Geomorphic Development of Terrace Landforms of the Tokachi Plain, Hokkaido, Northern Japan

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INTRODUCTION

The Tokachi plain is located on the eastern part of Hokkaido, which is mainly a depositional plain formed by the Quaternary series. The plain is bordered by the Shikaribetsu volcanic mountains to the north and by the Pacific ocean to the southeast where exists the Toyokoro hills lower than 350 m above sea level. The western border is the Hidaka range which trends NNE-SSW direction nearly from 42° N to 43° N with heights of 1,500–2,000 m above sea level (Fig. 1).

In the plain there exist many alluvial fans. They are formed by the Rivers of Satsunai, Tottabetsu, Rekifune and others originated from the Hidaka range and are dissected into several river terraces. Moreover, marine terraces are distributed on the southeastern slopes of the Toyokoro hills along the Pacific coast. Some kinds of fossil periglacial phenomena such as involution, earth-hummocks, vertical stone, ice-wedge cast and so on are observed in the plain (Nogawa et al. 1972, Koaze et al. 1974a, b). In the Hidaka range many glacial topographies are preserved well (Minato und Hashimoto 1954, Hashimoto et al. 1972, Hirakawa and Ono 1974, Ono and Hirakawa 1975).

Because of the usefulness of these abundant phenomena for the recognition of the past geomorphic environment, the Tokachi plain is considered as one of the most fruitful region for the Quaternary research of Japan as well as the Kanto plain in Central Japan.

From the view point of geomorphic development in the Tokachi plain and its environs, there are three subjects to be investigated, namely; (1) relation between glaciation in the Hidaka range and formation of alluvial fan in the Tokachi plain, (2) chronological relation between fluvial and marine terraces which indicate sea level fluctuations in the late Quaternary, (3) relation between geomorphic evolution and changes of climamorphogenetic environment through Glacial to Postglacial (Interglacial) age (Fig. 2). To advance these investigations, the chronological study of geomorphic surfaces must be carried out. The author has studied the development of terrace sequences in the late Quaternary of the Tokachi plain for these four years, based on the method of tephrochronology. The main purpose of present paper is to describe the topographies of fluvial and marine terraces and to arrange them chronologically with special reference to the Würm Glacial age.

MARINE AND FLUVIAL TERRACES

The author tried to classify the marine and fluvial terraces, using the Tokachi Loam as key beds and continuity of terrace surfaces. The Tokachi Loam which is very useful to correlate geomorphic surfaces consists of many characteristic pumice layers, one scoria layer and weathered tephra, as shown in Fig. 3. Terrace surfaces in the Tokachi plain can be subdivided into four marine and twelve fluvial surfaces. They are designated from older to

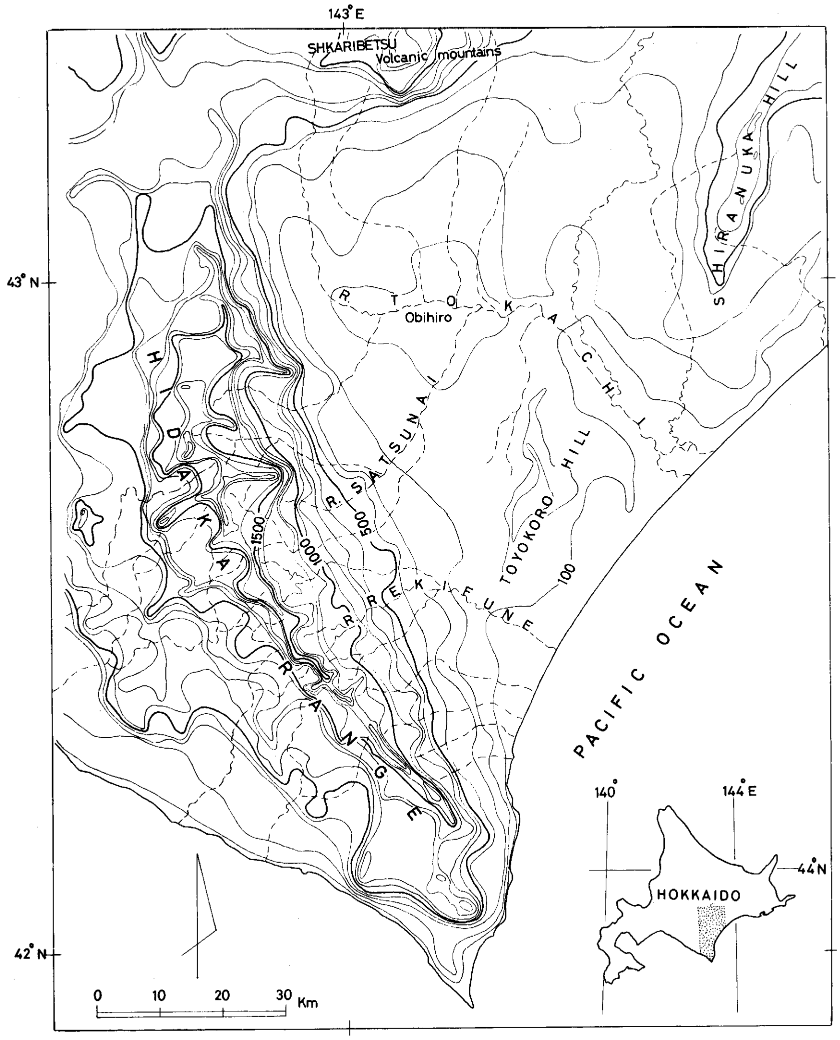

Fig. 1 Generalized topography of the Tokachi plain and its environs.
contour interval: 100 m

