The Geomorphological Development of Small Basins in Late Quaternary near Ôno, Iwate Prefecture

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General Description

The formation of many marine and river terraces is directly related to sea level changes and tectonic movement. But, besides these episodes, some terraces have been formed by changing environmental conditions (climatic conditions, etc.) which have influenced the geomorphic process. It is the purpose of this paper to demonstrate by means of tephrochronology and pollen analysis this sort of process and the age of conditional change.

Along the northeastern fringe of the Kitakami Mountains raised coastal terraces have developed. The highest, 270 m to 200 m a.s.l. in elevation, which was called the Kunohe Terrace by Nakagawa (1961), or the Mizunashi and Hirono Terraces named by Yonekura (1966), have rather broad surfaces compared to the lower terraces. A lower peneplain surface with ridge and ravine topography, is spread behind the coastal terraces (Nakamura 1964). Small basins near Ôno Village, about 15 km northeast of Kuji City, Iwate Prefecture (Fig. 1) have been investigated. These basins are drained by the Uge and Kôke Rivers which dissect the highest coastal terrace. In these basins river terraces, pediment-like gentle slopes, shallow valleys joining the main valley, and deposits, including tephra have been examined.

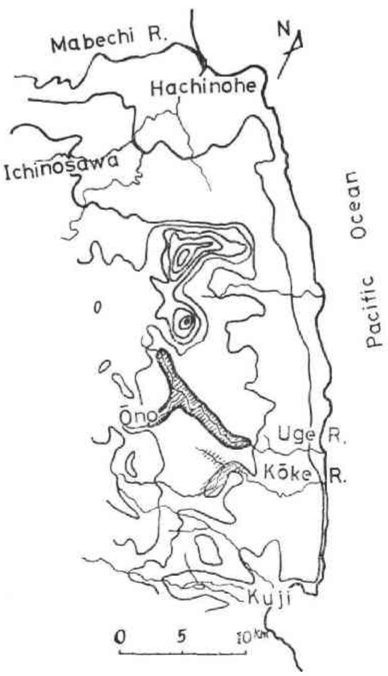

Fig. 1 Index Map
Small basins are hatched and the area encircled with heavy line is shown in Fig. 3. Contour interval is 100 m.

According to Nakagawa (1961), these basins are dissected slopes cut into coastal terraces. Nakamura (1964) described the valley plain and gentle slopes as erosional features. In a recent paper, Yonekura (1966) claimed that the basins were formed in conjunction with the level of transgression of the sea which agrees with the stage of the Mugyo Terrace.[1)]

The topographical contrast between the coastal terraces and the lower peneplain is clear on the projected cross profiles of the area (Fig. 2), and projected in the same figure there is a knickpoint at about 120 m a.s.l. on the long-profile of the Uge River. Small basins continue on the flat and smooth river floor upstream of the knickpoint, and downstream there runs a narrow and steep gorge. The knickpoint is not placed on the lithological boundary and the basins have not been formed by direct rock control. The drainage area of the Uge River consists of Palaeozoic granitic rocks and Palaeozoic sedimentary rocks exposed only along the uppermost part of the northern tributary.

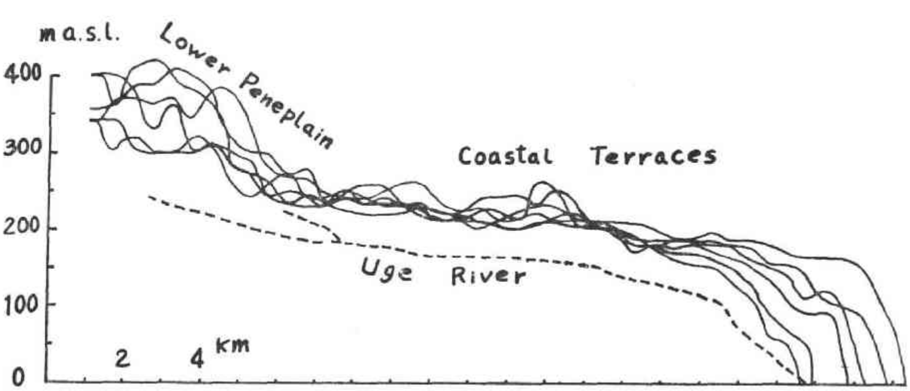

Fig. 2 Projected profiles of the area and long profile of the Uge River

At least two river terraces, the Lower and Upper Terraces, lie in the basins as small and fragmentary surfaces. Besides, pediment-like gentle slopes spread from the main valley sides to the valley plain, and Nakamura (1964) named such landform "hill-hoot surfaces". Shoulder surfaces below the residuals of the lower peneplain or Kunohe Terrace surface, surround the basins. In fact, the basins are almost fringed by these surfaces (Fig. 3).

