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Stratigraphical and Pollen Analytical Studies of the Pleistocene Deposits in the Northern Part of Nagano Prefecture, Central Japan

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INTRODUCTION

The Pleistocene deposits are exposed along the lower course of the Torii River in the northern part of Nagano Prefecture. This area has been studied by Suzuki (1938), Saito (1955, 1957) Tomizawa (1956, 1958), and others as to its stratigraphy and paleontology. There remain still, however, some questions. Until recently, the writers have been engaged in the research of the Pleistocene deposits in the area. This study is concerned chiefly with the stratigraphy and palynology of the peat beds interbedded in the Pleistocene deposits. Although laboratory works are now in progress, the field observations together with the data so far obtained from the laboratory work will be given here.

Acknowledgements are due to Prof. Shigeru Miki and Dr. Kunio Kobayashi for their kind guidance and encouragement, and to the members of the Toyono Research Group for their valuable discussions. This work was supported from the Science Expenditure Fund of the Ministry of Education.

STRATIGRAPHY

The stratigraphic sequence of the Pleistocene deposits in the area is summarized in Fig. 1.

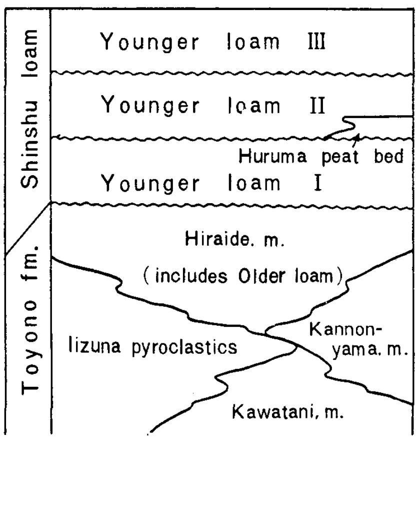

Fig. 1. Stratigraphic sequence of the Pleistocene deposits in the area of the lower course of the Torii River, Nagano Prefecture.

Toyono Formation

In 1957, Kobayashi proposed the name "Toyono formation" for the strata developed in the Toyono hill, including all members that Saito (1955) originally defined as the early Pleistocene deposits. Although the term Toyono was used as a member name by Suzuki, Tomizawa and Saito before its proposal, the latter usage has become well-established in geologic literature. In this paper, therefore, the term Toyono is adopted as a formational name.

The writers recognized four members in the Toyono formation: the Kawatani member, the Iizuna pyroclastics member, the Kan'non'yama member and the Hiraide member. The stratigraphical relationships of each member are as shown in Fig. 1.

Kawatani member—The Kawatani member was named by Saito (1955) for exposures along the Torii River in the vicinity of Kawatani, Samizu-mura. It changes into the Iizuna pyroclastics by interfingering at the Toyono hill. The base of the member has been observed at only a few localities. It overlies unconformably the Susobana member of the Ogawa formation in the southern part of the Toyono hill. In the south-western part of the same hill, the member can be traced to the uppermost part of the Upper Sarumaru member of the Shigarami formation. It is worth to note that the leaves of *Metasequoia disticha* Miki have been found in the lower part of the Upper Sarumaru member. Elsewhere along the Torii the base of the member is not exposed and is overlain by the Iizuna pyroclastics. The thickness is estimated to be about 60 m in the extent of the exposure.

The Kawatani consists of sandstone and conglomerate in frequent alternation, sometimes cross-laminated and irregularly bedded, occasionally it intercalates beds of lenticular dacitic tuff in the uppermost part. The conglomerate contains abundant cobbles or pebbles of basic andesites, diorites and porphyrites, all of which are derived from the eastern mountain region of the Chikuma River. No fossil except fragmentary plant remains has been found in the Kawatai member; hence, the exact age is unknown. It is however, assumed to be early Pleistocene in age, because it is certainly correlative with the uppermost part of the Upper Sarumaru member, and because the Kawatani interfingers with a part of the terrestrial Kan'non'yama.