younger as follows: marine surfaces; O I, O II, O III and O IV., fluvial surfaces; K, M, Ks I Ks II, Ks III, S, T, Ko I, Ko I', Ko II, Ko III, and Ko IV respectively. Their distributions and surface morphologies are shown in Fig. 4. The relationship between the Tokachi Loam and the terrace surfaces is shown in Fig. 3. Radiocarbon dates of some horizons in the Tokachi Loam are listed in Tab. 1. A lot of geomorphic works have been made in the plain (Hashimoto 1953, 1954, Hashimoto and Kumano 1955, Kaizuka 1956, Imai 1964, Tokachi Research Group 1968, Hashimoto et al. 1972, Hirakawa and Ono 1974). Almost all of these works were carried out tephrochronologically. Tokachi Research Group especially has contributed to clarify the tephra stratigraphy and classify the terrace surfaces. Correlation between the classification of the terrace surfaces in present paper and those after Tokachi Research Group (1968) is shown in Tab. 2.

Table 1. Radiocarobn dates of some pumice layers in the Tokachi Loam

Name of Pumice layer	Carbon-14 age (years B. P.)
Ta-b	590±80
To-c 1	1,610±90
Toc 2	5,500±150
Ta-d	8,940±160
E-a	15,400±400
Spfa 1	32,200±2,000

These data are compiled in Committee on Nomenclature of Pyroclastic Deposits in Hokkaido (1972).

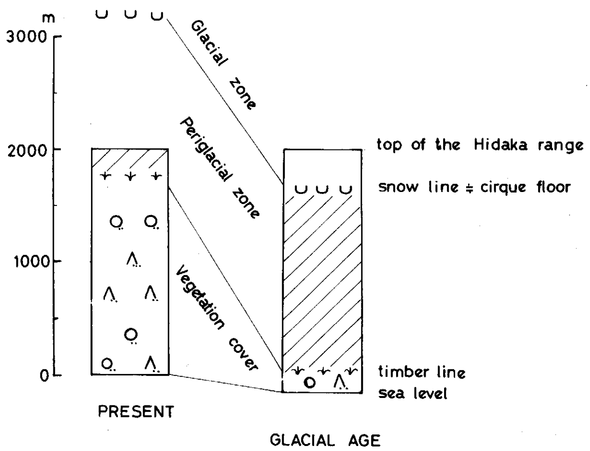

Fig. 2 Schematic columnar section showing changes of vertical zonation between glacial age and present.
Present snowline is after Kobayashi and Hoshiai (1955)

Marine terraces

Marine terraces occupy the southeastern fringe of the Toyokoro hills consisting of Tertiary rocks along the Pacific Ocean. The O I is the highest surface which is distributed fragmentarily. It is, broadly speaking, a depositional surface. Altitudes of the shoreline keep the height of 85–90 m above sea level. Although this terrace surface is dissected by many valleys, the terrace deposits is well preserved with at least 20 m in thickness and is composed of marine sands and pebbles.

The O II is the next higher surface which was designated as "C Surface" by Sakaguchi (1959). Altitude of the shoreline at that time is 55–60 m above sea level. Near the Lakes of Oikamanae and Chobushi, the elevated shoreline indicates such irregular features as small embayments. In places, the terrace deposits reaches 30–40 m in thickness. For instance,

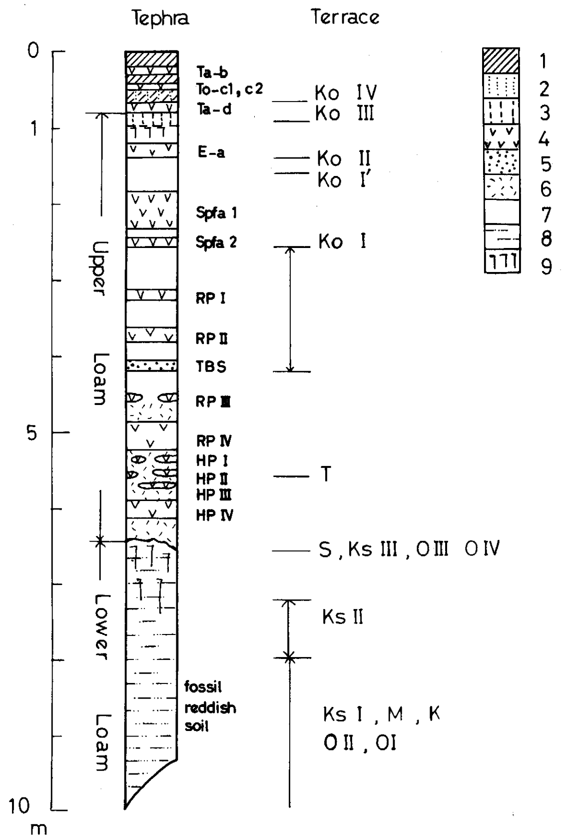

Fig. 3 Relation between the Tokachi Loam and terrace surfaces. 1, Humus. 2, Humic soil. 3, Soft loam. 4, Pumice. 5, Scoria. 6, Pumicious weathered tephra. 7, Weathered tephra. 8, Consolidated weathered tephra. 9, Crack.

thick marine deposits is exposed on the sea cliff at the left bank of the Tokachi river mouth as shown in Fig. 5. The terrace surface-making deposits of this exposure can be divided into the lower gravel bed, the middle marine mud bed containing much amount of fossil shells and the upper laminated marine sand bed. On the basis of the irregular features of the shoreline and the existence of thick cyclic constituent materials above-mentioned, it is obvious that the O II terrace was built under the environment of fairly large marine transgression.

The O III surface is, as a whole, an abrasion platform cutting the basement of Tertiary rocks or the O II surface-making deposits. The terrace deposits consists of thin homogeneous marine sand layer less than 3–5 m in thickness. The shoreline features of the O III surface also show an irregular pattern similar to that of the O II surface and seems to be influenced by the position of the O II shoreline. However, the O III surface might be built under a stillstand of sea level during the regression from the O II surface, on the basis of the thickness and depositional facies of sediments.

