POLLEN ANALYSIS OF CARBONACEOUS MATTER FROM THE HAKOBUCHI GROUP IN THE ENBETSU DISTRICT, NORTHERN HOKKAIDO, JAPAN.

PALYNOLOGICAL STUDY ON CRETACEOUS SEDIMENTS (I)

By

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Introduction

The Hakobuchi group, uppermost Cretaceous, in Hokkaidô contains terrestrial facies in various parts and produces many fossil remains of plants. A few papers have been published already on leaf fossils. However, no investigation has been carried out in Japan on the pollen and spores in this group.

It frequently happens in Hokkaidô that in places where the terrestrial facies of the Hakobuchi group are distributed close to Tertiary coal-bearing sediments discrimination of these two groups is practically difficult in the field. But, if workers are able to find the characteristic composition of spore and pollen grains contained in the Hakobuchi group, it is expected that spore and pollen grains from the carbonaceous sediments of these strata can be found and used to determine the geologic age: Tertiary or Cretaceous. Such result may give evidence to help explain the complicated geological structure with faults and foldings. It goes without saying that such work on pollen and spore content makes information on the flora of the Hakobuchi group more valuable.

The writer has made palynological examination of specimens of the Hakobuchi group at several localities in Hokkaidô, extracting many pollen and spore grains from the carbonaceous sediments of this group. The character of them was quite unique and possible to be distinguished easily from the Tertiary ones. In the present paper the writer describes the results of analysis of pollen and spores from the Hakobuchi group in the Enbetsu district, northern Hokkaidô.

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On samples and their preparation

Specimens discussed by the author are collected by Messrs. M. HATA and Y. SUMI of the Geological Survey of Japan, from the Hakobuchi group, of uppermost Cretaceous in the Enbetsu district, Teshio province, northern Hokkaidô. They were taken from carbonaceous seams and were mixed together at each locality.

The geologic succession in this district is as follows:

(Age)	(Formation)
Pliocene	Enbetsu formation
Late Miocene	Wakkanai formation
Middle Miocene	Kotanbetsu formation Chikubetsu formation
Late Cretaceous	Hakobuchi group Osoushinai formation

The Hakubochi group is composed mostly of arenaceous sediments; near the base, glauconitic sandstone is observed, while the middle part consists of glauconitic sandstone containing *Metaplacenticeras subtilistriatum* JIMBO. The stratigraphic horizon of coaly matter lies in the middle part of the formation overlain unconformably by the Chikubetsu formation. The upper part of the Hakobuchi group probably eroded out ground the sampling localities and the middle part containing carbonaceous matter may interfinger with the marine sediments with *Metaplacenticeras*. The samples were taken at two localities: A and B of different coal seams as shown in Fig. 1. The coal seam at locality A (45 cm. thick) occupies a higher horizon than the other one (30 cm. thick) at locality B.

The samples are powdered into 40~50 mesh. The powdered samples (0.5 cc) are put into centrifugal tubes and 5 cc Schulze solution is added to soak the samples for two days. Next, the samples are heated at 50~60°C with 10% KOH solution for 40 minutes after washing with distilled water by centrifugal machine. As soon as KOH solution is added the color of the solution changes into dark-brown or black. The samples are then washed again and again with distilled water until the dark color is almost completely removed. As the samples are usually rich in ash content, they are transfused into polyethylene centrifugal tubes and treated with 5 cc

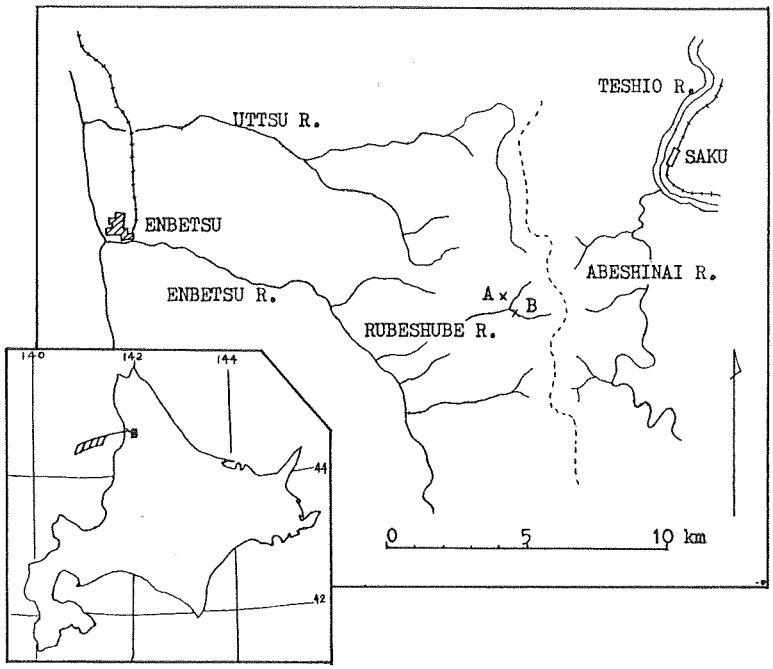

Fig. 1.

HF solution for 1 or 2 days. After being washed several times with distilled water the treatments will be quite finished. Then the treated samples are mounted with glycerine jelly, after which procedure they are ready to be examined under microscope (×600) provided with a mechanical stage.

Nomenclature of fossil pollen and spore

Since the beginning of studies on palynology differences in nomenclature of fossil pollens and spores of Tertiary and older times have appeared in the papers by WODEHOUSE, ERDTMAN, COOKSON, COUPER, R. POTONIE, THOMSON, PFLUG, IVEREN, TRAVERSE and other authors.

