Relief Distribution in the Northern Part of Kitakami Mountains

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I. Introduction

Geomorphological study on the mountainous and hilly regions has, generally speaking, not so much progressed as on the lowland plains, so that we have many problems to be studied. The writer is interested in the morphological process of dissection of the mountainland by the valleys, especially about the uplifited and dissected peneplain region. Last year the writer reported on the morphological development in the central part of the Kitakami Mountains (Nakamura, 1963a), and in its relation he found following problems. 1) Are materials related to the relation between the peneplain surfaces and the three stepped base levels of erosion available in the northern part of the mountains? 2) What is the factor that determines the present distribution of various erosional reliefs, as dissecting valleys of V-shaped, "*Sohlen-kerbtal*" and concave sloped types, erosion surfaces and basins? 3) Are there any common phenomena that may occur not only in a dissected peneplain region but also in any region of topographical types?

Now, on the other hand, there is a discussion about an existence of peneplain in the sense of cycle theory, for instance, whether a peneplain is really able to be formed or not as an ultimate product of erosion. Against this antagonism the writer supports the peneplain theory because there are many evidences of wide spread erosion surfaces in the world. Another question when the peneplains at Kitakami, Abukuma, Chugoku mountains, etc. in Japan were formed is also very important; the writer cannot say but that they seem to be built during Miocene or Pliocene. In late Miocene and whole Pliocene ages a large scale orogenic movement occurred in the backbone ridge zone of Tohoku district, but the present peneplain areas of Kitakami and Abukuma had been free from it and remained stable (Hanzawa, 1954, Kitamura, 1959).

Almost same as the central part, the northern half of the Kitakami Mountains consists of the Paleozoic (chiefly Permian) slate, sandstone, conglomerate and limestone formations and some granite massives, and partly of the Cretaceous and the Oligocene sandstone formations (Sassa, 1932, Onuki, 1956). And the northernmost area is covered with younger volcanic deposits composed of pumice grain layers, volcanic sands and ashes (Nakagawa, 1963). At the northwestern fringe develop the Neogene strata covered with the Pleistocene gravels and the volcanic layers. Along the northeastern fringe of the mountainland there develops a series of coastal terraces, they are the Kunohe, the Shiramae, the Taneichi and the Tamanowaki terraces (Nakagawa, 1961).

Roughly speaking, the altitude of the region decreases to north, and develops a rugged topography at southern area (nearer to the central part of the Kitakami Mountains), and an extensive rolling surface with a less relief at northern area.

In the following chapters the writer is going to classify the surfaces and valley levels, and to discuss the character of the erosional reliefs in this region on the view point that seeks some morphological evidences to explain the present distribution of the erosional reliefs, and their significance in the mountain morphology.

II. Several surfaces in the region

Following four surfaces are classified in the region; 1) the upper peneplain surface, 2) the lower peneplain surface, 3) the hill-foot surface, and 4) the valley plains.

The upper and the lower peneplain surfaces are composed of a series of erosion surfaces with an accordance of height at each level. The hill-foot surface is distributed at the foot of the valley side slopes which were formed resulting from dissection of the above two surfaces. The valley plains are considered to be formed as erosional basins.

1) The upper peneplain surface is located at 1100–700 m above sea-level, declining northward, and is mainly composed of rounded or sometimes rugged ridges with some flat surfaces on their tops, somewhere of pinnacles with an accordant height. The ridges and pinnacles are almost uniformly widespread in the region (Fig. 1). Restoring them it is clarified that the upper peneplain surface had once developed widely in this region and was afterward dissected to the present form.

There are three main ridges recognized; Mt. Akkamori—Mt. Hiraniwa-dake—Mt. Tatara-dake, Mt. Tsukushimori—Mt. Orizume-dake, and Mt. Anamega-dake—Mt. Kuromori—Mt. Nobe. With exceptions of Mt. Tsukushimori of the Tertiary igneous rock and Mt. Hashikami-dake of granite, these mountains are in the Paleozoic area. The erosion surfaces are covered with a veneer of rock fragments and surface soil, and their profiles are convex, steep and very smooth. On the slopes there are few ravines, so that the slopes are not cut any more. This means that the initial surface of the upper peneplain had been dissected and reached a graded state on the lower peneplain level. The writer has observed the same relation between the

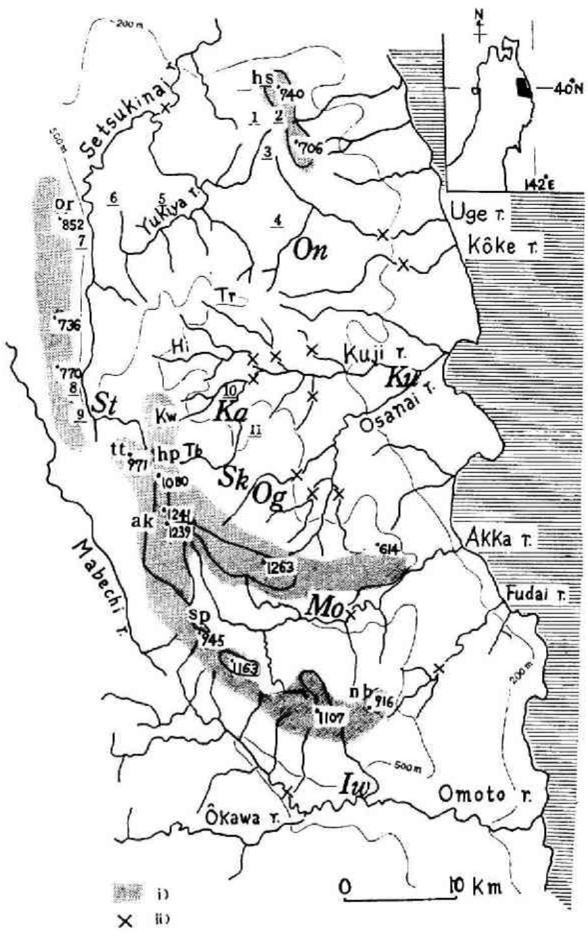


Fig. 1 Index map
1–11: location number, i): range with flat surface on mountain top,
ii): knickpoint,
Iw: Iwaizumi, Ka: Kawai, Ku: Kuji, Mo: Motomura, Og: Oguni, On: Ôno, Sk: Seki, St: Setsukinai, Hi: the Hinosawa r., Kw: the Kawai r., Tb: the Tôbetsu r., Tr.: the Toromachi r., ak: Mt. Akkamori, an: Mt. Anamega-dake, hp: Hiraniwa pass, hs: Mt. Hashikami-dake, nb: Mt. Nobe, or: Mt. Orizume-dake, sp: Suzu pass, tt: Mt. Tatara-dake,

slope of the upper peneplain remnants and the lower peneplain on the Abukuma Plateau (Nakamura, 1960).