On the O IV surface, the shoreline can be found 15–18 m above sea level. Although the

Table 2. Correlation of terrace surfaces

Hirakawa		after Tokachi Research Group (1968)	
marine surface	fluvial surface	fluvial surface	marine surface
	Ko IV	Kamisatsunai IIb	
	Ko III		
	Ko II	Kamisatsunai IIa Churui	
	Ko I′		
	Ko I		
	T		
O IV	S		Aiboshima
	Ks III	Kamisarabetsu III	
O III			
	Ks II	Kamisarabetsu II	Bansei III
O II			
	Ks I	Kamisarabetsu I	
	M	Makubetsu	Bansei II
O I			
	K	Kochien	Bansei I

O IV surface is fragmentarily distributed along the coast, the surface-making deposits consisting of beach gravels as well as sands reaches at least 10 m thick. According to the thickness of the deposits and the relation between the development of the O IV surface and that of fluvial terraces, the O IV surface might be built under a slight transgression. It will be discussed in detail later.

On the summits of the Toyokoro hills, there found a patch of flat surfaces of 320–350 m in height above sea level. Though any surface-making deposits could not be found there, it is presumed that the patch of flat surfaces were originally built as a marine terrace, on the basis of the features such as the distributed pattern, the flatness and the surface morphology.

The O I and O II surfaces are mantled by the Lower Loam, and the O III and the O IV surfaces only by the Upper Loam in the Tokachi Loam.

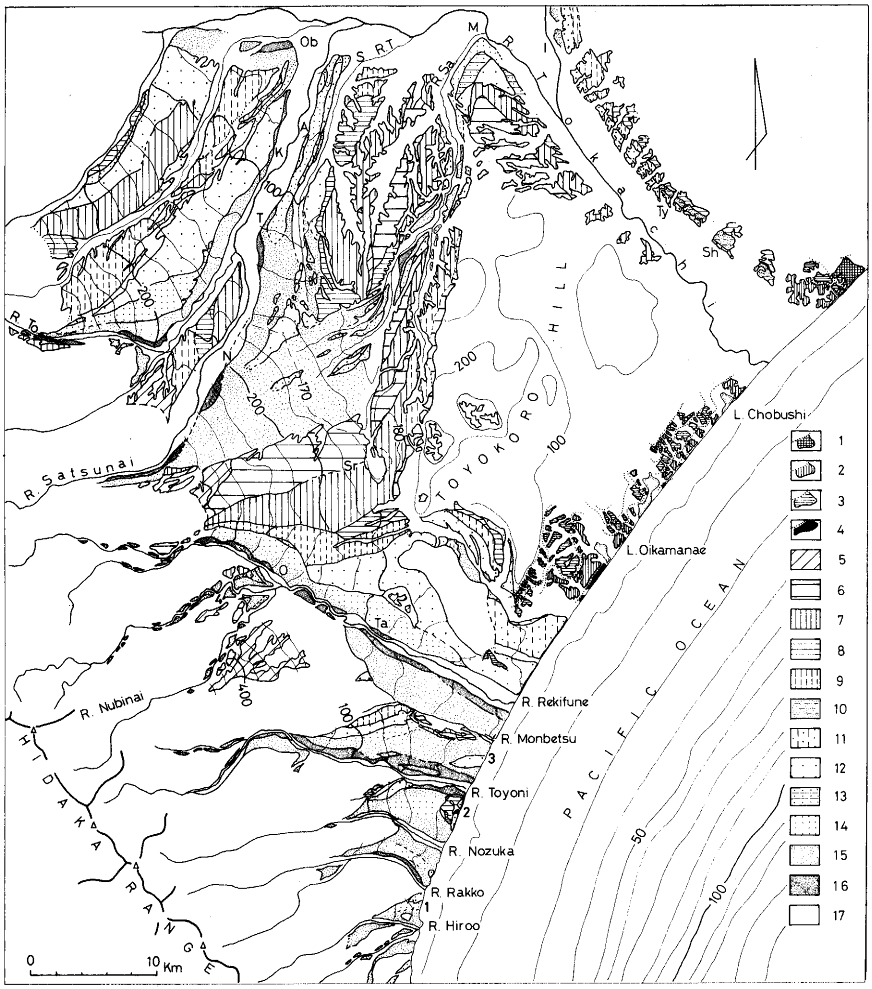

Fig. 4 Geomorphological map of the Tokachi plain.
1, O I surface. 2, O II surface. 3, O III surface. 4, O IV surface. 5, K surface. 6, M surface. 7, Ks I surface. 8, Ks II surface. 9, Ks III surface. 10, S surface. 11, T surface. 12. Ko I surface. 13, Ko I′ surface. 14, Ko II surface. 15, Ko III surface. 16, Ko IV surface. 17, Slope and scarp. R. To, Tottabetsu River., R. T, Tobetsu River., R. Sa, Sarubetsu River., Ob, Obihiro., S. Satsunai., I, Ikeda., M, Makubetsu., A, Aikoku., K, Kawanishi., T, Taisho., N, Nakasatsunai., Sr, Sarabetsu., O, Oda., Ta, Taiki., Ty, Toyoni., Sh, Shin-yoshino.

