Palynological Investigation of the Holocene Hojozu Submerged Forest in Toyama Prefecture, Central Japan

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——Palynological Investigations on the Quaternary System in Japan (3)——

Norio FUJI**

ПАЛИНОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ ЗАХОРОНЕННОГО ЛЕСА ХОДЖОЗУ В ГОЛОЦЕНЕ, ПРЕФЕКТУРА ТОЙЯМА* ЦЕНТРАЛЪНАЯ ЯПОНИЯ

ПАЛИНОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ ЧЕТВЕРТИЧНОЙ СИСТЕМЫ ЯПОНИИ (3)

Норио ФУДЖИ**

АННОТАЦИЯ

Результаты палинологических исследований захороненного леса Ходжозу следующие:

(1) Возраст формирования захороненного леса может быть либо самым мозднии Яойским, либо самым ранним периодом древних гробниц, т.е. 1600-1500 лет тому назад.

(2) По палинологическим, стратиграфическим и радиологическим данным исследований возраст формирования многих деревьев составляющих захороненный лес Ходжозу, произраставших в данном районе, по всей вероятности 4000-1500 лет.

(3) Причина формирования захороненного леса была, по-видимому, поднятие уровня моря, что более вероятно, чем погружение береговой линии вдоль бухты Тойяма. Это поднятие уровня моря известно как Яойская трансгрессия.

(4) Палеоклимат, в котором произрастали деревья до образования погруженного (захороненного) леса был холоднее, чем В настоящее время. Температура была приблизительно на 1-2° ниже средней температура в современное время. Время похолодания можно сравнить со временем незначительного опускания уровня моря, что соответствует середине третъего Емонского периода-самому позднему Яойскому времени, либо самому раннему периолу древних гробниц.

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**: Institute of Earth Science, Faculty of Education, Kanazawa University.

Introduction

The Hojozu district is situated in the innermost part of Toyama Bay, being characterized by the deltaic deposits, typical fans, Lagoon Hojozu, some submerged forests and some drowned valleys.

The Hojozu forest was reported first by the late I. Ishii (1936). He stated as a good evidence showing the subsidence of ground (Ishii, I. 1938, 1940-1941). He referred to Wakimizu's opinion that the submerged forest, which was subjected to sudden sinking, was represented only by immersed trunks. Ishii concluded that the coast of Toyama Bay had been submerged at the rate of only 2.16 meters in 1,000 years and the age of formation of the forests around Toyama Bay might be about 50,000 years ago.

The present writer was studying on the coastal sand dunes and Holocene alluvial deposits with peat layers and ancient forests of the Hokuriku region. The scope of this article is the determination of the age of this forest, palaeoclimate, geographical environments and origin of the submerged forests. The present report is the third paper of the series, "Palynological Investigations on the Quaternary System in Japan".

Geological Description

The Hojozu district is geologically characterized by the deltaic area, typical fans and some submerged forests as the Yokata forest.

The deltaic area named as the Imizu plain is a wide plain and might have been formed by such rivers as Sho River, Jinzu River and Joganji River. The fan is divided into two areas as the Joganji area and Shogawa-Oyabe area. The Pleistocene terraces are developed between these fans, juting out into the deltaic area.

Lagoon Hojozu, in which the New Toyama Harbour was constructed abou ten years ago, is situated at the coast between the Sho and Jinzu rivers. In this district the coastal sand dune extends only to near Lagoon Hojozu.

The Holocene deposits are most typical in the Imizu deltaic area, where the relationship between the Pleistocene and Holocene deposits is known better than those in the other areas of Hokuriku region. The boundary between the Pleistocene and Holocene deposits is found at a depth of 45 to 50 meters below the present sea level at the present coast.

The sediments during the Holocene major transgression named as the Flandrian transgression are mainly composed of mud, muddy sand and sand. Judging from the some well drilled in the area of the lower part of the Jinzu River, the gravel layer which overlies the Holocene transgressional deposits are found between about 20 meters and 5 meters below the present sea level in the coastal areas. The layer shows a remarkable distribution at an altitude of about 10 meters above the present sea level of the northern slope of Mt. Kureha-yama near Toyama City, and extends continually