Mt. Hashikami-dake (741 m), Mt. Kujihira-dake (704 m), and Mt. Wasarahi

(744 m), whose present forms are pinnacles or spits, belong to C-type* of the

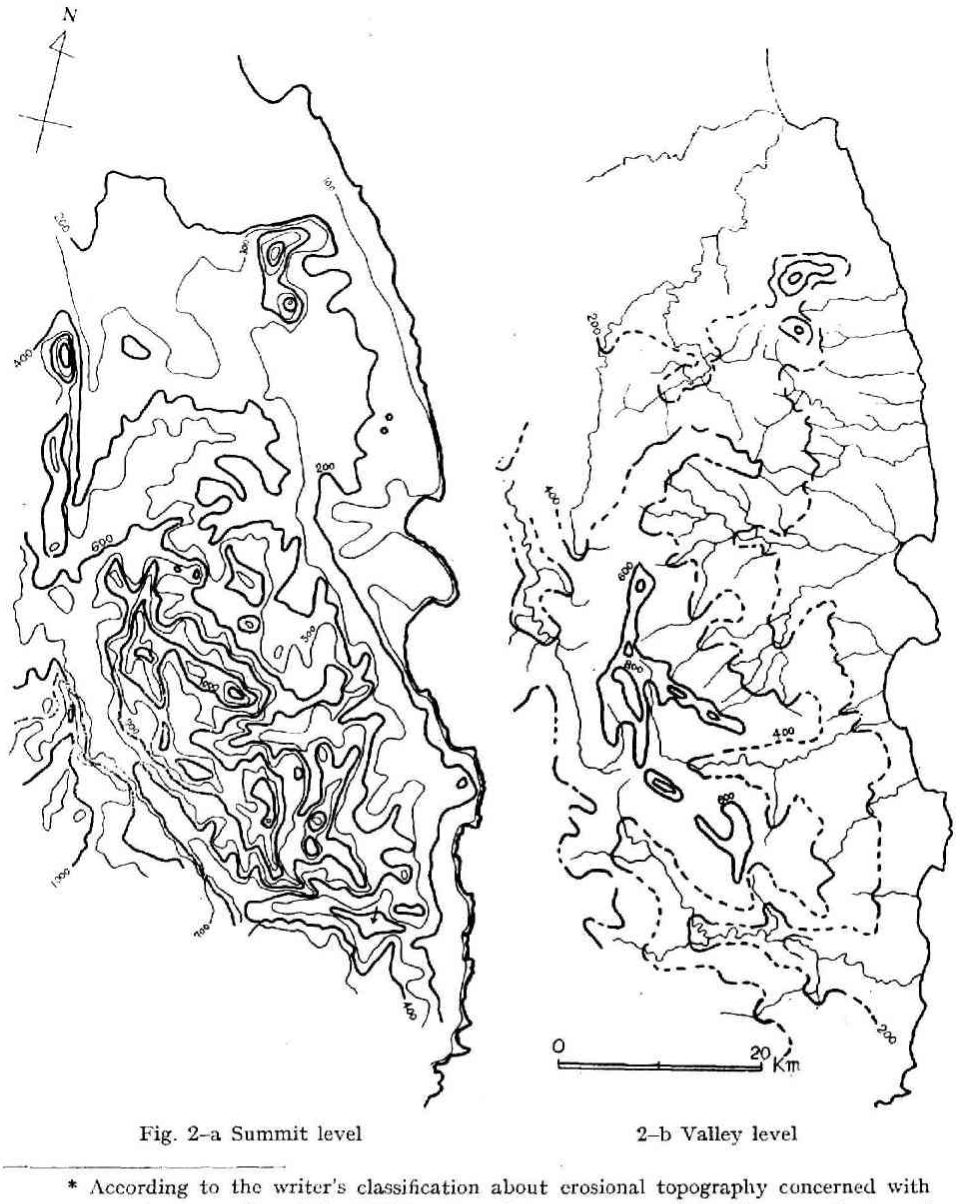


Fig. 2–a Summit level 2–b Valley level

* According to the writer's classification about erosional topography concerned with the degree of preservation of the initial surface, A-type has some flat surfaces on the top of surface, B-type remains as a ridge with an accordant height, and C-type is an isolated pinnacle with a similar height (Nakamura, 1963a, p. 87).

initial surface preservation, and they are distributed at outer extentions of B-type ridges. Although they have a similar altitude of about 700 m, it is not sure that the initial surface had occupied just such a height in this area. On the other hand, the drop of the upper peneplain surface from 1100m to only 700m northward seems too large, but it may be natural because of a distance of 30 km from south to north. On the remnants of the upper peneplain in this region, flat surfaces of A-type, which are often observed in the central part of the Kitakami Mountains, are less developed only at Hiraniwa pass and Suzu pass (Fig. 1), and this means that the upper peneplain has been almost destroyed in the region.