Iizuna pyroclastics—The Iizuna was named by Suzuki (1938), as the Iizuna tuff. The Iizuna consists mainly of tuff breccia and volcanic breccia of two-pryoxene andesite. Those pyroclastics were produced by the Iizuna volcanic activity during the depositions of the Kawatani, the Kan'non'yama and the Hiraide members. The name Iizuna can, therefore, be used on grounds of stratigraphy as well as of priority.

In the area, the type locality of the Iizuna is located in the valley of Banzhoyashiki, Mure-mura, where thin lenses of coarse sandstone and pebble conglomerate are irregularly intercalated in the lower part, and its thickness is estimated to be 40 m. The Iizuna thins eastwards from the type locality and on the eastern margin of the Toyono hill it does not exist. In a small area along the Torii River between the Mure and the Huruma railway stations there are found a few lava-flows in the lowermost part of the Iizuna pyroclastics.

Kan'non'yama member — The term Kan'non'yama should be adopted for the Toyono member of Saito (1955), accordingly its usage should, therefore, be restricted to an alternation of sand and siltstone exposed only along the eastern margin of the Toyono hill. The original type locality was a road side exposure at the foot of Kan'non'yama, Toyono-machi.

The Kan'non'yama member varies considerably in thickness, and generally is thickest along the margin of the Toyono hill: the known maximum thickness is about 50 m near the type locality. The lower part of the member consists largely of light and yellowish-gray, massive siltstone, the upper part consists of an alternation of brown, fine- and medium-grained sandstone and yellowish gray, soft diatomaceous siltstone which indicates occasionally varve-like laminations. It passes gradually into the lower part of the Hiraide member to the west. In the north-eastern margin of the Toyono hill, it grades downward into the Kawatani member by an increase of coarse sediments.

Such molluscan fossils as *Cristaria* cf. *plicata* (Leach), *Corbicula japonica* (Prime), occur sporadically with terrestrial plant remains at the type locality. Fresh-water diatoms from the Kan'non'yama member as described by Tomizawa (1956) are, *Amphora veneta* (Kütz.) Hust., *A. ovalis* Kütz., *Melosira granulata* (Ehr.) Ralfs var. *islandica* O. Müll., *Navicula placentula* (Ehr.) for. *rostrata A.* Mayer, *Synedra ulna* (Nitzsch) Ehr., and

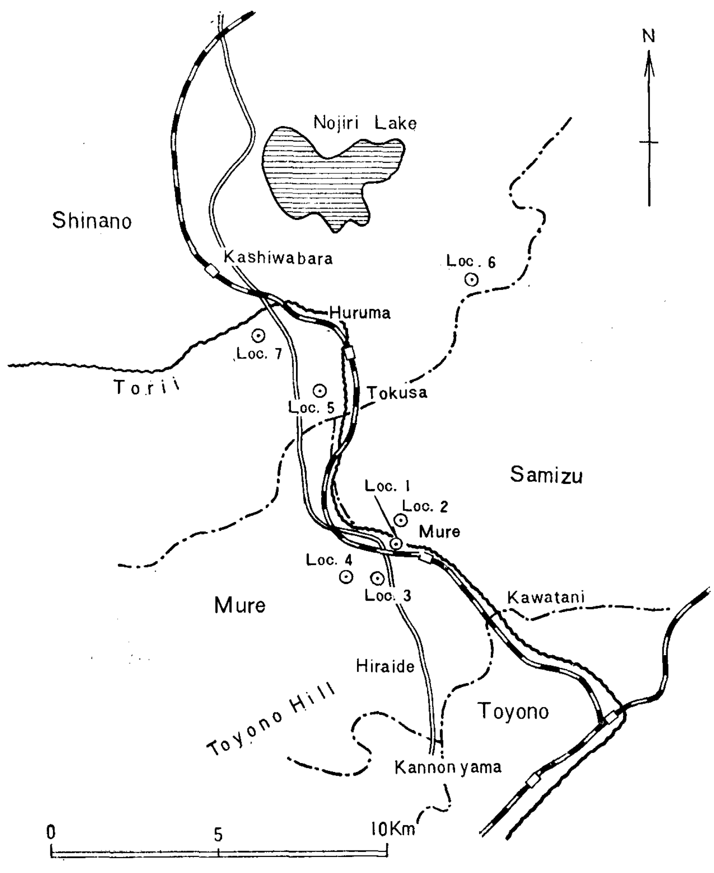

Fig. 2. Index map showing the localities of the peat beds in the Torii River area.