All Paleozoic spores belong to entirely extinct plants. The relationship between the macrofossils and their spores is frequently unknown. Accordingly, the artificial classification is preferred over the natural classification because of difficulties in identifying their position in systematic categories. On the other hand, as Quaternary pollens and spores are comparable to living plants, the natural classification is preferable in

making diagnostic identification. However, as Mesozoic and Tertiary, particularly Tertiary, pollen and spores are a mixture of the ones of extinct and extant plants in generic order, the classification and nomenclature for them are not unified: for instance, artificial classification and nomenclature have been used in some cases and natural one in other cases.

In this paper the writer has followed TRAVERSE's proposal which was recommended by the Palynological Conference in Stockholm, 1950. His proposal is briefly summarized in four points as follows:

1. Pollen inseparable from an extant genus is referred to that genus, with an appropriate specific name.
2. Pollen felt to be certainly representative of an extant family but not in a known genus, fossil or extant, is referred to a new genus of that family.
3. A well-characterized pollen form occurring abundantly in the deposit but of uncertain botanic relationships, is described as a member of an organ-genus, according to PFLUG's system.
4. If there are many pollen forms in the deposit not identifiable with extant or fossil genera or families and about which there is doubt because of inadaquate information as to range or size and structure, they are figured and described but not formally referred to a species.

In the present paper the writer employed the above-mentioned nomenclature, so far as he could, for pollens and spores. For instance, *Podocarpus hakobuchiensis* SATO sp. nov. is an example following the natural classification and *Fasciatisporites divergense* SATO sp. nov. is an another example following the form classification.

The writer holds an opinion on the nomenclature of fossil pollen and spore: In paleontology, the data on living creatures frequently are applied to those which lived in the past, and such a method is the only one to use in investigating the ecological condition in the past, although inorganic matter also gives a clue on the past condition in some cases. Then, on what ground should it be determined whether a creature which exists under certain ecological conditions at present was also living in the past? As one can not look at the ecological attitude of the fossil in the same manner as at that of the living one, one makes the fossil to correspond with the living specimen on the basis of morphological similarities, and gives it various characters as a life. Accordingly, it is a matter of course that fossils are classified following the natural classification in almost all sphere of paleontology. Of course, respecting fossil pollens and spores, it is desirable that the natural classification be used. The writer agrees with opinions that the identification of pre-Quaternary pollens and spores is

very difficult and artificial classification is inevitable in some cases. However, the writer bears always in mind that the effort to devise a nomenclature on the basis of the natural classification for the fossil pollens and spores must not be abandoned. It is an easy-going way and has little meaning to consider the vegetal assemblage and climatic condition in time and space to follow the artificial nomenclature for all fossil pollens and spores. From such a view point, the writer has preferred the nomenclature proposed by TRAVERSE.

Besides, sometimes new species of pollens and spores are reported in Japan only by figures without presentation of their descriptions. Such dealing is not adequate, because when others wish to compare a pollen or spore with them there is not sufficient information for full discussion. It is necessary to add the descriptions of them when new species are reported.

Occurrence of pollens and spores

The following is a systematic list of pollens and spores identified by the author from the present specimens:

	Locality (A)	Locality (B)
Pteriodophyta		
Equisetaceae		
Equisetum sp.	r	r
Filicales		
Osmundaceae		
Osmunda sp.	r	r
Gleicheniaceae		
Cf. *Gleichenia* sp.	r	r
Fasciatisporites divergens SATO sp. nov.	a	c
Cyatheaceae or Dicksoniaceae	r	r
Schizaeaceae		
Appendicisporites subtricornitatus SATO sp. nov.	a	c
Polypodiaceae		
Laevigato-sporites spp.	a	va
Incertae Sedis		
Deltoidospora enbetsuensis SATO sp. nov.	va	c
Other genera	r	r
Gymnospermae		
Cycadaceae or Ginkgoaceae		
Cycas sp. or *Ginkgo* sp.	r	r

Macrozamia ? hakobuchiensis SATO sp. nov.	r	r
Coniferae		
Podocarpaceae		
Podocarpus ezoensis SATO sp. nov.	r	r
Dacrydium ? transiens SATO sp. nov.	r	r
Pinaceae		
Picea sp.	r	r
Pinus sp.	r	r
Taxodiaceae	a	a
Angiospermae		
Salicaceae		
Salix sp.	r	r
Betulaceae		
Alnus sp.	r	r
Betula sp.	c	c
Carpinus sp.	r	r
Fagaceae		
Quercus sp.	r	r
Quercus (or *Castanea*) sp.	c	a
Juglandaceae		
Engelharditia sp.		r
Cf. Sapotaceae	r	r
Typhaceae	r	
Liliaceae	r	r
Incertae Sedis		
Aquilapollenites hakobuchiensis SATO sp. nov.	r	r
A. quadrilobus ROUSE	r	r
A. sp. nov.	r	

(va: very abundant, a: abundant, c: common, r: rare)

The floral composition in quantity of pollens and spores in the present specimens is shown in Table 1.

Pteridophyta is quite dominant, showing about 55% of existence; this is the characteristic feature of the present flora. The Pteridophyta presents mainly four sorts of spores as shown in Table 2.

As shown in Tables 1 and 2, the relative abundance of pollens and spores found in the coal seam at locality A present slight differences from that of at locality B. Also, though preparation 4 is not prepared from the average sample but from a piece of coal, it showed a different composition from the that of the average sample (preparations 2 and 3). Such difference of composition in the average sample and not average sample may

TABLE 1. Floral composition of pollen and spore of Hakobuchi formation in the Enbetsu district

	Locality	Locality B		
	prep. 1	prep. 2	prep. 3	prep. 4
PTERIDOPHYTA	55%	57%	53%	55%
GYMNOSPERMAE	13	15	16	27
ANGIOSPERMAE	13	23	30	17

TABLE 2. Lomposition of Pteridophyta of Hakobobuchi formation in the Enbets district

	prep. 1	prep. 2	prep. 3	prep. 4
Laevigato-sporites	13%	61%	63%	67%
Deltoidospors	66	4	3	2
Fasciatisporites	14	4	7	16
Appendicisporites	1	20	17	6

mean that a floral change existed through the coal seam.