2) The lower peneplain surface is a vast erosion surface cutting the Paleozoic rocks at 500–300 m above sea-level (Fig. 2a). The Ninohe Surface (Matsuyama, et al., 1962) is probably equal with this surface. Upon the summit level map this surface looks very flat, but in reality it is not so flat and has regional variations. At the southern area of this surface neighbouring to the central part of the Kitakami Mountains, it reaches to about 500 m in height and is dissected by valleys more than 200 m deep. These valleys are mainly "*Sohlen-kerbtal**" type (Louis, 1960, 61).

The surfaces have been dissected into ridges with an accordant height (B-type), and no more preserve the initial surface as A-type. Somewhere at the middle flank of valley wall, develops a piece of the hill-foot surface, e.g. at Kawai, Shizugawa (Fig. 6-B). Downstream from a major knickpoint in dissecting valleys (Fig. 3), the relief increases abruptly to more than 300 m.

On the contrary at the northern half of the region the lower peneplain surface descends to the height of 300 m, while the drop of valley floor is not so great, and therefore, relief in most areas is less than 100 m. Ridges and interfluves hold A-type preserving the initial surface as a rather extended and rounded divide, a waving or rolling surface with a small relief.

The surface is covered with younger volcanic deposits whose members are pumice, sand and ash alternately with total thickness of about 3–1,5 m. Beneath them black soil and thin layer of rock fragments directly cover the bed-rock (Fig. 4). About the volcanic deposits some researches are continued by a few geologists (Matsuyama, et al., 1962). Dissecting valleys belong to concave sloped valley type (translated from a German term "*Flachmuldentaltyp*" by the writer, 1963a), and partly to "*Sohlen-kerbtal*" type with a gently declined valley wall. Exceptionally at the attack side of meandering stream, the lower peneplain surface makes a steep scarp (east to Ōno, and right side of the Setsukinai river, etc.). Where the drainage system is well developed and has a fine texture upon the lower peneplain

* In the following chapters German terms are used in italics.

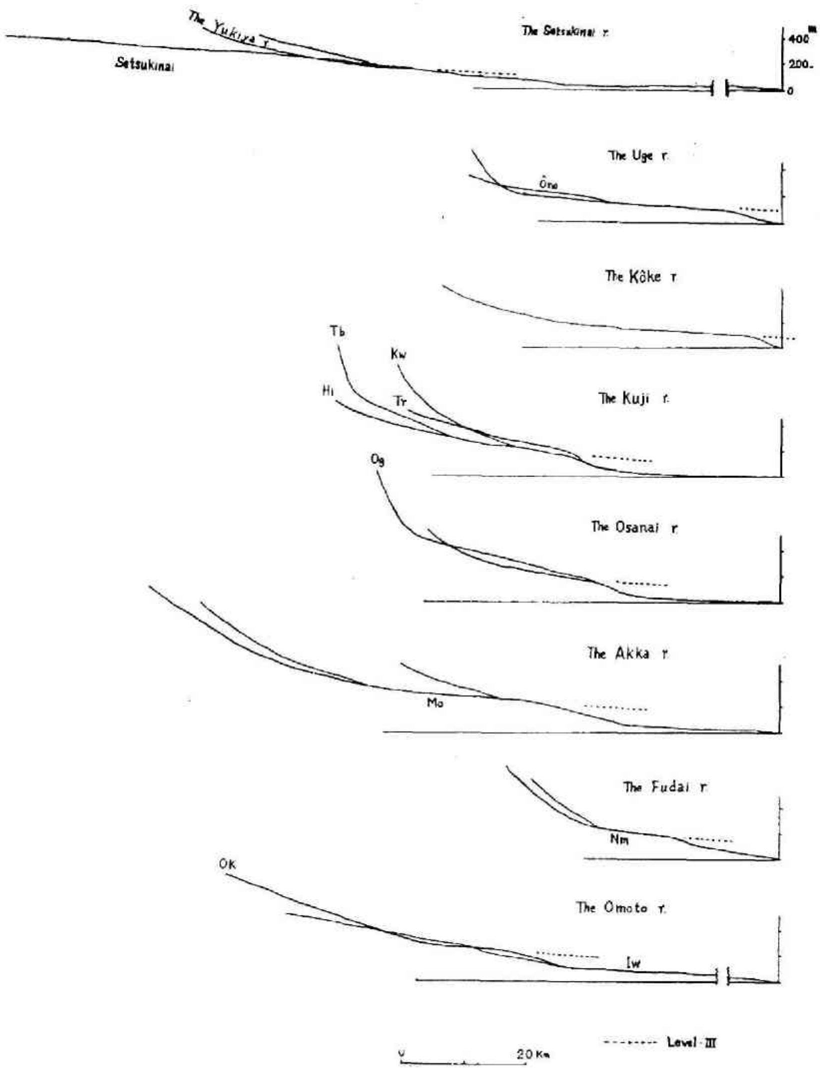


Fig. 3 Longitudinal profiles of dissecting valleys
Iw: Iwaizumi, Mo: Motomura, Nm: Numabukuro, Hi: the Hinosawa r., Kw: the Kawai r., Og: the Oguni r., Ok: the Ôkawa r., Tb: the Tôbetsu r., Tr: the Toromachi r.,

surface, the ridges are transformed to many small knobs. Judging from an altitude frequency of these knobs in 100km² west to Ôno shown in Fig. 5, the lower peneplain surface seems to have been at 400–320 m in this area.