Surirella sp.

Hiraide member — The Hiraide member was named by Saito (1955) for exposures near Hiraide, Mure-mura. Because the member changes laterally and vertically into the Older loam in the larger part of the area, it does not constitute a mappable unit and is therefore, mapped with the Older loam of the Shinshu loam. Thickness of the Hiraide is variable; it has a maximum thickness of 20 m at the type locality.

In general, the member consists of yellowish to gray-brown, medium- to coarse-grained, non-bedded, rarely cross-laminated, loose sandstone or conglomeratic sandstone and gray to gray-brown, thin-bedded, clayey siltstone, with a few thin pumice layers in the lower part. There are, in places, one or two peat beds each from 1 to 2 m thick, but sometimes about 3 – 4 m near and at the base of the member. The distribution of the peat beds is shown on the Index Map (Fig. 2). Loc. 5, about 1 km. west of Tokusa, Shinano-machi might be considered to be the typical occurrence of the peat bed in the Hiraide member, because it is covered directly with the Older loam at this locality.

Loc. 1 is at the bottom of the Torii River about 500 m west of the Mure railway station on the Shin'etsu Line. Here the contact of the peat bed with the underlying Iizuna pyroclastics is well exposed. This peat bed is probably an equivalent of the Tokusa peat bed (Loc. 5). The peat beds of Locs. 2 and 3 are of the same horizon and a little higher than the horizon of Loc. 1. Such plant remains as *Picea Koyamai* Shir., *Andromeda polifolia* L., *Scirpus mucronatus* L., *Alnus japonica* S. et. Z., and *Menyanthes trifolia* L. are well preserved in the peat beds at Locs. I, 2 and 3.

From the Hiraide member there have been discovered some molars of *Paleoloxodon namadicus naumanni* Mak. In association with the mentioned elephant are found the nut-shells of *Juglans Sieboldiana* Max. *hosenjiana*, which occurs in the peat bed of Asahiyama near Nagano City. These paleontological evidences seem to suggest that the Hiraide together with the Kan'non'yama is probably early Pleistocene in age.

Shinshu Loam

The term Shinshu loam sheets named originally by Kobayashi, are applied to the Pleistocene silty deposits of volcanic origin which occupy an extensive area in the Shinshu district. Based upon stratigraphic and lithologic characteristics, they should be classified into several local types, because the volcanoes that supplied the material over various areas are not considered to be the same. The Shinshu loam sheets in our area can be divided into the following two major members: the Older loam and the Younger loam. Fig. 3 shows the type section of the Shinshu loam obtained from an exposure at the cliff behind the Nojiri Middle School on the bank of Lake Nojiri.

A detailed description of this Shinshu loam will, in the future, be published by the Toyono Research Group in another paper.

Older loam — The Older loam, as already stated, is equivalent to the upper part of the Toyono formation which was deposited in the Paleo-Toyono Lake. The Older loam is overlain nonconformably by the Younger loam, but the contact is exposed at only a few places. The unconformity between the Older loam and the overlying Younger loam