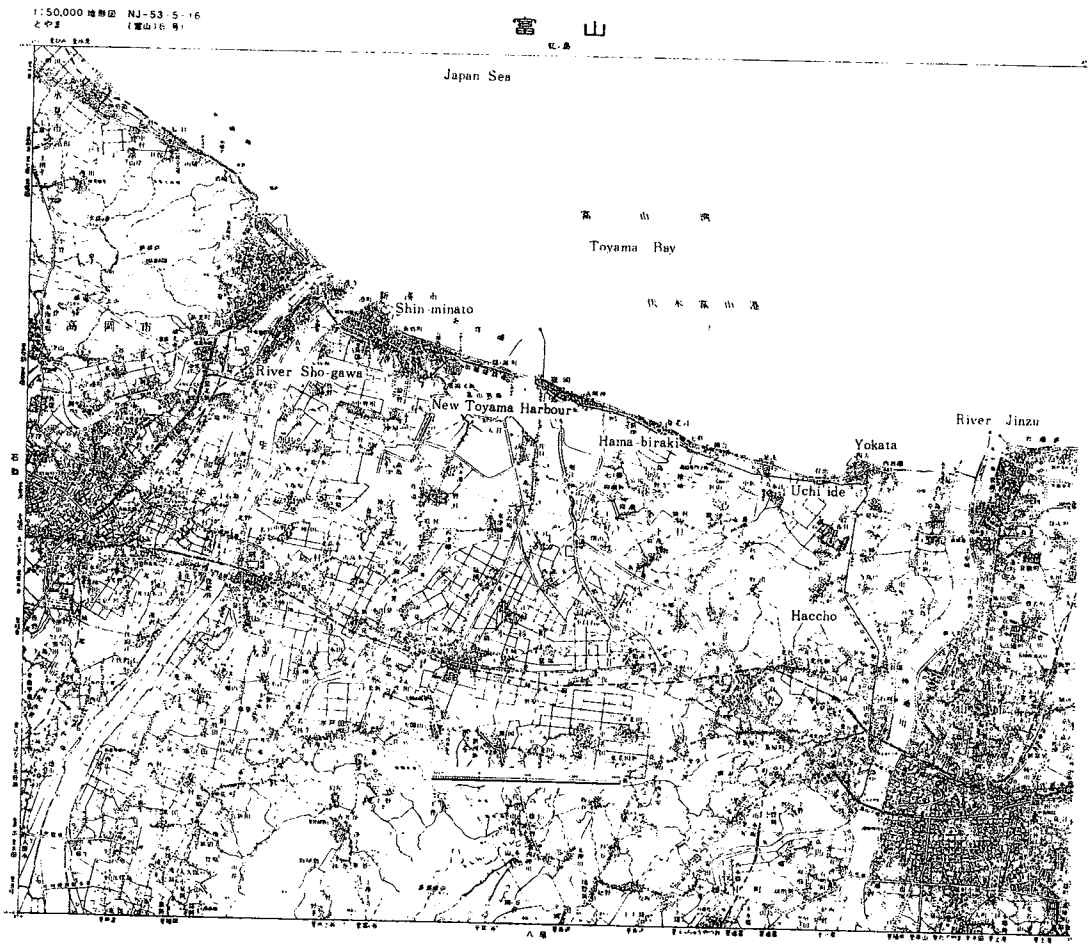

Fig. 1 Index map showing the locality of the samples and the topography around the Hojozu district, Toyama Prefecture.
X: sampling locality

the gravel layer of the lower Jinzu River above-mentioned. The gravel layer might have been a fan during the Flandrian transgressional and regressional ages.

This district is famous for the drowned valleys and submerged forests. There are the drowned valleys beneath the present alluvial fans formed by the Jinzu and Sho revers, being traced to the submarine canyon offing the mouths of above-mentioned rivers. The submerged forests are found at a depth of 5 meters to 10 meters below the present sea level and about 150 meters offshore of Uchi'idega-hama beach, Toyama and 2 meters below the present sea level at about 100 meters offshore of Shin-minato. Those geological and topographical phenomena suggest that a land was probably sunk in the geologically recent age, perhaps during the last 3,000 years.

The submerged forests have been found from some localities along the coast of

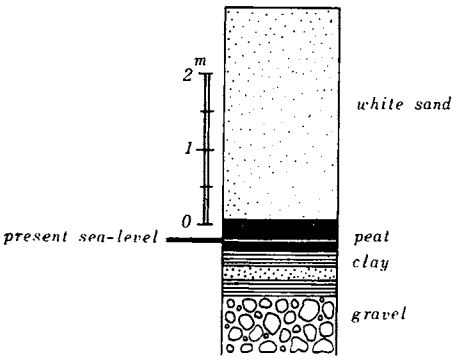

Fig. 2 Columnar section at the Locality No. 143 of the Hojozu district, Toyama Prefecture.

Toyama Bay since a discovery of the Uozu submerged forest. The Hojozu submerged forest called in this article includes the Uchi'idega-hama and Yokata forests. The identified erect stumps are *Fagus crenata* Blume., *Juglans ailanthifolia*, *Quercus glauca* Thunb., *Q. serrata* Thunb., *Cercidiphyllum japonicum* Sieb. et Zucc., *Machilus Thunbergii* Sieb. et Zucc., *Hovenia dulcis* Thunb. and *Camellia* sp.

The geological succession of the Hojozu district is classified into six layers, that is, gravel (1 meter in thickness), clay (0.5m), sand (0.5m),clay (0.5 m), dark brown peat (1 m) and sand (3 m) layers in ascending order. The gravel layer is considered to belong to the fan deposits which were sedimented during the Holocene regressional age. The erect stumps might have grown on the clay and sand layers. The peat layer is not found in the lowland area, being overlain by the New sand dune.

Radiocarbon ^{14}C Dating of Erect Stumps

Some samples from the erect stumps and the peat layers found in the Hojozu submerged forest were dated by Dr. Kigoshi of the Gakushuin University, Tokyo and the result of ^{14}C dating is as follows:

(1) Code No. GaK-539; a peace of the erect stump found from the sea bottom at about 100 meters offshore of Yokata, Toyama City; sampling by Tamotsu Takase; 2,730± 90 years before A.D. 1950.