1) According to Yonekura, coastal terraces are classified into eight levels and during the formation of these terraces, four transgressive periods, due to a eustatic rise of sea level, are recognized. The Mugyo stage precedes to the Holocene transgression.

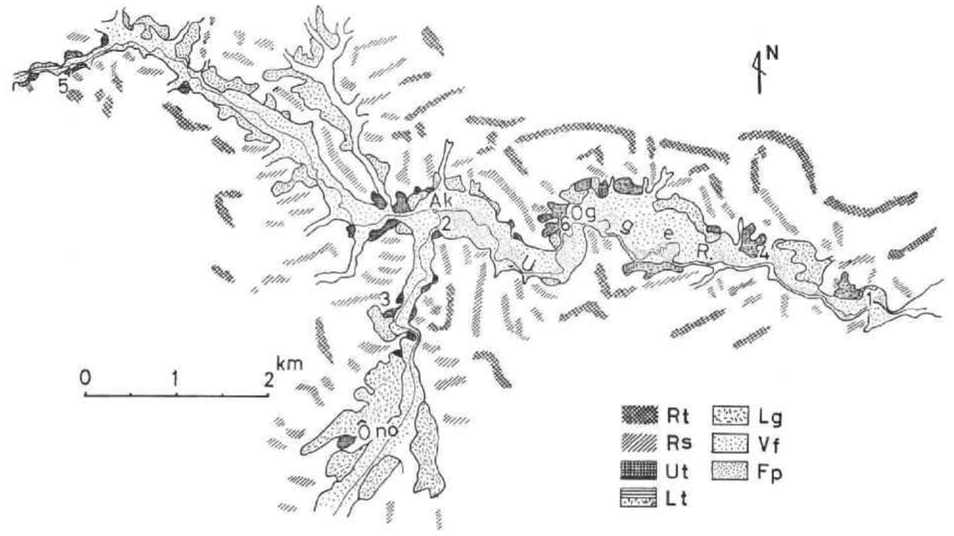

Fig. 3 Geomorphological Map
Rt: Residuals of Kunohe Terrace or Lower Peneplain Rs: Ridge like Shouder Surface
Ut: Upper Terrace Lt: Lower Terrace or Upper Gentle Slope Lg: Lower Gentle Slope
Vf: Valley Floor Fp: Flood Plain Ak: Akedo Og: Oginowatashi

River Terraces, Gentle Slopes, Valley Plains and Deposits

The valley plains are composed of two elements, the valley floor and the flood plain, and the flood plain has cut into the valley floor to a depth of $1 \sim 1.5$ m. Where there is no flood plain upstream, the stream channel has cut directly into the valley floor to a depth of $2 \sim 2.5$ m. At location 1, flood plain deposits about 1.5 m thick of dark grey and dark brown silt and sand with mica flakes, are exposed and are free of any tephra covering. The valley floor deposits observed at location 2 are in the form of a gravel bed about 3 m thick and consisting of round and cobble-size gravel, overlying an erosional surface of bed rock. Since the running water washes the exposed bed rock in places, the valley plain is erosional in origin, and bears no evidence of being buried or filled.

Since little data has been collected on the Upper Terraces detailed discussion is impossible. At location 3, 11 m above the valley floor level, a gravel bed 50 cm thick is found with a covering of cobble-size gravel and tephra.

The Lower Terrace is scarped by the valley floor and the height of the escarpments ranges from 5 to 13 m. The terrace surfaces are very small and are distributed fragmentarily. Terrace surfaces sometimes incline outward in an attitude that is not original but which is the result of gentle slope formation.

Terrace deposits are presented at location 3, 4 and 5, and are composed mainly of round gravel of cobble ~ pebble size, and sandy clay. The deposits at location 3 represent a cross structure with the terrace surface, and consist of a gravel bed near the terrace edge and at the back a clay bed, both beds being transitional with each other (columnar section in Fig. 4). At location 6, where samples for pollen analysis were collected, there is an outcrop of grey clay about 4 m in depth containing many wood pieces. The Lower Terraces are covered with tephra and their ages and chronological characteristics will be described in the following portion of this report.