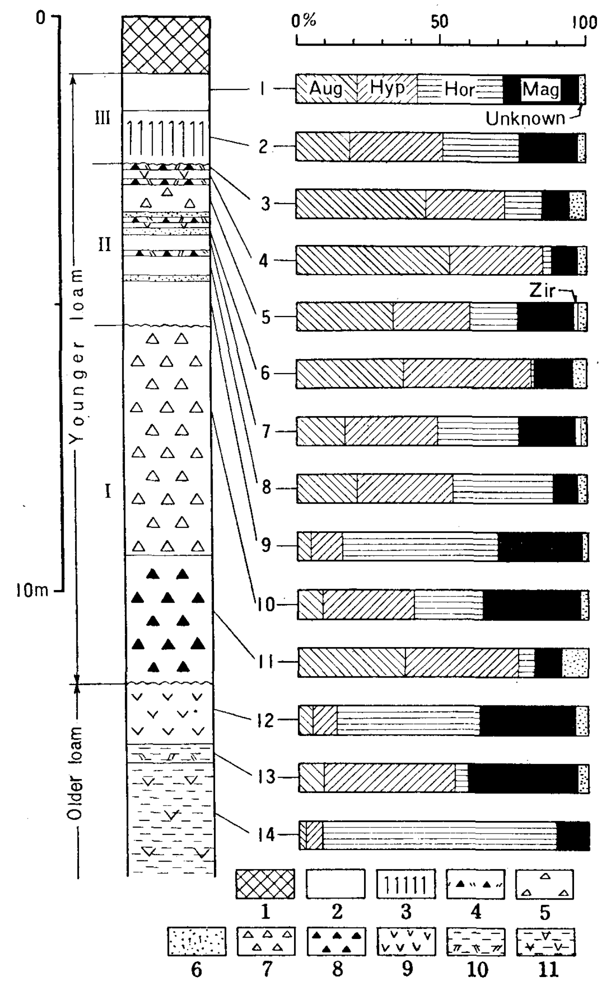

Fig. 3. Type section of the Shinshu loam from an exposure of the cliff behind the Nojiri Middle School, Shinano-machi.
Aug : Augite. Hyp : Hypersthene. Hor : Hornblende.
Mag : Magnetite. Zir : Zircon.
1 : Humus 2 : Fine- or medium-grained loam 3 : Chocolate coloured loam (Crack Zone) 4 : Scoriaceous tuff 5 : loam with andesite debris 6 : Volcanic sandstone 7 : Andesite debris in a matrix of loam (Breccia zone) 8 : Scoriaceous medium-conglomerate 9 : Hornblende-andesitic pumice 10 : Clayey tuff 11 : Pumiceous clayey loam.

shows the most distinct stratigraphical break in the succession of the Shinshu loam and indicates a period when peneplanation took place in the area.

The Older loam is the most wide-spread unit. The Older consists of dark- and reddish-brown clayey loam, with intercalated bluish-gray, medium- and coarse-grained volcanic sandstone bands. Characteristically, a bed of hornblende-andesitic pumice occurs near the base of the Older loam. It is an excellent stratigraphic marker or "key bed". Most heavy minerals in this loam are hornblende and magnetite. The majority of the feldspars are yellowish to blackish- brown due to excessive decomposition. The Older loam is variable in thickness, the maximum thickness of about 12 m is attained at the eastern foot of the Iizuna volcano. The Older loam is, in most places, less than 4 m thick in the environs of Lake Nojiri, indicating that the erosion interval which removed more than half of the loam might be placed prior to the deposition of the Younger loam.

The final deposition of the Older loam is significant in the sense that it filled the Paleo-Toyono Lake. The writers should like to believe that the Older loam may be correlated with the Tama loam in the Kanto district.

Younger loam — In our area, the Younger loam rests on the hilly-land along the Torii River ranging in altitude from 580 to 900 m. Although the materials do not exist on the terraces ranging from 400 to 580 m, probably covered once a much larger area than that which its present distribution indicates.

The Younger loam is divided into three units. Unconformities separate these three units from each other, as well as from the Older loam below. For convenience, the three units are tentatively defined in this paper, but they are not proposed as formal stratigraphic units.

Younger loam I : The Younger loam I is represented by the existence of a breccia zone composed of volcanic debris included in a matrix of yellowish brown loam. Locally, a bed of water-worn, scoriaceous medium-conglomerate occurs at its base and ranges from 30 cm to 2.2 m in thickness. This breccia zone which in most places does not exceed 4 m in thickness, contains commonly a small amount of carbonaceous materials. The only abundant heavy minerals in the matrix are hypersthene and augite. No glass is present. The maximum thickness of the Younger loam I is estimated to be 6.2 m in the type section.

Our studies in the present course can hardly afford plausible proof as to the age of the Younger loam I.

Younger loam II : The Younger loam II consists mainly of yellowish- to brown, fine- to coarse-grained hard loam intercalated with a few layers of scoriaceous tuff and volcanic sandstone. In some places, the basal part of this unit forms a conspicuous crack zone and is useful as a lithological marker. In the type section, heavy minerals are in order of abundance : hypersthene, augite, magnetite and hornblende. Augite increases in abundance upward in the sequence. Glass shards occurs rarely in the sequence at several points. The estimated thickness of the Younger loam II ranges from 3 to 6 m in our area.