It is very difficult to compare the marine terrace sequence in this region with those of other regions in Japan or correlate them with worldwide sea level changes in the late Quaternary. At present the author has no reliable information regarding ages of marine

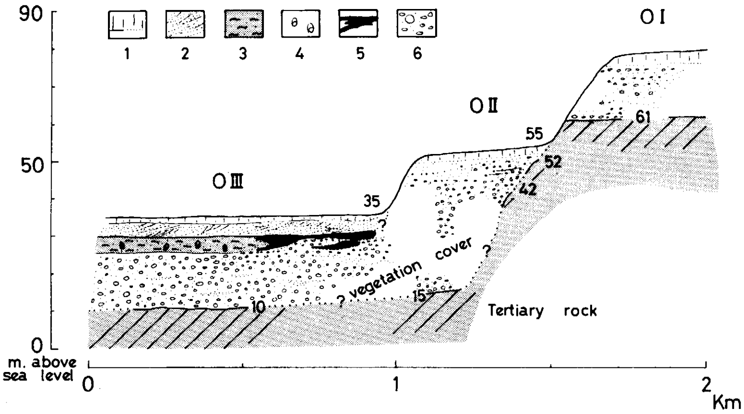

Fig. 5 Geologic section showing marine surface-making deposits on the sea cliff, left bank of the Tokachi river mouth. 1, Tephra. 2, Laminated marine sand. 3, Marine mud. 4, Shell. 5, Peat. 6, Pebble–cobble. partly fluvial in origin.

terraces in the Tokachi plain, it can howeven be presumably concluded that the O II surface is of the last large interglacial age or Eemian Interglacial age, on the basis of the shoreline feature and the character of surface-making deposits. Accordingly, the O I surface should have been formed during an interglacial or an interstadial age preceding the last great interglacial age. The O III and O IV surfaces have beeh formed in some minor interstadials preceding the maximum of the last glacial age. Then, from the view point of geomorphic development, these terraces could be correlated with those of the southern Kanto plain in Central Japan. The correlation with the ages obtained by Machida and Suzuki (1971) gives the absolute ages of the formation of the marine terraces in the Tokachi plain as follows; the O II surface: 120,000–130,000 F. T. years B. P., the O III surface: ca. 80,000 F. T. years B. P., the O IV surface: 60,000 F.T. years B. P., respectively.

Fluvial terraces

Along the rivers in southern part of the Tokachi plain

Along the River Rekifune there are several terraces distinctly seperated by river cliffs. The highest terrace surface, the K, is distributed between the Rivers Nubinai and Monbetsu. The terrace surface which extends to the ENE direction is originally an alluvial fan dissected by many deep valleys. Surface-making deposits is composed of conspicuously weathered fanglomerate, reaching 90 m in thickness.

The M surface is also a dissected alluvial fan consisting mainly of gravel bed more than 10–15 m in thickness. Surface morphology is well preserved as an alluvial fan in origin. The M surface descends steeper than the lower Ks I surface, being underlain by the Ks I surface near Sarabetsu village.

The Ks I surface is a widely preserved alluvial fan. On the basis of the distribution of both contour lines, 170 and 180 m, shown in Fig. 4, it is noted that the Ks I and the M surfaces are deformed so as to ascend again in the lower reaches of alluvial fan around Sarabetsu village. This topographic deformation must reveal upheavals of the Hidaka range as well as the Toyokoro hills during the pleistocene period. The Kamisarabetsu swampy lowland corresponds to the area of relative subsidence, influenced by the mode of the above mentioned crustal movement. On the ground of the distributions of the K, M and Ks I surfaces, the River Rekifune should be one of the tributaries of the River Tokachi, flowing northeastward during the formations of these alluvial fans.

During the formation of the Ks I surface, the course of the River Rekifune migrated southeastward to drain directly to the Pacific ocean. Such a migration caused a deep downcutting between the Ks I and the Ks II surfaces, 25–30 m in depth. The Ks II surface which consists of thin fluvial gravel bed lies along the lower reaches. As the Ks II surface is covered with the upper layer of the Lower Loam, i. e. the lower part of the Tokachi Loam, the Ks II should be formed prior to the formation of the marine O IV. It is apparent that the O II was formed prior to the formation of the Ks II, on the basis of their altitudes of surfaces.

The Ks III is ditributed along the Rivers Rekifune and Toyoni as a dissected alluvial fan surface which consists of 5–7 m thick fanglomerate. The relative height of terrace cliff between the Ks III and the lower Ko I surface is less than about 10 m along the River Rekifune and decreases to 0–1 m along the River Toyoni. Along the more southern rivers such as the Nozuka, the Rakko and the Hiroo, the Ks III surface could not be found, as being overlain by younger surfaces, the Ko I, Ko II, and Ko III.

The Ko I is a dissected alluvial fan surface, formed by the deposition of bulk fanglomerate. This surface is covered with the upper horizon younger than TBS–Spfa 1 in the Tokachi Loam and consists of a fanglomerate 20–40 m in thickness.

On the sea cliff of the Pacific coast attaining 15–30 m in height, the Ko I surface-making deposits unconformably overlies the layers of the marine sands of the O IV surface or older

