

Vegetational History of the Hosoike Moor in the Chugoku Mountains, Western Japan during the Late Pleistocene and Holocene

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The Hosoike moor is situated at alt. 970m on the smooth southwestern slope of Mt. Gorin in western Japan. A 500cm core consists of peat, muck, mucky clay, silty clay and tephra deposits, and had two radiocarbon dates of $18,500 \pm 225$ yr B. P. (190-180cm in depth) and $33,800 \pm \begin{smallmatrix} 1,290 \\ 1,120 \end{smallmatrix}$ yr B. P. (380-370cm in depth). The sediments therefore began to accumulate about 40,000 years ago.

From the results of pollen and spore analysis five pollen assemblage zones were recognized.

A zone (500-235cm in depth, 40,000-25,000 yr B. P.) with subarctic taxa (*Abies*, *Picea*, *Pinus*, *Tsuga*, *Betula*), cool-temperate taxa (*Fagus*, *Lepidobalanus*), temperate taxa (*Cryptomeria*, *Sciadopitys*, *Ulmus*, *Carpinus*, *Fraxinus*).

B zone (235-100cm in depth, 25,000-10,000 yr B. P.) with subarctic taxa and cool-temperate taxon (*Lepidobalanus*).

C zone (100-80cm in depth, 10,000-9,000 yr B. P.) with cool-temperate taxa, a temperate taxon (*Carpinus*) and subarctic taxa.

D zone (80-35cm in depth, 9,000-4,000 yr B. P.) with warm-temperate taxa (*Cyclobalanopsis*, *Castanopsis*), temperate taxa (*Ulmus*, *Carpinus*, *Celtis*) and cool-temperate taxa.

E zone (35-0cm in depth, 4,000-0 yr B. P.) with secondary forest taxa (*Pinus*, *Lepidobalanus*, *Cryptomeria*).

Although there is no evidence of unconformity in stratigraphic sequence between the pollen zones D and E, the examined core may show a sedimentary hiatus of about a few thousand years, because the extreme changes of the fossil pollen and spores are recognized between the both zones in the diagram. The reconstructed vegetational history can be regarded as typical of the Chugoku Mountains for the period corresponding from the later part of the last glacial stage to the present day.

Key words : ^{14}C -dating, Climatic change, Last glacial stage, Pollen analysis, Pollen zone, Tephra.

Introduction

Sakaguchi⁽¹⁾ undertook palynological study of a 20m core from Ozegahara Basin situated at an elevation of 1,400m, in Tochigi Prefecture, central Japan. His results provide information on

vegetational and climatic changes during the Holocene and late Pleistocene since 38,400 yr B. P. before the coldest period of the last glacial age. Yasuda,⁽²⁾ Sohma⁽³⁾ and Miyoshi⁽⁴⁾ carried out pollen-analytical work on the Holocene and late Pleistocene sediments. Their studies cover the last interstadial period after ca. 50,000 yr B. P. with samples from Lake Mikata in Fukui Prefecture, central Japan, after ca. 60,000 yr B. P. with samples from Akaiyachi Moor in Fukushima Prefecture, northeastern Japan and after ca. 100,000 yr B. P. with samples from Tokusa Basin in Yamaguchi Prefecture, western Japan.

Miyoshi and Yano⁽⁵⁾ carried out palynological work of the Holocene and late Pleistocene, including the coldest period, at Ohnuma Moor located about 45km northeast from the Hosoike Moor in the eastern area of the Chugoku Mountains, western Japan. However, there has been no pollen-analytical work on older sediments than the coldest period in such places as the Ozegahara Basin, the Lake Mikata, the Akaiyachi Moor and the Tokusa Basin in eastern area of the Chugoku Mountains.

The purpose of this study is to reconstruct the regional palynological history in the eastern area of the Chugoku Mountains during the late Pleistocene to Holocene, including some periods before the coldest period. Climatic changes are estimated from vegetational shifts.

Site description

Hosoike Moor is situated at an elevation of 970m on the smooth southwestern slope of Mt. Gorin (alt. 1,069m, coordinates 35°21'N, 134°08' E) in northeastern part of the Chugoku Mountains, Okayama Prefecture (Fig. 1). Mt. Gorin is occupied by the broad Gorinbara Plateau near its summit. The moor is a typical summit moorland, and covers an area of ca. 2.5 hectares with heart-shaped land. From a phyto-sociological study conducted by Hada,⁽⁶⁾ the following five communities can be distinguished in the moorland vegetation :

(1) Floating-leaved vegetation : *Nymphaea tetragona* community. This community is characterized by *Nymphaea tetragona*, *Scirpus juncoides* and *Eleocharis wichuriae*. It develops in ponds or an outflowing of water.

(2) Swamp vegetation : *Ligularia fischeri* - *Carex dispalata* community. This community is characterized by *Carex dispalata*, *Ligularia fischeri*, *Galium trifidum* var. *brevipedunculatum* and *Lastrea thelypteris*. It develops in high humidity.

(3) Moorland vegetation.

a. *Osmundastrum cinnamomeum* var. *fokiense* - *Sphagnum palustre* community. This community is characterized by *Sphagnum palustre*, *Osmundastrum cinnamomeum* var. *fokiense*, *Miscanthus sinensis*, *Hosta montana* and *Symplocarpus nipponicus*.

b. *Rhynchospora fujiana* community. This community is characterized by *Rhynchospora fujiana*, *Haloragis micrantha*, *Eriocaulon decemflorum* var. *nipponicum* and *Pogonia japonica*. These both communities develop in humid places.

