriangular with convex sides and rounded apices in polar view; laesurae extending almost to the equator; commissures flanked by narrow, raised lips, about 0.5 μ wide; exine very thin, ornamented with striae; on the distal side striae sculptured faintly, almost reduced on the proximal surface; striae about 1 μ wide; spaced less than 1 μ apart.

Size: 43-45 μ in equatorial diameter.

Remarks: A few specimens from the Tamagawa formation are ill-preserved, and are not evident in a pattern of striae. The adequate morphological informations were unable to obtain for specific comparison.

Occurrence: Rare in a sample (no. 67102510) from the Tamagawa formation.

Genus *Ischyosporites* BALME 1957
Ischyosporites sp.
Pl. 3, Fig. 4.

Description: Trilete spore; outline in polar view subtriangular, slightly convex in sides and broadly rounded in apices; laesurae simple, reaching almost near the equator; distal exine 2-4 μ thick, 8 μ at the apices, ornamented by reticulum, muri 4-8 μ wide, 4-5 μ high; lumina 10-15 μ diameter; proximal face smooth.

Size: Equatorial diameter 120, 125 μ (two specimens).

Remarks: The present specimens differ from other species of *Ischyosporites* in its larger size.

Occurrence: Only three from a sample (no. 68041604) of the Sawayama formation.

Genus *Reticulosporis* KRUTZSCH 1959
Reticulosporis sp.
Pl. 3, Fig. 5.

Description: Monolete spore; outline bean-shaped in lateral equatorial view; exine reticulate, 4μ thick; lumina 5-8 μ in diameter; muri consisting of many small rod-like projections arranged polygonal to circular; projections 2-3 μ high, 2μ wide at base; exine sometimes covered with perispore; monolete mark distinct, about 3/4 length of major axis.

Size: 93-116 × 32-45 μ in equatorial diameter, 63-80 μ in polar diameter.

Remarks: These spores are similar to *Shizaea plectilis* STANLEY and *S. triangula* STANLEY from the Upperemost Cretaceous and the Paleocene of South Dakota, U.S.A. (STANLEY, 1965), *Retimonoletes foveolatus* PIERCE from the Cenomanian of Minnesota, U.S.A. (PIERCE, 1961), and to some species of *Reticulosporis* KRUTZSCH(KRUTZSCH, 1967). Our specimens are distinguishable from these species in their muri consisting of rod-like projections.

Occurrence: Rare from the Sawayama formation.

Family DIKSONIACEAE (Provisional assignment)
Genus *Trilites* ERDTMAN ex COUPER emend. DETTMAN 1963
Trilites sp. A
Pl. 4, Fig. 5.

Description: Trilete spore; outline in polar view triangular with straight to weakly convex sides; laesurae straight, almost extending to the equator; exine differentially thickened in interradial regions (0.8-1 μ) and radial regions (1.5-2 μ), at radial regions sculptured valvae developed; sculptural elements include distal and equatorial sides, elongate verrucae or rugulae which are coalecent each other; proximal face less sculptured, compared with distal to equatorial area, in the contact area smooth to scabrate.

Size: 45-50 μ in equatorial diameter.

Remarks: The present spore is distinguished from other species of *Trilites* by its thinner exine and less developed sculpture.

Occurrence: A few from the Tamagawa and the Sawayama formations.

Trilites sp. B
Pl. 4, Fig. 6.

Description: Trilete spore; outline in polar view triangular, sides straight, apices rounded; laesurae straight, surrounded by contact area, extending into the equator; exine differentially thickened in interradial regions (ca. 2 μ) and radial regions (3 μ) where sculptured valvae are developed; sculptural elements of the distal face corrugae with flattend top, spaced sparsely; proximal side less sculptured than the distal side, and contact area 10 μ wide smooth to scabrate.

Size: 42 μ in equatorial diameter.

Remarks: These specimens are more strongly sculptured than *Trilites* sp. A, and is thicker in the exine. They are similar to *Trilites* cf. *solidus* (POT.) TH. & PF. from the Tertiary of GAMERRO, (KRUTZSCH, 1959), but they are rather larger in the sculptural elements and wider in the contact area than those of *T.* cf. *solidus.*

Occurrence: Only two specimens were found, one from the Tamagawa formation and another from the Sawayama formation.

Trilites sp. C.
Pl. 5, Figs. 7, 8.

Description: Trilete spore; outline in polar view triangular with straight sides and rounded apices; commissures straight, surrounded by margo-like contact area narrowing towards apices; exine rugulate on the distal face, smooth on the proximal face, thickened in radial regions (2.5 μ) where sculptured valvae are developed.

Size: 35 μ in equatorial diameter.

Remarks: This spore is distinguishable from other species of *Trilites* described in this paper, by its margo-like contact area narrowing towards apices.

Occurrence: Only one from a sample (no. 66081502) of the Sawayama formation.

Family CYATHEACEAE (Provisional assignment)
Genus ***Cyathidites*** COUPER 1953
Cyathidites australis COUPER
Pl. 4, Fig. 9.

1953 *Cyathidites australis* COUPER, New Zealand Geol. Surv., Paleontol. Bull. 22, p. 27, pl. 2, figs. 11, 12.

Size: 50-78 μ in equatorial diameter.

Remarks: These specimens from the Kuji group are referred to *Cyathidites australis* described originally by COUPER (1953) from the Jurassic of New Zealand. This species has been widely reported from the Jurassic to the Cenomanian in the world: from New Zealand (COUPER, 1953), Australia (DETTMAN, 1963), Europe (COUPER, 1958; MILLIOUD, 1967), North America (KIMYAI, 1966; HEDLUND, 1966; HEDLUND & NORRIS, 1968) and South America (ARCHANGELSKY & GAMERRO, 1967).

Occurrence: Only from the Tamagawa formation.

Family MATONIACEAE (Provisional assignment)
Genus ***Matonisporites*** COUPER 1958
Matonisporites ? sp.
Pl. 4, Figs. 10, 11; Pl. 5, Fig. 1.

Description: Trilete spore; outline in polar view subtriangular to subcircular; laesurae distinct, extending about 3/4 spore radius, occasionally ends of commissures branching like a fork, slightly developed margo bordering commissures; the margo occasionally bordered by small pits; exine smooth, 2 to 3 μ thick.

Size: 50-80 μ in equatorial diameter.

Remarks: Though these specimens may be referred to genus *Matonisporites* COUPER, they are different from any species which have been assigned to *Matonisporites* as far as the author knows. Our specimens are fairly thinner in the exine, and are indistinct in the margo. The present specimens are closely similar to *Hymenophyllumsporites furcosus* STANLEY, but it is doubtful whether *H. furcosus* STANLEY is assigned to genus *Hymenophyllumsporites* ROUSE by the following reason. Judging from the description and the figures given by STANLEY (1965), *H. furcosus* has distinct "margo", while the genus *Hymenophyllumsporites* by ROUSE (1957) has no "margo", but remarkable lists bordering commissures showing a ribbon-like appearance. In the author's opinion *H. furcosus* is closer, if not to be assigned, to genus *Matonisporites* COUPER than to genus *Hymenophyllumsporites* ROUSE.

Occurrenc : Usually restricted to lower part of the Tamagawa formation; but known in a smaple (no. 67102512) from the Sawayama formation.

Family POLYPODIACEAE (Provisional assignment)
Genus ***Laevigatosporites*** (IBRAHIM) emend, SCHOPF, WILSON & BENTALL 1944
Laevigatosporites ovatus WILSON & WEBSTER
Pl. 5, Fig. 2.

1946 *Laevigatosporites ovatus* WIL. & WEB., Am Jour. Botany, vol. 33, p. 273, fig. 5.

1964 *Laevigatosporites prominens* TAKAHASHI, Mem. Fac. Sci. Kyushu Univ. ser. D, vol. 14, p. 213, pl. 29, figs. 1-7, pl. 40, figs. 12, 18.

Size: 33-49-62 μ in equatorial maximal length.

Remarks: A number of specimens from the Kuji group are larger in size than those described by WILSON & WEBSTER (1946). This species shows a very wide range in size; POCOCK (1962) described 39-55 μ for the size of the specimens from the Jurasso-Cretaceous of Western Canada; DETTMAN (1963) gave 31-40-50 μ for those from the Upper Mesozoic of southeastern Australia; STANLEY (1965) 30-90 μ for those from the Upper Cretaceous and the Paleocene of South Dakota, U.S.A. *Laevigatosporites prominens* TAKAHASHI (1964) from the Hakobuchi Group (Campanian-Maestrichtian) of Hokkaido is synonymous to *L. ovatus. L. ovatus* is distinguishable from *L. haardti* by its spheroidal outline in lateral equatorial view. However, in the condition of preservation or orientation of the grain, *L. ovatus* is sometimes difficult to distingush from *L. haardti.*

Occurrence: Common throughout the Tamagawa and the Sawayama formations.

Laevigatosporites haardti (POT. & VEN.) TH. & PF.
Pl. 5, Fig. 3.

1953 *Laevigatosporites haardti* (POT. & VEN.) THOMSON & PFLUG, Paleontographica, Abt. B, bd. 94, p. 59, pl. 3, figs. 27-38.
1934 *Sporites haardti* POTONIÉ, & VENITZ, Arb. Inst. Paleontol. Petrogr. Brennst., Geol. L. –A., vol. 5, p. 13, pl. 2, fig. 13.
1946 *Laevigatosporites gracilis* WILSON & WEBSTER, Am. J. Botany, vol. 33, p. 273, fig. 4.
1947 *Monolites minor* COOKSON, B.A.N.Z. Antarct. Res. Exped. 1929-1931, Repts, Ser. A. vol. 2, p. 135, pl. 15, fig. 57.

Size: 28-38-52 μ in maximal equatorial length.

Remarks: *Laevigatosporites haardti* (POT. & VEN.) TH. & PF., *L. gracilis* WIL. & WEB. and *Monolites minor* COOKSON are closely similar each other, and it is imposible to distinguish them, based only on each original description and figures. The author is of opinion that *L. gracilis* and *Monolites minor* are synonyonous to *L. haardti.* Recently, TAKAHASHI (1961, 1964) described two species of *Laevigatisporites* from Japan: *L. dehiscens* and *L. senonicus* which are similar to *L. haardti.* According to his original description, the former is expanded in the fissure, while the latter is more or less shorter in the fissure. So, these two species may also be synonymous to *L. haardti.*

Occurrence: Abundant from both the Tamagawa and the Sawayama formations.

Genus ***Polypodiidites*** ROSS 1949
Polypodiidites sp. A
Pl. 5, Fig. 4.

Description: Monolete spore; outline in lateral equatorial view bean-shaped with flattened proximal polar area; length of monolete suture 2/3 maximal equatorial diameter; sculpture of exine, scabrate to punctate towards proximal polar area, conate-like around the distal polar area where outline looks wavy; exine 3 μ in maximum thickness, coni 1 μ in maximum height, about 3 μ in distance.

Size: 52-56 μ in maximal equatorial diameter, 34 μ in polar diameter.

Remarks: The present spores are different in their conate sculptural elements and rather weakly sculptured exine from the following related species: *Polypodiidites senonicus* ROSS from the Senonian of Scania (ROSS, 1949), *P. perverrucatus* COUPER and *P. inangahuensis* COUPER from the Miocene of New Zealand (COUPER, 1953) and *P. arcus* BALME from the Jurassic of Australia (BALME, 1957).

Occurrence: Only two in a sample (no. 67102512) from the Sawayama formation.

Polypodiidites sp B.
Pl. 5, Fig. 5.

Description: Monolete spore; outline in lateral equatorial view bean-shaped, with proximal polar area flattened; sculpture of exine consists of slightly flattened verrucae; verrucae 2-3 μ high, 4-6 μ in diameter, in many cases confused with each other; exine 3-5 μ in thickness.

Size: 57 μ in equatorial diameter, 43 μ in polar diameter.

Remarks: The present specimen is distinguishable from the above described *Polypodiidites* sp. A in its verrucate exine, and from *P. inangahuensis* in its more coarsely sculptured exine. *Polypodiidites* sp. B has no negative "reticulate" pattern observed in genus *Polypodiisporites* POTONIÉ,

Occurrence: Only one from the Tamagawa formation.

Genus ***Reticuloidosporites*** PFLUG 1953
Reticuloidosporites sp.
Pl. 5, Fig. 6.

Description: Monolete spore; outline bean-shaped in lateral equatorial view, with flattened proximal polar side; monolete suture simple, ca. 2/3 maximal equatorial length; exine 1-3 μ thick, sculpture consisting of closely dispersed depressions ("Foveat" of KRUTZSCH 1959); foveat 0.5-1 μ deep, polygonal to circular in outline, 2-5 μ in diameter; under high focus the grain surface looking reticulate.

Size: 47-52-60 μ in maximal equatorial length, 33-35 μ in polar length.

Remarks: These spores are similar to *Polypodiisporites favus* POTONIÉ, from the Tertiary of Europe (POTONIÉ, & GELLETICH, 1933) and *P. repandus* TAKAHASHI from the Hakobuchi group of Hokkaido (TAKAHASHI, 1964), but show positive reticulate pattern on its surface.

Occurrence: Both from the Tamagawa and the Sawayama formations.

Spores-INCERTAE SEDIS

Genus *Balmeisporites* COOKSON & DETTMAN 1958

Balmeisporites minutus BRENNER

Pl. 5, Fig. 9.

1968 *Balmeisporites minutus* BRENNER, Pollen spores, vol. 10, p. 352, pl. 5, fig. 3.

Size. 50-78 μ in diameter of central body.

Remarks: The Kuji specimens are slightly larger in a diameter of central body than the original specimens from the Lower Cretaceous (Albian) of Peru (BRENNER, 1968). *Balmeisporites* was reported first by COOKSON & DETTMAN (1958) from the Cretaceous sediments of Australia. Then, it has been known throughout the Cretaceous in the both hemispheres: the Upper Cretaceous (Cenomanian) of Iowa, U.S.A. (HALL, 1963), the Lower Cretaceous of Peru (BRENNER, 1968), and the Upper Cretaceous (Senonian) of West Siberian Lowland (KONDINSKAYA, 1966).

Occurrence: A few from the lower part of the Tamagawa formation.

Genus *Biretisporites* DELC. & SPRUM. emend. DELC., DETT. & HUGHES 1963

cf. ***Biretisporites potoniaei*** DELC. & SPRUM.

Pl. 5, Fig. 8.

1955 *Biretisporites potoniaei* DELCOURT & SPRUMONT, Mém. Soc. Berg. Géol. N.S. 4, p. 40, fig. 10.

Size: 45 μ in equatorial diameter.

Remarks: Only one specimen was found from the Sawayama formation, and is indistinct whether the lips are upturned extensions of the proximal exine or not. In all other respect this spore fits the original description.

Occurrence: Only one from a sample (no. 66081502) from the Sawayama formation.

Genus *Cardioangulina* (MAL.) POTONIÉ 1960

The genus *Cyathidites* COUPER is very similar in following characters with the genus *Cardioangulina*: concave triangular equatorial contour, broadly rounded apices and slightly longer laesurae. Therefore these two genera are difficult to distinguish and have been confused for their validity. DETTMAN (1963, p. 22) suggested that the genus *Cardioangulina* is synonymous with *Cyathidites,* and that *Cyathidites* had priority as *Cardiangulina* was not validated until 1960. STANLEY (1965, p. 247), and NORTON and HALL (1969, p. 22) admitted the validity of the genus *Cardioangulina* on the basis of the difference in the length of its laesurae: in *Cardioangulina* about 1/2 of spore radius and in *Cyathidites* over 2/3 of spore radius.

The author, however, has still a doubt about transitional morphological character between two genera. In the present study he stands on the same ground with STANLEY, or NORTON and HALL. *Cardioangulina* is distinguished from *Deltoidospora* MINER by the succeedings. *Deltoidospora* is not so broadly rounded in the apices, is either only slightly concave or convex in the sides, and is long in the laesurae.

Cardioangulina diaphana (WIL. & WEB.) STANLEY
Pl. 5, Figs. 10-13.

1965 *Cardioangulina diaphana* (WIL. & WEB.) STANLEY, Bull. Am. Paleontol., vol. 49, p. 248, pl. 30, figs. 17-21.

1946 *Deltoidospora diaphana* WILSON & WEBSTER, Am. J. Botany, vol. 33, p. 273, fig. 3.

Size: 30-37-50 μ in equatorial diameter.

Remarks: The Kuji specimens have distinctly concave sides in equatorial outline, and their laesurae extend 1/2 to 2/3 spore radius. Judging from the original description and a figure by WILSON & WEBSTER, *Deltoidospora diaphana* WIL. & WEB. evidently should be not assigned to *Deltoidospora* (MINER) POTONIÉ but to *Cardioangulina* (MAL.) POTONIÉ. *D. diaphana* WIL. & WEB. by ROUSE (1959) and by NORTON & HALL (1969) appears not identical with the holotype of *D. diaphana.*

The spores from the Kuji group are distinguishable from *Cyathidites minor* COUPER by the generic remarks above described.

