Relief Distribution in the Aizu Mountains

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Yoshio NAKAMURA

In the dissecting processes of mountain areas, relief development must be different from a place to another owing to several regional conditions. Here the writer is going to use the term "relief" as a concept that implies not only height difference between top surface and valley floor, but also certain morphological evolution and locational character of an area. To understand mountain morphology, it is significant that we treat the relief combining the height difference with slope form, slope gradient, valley density on the slopes etc. (Louis, 1957, 63, Tada, 1934). An area of large relief, for example, often has steep, linear, and less dissected slopes, sometimes has gentle and concave slopes, and at another time may have a double curved slope with a sharp knick on ridges. On the other hand, even in an area of small (or low) relief, steep slopes develop in a small scale as terrace scarps, at the same time gentle slopes as hill-foot surface (Nakamura, 1964). How does a relief change itself according to the dissecting process in the mountain areas, and what regional conditions can determine such a relief evolution? Slope forms and their development at some places seem to be closely influenced by relief condition which is induced primarily from a kind of spatial relation like height difference, horizontal distance from a base level of erosion of the area, besides lithological, structural, and other factors. In the last few years the writer has studied on mountain morphology and hill-land forms, especially on the mountains with small relief as Abukuma and Kitakami Mountains (Nakamura, 1960, 64, etc.). In the present paper he would present his opinion on the relief distribution in the central part of Aizu Mountains as an example of middle relief — about 500–1000 m — mountains.

This mountainland is situated at the bending point of Honshu Arc, and makes northeastern part of Mikuni Mountains. At the eastern part it is covered with volcanic deposits of Nasu Volcanoes, and to the south also with those if Nikko Volcanoes. Drainage system consists of two valleys; the Tadami and the Okawa Rivers, both join to the Agano River at the northwest corner of Aizu Basin, flowing into Japan Sea. On the mountain tops, it has been said, develops a summit level with an accordant height about 2000m, suggesting an uplifted peneplain (Tsujimura, 1952). Based on the writer's observations, as H. Sato described (1954), the summit level includes many surfaces in the area, in addition to several valley levels in different heights. Thus relief distribution in this area is complicated indicating a multicyclic, or staircase (Nishimura, 1963) feature.

After pointing out geological and structural background, and an outline of the landform of this area, the writer will classify the surfaces and valley levels in five sections and discuss the geomorphological development of the area. The relief distribution is understood as a consequence of landform evolution. Although along the mid-stream of the Okawa River and near Tajima many terraces are distributed, as well as some interesting landforms like a compound fan, the writer can say nothing on them in this paper, because of the lack of data.

I. Outline of geology and structure

Western part, about one third of the area, mainly consists of Paleozoic slate and sandstone (Permian), which belong to Chichibu Paleozoic Series (Fujimoto, 1951, Hanzawa, 1954, Nishioka, 1963, Kikuchi, 1964), and partly of granite intruding them*. And this part is characterized by the coexistence of many ranges mostly running in N-S direction and many deep-cutting valleys in the same direction. The distribution of deep, parallel valleys, judging from the scarcity of rectangular branching seems to be the result of adjustment to the strikes of the structure, which may be traced from vicinity of Aizu Basin (Suzuki, 1951). Central part of the area, along the Ina Rvier, a large tributary of the Tadami Rvier, is composed of Tertiary sandstone, tuffaceous sandstone, silt and conglomerate etc., liparite and agglomerate due to certain Tertiary volcanism are also exposed. In the northern half of the area develops dacitic welded tuff formation dated in late Pliocene or early Pleistocene (Kobayashi, 1944), and is distributed widely and continuously on ridges northward to the southern fringe of Aizu and Inawashiro Basins. This tuff formation lies under Nasu Volcanoes as their bedrock and is exposed again eastward in the piedmont area of the volcanoes (Shiki, Saito, and Hatano, 1959). Here and there the dacitic tuff makes plateau-like topograpy about 1500–1000 m above the sea level, so the writer uses "dacite plateau" according to K. Fujiwara and T. Takahashi (1960). Additionally we find some terraces and terrace gravels on them along the streams.