(4) Mantle vegetation: *Ilex crenata* - *Symplocos coreana* community. This community is characterized by *Ilex crenata*, *Symplocos coreana*, *Pedicularis resupinata* and *Disporum smilacinum*. It develops in elevated dry places.

Cryptomeria japonica and *Larix leptolepis* grow in almost all areas around the moorland, except in the northern parts, where remains of the primary forest associations, namely, *Lindero umbellatae* - *Fagetum crenatae* (Sasaki 1964) Sasaki 1970 including *Fagus crenata*, *Quercus mongolica* var. *grosseserrata*, *Sorbus commixta*, *Acer crataegifolium*, *Clethra barbinervis*, *Lindera umbellata* etc., occur.

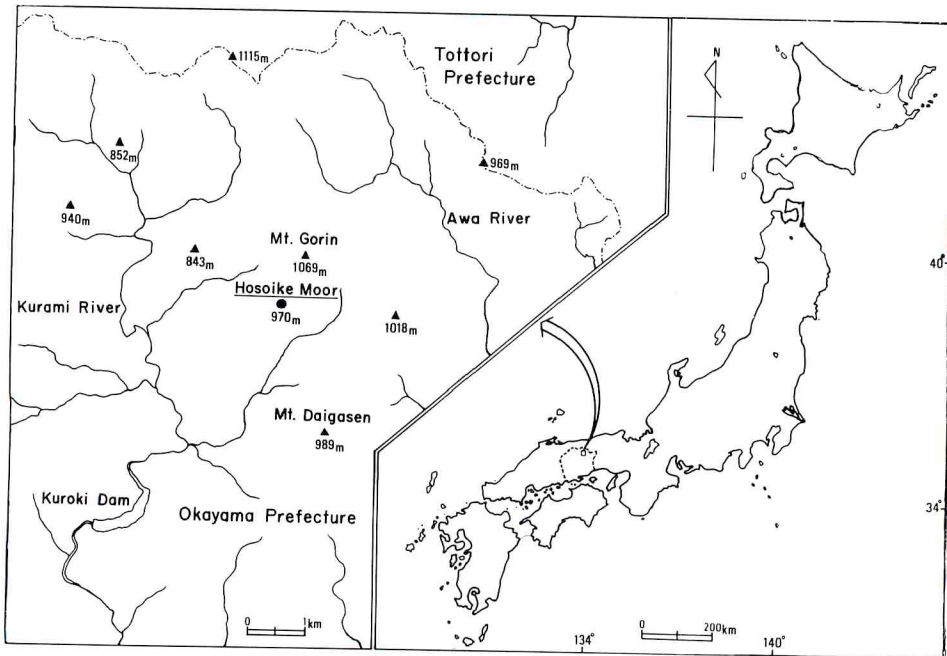


Fig. 1. Map giving the position of the Hosoike Moor.

The present climate of the Chugoku Mountains is cool-temperate in the montane areas and temperate in the highlands. The boundary of both climatic zones is estimated at an altitude of ca. 600m, judging from the distributional uppermost limit of evergreen broad-leaved trees.⁽⁷⁾ Some meteorological data of the site (alt. 970m), calculated from data of Kamo-cho (alt. 450m) located about 10km south, indicate that the annual temperature is 8.5°C; the lowest monthly mean temperature is -2.9°C (Jan.); the highest monthly mean temperature is 20.6°C (Aug.); the total annual precipitation is 1,684mm.

Materials and Methods

A 500cm core was collected at the center of the moor in October 1982. A modified Thomas borer with an inside diameter of 2cm and a length of 30cm was used. Peat bed extended down to 80cm below the ground, and it contained abundant remains of *Sphagnum*, *Carex* and various

other moorland plants. It also intercalated a thin layer of tephra. A muck bed was distributed between 80cm and 260cm below the ground, and intercalated two thin silty clay layers and two tephra layers. A mucky clay bed developed from -260cm to -370cm, and a thick silty clay bed developed from -370cm to -500cm. Samples for ^{14}C -dating were taken from 180-190cm and 370-380cm below the ground by boring ten times per level.

The core was cut at intervals of 5cm and each piece of it was put respectively in 50cc specimen bottle, which was kept up at 3°C in a refrigerator until using. The samples for studying pollen analysis were picked up at intervals of 5cm or 10cm, and of ca. 100cm for ignition loss. The five samples for ignition loss were heated at 550°C for one hour in a Muffle electric furnace. Results were calculated as percentage to dry weight. Two samples for ^{14}C -dating were dried in a hot-air drier and sent to the Japanese Radioisotope Association in Tokyo. Three tephra samples for EDX microanalyzer test were dried under room temperature, and sent to the Nara University of Education in Nara.

Fossil pollen and spores were extracted by boiling in 10% KOH solution and by applying mineral separation with ZnCl_2 (s. g. 1.75). The samples were subsequently treated with 40% HF and then with Erdtman's acetolysis method. By making the slides the treated materials were mounted in glycerine jelly. Palynological identification was carried out by using a Nikon microscope with magnifications of 150 and 600. The AP/NAP ratio diagram (Fig. 2) was made by each percentage to the total amount of pollen grains (tree, shrub and herb). Spores of Pteridophyta and Bryophyta were excluded from pollen account. In the pollen diagram, percentage values of each taxon were calculated for the sum-total of the AP, which consists of trees and shrubs. At least 300-500 pollen grains were counted per level.

Results

Ignition loss

Ignition loss is 14-17% in the lower half of the core below -260cm in depth, which contained clay with some decayed organic matters and silt (Table 1). The middle core between -90cm and -260cm consists mainly of muck containing much detritus and ranged from 29% to 41% in ignition loss. In the surface of the core above -90cm, which consists of peat with many plant remains, ignition loss is 67%.