Occurrence: Common from the Tamagawa formation, and rare from the Sawayama formation.

Genus ***Cingulatisporites*** THOMSON emend. POTONIÉ 1956
Cingulatisporites distaverrucosus BRENNER
Pl. 6, Fig. 1.

1963 *Cingulatisporites distaverrucosus* BRENNER, Maryland Dep. Geol., Mines Water Resources, Bull. 27, p. 58, pl. 13, figs. 6, 7, pl. 14, fig. 1.

Size: 27 μ (one specimen) in equatorial diameter.
Occurrence: A few from the lower part of the Tamagawa formation.

Genus ***Deltoidospora*** MINER 1935
Deltoidospora cascadensis MINER
Pl. 6, Figs. 2, 3.

1935 *Deltoidospora cascadensis* MINER, Am. Midland Naturalist, vol. 16, p. 618, pl. 24, figs. 9-12.

Size: 28-35 μ in equatorial diameter.
Remarks: This species is distinguishable from *Laevigatisporites hokkaidoensis* TAKAHASHI (TAKAHASHI, 1964) by its thinner exine.
Occurrence: Common from both the Tamagawa and the Sawayama formations.

Deltoidospora cf. ***psilotoma*** ROUSE
Pl. 6, Fig. 8.

1959 *Deltoidospora psilotoma* ROUSE, Micropaleontology vol. 5, p. 312, pl. 2, fig. 30.

Size: 60-70 μ in equatorial diameter.
Remarks: Except for convex sides (sides slightly concave in the original description by ROUSE (1959), the specimens from the Kuji group are identical with *Deltoidospora psilotoma* from British Columbia, Canada.
Occurrence: Only three from the Tamagawa formation.

Deltoidospora nodaense n. sp.
Pl. 6, Figs. 4-7.

Holotype: Slide No. 66081511-3; Location 90.3 × 39.6; pl. 6, Fig. 4.
Type locarity: Noda village, Kunohe-gun, Iwate Prefecture.
Type horizon: Tamagawa formation.
Name derivation: *nodaense* after Noda village, type locality of this species.

Description: Trilete spore; outline subtriangular in polar view, with straight to slightly convex sides and rounded in apices; laesurae simple, straight, extending to the equator; exine laevigate, trancelucent, very thin.

Size: 25-29-36 μ in equatorial diameter.

Remarks: These spores are closely similar to *Deltoidospora microforma* ROUSE from the Upper Cretaceous to the Tertiary in British Columbia (ROUSE, 1962), but are slightly larger than *D. microforma.* Furthermore, the figures illustrated by ROUSE are of ill-preserved specimens, and the sufficient comparison is too difficult to make specific reference. *D. nodaense* resembles *Deltoidospora cascadensis* MINER and *D. hallii* MINER from the Lower Cretaceous of Montana, U.S.A. (MINER, 1935); but the former is slightly larger in size, shorter in laesurae and more convex in its proximal side, the latter is also slightly larger in size, shorter in laesurae and slightly concave in its sides. *D. nodaense* is distinguishable from *Laevigatisporites hokkaidoensis* TAKAHASHI by its smaller size and thinner exine.

Occurrence: Commonly throughout the Tamagawa formation, rare from the Sawayama formation.

Genus *Foveosporites* BALME 1957
Foveosporites sawayamaensis n. sp.
Pl. 6, Figs. 10, 11.

Holotype: Slide No. 67102512-2; location 94.8 × 15.5; pl. 6, fig. 10.
Type locality: Kuji City, Iwate Prefecture.
Type Horizon, Sawayama formation.
Name derivation: after the name of type horizon Sawayama formation.

Description: Trilete spore; outline in polar view triangular with convex sides and rounded apices; laesurae simple, straight and extending to almost equator; exine scrobiculate, looking microreticulate under high focus, small-pitted under low focus, less than 1 μ in thickness; scrobiculae less than 1 μ in diameter on the outer surface of exine and smaller on the inner surface, some scrobiculae closely spaced or 2-3 μ apart.

Size: 30-35-40 μ in equatorial diameter.

Remarks: This new species is distinguishable from *Foveotriletes scro-*

biculatus (ROSS) POTONIÉ (POTONIÉ, 1956) in its convex sides. *Foveotriletes* ? *triangulus* KRUTZSCH from the Miocene of Germany (KRUTZSCH, 1962) differ from this new species in more or less straight sides, foveat sculpture, and shorter laesurae. *F. sawayamaensis* resembles some species of *Microfoveolatisporis* KRUTZSCH described from the Tertiary of Germany (KRUTZSCH, 1962), *M. tuemmlitzenis* KRUTZSCH, *M. apheoides* KRUTZSCH and *M. foveolatus* KRUTZSCH; but these Germany spores are circular in equatorial contour, double layered in exine, and foveat in sculpture. *Foveosporites cyclicus* STANLEY from the Paleocene of South Dakota, U.S.A. (STANLEY, 1965) differs from *F. sawayamaensis* in that the exine is slightly thicker, and that the lumina is elongate near spore periphery.

Occurrence: Common from the Sawayama formation.

Foveosporites sp.

Pl. 6, Fig. 12.

Description: Trilete spore; outline in polar view subcircular; commissures with 1-2 μ width, slightly thickend lips, extending about 2/3 the distance to the equator; exine 1-2 μ thick, scrobiculate (or foveolate); scrobiculae (or foveolae) circular in outline, ca. 0.5 μ in diameter, somewhat linearly arranged; rows of scrobiculae short, extending parallel to latitude in a broad sense.

Size: 44-55 μ in equatorial diameter.

Remarks: These specimens are somewhat similar to *Foveosporites canalis* BALME from the Upper Mesozoic of Australia (BALME, 1957), but are distinguishable by their smaller foveolae and slightly thinner exine.

Occurrence: Common only in a sample (no. 6682709) from the Tamagawa formation.

Genus ***Granulatisporites*** (IBRAHIM) POTONIÉ & KREMP 1954

Granulatisporites sp.

Pl. 6, Figs. 13, 14.

Description: Trilete spore; outline circular in polar view; laesurae straight with slightly thickend lips of 2 μ width, extending almost to equator; exine coarsely punctate, thickened at equatorial margin, forming cingulum-like zone of 2-3 μ width; exine thickened at distal pole, forming a crescent to circular pattern.

Size: 45-50 μ (six specimens) in equatorial diameter.

Remarks: The present spores are similar to *Granulatisporites dailyi* COOKSON & DETTMAN described from the Lower Cretaceous of Maryland, U.S.A. (BRENNER, 1963). According to the original description by COOKSON & DETTMAN (1958), *G. dailyi* is characterized by the distal surface with variable number of relatively large, thickened areas of unequal size and shape. But they did not describe on thickening of exine at distal polar area. Therefore BRENNER's specimens are not assignable to *G. dailyi.* The Kuji spores are closely similar to those of the living *Phaeoceros bulbiculosus* (BROTERO) of Porutogaru, which are illustrated by DETTMAN (1963, pl. 27, figs. 17, 18).

Occurrence: Rare from a sample (no. 66081511) of the Tamagawa formation.

Genus ***Jimboisporites*** SOHMA 1969
Jimboisporites kujiensis SOHMA
Pl. 6, Fig. 15.

1961 *Jimboisporites kujiensis* SOHMA, Sci. Rep. Tohoku Univ., Ser. 4 (Biol.), 35, p. 39, figs. 1-3.

Size: 38-50 μ in equatorial diameter.

Remarks: The genus *Jimboisporites* was recently established by K. SOHMA (1969) from the Sawayama formation (he used older name "Kadonosawa" formation). *Jimboisporites kujiensis* is similar in sculpture of proximal surface to *Taurocusporites segmentatus* STOVER from the Lower Cretaceous of Maryland, U.S.A. (STOVER, 1962), but is markedly different in not having trizonate sculpture of the distal surface.

Occurrence: Rare from the Sawayama formation.

Jimboisporites senonicus n. sp.
Pl. 7, Figs. 1-4.

1969 *Taurocusporites* sp. in NORTON & HALL, Palaeontographica Abt. B, bd. 125, p. 25, pl. 2, fig. 5.

Holotype: Slide No. 66082709-1; location 85.8 × 34.0; pl. 7, fig. 1.
Type Locarity: Kuji city, Iwate Prefecture.
Type Horizon: Kuji group (Senonian)
Name derivation: *senonicus* after Senon, the age of the horizon from which

the holotype was selected.

Description: Trilete spore; outline circular in polar view; commissures extending near the equator and their ends bifurcated, bordered by small, linearly arranged verrucae; exine smooth, 1-2 μ thick; proximal exine of interradial regions ornamented by small verrucae irregularly scatterd, (not like crescent appearance as *J. kujiensis*); verrucae 1-2 μ in diameter and 2-3 μ high.

Size: 35-50 μ in equatorial diameter.

Remarks: In some specimens the equatorial exine appears thickened by adhesion of proximal and distal exine at equator. This new species differs from *J. kujiensis* in irregularly dispersed verrucae on the proximal interradial regions. Furthermore, the verrucae in *J. senonicus* are of same size between the bordering commissures and the interradial regions.

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Genus *Leiotriletes* NAUMOVA ex POTONIÉ & KREMP 1954

Leiotriletes sphaerotriangulus (LOOSE) POT. & KR.

Pl. 7, Fig. 5.

1955 *Leiotriletes sphaerotriangulus* (LOOSE) POT. & KR., Palaeontographica Abt B, bd. 98, p. 41, pl. 11, figs. 107-109.

1932 *Sporites sphaerotriangulus* LOOSE, in POTONIÉ, IBRAHIM & LOOSE, Neues Jahrb. Mineral., Beil.-Bd. 67, Abt. B. p. 451, pl. 18, fig. 45.

1934 *Laevigati-sporites sphaerotriangulus* LOOSE, Arb. Inst. Paläobot. Petrog. Brennstein, bd. 4, p. 145.

Size: 38-45-58 μ in equatorial diameter.

Remarks: *Leiotriletes sphaerotriangulus* (LOOSE) POT. & KR. was reported by LOOSE (1932) and POTONIÉ and KREMP, (1955) from the Carboniferous sediments in Germany. This spore is distinguished from *Laevigatisporites hokkaidoensis* TAKAHASHI (TAKAHASHI, 1964) by its larger size and slightly thinner exine.

Occurrence: Common from the Tamagawa formation, and rare from the Sawayama formation.

Leiotriletes cf. *minutus* (KNOX) POT. & KR.

Pl. 7, Fig. 6.

1955 *Leiotritetes minutus* (KNOX) POTONIÉ & KREMP, Paleontographica Abt. B, bd. 98, p. 41, pl. 11, fig. 119.
1950 *Calamospora minutus* KNOX, in POTONIÉ & KREMP. 1955, p. 41.

Size: 31-37 μ in equatorial diameter.

Remarks: These specimens are more circular in equatorial contour than *Leiotriletes minutus* described by POTONIÉ & KREMP (1955), and are slightly longer in the laesurae.

Occurrence: Both from the Tamagawa and the Sawayama formations.

Leiotriletes sp.
Pl. 7, Fig. 7.

Description: Trilete spore; outline subcircular in polar view; laesurae simple, extending 1/2-2/3 spore radius; exine smooth, single-layered, 2 μ or less thick.

Size: 45-55 μ in equatorial diameter.

Remarks: Except for a single-layered exine, the present specimens are closely similar to *Leiotriletes pseudomaximus* (PF. & TH.) STANLEY which was newly combinated from *Laevigatisporites pseudomaximus* PFLUG & THOMSON. Though STANLEY (1965) did not refer about the structure of the exine, the original specimens of *Laevigatisporites pseudomaximus* PF. & TH. are double layered in exine.

Occurrence: Rare from the Sawayama formation.

Genus ***Punctatisporites*** (IBRAHIM) POTONIÉ & KREMP 1955
Punctatisporites punctulatus TAKAHASHI
Pl. 7, Figs. 8, 9.

1964 *Punctatisporites punctulatus* Takahashi, Mem. Fac. Sci., Kyushu Univ., Ser. D. vol. 14, p. 201, pl. 25, figs. 7-15, pl. 27, fig. 1.

Size: 25-31-40 μ in equatorial diameter.

Remarks: The specimens from the Kuji group appear to be somewhat coarsely punctate on the exine, compared with *Punctatisporites punctulatus* from the Hakobuchi group of Hokkaido (TAKAHASHI, 1964). This species is similar to *Deltoidospora rhytisma* ROUSE from Late Cretaceous Comox formation (Cammpanian) of Canada (ROUSE, 1957). *D. rhytisma,* however, is slightly concaved in equatorial outline and is slightly larger in size. *P. punctulatus* has been found only from the Lower part (Campanian) of the Hakobuchi group (TAKAHASHI, 1964).

Occurrence: Occasionally in samples from the Tamagawa formation; rather frequent from the Sawayama formation.

Punctatisporites cf. ***punctulatus*** TAKAHASHI
Pl. 7, Fig. 10.

1964 *Punctatisporites punctulatus* TAKAHASHI, Mem. Fac. Sci., Kyushu Univ. Ser. D, vol. 14, p. 201, pl. 25, figs. 7-15; pl. 27, fig. 1.

Size: 37-42 μ in equatorial diameter.

Remarks: This spore is similar to *Punctatisporites punctulatus* TAKAHASHI in its shape and sculpture of exine, but is differ in its straight sides and slightly finer sculpture of exine. *Punctatisporites hatunezawaensis* TAKAHASHI (TAKAHASHI, 1964) is differ from this species in its convex sides and smaller size.

Occurrence: A few specimens from the Tamagawa formation.

Punctatisporites sp. A
Pl. 7, Fig. 11.

Description: Trilete spore; outline in polar view subtriangular with convex sides and well rounded apices; laesurae simple, extending to the equater; exine coarsely punctate; outline of exine appears wavy under oil immersion lens; 1 μ in thickness.

Size: 40 μ in equatorial diameter.

Remarks: Only one specimen is found from the Tamagawa formation. It is distinguishable from other species of *Punctatisporites* described here, by its very coarsely punctate exine.

Occurrence: Only in a sample (no. 67102509) from the Tamagawa formation.

Punctatisporites sp. B
Pl. 7, Fig. 12.

Description: Trilete spore; outline subtriangular in polar view, sides convex, apices broadly rounded; laesurae simple, length 2/3-3/4 spore radius; exine about 1 μ thick, coarsely punctate.

Size: 50 μ in equatorial diameter.

Remarks: The present specimens are characterized by its subcircular equatorial outline and shorter length of laesurae. They appear similar to *Punctatisporites adriennis* POTONIÉ & GELLETICH from the Eocene of Hangary (POTONIÉ & GELLETICH, 1932), but they are smaller and are slightly shorter in laesurae.

Occurrence: Only two from a sample (no. 67102508) of the lower part of the Tamagawa formation.

Genus *Rugulatisporites* PFLUG & THOMSON 1953

Rugulatisporites sp.

Pl. 7, Fig. 13.

Description: Trilete spore; outline subcircular in polar view; laesurae simple, but with indistinct narrow lips, straight, extending almost to the equator; exine 1.5-2 μ thick, rugulate; rugulae reducing on the proximal surface; muri 3 μ wide, 1 μ high.

Size: 47-54 μ in equatorial diameter.

Remarks: These specimens are distinguishable from *Rugulatisporites salebrosus* TAKAHASHI from the Hakobuchi group of Hokkaido (TAKAHASHI, 1964) by reducing rugulate sculpture on their proximal surface and its longer laesurae. They differ also from *R. quintus* TH. & PF. from the Teritiary of Germany (THOMSON & PFLUG, 1953) by their coarser rugulate sculpture.

Occurrence: Few from a sample (no. 66081502) of the Sawayama formation.

Genus *Toroisporis* KRUTZSCH 1959

Toroisporis sp.

Pl. 8, Fig. 1

Description: Trilete spore; outline in polar view triangular with slightly convex sides; laesurae distinct; lips thickened and raised, 6-7 μ wide, ca. 10 μ high.

Size: 31 μ in equatorial diameter.

Remarks: This spore is somewhat similar to *Toroisporis (Toroisporis)* sp.

A. from the Tertiary of Germany (KRUTZSCH, 1959).
Occurrence: Only one from the Sawayama formation.

Genus *Uveaesporites* DÖRING 1965
Uveaesporites simplex (MULLER) n. comb.
Pl. 8, Fig. 2.

1968 *Distaverrusporites simplex* MULLER, Micropaleontology, vol. 14, p. 5, pl. 1, fig. 2.
1968 *Uveaesporites argenteaeformis* SCHULZ. Tralau, Sveriges Geol. Vundersökn. ser. C: 633, (Årsbok 62; 4), p. 68, pl. 3, fig. 4; pl. 4, figs. 1, 2.

Size: 25-35-36 μ in equatorial diameter.