(2) Code No. GaK-541; a peace of the erect stump from the mouth of the Jinzu River, Toyama City; sampling by Shoji Fujii; 1,950±110 years before A.D. 1950.

(3) Code No. GaK-560; a peace of dark brown peat below a rice-field soil of Hakko, Shimo-mura; sampling by the present author, Norio Fuji and Tamotsu Takase; 3,780±100 years before A.D. 1950.

(4) Code No. Gak-562; a peace of dark brown peat from the coast of Hama-biraki, Shin-minato; sampling by the present author; 1,400±90 years before A.D. 1950.

The result of ^{14}C dating above-mentioned is comparable to the result of ^{14}C dating of some erect stumps from some submerged forests as Uozu and Asahi forests situated along the coast of Toyama Bay.

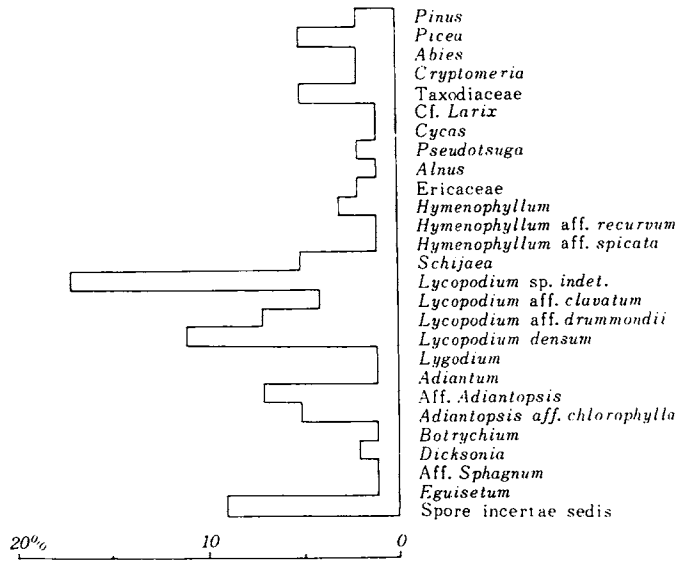

Fig. 3 Pollen diagram from Locality No. 135 of the Hojozu district, Toyama Prefecture.

Palynological Description

For the present study 14 samples from 14 localities of the Hojozu district were treated. The result of pollen analysis is shown in Fig. 3. The relationship among the pollen grains and spores is read from the pollen diagram.

Among those assemblage, *Lycopodium* and *Adiantopsis* occupies 36 per cent and 7 per cent respectively. *Picea*, Taxodiaceae (perhaps *Cryptomeria japonica* D.Don.), *Schizaea* and *Botrychium* each show 5 per cent. Pteridophyta as shown in Fig. 3 occupies about 70 per cent in the total frequency, trees as *Pinus*, *Picea*, *Abies* and *Cryptomeria* are rare. Therefore, the palaeotopographical condition of that time might have been similar to the present condition.

Conclusion

The result of the palynological research on the Hojozu submerged forest is summarized as follows:

(1) The age of formation of the submerged forest seems to be the lastest Yayoian or earliest Old tumb period, about 1,600 or 1,500 years before the present.

(2) The age in when many trees forming the Hojozu submerged forest were growing up in this area seems to be about 4,000 to about 1,500 years ago from the palynological, stratigraphical and radiochronological investigations.

(3) The cause of formation of the submerged forest is due to the rising of sea level rather than the sinking of the coast along Toyama Bay. The rising of sea level is named as Yayoian transgression.

(4) The palaeoclimate under which the trees were growing up before the formation of the submerged forest was cooler than that of the present time. It is about 1 to 2°C lower than that of the present time in average mean temperature. The decreasing warm age may be comparable to the time of the minor falling of sea level, middle age of the third Jomonian period to the latest age of the Yayoian or the earliest age of the Old tumb period.

