Researches in the Far East on the Study of the Holocene during the Inter-Congress Time, 1983-1987 （Ⅰ）

Researches in the Far East on the Study of the Holocene during the Inter-Congress Time, 1983-1987 (I)*

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Preface

In the 11-International Congress of the International Union for Quaternary Research held in Moscow, the Union of Soviet Socialist Republics on August of 1983, the International Union for Quaternary Research (INQUA) adopted that the Commission for the Study of the Holocene organized the Subcommission of the Far East for the Study of the Holocene, and then Prof. Dr. Norio Puji was elected for the first president of the subcommission.

During the Inter-Congress time, 1983 to 1987, many scientists of every country belonging to the Subcommission of the Far East have investigated on some problems concerning the Holocene as summarized in a following section. In this report, outlines of the main researches among them have been described on the basis of main publications by the academic societies of every country.

Researches of the Holocene in Japan

We can divide main subject concerning the Holocene esearches in Japan during the inter -congress time, late 1983 to early 1987, into following seven topics. They are:

(1) *Establishment of the type-locality of the Holocene/Pleistocene boundary in Japan*

(2) *Vegetational and Climatic Changes during the Holocene*

(3) *Sedimentary history during the Postglacial*

(4) *Submerged forest on the continental shelf, Toyama Bay*

(5) *Reconstruction of palaeoenvironment in the archaeological sites*

(6) *Sea-level changes during the Holocene*

(7) *Chronostratigraphic subdivision of the Holocene deposits.*

I : Establishment of the type-locality of the Holocene and Pleistocene boundary in Japan

About fifteen years ago, in the VIII-International Congress of the International Union for

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Quaternary Research held in Paris, 1970, the establishment of the international type-locality of the Holocene and Pleistocene boundary had been proposed by a lot of the scientists concerning the Holocene researches, and then the special working group (the chairman : Prof. Olausson of the Department of Ocheanography, Göeteborg University) of this problem was set up under the Commission for the Study of the Holocene (the president : Prof. Bob P. Hageman of the Rijks Geologiche Dienst, Haarlem, the Netherlands). In the inter-congress time 1978 to 1983, after some meetings in Göeteborg, Sweden and a field excurssion in and around lowland area near Göeteborg supported by the Commission for the Study of the Holocene, the working group had proposed a few localities for the international type-locality resulted from the researches of chronostratigraphy by radiocarbon datings, biostratigraphy by pollen and diatom analyses, foraminifera, nannoplankton and molluscs etc., lithostratigraphy, palaeomagnetism and climatostratigraphy. Then, the proposal had been discussed in the International Symposium held in the Uppsala University, Uppsala of Sweden, and in the 11-International Congress of the International Union for Quaternary Research held in Moscow in 1983, it was discussed that concerning international type-locality for the Holocene/Pleistocene boundary it was better to be established in Moltemyr and Solderga near Göeteborg, Sweden.

In the first place, the international type-locality should be satisfied completely some conditions such as the distribution of marine sediments for global correlation. The Quaternary possessess rather special characters that make in unique in the geologic record. However, there is a growing consensus that the subdivisions of the most recent part of the stratigraphic record should follow geologic procedures.

In terrestrial successions, lithostratigraphy and biostratigraphy constitute the basic units of classification at the local scale, and these can be clearly defined on the basis of observable criteria.

The International Subcommission on Stratigraphic Classification, which was set up by the International Union of Geological Sciences, recognises three principal categories of stratigraphic subdivision for use through the geologic column. These are "lithostratigraphy", "biostratigraphy", and "chronostratigraphy" which is also termed "timestratigraphy".

In the Quaternary stratigraphy, two further categories have been employed. There are "morphostratigraphy", which is the classification of landforms according to their relative order of age, and "geologic-climatic" units, which are the allotment of stratigraphic units to positions within a sequence of inferred climatic episods. The latter classification is generally referred as "climatostratigraphy".

A widely-employed basis for the subdivision of the Quaternary is climatic change, for instance, the characteristics of the stratigraphic record can be related directly to former climatic conditions. In recognition of this fact, the American Commission on Stratigraphic Nomenclature established a new stratigraphic subdivision termed a "geologic-climatic unit" in 1961. In areas affected by the Quaternary glaciation, glacials and interglacials constitute the principal geologic-climatic units, while stadials and interstadials from units of lesser rank. In areas not affected by glacier ice, it was anticipated that other geologic-climatic units, such as pluvials and interpluvials, would be established.

Geologic-climatic units are undoubtedly useful concepts and, insofar as the Quaternary at mid- and high-latitudes tend to the subdivision into glacials and interglacials. They form the basis for stratigraphic subdivision at the continental and regional scales. However, as climatic change is time-transgressive, the boundaries of geologic-climatic units are diachronous. It, therefore, is not appropriate to use geologic-climatic terms such as stage and substage etc. In most the areas formerly occupied by glacier ice, deposits may be laid down at a late stage in glaciation. Therefore, the actual time interval represented in the stratigraphic record by a till (geologic-climatic units) reflects only a part of the period of the glacial stage. Therefore, the geologic-climatic units are in some ways similar to chronostratigraphic units. However, in all areas not affected by glacier ice as the Japanese Islands the geologic-climatic units are not always similar to chronostratigraphic units.