The pollen and spore flora found from the present specimens has the following features:

1) Spores are more abundant than in Tertiary deposits.

2) Pollens and spores such as those of *Podocarpus, Aquilapollenites, Appendisisporites, Dacrydium*?, *Macrozamia*? Sapotaceae? and *Fasciatisporites* have hitherto been unknown from Tertiary sediments in Japan.

3) Gymnosperms such as *Cycas, Ginkgo, Macrozamia*?, *Picea, Pinus, Dacrydium*? *Podocarpus,* Taxodiaceae, etc. are rather commonly found.

4) But, Angiosperms such as *Alnus, Betula, Quercus,* etc. which are abundantly found in post-Cretaceous sediments are mixed with above-mentioned Gymnosperms. This feature indicates the existence of a transitional flora from the Mesozoic flora to Tertiary one.

5) Pollens and spores are abundantly found from the Hakobuchi group in the Hakobuchi valley and in the Hetonai—Hobetsu district, and these flora in respect to pollens and spores are similar to the one from the present specimens in quality, although not in quantity.

6) Moreover, it is very interetsing that the microplant fossil flora from the present district is similar in quality to that from the upper Cretaceous sediment in western Canada. However, because no quantitative relation is reported from Canada, quantitative similarity could not be

confirmed. That is to say, except *Appendicisporites*,* *Macrozamia*? and Sapotaceae? nearly all of the pollens and spores which are found from the present specimens are also reported from Canada.

7) Particularly, it is most characteristic that such a peculiar pollen as that of *Aquilapollenites* is also found from the present district. *Aquilapollenites* of which the taxonomic position is unknown, whether Spermatophyta or not, is reported from the upper Cretaceous in western Canada and Russia. So, it may be considered that it is an index fossil of upper Cretaceous.

8) Climatic condition under which the Hakobuchi group in the present area was deposited, could not be ascertained in detail from the observations made. More detailed and also extensive informations are needed before that can be done. However, it would not be far off if one assumes that the climatic condition were subtropical on the basis of the data obtained; the same conclusion is inferred from the macro-fossil plants. Especially, it seems qiute clear on the basis of the existence of the following plants: *Cycas*, *Macrozamia*?, *Taxodium*?, *Appendicisporites* (Schizaeaceae) and Sapotaceae?.

Moreover, preparations made from locality B shows that black fragments (some of them are certainly plant tissues, Plate II, Fig. 19) occur very abundantly under microscope, whilst pollens and spores are very rare (also the preparation from locality A shows such black fragments though not so abundant). As such black fragments have not been found in Tertiary sediments so far as the writer examined but are found from the Hakobuchi group in the Hakobuchi valley and Hobetsu—Hetonai district, the occurrence of black fragments may be a characteristic of the Hakobuchi group. So, it is a problem left for the future whether such a black colored materials are attributable to a special condition or to some vegetable matter.

The flora of the Hakobuchi group contains an interesting problem in that the flora is in a transitional phase from Mesozoic flora to Tertiary one. Especially, as the Cretaceous system in Hokkaidô is almost entirely marine in origin except the Hakobuchi group and some parts of the upper Yezo group and the Mikasa formation and does not contain fossil plants, the Hakobuchi group is important for investigating a floral change from Mesozoic to Tertiary. In the Hakobuchi group, it frequently happens that terrestrial facies exist and carbonaceous sediments are contained in it, but plant macro-fossils are not. In such a case, pollen analytical study is the only method to find a clue on the paleobotanical features. Though such

* but, Mohria which probably has very close relationship with it is reported.

study may have some defects in some points as compared with the study of macro-fossils of plants, it is expected that much interesting information may be gotten from such study. Especially, as the pollen analytical study is in an infant stage in Japan, it is hoped that much more data may be collected hereafter. Only on more such data can more detailed and more useful information be produced.

Descriptions of some noteworthy pollens and spores*

Pteridophyta
Gleicheniaceae?
Genus *Fasciatisporites* gen. nov.

Trilete, with long laesurae reaching to corners of subtriangular contour in polar view. The laesurae attended with slightly thickened rim. Exine rather smooth or faintly punctate and moderately thick with concave dark area extending interiorly from the wall along the contour or laesurae in polar view. Type species: *Fasciatisporites divergens* SATO sp. nov.

The genus *Fasciatisporites* is composed of one species, *Fasciatisporites divergens* SATO sp. nov. in the present specimens.

Fasciatisporites divergens SATO sp. nov.
(Plate. I, Figs. 6–10)

Description: Trilete with long laesurae reaching to corners of subtriangular contour in polar view; laesurae attended with slightly thickened narrow rims; exine rather smooth (or faintly punctate?) and moderately thick with concave dark area extending interiorly from the wall along the contour or laesurae in polar view; size 40~35 μ in diameter of the contour in polar view.