Remarks: The genus *Distaverrusporites* MULLER does not differ in any essential character from *Ueaesporites* DÖRING (DÖRING, 1965) and the former synonymous to the latter. *Uveaesporites simplex* (MULLER) n. comb. is closely similar to *Uveaesporites argenteaeformis* (BOLKH.) SCHULZ (TRALAU, 1968), and these two may be synonymous. The author has a doubt whether the specimens figured by SCHULZ (1967) and TRALAU (1968) were properly assigned to *Stenozonotriletes argenteaeformis* BOLKHOVITINA, compared the description and figures by TRALAU (This author is sorry that he has not seen the papers by SCHULZ (1967)) with those by BOLKHOVITINA. According to BOLKHOVITINA, the type-specimen of *S. argenteaeformis* is not verrucate, but is sculptured with vermiculae on the distal face*. In addition, the Original specimen is larger than those of Tralau. The author is of opinion that TRALAU's specimens should not be assigned to *S. argenteaeformis* but to *U. simplex*.

Occurrence: Only from the Tamagawa formation.

Uveaesporites margaritatus (MULLER) n. comb.
Pl. 8, Fig. 3.

1968 *Distaverrusporites margaritatus* MULLER, Micropaleontology, vol. 14, p. 5, pl. 1, fig. 3.

Size: 35-40 μ in equatorial diameter.

Remarks: The Kuji specimens are identical to *Distaverrusporites margaritatus* MULLER reported from Upper Cretaceous to Lower Tertiary sediments of Sarawak, Malaysia by MULLER (1968). No specimens which were disposed larger verrucae on the distal pole as like Malaysian specimens were

* Though she did not designated the distal side, the author judged from her figure.

observed. The specimens from the Kuji group are larger than Malaysian specimens (20-33 μ) by Muller. *U. margaritatus* is similar to *U. cerebralis* TRALAU from the Middle Jurassic of Scania (TRALAU, 1968), but is smaller.

Occurrence: Only four specimens from a sample (no. 68041709) of the upper part of the Tamagawa formation.

Genus *Geratosporites* COOKSON & DETTMAN 1958
Ceratosporites ? sp.
Pl. 8, Figs. 7-9.

Description: Tetrad grain ? ; a single grain of the tetrad spheroidal in shape; on the proximal side trilete mark discernible, trilete ray simple, usually opened; exine very thin, with echinae dispersed on the distal face; echinae 1.5 μ high, ca. 1 μ wide at base, scattered 2-3 μ apart; proximal face smooth.

Size: A single grain ca. 22 μ in equatorial diameter.

Remarks: These spores are originally tetrad in form, but are also found as a single grain. Trilete mark, though indistinct on the proximal side, may suggest this grain to be spore. Presence of echinae may suggest that this spore is assignable to the genus *Ceratosporites* COOKSON & DETTMAN (COOKSON & DETTMAN, 1958).

Occurrence: Rare from a sample (no. 68041706) of the Tamagawa formation.

Genus *Schizosporis* COOKSON & DETTMAN 1959
Schizosporis scabratus STANLEY
Pl. 8, Figs. 10-12.

1965 *Schizosporis scabratus* STANLEY, Bull. Am. Paleontol., vol. 49, no. 222, p. 269, pl. 35, figs. 10-17.

Size: 20-30 μ in equatorial diameter.

Remarks: This species has been reported only from the Latest Cretaceous of South Dakota, U.S.A. (STANLEY, 1965).

Occurrence: Common from the Sawayama formation, but very rare from the Tamagawa formation.

Spore Type A

Pl. 8, Fig. 4.

Description: Trilete spore; outline subcircular in polar view; laesurae straight, extending to the equator; proximal face pyramidal, each of three faces concaved inward; distal side rather flattened; exine thin, psilate, occasionally punctate about mid-latitudes of proximal hemisphere.

Size: 27-33 μ in equatorial diameter.

Remarks: The author could not find any adequate genus to which these spores are assigned.

Occurrence: Rare from the Sawayama formation.

Spore Type B

Pl. 8, Figs. 5, 6.

Description: Trilete spore; outline in polar view subtriangular to subcircular; exine thin, smooth, covered by perispore and outline of spore sometimes indistinct; laesurae sometimes indistinct, sometimes undulated, extending over 3/4 radius of spore; commissures raised 2-4 μ, occasionally 8 μ high.

Size: 35-43 μ in equatorial diameter.

Remarks: These spores appear assignable to the *Leiotriletes* NAUMOVA ex POTONIÉ & KREMP in their shape but are different in the perispore and raised commissure.

Occurrence: Common from a sample (no. 67102510) of the Tamagawa formation.

Class GYMNOSPERMAE

Order CYCADALES

Family CYCADACEAE

Genus ***Cycadopites*** (WODEHOUSE) WILSON & WEBSTER 1946

Cycadopites cf. ***follicularis*** WIL. & WEB.

Pl. 8, Figs. 13-16.

1946 *Cycadopites follicularis* WILSON & WEBSTER, Am. J. Botany vol. 33, no. 4, p. 274, fig. 7.

Size: 17-60 μ in length, 6-25 μ in width.

Remarks: The specimens from the Kuji group are similar to *Cycadopites* *follicularis* WILSON & WEBSTER, from the Paleocene of U.S.A., though they do not always settle down the size range given by WILSON & WEBSTER. Some of them are similar in size to *C. giganteus* STANLEY from the Maestrichtian of South Dakota, U.S.A. (STANLEY, 1965).

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Order GINKGOALES
Family GINKGOACEAE (Provisional assignment)
Genus ***Monosulcites*** COOKSON ex COUPER 1953
Monosulcites epakros BRENNER
Pl. 8, Figs. 17-20.

1963 *Monosulcites epakros* BRENNER, Maryland Dept. Geol., Mines Water Resources, Bull. 27, p. 75, pl. 25, figs. 5, 6.

Size: 20-40 μ in length, 8-18 μ in width.

Remarks: This species is similar in general appearance to the following species: *Monocolpopollenites acerrimus* LESCHIK from the Upper Triassic of Switzerland (LESCHIK, 1955), *Ginkgo tripartita* BOLKH. from the Upper Albian of Kazakhstan U.S.S.R. (BOLKHOVITINA, 1953), *Ginkgo praeacuta* BOLKH. from the Lower Jurassic of Yakutsk, U.S.S.R. (BOLKHOVITINA, 1956), *Ginkgo bilobaeformis* ZAKL. from Cretaceous-Paleocene sediments in Northern Aral Basin, U.S.S.R. (ZAKLINSKAJA, 1957), and *Ginkgo vesca* AGRANOVSKAYA, from the Upper Paleocene of West Siberia (POKLROVSKAYA & STEL'MAK, 1960). But *M. epakros* is distinguishable from all of them by its elongated, spindleshaped outline, and sharply pointed apices.

Occurrence: Common both from the Tamagawa and the Sawayama formations.

Family CAYTONIACEAE
Genus ***Vitreisporites*** LESCHIK emend. JANSONIUS 1962
Vitreisporites pallidus (REISSINGER) NILLSON
Pl. 8, Figs. 21, 22.

1958 *Vitreisporites pallidus* (REISS.) NILLSON, Pub. Inst. Min., Pal. & Quart. Geol., Univ. Lund, no. 53, pp. 77-78.

1938 *Pityosporites pallidus* REISSINGER, Palaeontographica, Abt. B, bd. 84, p. 14.

1950 *Pityopollenites pallidus* REISSINGER, Palaeontographica, abt. B, bd. 90,

p. 115, figs. 1-5.

1958 *Caytonipollenites pallidus* (REISSINGER) COUPER, Palaeontographica, Abt. B, bd. 103, p. 150, pl. 26, figs. 7-8.

Size: 25, 31, 40 μ (three specimens) in over all length.

Remarks: This species has been known mainly from the Jurassic to the Lower Cretaceous, of the world and rarely from the Cenomainan of Sarawak, Malaysia. Lately its rare occurrence has been reported from the Latest Cretaceous of Siberia (POKROVSKAYA, 1966).

Occurrence: A few from the Tamagawa and the Sawayama formations.

Order CONIFERALES
Family ARAUCARIACEAE (Provisional assignment)
Genus ***Araucariacites*** COOKSON ex COUPER 1953
Araucariacites australis COOKSON
Pl. 8, Figs. 23, 24.

1947 *Araucariacites australis* COOKSON, B.A.N.Z., Antarct. Res. Exped. (1929-1931), Ser. A, vol. 2, p. 130, pl. 13, figs. 1-4.

Size: 56-68-80 μ in diameter.

Remarks: A few Kuji specimens are referred to *Araucariacites australis* COOKSON from the Teritiary of Kerguelen Island. This generic reference is supported by the occurrence of foliage shoots and cones both from the Tamagawa and the Sawayama formations.

Occurrence: A few from the Tamagawa and the Sawayama formations.

Araucariacites limbatus (BALME) HABIB
Pl. 9, Figs. 1, 2.

1969 *Araucariacites limbatus* (BALME) HABIB, Micropaleontology, vol. 15, no. 1, p. 91, pl. 4, fig. 6.

1957 *Inaperturopollenites limbatus* BALME, C.S.I.R.O., coal Res. Sect., T.C. 25, p. 31, pl. 7, figs. 83, 84.

Size: 55-75 μ in diameter.

Remarks: The Kuji specimens are thinner in exine and slightly smaller in size than the original specimens from the Mesozoic of Australia (BALME, 1957).

Occurrence: Rarely both from the Tamagawa and the Sawayama formations.

Family PINACEAE

Genus *Pityosporites* SEWARD emend. MANUM 1960

Pityosporites constrictus (PIERCE) n. comb.

Pl. 9, Fig. 3.

1961 *Punctabivesiculites constrictus* PIERCE, Minnesota Geol. Surv., Bull. 42, p. 37, pl. 2, figs. 44, 45.

Size: 60-74-98 μ in over all length; body 40-51-58 μ in length, 23-28-34 μ in height; bladder 25-27-39 μ in height, 19-30-40 μ in breadth.

Remarks: This pollen is similar to *Pityosporites aliformis* TAKAHASHI from the Hakobuchi group of Hokkaido, (TAKAHASHI, 1964), but is of diploxylon type in the bladder and smaller. This pollen is distinguished from similar species, *Pinus cembraeformis* ZAKLINSKAIA from the Lower Oligocene of Irtysh Basin of U.S.S.R. and *Pinus strobiformis* ZAKLINSKAIA from the Upper Cretaceous of Irtysh Basin (ZAKLINSKAIA, 1957), by its punctate-microreticulate or pitted sculpture of dorsal exine. *P. constrictus* is larger than *Pinuspollenites elongatus* NORTON from the Paleocene sediments of Montana, U.S.A. (NORTON & HALL, 1969).

Occurrence: Common both from the Tamagawa and the Sawayama formations.

Genus *Abietineaepollenites* POTONIÉ 1951

Abietineaepollenites sp.

Pl. 9, fig. 4.

Description: Bisaccate pollen; central body elliptical to circular in pollar view, elliptical in equatorial view; bladders of the Haploxylon type, attached to the ventral side of body and rather indistinctly set off from it; in equatorial view outline passing smooth from the cap into the proximal roots of bladders; exine of cap intrabaculate, punctate to microreticulate in surface view, 0.5-1 μ thick; no marginal crest developed; exine of distal germinal region thinner, sculpture finer than that of dorsal side.

Size: 56-68-80 μ in over all length; body 50-55-70 μ in length, 23-30-37 μ in height; bladders 27, 33 μ in height 25-30 μ in width.

Remarks: There are several species similar to the Kuji specimens, though not identical. *Pinus sibiriciformis* ZAKL. and *P. singularis* ZAKL. from the Tertiary in Central Asia (ZAKLINSKAIA, 1957) are larger in size. *Retibivesiculites concors* PIERCE from the Cenomanian of Minnesota, U.S.A. (PIERCE, 1961) is larger, and is reticulate on the cap. *Pinus semicircularis* STANLEY from the Paleocene of south Dakota, U.S.A. (STANLEY, 1965) is smaller in size. *Abietineaepollenites latisulcatus* NORTON from the Paleocne in Montana, U.S.A. (NORTON & HALL, 1969) is developed in the marginal crest.

Occurrence: Rare throughout the Tamagawa and Sawayama formations.

Genus *Piceaepollenites* POTONIÉ 1931

Piceaepollenites saccellus TAKAHASHI

Pl. 9, Fig. 5.

1964 *Piceaepollenites saccellus* TAKAHASHI, Mem. Fac. Sci., Kyushu Univ., vol. 14, no. 3, p. 225 pl. 34, fig. 3, pl. 35 figs. 1, 2, 7.

Size: 50-75 μ in over all length.

Remarks: This species is distinguishable from *Abietineaepollenites* sp. above described. It is strongly bent beanshaped outline in equatorial view, and has the bladders closer to equator than those of *Abietineaepollenites* sp.

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Genus *Cedripites* WODEHOUSE 1933

Cedripites sp.

Pl. 9, Fig. 6.

Description: Bisaccate pollen; central body elliptical in equatorial view; proximal cap and marginal crest well developed, 5-7 μ high, sacci attached distally, merged into proximal cap, giving the impression that they connect across the proximal pole; sacci usually more or less concave on distal side as if it envelopes the distal hemisphere; proximal cap intrabaculate, punctate in surface view; sacci reticulate; its lumina 2-4 μ in diameter; distal germinal region scabrate, ca. 5-7 μ wide.

Size: Body 52, 63, 68, 73 μ (4 specimens) in length, 35-30 μ (2 specimens) in height; bladder 25 μ (one specimen) in width, 30 μ (one specimen) in height; 75-80 μ in over all length.

Remarks: No other species to which this pollen is assigned have not been reported as far as this author knows.

Occurrence: Rare from a sample (no. 68041602) of the Sawayama formation.

Family PODOCARPACEAE

Genus ***Podocarpidites*** COOKSON emend. POTONIÉ 1958

Podocarpidites ezoensis (SATO) n. comb.

Pl. 9, Fig. 7.

1961 *Podocarpus ezoensis* SATO, Jour. Fac. Sci., Hokkaido Univ., Ser. IV, vol. 11, no. 1, p. 89, pl. 1, figs. 29, 30.

Size: Body 28, 29, 31 μ in length 23, 30, 33 μ in hight; bladder 38, 40, 43 μ in hight, 28, 30, 31 μ in width (three specimens).

Remarks: *Podocarpus ezoensis* SATO was reported from the Hakobuchi group of Northern Hokkaido by SATO (1961).

Occurrence: A few both from the Tamagawa and the Sawayama formations.

Coniferales-INCERTAE SEDIS

Genus ***Inaperturopollenites*** PFLUG & THOMSON 1953

Inaperturopollenites sp.

Pl. 9, Fig. 10.

Description: Inaperturate pollen, outline circular; exine smooth to scabrat, single layered, 2 μ thick, often showing foldings.

Size: 65-85 μ in diameter.

Remarks: This species is similar to *I. magnus* (POT.) PFLUG & THOMSON, but *I. magnus* is of double layer and thinner in the exine. The Kuji pollen is also similar to *I. giganteus* GÓCZÁN from the "Wealden" of Netherland (BURGER, 1966).

Occurrence: Rare from a sample (no. 68041604) of the Sawayama formation.

Genus *Classopollis* PFLUG emend. POCOCK & JANSONIUS 1961
Classopollis sp.
Pl. 9, Figs. 11-14.

Description: Monoporate pollen; shape more or less spherical; exine double layered, but often indistinct; endexine very thin, laevigate; ektexine 1-2 μ thick, punctate, reducing from equatorial region toward polar region; tectate structure indiscernible; equatorial girdle 1.5-2 μ thick, 6-8 μ wide and provided with endostriae, running parallel around the equator, 6-10 in number; a "rimula" present, formed by a thinning of the ektexine; distal pole showing a small circular area, about 5-6 μ in diameter where ektexine absent; proximal polar area showing a triangular area where ektexine absent.

Size: 28-34 μ in equatorial diameter.

Remarks: The Kuji specimens which were all compressed, are unable to show equatorial area. We could not observe the structure of the exine in detail, especially of ektexine. These pollen is similar to *C. torosus* (REISSINGER) COUPER emend. BURGER from the Jurasso-Cretaceous of Netherlands (BURGER, 1966), and *C. ezoensis* TAKAHASHI from the lower Senonian of Hokkaido (TAKAHASHI, 1967). But *C. torosus* is tectate structured in the ektexine, and *C. ezoensis* is ornamented by many small pits in the ektexine, giving micro-reticulate appearance.

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Genus *Rugubivesiculites* PIERCE 1961
Rugubivesiculites fluens PIERCE
Pl. 9, Fig. 15.

1961 *Rugubivesiculites fluens* PIERCE., Minn. Geol. Surv. Bull. 42, p. 40, pl. 2, figs. 61, 62.

Size: 58-90 μ in over all length; body 40-70 μ in length, 30-40 μ in hight; bladder 22-35 μ in hight, 18-33 μ in breadth.

