# The Downstream Progressing Degradation Since the Würm Stage in the Naruse River Basin, Northeastern Japan

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## 1 Introduction

In previous studies of river terrace in mountain area of Tohoku District (Northeastern Japan), the writer suggested that the latest valley-filling was replaced by downcutting at about 20,000 yr B.P., and that following the filltop one a well-traceable terrace was commonly formed in the degradation process (Toyoshima 1984, 1987).

River bed degradation can proceed downstream as well as upstream depending upon the cause of degradation (Galay 1983). It is an interesting problem to determine the prevalent degradation type after the latest valley-filling.

The purpose of this study is (1) to identify a filltop terrace of the Würm Stage, and (2) to reconstruct the river profile of 10,000 yr B.P. evidenced by tephra in this age, to discuss the degradation type after the latest valley-filling.

## 2 Outline of the study area

The Naruse River in Miyagi Prefecture rises in the Ou Backbone Range, the main divide in Northeastern Japan, and flows into Ishinomaki Bay facing the Pacific Ocean (Fig. 1).

River terraces are formed in the upstream of Nakaniida, where the river flows downstream on the alluvial plain. The Tsutsusunako River, a tributary confluent with the Naruse River at Utsuno, has nearly the same drainage area as the main river upstream of the junction.

The Naruse River basin has the highest point at Mt. Funagata of 1,500 m above sea level. The alluvial plain is about 30 m a.s.l. near Nakaniida. The Naruse River basin upstream of Nakaniida has a drainage area of 245 $km^2$ and a relief ratio of 0.038.

According to the geological map 1 : 200,000 in scale (Kitamura ed. 1967) and Ishida (1981), the higher part around Mt. Funagata is underlain by Pleistocene Andesitic tuff breccia and lava, other erosional part by Miocene rocks. The hilly lands of 300 to 100 m a.s.l. between the Ou Backbone Range and the alluvial plain are underlain by Pliocene formation, partly being unconformably overlain by terrace deposits.

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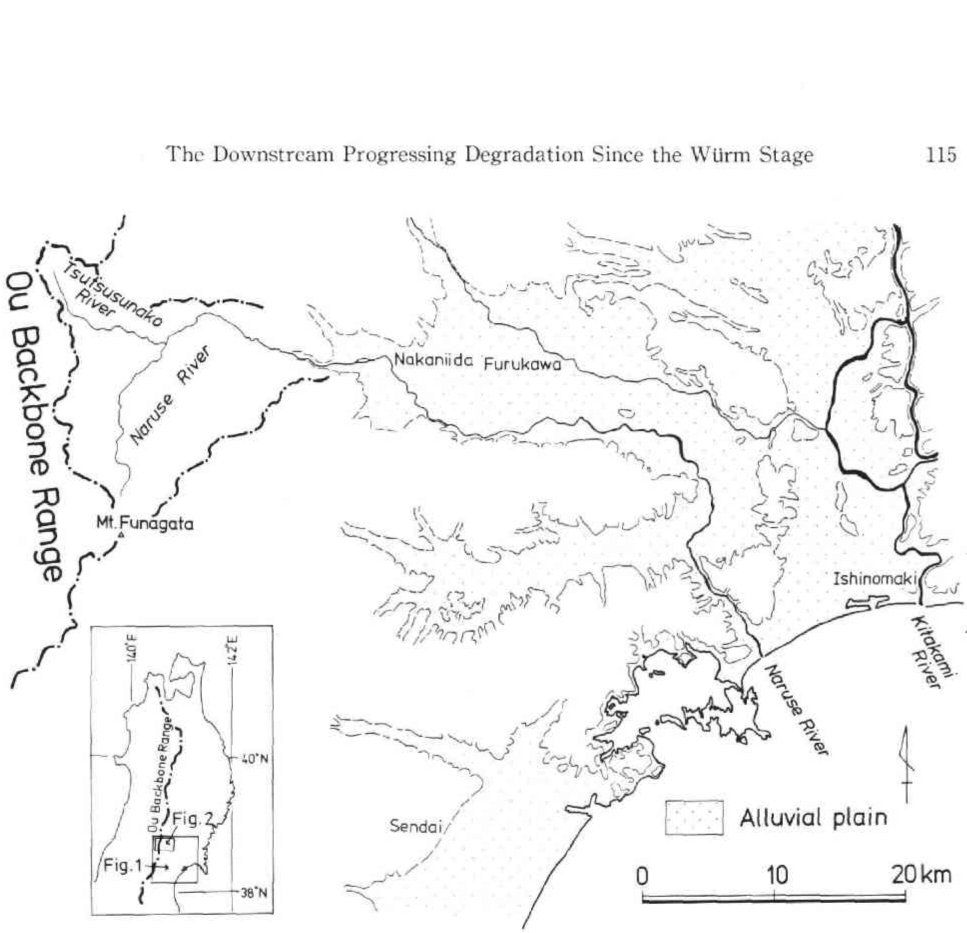