The Japanese scientists don't yet start any research concerning the Holocene/Pleistocene boundary problem. We, therefore, should do on the research as soon as we possible. Although we don't yet estabish the type-locality in Japan, at the present time, the author wishes to descrive this problem, for instance, on the Holocene deposits of the Kanazawa lowland area in the Japan Sea side of the Japanese Islands from the view points of five principal categories for stratigraphic subdivision of the Postglacial deposits as mentioned above.

Firstly, with regard to "lithostratigraphy", the latest Quaternary deposits during the past nearly 18,000 years after the last glaciation developing in the coastal areas near seas, are divided into four members such as the lowermost member (mainly gravels), lower member (alternation of clay and sand with thin peat layers), middle member (mainly sand with marine and/or brackish water shells and diatoms), and upper member (sandy or clayey sediments) in ascending order. Among them, the middle member is composed of well-sorted fine or silty sand and generally contains marine and/or brackish water shells and/or diatoms. It is intercalated at 25 to 40m below the present sea-level in the geologic column, and directly covers the lower buried abrasion platform. It is thinner than 15m thick, and the N-value is 15 to 30 in the sandy layers and 5 to 15 in the silty layers respectively. The middle member is presumed to represent the foreset bed of former deltas accumulated when there was a halt of sea-level in the process of the Frandrian Transgression. The age of this short stillstand of the sea-level had been 10,000 years ago on the basis of many radiocarbon ^{14}C datings.

The Postglacial deposits in the Japanese Islands comprise sediments that fill basins, valleys, and lakes. They consist of clay, silt, and gravel, and locally of peat layers. As the base level of rivers have not been influenced by the eustatic changes in sea-level, unlike the mode of occurrence of the Postglacial deposits in the coastal areas as mentioned above, very are inland peat, and not the deposits in the drowned valley. It is possible to determine the age of the deposits only by taking advantage of volcanic ashes or prehistoric remains belong to either the Holocene or Pleistocene epoch. In the inland areas near coasts, the Postglacial deposits are represented mainly by the alluvial fan deposits.

The Postglacial deposits in the offshore areas of bays are composed mainly of soft, clayey

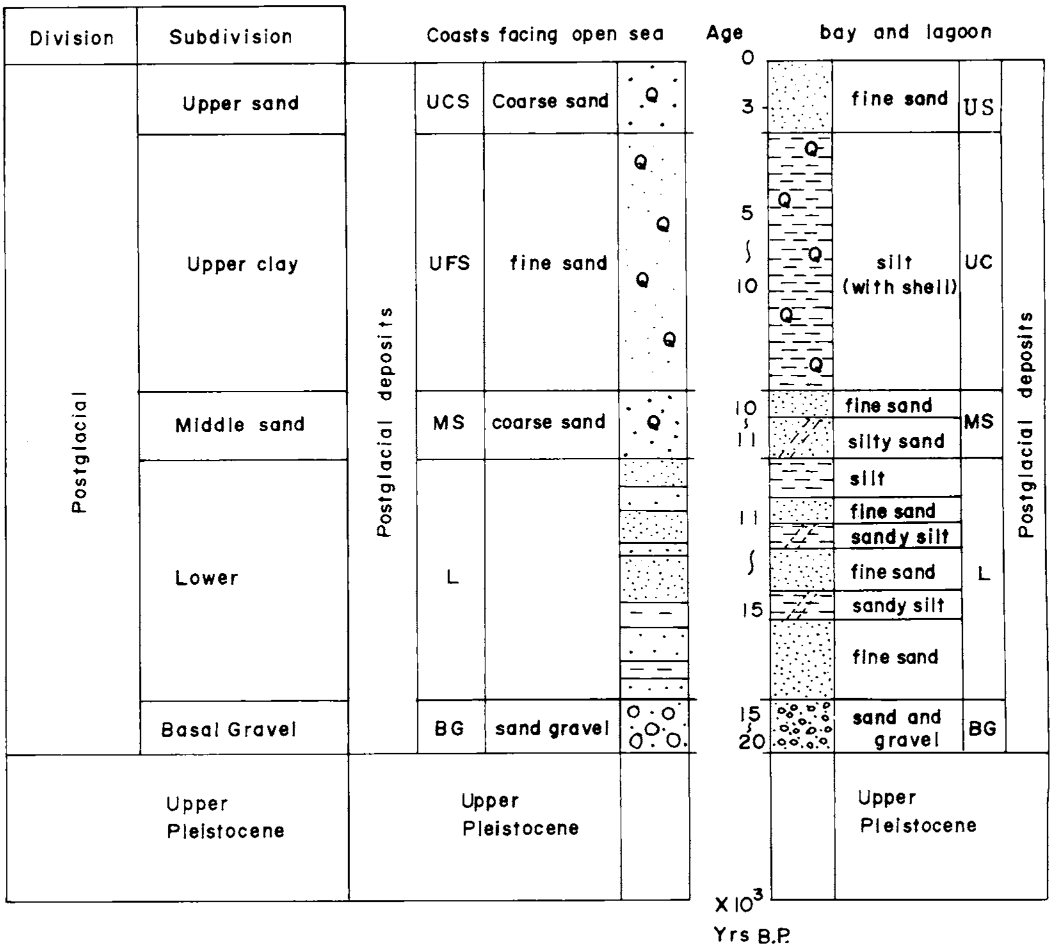

Fig. 1. Schematical chronostratigraphical subdivision in the coastal areas facing open seas and in the bay and lagoonal areas of the Japanese Islands (Fuji, 1982).

sediments corresponding with the clay layer of the Lower member. However, in the areas, there are lack of sands corresponded with the sand layer of the Upper member.