Remarks: This species is similar to *Pinus aralica* BOLKH. from the Lower Cretaceous of Kazakhstan, U.S.S.R. (BOLKHOVITINA, 1953), but is distinguished by its more strongly rugulate cap.

Occurrence: Commonly both from the Tamagawa and the Sawayama formations.

Order GNETALES
Family EPHEDRACEAE
Genus *Ephedripites* BOLKHOVITINA 1953
Ephedripites sp.
Pl. 9, Figs. 8, 9.

Description: Shape perprolate with rounded apices; exine composed of striae which are parallel to longer axis; striae extending from an apex to another, 2-4 μ wide, 8-12 in number, surface laevigate; most specimens twisted, forming a crisscross pattern.

Size: 36-49 × 12-23 μ.

Remarks: These specimens are similar to *Ephedra voluta* STANLEY from the Uppermost Cretaceous of South Dakota, U.S.A. (STANLEY, 1965) and *Ephedripites multicostatus* BRENNER from the Lower Cretaceous of Maryland (BRENNER, 1963), but differ in number of the striae of exine. *E. voluta* is of less number in the striae, while *E. multicostatus* has more striae.

Occurrence: Occasionally both from the Tamagawa and the Sawayama formations.

Class ANGIOSPERMAE
Subclass MONOCOTYLEDONES (Provisional assignment)
Genus *Monocolpopollenites* PFLUG & THOMSON 1953
Monocolpopollenites kyushuensis TAKAHASHI
Pl. 9, Figs. 16-19.

1961 *Monocolpopollenites kyushuensis* TAKAHASHI Mem. Fac. Sci. Kyushu Univ., Ser. D, Geol. 11, (no. 3), p. 292, pl. 16, figs. 17-23.

Size: 18-30 × 7-18 μ.

Remarks: The specimens from Kuji group have slightly thinner exine than those from the Paleogene Tertiary in western Japan. This species is distinguished from *M. tranquillus* (POT.) PF. & TH. from the Tertiary of Germany (THOMSON & PFLUG, 1953) by its spindle-shaped equatorial contour with pointed apices and thinner exine.

Occurrence: Common throughout the Tamagawa and the Sawayama formation.

Monocolpopollenites* cf. *universalis TAKAHASHI
Pl. 9, Fig. 20.

1957 *Monocolpopollenites universalis* TAKAHASHI, Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol., vol. 5, p. 215, pl. 38, figs. 6-10, pl. 39, fig. 11.

Size: 14-24 X 8-12 μ

Remarks: These pollen are similar to *M. universalis* TAKAHASHI from the Paleogene of Kyushu, but are smaller.

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Monocolpopollenites pflugii TAKAHASHI
Pl. 10, Figs. 1-3.

1961 *Monocolpopollenites pflugii* TAKAHASHI, Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol., vol. 11, (no. 3), p. 294, pl. 16, figs. 31-32.

Size: 24-37 X 13-24 μ

Occurrence: Rarely from the Tamagawa formation; common from the Sawayama formation.

Genus ***Spinizonocolpites*** MULLER 1968
Spinizonocolpites echinatus MULLER
Pl. 10, Figs. 4-5.

1968 *Spinizonocolpites echinatus* MULLER, Micropaleontology, vol. 14, no. 1, p. 11, pl. 2, fig. 3.

Size: 30-45 X 20-30 μ.

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Subclass DICOTYLEDONES
Family-INCERTAE SEDIS
Genus ***Retitricolpites*** VAN DER HAMMEN ex PIERCE 1961
Retitricolpites vulgaris PIERCE
Pl. 10, Figs. 6, 7.

1961 *Retitricolpites vulgaris* PIERCE, Minn. Geol. Surv. Bull., vol. 42, p. 50, pl. 3, figs. 101, 102.

Size: 15-26 × 10-23 μ.

Remarks: This species was described from the lower part of the Upper Cretaceous of Minnesota, U.S.A. (PIERCE, 1961) and of Sarawak, Malaysia (MULLER, 1968). This species is similar to some species of *Tricolpopollenites* from the Tertiary and the Cretaceous sediments, but is distinguishable in the exine characters. *Tricolpopollenites retiformis* PFLUG & THOMSON from the Tertiary of Germany (THOMSON & PFLUG, 1953) and *T. reticulatus* TAKAHASHI from the Paleogene Tertiary of Kyushu, Japan (TAKAHASHI, 1961) are baculately sculptured in the exine. *T. micromunus* GROOT, PENNY & GROOT from the Cretaceous of the eastern United States (GROOT & PENNY, 1960) is smaller in grain size. *T. platyreticulatus* GROOT, PENNY & GROOT from the Cretaceous of the eastern United States (GROOT, PENNY & GROOT, 1961) is larger in grain size and is baculate-reticulate in exine.

Occurrence: Common found from the upper part of the Tamagawa formation; rare from the lower part of the Tamagawa formation and the Sawayama formation.

Retitricolpites cf. ***prosimilis*** NORRIS
Pl. 10, Fig. 8.

1967 *Retitricolpites prosimilis* NORRIS, Paleontographica, B, bd. 120, p. 108, pl. 18, figs. 5-14.

Size: 22-24 μ (Two specimen) in equatorial diameter.

Remarks: Except for grain shape the Kuji specimens well match with *Retitricolpites prosimilis* originally described by NORRIS (1967). *R. prosimillis* is subprolate to perprolate in shape, while the Kuji specimens are probably oblate to spheroidal. Unfortunatly the author could find no specimen showing equatorial view from the Kuji group.

Occurrence: Only two in a sample (no.67102508) from the Tamagawa formation.

Retitricolpites sp. A
Pl. 11, Figs. 10, 11.

Description: Tricolpate pollen; shape subprolate; exine thin, less than 0.5 μ thick, finely reticulate; lumina less than 0.5 μ in diameter; colpi simple.

Size: 21-28 μ long in the polar axis, 18-20 μ in equatorial diameter.

Remarks: These pollen are distinguishable in its finer sculpture of exine and in smaller size than *R. vulgaris* PIERCE.

Occurrence: Only two specimens from the Sawayama formation.

Retitricolpites ? sp.
Pl. 10, Fig. 12.

Description: Tricolpate ? pollen; shape spheroidal; exine reticulate; muri ca. 0.5 μ high; lumina ca. 0.5 μ in diameter; colpi indistinguishable.

Size: 28 μ maximal length.

Remarks: As these specimens are indistinct in colpi, and it is doubtful whether this pollen belongs to tricolpate type.

Occurrence: Only two in a sample (no. 67102901) from the Tamagawa formation.

Genus ***Tricolpopollenites*** PFLUG and THOMSON 1953
Tricolpopollenites minutiretiformis TAKAHASHI
Pl. 10, Figs. 13, 14.

1964 *Tricolpopollenites minutiretiformis* TAKAHASHI, Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol., vol. 14, p. 238, pl. 38, figs. 4-27; pl. 41, figs. 16, 17.

Size: 15-26 × 12-20 μ.

Remarks: Though the Kuji specimens appear to be clavate in the exine, they are identical with *Tricolpopollenites minutiretiformis* TAKAHASHI from the Hakobuchi group in Hokkaido, which shows intrabaculate structure in the exine. *Retitricolpites prolatus* PIERCE from the Middle Cretaceous of Minnesota, U.S.A. (PIERCE, 1961) is similar to the Kuji specimens, but it is very finely reticulate and thicker in the exine.

Occurrence: This species is found commonly both the Tamagawa and the Sawayama formations.

Tricolpopollenites vulgaris TAKAHASHI
Pl. 10, Figs. 15, 16.

1957 *Tricolpopollenites vulgaris* TAKAHASHI, Mem. Fac. Sci., Kyushu Univ., Ser. D, Geol. vol. 5, no. 4, p. 218, pl. 38, figs. 44-45; pl. 39, fig. 38.

Size: 22 × 16 μ (only one specimen).

Occurrence: Only one in a sample (no. 68041604) from the Sawayama formation.

Tricolpopollenites micromunus GROOT & PENNY
Pl. 10, Fig. 9.

1960 *Tricolpopollenites micromunus* GROOT & PENNY, Micropaleontology vol. 6 (2), p. 232, pl. 2, figs. 6, 7.

Size: 17 × 13 μ.

Occurrence: Only two specimens from a sample (no. 67102605) from the Sawayama formation.

Tricolpopollenites cf. **simplicissimus** GROOT, PENNY & GROOT
Pl. 10, Fig. 17.

1961 *Tricolpopollenites simplicissimus* GROOT, PENNY & GROOT, Palaeontographica, Abt. B, bd. 108, p. 132, pl. 26, fig. 6.

Size: 15-20 × 11-14 μ.

Remarks: Only two specimens are similar to *Tricolpopollenites librarensiss librarensis* (POT.) PF. & TH. from the Tertiary of Germany (THOMSON & PFLUG, 1953) and *T. simplicissimus* GROOT, PENNY & GROOT from the Cretaceous of the eastern United States (GROOT, PENNY & GROOT, 1961), especially close to the latter. But the difinite specific assignment is remained pending here, until more specimens are obtained.

Occurrence: Only two specimens in a sample (no. 67102510) from the lower Part of the Tamagawa formation.

Tricolpopollenites cf. **meinohamensis rotundus** TAKAHASHI
Pl. 10, Fig. 18.

1961 *Tricolpopollenites meinohamensis rotundus* TAKAHASHI, Mem. Fac.

Sci., Kyushu Univ., Ser. D, Geol., vol. 11, (no. 3), p. 315, pl. 23, figs. 16-18.

Size: 28 X 22 μ.

Remarks: Except for its slightly larger size, the Kuji specimen is identical with *Tricolpopollenites meinohamensis routundus* TAKAHASHI from the Paleogene and the Miocene sediments of Kyushu, Japan.

Occurrence: Only one specimen from a sample (no. 66081511) of the upper member of the Tamagawa formation.

Tricolpopollenites sp. A
Pl. 10, Fig. 19.

Description: Tricolpate pollen; shape prolate; colpi long; exine psilate, a faint scabrate sculpture discernible under oil immersion lens; thickness less than 0.5 μ thick.

Size: 12-16 X 7-12 μ.

Remarks: These specimens are similar to *Tricolpopollenites meinohamaensis rotundus* TAKAHASHI from the Paleongene of Kyushu (TAKAHASHI, 1961), *T. librarensis fallax* PF. & TH. from Tertiary of Germany (PFLUG & THOMSON, 1953) and *T. debilis* GROOT, PENNY & GROOT from the Cretaceous of the eastern United States (GROOT, PENNY & GROOT, 1961). But *T. meinohamaensis rotundus* is spheroidal to subspheroidal in shape, while germany species is thicker in exine than the Kuji specimens. *T. debilis* is most closely similar in general appearance to the Kuji pollen, but is of slightly thicker exine, and slightly larger in size.

Occurrence: Commonly from the lower member of the Tamagawa formation.

Tricolpopollenites sp. B
Pl. 10, Fig. 20.

Description: Tricolpate pollen; shape sheroidal to subprolate; usually seen in polar to oblique polar view; exine double layered; endexine very thin, ektexine baculaclavate; total thickness less than 1 μ; structure of exine not recognized under ordinary lens (X 600) but done under oil immersion lens (X 1000); clavae under 1 μ high; capita of them fused with adjacent one each other, producing very fine reticulate sculpture; under ordinary lens

(×400–600) exine seen only smooth or scabrate.

Size: 10–16×9–13 μ.

Remarks: This species is similar to *Tricolpopollenites minutiretiformis* TAKAHASHI above described, but is smaller and finer in the sculpture of exine. Furthermore, *T. minutiretiformis* is subprolate in shape.

Occurrence: Commonly throughout both the Tamagawa and the Sawayama formations.

Tricolpopollenites sp. C
Pl. 10, Fig. 21.

Description: Tricolpate pollen; shape prolate; colpi extending almost to the poles; exine very thin, less than 0.5 μ thick, punctate, very finely flecked.

Size: 18-22 × 13-14 μ (Two specimens).

Remarks: The Kuji specimens are similar to *Tricolpopollenites meinohamensis rotundus* TAKAHASHI and *T. micropunctatus* GROOT, PENNY & GROOT from the Cretaceous of the eastern United States (GROOT, PENNY & GROOT, 1961). *T. meinohamensis rotundus* differs from our pollen in its chagrenate to intrapunctate exine and more spheroidal shape, while *T. micropunctatus* has slightly thicker exine.

Occurrence: Rare both from the Tamagawa and the Sawayama formations.

Tricolpopollenites sp. D
Pl. 10, Fig. 22.

Description: Tricolpate pollen; shape prolate; colpi almost reaching to poles; exine punctate, ca. 0.5 μ thick.

Size: 22 × 15 μ (one specimen).

Remarks: This specimen is somewhat similar to *Tricolpopollenites micropunctatus* GROOT, PENNY & GROOT , but is slightly larger and thinner in exine.

Occurrence: Only one in a sample (no. 67102512) from the Sawayama formation.

Genus *Tricolpites* Cookson ex Couper 1953
Tricolpites sp. A
Pl. 10, Figs. 23, 24.

Description: Tricolpate pollen; shape spheroidal to suboblate; outline some what triangular in polar view; colpi extending near the poles; margo present, but indistinct in some specimens; furrow margin smooth; exine double-layered; endexine thin, less than 0.5 μ thick; ektexine bacula-clavate, 0.5-1.5 μ high; capita of the bacula-clavae fused with adjacent one, producing a reticulate sculpture; lumina 0.5-1 μ wide; reticulate sculpture reducing towards the colpi and polar area, perfectly absent around the colpi.

Size: 22 μ in pollar axis, 25 μ in equatorial diameter (one specimen).

Remarks: These pollen is similar to *Tricolpopollenites clavireticulatus* Norton from the Upper Cretaceous of Montana, U.S.A. (Norton & Hall, 1969), but *T. clavireticulatus* is prolate in shape.

Occurrence: Rare from lower member of the Tamagawa formation; common in a sample (no. 66102818) from the Sawayama formation.

Tricolpites sp. B
Pl. 10, Figs. 25, 26.

Description: Tricolpate pollen; shape oblate, outline subtriangular with well rounded apices and convex sides in polar view; colpi simple; exine double-layered, endexine very thin; ektexine baculate; baculae ca. 1 μ high.

Size: 27-34-40 μ in equatorial diameter.

Remarks: No species similar to these pollen has not been reported.

Occurrence: Rare in a sample (no. 68041602) from the Sawayama formation.

Tricolpites sp. C
Pl. 11, Fig. 1.

Description: Tricolpate pollen; outline triangular in polar view; colpi simple; exine finely punctate, 0.5 μ thick in maximal and reducing around the colpi.

Size: 23 μ in equatorial diameter (one specimen).

Occurrence: Only one in a sample (no. 67102508) from the lower part of the Tamagawa formation.

Genus ***Tricolporopollenites*** PFLUG & THOMSON 1953

Tricolporopollenites sp.

Pl. 11, Fig. 5.

Description: Tricolporate pollen; shape subprolate; exine thin ca. 0.5 μ thick, very finely granulate.

Size: 18 × 14 μ (one specimen).

Occurrence: Only one in a sample (no. 67102508) from the Tamagawa formation.

Genus ***Triporopollenites*** PFLUG & THOMSON 1953

Triporopollenites shimensis TAKAHASHI

Pl. 11, Fig. 3.

1961 *Triporopollenites shimensis* TAKAHASHI, Mem. Fac. Sci. Kyushu Univ., Ser. D, Geol., vol. 11, p. 301, pl. 20, figs. 5-14.

Size: 23 μ in equatorial diameter.

Occurrence: Only one from the Sawayama formation.

Triporopollenites sp.

Pl. 11, Fig. 4.

Description: Triporate pollen; outline subtriangular with straight to slightly convex sides in polar view; pore simple with no annulus, labrum nor tumescence, meridionally elongated in outline; exine single-layered, thin ca. 0.5 μ thick, chagrenate or intrapunctate.

Size: 32, 35 μ in equatorial diameter (two specimen).

Occurrence: Very rare both from the Tamagawa and the Sawayama formations.

INCERTAE SEDIS Pollen

Genus ***Accuratipollis*** CHLONOVA 1961

Accuratipollis evanidus CHLONOVA

Pl. 11, Figs. 6-8.

1961 *Accuratipollis evanidus* CHLONOVA, Tr. Inst. Geol. Geofiz., Sibirsk. Otd.

Akad. Nauk. S.S.S.R., vol. 7, p. 91, tabl. 16, fig. 125.

Size: 27-42 μ in equatorial diameter, 12-31 μ in polar diameter.

Remarks: This species was distinguished from *Accuratipollis enodatus* CHLONOVA from the Upper Cretaceous of West Siberian Lowland (CHLONOVA, 1961) by its smaller size. *Scoraldia trapaformis* SRIVASTAVA from the Maestrichtian of Alberta, Canada (SRIVASTAVA, 1966) differs from this species in providing no polar protrusion and its shorter colpi.