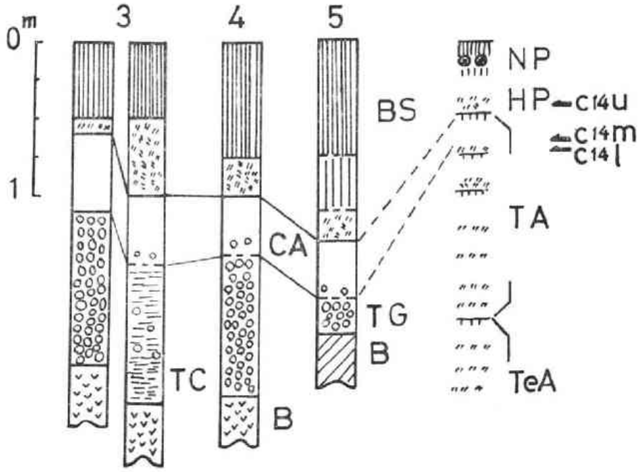

Fig. 4 Columnar sections of Lower Terrace deposits and covering tephras. Schematic column of the standard tephra sequence in the vicinity of Hachinohe at the right.
BS: Black Soil NP: Nambu Pumice HP: Hachinohe Pumice CA: Clayey Ash
TA: Takadate Volcanic Ash Bed TeA: Tengutai Volcanic Ash Bed
TG and TC: Lower Terrace deposits B: Bedrocks
c14u: 12,700±270 years B.P. c14m: 25,850±1,360 years B.P.
c141: 31,900<years B.P.

The gentle upper slope, shown in Figs. 3 and 6, continues upward from the back of the terrace surfaces (mostly of the Lower Terrace) and a gentle lower slope projects toward the valley floor. The gentle lower slope is cut in many places by shallow open valleys which form hanging valleys where they join the main valley, and which widen and extend their lower sections into a valley plain. Sometimes, as shown in Fig. 5 the gentle lower slope is terminated in small scarps. The ridge-like surface which stretches from northwest to southeast near this location is not a residual of the Kunohe Terrace surface, but is a shoulder surface as mentioned

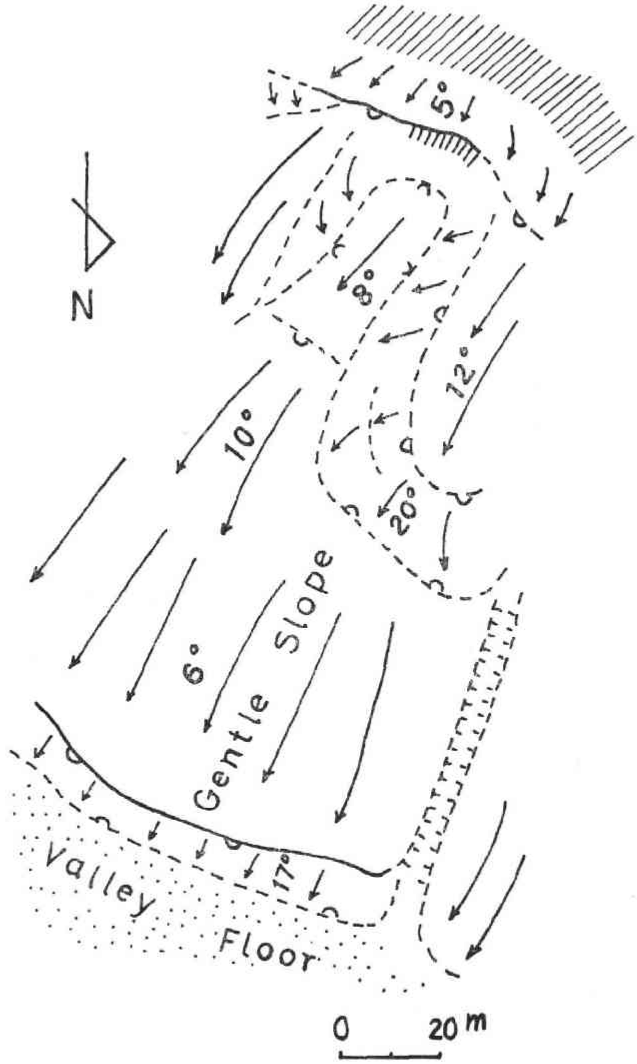

Fig. 5 Sketch map of gentle slope near location 3

above. Where the lower part of a shallow valley is cut deeply by the valley floor, there are outcrops of deposits consisting mainly of clayey materials. These deposits, including angular gravel, peaty clay and pumice grains, do not exceed 2 m in thickness, and are covered with all the tephra members except the lowest (for the uppermost member of the Takadate Volcanic Ash Bed, see Fig. 4), which indicates a process of gentle slope formation.