Radio-carbon dating

Two samples for ^{14}C -dating were analyzed by the gaseous Geiger scintillation counter method in the Japanese Radioisotope Association and consequently showed $18,500 \pm 225$ yr B. P. (190-180cm in depth, N-4750) and $33,800 \pm \begin{matrix} 1,290 \\ 1,120 \end{matrix}$ yr B. P. (380-370cm in depth, N-4751) in age.

Table 1. Ignition loss of the sediments from the Hosoike Moor

Depth (cm)	Sediment type	Ignition loss (%)
55-50	Peat	67
155-150	Muck	41
255-250	Muck	29
355-350	Mucky clay	17
455-450	Silty clay	14

Tephra identification

The major elements being composed of volcanic glasses from three tephra were examined by EDX microanalyzer, and their data were compared with the standard tephra (Table 2). As a result these tephra were estimated to originate from the following tephra.

75-70cm in depth : Akahoya ca. 6,300 yr B. P.

145-140cm in depth : Sakate ca. 15,000 yr B. P.

220-210cm in depth : Aira ca. 24,000 yr B. P.

On the basis of these ^{14}C -datings and tephra identification, an approximate age was estimated for each palynological zone.

Table 2. EDX results of tephra from the Hosoike Moor and comparison with standard elementary compositions of the three tephra (*) analyzed by Nishida, S., T. Yokoyama and S. Ishida⁽⁶⁾

Tephra	Element	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	K ₂ O	CaO	TiO ₂	FeO (%)
Akahoya	N660*	2.15	0.09	10.72	76.83	2.19	2.77	0.42	4.02
Hosoike	75-70cm	2.38	0.92	10.73	76.19	2.22	2.91	0.42	4.23
Sakate	N553*	3.29	1.42	12.17	77.23	1.81	2.50	0.12	1.45
Hosoike	145-140	2.38	1.06	11.74	78.94	2.01	2.26	0.10	1.52
Aira	N003*	2.39	1.00	10.84	80.25	2.37	1.34	0.10	1.70
Hosoike	22-210	2.82	1.11	11.30	79.15	2.42	1.38	0.10	1.73

Analytical results

The general sequence of principal pollen types shows that subarctic taxa such as *Abies*, *Picea*, *Tsuga*, *Pinus* and *Betula*, and cool-temperate deciduous broad-leaved trees such as *Fagus* and *Lepidobalanus* were dominant in the lowest layer (520-235cm in depth). This includes such temperate elements as *Cryptomeria*, *Sciadopitys*, *Carpinus*, *Fraxinus* and *Ulmus*. Subarctic taxa