Fig. 1 Location of the Naruse River basin

The alluvial plain is underlain by thick alluvium burying the subsurface valley. At the location 1 km downstream from Nakaniida, the thickness of the alluvium attains about 40 m and the subsurface valley bottom is about −10 m a.s.l. (Hase 1967).

The Hijiori pumice (Obanazawa pumice) layer is effective as a time-marker bed. It is originated from the Hijiori caldera situated 30 km west of the main divide and distributed over the study area. The Hijiori pumice layer is a pyroclastic fall deposit followed by the Hijiori pyroclastic flow deposit (Yonechi and Kikuchi 1966). The thermoluminescence age of the former is 9,700 yr B.P. (Ichikawa 1983) and the radiocarbon ages of the latter range from 9,500 to 11,000 yr B.P. (Ui *et al.* 1973, Yonechi and Nishitani 1975). The volcanic eruption associated with both tephras occurred at about 10,000 yr B.P. The Hijiori pumice is identified by a high content of hornblende and quartz in it.

## 3 River terraces

### 3.1. Description

In the study area river terraces are classified into the Urushizawa terrace, the

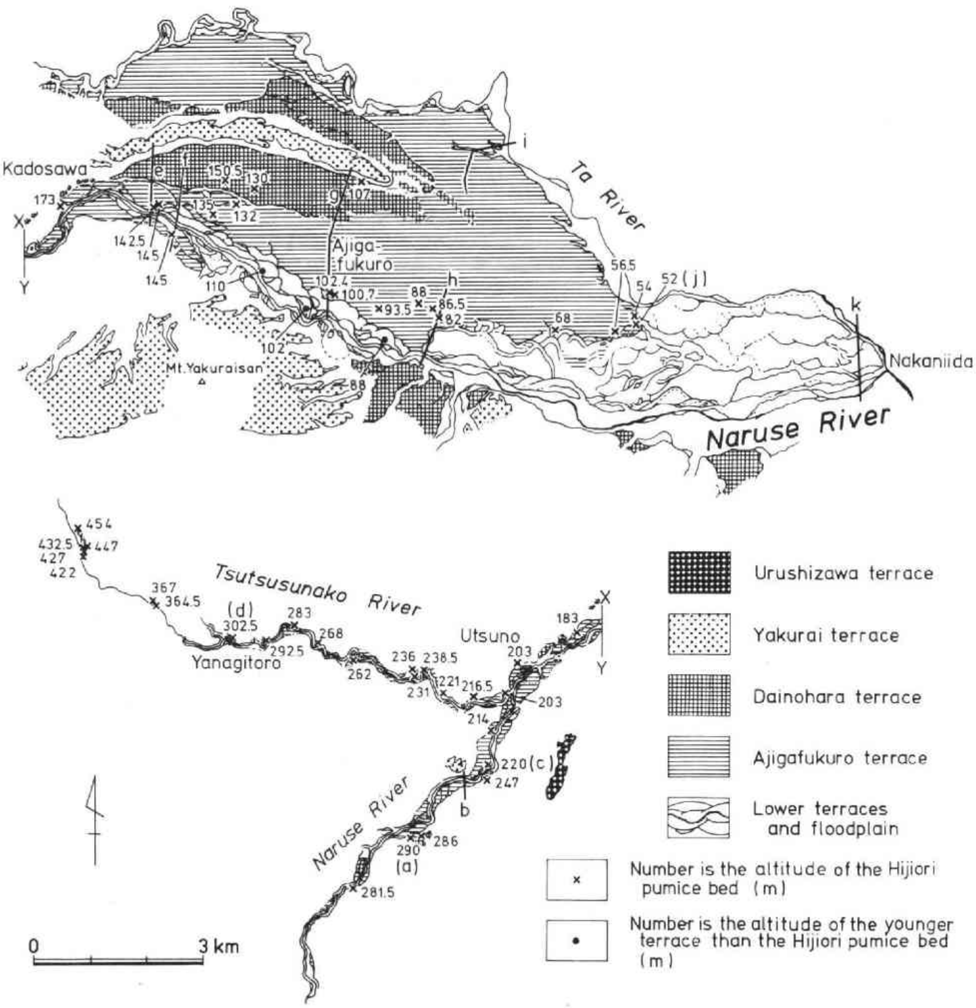


Fig. 2 Map showing river terraces and the location of outcrops and geologic sections in Photo 1 and Fig. 3 to 6

Yakurai terrace, the Dainohara terrace, the Ajigafukuro terrace, and lower non-cyclic terraces, in descending order. The distribution of these terraces is shown in Fig. 2.

Among these terraces, the Dainohara, the Ajigafukuro, and lower terraces are intensively surveyed.

The Dainohara terrace is a filltop one underlain by valley fill. At location (a), 7 m and over thick fluvial deposit, partly colluvium, fills the branch valley (Photo 1). The valley fill is overlain by the Hijiori pumice layer. At location (g), the upper part of the valley fill is composed clay to silt-size material containing intercalated lenses of

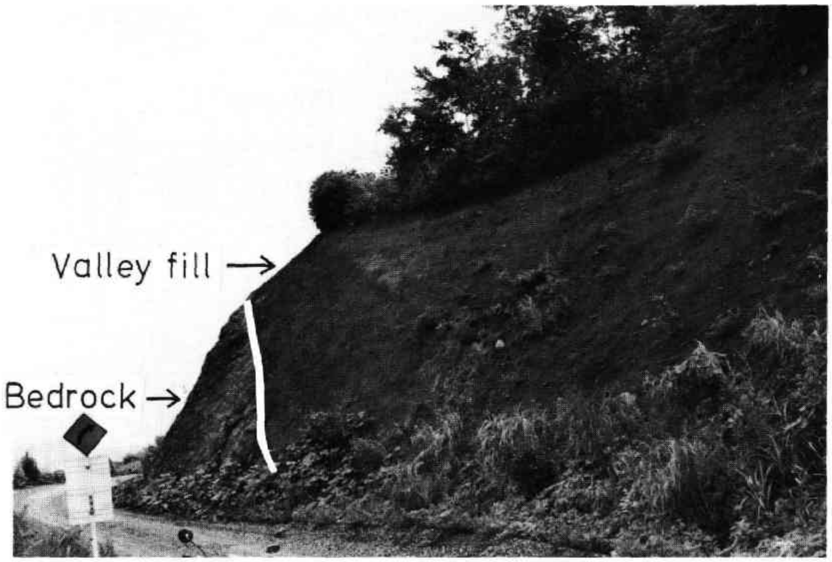


Photo 1 Valley fill underlying the Dainohara terrace at location (a)

cobble. The radiocarbon age of the wood buried at the depth of 3 m in this deposit is older than 31,230 yr B.P. (TH-943) (Fig. 6, Loc. g). After the Dainohara terrace was formed, no valley-filling has occurred.