Remarks: This new species is very similar to *Deltoidospora diaphana* WILSON & WEBSTER reported by ROUSE from the upper Cretaceous sediment in western Canada (*Can. Jour. Bot. vol. 35, Pl. I, fig. 15,* 1957), but the original description and the photograph (WILSON, L. R. and WEBSTER: *Am. Jour. Bot. vol. 33, no. 4, fig. 3,* 1946—from Fort Union coal (Eocene) of Montana) seem to be different from the one reported by ROUSE. Also, the description by ROUSE (*Can. Jour. Bot. vol. 35, p. 360, Pl. I, fig. 19,* 1957) of *Tricolpopollenites divergens* ROUSE is well applicable to the present species, especially the existence of "dark area extending interiorly from wall" is also a characteristic feature of the present species. So, the only

* Only characteristic or abundant pollens and spores are described.

feature of *Tricolpopollenites divergens* ROUSE distinguished from the present species according to the description is tricolpate-shape as is shown by the name "*Tricolpopollenites.*" However, in ROUSE's paper (*Can. Jour. Bot., vol. 35,* 1957), only the polar view of the grain is shown in photograph, and both the tricolpate-shape and length of the polar axis are not referred to. Commonly, grains of tricolporate-shape are more frequently seen under microscop in lateral view than in polar view. Nevertheless, why are the description and figure in lateral view not reported? At any rate, ROUSE's description well represents the characters of the present species. So, it is assumed that *Tricolpopollenites divergens* ROUSE established by ROUSE may be conspecific with the present species, and is not a pollen, but a spore. The reason that the writer employed the specific name "*divergens*" is based on the above-mentioned matter. Besides, the present species is similar in shape to *Concavisporites exiguus* PFLUG (THOMSON & PFLUG: *Palaeontographica, vol. 94, Abt. B, p. 50, pl. 1, figs. 44-46,* 1953) found from the upper Cretaceous to the lower Tertiary in Germany and to *Cibotiumsporites concavus* ROUSE (*Can. Jour. Bot., vol. 35, p. 354, pl. 1, figs. 36, 37,* 1957) found from the upper Cretaceous in Canada, but in the descriptions of both there is no reference to the existence of the dark area. At first, the writer considered using the name "*Concavisporites.*" However, as *Concavisporites* seems to be higher than generic in the natural classification, the writer does not use it as a generic name, but gives the pollen the new generic name "*Fasciatisporites.*" Also, the present species is similar in shape to *Gleichenidites senonicus* ROSS (COUPER, R. A., *Palaeontographica, p. 138, Pl. 19, figs. 14, 15,* 1958) reported from the Middle and Upper Jurassic and Lower Cretaceous in England; COUPER assumed it to belong to Gleicheniaceae. Moreover, *Gleichenia concavisporites* ROUSE was reported by ROUSE (*Can. Jour. Bot., vol. 35, p. 363, pl. 2, figs. 36, 48, pl. 3, fig. 49,* 1957) from the upper Cretaceous in Canada. So, the present species may belong to Gleicheniaceae.

Schizaeaceae

Genus *Appendicisporites* WEYLAND & KRIEGER

Appendicisporites subtricornitatus SATO sp. nov.

(Pl. II, Figs. 22-26)

Description: Trilete, laesurae long; contour convex rounded-triangular in the polar view; distal surface sculptured with ribs of 2 to 5 μ wide; the ribs spaced 1 to 4 μ apart, running parallel to the equatorial plain; riges observed on corners of the subtriangular contour in the polar view, about 5 μ in hight; ornamentation finely punctate on the distal surface,

sometimes seeming smooth; size 55~75 μ in equatorial diameter.

Remarks: The present species is very similar to *Appendicisporites tricornitatus* WEYLAND and GLEIFELD reported by WEYLAND and GREIFELD (*Palaeontographica, vol. 95, Abt. B, p. 43, pl. 11, fig. 52,* 1953) and COUPER, R. A. (*Palaeontographica Bd. 103, p. 135-136, pl. 17, figs. 7-9,* 1958) from the Wealden and Aptian (Jurassic-Lower Cretaceous) in England. The present species is, however, larger than it (45~65 μ in equatorial diameter). *Appendicisporites,* an artificial genus, is similar in form to *Anemia* and *Mohria,* both Schizaeaceae, among living plants. The present species is more similar to the latter than the former. *Mohria*-type spores are reported in many papers: for example, as *Mohria mutabila* BOLKHOVITINA and *Anemia tricostata* BOLKHOVITINA by BOLKHOVITINA (*Trans. Inst. Geol. Sci. U.S.S.R., Rel. 145, Geol. Ser. no. 61, p. 38, pl. 4, figs. 9-12,* 1953) from the lower Cretaceous in the central regions of U.S.S.R., Cfr. *Mohria* type by RADFORD and ROUSE (*Can. Jour. Bot., vol. 32,* 1954) from the uppermost Cretaceous in western Canada, and *Cicatricosisporites dorogensis* POTONIE and GELLETICH by ROUSE (*Can. Jour. Bot., vol. 35, p. 362, pl. II, figs. 38, 39,* 1957) from the upper Cretaceous in western Canada. But, all these similar forms do not have ridges as found in the present species.

Schizaeaceae is not found and also fossil Schizaeaceae have not been reported from Japan. In the present specimens Schizaeaceae is composed of only the present species. At the present, *Anemia* is composed of 90 spcies: nearly all of these are distributed in tropical America, a few in Africa and Madagaskar, one in India. *Mohria* is composed of three species distributed as known at present in eastern Africa and Madagaskar after A. ENGLER and L. DIELS (Syllabus der Pflanzenfamilien, p. *109,* 1936).

Polypodiaceae

Genus *Laevigato-sporites* (Ibrahim) emend SCHOPH, WILSON and BENTALL
Laevigato-sporites gracilis WILSON & WEBSTER

(Pl. II, Fig. 5)

Description: Grains narrowly bean-shaped; monolete, with a simple suture always occurring along concave crest; wall smooth; length 35~48 μ, width 23~28 μ.

Remarks: The spores of the present species found in the present specimens are identified with *Laevigato-sporites gracilis* WILSON & WEBSTER described by WILSON and WEBSTER (*Am. Jour. Bot., vol. 33, p. 273, fig. 4,* 1946), except the former is larger than the latter (the latter, length 27~30 μ, width 16~19 μ). The present species is found very abundantly

in the present specimens, and also abundantly or commonly in many deposits from Paleozoic to Quaternary.