At Loc. 7, south of Huruma, Shinano-machi, the writers found that 2.3 m of the peat bed is best developed in the basal part of the Younger loam II. This is the one of the few localities in a small area in the vicinity of Huruma. Herein, it is designated as the Huruma peat bed. The palynological result of the Huruma peat bed will be discussed with that of the Tokusa peat bed in another part of this paper.

Younger loam III : In most places, the lower part of the Younger loam III, composed of dark brown hard loam is characterized by a crack zone. This zone ranges from 30 to 90 cm in thickness and is overlain by about 70 cm of yellowish- brown colored, fine-grained soft loam. In the type section, the Younger loam III contains approximately 20 percent glass shards, but strictly speaking the amount of glass shards, ranges from 30 per cent in soft loam to 10 per cent in hard loam. Feldspars are commonly fresh. In soft loam, the total amount of heavy minerals does not exceed 20 per cent. The thickness is estimated to be 155 cm in the type section.

Recently, human remains of non-ceramic culture were found from the upper part of the Younger loam III on the bank of Lake Nojiri. Thus, it is considered to be late Pleistocene in age.

Pollen Analysis

The pollen diagram is based upon counts of more than 150 tree pollen grains per sample, excluding *Pinus* and *Alnus* : the values for the individual pollen types are expressed as percentages of this number. The pollen diagrams, which show approximately the actual composition of forests by pollen percentages, of which calculations are based on Iversen's improved method (Tsukada, 1958), will be given in another paper.

It is considered from the stratigraphical survey that the Tokusa peat bed (T. P.) is older than the Huruma peat bed (H. P.). Pollen sedimentation throughout both layers especially the spruce pollen maximum is the significant portion. Such a maximum projects further into the relative value than any section inspected heretofore on Pleistocene deposits of Japan, except for northern Hokkaido (Yamazaki 1957, Shimada 1956, 1958, Yamagata