Occurrence: Rare both the Tamagawa and the Sawayama formations.

Genus ***Ocellipollis*** CHLONOVA 1961
Ocellipollis obliquus CHLONOVA
Pl. 11, Figs. 9, 10.

1966 *Ocellipollis obliquus* CHLONOVA, Palynology of Siberia, Inst. Geol. Geofiz. Sibirsk. Otd. Akad. Nauk S.S.S.R. p. 67, Tab. 1, figs. 5, 6.

Size: 39-50 μ in length, 22-30 μ in width.

Remarks: In some specimens two pores (3-7 μ in diameter) are observed on the equatorial side.

Occurrence: A few in a sample (no. 67102512) from the Sawayama formation.

Genus ***Tricolpites*** COOKSON ex COUPER 1953
Tricolpites? sp.
Pl. 11, Fig. 2.

Description: Tricolporate ? or tricolpate? pollen; outline in polar view triangular with slightly concave to convex sides; colpi only on the proximal surface, extending from pore to pole where they disappear; exine smooth, very thin.

Size: 16-21 μ in equatorial diameter.

Occurrence: Commonly in a sample (no. 68041706) from the upper part of the Tamagawa formation.

Pollen Type A
Pl. 11, Figs. 11-13.

Description: Tetrad inaperturate ? pollen; single grain of tetrad spheroidal in shape; exine very thin, punctate, fine baculate sculpture discernible under oil immersion lens (X1000); baculae closely dispersed, less then 1 μ in hight. There three small circular spots on the proximal hemisphere, 5 μ in diameter, suggesting contact portion (?), where exine raising as like small hills and baculae spaced less close than surrounding area so that exine looks thinner.

Size: ca. 30 μ in equatorial diameter.

Occurrence: Commonly only in a sample (no. 68041602) from the Sawayama formation.

Pollen Type B

Pl. 11, Figs. 15, 16.

Description: Inaperturate pollen; shape spheroidal to oblate; exine of the distal (?) hemisphere ornamented by warts; the warts 1-1.5 μ high, 1-3 μ wide at base; exine of the proximal (?) hemisphere smooth, very thin.

Size: 30-35 μ in diameter.

Occurrence: In a sample (no. 67102508) from the lower part of the Tamagawa formation.

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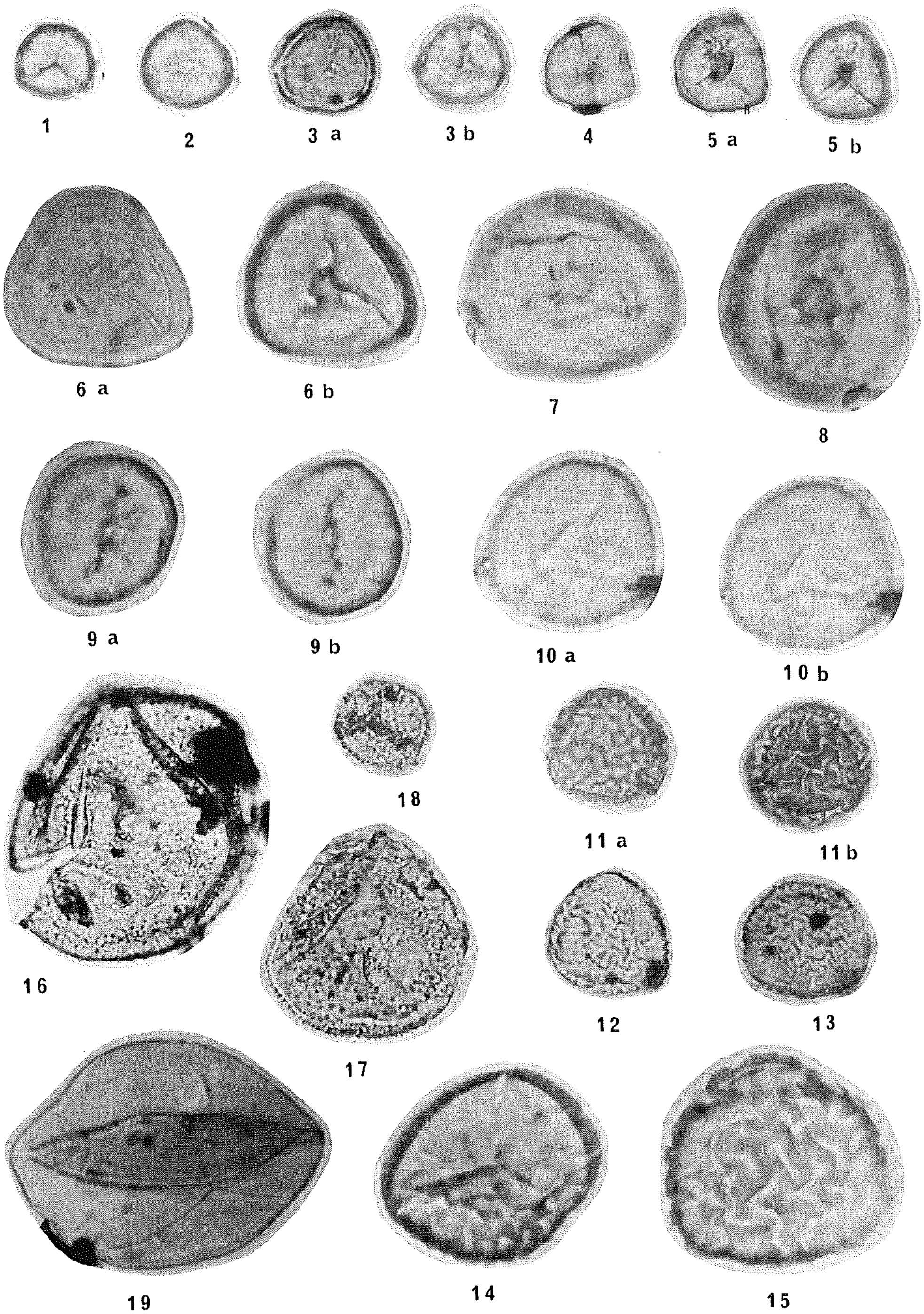
Explanation of Plate 1
(All figures X 600)

Fig. 1.	*Stereisporites antiquasporites* (WIL. & WEB.) DETTMAN. Phase contrast, slide 66082709-1, 98.7 X 17.0.
Fig. 2.	*Stereisporites antiquasporites* (WIL. & WEB.) DETTMAN. Phase contrast, slide 67102512-2, 91.5 X 44.3.
Figs. 3a, b.	*Stereisporites antiquasporites* (WIL. & WEB.) DETTMAN. Slide 67102510-1, 99.0 X 46.2. a: bright light. b: phase contrast.
Fig. 4.	*Stereisporites antiquasporites* (WIL. & WEB.) DETTMAN. Slide 67102512-4, 98.0 X 24.2.
Figs. 5a, b.	*Stereisporites apolaris* (REINHARDT) n. comb. Slide 67102501-2, 100.1 X 58.6 a: distal focus. b: proximal focus, phase contrast.
Figs. 6a, b.	*Stereisporites grossus* TAKAHASHI. Slide 68041604-1, 99.9 X 53.4 a: bright light. b: phase contrast.
Figs. 7, 8.	*Stereisporites grossus* TAKAHASHI. Phase contrast slide 68041604-1, 95.0 X55.0 7: proximal focus. 8: distal focus.
Figs. 9a, b.	*Stereisporites* sp. Phase contrast, slide 68041604-1, 85.7 X 43.9 a: high focus. b: low focus.
Figs. 10a, b.	*Stereisporites* sp. Phase contrast, slide 68041604-1, 84.6 X 23.0 a: low focus. b: high focus.
Figs. 11a, b.	*Lycopodiacidites hamulatis* (KRUTZSCH) KLAUS. Slide 66081502-1, 95.5 X 27.1 a: proximal focus. b: distal focus.
Fig. 12.	*Lycopodiacidites hamulatis* (KRUTZSCH) KLAUS. Slide 67102512-2, 90.8 X 54.1.
Fig. 13.	*Lycopodiacidites hamulatis* (KRUTZSCH) KLAUS. Slide 67102512-2, 103.9 X 47.1.
Fig. 14.	*Lycopodiacidites amplus* (STANLEY) n. comb. Proximal focus, slide 68041604-1, 90.9 X 45.1.
Fig. 15.	*Lycopodiacidites amplus* (STANLEY) n. comb. Distal focus, slide 68041604-1, 85.0 X 35.0.
Fig. 16.	*Osmundacidites wellmanii* COUPER. Slide 66081502 1, 96.9 X 304.
Fig. 17.	*Osmundacidites wellmanii* COUPER. Slide 67102510-3, 88.5 X 19.1.
Fig. 18.	*Osmundacidites alpinus* KLAUS. Slide 66081502-1, 100.5 X 48.6.
Fig. 19.	*Todisporites major* COUPER. Slide 67102508-3, 88.3 X 60.2.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Explanation of Plate 2
(All figures X 600)

Fig. 1. *Gleicheniidites senonicus* ROSS. Slide 67102512-4, 97.6 X 42.1.

Figs. 2a, b. *Gleicheniidites laetus* (BOLKH.) KRUTZSCH. Slide 66081511-3, 83.5 X 51.7. a: bright light. b: phase contrast.

Fig. 3. *Gleicheniidites circinidites* (COOKSON) KRUTZSCH. Slide 68041709-1, 98.3 X 32.1.

Fig. 4. *Gleicheniidites marginatus* TAKAHASHI. Slide 66081511-3, 91.6 X 48.6.

Fig. 5. *Gleicheniidites* cf. *delicatus* (BOLKH.) KRUTZSCH. Slide 66102901-1, 89.0 X 37.5.

Figs. 6a, b. *Gleicheniidites* cf. *echinatus* (BOLKH.) KRUTZSCH. Slide 66081502-4, 91.5 X 31.8. a: phase contrast.

Fig. 7. *Appendicisporites tricornitatus* Weyland & GREIFELD. Proximal foucs, slide 68041706-1, 90.8 X 54.1.

Fig. 8. *Appendicisporites tricornitatus* Weyland & GREIFELD. Distal focus, slide 68041706-1, 87.0 X 55.7.

Figs. 9a, b. *Appendicisporites ethmos* DELCOURT & SPRUMONT. Slide 68041706-2, 88.5 X 23.2. a: proximal focus. b: distal focus.

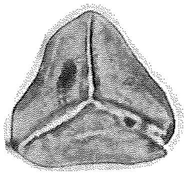
Fig. 10. *Appendicisporites ethmos* DELCOURT & SPRUMONT. Slide 68041706-2, 85.0 X 53.2.

Fig. 11. *Appendicisporites* cf. *potomacensis* BRENNER. Slide 66081502-1, 97.1 X 26.8.

Fig. 12. *Appendicisporites* cf. *potomacensis* Brenner. Equatorial view, slide 66081502-1, 83.7 X 40.6.

Fig. 13. *Cicatricosisporites australiensis* (COOKSON) POTONIÉ. Slide 68041706-1, 102.7 X 34.4.

Figs. 14a, b. *Cicatricosisporites australiensis* (COOKSON) POTONIÉ. Slide 68041706-1, 97.7 X 20.2 a: proximal view. b: distal view.



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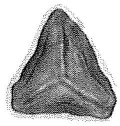

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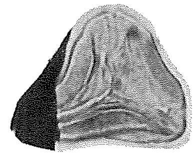

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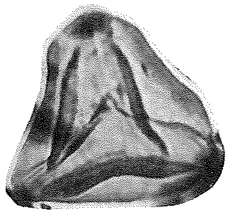

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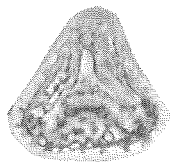

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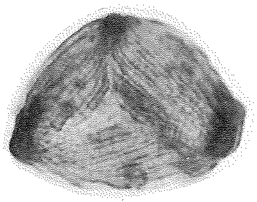

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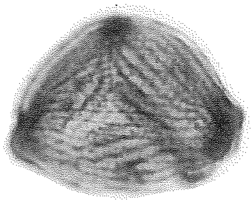

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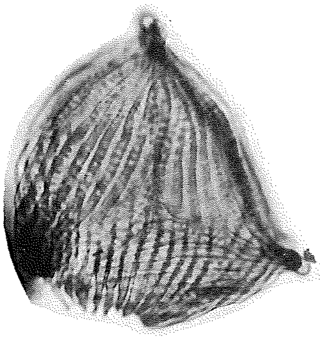

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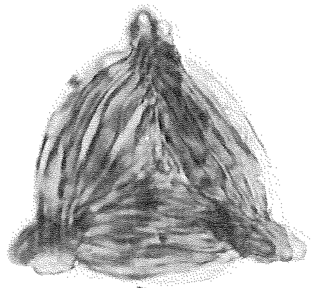

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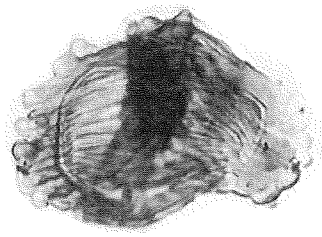

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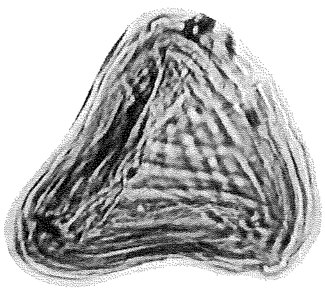

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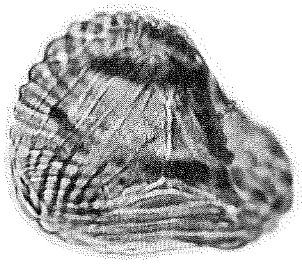

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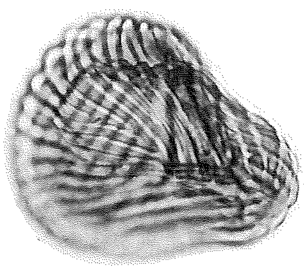


14 b

Explanation of Plate 3

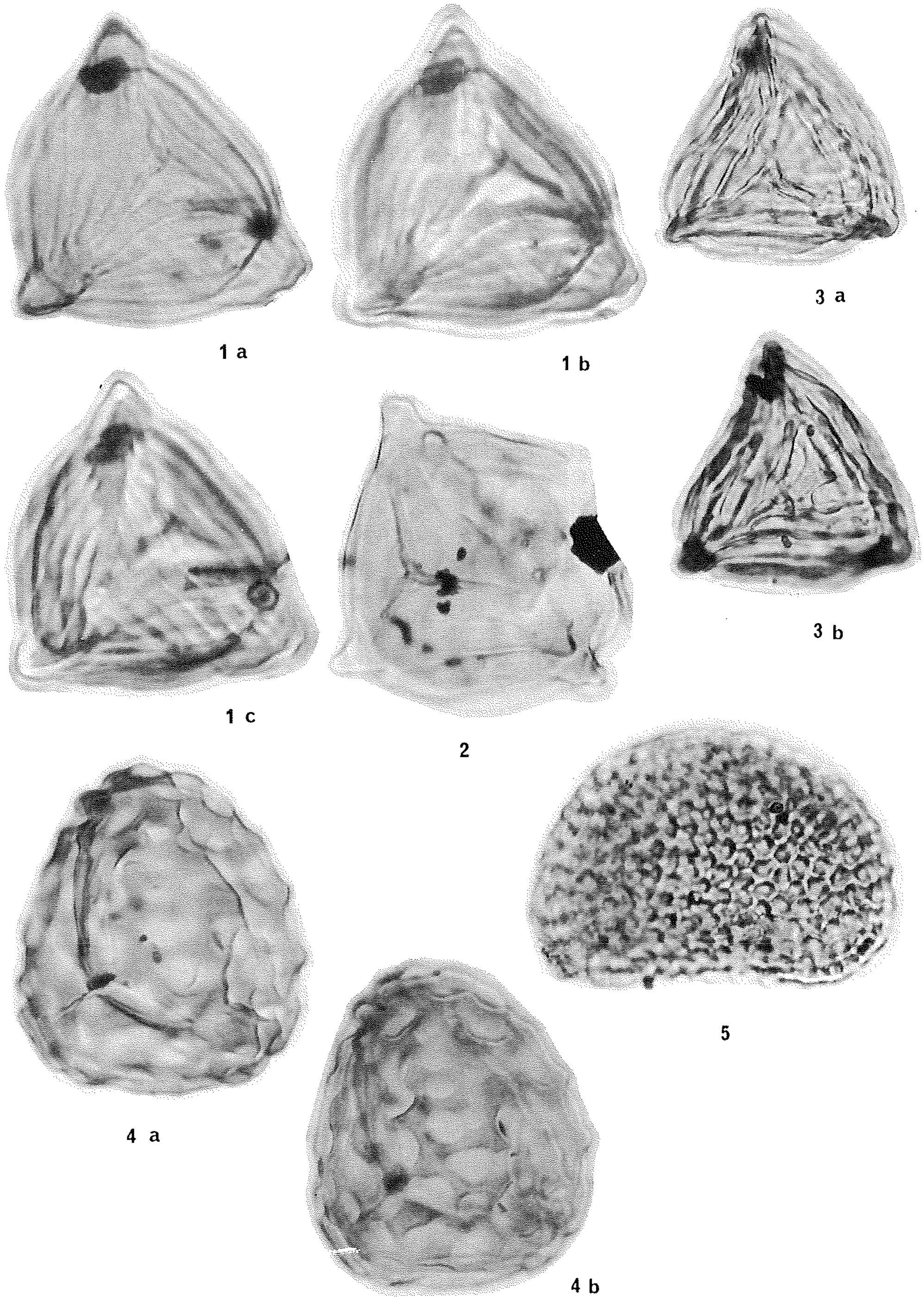
Figs. 1a-c. *Appendidisporites* sp. A. Slide 68041604-2, 88.5 X 18.2. a: bright light. b: proximal focus, phase contrast. c: distal focus, phase contrast. (X 600)