As above-mentioned, in the coastal areas in where the marine and/or brackish deposits were mainly distributed, we can decide perhaps an establishment of the type-locality of the Holocene and Pleistocene boundary in the near future on the basis of "lithostratigraphy", but we cannot decide the type-locality in the other areas such as inland and offshore areas.

Secondly, with regard to "biostratigraphy", macrofossil- and microfossil-analyses of the Postglacial deposits, especially the Middle and Upper members, from the offshore and coastal areas have been carried out for pollen grains, foraminifera, diatoms, and shells etc. However, microfossils except for pollen grain fossils are very rare in the Lower member. Among these microfossils, in the clay and sandy silt layers of the Upper member the diatom assemblages are dominant, being those of coastal water of strong embayment degree and litoral water, and accompanied by many brackish and freshwater dwellers. These assemblages, therefore, indicate an environment as embayment. Most of the microfossil assemblages included in the Middle member are generally marine. However, a freshwater assemblage of diatoms is contained sometimes in the member. On the other hand, the diatom assemblages in the Lower member consist mainly of the freshwater one.

Judging from the palynological and diatom analyses, and the macrofossils such as molluscs, it is suggested that microfossil and macrofossil assemblages were rapidly changed , and especially marine and/or brackish water elements were yielded at that time of the lowermost horizon of the Middle member in the coastal areas. The fact suggests that the Holocene and Pleistocene boundary may be established between the Lower member and Middle member distributing in the coastal regions. However, the biostratigraphy is not useful unfortunetely in the areas except for the coastal areas.

Thirdly, in respect of morphostratigraphy, the present outline of the Japanese Islands has been resulted from earth movements since the late Pleistocene. Four principal geomorphic surfaces of the Holocene epoch can be recognized in the Islands. In as much as these are distributed typically in the Kanto district, especially around the Tokyo Bay, these have been called by names of the local surfaces in this district as the Shimosueyoshi, Musashino, and Tachikawa from older to younger surface. Each surface can be further subdivided from terraces and uplands.

The Holocene alluvial-plain was formed since about 8,000 years ago. The surfces are composed mainly of upper Pleistocene deposits, underlain by the upper Pliocene to lower Pleistocene deposits, and by the middle to upper Pleistocene ones. Most of

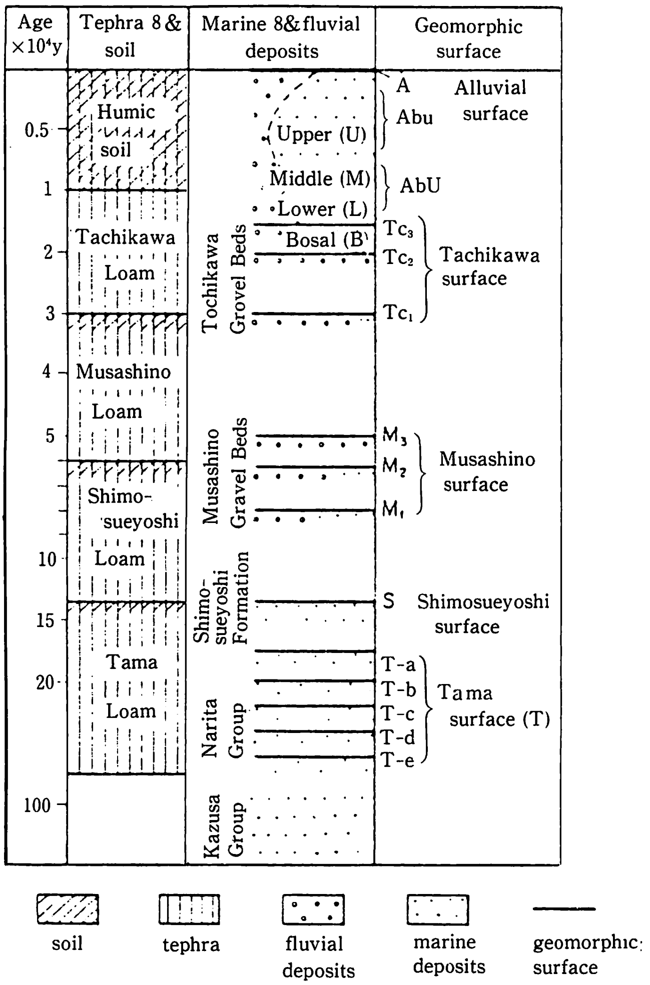

Fig. 2 Chronostratigraphy of the Quaternary deposits and geomorphic surfaces in the southern Kanto district, Central Japan (Kaizuka *et al.*, 1977 ; Fuji, 1982).

these surfaces are thickly covered with tephra layers in almost areas over the Japanese Islands except parts of areas facing the Japan Sea. Using these tephra layers as stratigraphic key beds, the chronostratigraphic succession of the surfaces as well as the certain buried terrace features below the Postglacial deposits may have been established.