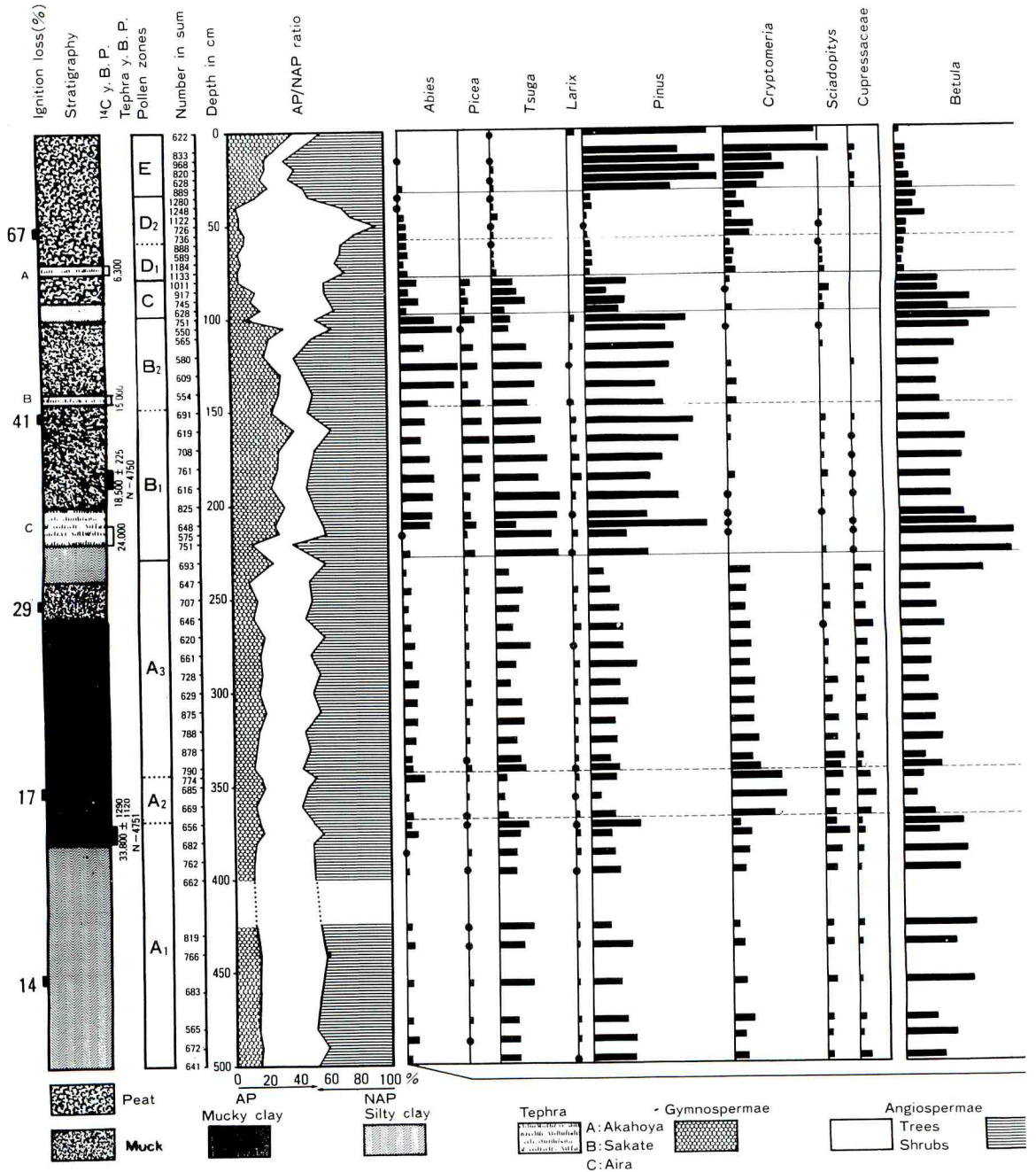


Fig. 2. Stratigraphic sequence and pollen (AP) diagram from the Hosoike Moor.

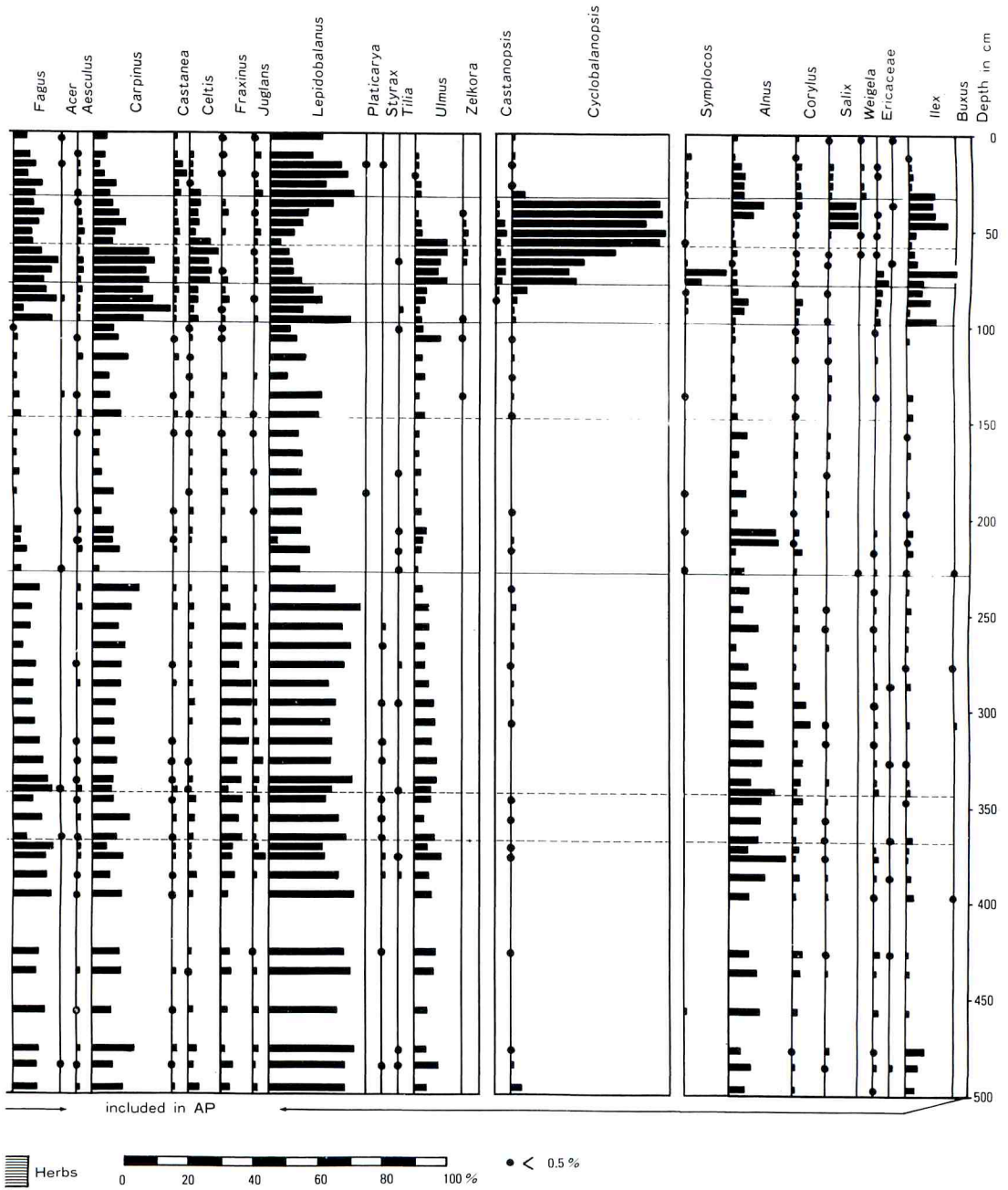


Fig. 3. A continuation of the pollen (AP) diagram for the Hosoike Moor.