Where the gentle lower slope reaches the valley floor, there is sometimes no

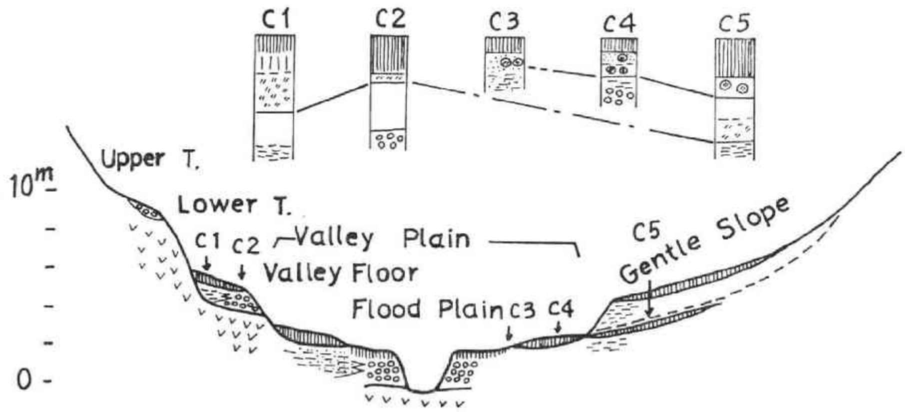

Fig. 6 Schematic cross section of geomorphological elements

clear boundary between these two, but, in many cases they can be distinguished by an obscure break and the flatness of the valley floor. The surface materials of clay on the gentle slope and of sand and gravel on the valley floor, are interfingered, so that orange-brown pumice covers the gentle slope and the valley floor is absent tephra. Therefore, the surface of the valley floor was filled close to the time of the falling of the orange-brown pumice.

The lower and upper gentle slopes are distinguished by their appearance but, as will be discussed later, there is no essential difference in the process of their formation. The apparent difference is due to the topographical location according to which, either a shallow valley or a simple slope developed. For example, at location 6, the Lower Terrace surface is covered and bevelled by a gentle slope. The topographical landscape in this area is wave-like and appears very smooth because of the development of these gentle slopes. Generally, tephra and black soil are thicker at the lower part of the slope. However, it can not be overlooked that the micro-relief has been buried with the tephra to which the gentle landform is attributed. These geomorphological elements and deposits are schematically shown in Fig. 6.

Tephrochronological Considerations

Tephra in the studied area, which fell during the period from Middle Pleistocene to Holocene, is distributed as surface materials. The stratigraphic sequence of tephra in late Quaternary, is, from upper to lower, 1) black soil, 2) orange-brown coarse pumice of Holocene[2] origin, 3) dark brown clayey ash with orange pumice,

2) A boundary between Pleistocene and Holocene is discussed from two points of view, namely the Last Glacial Maximum and about 11,000 years B.P. The writer adopts the latter opinion.

4) yellow-brown, greyish-white coarse pumice of the latest Pleistocene, and 5) brown clayey ash of late Pleistocene (See column at right in Fig. 4 and T.R.Q.R.G. 1969). The second, the fourth and the fifth horizons are called Nambu Pumice, Hachinohe Pumice and the uppermost member of the Takadate Volcanic Ash Bed. The age of Hachinohe Pumice by means of the C-14 method has been dated at 12,700 years B.P.[3] Based on this tephra the geomorphological evolution of the small basins since the time of the Lower Terrace formation is considered chronologically as follows;

Preceding the fall of the uppermost member of the Takadate Ash Bed, a valley plain wider than the present one was built in the basin, which consisted of the Lower Terrace surface and its extension. Lateral erosion, dominant in this stage, remove the clayey materials from the upper valley side and deposited a gravel bed in the stream. At the time of the fall of the uppermost member of the Takadate Ash Bed, the dissection of the valley plain was started, and the former valley plain was cut down to the level of the present one, which was terraced until the fall of Hachinohe Pumice. Linear erosion was a relatively dominant process in this stage.