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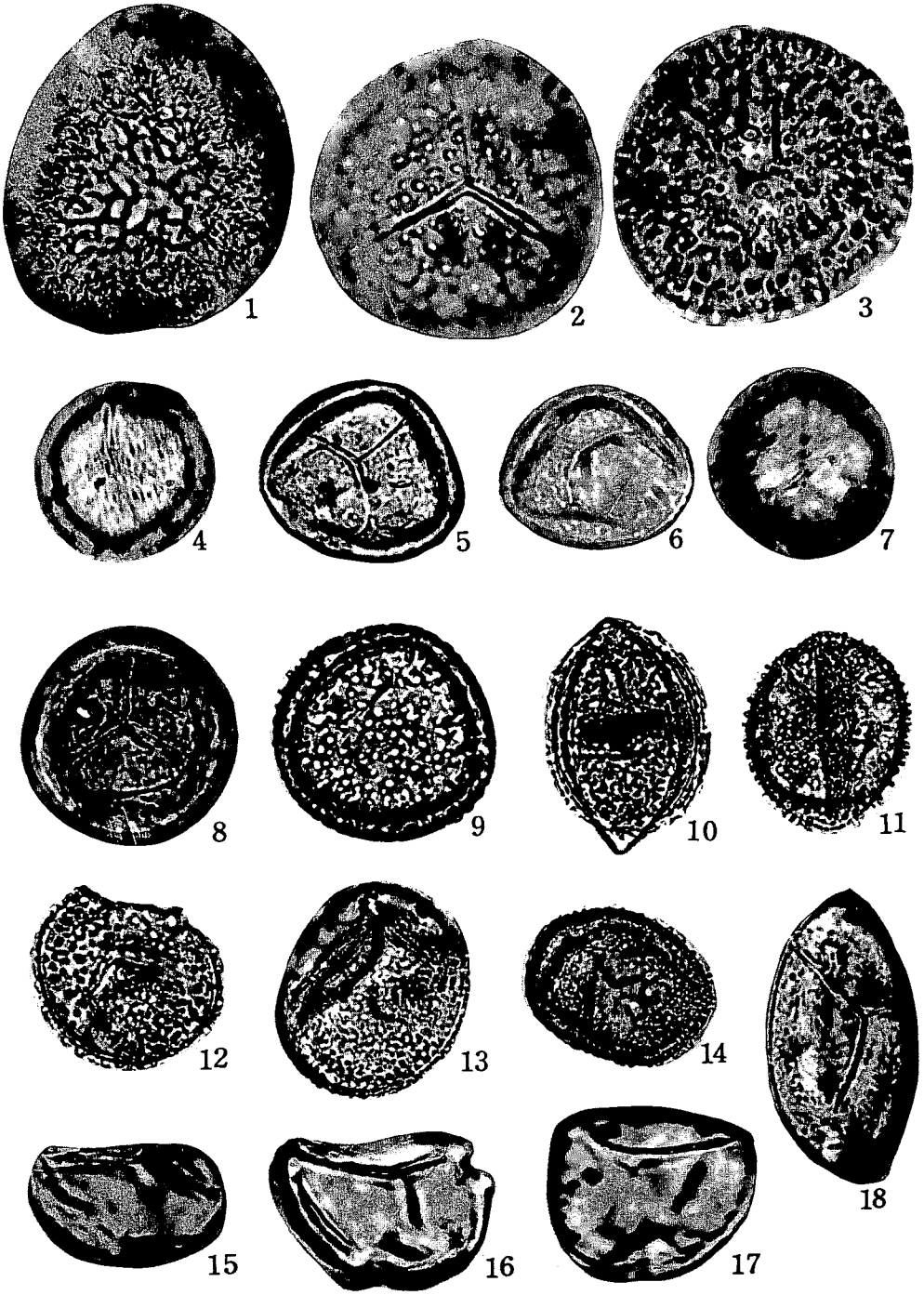
Explanation of Plate I