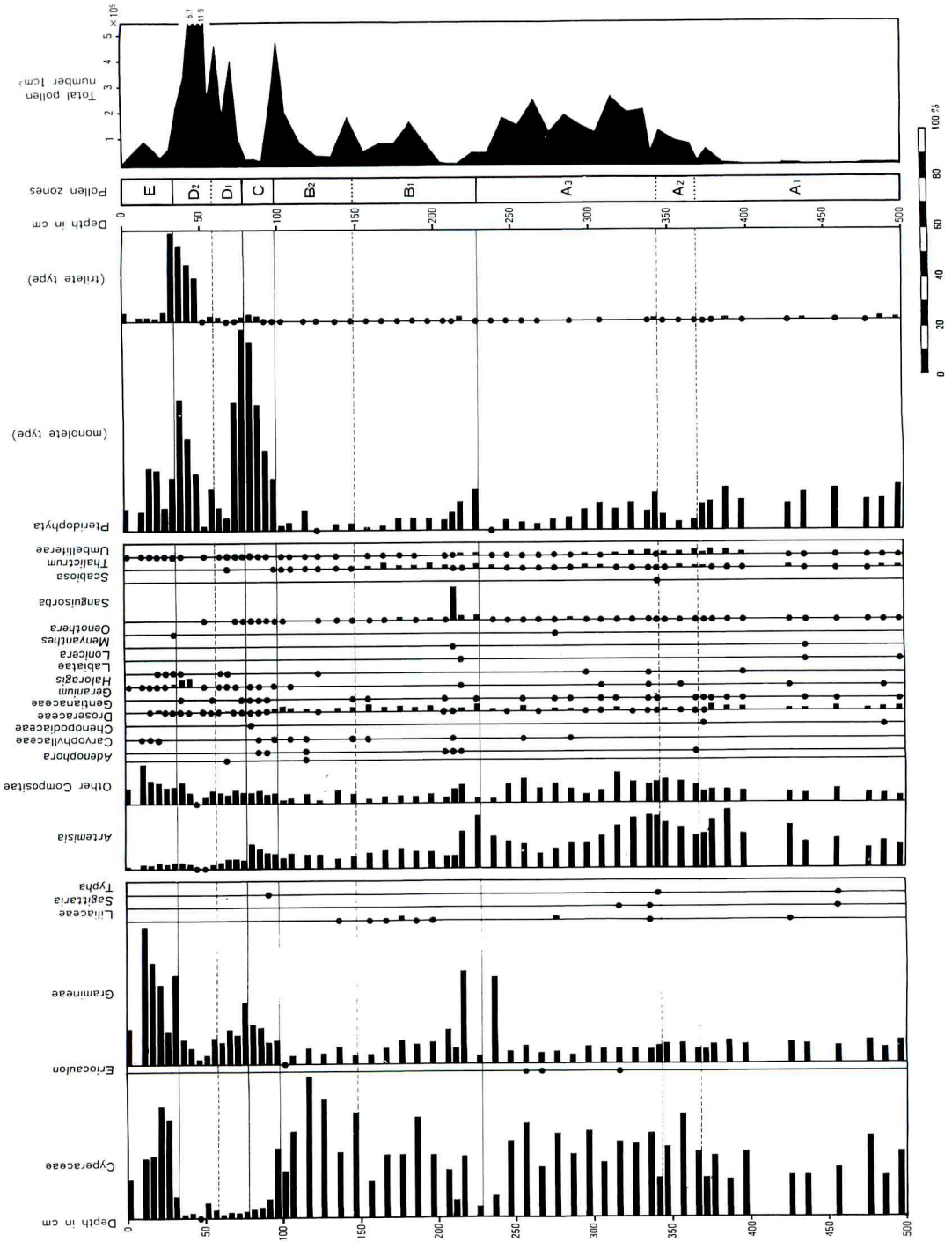


Fig. 4. A continuation of the pollen (NAP) and spore diagram for the Hosoike Moor.

increase further in appearance in the lower middle layer (235–100cm in depth). Almost the same elements as taxa in the lowest layer become dominant again in the central middle layer (100–80cm in depth). Cool-temperate and temperate elements of deciduous broad-leaved trees such as *Fagus*, *Lepidobalanus*, *Carpinus* and *Ulmus* pollen were dominant in the lowest part of the upper middle layer, while warm-temperate elements of evergreen broad-leaved trees such as *Cyclobalanopsis* and *Castanopsis* pollen showed a dramatic increase in the uppermost horizon of upper middle layer (80–35cm in depth). In the surface layer (35–0cm in depth), *Pinus*, *Cryptomeria* and *Lepidobalanus* pollen appear dominantly.

Among the shrubs and the NAP, the percentages of *Alnus* pollen are high in the lowest layer (520–210cm in depth). *Ilex* pollen is dominant only between –100cm and –40cm. Cyperaceae pollen shows a drastic increase in both the lowest and the surface layers (520–95cm and 30–0cm in depth). Gramineae pollen and Pteridophyta (monoete type) spores indicate a marked increase in appearance above –100cm. *Artemisia* pollen is dominant in the lowest layer (520–220cm in depth). Other Compositae pollen occurs relatively constantly less than 20%. Pteridophyta (trilete type) spores show an increased appearance only between –50cm and –30cm.

Palynological zonation

The division into pollen zones or subzones is mainly based on the AP curves, ¹⁴C-dating and tephra.

(1) Subzone A₁: 500–370cm in depth (380–370cm in depth: ¹⁴C-dating $33,800 \pm \frac{1,290}{1,120}$ yr B. P.) Of the coniferous genera, *Pinus* (*Haploxylon* type) and *Tsuga* pollen are 6–15% in appearance. *Cryptomeria*, *Sciadopitys*, Cupressaceae, *Abies* and *Picea* pollen are low, but they vary in a similar way to that of *Pinus* and *Tsuga* pollen. High percentages are recorded for *Lepidobalanus* and *Betula* pollen. The pollen curves of *Fagus*, *Carpinus*, *Ulmus* and *Alnus* sustains more or less constantly with high percentages. The NAP is dominated by Cyperaceae, *Artemisia* pollen, and monoete spores of Pteridophyta.

