Some Relations between Dissecting Valleys and Erosional Reliefs in the Southwestern Part of the Abukuma Plateau

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The Abukuma Plateau is one of the better fields where we can observe so-called uplifted peneplain, together with Kitakami and Kibi mountainlands in Japan. As to the geomorphological problems of uplifted peneplains and their remnants in Japan, a large number of papers has been written on this problem, and its theoretical interpretations, but apparently they are based on cartographical measurement with an exception of Y. Mino's work.[1] In order to make some basic idea on such topography, the writer thinks it necessary to make much more field surveys in detail, and correlate the results on another. Under this consideration the writer has studied Abukuma region, especially on its erosional character or geomorphological development. To begin with, the writer paid attention upon the characters of the dissecting valleys as a factor changing the features of the relief which belongs to a former stage in the erosional cycle.

This area mainly consists of old granite, granodiorite, gabbro, gneiss, crystalline-schist and other Paleozoic and Mesozoic rocks[2]; and the area where the writer made a survey also consists of these rocks, but its northwestern part is of Tertiary sandstone and shale. Roughly speaking the boundary of topography in this area is accordant with the boundary of geological constitution, as is the case in other areas in Japan with similar geomorphological characters.

This area can be classified as follows according to the nature of topography (Fig. 1); 1) Abukuma Plateau, 2) Abukuma marginal hill lands, 3) River terraces, 4) Alluvial plains. Abukuma Plateau has three step-like levels[3]; the lst consists of remnants such as pinacles or flat topped mountains (800–1000 m), the 2nd is most widespread, and is preserved in the form of hill-top surfaces (600–700 m), and the 3rd (350–400 m) is a kind of a marginal peneplain unlike the upper two surfaces. This is often distinguished from Abukuma Plateau as Abukuma marginal hill lands. Here the hill-top surfaces or table-like reliefs are so flat, they are

1) Y. Mino: Chikei-Genron (Principle of Geomorphology) 1942.
2) M. Watanabe; Geological Map of Fukushima Prefecture, 1954.
3) Y. Nakamura; Geomorphological Development of th Northern Part of Abukuma Plateau, Ann. Tohoku Geogr. Assoc. Vol. 12, No. 3, pp. 62–70.