Difference of height between the surface and Kunohe terrace is less than 100 m,

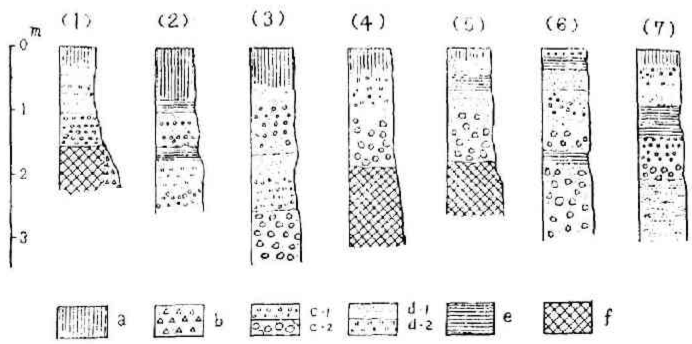


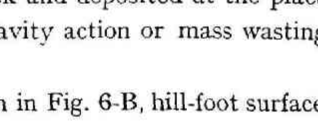
Fig. 4 Sections of the hill-foot surface
(1) Ôhira, Loc. 6 (2) Daidôguchi, Loc. 1 (3) Tsurugai, Loc. 2
(4) Shizugawa, Loc. 11 (5) Hiranai, Loc. 9 (6) Sane, Loc. 8
(7) Tsujigasawa, Loc. 5
a: surface soil, b: detritus, c–1: gravel (pebble), c–2: gravel (cobble-boulder), d–1: sand, d–2: sand with pumice grains, e: silt or clay, f: bed-rock (slate, limestone, granite, etc.)

so the uplift that followed the formation of the lower peneplain must be small.

3) The hill-foot surface is a gentle slope, which develops like a pediment along the dissecting valleys. On the Abukuma Plateau, the writer has considered it as a level index to represent the erosion surface (level III, Nakamura, 1960), and T. Wakô named such a surface a gentle slope behind the terrace (1961, 62, 63a), and Y. Akagi treated it as a pediment (1961, 62). The writer would use a new term "a hill-foot surface" for these analogous features. Owing to observations at some locations (Fig. 4), their profiles have a common aspect; that is, from upper slope to lower, a series of surfacial mantles covers the bed-rock, they are surface soil black or dark brown in colour, 20–30 cm, and angular gravels, cobbles or fragments of granite, sandstone, slate, etc., mostly 0,5–1,5 m thick, which must have been produced by weathering and decomposition of bed-rock and deposited at the place, by the way of perhaps not a normal fluvial but a gravity action or mass wasting, judging from angularity and bad sorting of gravels.

Along the Tôbetsu and the Kawai rivers, as shown in Fig. 6-B, hill-foot surfaces

Fig. 5 Altitude frequency of the lower peneplain surface, west of Ôno, N: number of smallest closed contours within each 40 m of altitude in 10 km × 10 km area on the topographical map "Rikuchu-Ôno" (1: 50,000)



are continuous from back slopes with gradient 5–7° at their lower parts, and are terminated as small scarps. An area of each segment of the surface extends about 100 m × 100 m, and is often combined each other. The existence of soil or relict soil beneath the volcanic deposits and, at the same time, upon the veneer of rock fragments means that there had been a long time passage since the formation of the hill-foot surface.

Usually the surface has a waving form, not always a flat surface, so the veneer is thicker at the surface bottom than at the surface top, and at the latter sometimes fragment layer is missing. But the volcanic layers are almost uniform, and are not concerned with their locations on the waving surfaces, but are controlled by distance from their origin, probably Towada Caldera (Fujiwara, 1962).

Though most hill-foot surfaces are cut by dissecting valleys, exceptionally at some places an initial form of the surface is free from dissection. This case is limited only at the small tributaries, e.g. near Ôno and Tamagawa. The writer sketched such a form at Nagura on the Abukuma Plateau (Nakamura, 1962, p. 53). A great many tributaries of dissecting valleys join to a major valley in discordance. As a reason why such small tributaries often could contain a hill-foot surface preserved from erosion, the writer considers that in such a case a dissecting agency or an erosive power of stream may be so weak that it can not cut any more, because of its location near the divide and of less supply of water into channel. In short, a distribution of a preserved hill-foot surface depends upon the location whether a tributary has an enough potentiality to cut and widen a valley floor or not.

Northward declination of the level above which the hill-foot surface was built is more gentle (100 m/30 km) than of the upper (400 m) and the lower (200 m) peneplain surfaces.

At Nakakubo, upstream the knickpoint dividing the level-III and the level-IV, the hill-foot surface is cut by gorge of the Tôbetsu river (Loc. 11). Back slope of the surface is steep and has a linear profile in the southern area but is gentle and continuous to the surface in the north. The writer supposes that the type of dissecting valleys which developed on the peneplain surfaces and at the same time formed the hill-foot surface is different to the north and to the south of the region, considering a contrast of distribution of two types of valleys in each area, concave-sloped type to the north and "*Sohlen-kerbtal*" type to the south. On the central part of the mountainland also "*Sohlen-kerbtal*" type is dominant in the stage of dissecting the lower peneplain surface, but the writer found that concave sloped valley developed in the same stage particularly in the northern area. For the reason of this coexistence of the two in the mountainland, the writer deduces it significant that relief between the lower peneplain surface and the level-II (described later) is larger to the south than to the north. Of course for this deduction there is a premise that a concave sloped valley develops in an area with small relief and the other in an area with large relief.

The level or niveau which produced the hill-foot surface played a very important role to modify the region in detail, for it established the outline of the erosion basins by the way of dissecting the peneplains.

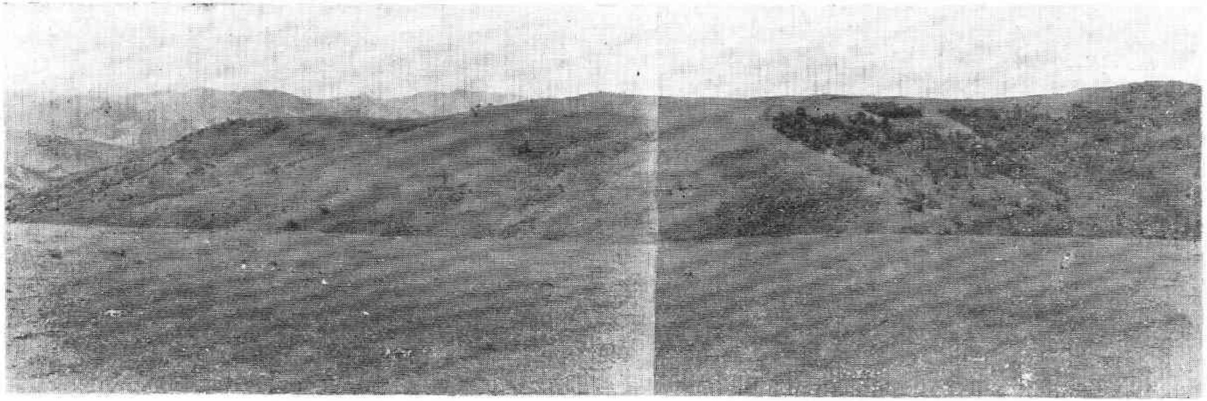
4) The valley plains are distributed only in an area above the knickpoint, contrasting with existence of the hill-foot surface in down stream area in some places, accordingly their origin is thought to be erosion basins which were built during a stagnant retreat of the knickpoint. On the present floor, bed-rocks are exposed place to place, and alluvium on the floor is rather thin, for example, at Ôno a boring stick reached to the granite only 50 cm beneath the surface.