The basal topography buried below the Postglacial deposits has been analysed in some coastal alluvial plains, especially around Tokyo Bay, Nagoya Harbor, Osaka Bay, Kanazawa lowland areas, Nigata plain, around Ariake Bay, and Sendai Bay etc. with reference to the following sources:

1: geologic descriptions of drilled wells and geologic observation of core samples from them,
2: results of radiocarbon datings,
3: palaeoenvironmental investigation based on microfossils as pollen grains, foraminifers, and diatoms, and molluscan fossils, and
4: pedological investigation.

The basal topography below the Postglacial deposits analysed by these sources is classified into a few geologic units such as buried abrasion platforms, buried valleys, and buried river terraces.

The Holocene terraces underlain by marine sediment and with an elevation of several to some dozen meters are sometimes recognized along the coastal lines of the Japanese Islands. As the terrace surfaces were formed during the Jomonian cultural age, they are often called the Jomonian beach or the raised beach by the Japanese geologists and geomorphologists. Former strand lines indicated by these Holocene terraces vary in height at each locality, and the fact simply implies that local vertical fluctuation of terraces since the formation of the terraces has occurred in the Japanese Islands, and that its value may be generally several meters within the last 6,000 years. In the Hokuriku district facing the Japan Sea, there are coastal sand dunes, which are separated into three belts by the distribution and age of these formations. Judging from the results on the change of the sea-level and the formation of the coastal nand dunes, the present author concluded that the relative lowering of sea-level is estimated to be about 6m during the late half of the Holocene epoch, that last 6,000 years, since the time of the highest Holocene sea-level.

The southern coastal areas of Shikoku and Kanto districts are famous for localities of the best developed Holocene terraces and of remarkable upheaval. In the Numa area of the Kanto district, the Holocene terrace is composed mainly of sediments with coral reefs and shells are found on the abration platform of the basement rocks. Among these coral reefs, there are stme species living in warm water condition. An age of a fragment of the coral reefs has been at 6,160=120 years B. P. (^{14}C). Most species of these shells do not live in the present sea around Numa area, but live in the southern sea of the Japanese Islands.

Judging from the above-mentioned results, in the early Jomonian cultural age, about 6,000 years ago, the sea is presumed to have been warmer than at the present-day. This inference is supported by a palynological investigation of some sediments of similar age. This warm age is clearly correlated with the climatic optimum and occurred within the Flandrian Transgression.

As already mentioned above, we cannot find out geomorphologic evidence such as terraces which index just the earliest Holocene and/or the latest Pleistocene as the Younger Dryas stage. Therefore, it is difficult that the establishment of the type-locality for the Holocene and Pleistocene boundary is settled on the basis of morphostratigraphy at the present-day.

Fourthly, concerning climatostratigraphy, judging from the author's investigation of the coastal area in the Central Japan, the palaeoclimate during the last 20,000 years may be inferred as follows :

20,900-16,500 years ago : cold or slightly cold, dry,
16,500-14,000 years ago : cold and dry,
14,000-12,000 years ago : slightly cold and dry,
12,000-10,500 years ago : cool and slightly wet,
10,500-9,000 years ago : slightly cold and wet,
9,000-5,000 years ago : warm and wet,
5,000-1,500 years ago : cool and slightly dry,
the last 1,500 years : mild and wet.

On the basis of the palynological investigation of the Holocene deposits distributed in some regions of the Japanese Islands, the change of the palaeovegetation and palaeoclimate during the Holocene can be divided into several phases. There are summarized as follows ;

1 : Cold stage : This stage includes the E, F, and G phases in Table 1, and is dated between about 12,000 and 10,000 years ago. The G phase is characterized by *Fagus, Abies, Pinus haploxylon*-type, and *Larix* ; the F phase by *Carpinus, Fagus,* and *Alnus* ; the E phase by *Fagus, Abies,* and *Larix.* The F phase may be correlated with the Alleröd oscillation of the North-western Europe.

2 : Increasing warm stage : This stage is the D phase in the author's investigation, and dated between about 10,000 and 8,000 years ago, and also, the stage means climatically transitional stage from the Late Glacial to the climatic optimum in the middle Holocene epoch. The dominating pollen grains are deciduous *Quercus* (*Lepidobalanus*), *Fagus, Pinus*, and *Alnus* with *Picea* as the subordinate associates.

3 : Postglacial warmest stage : This stage is the C phase, and dated between about 8,000 and 4,000 years ago. The warmest stage is corresponded to the Atlantic and early Subboreal of Europe. The characteristic genera are evergreen *Quercus* (*Cyclobalanopsis*), deciduous *Quercus* (*Lepidobalanus*), and *Alnus*, reaching to the higher altitudes ; namely, the forest line was 200 to 300m higher than that of the present-day, and the mean temperature was 2° or 3℃ higher than that of the present-day. This stage is corresponded mostly to the late stage of the Flandrian Transgression.