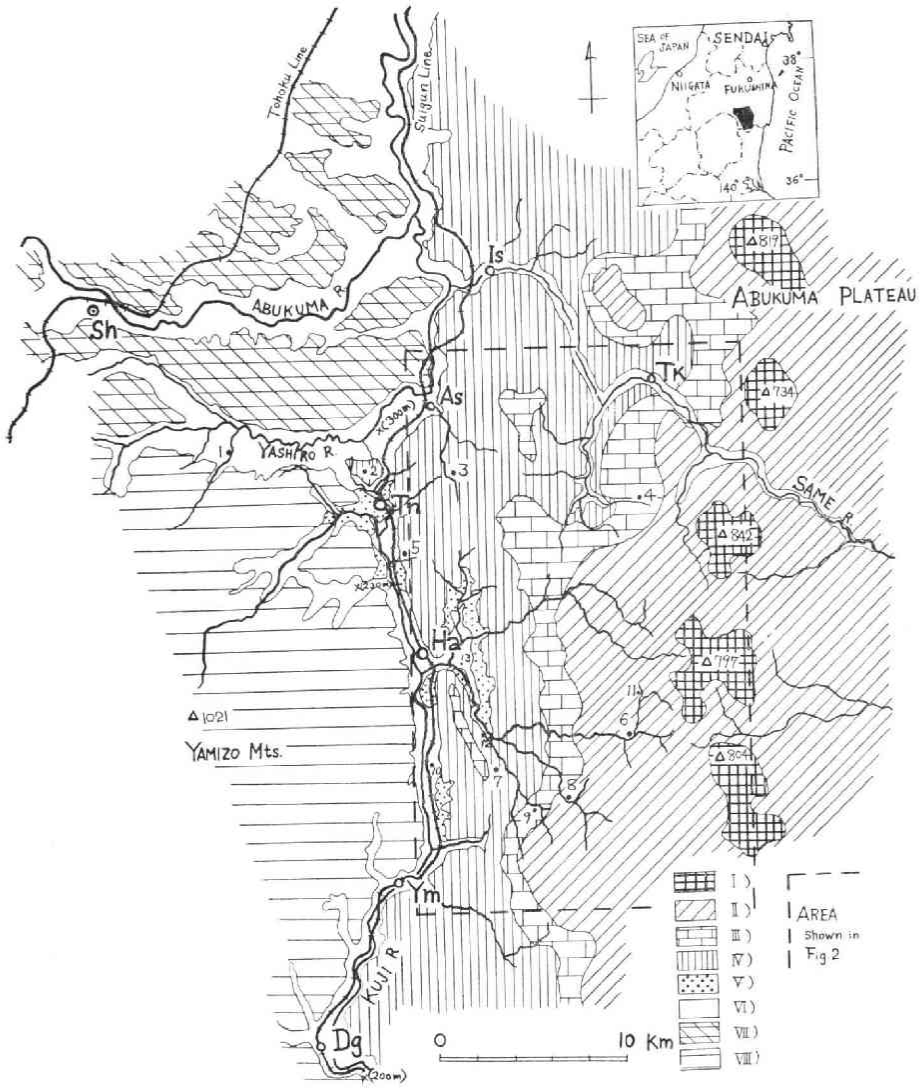


Fig. 1. Index map

I) Remanants of I-plane as monadonocks or pinacles, II) II-plane as hill-top surface, III) Bordering zone of II- and III-plane IV) III-plane as marginal hill land, V) River terraces, VI) Alluvial plain, VII) Shirakawa hill lands, VIII) Yamizo mountainlands.

As : Asakawa, Dg : Daigo, Ha : Hanawa, Is : Ishikawa, Sh : Shirakawa, Tk : Takenuki, Tn : Tanakura, Ym : Yamatsuriyama.

1. Kanayama, 2. Uwadai, 3. Okusa, 4. Togaryu, 5. Nagare, 6. Nagura, 7. Kinosori, 8. Katagai, 9. Hidoro, 10. Ishii, 11. Yobiishi, 12. Maeda, 13. Kawashimo.

considered to make the 3rd plane. It is very interesting to know, however, that according to the different heights of the floors of present larger rivers, not only the degree of dissection on the 3rd plane, but also the profiles of valley floor, and valley walls are quite different by each case. The writer would point out in this paper which factor is dominant in this differentiation and how was its influence on the geomorphological development of this area.

I. Dissecting valleys on the Abukuma 2nd plane

Regarding to the origin of the stepped feature on the Abukuma Plateau, many possible reasons have been considered, e.g. the result of episodic lowerings of erosional baselevel, of differential resistance of the rocks to erosion, and their combination in long geological history. This is an important but difficult problem not only in this area but also in Kitakami and any other region with more or less the same geomorphological conditions.

The outer boundary of the 2nd plane may be drawn from the topographical map as Fig. 1, but it shows no clear scarps. From the longitudinal profiles of the river floors (Fig. 5), we can recognize two clear knick points. In the section above the upper knick point, well rounded subdued hills are observed and the cross sections of valleys are generally open and wide (Fig. 3-a, b). Around Nagura, Katagai, Hidoro and Togaryu, the streams in the dissecting valleys flow in narrow but straight channels only a few meters wide, however, there are relatively broad valley bottom plains along the channels, and their back slopes are rather steep (about 30–50°), making a convex slopes (Fig. 3–a, b). For the classification of valley types, the writer will use German terms which he thinks are more to the purpose of classification[4]. The above mentioned type is classified as *Sohlen-kerbtal*.

The relief in this area is only 60–100 m/km², but in the downstream area within this plane the streams make a deep gorge, and typical V-shaped (*Kerbtal*) valleys develope until they reach the level of the 3rd plane or alluvial plains in which the streams have a wide flat plain along their both sides as *Sohlental*. The relief of this V-shaped area is more than 300 m/km², which is regarded as the result of an erosional rejuvenation in cutting the 2nd plane during a process to converge into a new erosional baselevel of the 2nd plane. These gorges played a part as local baselevel, and were apparently so stable that the region above them well preserves a level landform originated in an earlier erosion cycle.

In this region, the writer was especially interested in the topography of small tributaries, summarized in following three points; 1) there are many tributaries

(4) H. Louis; Allgemeine Geomorphologie, 1960, s. 70.