The Ajigafukuro terrace is underlain by a veneer of gravel 5 m or less thick. It is named the Ajigafukuro terrace gravel bed. The bore-hole records at location (b)

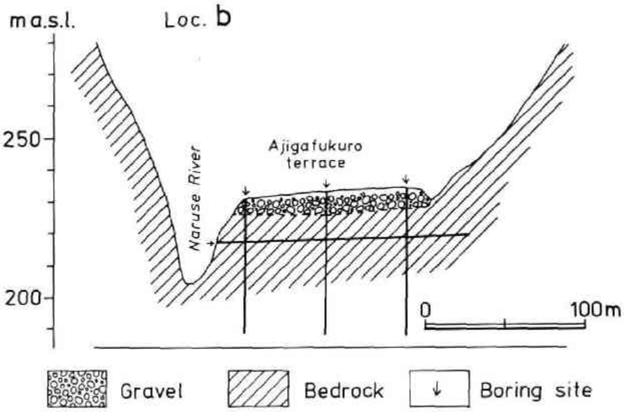


Fig. 3 Geologic section at location (b)

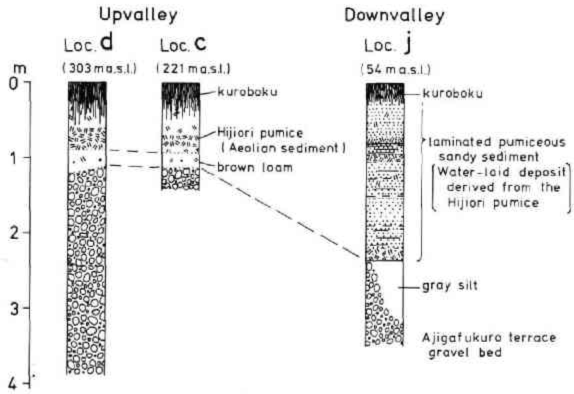


Fig. 4 Columnar sections at location (c), (d) and (j)

show the almost horizontal contact between the Ajigafukuro terrace gravel bed and bedrock (Fig. 3).

The Ajigafukuro terrace gravel bed is overlain by a brown loam (rarely containing pumice) and the Hijiori pumice in ascending order at upvalley locations (c and d), while it is directly overlain by a water-laid deposit derived from the Hijiori pumice at a downvalley location (j) (Fig. 4).

At location (f), the Ajigafukuro terrace gravel bed is overlain by a 5 m thick alluvial cone deposit composed of silt containing rounded to subangular gravel (Fig. 5). The woods obtained from the upper and the basal part of this alluvial cone deposit gave radiocarbon ages of $17,430^{+580}_{-540}$ yr B.P. (TH-1170) and $21,680^{+1000}_{-890}$ yr B.P. (TH-1171), respectively.

At location (i), a bore-hole record reveals that the thick gravel deposit (10 m and over thick) underlies the Ajigafukuro terrace (Fig. 6, Loc. i). The lower part of this

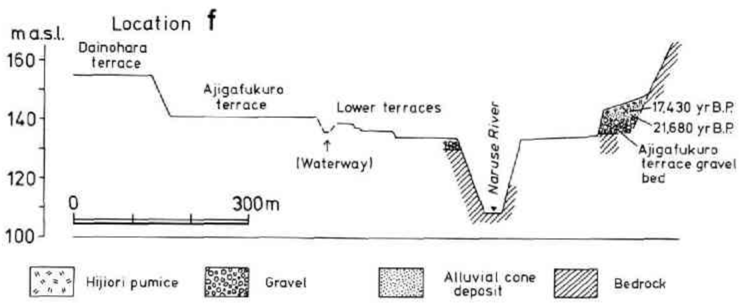


Fig. 5 Geologic section at location (f)