(2) Subzone A₂: 370–345cm in depth

The percentages of subarctic and cool-temperate elements such as *Pinus*, *Tsuga*, *Betula* and *Fagus* pollen decrease temporarily, and temperate *Cryptomeria* pollen increases from 3% to 14%. The NAP remains more or less constantly from the subzone A₁ except monoete spores of Pteridophyta, which decrease to lower percentage. The subzonal boundary (–370cm) between the subzones A₁ and A₂ is mainly determined on the basis of marked increase in the percentages of *Cryptomeria* pollen.

(3) Subzone A₃: 345–235cm in depth

The pollen values in this zone are almost the same as those in the subzone A₁. However, both *Abies* and *Fraxinus* pollen increase somewhat more than the subzone A₁. The subzonal boundary (–345cm) between the subzones A₂ and A₃ is mainly determined on the basis of the increase of

subarctic pollen and the decrease of *Cryptomeria* pollen from 17% to 9%.

(4) Subzone B₁: 235–150cm in depth (220–210cm in depth: Aira tephra ca. 24,000 yr B. P.; 190–180cm in depth: ¹⁴C-dating 18,000 ± 225 yr B. P.)

The pollen percentages of subarctic conifers such as *Abies*, *Picea*, *Tsuga* and *Pinus* are high in this subzone. The appearance of *Betula* pollen reaches the climax in the lower parts, and then decreases gradually upwards. Great decreases in the percentages of *Cryptomeria*, *Fagus*, *Carpinus* and *Lepidobalanus* pollen are noticeable. The NAP remain almost the same as in the subzone A₃. The zonal boundary (–234cm) between the zones A and B is established on the basis of the increase of the subarctic conifer pollen and the marked decrease of pollen of cool-temperate and temperate elements.

(5) Subzone B₂: 150–100cm in depth (145–140cm in depth: Sakate tephra ca. 15,000 yr B. P.) The dominant genera in the subzone B₁ such as the subarctic conifer, *Betula* and *Lepidobalanus* continue to have high percentages. The percentages of *Carpinus* pollen increase. Among the NAP, Cyperaceae appears with the highest percentages, while other herbaceous pollen grains and monoete spores of Pteridophyta decrease gradually. Though the subzonal boundary between B₁ and B₂ is determined by above-mentioned characteristics, the fluctuations of main pollen taxa in both the subzones are comparatively small.

(6) Zone C: 100–80cm in depth

The pollen percentages of deciduous broad-leaved trees such as *Fagus*, *Lepidobalanus* and *Carpinus* increased. Pollen of the *Ilex* (probably *I. crenata*), a shrub locally growing on the moor, attains the high percentage. Subarctic coniferous and *Betula* pollen decrease quickly at the end of the zone C. *Picea* pollen disappears completely at the end of the zone C. Among the NAP, Gramineae pollen and monoete spores of Pteridophyta appear highly, while Cyperaceae pollen percentages decrease rapidly. The boundary (–100cm) between the zones B and C is set on the basis of the increasing percentages of the pollen of deciduous broad-leaved trees and the decrease of subarctic coniferous pollen.

(7) Subzone D₁: 80–60cm in depth (75–70cm in depth: Akahoya tephra, ca. 6,300 yr B. P.)

This subzone begins with a sudden increase of evergreen broad-leaved *Cyclobalanopsis* pollen from 5% to 20%. *Celtis* and *Ulmus* pollen also show somewhat higher percentages. Though *Fagus* and *Carpinus* continue the same curve as in the zone C with high percentages, *Lepidobalanus* decreases. An extreme decrease or even extinction of the conifers and *Betula* is noticeable. The boundary between the zones C and D (–80cm) is established on the basis of the abrupt abundance of *Cyclobalanopsis* pollen and the extreme decrease of conifer and *Betula* pollen.

(8) Subzone D₂: 60–30cm in depth

Cyclobalanopsis pollen shows the highest values of appearance. *Cryptomeria* and *Lepidobalanus* pollen increase gradually in percentage. Deciduous broad-leaved trees such as *Fagus*, *Carpinus*,

Celtis and *Ulmus* show somewhat more decrease in pollen percentage. Shrubs such as *Alnus*, *Salix* and *Ilex* increase somewhat. Although the NAP pollen are low in percentage, monolete and trilete spores of Pteridophyta increase remarkably. The boundary between the subzones D₁ and D₂ (-60cm) is determined by increase of *Cyclobalanopsis* and *Cryptomeria* pollen and decrease of *Fagus*, *Carpinus* and *Ulmus* pollen.

(9) Zone E : 30-0cm in depth

The pollen values of *Pinus* (*Diploxylon* type) show a sudden increase. *Cryptomeria* pollen also shows a marked increase. The percentage of *Lepidobalanus* pollen becomes high from the end of the subzone D₂, but it decreases gradually towards the surface. *Cyclobalanopsis* pollen shows a sudden and extreme decrease in percentage from the end of the subzone D₂. The NAP pollen show the highest percentage of Gramineae and other Compositae. Cyperaceae pollen also shows a noticeable recovery in percentage towards the surface. The boundary between the zones D and E (-30cm) is set on the basis of increasing percentages of *Pinus* and *Cryptomeria*, and of decrease of *Cyclobalanopsis*.