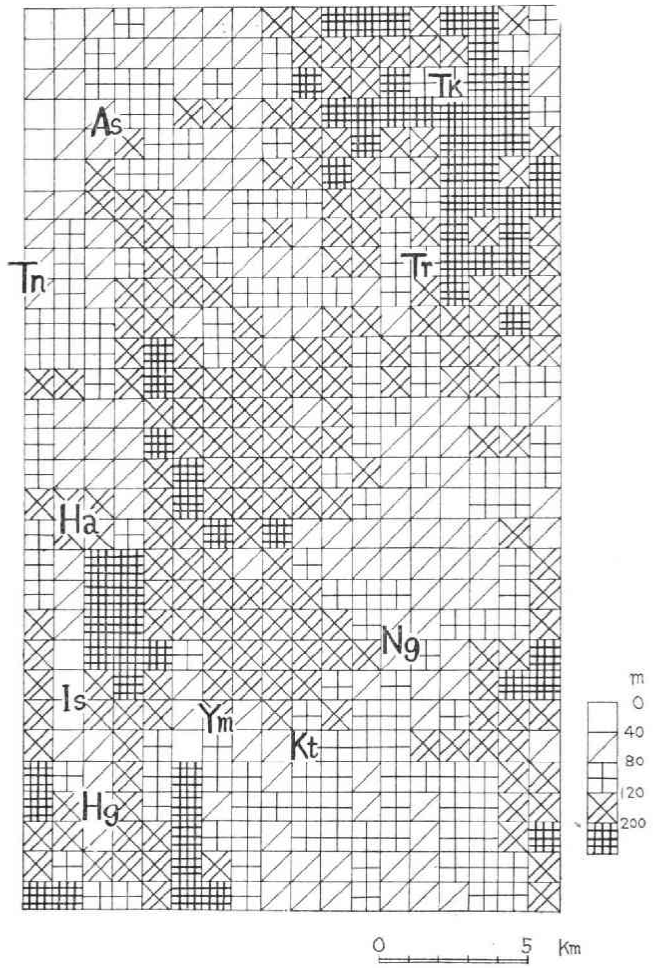


Fig. 2. Relief map

R=T-L (m) R=relief in m. per 1 km², T=highest point in unit area, L=lowest point in unit area.

As : Asakwa, Ha : Hanawa, Hg : Higashidate, Is : Ishii, Kt : Katagi, Ng : Nagura, Tk : Takenuki, Tn : Tanakura, Tr : Togaryu, Ym : Yujimata.

which have a characteristic of aggradation valleys with their straight stream cources, low gradient floors seemed to have just reached to the grade, and frequently drained channels. 2) In the case of smaller tributaries, each of them makes a hanging valley at its confluent into the main stream, with scarps 3–5 m high, as is shown in Fig. 3-c, and 6. This is true not only in this area but all of the Abukuma highland, and it has been interpreted as the result of recent rejuvena-

tion in the main streams, and as the remnant from former cycles. There are other conditions which helped the formation of such landforms. At the heads of these small tributaries there are divides or small ridges, and water supplying area is limited (only a few hectres), and present streams, if there is any, are cutting down. It will be discussed later in this paper why it is well preserved. 3) Some major streams have gullies like those at the heads of streams (Fig. 4–c). The head of a dissecting valley near the divide or col has a small V-shaped profile, down the valley, it soon becomes a *Sohlental*-like profile as described above. Many cols are relatively flat, and consequently they are accordant with the floors of hanging valley-like tributaries. Such a feature is reported as *Tobel* in Austria,[5] but the

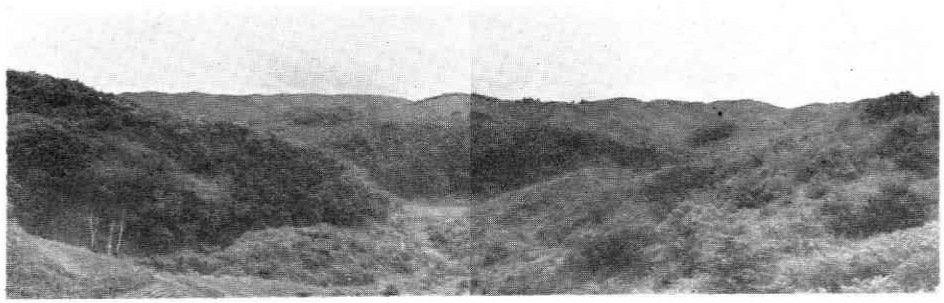


Fig. 3. a

b

c

Fig. 3. a. Dissecting valley near Yobiishi (Loc. 11) ; "Sholen-kerbtal" type ; hill tops are 680–700 m.

b. Near the divide bordering Fukushima Pref. and Ibaraki Pref. about 4km to the east of Nagura (Loc.6) ; the valley makes a wide floor and narrow straight channel with low gradient, and belongs to "Sohlen-kerbtal" type

c. Small tributary showing a hanging valley type ; its floor is higher than the floor of the major tributary about 10 m, cut down by a narrow channel (left side in photo.) ; near Hidoro (Loc. 9)

(5) S. Morawetz ; Die Tobel östlich von Graz, Mitt. Geogr. Gesell. Wien, Bd. 99, Heft 1, ss. 194–198 (1957).

origin is not always same. A. Strahler has described a case of severe erosion introduced by human land use.[6]

II. Dissecting valleys and erosional flat surfaces in hill lands

Along the western fringe of the Abukuma Plateau, hill lands about 380–400 m high, and sometimes with flat erosional surfaces are observed. The writer will describe them dividing into following three areas.

a) Upperstream area of the Kawakami River

There is a typical and widespread distribution of erosional flat surfaces (pediment-like slopes), for example, near Yujimata, Kinosori and Maeda (Fig. 4–a).