Fig. 2. *Appendicisporites* sp. A. Slide 68041604-1, 86.7 X 19.7 (X ca. 520)

Figs. 3a, b. *Appendicisporites* sp. B. Slide 67102509-2, 90.0 X 21.1. a: proximal focus. b: distal focus. (X 600)

Figs. 4a, b. *Ischyosporites* sp. Slide 68041604-2 99.1 X 29.1. a: proximal focus. b: distal focus. (X 400)

Fig. 5. *Reticulosporis* sp. Slide 6710259lb-1, 104.3 X 37.9 (X 600).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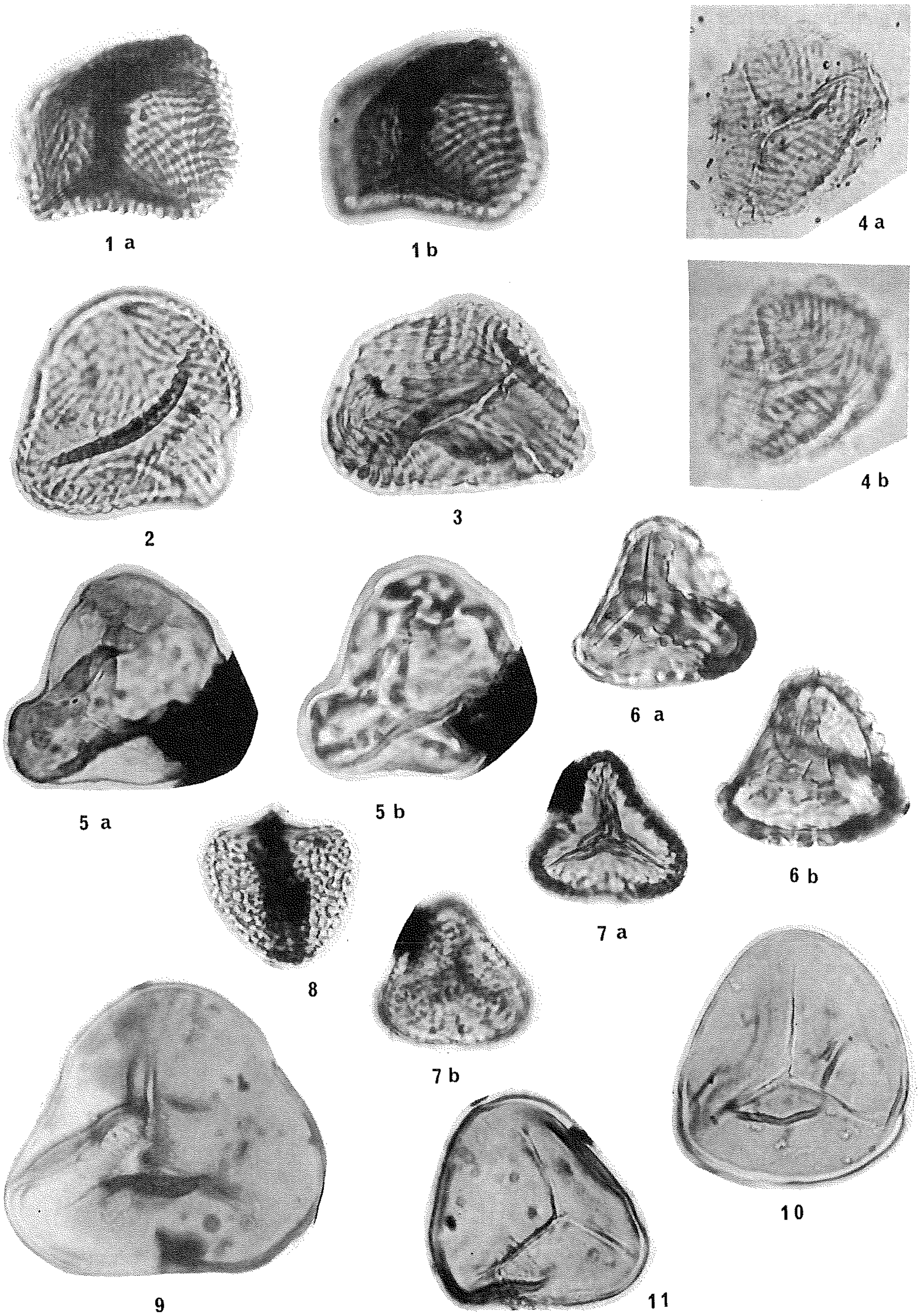
Explanation of Plate 4
(All figures X 600)

Figs. 1a, b. *Cicatricosisporites mediostriatus*(BOLKH.) POCOCK. Slide 68041706-1, 90.3 X 33.0 a: distal focus. b: proximal focus.
Fig. 2. *Cicatricosisporites* cf. *dorogensis* POTONIÉ & GELLETICH. Slide 66081502-1, 97.3 X 44.5.
Fig. 3. *Cicatricosisporites* cf.*dorogensis* POTONIÉ & G ELLETICH. Slide 66082709-1, 87.5 X 23.2.
Figs. 4a, b. *Cicatricosisporites* sp. Slide 67102510-3, 96.7 X 27.5. a: bright light. b: phase contrast.
Figs. 5a, b. *Trilites* sp. A. Slide 67102508-3, 101.0 X 45.5. a: bright light. b: phase contrast.
Figs. 6a, b. *Trilites* sp. B. Slide 66081502-1, 100.2 X 42.4. a: proximal focus. b: distal focus.
Figs. 7a, b. *Trilites* sp. C. Slide 66081502-1, 89.4 X 49.8. a: proximal focus. b: distal focus.
Fig. 8. *Trilites* sp. C. Equatorial view, slide 66081502-1, 90.9 X 51.9.
Fig. 9. *Cyathidites australis* COUPER. Slide 68041706-1, 89.0 X 22.0
Fig. 10. *Matonisporites* ? sp. Slide 67102509-3, 82.3 X 54.0.
Fig. 11. *Matonisporites* ? sp. Slide 67102512-2, 84.8 X 47.2.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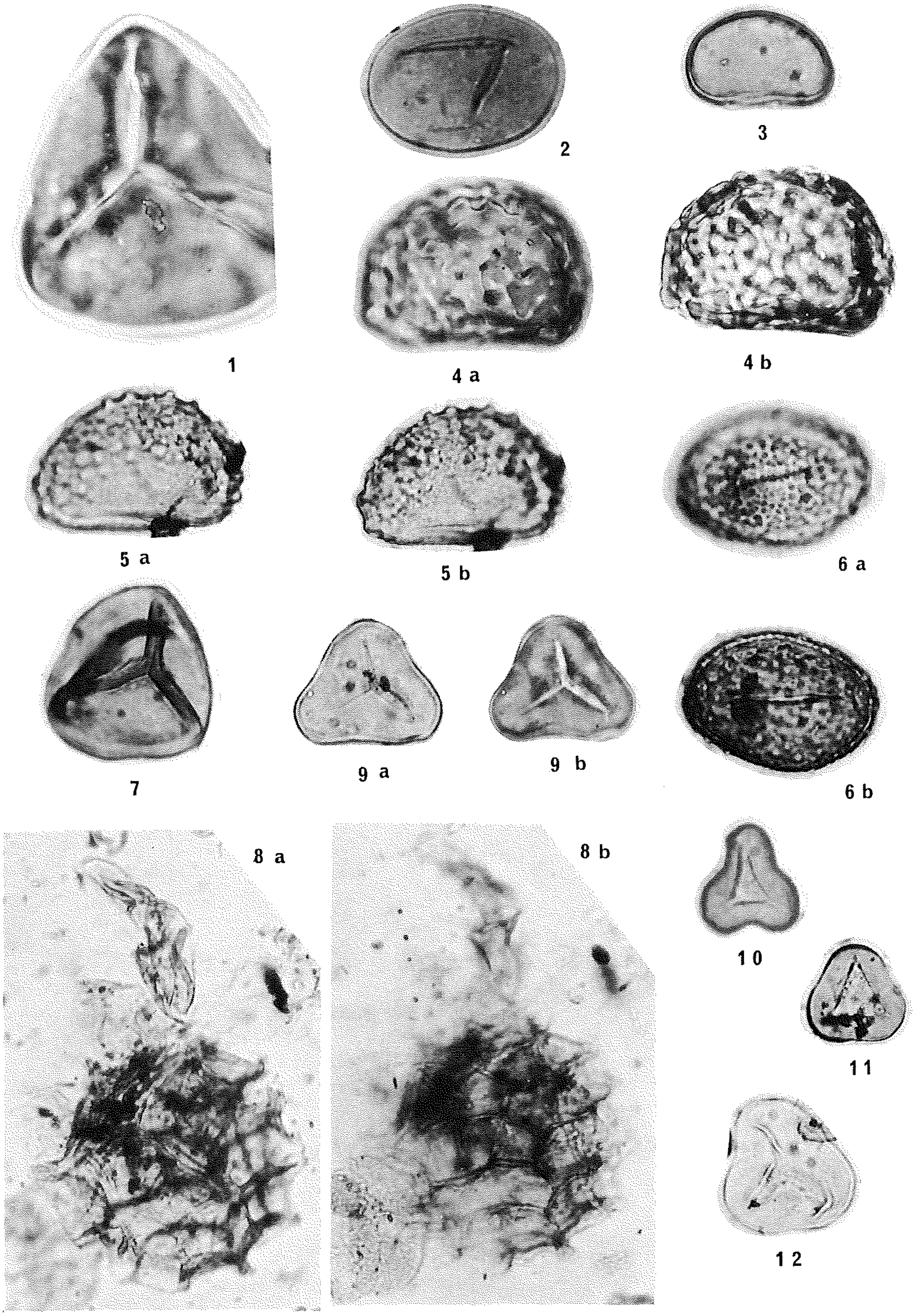
Explanation of Plate 5

Fig. 1.	*Matonisporites* ? sp. Phase contrast, slide 67102508-3, 93.2 X 19.0 (X 600)
Fig. 2.	*Laevigatosporites ovatus* WILSON & WEBSTER Slide 66081511-3, 93.8 X 49.1. (X 600)
Fig. 3.	*Laevigatosporites haardti* (POT. & VEN.) Thomson & PFLUG. Slide 66081502 -1, 92.3 X 59.2. (X 600)
Figs. 4a, b.	*Polypodiisporites* sp. A. Slide 67102509-1, 97.7 X 21.5. a: high focus. b: low focus. (X 600)
Figs. 5a, b.	*Polypodiisporites* sp. B. Slide 67102512-2, 103.7 X 38.3. (X 600)
Figs. 6a, b.	*Reticuloidosporites* sp. Slide 66081502-1, 91.0 X 58.8. a: distal focus. b: proximal focus. (X 600)
Fig. 7.	cf. *Biretisporites potoniaei* Delcourt & SPRUMONT. Slide 66081502-1, 99.0 X 38.0. (X 600).
Figs. 8a, b.	*Balmeisporites minutus* BRENNER. Slide 67102510-3, 104.5 X 36.0. a: low focus. b: high focus. (X 500)
Figs. 9a, b.	*Cardioangulina diaphana* (WIL. & WEB.) STANLEY. Slide 67102510-3, 98.4 X 32.9. a: bright light. b: phase contrast. (X 600)
Fig. 10.	*Cardioangulina diaphana* (WIL. & WEB.) STANLEY. Slide 66081503-1, 103.1 X 23.8. (X 600)
Fig. 11.	*Cardioangulina diaphana* (WIL. & WEB.) STANLEY. Slide 66081503-1, 86.9 X 57.3. (X 600)
Fig. 12.	Cardioangulina diaphana (WIL. & WEB.) STANLEY. Slide 66082709-1, 88.7 X 24.4. (X 600)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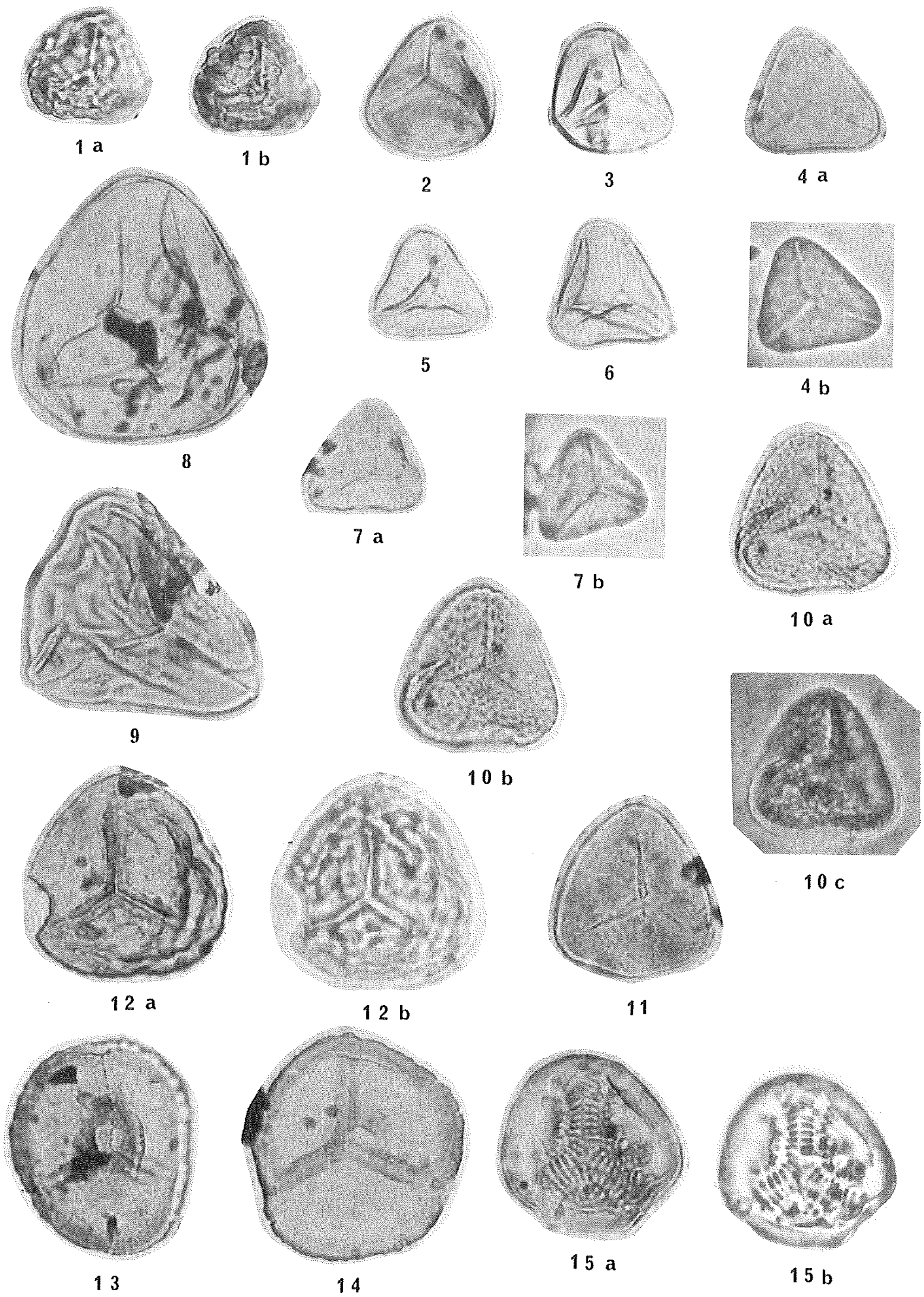
Explanation of Plate 6
(All figures X 600)