4 : Cool stage : this stage is the B phase, and dated between about 4,000 and 1,500 years ago. The characteristic plants are the mixed flora of evergreen broad-leaved trees and *Fagus crenata* in the Hokuriku region of Central Japan. It is about 1° to 2℃ lower than that of the

present-day in the mean annual temperature. The dominating pollen grains are *Cryptomeria*, evergreen *Quercus* (*Cyclobalanopsis*), deciduous *Quercus* (*Lepidobalanus*), *Fagus*, and *Pinus*. The decreasing warm stage may be corresponded to the stage of minor falling of the sea-level.

5 : Present climatic stage : This stage is the A phase, and dated to the last 1,500 years.

The beginning of the Holocene epoch in the Japanese Islands is generally correlated with that of Northwestern Europe. The early Holocene epoch is divided into the Preboreal and Boreal ages in Northwestern Europe. The early Holocene epoch in the Japanese Islands, however, has not been divided into such ages except for a few regions.

As already described above, climatic change is time-transgressive. The boundary of geologic-climate, therefore, is diachronous. Accordingly, we cannot decide the type-locality of the Holocene and Pleistocene boundary in the Japanese Islands except for a few localities as the coastal regions etc.

Finally fifthly, with regard to chronostratigraphy, samples dated by radiocarbon method for morphological, palynological, Quaternary geological and archaeological investigations amount perhaps to about 5,000 and more samples in total only the Holocene. On the basis of the samples, the author can summarize the Holocene deposits developed in the Japanese Islands from the view point of chronostratigraphy as following section VII.

Judging from the discussion concerning the Holocene deposits in the Japanese Islands on the basis of five principal categories, it is concluded that these four categories such as lithostratigraphy, climatostratigraphy, morphostratigraphy, and biostratigraphy except for chronostratigraphy, are not always useful methods to decide the establishment of the type-locality for the boundary between the Holocene and Pleistocene in the Japanese Islands at the present time.

II : Vegetational and climatic changes during the Holocene

On the basis of the author's investigation from the view point of palynology during the last 20,000 years in the coastal lowland areas (Fuji, 1980), the palaeovegetational and palaeoclimatic changes may be summarized as following sentenses.

Changes concerning both of the vegetation and climate can be divided into several phases.

1 : Cold stage : This stage includes the E. F, and G phases as shown in Table 1, and is dated between about 12,000 and 10,000 years ago. The G phase is characterized by *Fagus, Abies, Pinus haploxylon-type*, and *Larix* ; the F phase by *Carpinus, Fagus, Alnus* and *Ulmus* etc. ; the E phase may be correlated with the Alleröd oschllation of the Northwestern Europe.

2 : Increasing warm stage : This stage is the D phase, and dated between about 10,000 and 8,000 years ago. The stage means climatically transitional stage from the Late Glacial to the climatic optimum in the middle Holocene epoch. The dominating pollen grains are deciduous *Quercus* (*Lepidobalanus*), *Fagus, Pinus,* and *Alnus* with *Picea* as the subordinal associates.

3 : the Holocene warmest stage : This stage is the C phase, and dated between about 8,000 and 4,000 years ago. The warmest stage corresponds to the Atlantic and the early Subboreal stages of the Northwestern Europe. The characteristic genera are evergreen *Quercus* (*Cyclobalanopsis*), deciduous *Quercus* (*Lepidobalanus*), and Alnus, reaching to the higher alti-