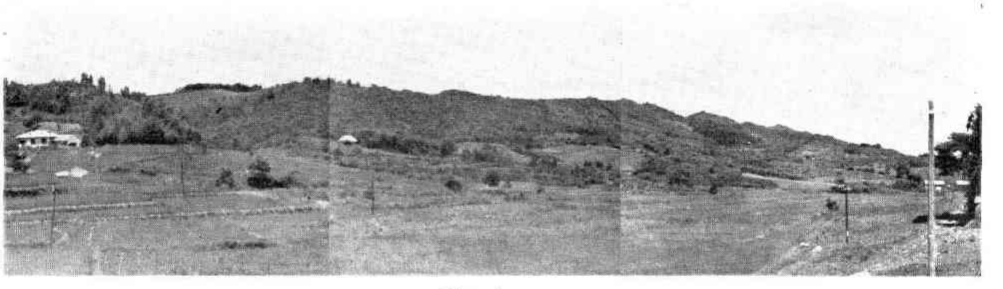
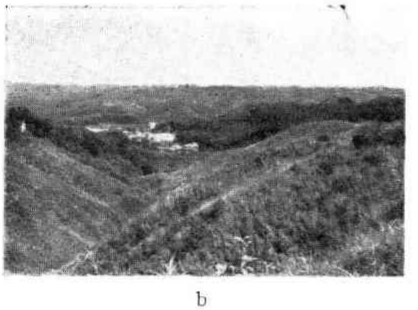


Fig. 4. a



b

c

Fig. 4–a. Pediment-like slope at Kinosori (Loc. 7) ; Valley type is "*Flachmuldental*" (shallow concave valley), and this level of the slope is referred to the II-plane. Back hill is Kokonotsu Range (500 m).

b. V-shaped valley (*Kerbtal*), one of small tributaries near Kamitoyo, 4 km to the southeast of Tanakura. Flat surface on the hill tops is the III-plane (400 m), and the valley in the central part of photo is one of the major tributaries of the Kuji River.

c. Gully head of a small tributary. "*Mulden-kerbtal*" type (concave floor is cut by the rejuvenated channel), 4 km east from Nagare (Loc. 5). Valley head of this kind is common on the II-plane, e.g. at Katagai and Nagura.

(6) A.N. Strahler ; The nature of Induced Erosion and Aggradation. Man's role in changing the face of the earth. pp. 621-638 (1956)

In this area, the Kokonotsu range, a monadonock of crystalline schist which is highly resistant to erosion, remains as a *Härtling* and along its foot, there are pediment-like gentle slopes (Fig. 4–a) showing a baselevel of about 400 m in height. The Kawakami river has a clear knick point at Maeda, and above it, the stream has a wide-open valley floor (*Flachmuldental*), both sides of which are accompanied with such pediments. Going up further, south of Yujimata, the stream becomes narrow again making a gorge, and finally it reaches to 600–700 m area described above, at Hidoro or Katagai. Downstream from Maeda, the flat surfaces involving these pediments become narrower, and near Kawashimo, where alluvial plains of this river and its main tributary, the Watase river, are dominant, they are recognized as remnants in the form of hills with or without flat tops at the level of about 400 m.

Around the Kawashimo basin, there are 4 series of river terraces. The writer proposes to call them after local place names. Such are from upper to lower, the Nakatsuka (280–260 m), Mizumoto (250–230 m), Hachiman (215–210 m), and Itaniwa (200 m) terraces. These terraces have, generally, terrace gravels of granite, grandiorite, crystalline schist, gneiss and other rocks consisting this area. The gravel layers are 2–3 m thick and loosely compacted, well rounded and well sorted, but their conditions are different from a place to another, sometimes lenses of fine sand or clay are inlaid in them. At Maeda, the 3rd and the 4th terraces can not be observed, and the 2nd terrace penetrates into 400 m surface with the process of cutting down by the streams making gorges.

Along the Watase river, one of the main tributaries of the Kawakami river, no river terraces can be traced, and the distribution of terraces is limited within the Kawashimo basin.

On the other side of the Kokonotsu range from the drainage basin of the Kawakami river, there develop some ridges 360–400 m high, and with E-W direction. As to this level, the writer thinks that it is correlated to the 400 m level of surfaces along the Kawakami river. The important topographical difference between these two surfaces of the same level is that at the Kawakami region the surfaces are rather well preserved in the form of flat planes or pediment-like slopes, but in this section, as it belongs directly to the drainage basin of the Kuji river, and according to the larger relative height between river floor and this surface, the dissection by many tributaries, which confluent into the Kuji river with right angle (from E-W) having a shorter course of only 1–2 km, is much quicker and stronger, so the surfaces at the level of 360–400 m have been dissected into present forms.