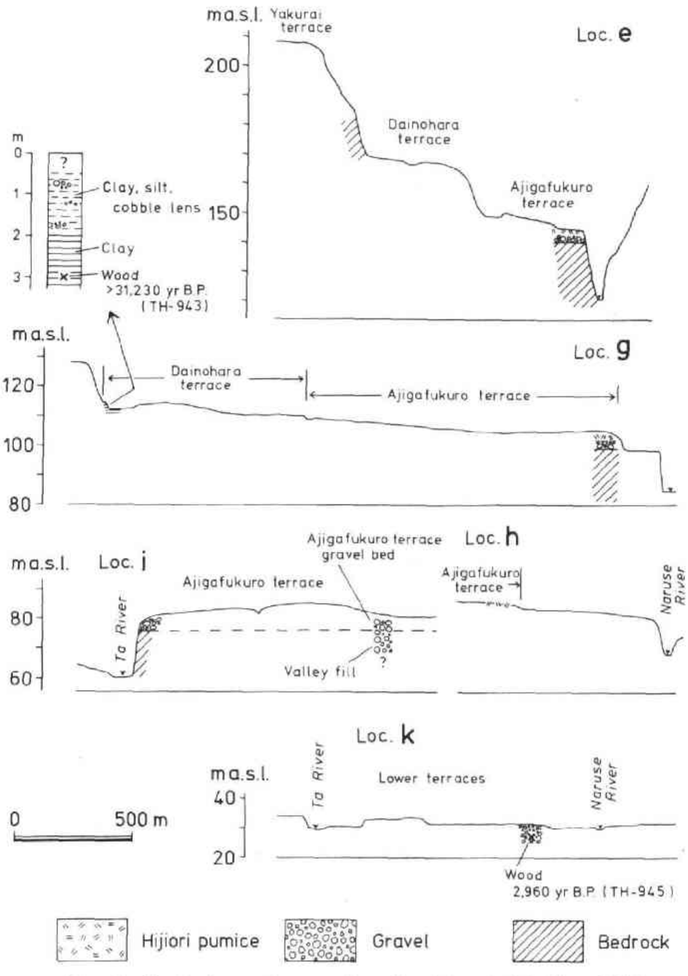


Fig. 6 Geologic sections at location (e), (g), (h), (i) and (k)

deposit is accompanied by frequent intercalations of clay, while the upper part is not accompanied by them. From the fact it may be inferred that the lower part of the thick deposit is the valley fill followed by the Ajigafukuro terrace gravel bed.

The Ajigafukuro terrace is about 15 m below the Dainohara terrace at location (e) (Fig. 6). The relative height between the two terraces decreases downstream and attains a small value at location (g) (Fig. 6). The longitudinal profiles of the two terraces show that the Ajigafukuro terrace is gentler in slope than the Dainohara terrace (Fig. 8).

At location (k), the radiocarbon age of the wood buried in the gravel underlying

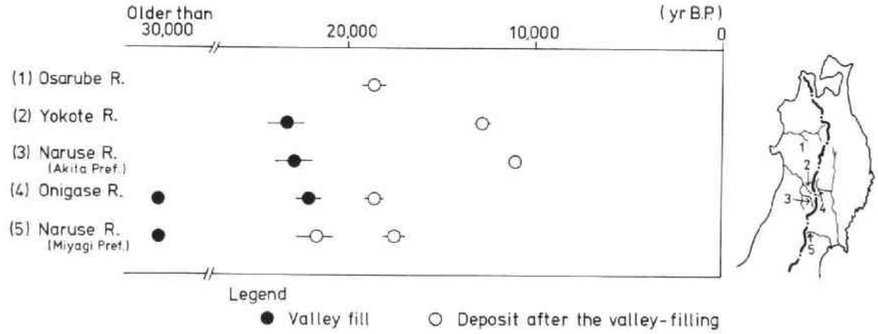


Fig. 7 $^{14}$C ages of the latest valley fill and deposit after the valley-filling
(1) : After Toyoshima (1987) (2), (3) and (4) : After Toyoshima (1984) (5) : After this paper

a correlative of lower terraces is 2,960±120 yr B.P. (TH-945).