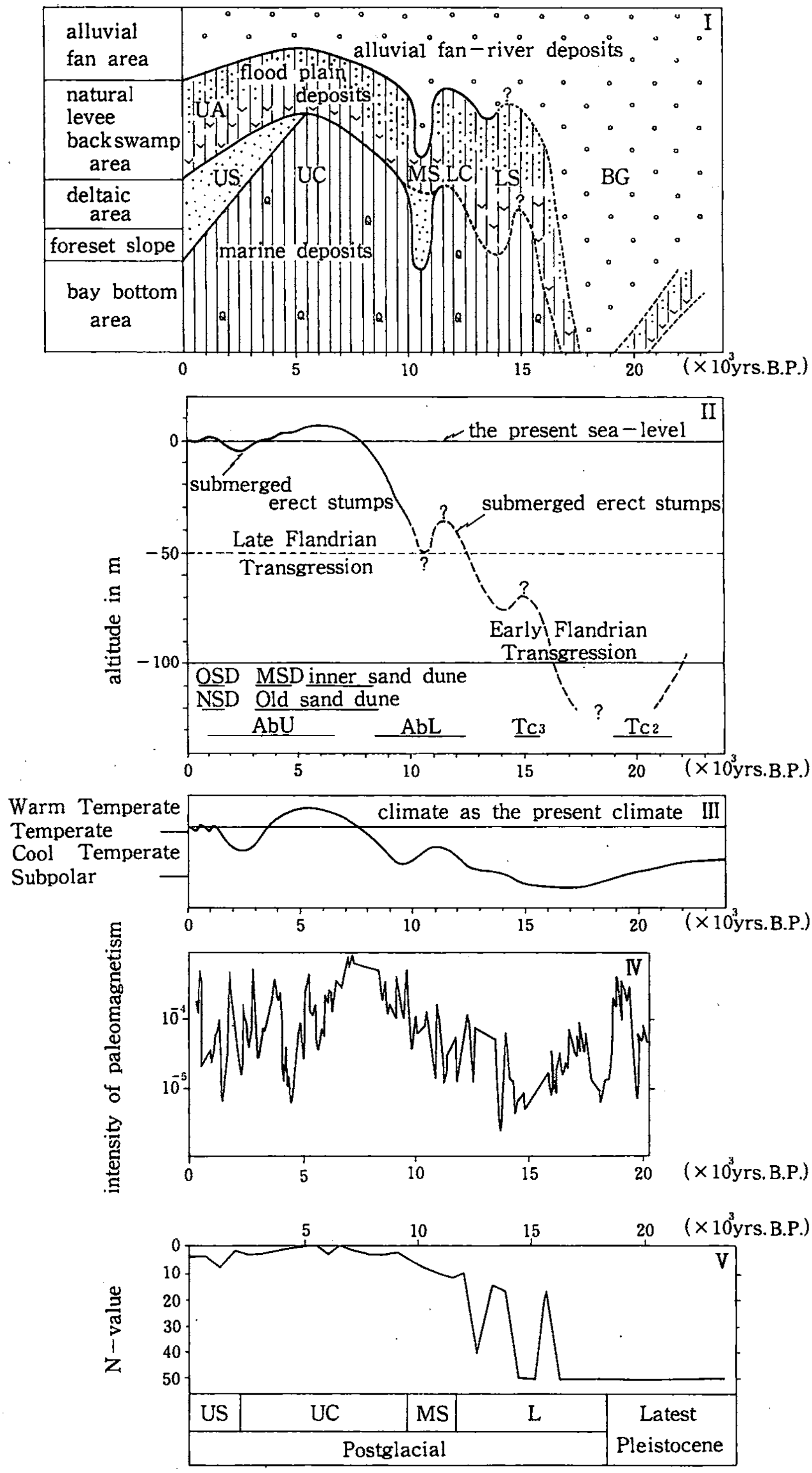

Fig. 3 Schematical "depositional environment-time" diagram of the lithofacies of the Postglacial deposits (I) (After Kaizuka *et al.*, 1977), "depth-age" diagram of the dated Postglacial deposits with a probable sea-level change curve, estimated ages of buried landforms and dated coastal sand dunes (II), change of palaeoclimate based on pollen analysis since 24,000 years ago (III), change of the intensity of palaeomagnetism from Lagoon Kahoku-gata (IV) (After Fuji, 1980; measurement by Kawai, Hirooka & Nakazima), change of the N-value of the standard penetration resistance (V). In II, OSD: Outer sand dune, MSD: Middle sand dune, NSD: New sand dune, AbU: Upper buried abrasion platform, AbL: Lower buried abrasion platform, Tc3: the latest Tachikawa surface, Tc2: lower buried terrace surface in Tachikawa age. (Fuji, 1982).

tudes ; namely, the forest line was 200 to 300m higher than that of the present-day, and the mean annual temperature may be inferred as about 15.5° or 16.5℃ in the Hokuriku district where is located in the Japan Sea side of Central Japan, and that temperature suggests that the mean annual temperature was about 2° or 3℃ higher than that of the present-day. This stage is corresponded mostly to the late stage of the Flandrian Transgression.

4 : Cool stage : this stage is the B phase, and dated between about 4,000 and 1,500 years ago. The characteristic species are the mixed flora of evergreen broad-leaved trees and *Fagus crenata* in the Hokuriku district. The fact suggests that it was about 1° to 2℃ lower than the present-day in the mean annual temperature. The dominating pollen grains are *Cryptomeria*, evergreen *Quercus* (*Cyclobalanopsis*), deciduous *Quercus* (*Lepidobalanus*), *Fagus*, and *Pinus diploxylon*-type (perhaps *P. thunbergii* and/or *P. densiflora*). The decreasing warm stage may be corresponded to the stage of minor falling of the sea-level.

5 : Present climatic stage : This stage is the A phase, and dated to the last 1,500 years. In the Hokuriku district, the mean annual temperature is about 13.5℃, and the mean annual

Tab. 1. Comparison of the division of the Holocene epoch between Northwestern Europe and the Japanese Islands (Fuji, 1982).