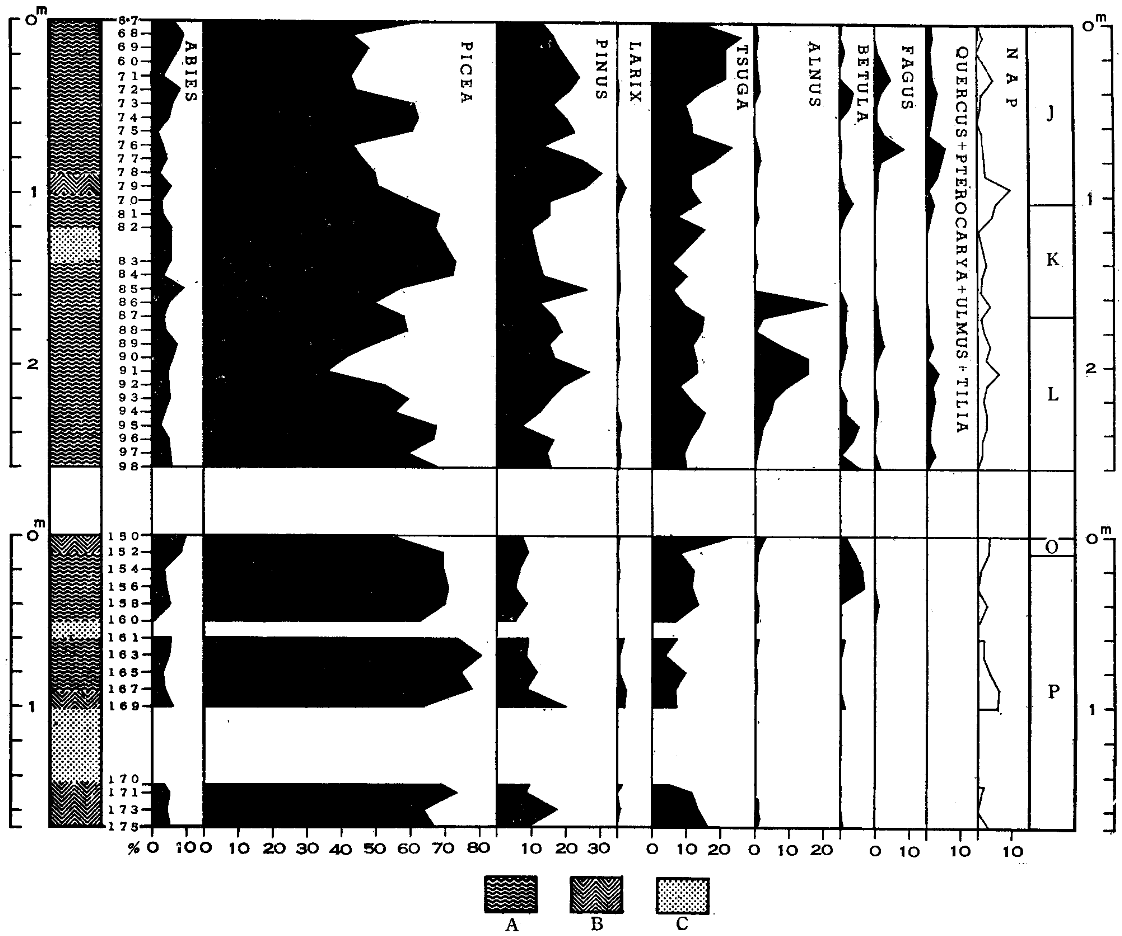

Fig. 4. Pollen diagrams from the Torii River area, Huruma peat (upper) and Tokusa peat (lower).
A : Peat B : Peaty clay C : Clay (or Sand)

and Sohma 1956, and Sohma 1957 b and c). This is very important, as compared with the fact that most parts of the present distribution of the spruce are restricted to the subalpine zone in central Japan and in northern Hokkaido. The phenomena related to the problem will be discussed with further considerations. Fir (*Abies*), is also significant, although this genus is represented as one of climax conifers in the same environment occupied by the spruce at present. Hemlock (*Tsuga*) is rather predominant at the upper part of the T.P. section and almost throughout the H.P. section, while the pollen sedimentation below sample No. 152 level shows lower value than that of the hemlock of the H.P. section. Pine represents a quite similar trend even in relative value, to that of the hemlock. While this tree produces greater amounts of pollen than spruce, hemlock, and other conifers and therefore highly represented in the deposits, the abundance of pine in H.P. section is of course apparently not of importance. Only a small proportion of the larch (*Larix*) with several interruptions throughout the profiles suggests a remnant of the earlier *Larix* period (Miki, 1957). The trend of birch also followed a more of less similar trend to that of larch. Alder, in the case of T.P. section is poorly represented, while in that of the H.P. section this genus which produces a great quantity of pollen is more important; the pollen occurs abundantly in the lowest one. In general, alder species, especially *Alnus japonica* Staud., predominates in peat bogs. The abundance of the alder pollen in the lowest peat from the T.P. section is therefore considered to be the probable *A. japonica* growing in the bog at the time of earlier peat deposition. There is, moreover, an important fact that although spruce from 93 to 86 levels is lower than that of the other levels, it is attributed in part to the alder succession, which always has the local origin of it.

It is of interest that the appearance of appreciable values of deciduous hardwoods is made only in the H.P. section, especially with respect to samples at Nos. 71 to 78 and 89 to 94 levels. These plants, however, now occur in the montane zone (ranging from ca. 1000 to 1700 m. above sea-level in central Japan) below the subalpine conifers zone. It is suggested that in view of the vegetational changes as compared with the preceding period the conditions were becoming warmer in these levels, although there is little evidence of climatic change in this period. The NAP values are low, except for the rather high value at 79 level, and more or less complete forest coverage is indicated.

From the characters of pollen succession indicated above, the sequence consists of five periods, P, O, L, K and J as are shown in the right column in Fig. 4. The interval between zones L and O indicates a certain time gap with unconformity. The detailed palynological pollen contribution concerning these horizons will be given in another paper. The boundaries of this sort should not be considered to signify the well-fixed demarcation of the Pleistocene period. It is certain that the *Picea* forest had been prevailing as the climax in this area, although it was accompanied with a few *Tsuga*, *Abies* and other subalpine trees. And in a certain time, for example in the P zone, *Picea* might have been formed almost as the pure forest.