### 3.2. Age of the change to downcutting from the latest valley-filling

The Dainohara terrace is the latest filltop one, and the Ajigafukuro terrace, a conspicuous strath (partially fillstrath) terrace, and non-cyclic lower terraces succeede it.

The Dainohara terrace has steeper slope in longitudinal profile than the present river floor in the downstream of Ajigafukuro (Fig. 8). The two profiles seem to intersect between Ajigafukuro and Nakaniida. This suggests that the Dainohara terrace profile corresponds to the lower sealevel prior to the Postglacial transgression. Therefore it is inferred that the change to the downcutting from the latest valley-filling occurred in the Würm Stage. The radiocarbon age determination on the alluvial cone deposit overlying the Ajigafukuro terrace (Fig. 5) shows that the formation of the Dainohara terrace, as well as the Ajigafukuro terrace, dates back to older than 22,000 yr B.P.

The radiocarbon ages of the latest valley fill and of the deposit after the valley-filling in the Tohoku District (Northeastern Japan) are shown in Fig. 7. In the Naruse River of Miyagi Prefecture, the latest valley-filling appears to have ended somewhat earlier than those in others.

## 4 Degradation process after the Dainohara terrace formation

### 4.1. Type of degradation

Galay (1983) pointed out the two different types of degradation, downstream and upstream progressing degradation, for a period of 30 years or less and presented causes of degradation from engineering literature.

In a case of degradation since the Würm Stage, type of degradation may approxi-

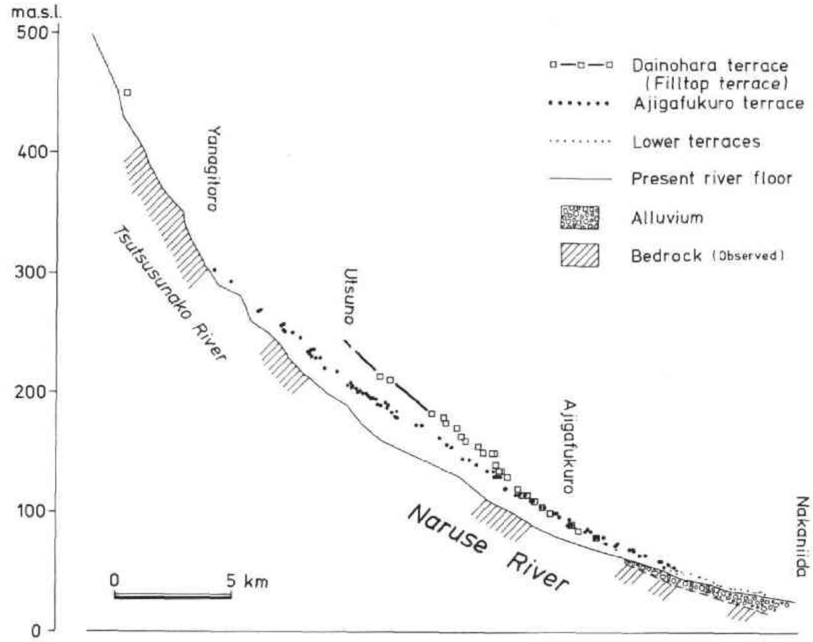


Fig. 8 Longitudinal profiles of the Dainohara terrace, the Ajigafukuro terrace, lower terraces, and present river floor.