Geologic age		North Western Europe: Jessen 1938	Nilsson 1964	Königsson 1968	Fuji-Köning 1976	Japan: Hokkaido Nakamura	Tohoku Yamanaka	Hokuriku Fuji	Tokai Nakamura	Kyushu Hatanaka	Years B. P.
Holocene	Subatlantic	IX *Fagus*	SA 2	IX		*Quercus* *Abies*	*Pinus* *Fagus*	Pinus A *Quercus*	*Pinus*	*Pinus*	1950 0 1000 2000
			SA 1				*Fagus* *Quercus* *Alnus*	*Crypto-meria* B *Quercus* *Fagus*	*Cyclobala.* *Quercus*	*Cyclobala.* *Abies* *Tsuga*	A. D.0 2000 B. C. 1000 3000 2000 4000
	Subboreal	VIII *Quercus*	SB 1 SB 2	VIII		*Quercus* *Ulmus* *Juglans*		C *Cyclobala* *Alnus* *Quercus*	*Shiia* *Cyclobala* *Quercus*	*Cyclobala.* *Podocarpus*	3000 5000
	Atlantic	VII *Quercus*	AT 2 AT 1	VII			*Quercus* *Fagus*				4000 6000 5000 7000 6000 8000
	Boreal	VI *Corylus*	BO 2	VI		*Betula*		*Quercus* D *Pinus* *Fagus*	*Quercus* *Fagus*	*Pinus* *Ulmus* *Quercus*	
		V *Pinus*	BO 1	V	8~18		*Betula*				7000 9000
	Preboreal	IV *Betula*	PB	IV	4~7			*Fagus* E *Abies*			8000 10000
Late Glacial	Yg. Dryas	III *Pinus*	DR III		1~3	*Betula* *Abies* *Pinus*	*Betula* *Abies* *Picea*	*Fagus* F *Ulmus*	*Pinus* *Abies* *Tsuga* *Quercus*	*Pinus* *Picea* *Ulmus* *Fagus*	9000 110000
	Alleröd	II *Betula*	AL								10000 12000
	Older Dry.	IC *Pinus Salix*	DR II					*Pinus* G *Abies* *Pinus*			11000 13000
	Bölling	Ib	BÖ								12000 14000
	Oldest Dry	Ia	DR I								

precipitation is about 2,500mm or more.

The comparison between the geochronologic subdivisions of the Holocene epoch on the basis of the palynological investigation in the Southeastern Sweden and the Japanese Islands by the author is shown in Table 1. Although the Late Glacial age of Sweden has been divided into five substages as the Oldest Dryas, Bölling, Older Dryas, Alleröd, and Younger Dryas, in the Japanese Islands the Late Glacial age has not always been divided in such detail.

The beginning of the Holocene epoch in the Japanese Islands is generally correlated with that of Northwestern Europe. The early Holocene epoch is divided into the Preboreal and Boreal stages in the Northwestern Europe. The early Holocene epoch in the Japanese Islands, however, has not been divided into such detail except for a few districts.

Although the beginning of the warmest age (Atlantic stage) in the Japanes Islands has been correlated with that of Sweden, the end of the warmest age is not corresponded to that of Sweden, and is inferred to be about 4,000 years ago rather than 5,000 years ago by the means of radiocarbon datings and archaeological remains, and the cool age (Subboreal stage) followed until about 1,500 years ago.

As mentioned above, in regard to the comparison of the climatic change and geochronological subdivision during the Holocene epoch in the Japanese Islands and Sweden, there are two large differences ; one is the difference of the beginning time of the Subboreal age, and another is the difference that the early Holocene epoch and the Late Glacial age are not divided into detail in the Japanese Islands as divided in the Southeastern Sweden and Denmark.

The beginning of the Subboreal age in Sweden, about 5,000 years ago, corresponds to the time of the highest sea-level in the Islands named the Jomonian Transgression correlated with the late stage of the Flandrian Transgression, when the climate of the Japanese Islands was not so cool as in Sweden.

In regard to the detailed geochronological subdivision of the early Holocene epoch, the Japanese Islands are located south more than the latitude of Sweden, and were not covered by a continental ice sheet. The mountains are higher and more complex, so the flora is diverse and the vegetation of some localities was not always definitely influenced by minor changes of climate during the early Holocene epoch and the Late Glacial age. This problem may be unsolvable before many more detailed pollen diagrams and numerous radiocarbon dates are completed throughout the Islands.

III : Sedimentary hisory during the Postglacial

The age of the lower half of the Postglacial deposits is estimated to range from about 20,000 or 18,000 to 10,000 years B. P., while that of the upper half of the Postglacial deposits is younger than about 10,000 years B. P. The Middle sand member may belong to a period of slight drop in sea-level at about 10,000 to 11,000 years ago. Based on the sea-level curve in figures of this report and the known changes in the facies of the Postglacial deposits, a schematic time-space diagram for the sedimentary facies from bays, lagoons, and open sea areas of the Japanese Islands is shown in I of Fig. 3,. The lithologic boundary in the Postglacial deposits often intersect obliquely with the timeplane and are diachronous ; for example, since the Upper clay layer was also deposited in the outside of the delta during the deposition of the Upper sand layer (foreset sand), the latter represents a heterotopic facies of the upper part of the Upper clay layer in the offdelta area.

The following six stages are distinguished in the history of the Postglacial age.

Regressional age, ca. 30,000-20,000 *years B. P.*

The Tachikawa surfces divided into the Upper buried terrace surface, Lower buried terrace surface, and Buried valley floor were formed during the relatively lowered sea-level in the latter half of the Würmian glacial age. Judging from the longitudinal profile of the

Tachikawa surface (the Upper buried terrace surface) along the rivers, the sea-level then is thought to have been at about the -40m horizon, so that in Tokyo the sea may have extended into the central part of Tokyo Bay. The Lower buried terrace surface was formed later at a time of further lowered sea-level.