Figs. 1 & 2 : *Lycopodium* aff. *clavatum*, Figs. front of grain, Loc. No. 146, EKZJ coll. cat. no. 20448, 20449.
Fig. 3 : *Lycopodium*, Loc. No. 139, EKZJ 20450.
Fig. 4 : *Lycopodium* aff. *drummondii*, Loc. No. 146, EKZJ 20451.
Figs. 5 & 6 : *Adiantum*, Fig. 5 front of grain, Loc. No. 144, EKZJ 20452.
Fig. 7 : *Hymenophyllum*, front of grain, Loc. No. 146, EKZJ 20453.
Fig. 8 : *Hymenophyllum* aff. *recurvum*, Loc. No. 138, EKZJ 20454.
Fig. 9 : *Lycopodium* cf. *densum*, Loc. No. 141, EKZJ 20455.
Fig. 10 : *Lycopodium* cf. *densum*, Loc. No. 142, EKZJ 20456.
Fig. 11 : *Lycopodium* aff. *densum*, Loc. No. 142, EKZJ 20457.
Fig. 12 : *Lycopodium* cf. *densum*, Loc. No. 149, EKZJ 20458.
Fig. 13 : *Lycopodium* cf. *densum*, Loc. No. 138, EKZJ 20459.
Fig. 14 : *Lycopodium* cf. *densum*, Loc. No. 138, EKZJ 20460.
Fig. 15 : *Lycopodium*, Loc. No. 144, EKZJ 20461.
Fig. 16 : *Lycopodium*, Loc. No. 147, EKZJ 20462.
Fig. 17 : *Lycopodium*, Loc. No. 150, EKZJ 20463.
Fig. 18 : *Lycopodium*, Loc. No. 150, EKZJ 20464.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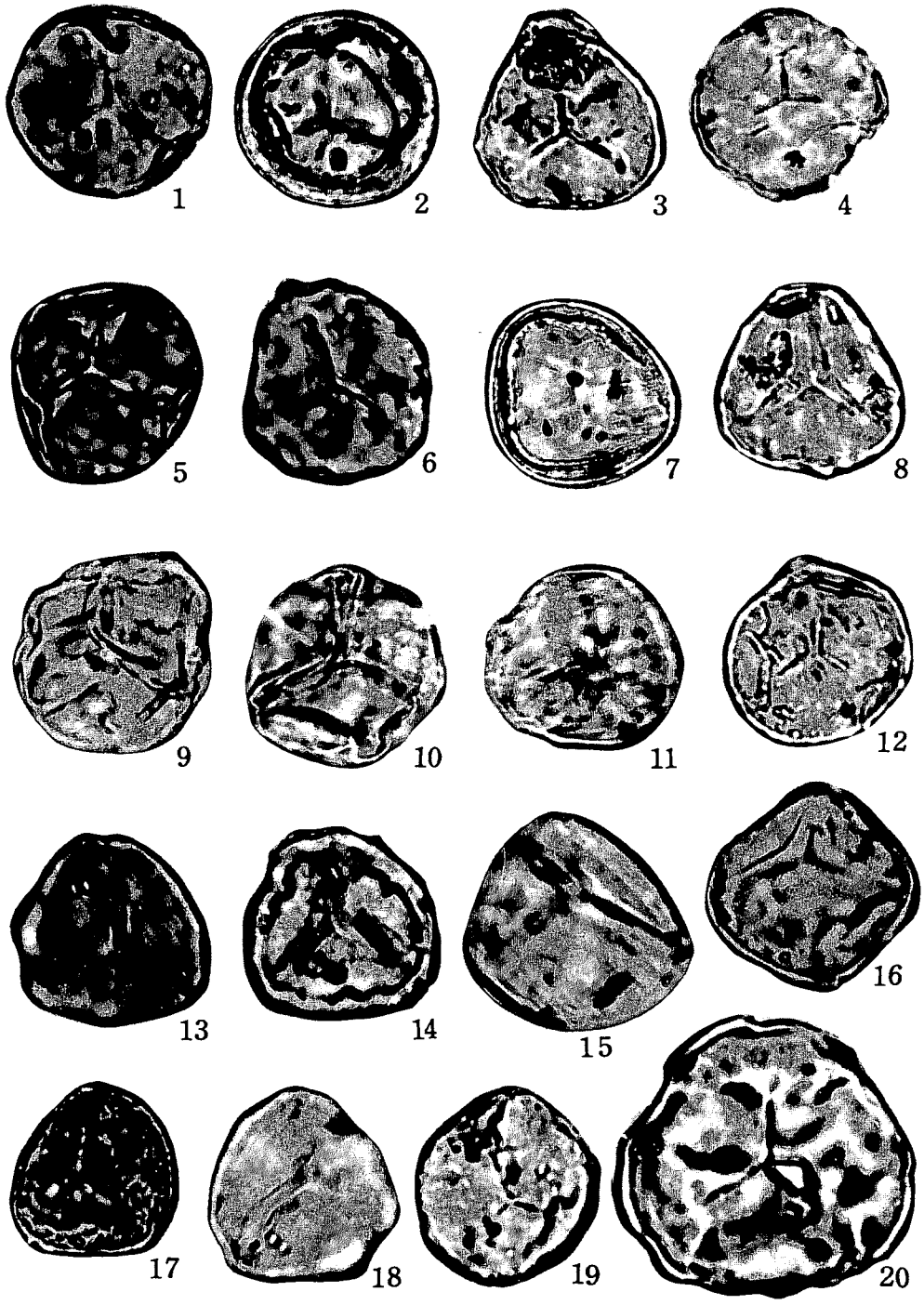
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Explanation of Plate II

Figs. 1 & 5 : *Adiantopsis* aff. *chlorophylla*, Fig. 1 front of grain, Loc. No. 147, EKZJ coll. cat. no. 20465.

Fig. 2 : *Botrychium*, Loc. No. 139, EKZJ 20466.

Fig. 3 : Cf. *Dicksonia*, Loc. No. 139, EKZJ 20467.

Fig. 4 : Aff. *Sphagnum*, Loc. No. 150, EKZJ 20468.

Fig. 6 : *Botrychium*, Loc. No. 143, EKZJ 20469.

Figs. 7 & 8 : Polypodiaceae gen. indet., Fig. 8 front of grain, Loc. No. 146, EKZJ 20470.

Fig. 9 : Ericaceae, Loc. No. 138, EKZJ 20471.

Fig. 10: Cf. *Lygodium*, Loc. No. 141, EKZJ 20472.

Figs. 11&12: *Lycopodium* aff. *drummondii*, Loc. No. 143, EKZJ 20473.

Figs. 13&14: *Adiantopsis* aff. *Chlorophylla*, Fig. 13 front of grain, Loc. No. 144, EKZJ 20474.

Figs. 15&16: *Lygodium* Loc. No. 143, EKZJ 20475.

Fig. 17: *Lycopodium* aff. *drummondii*, Loc. No. 146, EKZJ 20476.

Fig. 18: *Botrychium*, Loc. No. 137, EKZJ 20477.

Fig. 19: Aff. *Sphagnum fimbriatum* (bryophyta), Loc. No. 139, EKZJ 20478.

Fig. 20: Aff. *Adiantopsis*, Loc. No. 146, EKZJ 20479.