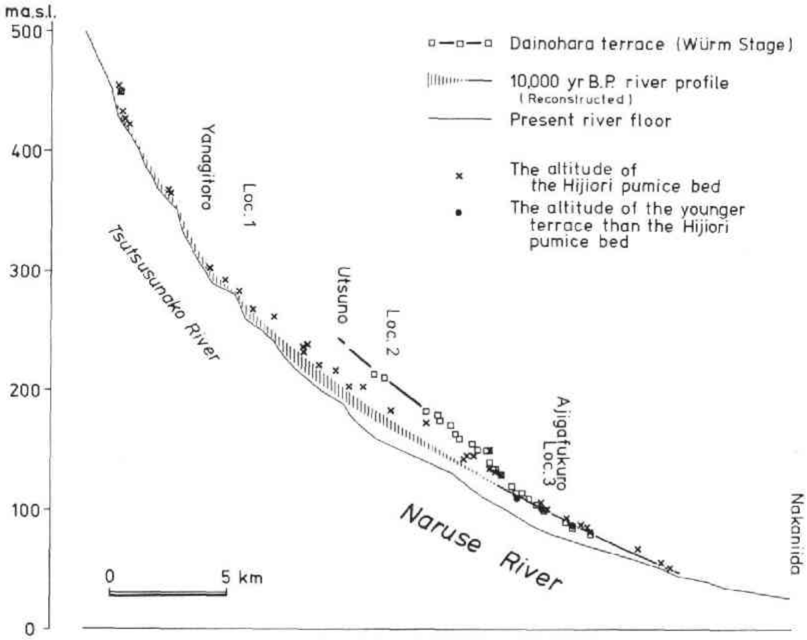


Fig. 9 Evolution of longitudinal river profile

mately be determined by successive longitudinal profiles of river terraces. In the strict sence, this procedure is not adequate to the purpose, because a terrace profile is not always the same as the past river profile on a short time scale. In fact, the Ajigafukuro terrace is younger downstream on a basis of the stratigraphic relationship between the Ajigafukuro terrace gravel bed and the Hijiori pumice bed (Fig. 4). Therefore the Ajigafukuro terrace profile is not adopted as a past river profile.

Then, the 10,000 yr B.P. river profile is reconstructed on the basis of the Hijiori pumice of about 10,000 yr B.P. as follows.

The river floor of about 10,000 yr B.P. can be estimated to be somewhat above the lower terraces not covered by the Hijiori pumice, and below the Ajigafukuro terrace overlain by the Hijiori pumice. The altitude of 10,000 yr B.P. river floor is estimated around 100 m a.s.l. at location (g), where the lower terrace is no more than 2 to 3 m below the Ajigafukuro terrace (Fig. 6, Loc. g). At three locations near Ajigafukuro, the altitudes of 10,000 yr B.P. river floor are determined on the same way.

Both upstream and downstream from Ajigafukuro, the 10,000 yr B.P. river profile is reconstructed based on the altitudes of the Hijiori pumice bed, as well as the slope of the river profile obtained from the above three locations. Thus, the 10,000 yr B.P. river profile is reconstructed over the whole reach as shown in Fig. 9, although the range of the estimated altitude of the profile attains a maximum value of 15 m at Utsuno.

The relative height between the Dainohara terrace and the 10,000 yr B.P. river floor is as much as about 25 m at Utsuno, but nothing at Ajigafukuro (Fig. 9). Through the period, the downcutting rate decreases downstream. Downstream from Ajigafukuro, the downcutting began later after 10,000 yr B.P. These facts lead to the explanation that after the latest valley-filling of the Würm Stage river bed degradation has proceeded downstream.

### 4.2. River channel slope change in the downstream progressing degradation process

River channel slopes are measured from each longitudinal profile segmented at an interval of 2 km (partly more than 2 km). The downstream variations in slope for each longitudinal profile are shown as Fig. 10. As for the 10,000 yr B.P. river slope both maximum and minimum values are measured for the reach upstream from Ajigafukuro, where a definite slope cannot be obtained from the reconstructed river profile.

River channel slope for the present river profile decreases downstream more rapidly than for the 10,000 yr B.P. river profile.