Four fault lines are known with parallel strike N-S around Aizu Basin, but they disappear at the southern margin of the basin and are not traced into the mountains. Apart form them, fault lines in NNE-SSW strike run along the upper streams of the Okawa and the Ina Rivers and some of their tributaries. In the area neighbouring

* Referenced geological maps; 1: 200,000 Fukushima, and Niigata Pref., 1: 300,000 Kanto District, and 1: 50,000 Hiuchigatake and Nantai-san Quadrangles

to the south, Pleistocene volcanoes, Mt. Hiuchigatake, Nikko Mountains, cover the Paleozoic strata whose upper surfaces are relatively high deduced from the evidence at a fall on the Tadami River in the Oze Moor. In whole periods since Neogene Tertiary, this area must have been under subaerial condition and tectonic movements occurred only epeirogenic to produce the several levels of surfaces. It is presumed, however, that some block movements may have dislocated the separated surfaces to different altitudes in relation to fault lines (Sato, 1954).

Now these geological conditions contribute the area with such a significance that indicates when the surfaces supposed from ridges with similar height were formed and when the drainage system was formed. Climatologically, this area

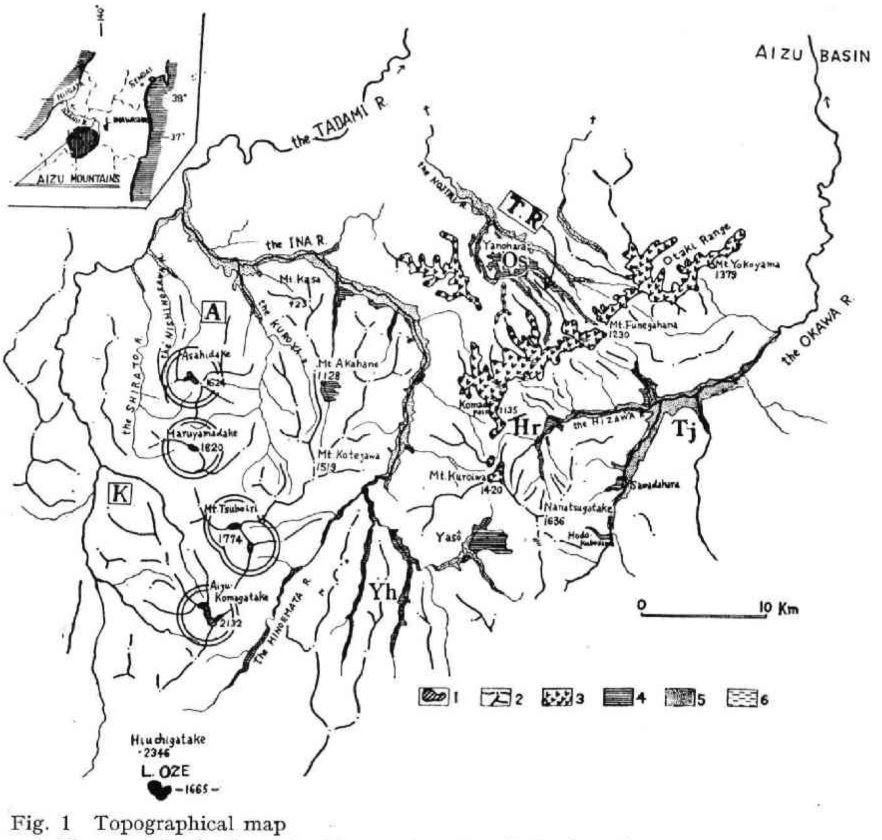


Fig. 1 Topographical map

1. Komagatake Surface 2. ridges and peaks 3. Dacite Plateau 4. Oashi, Haryu, and Yunohana Terraces 5. valley plain 6. swamp

A: Akahane Surface area K: Komagatake Surface area T.R: Takamatsu Range Hr: Haryu Os: Oashi Tj: Tajima Yh: Yunohana belongs to a deep snow region of Japan, and the snow is usually preserved on mountain tops during more than half of the year. Plenty of rainfall in summer, in addition to melting water in spring, works as a strong agent of active fluvial erosion which sometimes gives rise to landslides on slopes or floods over valley plains.