Explanation of Plate Ⅲ

Figs. 1, 9, 10, 11, 13, 14, 15, 16 and 17: incertae sedis; Fig. 1: Loc. No. 139, EKZJ coll. cat. no. 20480; Fig. 9: Loc. No. 150, EKZJ 20481; Fig. 10: Loc. No. 143, EKZJ 20482; Fig. 11: Loc. No. 143, EKZJ 20483; Fig. 13: Loc. No. 146, EKZJ 20484; Fig. 14: Loc. No. 150, EKZJ 20485; Fig. 15: Loc. No. 137, 20486; Fig. 16: Loc. No. 141, EKZJ 20487; Fig. 17: Loc. No. 141, EKZJ 20488.

Fig. 2: Aff. *Hymenolepis spicate*; Loc. No. 143, EKZJ 20512.

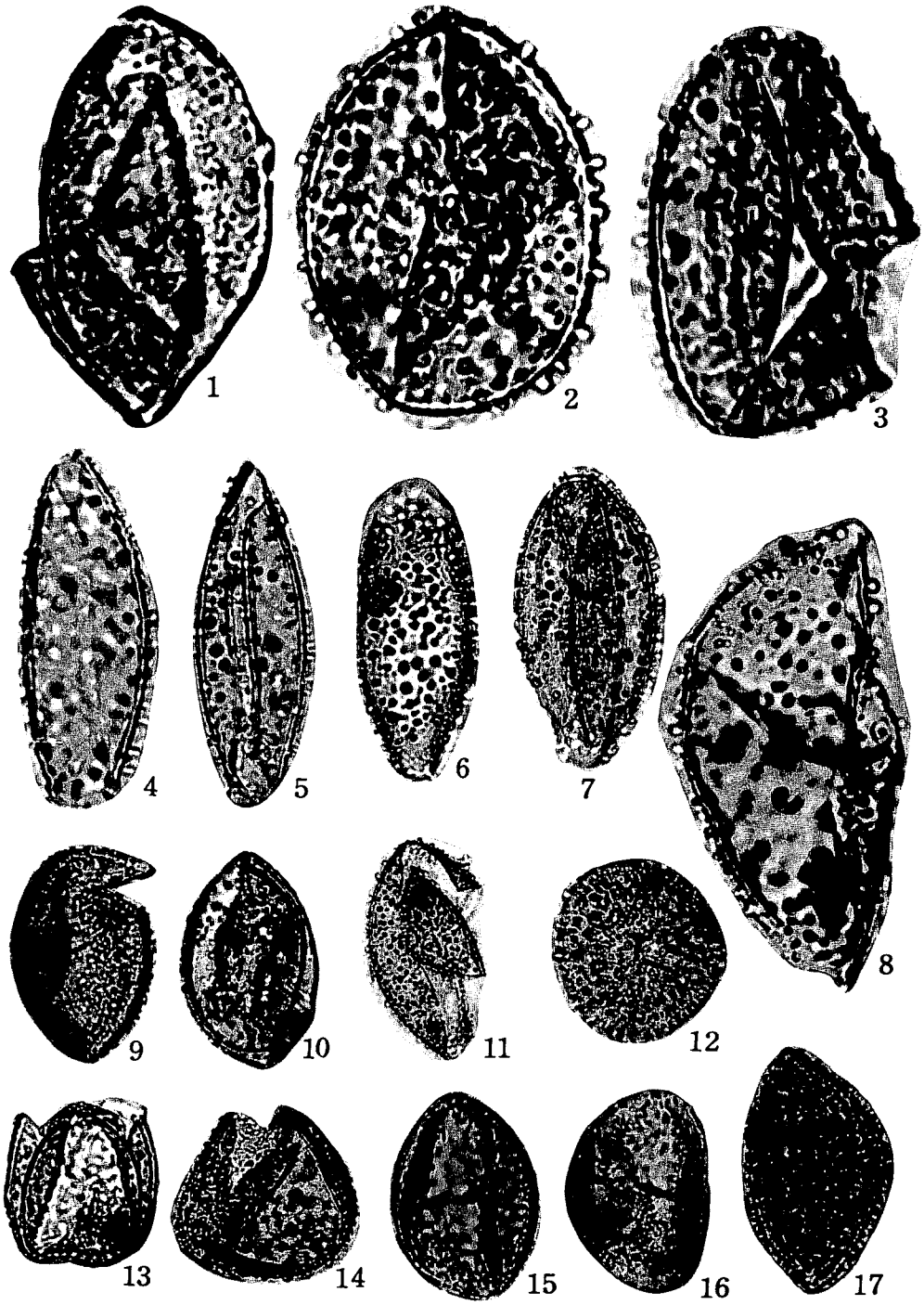
Fig. 3: Spore incertae sedis; Loc. No. 144, EKZJ 20489.

Figs. 4 & 5: *Schizaea*; Loc. No. 147, EKZJ 20490, 20491.

Fig. 6: Spore (?) incertae sedis; Loc. No. 146, EKZJ 20492.

Figs. 7 & 8: *Schizaea* aff. *digitata*; Loc. No. 147, EKZJ 20493, 20513.