Laevigato-sporites ovatus WILSON & WEBSTER

(Pl. II. Figs. 20-21)

Descriyption: Broadly bean-shape; monolete with a suture opened frequently, length of the suture about 3/4~1/2 of whole length; wall smooth; length 48~55 μ, width 35~43 μ.

Remarks: The present species is also similar to *Laevigato-sporites discordatus* THOMSON and PFLUG (*Palaeontographica, Bd. 94,* 1953) reported by ROUSE (*Can. Jour. Bot., vol. 35, p. 364, figs. 21, 22,* 1957). Distinction between the two is not clear. Also, the present species occurs frequently or abundantly in sediments from Paleozoic to Quaternary, and also in the present specimens very abundantly.

Filicales-Incertae Sedis

Genus *Deltoidospora* MINER

Deltoidospora enbetsuensis SATO sp. nov.

(Pl. II, Figs. 1-5)

Description: Trilete, laesurae with length about 3/4 of diameter in polar view; contour slightly convex subtriangular with rounded corners in the polar view, broad spindle-shape in lateral view, sometimes corners compressed and seen as a fold in lateral view; exine rather thin, punctate or fine granular; size 27~38 μ in the equatorial diameter, 25~35 μ in the length of the polar axis.

Remarks: No botanical affinity with the present plant is known so far as the writer is aware. However, it is similar to *Deltoidospora rhytisma* ROUSE which is presumed to belong to Filicales, but the present species is smaller than it: *D. rhytisma* ROUSE 32~50 μ, the present species 25~35 μ. Also, it is similar to *Divisisporites subtilis* PFLUG, but as the name *Deltoidospora* was used earlier than the name *Divisisporites,* the writer employs the former name. *Deltoidospora rhytisma* ROUSE is reported from the upper Cretaceous in Canada (*Can. Jour. Bot., vol. 35, pp. 355-356, pl. I, figs. 17, 34, 35,* 1935); the geological horizon of source site of *Divisisporites subtilis* PFLUG is from the upper Cretaceous to the lower Tertiary (*Palaeontographica vol. 94, Abt. B, p. 51, pl. 1, figs. 62-63,* 1953). The present species is also found from the Hakobuchi group (uppermost Cretaceous) in the Hakobuchi valley, southern central Hokkaidô.

Gymnospermae

Podocarpaceae

Genus *Podocarpus* PERS.

Podocarpus ezoensis SATO sp. nov.

(Pl. I, Figs. 29-30)

Description: Grain provided with two larger bladders than body; bilaterally symmetrical in shape; exine reticulate (or granular?); thick (4~5 μ) undulated marginal ridge existing on boundary between cap and the bladders or dorsal surface; furrow long, reaching from one end to the other of the body, restricted from both bladders by slightly raised rim; bladders having a coarser (2~3 μ) reticulation than the body; size in Fig. 30 body 30×30 μ, bladders 45×28 μ, 44×30 μ, furrow with 8 μ (at the widest), in Fig. 29 body 32×27 μ, bladder 30×45 μ, furrow with 5 μ (at the widest).

Remarks: The present species is very similar to *Podocarpidites nageiaformis* ZAKLINSKJA reported by ZAKLINSKJA (*Acad. Sci. SSSR, Works of the Geol. Inst. Contr. 6, Moscow, p. 106, pl. 2, figs. 8-11*, 1957) from the lower Oligocene in Northern Aral basin. Also, though *Podocarpidites biformis* ROUSE is reported by ROUSE (*Can. Jour. Bot., vol. 35, p. 367, fig. 13*, 1957) from the upper Cretaceous in western Canada, the crest of the present species is not so undulating as it and the bladders of the present species are much larger than the body as compared with *Podocarpidites biformis* ROUSE. Moreover, many pollen grains of *Podocarpus* are frequently found from the Cretaceous deposits of various districts in the world. *Podocarpus* is found sometimes from the Hakobuchi group in Hokkaidô.

Distribution of *Podocarpus* is restricted now to the southern hemisphere and the Orient, and is composed of about 70 species according to ENGLER and DIELS.

Dacrydium ? *transiens* SATO sp. nov.

(Pl. I, Figs. 23-24)

Description: Grain ellipsoidal in shape; monolete with two meager and wrinkled bladders at both sides of furrow which opens widely; ornamentation granular; size, body 37~42×25~30 μ, bladders 4~7 μ in width, 20~40 μ in length.

Remarks: The present species is similar to the pollen grain which is illustrated by ERDTMAN (Pollen and Spore Morphology/Plant Taxonomy, 1957, *p. 16, fig. 24*) as a deviating form of *Dacrydium franklinii* so far as the writer examined. So, the writer identified the species at hand with

Dacrydium for the time being. As the present species often appears in the form as shown in Figs. 23 and 24 (Pl. I), it remains a problem whether such a form is a deviation or not: the present species may be not a deviating form but may belong to another genus. However, at any rate, it seems sure that the present species belongs to Gymnosperm based on the existence of the single furrow with two bladders on both sides thereof. Besides, though the pollen grains as shown in Fig. 21 (Pl. I) are found in the present specimens and the writer identified them with *Pinus* or *Dacrydium*, these pollens are too small for *Pinus* of the recent and fossil of post-Tertiary. But, there are not available data on the size range of *Pinus* in Cretaceous, and also the writer could not find a positive character of the grains for *Dacrydium*.

Dacrydium is composed of 20 species and is known to be distributed in Melanesia, Tasmania, New Zealand and south Chile at the present according to ENGLER and DIELS (Syllabus der Pflanzenfamilien, p. 122, 1936).

Cycadaceae

Macrozamia? hakobuchiensis SATO sp. nov.