Since the Pliocene, the climate of Japan has undergone certain several cold ones, as indicated by botanical, geological and geomorphological evidences. The greatest wealth of information is provided by the records of abundant plant remains (Miki 1933, 1938, 1939, 1941, 1948, 1956, 1957, 1958) and many kinds of fossil glacial features, especially more than 70 cirques of the Japan Alps and the Hidaka mountains indicating a certain cold age (Kobayashi 1955, 1958), and the discrete distribution of morphometric values of *Menyanthes* seed remains (Kokawa 1958). In general, it is believed now that the atmospheric temperature in the glacial ages of Japan was at least lower by 7°C than that of the present day.

It, however, is doubtless that this area was not covered with glaciers, although glaciation in the past has differentially modified the mountain tops, and also in most places it seems to have been local or generally weak. The component of pollen assemblage seems reasonable to assume, in view of the exiting distributions and of ecological compositions of the plants, that the plants may be those of the subalpine zone. In this area, the subalpine conifer zone, therefore, was by at least 1000 m lower than now.

More convincing evidence for cold climate is estimated by the present distribution of growing peat bogs. That multiple bogs formed have relation with climate in the islands is well known, but regarding climate it has hardly been discussed by any authors, although Tsukada's conclusions that the recent distribution of the bulk of bogs is limited in the area from the uppermost part of montane hardwood zone upwards to exactly the timber line itself, are corroborated with the observations made on bogs since these several years in Japan. (See Selling 1948 and also Salt 1954). Namely, assuming that most of peats bogs are formed under subalpine climatic conditions at present, the peats at the level shown in the present paper could possibly be formed when the temperature was lower at least 6.6°C than to-day.

CONCLUSIONS

The following conclusions are drawn from our studies:

1) A local unconformity which might originate from the marine transgression of the late Shigarami stage, is recognized between the Ogawa formation and the overlying Toyono formation. It is supposed that a marine basin was cut off from the open sea after the maximum transgressive stage and later in the early Pleistocene period it changed into a lacustrine basin to which we adopted the name "the Paleo-Toyono Lake".

2) It is in the Paleo-Toyono Lake that the Toyono formation was deposited. The Paleo-Toyono Lake decreased its depth and finally it became possible to provide a condition under which peat beds might have been deposited. The withdrawal of the Paleo-Toyono Lake was followed by the areal uplifting with the result that the area had been subjected to denudation. After a certain time-interval, during which denudation was in progress, intense volcanism began to deposit thick beds of ashes. The Younger loam I and II are considered to have settled in some places on the subaerial land surfaces, and in other places in the water, as are shown by water-sorted or stratified lithologies and especially by the occurrence of the peat bed in the basal part of the Younger loam II. On the other hand, the Younger loam III seems to have originated from aeolian volcanic ash.

3) Peat beds occur at two horizons in the Pleistocene deposits, one belongs to the Hiraide member and the other, to the Younger loam II. The palynological results of the just mentioned peat layers, namely the Tokusa peat (T.P.) and Huruma (H.P), are shown in

Fig. 4. In general, subalpine conifer pollen grains, especially spruce pollen were dominant throughout both layers without exception. It is certain that a *Picea* forest had once prevailed as the climax in this area, because of the NAP's low values, although it was accompanied with a few *Tsuga*, *Abies* and other subalpine trees. Such expansion of this spruce is the most important phenomenon to the vegetation development of the post-glacial period in central and northernmost Japan. It is obvious now that the conifer forest belt was lower more than 1,000 m in its relative height as compared with the present level, and that most of the peat bogs are forming under subalpine climatic conditions at present. This indicates, therefore, that the air temperature at the time of peat depositions was lower, at least 6.6°C than that of the present.

4) Judging from the available evidences, the Tokusa peat bed may be infered to be of early Pleistocene in age (probably the Mindel glacial age). As to the age determination of the Huruma peat bed, it will be necessary to collect more data that will serve as time-indicators. But it is possible to assume that the Huruma peat bed may be of late Pleistocene age — perhaps of the Würm glacial age.

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