At Seki and Oguni, a series of growing fans (Tomita, 1955) is being built. At the outlet from the mountains to the valley plain of the Tôbetsu and the Oguni rivers, the gravels in various sizes are deposited, now and these valleys make aggradated streams, so most of the water permeates into ground. Additional valleys in this area, even belonging to the level-III, still continue to dissect the mountains.

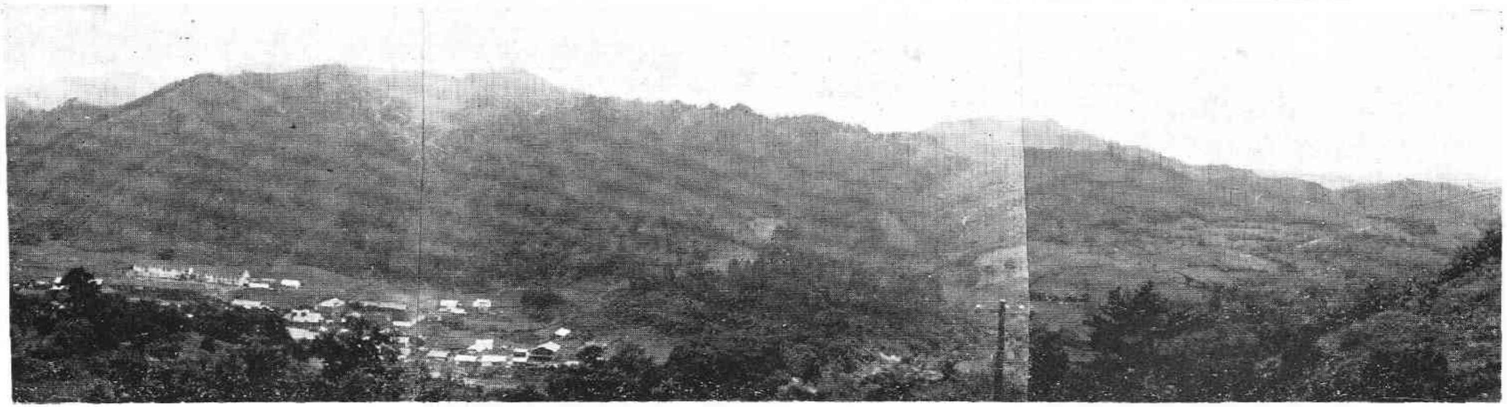
On the contrary, however, in the northern area valley plains developed near the divide with a fine textured drainage system have a "*Kerbtal-*" and "*Sohlen-kerbtal*" types cutting the hill-foot surface and often the lower peneplain surface directly. The development of the valley plains to the north may be owing to a less uplift of the land after the hill-foot surface had been formed, and the area as a whole seems to have reached in a stage of "ridge and ravine topography" (Hack, 1960).

III. Base levels of erosion in the region

To discuss an erosional topography it is inevitable to introduce a concept of the base level of erosion, but its application is difficult because it is an assumed concept and is not indicated with substantial heights or distances from the sea. Now the writer is going to treat this concept after following modifications on its original meaning for the purpose of simplification. He tries to represent the hypothetical or supposed existence of "the base level of erosion" by the valley floor level which is a result of morphological development until present and which, at the same time, controls the changes of landforms today. It is sure that in a closed area a relief is determined by a vertical difference between the top of slope and the valley floor, so the valley floor is a main factor that makes relief variable. In short, the relief distribution of an area is controlled by the present valley floor level, and was controlled by the foregoing one. Additionally the distribution of various forms of



← Fig. 6–A



↑ Fig. 6–B

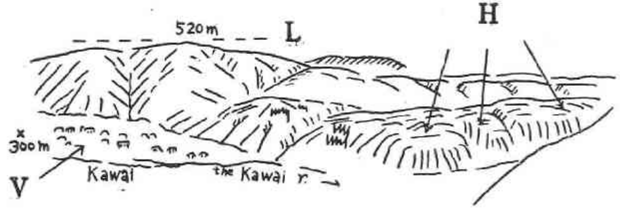


Fig. 6-A The upper peneplain surface, Mt. Tatara-dake (971 m) viewed from Hiraniwa pass.

Fig. 6-B Near Kawai, Loc. 10, L: the lower peneplain surface, H: the hill-foot surface, V: the valley plain of the Kawai river.