Along the Kuji river there are four series of terraces, like in the Kawashimo basin, for example, at Tanakura, Hanawa, Ishii and Higashidate. These terraces

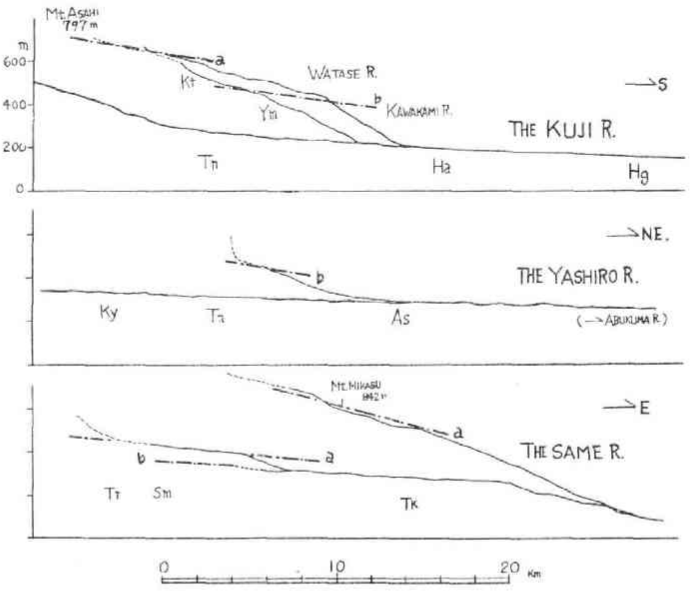


Fig 5. Longitudinal profiles of the river floors in this area
a : level of the II-plane
b : level of the III-plane
Ha : Hanawa, Hg : Higashidate, Kt : Katagai, Ky : Kanayama, Sm : Samegawa, Tk : Takenuki, Tn : Tanakura, Tr : Togaryu Ym : Yujimata.

are probably formed according to the intermittent lowerings of the base-level of erosion of the Kuji river.

b) Eastern hilly area of Tanakura

About 1 km northward from Tanakura railroad station, there is a table-like flat plain of 320–330 m, which the writer will tentatively call "Uwadai plane". Its surface is covered by a fine gravel layer about 1.5 m thick. These gravels mainly consist of granitic rocks supposedly transported from the central part of the Abukuma plateau. The gravels are 3–5 cm in diameter, well rounded, having high sphericity and good sorting. This plane is slightly inclined northward with a gradient of 10–15‰, and here small streams run often with dry channels in the shallow, wide valleys northward to the Yashiro river floor. Northern fringe of this plane is bordered by a steep scarp with 10–15 m, and below this scarp the alluvial plain of Yashiro river is followed with a width of 2 km. Southern fringe is, on the contrally, bordered by a much steeper scarp with a rugged outlines and with a relative height of 50–60 m from the lower plain of the Kuji river. The dissecting valleys on this side have V-shaped walls. The streams in these valleys

are now more active in dissection than the ones flowing to the north. This difference depends upon the difference of relief energy on both sides, that is, to this plane the baselevel altitude is about 300 m on the northside (the Yashiro river), while it is no more than 240 m on the other side (the Kuji river).

It is important that we can find here two relatively stable base-levels of erosion of the Kuji and the Yashiro river within a distance of only a few kilometers and in different height making their interfluve asymmetrical in the features both horizontal and vertical. It must be also noticed that the shallow valleys to the north are now being captured of their upper parts by the deeply cutting valleys to the south, and are therefore reducing themselves, whereas the valleys to south are growing up in the early mature stage.

From Asakawa southward near Itabashi and to the east of Tanakura, there is a hill-top level with an altitude of 340–380 m. This is the divide of the Rivers Yashiro and the Kuji, in the same way as Uwadai plane. On the Yashiro river area these hills are dissected by the shallow and often aggraded valleys with a relief of 20–30 m/km². The baselevel of these valleys is accordant with that at Uwadai plane. In the Kuji river area, deep valleys are common, and a distinct feature of piracy is observed at Okusa, where a tributary to the Yashiro flowing northward has been intercepted of its half length by one of the tributaries to the Kuji which has been extended northeastward with a violent head erosion. Now the stream flows down turning its course at right angle, and the lower part of the captured river makes a large wind gap or *Trockental* near Hamaiba (Fig. 8). Besides these the migration of the knickpoint has reached Kamihanawa about 2 km to the south (upperstream)

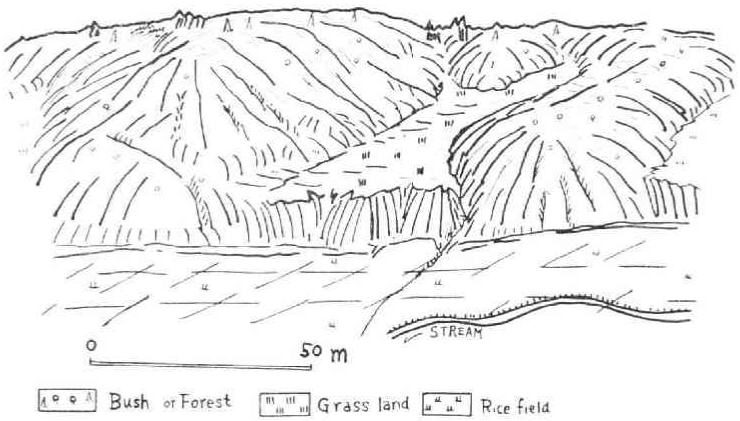


Fig. 6. Small tributary showing a hanging valley type, near Nagura (Loc. 6). The floor is shallow and concave (*Flachmuldental*), but the floor of the major valley is "*Sohlen-kerbtal*".

of the point of capture.