Figs. 1a, b. *Cingulatisporites distaverrucosus* BRENNER. Slide 67102510-3, 96.5 X 39.0. a: proximal focus. b: distal focus.
Fig. 2. *Deltoidospora cascadensis* MINER. Slide 67102512-4, 87.0 X 22.3.
Fig. 3. *Deltoidospora cascadensis* MINER. Slide 67102605b-1, 83.3 X 35.2.
Figs. 4a, b. *Deltoidospora nodaense* n. sp. Holotype, slide 66081511-4, 90.3 X 39.6. a: bright light. b: phase contrast.
Fig. 5. *Deltoidospora nodaense* n. sp. Slide 66081511-4, 93.2 X 42.2.
Fig. 6. *Deltoidospora nodaense* n. sp. Slide 66081511-3, 90.5 X 56.5.
Figs. 7a, b. *Deltoidospora nodaense* n. sp. Slide 66081511-3, 90.5 X 56.5. a: bright light. b: phase contrast.
Fig. 8. *Deltoidospora* cf. psilotoma ROUSE. Slide 66082709-1, 86.0 X 24.2.
Fig. 9. *Deltoidospora* cf. rhytisma ROUSE. Slide 67102509-1, 10.5 X 24.5.
Figs. 10a-c. *Foveosporites sawayamaensis* n. sp. Holotype, slide 67102512-4, 83.0 X 53.2. a: low foucs. b: high focus, c: phase contrast.
Fig. 11. *Foveosporites sawayamensis* n. sp. Slide 67102512-2, 95.5 X 54.1.
Figs. 12a, b. *Foveosporites* sp. Slide 66082709-1, 93.9 X 20.6. a: bright light. b: phase contrast.
Fig. 13. *Granulatisporites* sp. Slide 66081511-1, 84.6 X 22.9.
Fig. 13. *Granulatisporites* sp. Slide 66081511-1, 82.2 X 44.4.
Figs. 15a, b. *Jimboisporites kujiensis* SOHMA. Slide 67102501b-1, 89.3 X 51.5. a: bright light. b: phase contrast.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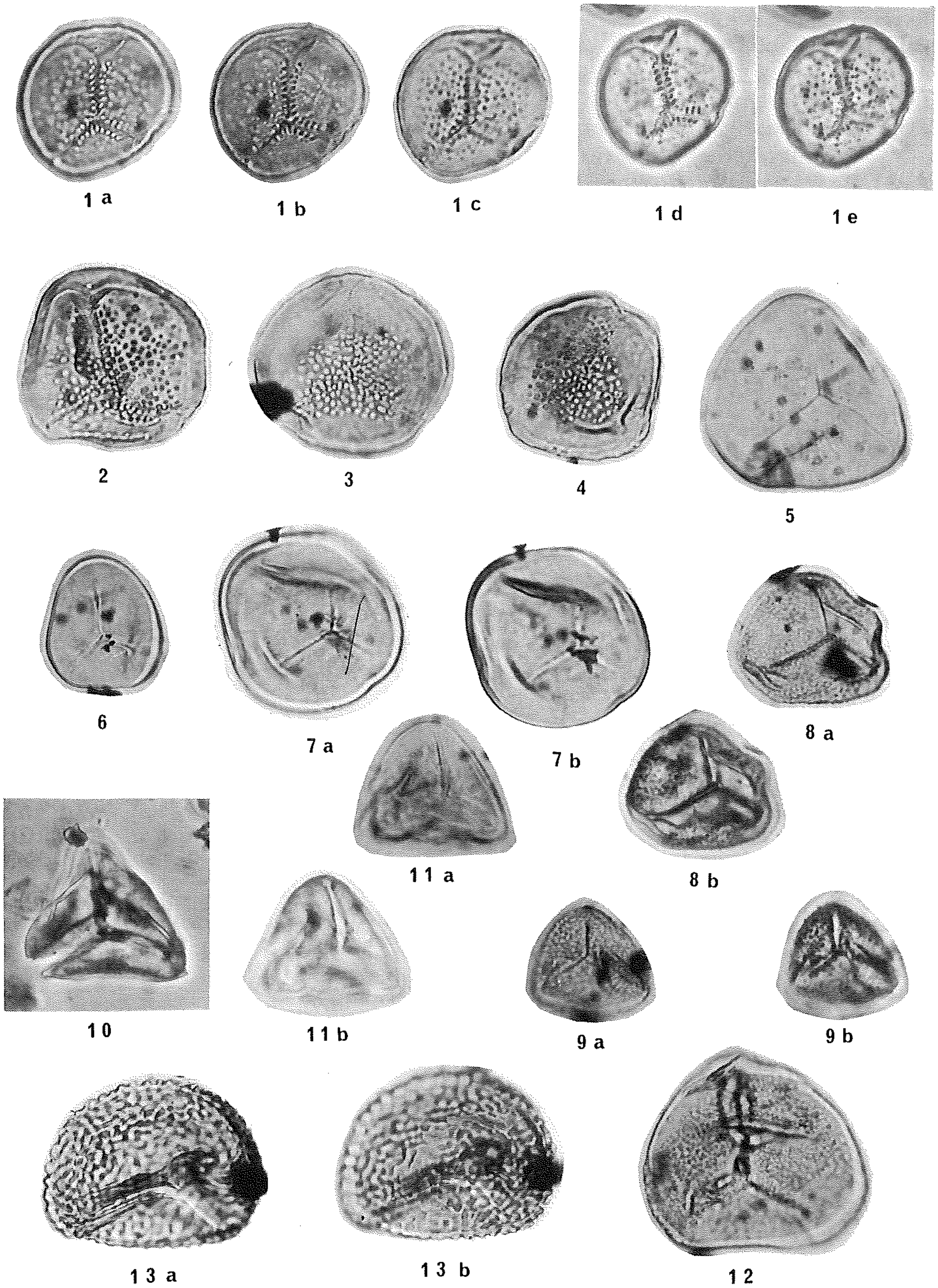
Explanation of Plate 7
(All figures X 600)

Figs. 1a-e.	*Jimboisporites senonicus* n. sp. Holotype, slide 66082709-1, 85.8 X 34.0. a: high focus. b: middle focus. c: low focus. d: phase contrast, high focus. e: phase contrast, low focus.
Fig. 2.	*Jimboisporites senonicus* n. sp. Slide 66081511-3, 88.3 X 28.8.
Fig. 3.	*Jimboisporites senonicus* n. sp. Slide 66081511-4, 84.5 X 42.4.
Fig. 4.	*Jimboisporites senonicus* n. sp. Slide 66081511-4, 91.2 X 38.4.
Fig. 5.	*Leiotriletes sphaerotriangulus* (LOOSE) POTONIÉ & KREMP. Slide 67102501-3, 90.1 X 18.8.
Fig. 6.	*Leiotriletes minutus* (KNOX) POTONIÉ & KREMP. Slide 66081509-1, 103.6 X 48.1.
Figs. 7a, b.	*Leiotriletes* sp. Slide 67102605b-1, 93.8 X 62.0. a: proximal focus. b: distal focus.
Figs. 8a, b.	*Punctatisporites punctulatus* TAKAHASHI. Slide 67102512-2, 101.5 X 37.8. a: bright light. b: phase contrast.
Figs. 9a, b.	*Punctatisporites punctulatus* TAKAHASHI. Slide 67102512-2, 98.0 X 54.0. a: bright light. b: phase contrast.
Fig. 10.	*Punctatisporites* cf. *punctulatus* TAKAHASHI. Phase contrast, slide 67102509-1, 102.3 X 24.7.
Figs. 11a, b.	*Punctatisporites* sp. A. Slide 67102509-2, 100.0 X 27.3. a: bright light. b: phase contrast.
Fig. 12.	*Punctatisporites* sp. B. Slide 67102508-3, 96.0 X 47.5.
Figs. 13a, b.	*Rugulatisporites* sp. Slide 66081502-1, 101.5 X 51.8. a: proximal focus. b: distal focus.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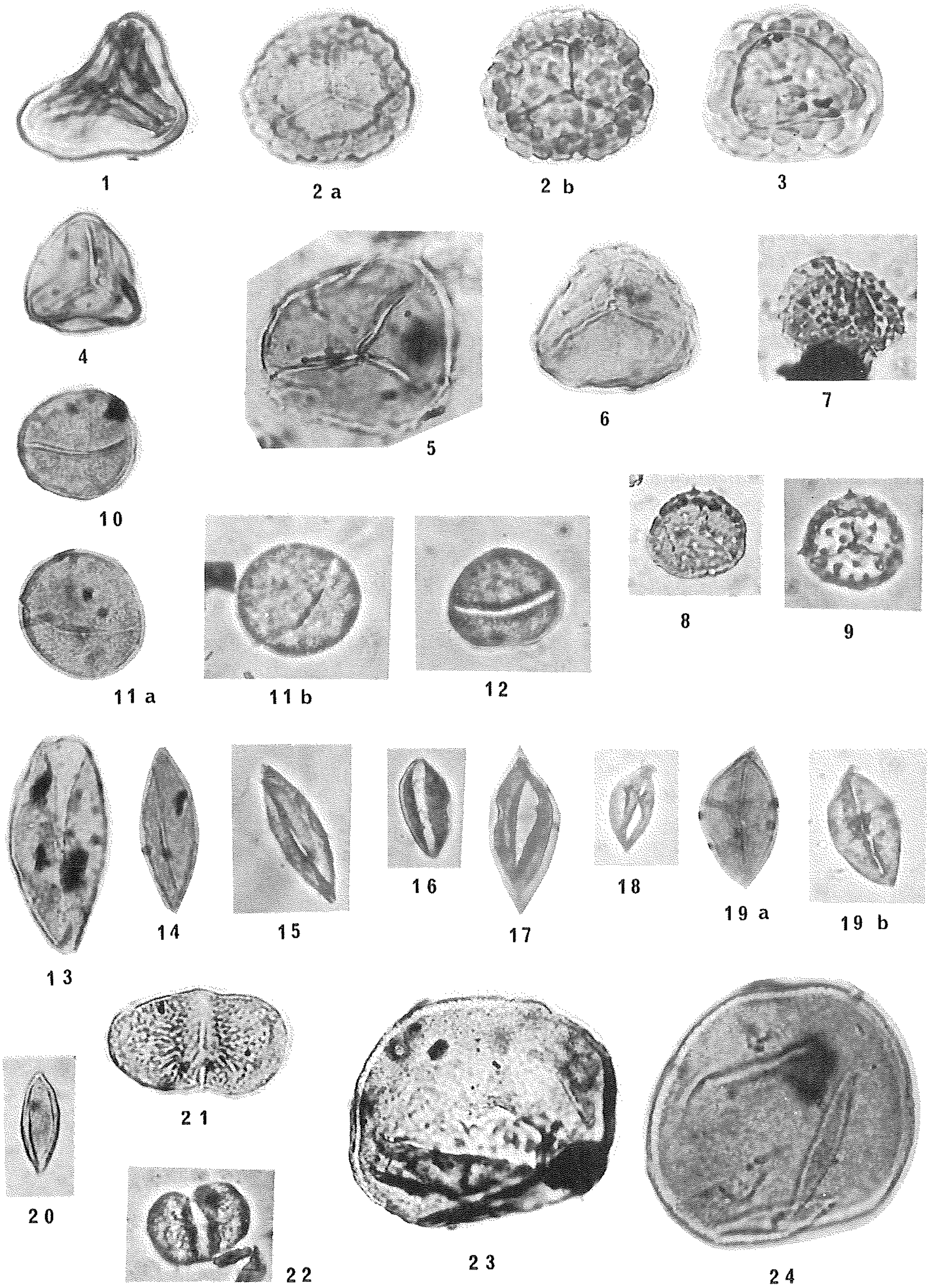
Explanation of Plate 8
(All figures X 600)

Fig. 1.	*Toroisporis* sp. Slide 67102818-1, 101.5 X 56.3.
Figs. 2a, b.	*Uveaesporites simplex* (MULLER) n. comb. Slide 68041706-1, 88.3 X 54.5. a: distal focus. b: proximal focus.
Fig. 3.	*Uveaesporites margaritatus* (MULLER)n. comb. Slide 68041709-1, 95.8 X 19.0.
Fig. 4.	Spore Type A. Slide 67102512-4, 95.2 X 47.7.
Fig. 5.	Spore Type B. Slide 67102510-3, 102.8 X 25.0.
Fig. 6.	Spore Type B. Slide 67102510-3, 91.4 X 31.4.
Fig. 7.	*Ceratosporites* ? sp. Tetrad grain, slide 68041706-1, 90.3 X 28.4.
Fig. 8.	*Ceratosporites* ? sp. Slide 68041706-1, 96.6 X 31.1.
Fig. 9.	*Ceratosporites* ? sp. Phase contrast, slide 68041706-1, 86.8 X 17.3.
Fig. 10.	*Schizosporis scabratus* STANLEY.Slide 67102605b-1, 90.7 X 24.3.
Figs. 11a, b.	*Schizosporis scabratus* STANLEY.Slide 67102512-2, 92.8 X 41.5. a: bright light. b: phase contrast.
Fig. 12.	*Schizosporis scabratus* STANLEY. Phase contrast, slide 67102605b-1, 103.1 X 32.8.
Fig. 13.	*Cycadopites* cf. *follicularis* Wilson & WEBSTER. 67102512-2, 101.5 X 40.4.
Figs. 14-15.	*Cycadopites* cf. *follicularis* Wilson & WEBSTER.Slide 67102605b-1, 100.5 X 37.3. 14: bright light. 15: phase contrast.
Fig. 16.	*Cycadopites* cf. *follicularis* WILSON & WEBSTER. Phase contrast, slide 67102509 -1, 86.0 X 20.3.
Fig. 17.	*Monosulcites epakros* BRENNER. Slide 66081502-1, 98.5 X 49.0.
Fig. 18.	*Monosulcites epakros* BRENNER. Phase contrast, slide 67102605b-1, 83.3 X 39.6.
Fig. 19a, b.	*Monosulcites epakros* BRENNER. Slide 67102501b-3, 96.1 X 24.1. a: bright light. b: phase contrast.
Fig. 20.	*Monosulcites epakros* BRENNER.Slide 67102605b-1, 103.8 X 20.7.
Fig. 21.	*Vitreisporites pallidus* (REISINGER) NILLSON. Slide 67102501b-3, 86.9 X 24.1.
Fig. 22.	*Vitreisporites pallidus* (REISINGER) NILLSON. Phase contrast, slide 68041602-1, 84.3 X 61.2.
Fig. 23.	*Araucariacites australis* COOKSON. Slide 67102510-3, 99.7 X 32.0
Fig. 24.	*Araucariacites australis* COOKSON. Slide 66081502-1, 91.3 X 49.0.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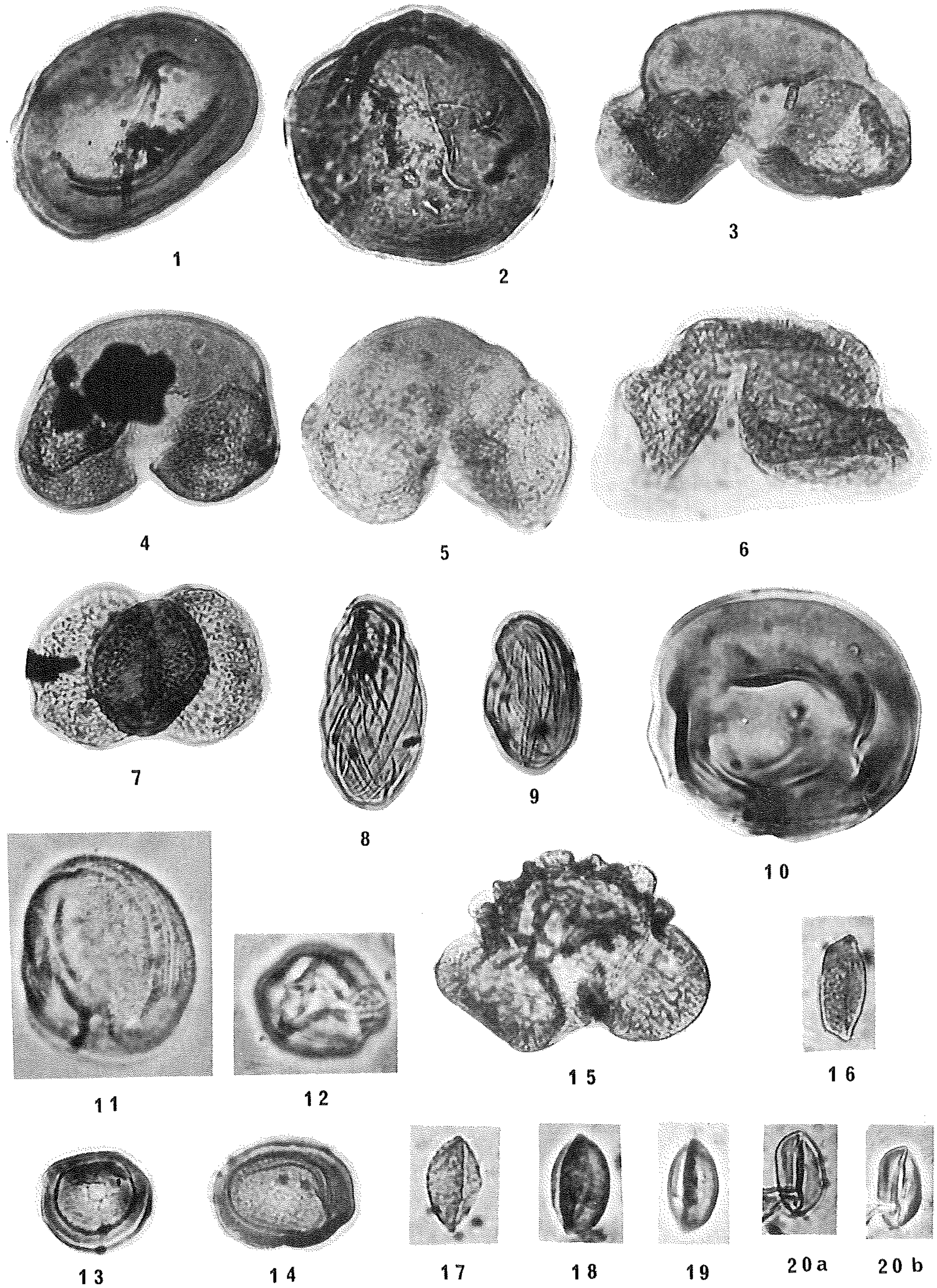
Explanation of Plate 9
(All figures X 600)