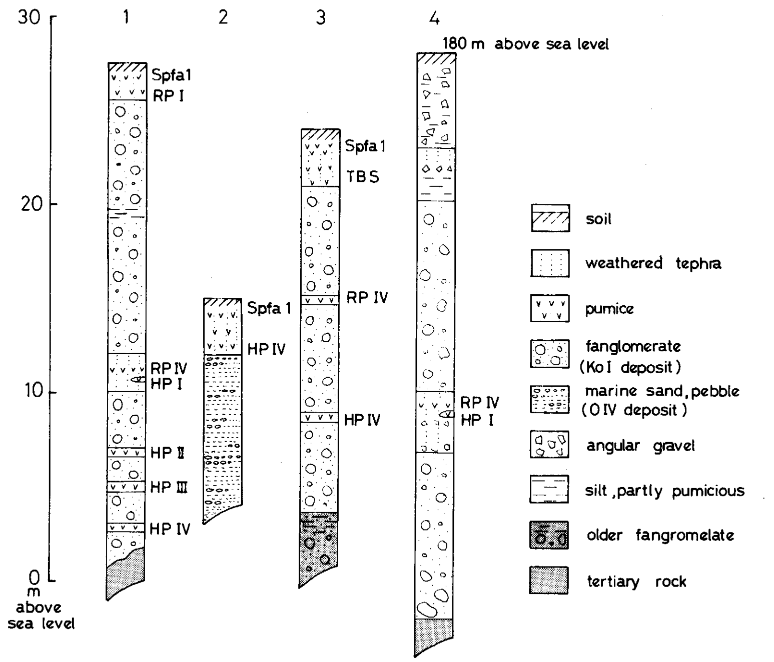

Fig. 6 Columnar sections of the Ko I and the O IV surface-making deposits.
Localities are shown in Fig. 4.

fluvial gravels. As the top of the O IV marine bed lies 12–13 m above sea level and the bottom height of the Ko I surface-making deposits is exposed at 2–5 m above sea level respectively, it is apparent that the large downcutting occurred between the formation of the O IV and the Ko I surfaces. Some pumice layers are inserted in the Ko I deposits, namely, the HP IV near the basal part and the RP IV in the middle part of the Ko I surface-making fanglomerate (Fig. 6).

On the river cliffs, the author found in some places the buried valleys which were filled up by the Ko I surface-making fanglomerate intercalating the RP IV and a peat layer in the middle part (Fig. 6). The altitudes of the buried valley bottom keep 3–7 m above present river bed. In contrast to the sediments of present river bed, the deposits filling the former valley contains large quantity of gravels originated from Hidaka Group which consists of a lower relief of the Hidaka range, 200–1,500 m above sea level. Whereas, sediments in the present river bed are composed of much amount of metamorphic gravels originated from the highest part of the Hidaka range.

The Ko II can not be distinguished from the Ko III in this area, because the key pumice layer, E-a, is not distributed here. Along the River Rekifune the Ko II+III were fill-strath surfaces cutting into the Ko I or Ks III surfaces. However, the downward erosion was very weak, especially in the mountainous region. The Ko II+III surfaces show an alluvial fans with almost the same altitudes as the Ko I surface along the Rivers of Rakko and Hiroo, the Ko II+III surface-making blueish gravels widely overlap the Ko I surface, which become thicker to ca. 5 m. The alluvial fans consisting of the Ko II+III surfaces are much smaller than that of the Ko I surface.

Fragmentarily distributed terraces lie near the present valleys. They are designated as the Ko IV. The Ko IV is an erosional surface with a thin gravel layer less than 1–2 m in thickness at most, cutting the Ko I, Ko II or Ko III respectively. Downcutting after the formation of the Ko III amounts to 20–50 m during the Postglacial age.

It is interesting that no drowned valleys could be found in the Holocene alluvial lowlands along the downstreams of this region, though the rivers directly drain to the Pacific ocean. This phenomena may be due to the fact that the longitudinal profile of the sea floor is gentler than that of rivers.

Along the Rivers of Satsunai and Tottabetsu between Obihiro city and alluvial fan apex

Along the Rivers of Satsunai and Tottabetsu that were fed by some local glaciers in the uppermost reaches, there found all of fluvial surfaces mentioned above, except the Ko I', S and T surfaces. Broadly speaking, these terraces show the same sequence as that of the southern part of the Tokachi plain.

In the area of the left bank along the River Tottabetsu, the Ko I, a dissected fan surface, develops widely, which is bordered by the higher Ks I, Ks II and Ks III surfaces with gentle and low fluvial cliff less than 5 m in height. The original fan surface is still well preserved and lies 15–20 m above the present river bed. The Ko I surface-making deposits has filled up the former valley. The buried valleys are exposed near the fan apex of the River Tottabetsu in the upper reaches and at the place 5 km south from Obihiro city in the lower reaches along the valley walls of present river. The structure of the buried valley is resemble to that of the present valley dissecting an alluvial fan in the both reaches. The gravel bed filling the former valley reaches 20 m in thickness. It is an important fact that the buried valley was formed under the Ko I surface even in a inner region of the plain where a sea level fluctua-

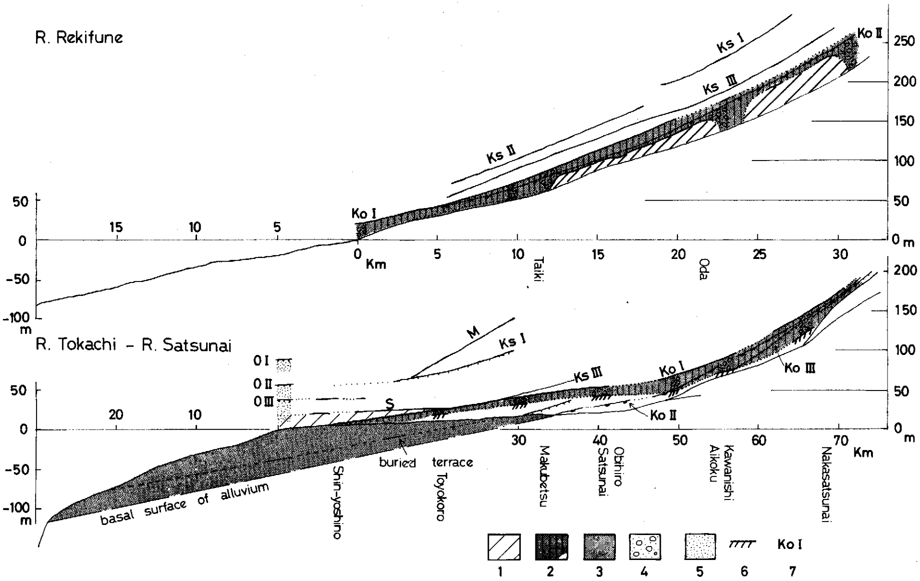

Fig. 7 Longitudinal profiles of terrace surfaces.
1, S surface-making deposits. 2, Ko I surface-making deposits. 3, Alluvium filling the former valley. 4, Fluvial gravel. 5, Marine sand. 6, Basement of the Ko I surface. 7, Names of terrace surfaces.

tion did not influence.