It attracts our attention that the altitudes of the hill-top surfaces on both sides of this straight tributary are different by about 100–150 m, that is, 380–400 m on the left side (Eastern Tanakura hill lands) and 500–550 m on the right; this is considered to be a geomorphological expression of the fault line bordering the eastern margin of Tanakura sheared zone[7] in the geological structure of this region. Of course this 500–550 m hill-top surface is not the same plane as the above mentioned 600–700 m plane, because the former is much dissected and rugged, and has no streams of gentle gradient which characterize the latter. Although the profiles of valleys and interfluves show clear differences or asymmetricities between these two areas with quite different reliefs, the diference in the relief is not manifested in the change of the density of the dissecting valleys. One may generalize that on the hill land with low relief, the flat bottomed valleys are dominant, and with large relief the flat bottomed valleys but steep scarped valleys (*Sohlen-Kerbtal*) are common, while valley density is not so different in both areas.

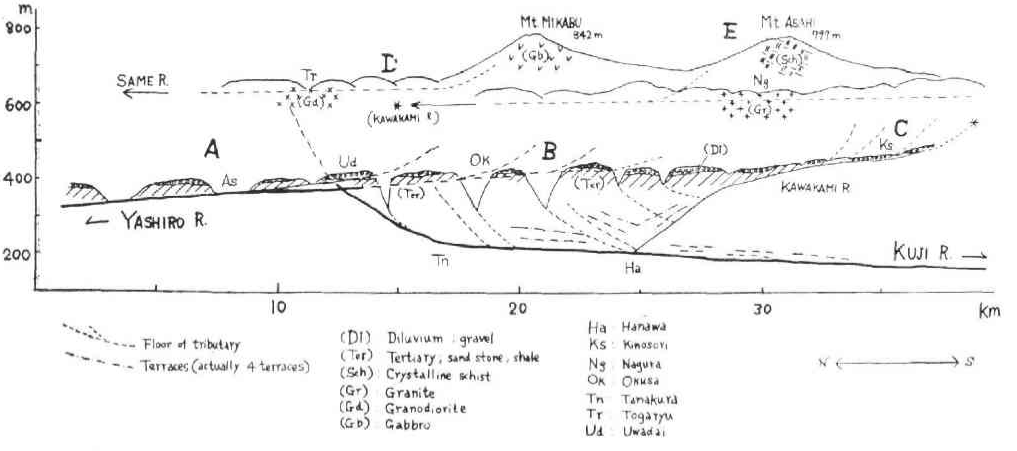


Fig. 7. Diagram showing the distribution of various types of valleys. A, B, and C belong to the III-plane. A— "*Sohlen-kerbtal*", B.—V-shaped valley ("*Kerbtal*"); river capture occurred at this point, C— shallow concave valley ("*Flachmuldental*"), or pediment-like slope, D. belongs to the II-plane: "*Sohlen-kerbtal*" type is dominant, and E. is regarded as a renmant of the I-plane.

Additionally, in the Yashiro area the hill tops of 380–400 m are much rounded and have a convex slopes downwards but in the Kuji area they are characterized

7) M. Omori and others : On the Tanakura Sheared Zone in the SW Margin of the Abukuma Mountainland. - Study of Geologic History of Southeastern Margin of Abukuma Plateau Pt. 3 – (Abstract) Jour. Geol. Soc. Jap., Vol. 59, pp. 217–223, 1953.

by the sharp ridges and concave slopes as shown in Fig. 4-b. This extreme contrast is regarded as the result of the above mentioned condition, namely, owing to the difference of the relief energy in both areas, the erosional forces are not equal in them. Dissecting valleys in the Yashiro area have a similarity in their profiles or cross sections to the valleys on the upper plane, that is, the characteristic form of "*Sohlen-Kerbtal*" type.

c) Southeastern part of Tanakura (near Nagare)