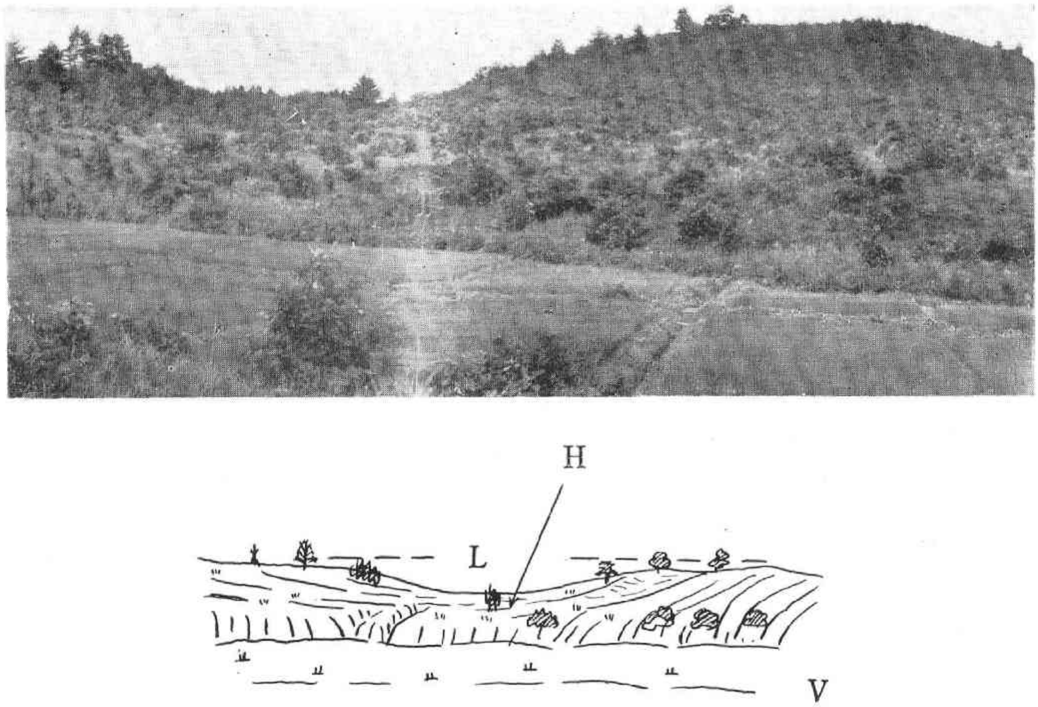


Fig. 7-A Ippon-yanagi, about 3 km northwest of Ôno, Loc. 4, L: the lower peneplain surface, H: the hill-foot surface, V: the valley plain of a tributary of the Uge river.

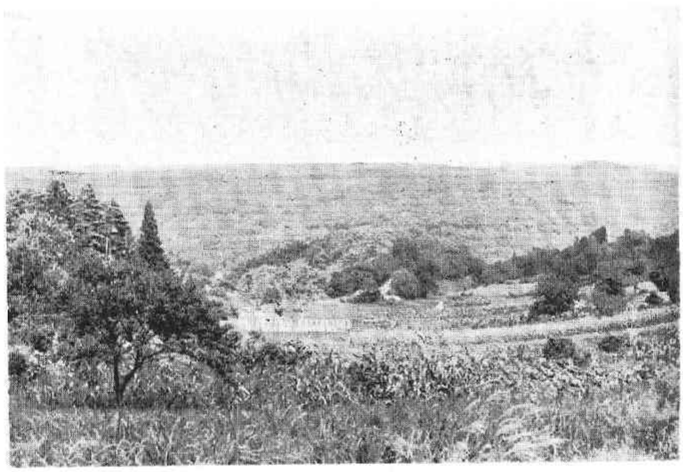


Fig. 7-B The lower peneplain surface and the hill-foot surface (foreground), viewed from near Esashika (Loc. 7)

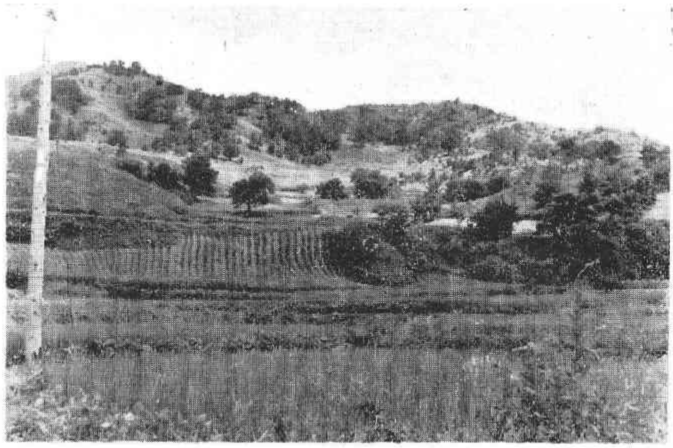


Fig. 7-C Sasawatashi, about 10 km northwest of Ôno (Loc. 3), the hill-foot surface is terraced.

valleys — V-shaped, *Sohlen-kerbtal,* or concave sloped valley, etc. — means a regional variation of geomorphological development.

Upon this point of view the writer would pay an attention on these matters. At first, there are for levels (in following sentences "level" is used instead of "the base level of erosion") named the level-I, -II, -III, and -IV from upper to lower. About the areal range of the level, the writer considers that two sections separated by a knickpoint belong to different areas each other, for instance, Seki, Kawai, and Hinosawa areas belong to upstream (the level-III), different from Kuji area included in the range of the level-IV.

Four levels and their relations to the surfaces

Connecting the knickpoints dividing the areas of the level-III and -IV to distinguish the dissected area by the level-IV from the undistinguished area, figure 9 and table 1 were gained. "S" is total drainage area of a river, and "S_0" is the area that still remains out of influence of the level-IV. The Osanai, the Fudai, and the Omoto rivers have S_0/S under 60%, the Uge and the Akka rivers have more than 70%, and the others have within 60–70%. Roughly speaking, the northern rivers have larger S_0/S than the southern rivers, and this means that the degree of dissection based on the level-IV is uneven, more to the south and less to the north. On the other hand, preservation of the upper peneplain is better to the south, and of the lower peneplain and of the hill-foot surfaces are better to the north, in accordance with the present dissecting condition.

Describing as to the relation between the level-III and -IV, the profiles of slopes in the level-IV area are linear and steep with large relief, and remnants of the

Table 1. Ratio of preserved area to total area of drainage basin S_0 is area above the knickpoint, and S is a total area of each drainage basin.