The Ko II is also distributed as a dissected alluvial fan in much smaller extention than the Ko I. The Ko II is distinguished from the Ko I by the differences of tephra layers covering the surfaces. The terrace cliff between the Ko I and the Ko II surface is very low and indistinguishable. The Ko I surface is, however, dissected into a slightly undulating relief. Whereas, the Ko II surface is not dissected but very flat. In some places near the fan apex, the Ko II surface-making deposits overlaps the Ko I surface. There is no reliable information whether a downward erosion occurred prior to the deposition of the Ko II surface-making gravels, and when the Ko I gravels began to deposit. It is, however, likely that the alluvial fan formation may have occurred in different two ages.

A distribution of the Ko III surface is limited near the present valley. The Ko III surface is the erosional one consisting of thin gravel layer less than 2–3 m in thickness. Between the Ko I and/or Ko II and the Ko III surfaces, there exists very low but steep cliff less than 1 m in height. In the lower reaches from Kawanishi, 7 km south of Obihiro city, this terrace cliff progressively increases its height to 15 m near Obihiro. Such increases of the height of terrace cliff toward downstreams can be found along the right bank of the lower reaches of the River Satsunai. The height of the Ko II and Ko III surfaces rapidly descends from Aikoku to Satsunai. The height of terrace cliff between the Ko I and Ko II surfaces is less than 1–2 m near Aikoku, but increases to ca. 20 m near Satsunai, 7 km north of Aikoku (Fig. 7). Such differences of altitude among the terrace surfaces of the Ko I, Ko II and Ko III should imply that the River Tokachi had already began to erode actively downward during the formation of the Ko I and Ko II surfaces, because the behaviour of the River

Satsunai in the lower reaches was affected by a local base level of erosion of the River Tokachi. It is interesting that in spite of downcutting along the River Tokachi, the Rivers of Satsunai and Tottabetsu had maintained almost same level or in places aggradated in their upper reaches.

The Ko IV surface is also the erosional one occurring fragmentarily along the present river valleys. This surface is composed of a veneer gravel layer less than 1–2 m in thickness.

As shown in Fig. 4, the higher terraces, K, M, Ks I, Ks II and Ks III, are widely preserved as a tableland between the Rivers of Tobetsu and Sarubetsu. According to the observation of some exposures, the K and M could be considered as depositional surfaces with a gravel layer more than 13 m in thickness. The Ks I, -II and -III are probably erosional surfaces cutting into the K or M. Longitudinal profiles of these terrace surfaces show extraordinary gentle gradient in contrast to that of the present river bed of Satsunai. Differences in altitude between the Ks I and Ko I surfaces reaches 50–60 m along the western border of this tableland, along the left bank of the River Satsunai, however, less than 7 m. The lower Ko I, Ko II and Ko III surfaces are seperated by steep terrace cliffs respectively along the River Sarubetsu flowing between the tableland and the Toyokoro hills. Whereas, terrace cliffs among these surfaces are very low in the area between Aikoku and Nakasatsunai along the River Satsunai. On the basis of the facts mentioned above, a very sharp escarpment bordering the western fringe of the tableland may be a structural line connected with a upheaval of the Toyokoro hills. It is easily noted that the longitudinal axis of the Kamisarabetsu swampy lowland is traced to the sharp escarpment mentioned above (Fig. 1 and Fig. 4). The fluvial surfaces have been deformed by a crustal movement in the area between the Rivers Satsunai and Sarubetsu. However, the development of the lower Ko I, Ko II, Ko III and Ko IV surfaces in this area can be regarded as same as that of the area along the left bank of the River Tottabetsu. The Ko I is the surface of fill-top terrace in character and others are fill-strath terraces.

Along the lowest reaches of the River Tokachi

The Tokachi is the antecedent river between the hills of the Toyokoro and the Shiranuka. The topographic features of the alluvial lowlands suggest that there exists a drowned valley before the deposition of alluvial sediments as reported by Torii (1966). Geomorphic development of this region is very different from that of the Tokachi plain described above. Detailed survey have been carried out concerning the S, Ko I, Ko I' and Ko II surfaces.

A distribution of the S surface is limited to the lowest reaches of the Tokachi river, which lies about 20 m above sea level. Surface-making deposits is composed of well rounded pebbles and sorted sands more than 10–15 m in thickness. Although the marine O IV surface is not distributed around the mouth of the River Tokachi, it is likely that according to the altitude the S surface is regarded as being followed by the marine O IV surface. In other words, the S surface consists of fluvial deposits associated with a slight marine transgression which formed the O IV surface. Since the Ks III possibly extends to the basal surface of the S surface-making deposits, the Ks III appears to be built during the marine regression preceding the formation of the S or O IV surfaces (Fig. 7).

The Ko I is as a whole an erosional terrace surface between the Towns of Ikeda and Shin-yoshino, which consists of pebbles or/and cobbles less than 7 m in thickness. The Ko I surface is buried under the Holocene alluvial lowlands near Shin-yoshino at 6 km upstreams from the river mouth. The Ko I' surface is distributed only near the Town of Makubetsu, which is also overlain by the Holocene alluvial surface at about 30 km upstreams from the river mouth (Fig. 7).