In this section two similar interesting phenomena are observed. The tribu-

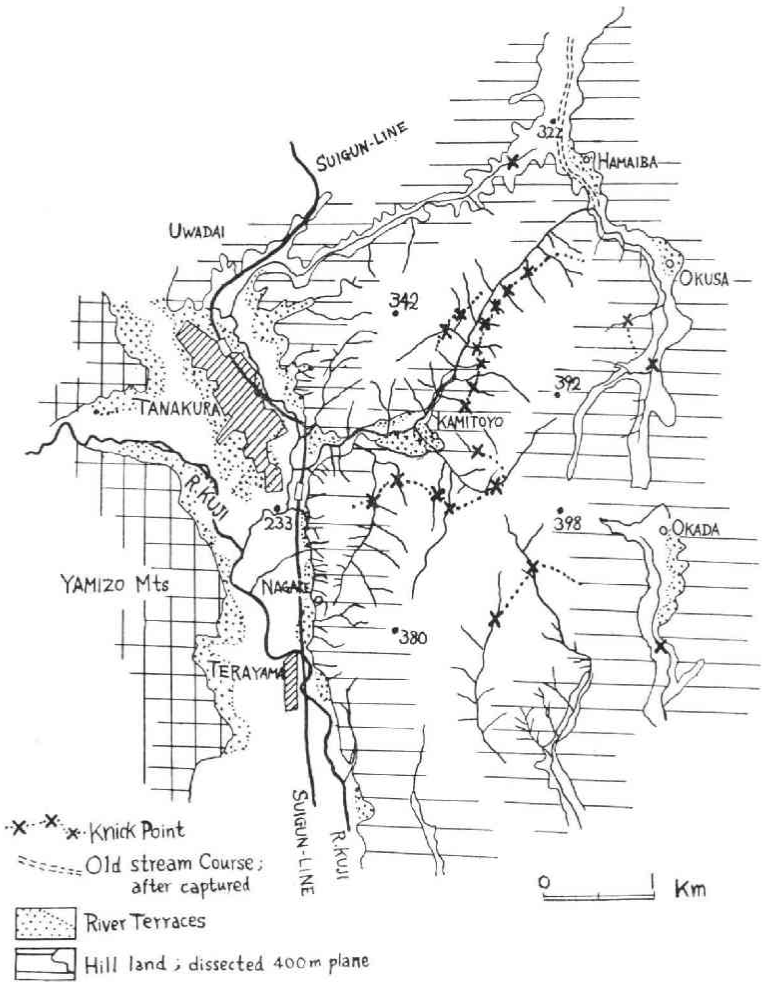


Fig. 8. Distribution of the clear knick points of small tributaries, on the part of the III- plane; these points are connected with dot line.

taries directly confluenting into the Kuji river at right angle have V-shaped cross sections without exception, for the relative height between hill top surface and river floor is nearly 150 m or more and the stream courses are very short, so their gradient ought to be steeper and erosional force to be strong in spite of its short length. However the secondary tributaries which generally flow northward or southward into major tributaries running westwards have some knick points in their streams and their upper parts are a gentle gradient valleys, or *Sohlen-Kerbtal* type like in the Yashiro area but these tributaries surely belong to the Kuji drainage basin and never belong to the Yashiro area.

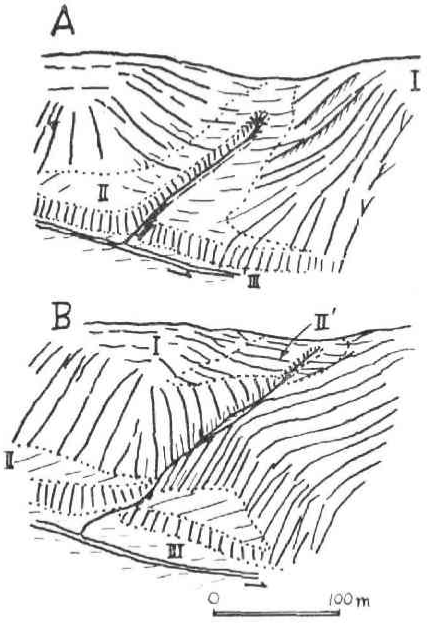


Fig. 9. Two types of relations to the terrace, at Kamitoyo, 2km east from Tanakura

A : The terrace of major stream is traced along its tributary to the head, where developes a type seen at Fig. 4–c.

B : The floor of tributary is clearly separated from the terrace by a large knick point.

I : Flat surface on the hill tops (the III-plane)

II : River terrace (actually 4 terraces)

II' : Shallow concave floor of tributary, sometimes as a pediment-like slope

III : River floor of major stream

Because of the presence of these two types of valleys within a very narrow area, here also a similar geomorphological condition occurs. The upper streams of the secondary tributaries are now under the process of piracy by the third ordered tributaries which run with shorter courses directly into the Kuji river. When the knick-point migration of these secondary tributaries is finished at the valley head, a gully like valley head is often formed, which also looks like "*Tobel*", in the same way as near the divides on the 600–700 m plane.

Another interesting thing is the coincidence of the knick point with the river terrace surface. In such cases, there are two types (Fig-9). The type (A) is where the knick point is not so clear and tributary has a valley floor, which is cut down by

the stream. However the valley floor is continuous, and is traced to the surface of river terrace of the major stream. Near the valley head, here also developes a *Tobel*-like gully. These features may be summarized as "*Mulden-Kerbtal*" type. The type (B) is the case in which the knick point is very distinct and persistent. Above this point, the tributary developes a valley floor, which is also cut down by the channel same as the case of the type (A). In this case, however, the upper valley floor has not a direct continuity to the surface of the river terrace. Probably it is accordant with that, though separated by a large knick point.