Rivers	S (km^2)	S_0 (km^2)	S_0/S
the Setsukinai	82,8	55,6	67,1
the Uge	95,2	74,0	73,8
the Kôke	66,4	44,4	66,6
the Kuji	283,0	191,0	67,6
the Osanai	214,0	93,2	43,5
the Akka	215,0	168,0	78,2
the Fudai	84,0	40,4	48,0
the Omoto	752,4	447,2	59,4

level-III are found on flanks of slopes contrasting with existence of some residuals of the hill-foot surface recognized on slopes. Owing to this fact the level-III must have been formed as a local base level during standing or stagnant retreats of the knickpoints. The existence of the hill-foot surface in the level-IV area is an evidence that the level-II is free from present positions of the knickpoints and is the level of a foregoing cycle of erosion. Consequently the level-III and -IV are simultaneously developed in the region, but they have geomorphologically different effects to modify the landforms.

The level-II is very important, as previously mentioned, in the sense of accompanying with the hill-foot surface. The level-I is actually preserved only upon ridges or passes as a form of a concave sloped valley and in the broad area of the vanished level-I it may have produced the lower peneplain surface.

IV. Hypothetical concept of "the potential relief"

For the interpretation of present relief distribution, the writer would propose the concept of the potential relief, which is determined as a difference of heights between the initial surface and the valley level upon which valleys dissect the initial surface. Usually real relief accesses to the potential relief at first, and reaches it in the stage of the maximum relief, then diminishes after the initial surface disappeared. When an interruption such as a lowering of sea-level happens, the potential relief changes unconcerned with real relief at that time depending upon the manner of the interruption.

Now when the potential relief is rather large, dissecting valleys may transform themselves according to a series of V-shaped—*Sohlen-kerbtal*— concave sloped valley type, and when it is small they may reach to concave sloped type directly. In the case of the northern half of the Kitakami Mountains, the potential relief is apparently large to the south and small to the north.

Relief distribution and the potential relief

Where the upper peneplain widely remains, relief is larger and especially where the knickpoint has much retreated upstream, it gets more than 500 m/km², for example in the drainage basin of the Fudai and the Omoto rivers. On the contrary, along the Uge and the Kuji rivers, where the knickpoint has not yet retreated much, the relief is moderate (100–200 m). To connect the upper limits of the hill-foot surfaces, a boundary is drawn which distinguishes the still effective section of the level-II from no more effective section. Most of the Kitakami Mountains is now dissected by the valleys based not on the level-I but on the level-II and -III. It is interesting that, though absolute values of reliefs are equal each other, their qualities are not always the same, and considering this fact the writer classifies the reliefs of the region as follows.

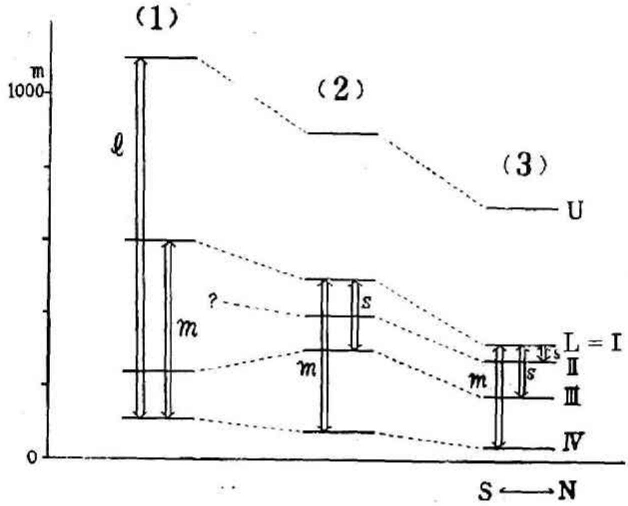


Fig. 8 Schematic profile of relief distribution
(1) drainage basins of the Omoto, the Fudai and the Akka rivers
(2) of the Kuji and the Osanai rivers
(3) of the Uge, Kôke and the Setsukinai rivers
U: the upper peneplain surface, L: the lower peneplain surface, I–IV: the level-I—IV, l large relief area, m: moderate relief area, s: small relief area.

1) large relief area — a result of the combination of the upper peneplain surface and the level-IV (U+IV)

2) moderate relief area — U+II or U+III, or L (the lower peneplain surface

including the hill-foot surface) +IV

3) small relief area — U+I (rarely distributed), and L+II or L+III

Regionally the case 1) coincides with the southern area of the region, the case 2) with the middle (the drainage basin of the Kuji river), and the 3) with the northern area. Remnants of the initial surface, particularly of the lower peneplain and the hill-foot surface, are preserved as a form of A-type in the case 3), of B-type in 2), and of C-type in 1). The upper peneplain now diminished may have been preserved in the manner of present lower surfaces.

Thus the present distribution of various landforms is concerned with the correlative combinations of the surfaces and the valley levels, in other words, the nature of relief of an area is determined by the location, the area occupies concerned with the potential relief in the region.

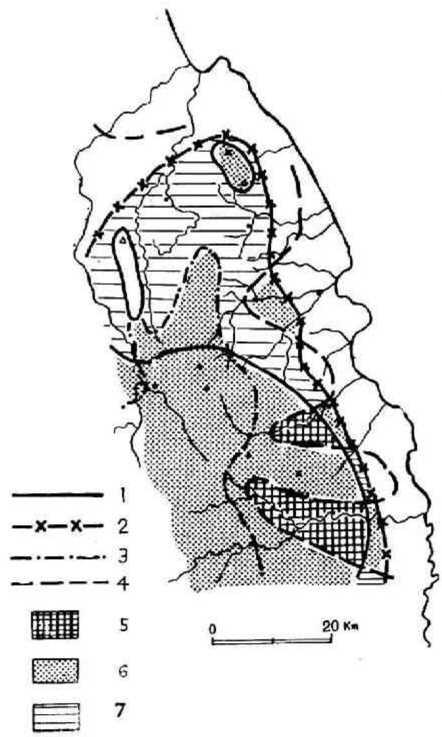


Fig. 9 Relief distribution
- 1: outer boundary of the upper peneplain surface
- 2: outer boundary of the lower peneplain surface
- 3: upper limit of the level-III
- 4: upper limit of the level-IV
- 5: large relief area
- 6: moderate relief area
- 7: small relief area