II. Surfaces and valley levels in each section

1) Komagatake Surface (2000–1600 m)

Distribution of some size is limited to the mountain tops of Mt. Aizu-Komagatake (2132 m), Mt. Chumondake (2070 m), Mt. Maruyamadake (1820 m), Mt. Asahidake (1624 m) etc., but the level of the surface is observed clearly on ridges, declining northward as a whole. On the divide near the crest of Mt. Komagatake gentle slopes and small ponds are found. Slopes are covered with thin soil weathered from the bedrock, and at some places the bedrock is exposed. This mountain block is located between the Tadami and the Ina Rivers (here it is named K-Block after Mt. Komagatake), and is dissected by their tributaries which deeply cut with a relief of about 1000m. Valley slopes are steep and straight, just have an equal height to the local relief itself. Summit level lowers gradually to the north in Paleozoic and granite area but suddenly becomes flatter in Tertiary area, at 1100–900m (Akahane Surface), somewhat lower than the former. This means that after K-Surface (in short in stead of Komagatake Surface) had been formed a level of about 1000 m altitude prevailed here, upon which K-Surface was once suffered the dissection. Present dissecting streams are based on the much lower level — of the Tadami and the Ina Rivers —, but they are in V-shaped valleys upstream even near the divide, and flow intrenching the terraces downstream. In other words, the valleys have a distinct point at their mid-stretches, in upper section they are V-shape and in lower section they have valley plains actually terraced by cutting channels. Upstream increase of the altitude of valley floors is 550 m/18 km by the Shirato River from its confluenting point to the Tadami to the foot of Mt. Maruyamadake, 400 m/12 km by the Nishinosawa to Mt. Asahidake, 600 m/20 km by the Kuroya from the Ina to Mt. Tsuboiri (1774 m), 300 m/13 km by the Shionomata to Mt. Kotezawa (1519 m), etc. On the other hand increase of altitude of ranges is 800m/20 km from a peak of 942 m–Mt. Asahidake-Mt. Maruyama-Mt. Tsuboiri, 600 m/12 km from Mt. Kasa (923 m)–Mt. Akahane (1128 m)–Mt. Kotezawa, etc. At the summit level (almost equal to K-Surface) and the valley rise parallel to south, relief is roughly constant elswhere within 600–1000 m range.

On the valley floors, although streams flow in narrow channels cutting the terraces or often in gorges, knickpoint meaning a certain abruption of valley

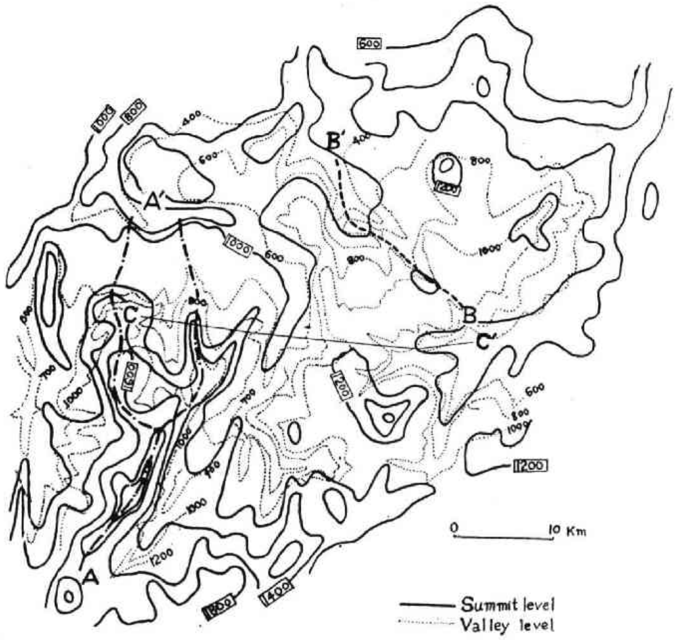


Fig. 2 Summit level and valley level (AA', BB', CC'······c.f. Fig. 4)

development and bringing a step-like feature to the distribution of valley levels is not found in this block. High leveled floor does not exist with a few exceptions partly on K-Surface. Consequently there is no more large potential relief than, for instance, Kitakami Mountains (Nakamura, 1964). The potential relief once existed through the period of valley development since the uplift of this block has been changed into real relief.