Fig. 1. *Araucariacites limbatus*(BALME) HABIB. Slide 67102510-3, 95.2 X 32.0
Fig. 2. *Araucariacites limbatus* (BALME) HABIB. Slide 67102510-3, 99.0 X 25.2.
Fig. 3. *Pityosporites constrictus*(PIERCE) n. comb. Slide 67102509-3, 102.0 X 59.1.
Fig. 4. *Abietineaepollenites* sp. Slide 66081511-3, 103.3 X 46.0.
Fig. 5. *Piceaepollenites saccellus* TAKAHASHI. Slide 67102512 2, 91.5 X 42.8.
Fig. 6. *Cedripites* sp. Slide 68041602-2, 103.6 X 25.0.
Fig. 7. *Podocarpidites ezoensis* (SATO) n. comb. Slide 67102603-3, 104.2 X 52.1.
Fig. 8. *Ephedripites* sp. Slide 67102508-3, 89.0 X 48.2.
Fig. 9. *Ephedripites* sp. Slide 67102512-2, 99.0 X 15.8.
Fig. 10. *Inaperturopollenites* sp. Slide 68041604-1, 93.4 X 24.8.
Fig. 11. *Classopollis* sp. Phase contrast, slide 68041604-1, 95.5 X 19.4.
Fig. 12. *Classopollis* sp. Phase contrast, slide 68041709-1, 93.5 X 36.8.
Fig. 13. *Classopollis* sp. Slide 68141706-2, 87.6 X 34.3.
Fig. 14. *Classopollis* sp. Slide 68041706-1, 95.5 X 42.8.
Fig. 15. *Rugubivesiculites fluens* PIERCE. Slide 66081502-1, 89.2 X 39.8.
Fig. 16. *Monocolpopollenites Kyushuensis* TAKAHASHI. Slide 67102510-1, 104.3 X 57.5.
Fig. 17. *Monocolpopollenites kyushuensis* TAKAHASHI. Slide 67102509-1, 95.4 X 61.8.
Fig. 18. *Monocolpopollenites kyushuensis* TAKAHASHI. Phase contrast, slide 67102501b-1, 84.5 X 60.5.
Fig. 19. *Monocolpopollenites kyushuensis* TAKAHASHI. Phase contrast, slide 67102501b-1, 93.0 X 30.0.
Figs. 10a, b. *Monocolpopollenites* cf. *universalis* TAKAHASHI. Slide 67102510-3, 103.6 X 27.7. a: bright light. b: phase contrast.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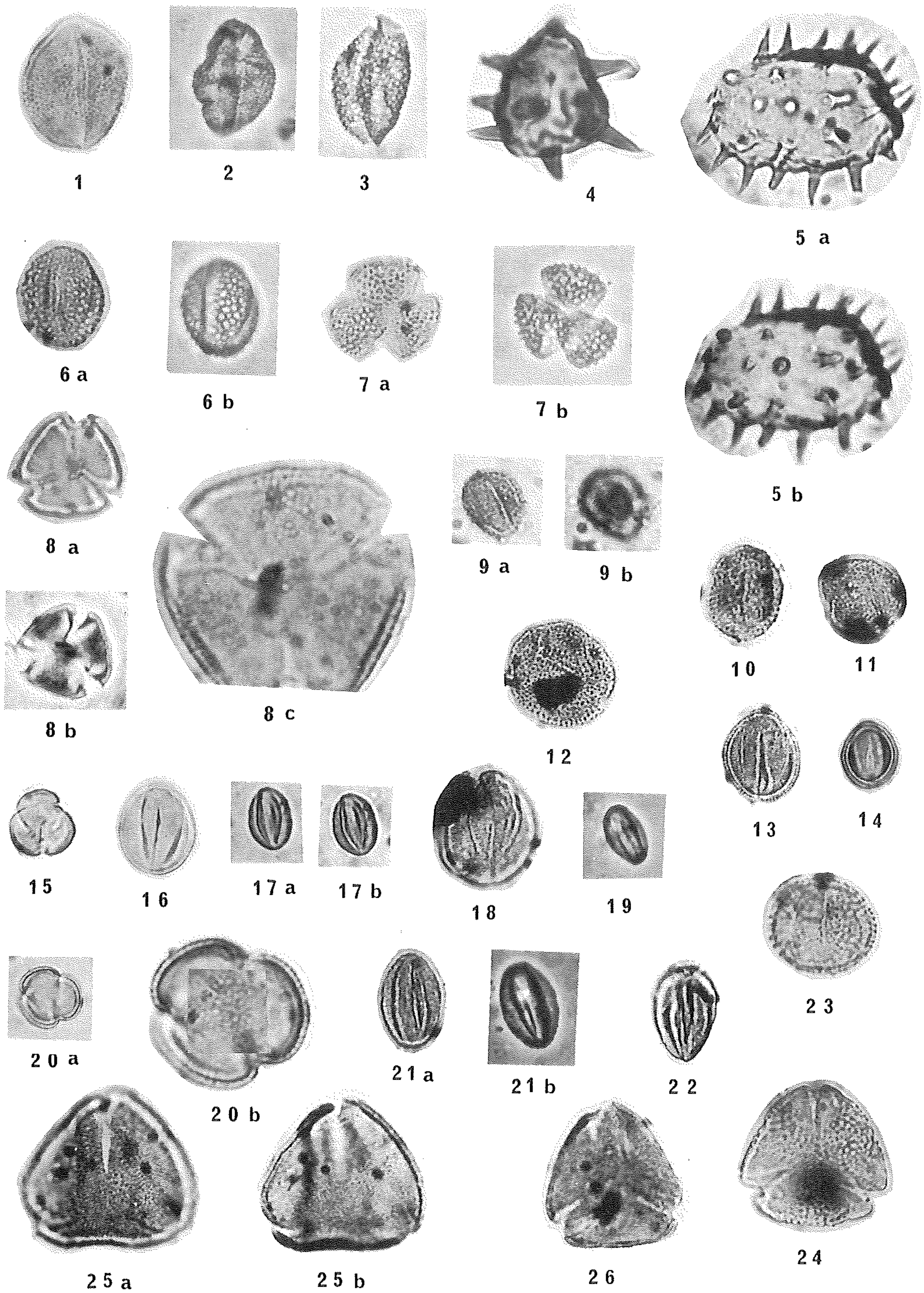
Explanation of Plate 10
(All figures X 600)

Fig. 1. *Monocolpopollenites pflugii* TAKAHASHI. Slide 67102501b-1, 93.5 X 47.1.
Fig. 2. *Monocolpopollenites pflugii* TAKAHASHI. Phase contrast, slide 67102501b-3, 88.6 X 25.4.
Fig. 3. *Monocolpopollenites pflugii* TAKAHASHI. Phase contrast, slide 67102605b-1, 85.9 X 36.4.
Fig. 4. *Spinizonocolpites echinatus* MULLER. Slide 67102605b-s, 103.5 X 35.0.
Fig. 5a, b. *Spinizonocolpites echinatus* MULLER. Slide 68041604-4, 83.3 X 60.4. a: bright light. b: phase contrast.
Figs. 6a, b. *Retitricolpites vulgaris* PIERCE. Slide 66081511-3, 89.5 X 53.5. a: bright light. b: phase contrast.
Figs. 7a, b. Retitricolpites vulgaris PIERCE. Slide 66081511-3, 88.5 X 57.0. a: bright light. b: phase contrast.
Figs. 8a-c. *Retitricolpites* cf. *prosimilis* NORRIS. Slide 67102508-1, 102.1 X 57.3. a: bright light. b: phase contrast. c: (X 1500).
Figs. 9a, b. *Tricolpopollenites micromunus* GROOT & PENNY. Slide 67102605b-1, 86.0 X 28.0. a: low focus. b: high focus.
Fig. 10. *Retitricolpites* sp. A Slide 67102501b-1, 84.8 X 32.9.
Fig. 11. *Retitricolpites* sp. A. Slide 66102818-1, 96.0 X 57.6.
Fig. 12. *Retitricolpites* ? sp. Slide 67102901-1, 88.5 X 22.5.
Fig. 13. *Tricolpopollenites minutiretiformis* TAKAHASHI. Slide 67102512-2, 96.2 X 35.6.
Fig. 14. *Tricolpopollenites minutiretiformis* TAKAHASHI. Slide 66081502-3, 94.3 X 18.4.
Fig. 15. *Tricolpopollenites vulgaris* TAKAHASHI. Slide 67102501b-3, 99.2 X 22.3.
Fig. 16. *Tricolpopollenites vulgaris* TAKAHASHI. Slide 67101604-1, 87.3 X 20.2.
Figs. 17a, b. *Tricolpopollenites* cf. *simplicissimus* GROOT, PENNY & GROOT. Slide 67102510-3, 102.5 X 34.3. a: bright light. b: phase contrast.
Fig. 18. *Tricolpopollenites meinohamensis rotundus* TAKAHASHI. Slide 66081511-3, 88.3 X 55.5.
Fig. 19. *Tricolpopollenites* sp. A. Phase contrast, slide 66082709-1, 96.3 X 22.1.
Figs. 20a, b. *Tricolpopollenites* sp. B. Slide 66081502-1, 104.8 X 31.3. a: (X 600) b: (X 1500).
Figs. 21a, b. *Tricolpopollenites* sp. C. Slide 67102508-3, 104.1 X 46.2. a: bright light. b: phase contrast.
Fig. 22. *Tricolpopollenites* sp. D. Slide 67102512-2, 100.1 X 44.5.
Fig. 23. *Tricolpites* sp. A. Slide 66102818-1, 86.2 X 57.4.
Fig. 24. *Tricolpites* sp. A. Slide 67102509-1, 104.2 X 33.4.
Fig. 25a, b. *Tricolpites* sp. B. Slide 68041602-1, 86.8 X 27.0. a: high focus. b: low focus.
Fig. 26. *Tricolpites* sp. B. Slide 68041602-2, 103.3 X 33.1.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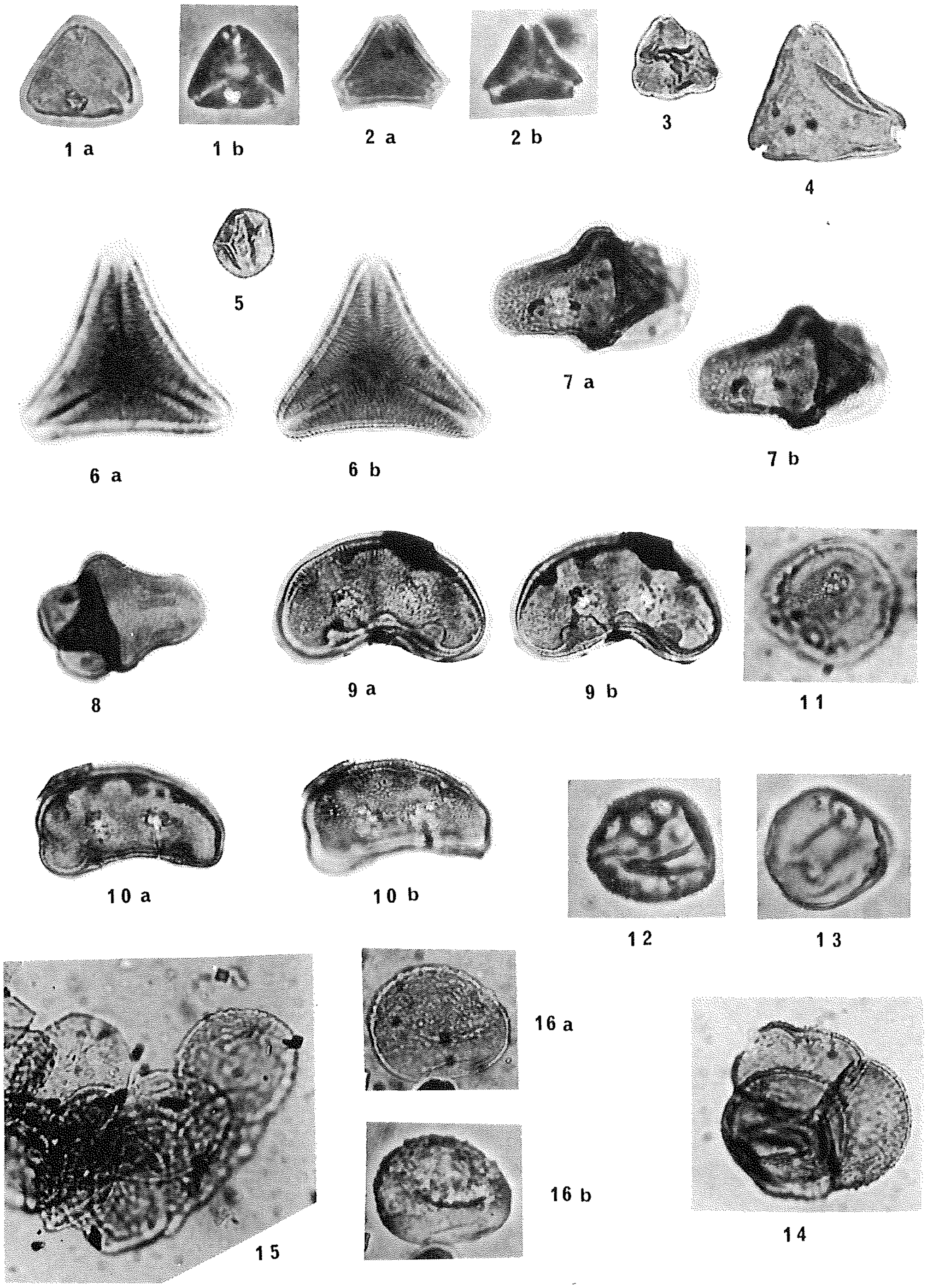
Explanation of Plate 11
(All figures X 600)

Figs. 1a, b. *Tricolpites* sp. C. Slide 67102508-3, 100.0 X 46.9. a: bright light. b: phase contrast.
Figs. 2a, b. *Tricolpites* ? sp. Slide 68041706-1, 96.5 X 54.0. a: bright light. b: phase contrast.
Fig. 3. *Triporopollenites shimensis* TAKAHASHI. Slide 68041602-1, 83.1 X 22.9.
Fig. 4. *Triporopollenites* sp. Slide 68041604-1, 85.8 X 50.1.
Fig. 5. *Tricolporopollenites* sp. Slide 67102508-3, 93.0 X 30.0.
Figs. 6a, b. *Accuratipollis evanidus* CHLONOVA. Slide 68041602-1, 94.8 X 55.4. a: high focus. b: low focus.
Figs. 7a, b. *Accuratipollis evanidus* CHLONOVA.Slide 68041602-1, 93.3 X 24.0. a: low focus. b: high focus.
Fig. 8. *Accuratipollis evanidus* CHLONOVA. Slide 67102605b-1, 93.4 X 37.0
Figs. 9a, b. *Ocellipollis obliquus* CHLONOVA. Slide 67102512 2, 82.7 X 42.1. a: low focus. b: high focus.
Figs. 10a, b. *Ocellipollis obliquus* CHLONOVA. Slide 67102512-2 98.3 X 23.0. a: high focus. b: low focus.
Fig. 11. Pollen Type A. Slide 68041602-1, 98.8 X 19.5.
Fig. 12. Pollen Type A. Phase contrast, slide 68041602-2, 86.9 X 32.0.
Fig. 13. Pollen Type A. Phase contrast, slide 68041602-1, 90.8 X 19.5.
Fig. 14. Pollen Type A. Tetrad grain, slide 68041602-1, 85.4 X 38.9.
Fig. 15. Pollen Type B. Slide 67102508-3, 103.1 X 29.7.
Figs. 16a, b. Pollen Type B. Slide 67102508-3, 86.0 X 51.8. a: bright light. b: phase contrast.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