Also the geomorphological development of the region consequently can not be out of this condition. As to the geomorphological development of the region, the writer would introduce this concept. At first, the upper peneplain surface was built there, but about the reason why and when this surface was formed the writer is obliged to agree with the opinion that the whole area of the Kitakami Mountains had been under a subaerial denudation for a very long time under intermittent epeirogenic uplfits, since the pre-Tertiary orogenic movements in the region (Hanzawa, 1954, et al.). As to the stepped erosion surfaces in the world, many authors have described, for instance, on the Ural Mountains (Varsanof'eva, 1956), the Kaukasus (Dumitraško, 1956), the Tenshan (Ličkov, 1956), and correlative studies on the world wide spread erosion surfaces (Geyl, 1961, Meshcheryakov, 1963), etc.

After the upper peneplain surface was uplifted, dissecting valleys developed and the lower peneplain surface was formed. And later there may have appeared an equilibrium in the process of dissection, and at that time the stepped erosion surfaces (or staircase morphology, Nishimura, 1963) were established and have remained. The process in which the upper peneplain surface had been dissected to the lower peneplain surface is considered to be a down wearing about which Mino described on the Abukuma Plateau (1942), for concave sloped valleys which are thought as an index to the process of down wearing are distributed in a large scale in the central part of the Kitakami Mountains (upon the level-I, and -II). On the other hand, at the present the Mountains suffer dissection in the way of lateral retreat of slopes, for valleys now dissecting are mainly V-shaped or *Sohlen-kerbtal* type upon the level-III or -IV. After the second uplift the Mountains began to be affected by dissection and to permit a formation of the initial outline of erosion basins. Now it is recognized that the second uplift followed a tilting or upwarping tendency declining northward, and the gradient of the level-II nearly horizontal, thus the potential relief was much more to the south than to the north. Consequently at the northern area A-type preservation of the lower peneplain surface and concave sloped valleys are characteristic, in spite of its close location to the lower base level of erosion.

Here arises a question whether there is any special structural control that has dissected so completely in the area to the north. The writer would answer to this question as follows; that is, though the drainage pattern is affected by the geological structure to some extent, in most areas of the region the erosion surfaces are widespread without relation to the various kinds of the Paleozoic rocks except at some granite areas. So the lower peneplain surface probably developed by means of down wearing of surface from the outer part into the inner part of the upper peneplain surface, and in this process no special condition was effective.

As to the problems which should be studied later, the writer would propose as follows: 1) How is the hill-foot surface correlated to the terraces in the lowland plains around the Mountains? Perhaps it may be associated with the Kunohe terrace at the northeastern margin of the Mountains. Furthermore what a significance has the level-II which is accompanied with the hill-foot surface in the region upon the process of development of the mountains or hill-lands in whole Japan? It may be connected to the dissecting valleys preserved in high level at hill-land, for instance, at the Nonodake Hill in Miyagi Prefecture (Nakamura, 1963b).

2) It is important for determination of a potential relief that an initial surface and a valley floor level as a base level of erosion must be accurately pointed out. Is there any more effective method for it besides the present field survey, map analysis, and photo interpretation?

3) In the mountains or hill-land, usually main streams are easily caught into the lower level in the manner of rejuvenation of erosion (by a rapid retreat of knick-point on valley floor), but the landforms belonging to the level of a previous cycle of erosion are often well preserved at the small tributaries or at the most upstream area of a stream. Thus we have a vast room for study about the morphology of tributaries and of upstream area of dissecting valleys in mountainlands.

V. Conclusion

According to the above mentioned matters the writer arrived at the following conclusions:

1) Four surfaces develop in the northern part of the Kitakami Mountains. They are, from upper to lower, the uper peneplain surface (1100–700m) preserved on the rugged ridges or in form of pinnacles with a similar height, the lower peneplain surface which develops around and cutting in the upper one, and both declining toward the north, the third is the hill-foot surface which develops along the foot of valley walls. It is an erosional surface cutting the bed-rock and is covered with a veneer of rock fragments, and is scattered. The last is a valley plain, that extends above the knickpoint and cuts the upper surfaces. Its origin is of erosion basin with reference to a stagnation of upward retreat of the knick-point and the plain is covered with only thin alluvium.

2) At the same time the writer classified four levels actually existing as local base levels of erosion in the region. The level-I is represented by concave sloped valleys, now rarely preserved on the mountains or ridges, and seems to be a base level for dissection of the upper peneplain to transform into the lower peneplain. The level-II is followed by two kinds of valleys, concave sloped valleys in the northern area and V-shaped and *Sohlen-kerbtal* type to the south. Upon this level the erosion basins in the region were formed. The level-III is a local base level existing above the knickpoints and upon which the valley plain is built. The level-IV is continuously extended from lowland plains, and divides the upper levels by the clear knickpoints at 150–280 m above sea-level.

3) These surfaces and levels are just correlated to the ones in the central part of the Kitakami Mountains, but the degree of their preservation and the relief distribution are not the same as there, less preserved and of various reliefs in this area.

4) The factor that the writer believes most important in determining the relief distribution is the potential relief, which is derived by a combination of two elements with different heights at an arbitrary location, the initial surface and the valley floor level.

5) From this point of view the region is divided into three zones ;

a) large relief area — U+IV (southern area, V-shaped valleys prevailing, as in the drainage basin of the Omoto river)

b) moderate relief area — U+II or U+III (Kawai, Seki), L+IV (downstream area of the Kuji river)

c) small relief area —U+I (Hiraniwa pass), L+II or L+III (northern area, concave sloped valleys prevailing)

Of course the determination of the potential relief itself is influenced by lithological condition, crustal movement, relative location to sea-level and sometimes by changes of sea-level or climatic conditions, but these agencies are seemed to be effective only to modify and transform the landform into a more complex feature as is seen at the present time.

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