Discussion

The zone A, the oldest part of the section, shows that the pollen assemblage comprises many taxa of conifers, deciduous broad-leaved trees and shrubs, which show respectively a moderate pollen percentage. Miyoshi and Yano⁽⁵⁾ described that conifers such as *Abies*, *Picea*, *Tsuga*, *Pinus*, and *Betula* which appeared dominantly during the last full glacial age in the Chugoku Mountains, and they suggested that these may belong to subarctic species. The four conifer genera and *Betula* in this zone also belong to subarctic species, while other conifers such as *Cryptomeria*, *Sciadopitys* and Cupressaceae are temperate elements. The deciduous broad-leaved trees comprise two climatic types, one of which is a cool-temperate one, such as *Fagus* and *Lepidobalanus*, another is temperate, such as *Carpinus*, *Fraxinus* and *Ulmus*. Among this pollen assemblage there are also moisture loving genera such as *Cryptomeria* and *Fagus*. These results suggest that the zone A was during a subglacial period of cool and wet climate in the last glacial age including a short term represented by the subzone A₂ with a temperate and wetter climate. This period may be one of the interstadials during the last glacial period. Judging from the results of ¹⁴C-dating (380-370cm in depth : 33,8000 ± $\frac{1,290}{1,120}$ yr B. P.) and tephra (220-210cm in depth : Aira ca. 24,000 yr B. P.), the zone A seems to have begun ca. 40,000 years ago, and continued until ca. 25,000 years ago, spanning a period of ca. 15,000 years. The pollen assemblage of the zone A is the first evidence for a vegetational history in the eastern area of the Chugoku Mountains prior to the last full glacial period.

The zone B, in which the subarctic elements such as *Pinus*, *Tsuga*, *Abies*, *Picea* and *Betula* appear dominantly accompanied by some decreased cool-temperate and temperate elements, consists of some deciduous broad-leaved trees and conifers. The increase of subarctic genera

indicates that evergreen needle-leaved trees were distributed most extensively in the montane zone of the Chugoku Mountains during the zone B. Because of certain species of *Betula* are important members of the secondary forests of cool-temperate and subalpine zones at present, the high frequency of *Betula* pollen may mean that forest conditions were unstable. The *Betula* pollen is presumed to have derived from a subalpine species, *B. ermanii*. The conspicuous increase of *Betula* pollen at the transition between the zones A and B means that the secondary forests such as *B. ermanii* were dominant before the change of vegetation from the climax forests of cool-temperate deciduous broad-leaved trees to the subarctic evergreen needle-leaved climax forests. The subzone B₁ reflects a colder and drier climate than that in the previous zone, and the subzone B₂ a more moderately cold and dry climate as compared with the subzone B₁, because the temperate element such as *Carpinus* had already increased. From the results of both ¹⁴C-dating (190–180cm in depth : 18,500 ± 225 yr B. P. and tephra (220–210cm in depth : Aira, ca. 24,000 yr B. P. ; 145–140cm in depth : Sakate, ca 15,000 yr B. P.), the zone B seems to have continued until ca. 10,000 yr B. P. and covered a period of ca. 15,000 years. The boundary between the subzones B₁ and B₂ is ca. 15,000 yr B. P. The former corresponds to the last full glacial period and the latter to the glacial period. The vegetational character of the zone B is almost the same as that of the Ohnuma Moor which located about 45km east of the Hosoike Moor.⁽⁵⁾

The zone C is a transitional zone from subarctic to cool-temperate and temperate forests. The deciduous broad-leaved trees such as *Fagus*, *Lepidobalanus* and *Carpinus* show a remarkable increase in this zone. On the other hand, the subarctic genera such as *Abies*, *Picea*, *Pinus*, *Tsuga* and *Betula* decrease fairly. *Picea* trees disappeared completely at the end of the zone C, and did never reappear in the Chugoku Mountains. The noticeable increase of *Betula* pollen at the transition between the zones B and C means that the secondary forest of *B. ermanii* was dominant before vegetational change from the climatic forests of subarctic conifers to the cool-temperate or temperate deciduous broad-leaved ones. Compared with the zone B, this zone had a more moderately cool and wet climate. This zone represents the first postglacial period with pollen zone R-I in the Japanese pollen zone system.⁽⁹⁾

The zone D is characterized by two vegetational types, namely the deciduous broad-leaved forests in the subzone D₁ and evergreen broad-leaved ones in the subzone D₂. In both zones C and D, *Fagus* pollen appears increasingly. This fact indicates that the forest of *Fagus crenata* extended widely through the Hosoike area. A small area of the primary forest association *Lindero umbellatae-Fagetum crenatae* (Sasaki, 1964) Sasaki 1970 remains on the northern part of the moor. There is a noticeable increase of *Cyclobalanopsis* pollen, which is presumed to be derived from the temperate or warm-temperate evergreen broad-leaved trees such as *Quercus salicina*, *Q. acuta* and *Q. glauca*. Together with occasional appearances of *Castanopsis*, this increasing abundance implies that this zone indicates the highest temperature, which is

temperate and wet, and supports evergreen broad-leaved tree vegetation in the post glacial period. The AP percentages in AP/NAP ratio and the total pollen number/1cm³ also have the highest value in any sections of the zone. Although the uppermost distributional limit of evergreen broad-leaved trees in the Chugoku Mountains at present is at altitudes of ca. 600m, this limit is presumed to have risen to altitudes of ca. 900m during the subzone D₂. The subzone D₂ corresponds with the pollen zone R-II of the Japanese pollen zone system. The pollen zone R-II in the Hosoike Moor is characterized by the forests of deciduous broad-leaved trees and evergreen broad-leaved ones, but the same zone on the Ohnuma Moor is characterized by the remarkable increases of *Cryptomeria* pollen. This vegetational difference may be caused by total annual precipitation which amounts to 1,684mm in the former and 2,294mm in the latter.