The Ko II surface is buried near the Town of Makubetsu to form a basal surface of Holocene alluvium in the lower reaches of the River Tokachi. Namely, the buried Ko II surface is a deep valley bottom which was scoured by a vigorous incision of the Tokachi river. The longitudinal profile of the Ko II surface equivalent to the basal surface of the Holocene alluvium can be traced seaward to the outer margin of continental shelf with a depth of -120 m. The thickness of the Holocene alluvium filling the former valley attains 60 m around the area of the Tokachi river mouth (Torii 1966). Accordingly, it is obvious that the Ko II surface was built under the condition of the lowest stage of the sea level in the late Würm Glacial age preceding the Holocene or Frandrian transgression. The Ko III and Ko IV surfaces are not distributed in this area, which are correlated with a certain horizon of the alluvium consisting of the Holocene lowlands. Concerning the formation of higher surfaces, there is little reliable information owing to a shortage of field surveys. However, the longitudinal profiles of the M and Ks I surfaces and their distributions suggest that the M surface may be formed preceding the last large marine transgression in the lower streams of the

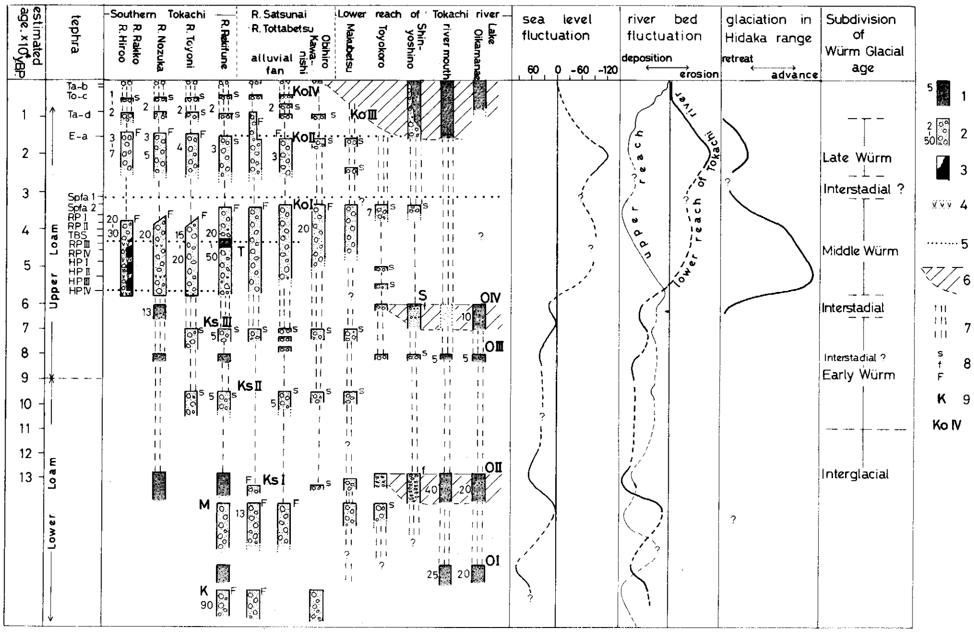

Fig. 8 Chronology of the Tokachi plain.
1, Marine deposits and its thickness. 2, Fluvial deposits and its thickness. 3, Peat. 4, Pumice. 5, Distribution of pumice layers, Spfa 1, E-a, RP IV, HP IV. 6, Alluvium filling the former valleys in the lower reaches of the Tokachi river. 7, Downward erosion rate; single dashed line, below 5 m/10,000 years., double, 5-10 m/10,000 years., tripple, over 10 m/10,000 years. 8, s, fill-strath terrace., f, fill-top terrace. F, Alluvial fan surface. 9, Names of terrace surfaces. Thicknesses of deposits are in meter.

River Tokachi.

Some problems

The fluvial and marine terraces in the Tokachi plain described above are chronologically arranged as shown in Fig. 8. Regarding a geomorphic development of fluvial terraces, the Tokachi plain can be distinctly divided into two regions, i. e., the regions of the lower reaches of the Tokachi river and the alluvial fans. During a marine transgression stage (interglacial or Postglacial stage), a deposition occurred in the lower reaches of the Tokachi river and incision in the alluvial fans or the mountainous valleys. Whereas, during a marine regression stage (glacial stage), a deep downcutting occurred in the lower reaches of the Tokachi river and a deposition in the alluvial fans or the mountainous valleys. Considering such a difference in geomorphic development, fluvial surfaces distributed in the both regions in Fig. 4, for example the Ks I surface, can not be strictly correlated with those in the alluvial fan region. The Ks I surface was probably formed a little prior to the maximum stage of the marine transgression in an alluvial fan or a mountainous region. This interpretation depends on the geomorphic development during the Postglacial age and may be applicable to that of the older terrace sequences. In short, the surface formation (deposition) took place in the lower reaches of the Tokachi river and the downcutting in the alluvial fan region. Such considerations may be valid for the interpretation of terrace development in a stillstand stage of the sea level, for instance the formation of the O III surface.

DEVELOPMENT OF FLUVIAL TERRACES DURING THE WÜRM GLACIAL AGE ——A DISCUSSION

If the last Interglacial age (Eemian Interglacial age) is indicated by the marine O II terrace, the age of fluvial terraces, i. e., Ks II, Ks III, S, T, Ko I, Ko I' and Ko II, are definitely included in the Würm Glacial age. It is likely that the O III and O IV surfaces may correspond to an interstadial and/or an interphase in the early Würm Glacial age respectively. However, the absolute age of the O II surface indicating the maximum–final phase of the last Interglacial age, 110,000–130,000 F. T. years B. P., is much older than that reported in European countries. The beginning of the Würm Glacial age has been reported as ca. 70,000–75,000 C-14 years B. P. in the European countries (e. g., Gross 1964, van der Hammen et at. 1967, Mojski 1969). The age by the C-14 dating may be less reliable and show younger, as stressed by van der Hammen et al. (1967) and Mojski (1969). Much older ages of the beginning of Würm Glacial age are recently reported from France (Bonifay 1973, Lumley et al. 1973).