Fig. 12: *Lycopodium*; Loc. No. 150, EKZJ 20494.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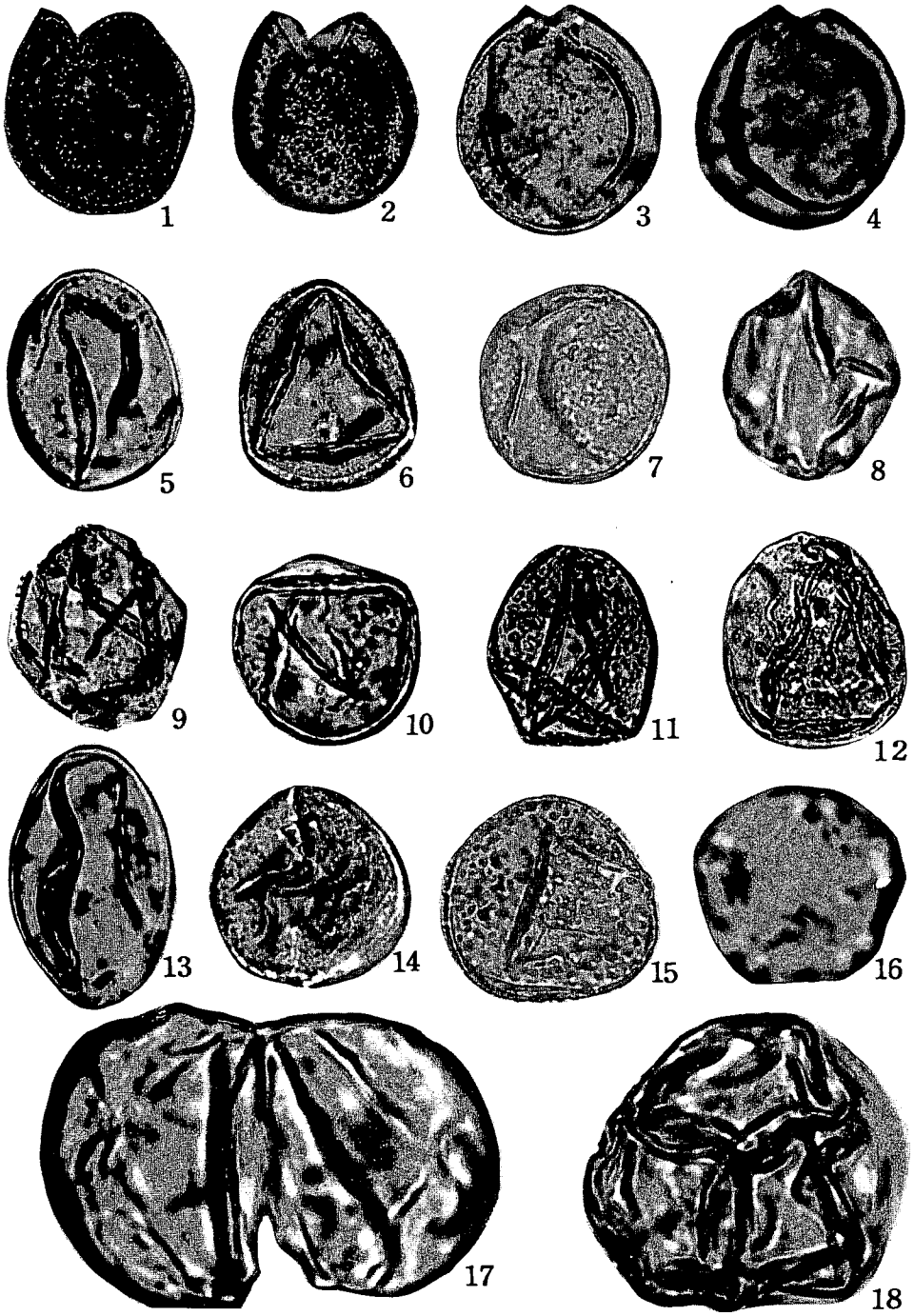
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Explanation of Plate IV

Figs. 1 & 2 : Spore (?) incertae sedis; Loc. No. 143, EKZJ coll. cat. No. 20495, 20511.

Figs. 3 & 4 : Spore (?) incertae sedis; Fig. 4 : front of grain; Loc. No. 150, EKZJ 20496, 20497.

Fig. 5 : *Equisetum*; Loc. No. 139, EKZJ 20498.

Fig. 6 : *Lycopodium*; Loc. No. 140, EKZJ 20499.

Figs. 7 & 8 : *Lygodium*; Loc. No. 149, EKZJ 20500.

Figs. 9 &11: Cf. *Pseudotsuga*; Fig. 9 : Loc. No. 142, EKZJ 20501, Fig. 11: Loc. No. 150, EKZJ 20502.

Fig. 10: Cf. *Larix*; Loc. No. 150, EKZJ 20503.

Fig. 12: Aff. *Lygodium*; Loc. No. 148, EKZJ 20504.

Fig. 13: *Cycas*; Loc. No. 143, EKZJ 20505.

Fig. 14: *Lygodium*; Loc. No. 137, EKZJ 20506.

Fig. 15: *Lycopodium*; Loc. No. 139, EKZJ 20507.