The zone E is a period in which human impact to natural vegetation became more marked. Forest disturbance at -35cm is indicated by a remarkable reduction of *Cyclobalanopsis* pollen and an appreciable increase of the characteristic species of secondary forests, such as *Pinus densiflora* and *Quercus serrata*, and the introduced one such as *Cryptomeria japonica*. Although the present forest vegetation belongs to *Quercus-Pinion densiflorae* H. Suzuki et Toyohara 1971, the potential natural vegetation may be *Saso-Fagion crenatae* (Suzuki et Toyohara 1952) Miyawaki et al. 1961. Values of the NAP (Cyperaceae, Gramineae and Compositae) also increase here drastically. The AP/NAP ratio indicates a total decrease of forest pollen and an increase of herbal pollen. Total pollen concentrations decrease drastically. This zone belongs to the pollen zone R-IIIb in the Japanese pollen zone system. Although there is no evidence of unconformity in stratigraphic sequence between the zone D and E, the pollen zone R-IIIa seems to be lacking here with the time gap of about a few thousand years between the both zones showing the extreme change of the microflora. The Hosoike pollen spectra corresponding to the Japanese pollen zone system established by Tsukada⁽¹⁰⁾ are as follows :

Hosoike pollen zone	Tsukada's Japanese pollen zone
E	R-IIIb
-	1,500 - 0 yr B. P.
	R-IIIa
	4,500 or 4,000 - 1,500 yr B. P.
D ₂	
	R-II
	9,500 - 4,500 or 4,000 yr B. P.
D ₁	
C	R-I
	10,500 - 9,500 yr B. P.
B ₂	L
	15,000 - 10,500 yr B. P.
B ₁	FG*
	25,000 - 15,000 yr B. P.
A ₃	PFG**
	30,000 - 25,000 yr B. P.
A ₂	PFG
	33,000 - 30,000 yr B. P.
A ₁	PFG
	40,000 - 33,000 yr B. P.
* : Full glacial period	** : Pre-full glacial period

The pollen zones reflected the past vegetation and climates of the Hosoike Moor are summarized in Table 3.

Table 3. Pollen zones, presumed past vegetations and climates of the Hosoike Moor

Pollen zones		Vegetations class	Climate	
Hosoike	Japan yr B. P.		Temperature	Moisture
E	R-IIIb	<i>Fagetea crenatae</i> Miyawaki et. al., 1964	Cool-temperate	Wet
	1,500			
	R-IIIa			
	4,500			
D ₂	R-II	<i>Camellietea japonicae</i> Miyawaki et Ohba, 1963	Warm-temperate	Wetter
D ₁			Temperate	Wet
	9,500			
C	R-I	<i>Fagetea crenatae</i> Miyawaki et al., 1964	Cool-temperate	Dry-wet
	10,500			
B ₂	L	<i>Vaccinio Piceetea</i>	Subarctic~Cool-temperate	Dry
	15,000	BR. - BL. - 1939		
B ₁	FG		Subarctic	Dryer
	25,000			
A ₃	PFG ₃		Cool-temperate	Wet
	30,000			
A ₂	PFG ₂	<i>Fagetea crenatae</i> Miyawaki et al., 1964	Cool-temperate~Temperate	Wetter
	33,000			
A ₁	PFG ₁		Cool-temperate	Wet
	40,000			

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中国山地・細池湿原の後期更新世と完新世の植生変遷史

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細池湿原は、中国山地東部（岡山県苫田郡加茂町）の五輪山南西側のゆるやかな斜面にある典型的な山頂湿原である（海拔 970 m）。500 cm の堆積物は、泥炭、黒泥、黒泥質粘土、シルト質粘土からなり、3 枚の火山灰（アカホヤ、坂手、アイラ）をはさんでいる。¹⁴C年代測定により、 $18,500 \pm 225$ yr B. P.（190–180 cm）と $33,800 \pm \begin{smallmatrix} 1,290 \\ 1,120 \end{smallmatrix}$ yr B. P.（380–370 cm）の値を得た。この値から本湿原は、約 40,000 年前から堆積を始めたとみられる。花粉・胞子分析の結果から、次の 5 花粉帯を確認した。

A 帯（500–235 cm, 40,000–25,000 yr B. P.）
 亜寒帯性（モミ属、トウヒ属、マツ属、ツガ属、カバノキ属）、冷温帯性（ブナ属、コナラ亜属）、温帯性（スギ属、コウヤマキ属、ニレ属、クマシテ属、トネリコ属）。

B 帯（235–100 cm, 25,000–10,000 yr B. P.）
 亜寒帯性、冷温帯性（コナラ亜属）。

C 帯（100–80 cm, 10,000–9,000 yr B. P.）
 冷温帯性、温帯性（クマシテ属）、亜寒帯性。

D 帯（80–35 cm, 9,000–4,000 yr B. P.）
 暖温帯性（アカガシ亜属、シイノキ属）、温帯性（ニレ属、クマシテ属、エノキ属）、冷温帯性。

E 帯（35–0 cm, 4,000–0 yr B. P.）
 二次林性（マツ属、コナラ亜属、スギ属）。

この花粉帯は、約 40,000 年間の植生変遷史を含んでいるが、D 帯と E 帯の間に不整合面があり、数 1,000 年間の空白が認められた。本湿原の分析結果は、中国山地東部の後期更新世から完新世にわたる代表的な植生変遷史を示しているとみられる。