(Pl. I, Fig. 22)

Description: Grain spherical or ellipsoidal in shape; monolete, furrow broad and rounded at its ends, sometimes with overhanging rims; ornamentation faintly granular; size 45~50 $\mu \times 40$~45 μ.

Remarks: The grains of the present species have a characteristic feature of Cycadales: a single longitudinal furrow. Similar forms are found in pollens of Cycadales: *Cycas, Zamia, Ceratozamia, Dioon* and *Microzamia*. But, the sizes of these are smaller than that of the present species: *Cycas* 25~32 μ, *Zamia* 26~29 μ, *Ceratozamia* ±39 μ, *Dioon* 27~30 μ, *Microzamia* ±29 μ (all the values are in length) after WODEHOUSE (Pollen Grains *pp. 237-240*, 1935). Though the description of the present species is not referred to by WODEHOUSE, it concides well with *Macrozamia* described by ERDTMAN (Pollen and spore Morphology/Plant Taxonomy, *p. 29, Fig. 46*, 1957) in its size and shape.

Macrozamia is composed of 15 species and is distributed in Australia as known at present according to ENGLER and DIELS (Syllabus der Pflanzenfamilien, *p. 118*, 1936).

Pollen and Spore—Incertae Sedis

Genus *Aquilapollenites* ROUSE

The present genus is characteristic in its shape. The position of

plants which produce pollen grains of Aquilapollenites in the natural classification is utterly unknown. Though occurrence of the present genus is reported from Canada and U.S.S.R., its occurrence is restricted to the upper Cretaceous at present with only one exception: a similar form from the pre-Carboniferous sediments in Canada reported by RADFORTH and McGREGOR (*Can. Jour. Bot., vol. 32, pl. 1, fig. 4,* 1954). RADFORTH and McGREGOR gave the name "B_{12}" to it, and reported many other spores with it. But, when known knowledge on plant history is considered, such existence of many land plants in pre-Carboniferous is dubitable. Is it necessary moreover to make sure of the age of the horizon of its occurrence. At any rate, there is a possibility that Aquilapollenites may be an index fossil of the upper Cretaceous. The following species of Aquilapollenites have been reporte: *Aquilapollenites quadrilobus* ROUSE, *A. trialatus* ROUSE, *A. bullatus* BOLKHOVITINA, *A. aequus* BOLKHOVITINA, and writer reports newly two species: *A. hakobuchiensis* SATO and *A.* sp. nov.

Aquilapollenites hakobuchiensis SATO sp. nov.

(Pl. I, Figs. 13-14)

Description: Bilaterally symmertical; body along the symmetrical axis split into two parts at the one tip and two thick walled (2~3 μ) subspherical bodies attached near center part on both sides; grooves with thick rim radiating from center on the middle of wing-like bodies; wall smooth or granular, but on the wing-like bodies, especially at the tips, granular ornamentation sometimes seen; size 40 μ long at the central body, width of the wing-like bodies at the base 20 μ and length 20 μ, the subspherical body about 15 μ in diameter (in Fig. 14), 33 μ long at the central body, length of wing-like body 20 μ, diameter of subspherical body diameter 11 μ (in Fig. 13).

Remarks: Botanical affinity to any recent plant is not known, but it is similar in shape to genus *Aquilapollenites* ROUSE which is assumed by ROUSE to belong to the conifers. The writer has doubt about the disposition. Though ROUSE considered it to be a conifer based on the existence of two wing-like bodies which he made correspond to the bladders of the conifers, it was observed in the Hakobuchi group in the Hakobuchi valley and the Hetonai—Hobetsu district that these grains transform to a shape which differs from that of *Aquilapollenites* described by ROUSE. Though the present species is found in small quantity in the present specimens, it is frequently found in the Hakobuchi group (uppermost Cretaceous) from the Hakobuchi valley and the Hobetsu—Hetonai district, southern central Hokkaidô. Two species belonging to *Aquilapollenites* have been reported

up to the present from the upper Cretaceous in Canada: *A. quadrilobus* ROUSE and *A. trialatus* ROUSE (ROUSE, G. E.: *Can. Jour. Bot., vol. 35, pp. 349-375, pl. II, figs. 8, 9, 14, 15,* 1957), but, the present species is distinguishable from the above two on the basis of the ornamentation and shape. Moreover, two species of *Aquilapollenites* have been reported from the upper Cretaceous in U.S.S.R.: *A. bullatus* BOLKHOVITINA and *A. aequus* BOLKHOVITINA (BOLKHOVITINA, N. A.: *Acad. Sci. SSSR, Bull. Geol. Inst., vol. 24,* 1959), but the present species is distinctly distinguishable from them on the basis of the shape.

Aquilapollenites sp. nov.

(Pl. I, Fig. 20)

Description: Grain consisting of two bodies crossed in T shape, one of the two bodies subrectangular; bilaterally symmetrical, with rather stumpy form; thick 2~1.5 μ) exine enveloping; aperture-like slit existing on the crossed part; ornamentation papillated, especially coarse papillae arranged on the body along symmetrical axis; size 29 μ along symmetrical axis, length of the subrectangular body 42 μ, width of the subrectangular body 18 μ.

Remarks: The present specimen is the only one found in the slides, so the writer does not define it under a specific name. Botanical affinity to any recent plant is not known. However, it has the most similarity with *Aquilapollenites quadrilobus* ROUSE (*Can. Jour. Bot., vol. 35, p. 371, p. I, figs. 8, 9,* 1957).