The Dainohara terrace profile, being substituted for a river profile of the Würm Stage, has a maximum slope between locations 2 and 3. This maximum seems to be

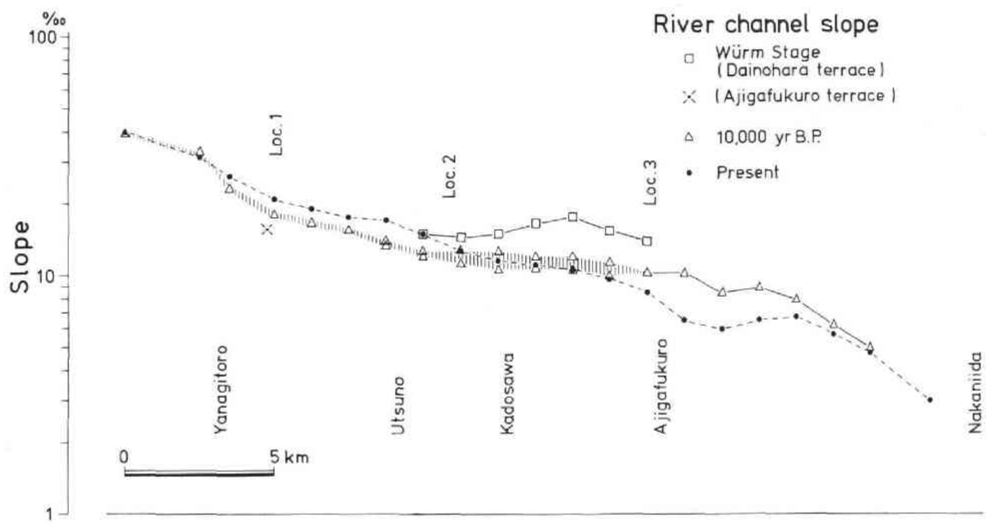


Fig. 10 Downstream variation in slope of each river profile of the Würm Stage, 10,000 yr B.P. and present

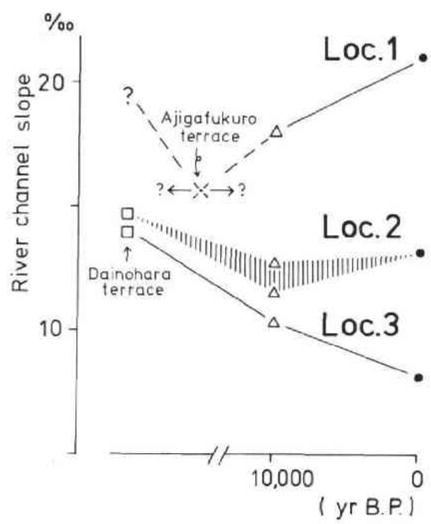


Fig. 11 River slope change since the Würm Stage at each location of 1, 2 and 3

related to local deformation of the Dainohara terrace due to crustal movement.

At location 3 (downvalley position), river channel slope is the steepest for Würm Stage river profile and has decreased successively.

At location 2 (midvalley position), the gentlest slope appears for 10,000 yr B.P.

river profile. These features are shown in Fig. 11 (Loc. 2 and 3).

At location 1 (upvalley position), the slope of the Ajigafukuro terrace prior to 10,000 yr B.P. is 0.016, which is gentler than that of 10,000 yr B.P. river profile. Although the slope of the Dainohara terrace profile isn't obtained, the Dainohara terrace is inferred to be steeper than the Ajigafukuro terrace from the fact of the downstream intersection of the two terraces. Therefore, at location 1 the river channel slope attains a minimum in the time of the Ajigafukuro terrace formation (Fig. 11).

In summary, a river slope decreased at the beginning of the degradation within the studied reach, although the degradation possibly began later at progressively downstream site. Then, a river slope has reversely increased earlier at more upstream site. At downstream site (Loc. 3) the conversion of river slope to increase has not appeared yet.

## 5 Conclusions

The Dainohara terrace is of the Würm age, and it is a filltop one underlain by the latest valley fill.

The 10,000 yr B.P. river profile was reconstructed based upon the altitude of the Hijiori pumice bed of ca. 10,000 yr B.P. By comparing the three river profiles of the Würm Stage, 10,000 yr B.P. and present, it is concluded that the degradation has proceeded downstream since the Würm Stage.

At the beginning of the degradation a river slope decreased, then the conversion of river slope to increase has appeared earlier at more upstream site.

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