On the basis of the development of marine terraces, it is assumed that Würm Glacial age started at least 100,000 years B. P. in the Tokachi plain and Würm Glacial age could be divided into three periods by the sequence of fluvial terraces, which are tentatively designated as Early, Middle and Late Würm, respectively (Fig. 9). The fluvial activities in each period are described below.

(1) Early Würm: the age represented by the Ks II and Ks III surfaces (ca. 100,000–60,000 years B. P.)

Broadly speaking, there is no indication of a special phase of gravel deposition or linear downcutting by streams except the River Rekifune. The Ks II surface fragmentarily lies in a limited area, but the Ks III surface was fairly widely formed as an alluvial fan. Both surfaces are composed of thin gravel layer less than 5–7 m in thickness.

(2) Middle Würm: the age represented by the Ko I surface (ca. 60,000–30,000 years B. P.)

As indicated by the deep incision reaching 20–50 m along the whole reaches of rivers

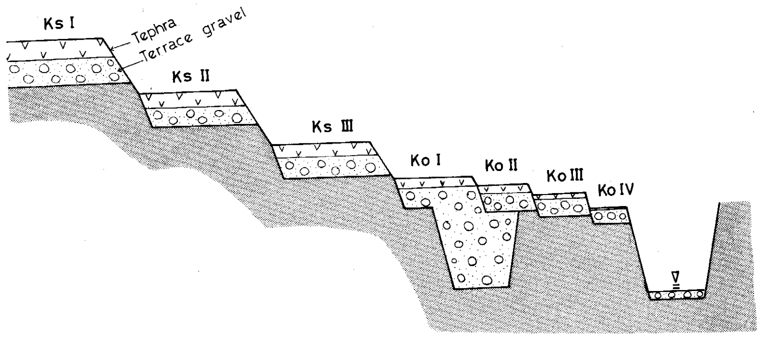

Fig. 9 Schematic geologic section of the terrace sequence during the Würm Glacial age in the Tokachi plain. Basements of each surface-making deposits depends on the location, which are Cretacious rock, Tertiary rock, older fanglomerate and marine sands consisting of the O IV surface.

except the lower reaches of the Tokachi, the fluvial activity was much stronger than in the Early Würm. Such a strong downcutting has been prevailing to the beginning, which was replaced by vigorous accumulation of gravels to form an alluvial fan along the mountain foot of the Hidaka range and a waste-filled valley in the mountainous region. It is remarkable that debris production was simaltaneously dominant in the whole regions of Hokkaido during this age as stressed by Fujiki (1974). It is likely that the gravel accumulation may last at least for about 15,000 years. According to Hirakawa and Ono (1974) and Ono and Hirakawa (1975), cirque glaciers expanded most widely in the Hidaka range in this age. This age is designated as the Poroshiri Stadial.

(3) Late Würm: the age represented by the Ko II and Ko III surfaces (ca. 30,000–10,000 years B. P.)

The so called "maximum Würm" and "latest Würm Glacial age" are included in this age designated as the Tottabetsu Stadial (Hirakawa and Ono 1974). In the valleys of the mountainous region and on the alluvial fans there is an evidence that a fluvial activity should slow down. No remarkable deposition and downcutting had appeared on the Ko II and Ko III alluvial fans. However, small accumulation of the Ko II fanglomerate occurred again in a limited area. Glaciers in the Hidaka range retreated to occupy a small part of the previous cirque floor of Middle Würm age. Considering the absolute ages of the Ko II and Ko III surfaces and geomorphic interpretation between them (Fig. 8), the Ko II surface may indicate the maximum Würm phase and the Ko III the latest Würm phase respectively. The active behaviour of the lower Tokachi river during this time is due to the marine regression in the maximum Würm age and following transgression.

As to the interruptions among each ages, the O IV surface can be reasonably correlated with Brörup Interstadial, referring to the succession of Würm Glacial age obtained in Europe (e. g., van der Hammen et al. 1967, Mojski 1969). Therefore, the O III surface is correlative with Amersfoort Interstadial (Interphase) in chronological order.

Considering the fluvial activity, the interruption between the Ko I and the Ko II surfaces is not so distinct as preceding one. Although there is no reliable evidence indicating the Interstadial such as the fossil soil, the pollen succession, the marine terraces and so on, the author considers the changes of fluvial activity as a significant criteria. This interruption can be correlated with the well known Paudorf Interstadial which is one of the most remarkable and distinct interruption during the Würm Glacial age in Europe, on the basis of the absolute age (Kraus 1961, Woldstedt 1962, Starkel 1964, Fink 1965, Semmel 1968, Mojski 1969, Fucks 1969). Although the exact correlation of the Würm Glacial successions between the Tokachi plain and European countries is impossible at present, it is, however, reasonable to assume that the Würm Glacial age can be divided into some interstadials and stadials in the Tokachi plain.

The area of the Tokachi plain and its environs which is situated in a periglacial region provides several interesting problems for the Quaternary stratigraphy and geomorphology, because this plain links the Hidaka glaciated area with the area where the marine terraces develop. But it is still difficult to connect periglacial and glacial terraces even around the European Alps, as emphasized by Semmel (1973). Therefore, the research of geomorphic development must be independently carried out in Northern Japan, especially in Hokkaido. Identification and differentiation of the geomorphic events both in eastern and western regions of the Eurasia continent should bring a great contribution to the progress in climatic geomorphology in cold environments.

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