Next, at about the time of the fall of Nambu Pumice the present valley plain was built. Since the deposits are less than 3 m thick, as Yonekura (1966) has suggested, the basin has none of the nature of a buried valley.

Angular gravel, peaty clay and clay with pumice grains beneath the Hachinohe Pumice indicate the process of the formation of a gentle slope. Bed rock texture has not remained in the facies of deposits in which thin layers alternate in colour tones and grain size. The facies may suggest a process as evidenced by the denudation weathered layer of bed rock, and by its removal and sedimentation. It is assumed that this process is a kind of mass-movement. Gentle slopes covered with Hachinohe Pumice at many locations are proof of their formation before the fall of tephra. However, the period of the formation is not limited to the latest Pleistocene, for such processes were active periodically at least throughout the late Pleistocene. At many exposures in and out of the investigated area, sections including clayey materials covered with considerably older tephra are found, and these materials are the same in facies as above described. However, there is no doubt as already reported (Tamura and Miura 1968) that many mass-movements occurred during the stage preceding the fall of Hachinohe Pumice.

In this stage before the fall of the uppermost member of Takadate Ash Bed the

3) S. Oike (1964): Absolute Dating of Hachinohe Pumice, Earth Science, 70, 38–39
4) H. Nakagawa (1968): A Geological Report on the Nambu Central Region (Northeastern Part), Tohoku Agricultural Office and data from Mr. S. Oike by personal communication, 1969.

process changed from lateral to linear erosion. The stage of terracing and gentle slope formation is tephrochronologically thought to have existed mainly between the uppermost member of the Takadate Ash Bed and the Hachinohe Pumice. As is shown in Fig. 4, the top key horizon (pumice and lapilli) is dated by the C-14 method at about 25,000 years B.P.[4] which is intercalated with the Takadate Volcanic Ash Bed and is not represented within the discussed tephra. The age of this stage corresponds to the Würm Glacial, especially to the period between the last Würm Maximum[5] and the early Holocene.

Discussion based on Pollen Analysis

Materials for pollen analysis were sampled at two locations. One sample is from the Lower Terrace deposits at Oginowatashi (location 6) within the study area, and the other is from the gentle slope deposits at Ichinosawa on the Kunohe Terrace at about 12 km southwest of Hachinohe City (Fig. 1).

The horizon samples selected in these two sections consisted of clayey materials with abundant chips of wood. In this horizon there is a marked concentration of organic matter and peat. The results of pollen analysis by the acetolysis method are shown in Fig. 7. Both diagrams are characterized by the high percentage of coniferous tree pollen, *Pinus* and *Abies*. However, because of the presence of *Picea* pollen, the characteristics of both diagrams are distinguished.

On the pollen diagram of Oginowatashi, *Picea* is not present except in the first horizon, and toward the lower horizon a gradual increase in broad leaved tree pollen is shown, while *Alnus* in the fifth horizon increases rapidly. From the pollen composition, it is assumed that these materials deposited during the formation of the Lower Terrace, indicate a ralatively warm climate.[6] The first horizon is dominated by *Abies* and *Pinus*, but there is a conspicuous presence of *Picea* as well. An uncomformity in sedimentary facies between this and the underlying horizons has not been found by field observation. Pollen in this horizon are poorer than in others and the pollen included are deformed or remarkably destroyed. Besides these facts, the terrace surface of the section continues through the back of the terrace to the gentle slope. Therefore, the top materials of the section are presumably a part of mass-movement deposits which are related to gentle slope formation.

On the contrary, in the pollen diagram of Ichinosawa, *Picea* and *Abies* are

5) K. Kobayashi (1965): The Late Quaternary Chronology of Japan, Earth Science, 79, 1–17

6) Under the present climate, it is assumed that climax vegetation is dominanted by *Fagus crenata* in this area