III. Some considerations on the conditions for the development of these valley types

Now it is necessary to analyse the relation between the valley types and the geomorphological conditions, based on the observations, in this region. Here we may point out next four features as significant, those are, 1) gentle gradient and straight valleys, 2) small tributaries of hanging valley type, 3) *Tobel*-like gullies at valley heads, and 4) asymmetrical development of dissecting valleys. These features correspond to various valley types mentioned in previous chapters.

1) Gentle gradient and straight valleys are observed in the upper plane and in the Yashiro area in the lower hill land, but not in the Kuji area, and this is explained as follows; these valleys belong to "*Sohlen-Kerbatal*" type whose cross section is shown in Fig. 3-a, b, and this type is common where the relief is about 60–100 m/km^2, with gentle gradient as a whole. The area where this type developes may be regarded as a base-level of erosion in the past or at present, in the sense of a local baselevel; and as to this region, their presence at 600–700 m and 400 m levels is an evidence of the two peneplanations now preserved in the form of two levels at present altitudes. It is quite natural that, where a harder or more resistant rock is exposed, even under the condition above mentioned, the stream must be narrower and unable to make a wide valley floor. Fortunately in this region the resistivity of the rocks is rather uniform, so the effect of this kind seems to be negligible.

2) Small tributaries of hanging-valley type are distributed on the upper plane only. They have several characters as; a) depsite of their short distance and less water supply, they have a relatively wide floor (30–50 m), b) dry channels (*Trockental*), and c) their localities in places ordinarily are difficult to build such valleys. We must regard them as the products of the processes of a very long period, in which the base-level of erosion was stable enough to enable them to develop at such unsuitable places. Moreover, this means that these valleys once

built are maintained more easily, and later when the main stream underwent a rejuvenation, they were unable to adjust themsevles to a new level. If the main stream rejuvenated more strongly and acquired a large relief energy in this area, these hanging tributaries would disappear immediately. Actually in the Kuji area, where the 400 m plane has undergone recent rejuvenation, these small tributaries are not to be found, as was described previously.

3) *Tobel*-like gully heads are distinguished from the *Tobel* in the point that the latter is formed at any part of the channel in a land-slide area or at an exuding point of underground water. The former is, however, limited only at the head of streams. So this must be related to some change of the erosional condition, especially to its lowering of baselevel. And this is surely connected with the floor surface of hanging tributaries above mentioned. At this section, the valley shape is "*Flachmuldental*" (above this gully) and "*Mulden-Kerbtal*" (below the gully) type (Fig. 4–c).

4) Asymmetrical development of dissecting valleys was mentioned in detail previously. It must be repeated here to emphasize that the most important factor controlling the erosional features of this region is the distance from the base-level, of erosion in the sense of directions both vertical and horizontal. This is derived from the difference between the heights of the floors of the two major rivers. Moreover, the erosional force of the tributaries which characterize the surface relief more in detail depends upon the volume of the water supplied or accumulated into their channels. The extremely small tributaries or uppermost parts of ordinal streams can be supplied with a little water, becuase the ridge or divide is near. Here comes a more significant probelm which is very interesting to the writer. That is how the valley types responded to the changed conditions caused by the change of erosional level. The asymmetrical development of valleys seems one of the appropriate clues to the study of this problem.

IV. Summary

The relations between the types of the dissecting valleys and the erosional reliefs are summarized below, based on the analysis of relief energy, and several other factors combined to it.

Conditions \ Relief energy		less (30–60m/km²) → much (200m–/km²)	
Length of stream or channel	short ↓ long	hanging valley (Hidoro, Loc. 9) pediment-like slope (Kinosori, Loc. 7) ←1)→	small V-shaped (Ishii, Loc. 10)
		Sohlen-kerbtal, or gentle straight valley (Yobiishi, Loc. 11) (Yashiro area) ↖	*Sohlental*,.... at major valley (Kuji, r., Yashiro r.)
Location, or distance from base-level of erosion	near the level of major valley floor ↓ far from it and near the divide	*Sohlental*, ... confluent accordant (Higashidate, Hanawa) 2) ↘	steep solpe (Nangare), or small V-shapet (s. Uwadai, Loc. 2)
		Flachmuldental *Mulden-kerbtal* hanging valley (Nagura)	gentle slope, as a slope of monanock of I-plane[4]
Volume of supplied water to its drainage basin	little ↓ much	hanging valley, relatively shallow and wide (*Muldental*) (Nagura, Katagai) ↖	gentle slope, not sculptured (same as above)
		Sohlental (Yashiro area) 3) ↘	large V-shaped (Maeda, Watase)

1) asymmetrical relief at the east and west side of Kokonotsu range
2) asymmetrical releif at Uwadai, and eastern hill of Tanakura
3) clear knick-point of Kawakami and Waase river between them
4) Mt. Asahi, Hanazono, Mikabu etc., 800 m or more.