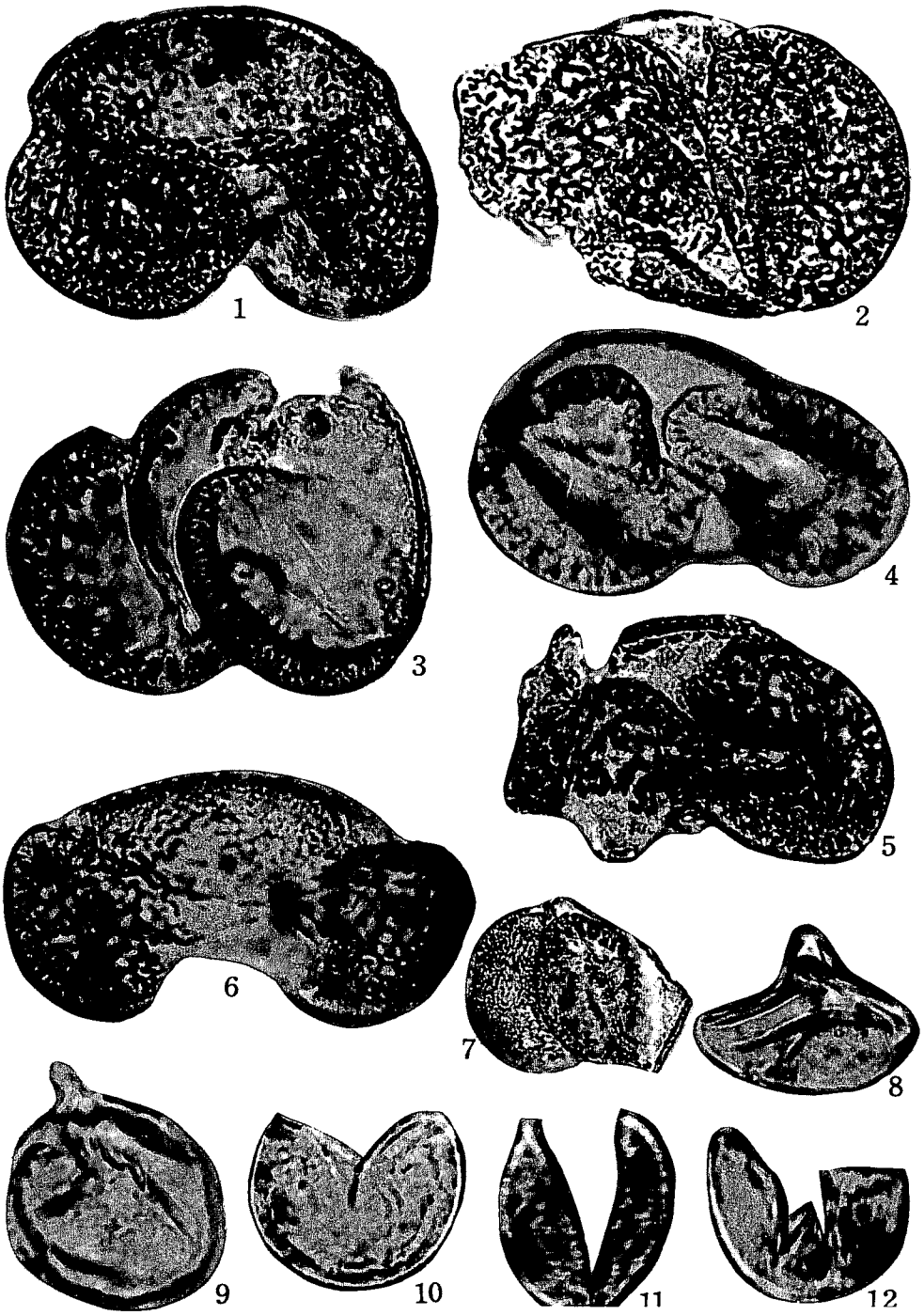
Fig. 16: *Alnus*; Loc. No. 143, EKZJ 20508.

Fig. 17: Pollen incertae sedis; Loc. No. 150, EKZJ 20509.

Fig. 18: Ericaceae; Loc. No. 146, EKZJ 20510.

Explanation of Plate V

Fig. 1 : *Picea*, lateral view, Loc. No. 139, EKZJ coll. cat. No. 20436.
Fig. 2 : *Picea*, lateral view, Loc. No. 138, EKZJ 20437.
Fig. 3 : *Picea*, lateral view, Loc. No. 150, EKZJ 20438.
Fig. 4 : *Abies*, lateral view, Loc. No. 150, EKZJ 20439.
Fig. 5 : *Pinus*, lateral view, Loc. No. 149, EKZJ 20440
Fig. 6 : *Abies*, lateral view, Loc. No. 137, EKZJ 20441
Fig. 7 : *Pinus*, oblique lateral view, Loc. No. 139, EKZJ 20442
Figs. 8 & 9 : *Cryptomeria japonica*, lateral view, Loc. No. 137, EKZJ 20443, 20444.
Figs. 10, 11 & 12: Taxodiaceae (Cf. *Cryptomeria*), lateral view, Loc. Nos. 146, 150, 139, respectively EKZJ 20445, 20446, and 20447.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