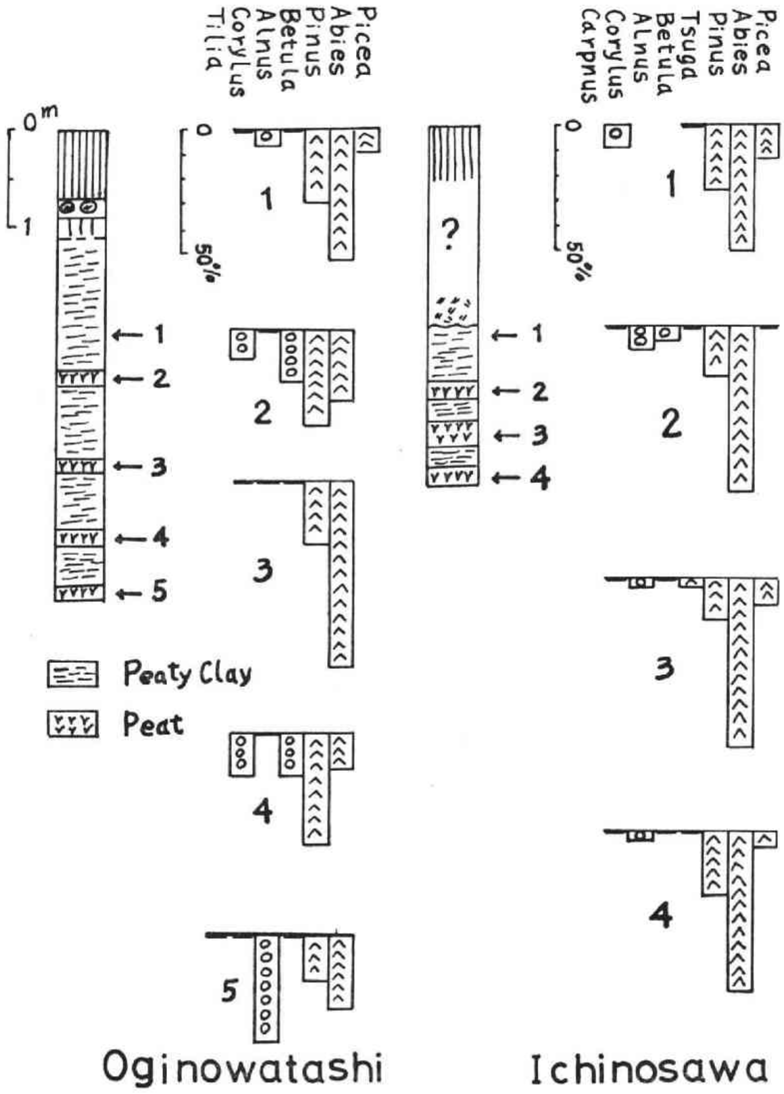

Fig. 7 Arboreal pollen diagrams of the deposits

dominant, *Picea* being deficient in the second horizon, and *Pinus* in all horizons. This pollen diagram indicates a relatively colder climatic condition. Judging from both diagrams, the period of downcutting was colder than that of terrace-surface-building. It seems that under such conditions, the Lower Terrace was cut down and the development of gentle slopes was accelerated. This result, moreover, coincides with that of the tephrochronological considerations.

Conclusion

The geomorphological evolution of the investigated area was caused principally by climatic change. A certain accident in the erosional process took place during the late Pleistocene, which formed the river terrace. It may be assumed that the age of the accident corresponds with the Last Glacial Maximum, while no direct effect of a drop in sea level is recognized. The results, summarized as the geomorphological development of the basins, are shown in Fig. 8.

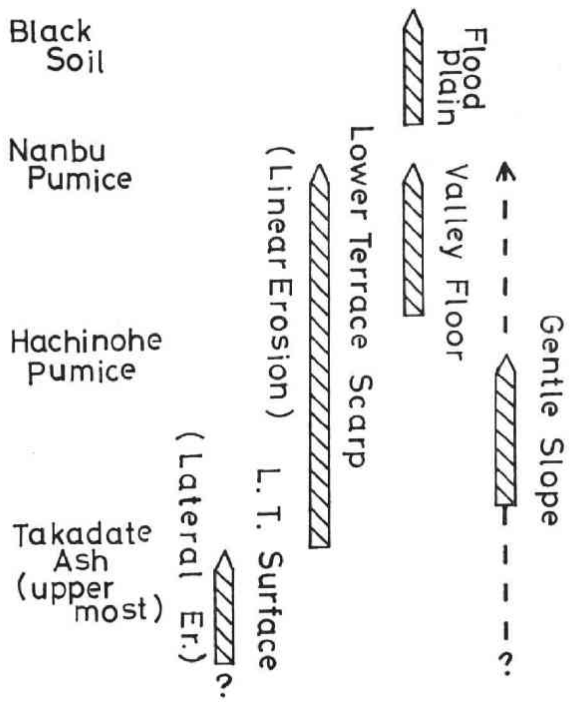

Fig. 8 Geomorphological development of the small basin

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