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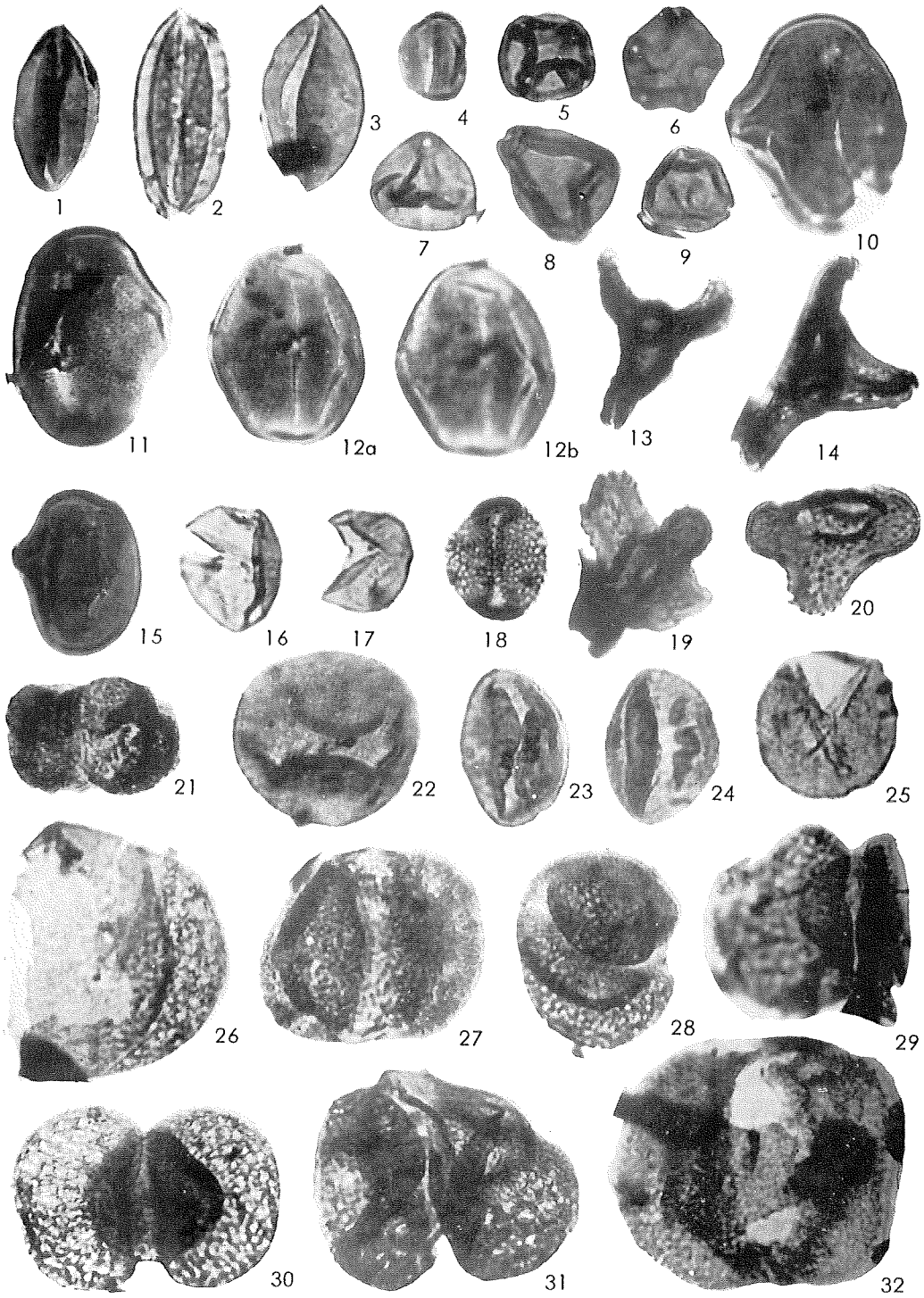
Explanation of Plate 1