The lowest stand of sea-level during the Last Glacial age, ca. 20,000-18,000 *years B.P.*

Owing to the lowering sea-level as same as about 130m below the present level around Tokyo Bay, but about 100m of water in the Hokuriku district, the whole area to the north of the Uraga Strait emerged above sea-level. For the lowering of sea-level at that time, there is another opinion. According to this opinion, the lowest sea-level is inferred to have been about 80m below the present sea-level. The ancient river system beneath the Postglacial deposits was formed. It emptied into the Tokyo Submarine Canyon through the Palaeo -Tokyo River. The depth of the valley floor of the Palaeo-Tokyo River extended to about -70m in the north of Tokyo Bay and to the present-90m (about -135m at that time) at the head of the Tokyo Submarine Canyon. The gravel (the Basal gravel layer), the lowest bed of the Postglacial deposits, accumulated as river-floor deposits of the Palaeo-Tokyo, Palaeo-Ara and Palaeo-Tama rivers. The present author can find out the old river-floors not only under the present alluvial plains, but also on the present continental shelf such as at the present shallow bottom, about 400m to 50m of water, of Toyama Bay.

The early Flandrian Transgression, 18,000-11,000 *years B. P.*

The ancient valleys and these tributaries valleys were drowned to form long, narrow embayments as the sea-level rose. Continuous, build up of birdfoot deltas would have ensued in the Tokyo Valley where the supply of clastics was plentiful. The Lower clay and Lower sand layers were sdeimented at that time. The highest sea-level horizon reached by the transgression is inferred to have been between -20 and -30m based on the height of the highest marine horizon of the Lower clay layer and the Lower sand layer. The climate at this stage is presumed to have been a condition as the Cool Temperate zone in the present-day. On land, plants adapted to the Cool Temperate zone and the southern part of the Subpolar zone grew luxuriantly. A slight lowering or oscillation of sea-level may have occurred at some 15,000 years B. P. in the course of the early Flandrian Transgression, usually called the early Yurakucho Transgression, although this problem awaits further studies. The complex lithofacies structure of the Lower clay layer and the Lower sand layer probably arose in the unstable environment of birdfoot deltas and of the oscillating sea-level in the long and narrow embayments.

Slight regression, ca. 11,000-10,000 *years B. P.*

The sea-level fell to about -40m, as is known from the depth of the base of the Middle sand layer, leading to partial fluvial and marine erosion of the Lower member of the Postglacial deposits and formation of the Lower member abrasion platform, though the formation of the abrasion platform may extend over a long time before and after the lowest stand of sea-level at 11,000-10,000 years B. P. This abrasion platform was then overlain by a sand veneer (the Middle sand layer) with recession of the sea cliffs, while the foreset bed (the Middle sand layer) was formed in the deltaic areas in the Japanese Islands. The submerged forests, which had grown on the ancient submerged deltaic area below the present sea-level, have been about -40m high in the present Toyama Bay.

Late Flandrian Transgression, ca. 10,000-5,000 *years B. P.*

A rising of the sea-level began rapidly again, with widespread marine invasion of the present inland areas along the former valleys (the Yurakucho Transgression).

The broad features in the present coastal areas as Tokyo Bay, Nagoya Bay, and Ariake Bay were thus established and marine clay (the Upper clay layer) began to be deposited. Along the coastal areas facing the open Japan Sea, coastal sand dunes were formed just before and just after times of the highest level (about 6,000 years B. P.), and of the slightly higher one (5,000 years B. P.) of the late Falandrian Transgression respectively. The dunes are generally called the Inner sand dune or the Old sand dune.

Relatively stable sea-level with a slight fluctuation, the last 5,000 *years*

So far as is known in the northern area of Tokyo Bay, where earth movements may have been small since the time of the Shimosueyoshi age correlated with the Riss-Würm interglacial age, the sea-level slowly assumed its present level after attainment of level at a height of about +5m. Based on the data from the Postglacial deposits in several districts, there was a slight fluctuation of sea-level during the last 5,000 years. A slight lowering (about 2m high) of sea-level had been about 4,000-2,000 years ago, and a slight rising of sea-level (the Yayoian Transgression) occurred about 2,000-1,500 years ago. At this stage, the sea cliffs bordering the Pleistocene uplands retreated through wave erosion leaving wide abrasion platforms at their foot. The larger bays such as Osaka, Ariake, Nagoya, and Tokyo Bays expanded on the one hand ; on the other hand, deltas continued to advance into it as arcuate forms and sand bars formed, closing the mouth of small inlets. Thus the Upper clay layer and the Upper buried abrasion platform were both covered with widespread sandy material (the Upper sand layer). During this time, rivers deposited the alluvial deposits which now extensively cover these deltaic sand areas.

Along the coastal areas of the Japan Sea, a slight rising of the sea-level upto the present sea-level (about 2,000 to 1,500 years ago) occurred, and coastal sand dunes were formed. The older dune is named the Middle sand dune, and the newest one the Outer sand dune respectively.

Explanation for Figures and Table (FUJI's paper)