Explanation of Plate I

		size (μ)
1.	*Cycas* sp. or *Ginkgo* sp.	40×21
2.	*Cycas?* sp. or *Ginkgo?* sp.	50×23
3.	*Cycas* sp. or *Ginkgo* sp.	44×25
4.	*Quercus* sp.	22×16
5.	*Alnus* sp.	25×22
6.	*Aluns* sp.	25×24
7.	Cf. *Carpinus* sp.	26×24
8.	*Betula* sp.	31×27
9.	Cf. *Engelharditia* sp.	22×21
10.	Undeterminable pollen (Sapotaceae?)	53×42
11.	Undeterminable pollen (Sapotaceae?)	53×39
12.	a. b. Undeterminable pollen (Sapotaceae?)	48×38
13.	*Aquilapollenites hakobuchiensis* SATO sp. nov.	45×35
14.	*Aquilapollenites hakobuchiensis* SATO sp. nov.	58×33
15.	Undeterminable pollen (Sapotaceae?)	40×30
16.	Taxodiaceae	30×24
17.	Taxodiaceae	25×20
18.	Liliaceae?	30×25
19.	*Aquilapollenites quadrilobus* ROUSE	43×40+
20.	*Aquilapollenites* sp.	42×29
21.	*Pinus* or *Dacrydium* sp.	42×28
22.	*Macrozamia? hokobuchiemsis* SATO sp. nov.	45×42
23.	*Dacrydium? transiens* SATO sp. nov.	41×25
24.	*Dacrydium? transiens* SATO sp. nov.	38×28
25.	Taxodiaceae (Taxodium?)	38×34
26.	*Picea* sp.	62×48+
27.	*Pinus* sp.	55×47
28.	*Pinus* sp.	48×38
29.	*Podocarpus ezoensis* SATO sp. nov.	45×47+
30.	*Podocarpus ezoensis* SATO sp. nov.	64×45
31.	Pinaceae	64×52
32.	*Picea* sp.	68×58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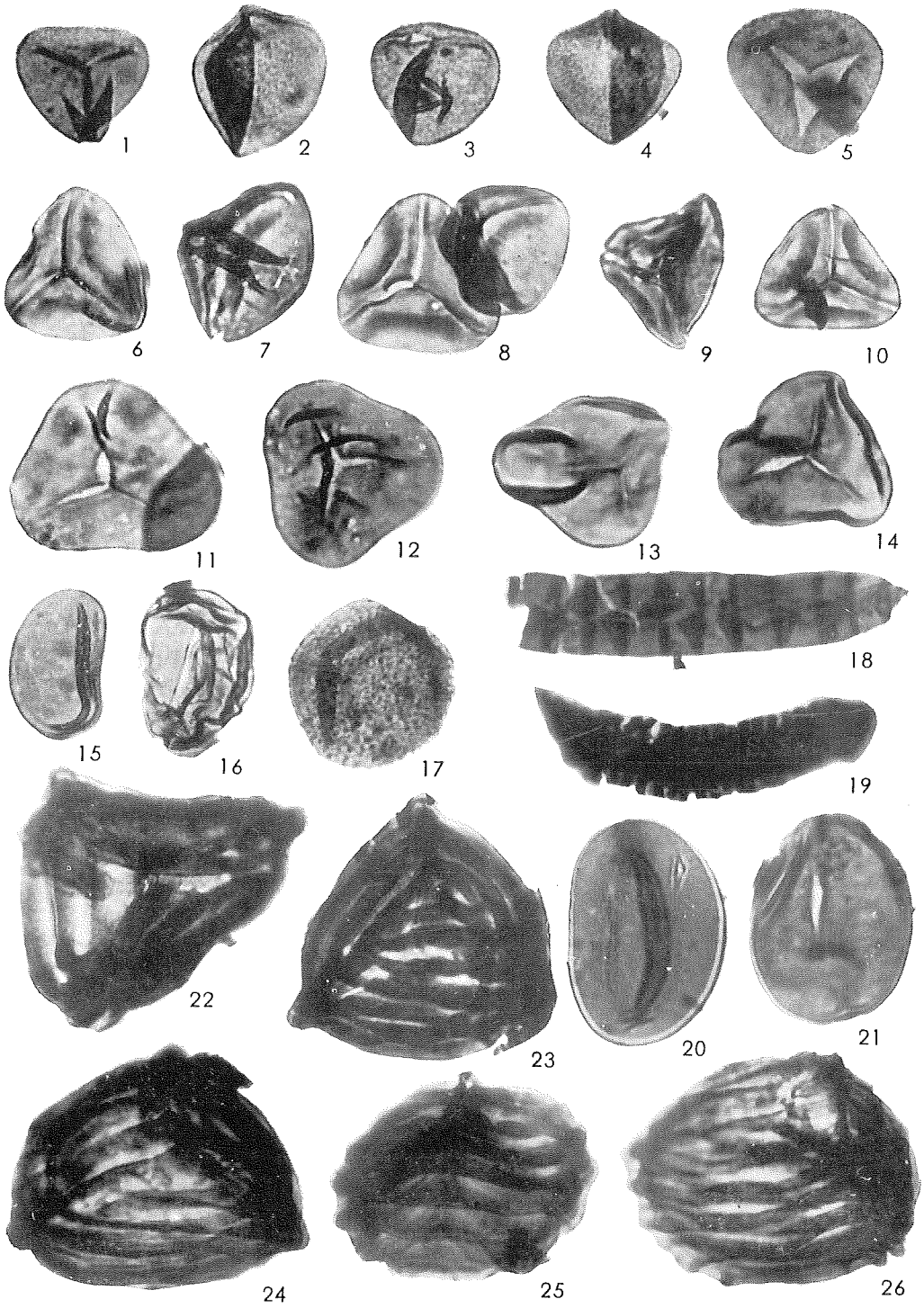
S. SATO Photo.

Explanation of Plate 2

Explanation of Plate II

		size (μ)
1.	*Deltoidospora enbetsuensis* SATO sp. nov.	32×27
2.	*Deltoidospora enbetsuensis* SATO sp. nov.	36×32
3.	*Deltoidospora enbetsuensis* SATO sp. nov.	30×28
4.	*Deltoidospora enbetsuensis* SATO sp. nov.	32×30
5.	*Deltoidospora enbetsuensis* SATO sp. nov.	38×33
6.	*Fasciatisporites divergens* SATO sp. nov.	37×35
7.	*Fasciatisporites divergens* SATO sp. nov.	41×33
8.	*Fasciatisporites divergens* SATO sp. nov.	40×38
9.	*Fasciatisporites divergens* SATO sp. nov.	38×30
10.	*Fasciatisporites divergens* SATO sp. nov.	35×29
11.	Cyatheaceae or Dicksoniaceae	47×40
12.	Cyatheaceae or Dicksoniaceae	43×42
13.	Cyatheaceae or Dicksoniaceae	41×37
14.	Cyatheaceae or Dicksoniaceae	43×38
15.	*Laevigato-sporites gracilis* WILSON & WEBSTER	35×23
16.	Cf. *Equisetum* sp.	38×28
17.	*Osmunda* sp.	39×39
18.	Fungus (Septonema?)	93×20
19.	"black fragment"	
20.	*Laevigato-sporites ovatus* WILSON & WEBSTER	57×38
21.	*Laevigato-sporites ovatus* WILSON & WEBSTER	52×40
22.	*Appendicisporites subtricornitatus* SATO sp. nov.	74×55
23.	*Appendicisporites subtricornitatus* SATO sp. nov.	65×57
24.	*Appendicisporites subtricornitatus* SATO sp. nov.	73×59
25.	*Appendicisporites subtricornitatus* SATO sp. nov.	66×50
26.	*Appendicisporites subtricornitatus* SATO sp. nov.	75×56



S. SATO Photo.