2) Dacite Plateau (1500–1100 m)

Dacite or dacitic wedled tuff formation widely covers the northeastern part of the region, and morphologically it is in an advanced stage of dissection showing mesa-like table land here and there. Where it does not take such a form, it constructs broad ranges with an accordant height. Rocks are very hard and compact with many vertical joints, suggesting that the core area of the plateau must be a spatial origin of its eruption. On the table land, there develop some shallow valleys and many swamps. Valley slopes are very gentle, densely covered with forest and the relief is less than 100 m. Most swamps on the plateau are situated near the valley head where many small streams gather into a draining valley. This section is divided into following three subdivisions. a) Funegahana-Otaki Range — Mt. Funegahana (1224 m), Mt. Gozengatake (1233 m), Mt. Yokoyama (1379 m) and others make a broad divide 1 km wide, running NE-SW with some rectangular ridges. The plateau has steep side slopes clearly breaking down from its edges. On the west side of Mt. Funegahana, 1140–1000 m in height, there is a swampy valley floor about 1.5 km long, which may be a remnant of the ancient floor indicating the previous level of erosion correlated to the lower surface developing on the rugged ridges around the plateau and on the flanks of the plateau side slopes (1000 m level, surely equals to Akahane Surface in K-Block (Fig. 4). Morphologically it is conspicuous that there are gentle and less dissected slopes on the plateau (e.g. with swamps) and steep slopes much dissected by a great number of ravines. The former is induced from a little difference of altitude between the plateau level and the 1000 m level, and the latter from a large one between the plateau level and the lowland level (later described). b) Komado-Kijigoya Range — At the height of 1160–1120 m a flat table land widely spreads with low relief, rolling surface and a lot of swamps on open valley bottoms. Slope forms are like the Funegahana Range. A deep cutting stream penetrates here from the Hizawa River, and separates this range from the Funegahana at Korobushi Pass (1115 m). c) Kuroiwa-Nanatsugatake Range — Table surfaces are narrower often making knife ridges. Mt. Nanatsugatake (1636 m) protrudes on the level.

3) Oashi Basin

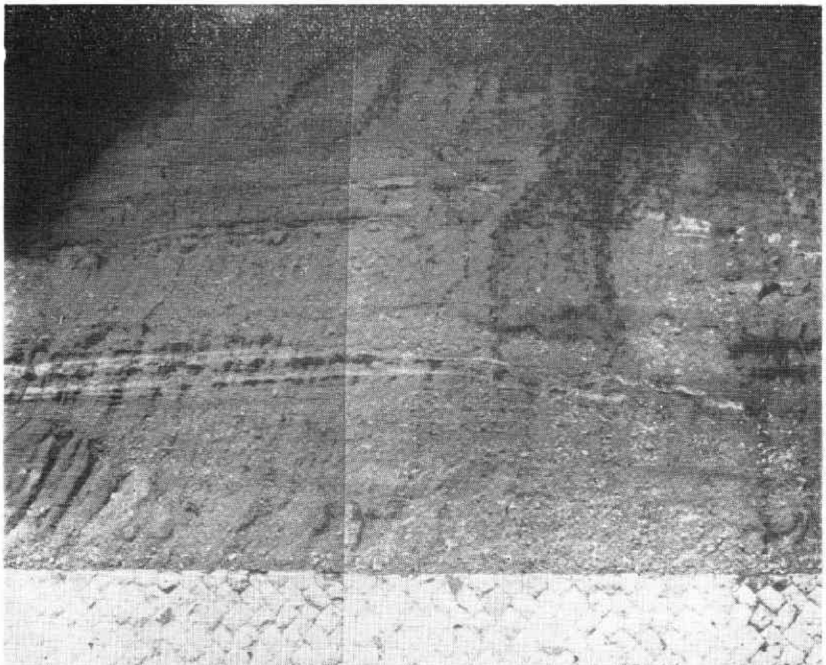
Oashi Basin is situated surrounded by ridges and peaks of dacite and Tertiary rocks, composed of following four surfaces. a) Takamatsu Range (900–800 m, partly 740 m) — Rugged ridges and peaks correlated to the 1000 m level are an erosion surface judging from the evidence that certain parts of the ridges are Tertiary siltstone, not covered with dacite. At Yanohara a waving surface is observed in 760–740 m, composed of dacite. In relation to the shallow open valley (*Muldental*-like) on the dacite plateau, the erosion process during the period building this erosion surface may be a kind of surfacial denudation (*flächenhafte Denudation*).

b) Oashi Terrace (720–560 m) — Along the Tamagawa River develops a terrace, which consists of thick gravles (7 m, Fig. 3) on the Pliocene sandstone, and is covered with volcanic ash about 1 m thick. The gravels are composed of subrounded dactie, tuffaceous sandstone, slate and many lenses of pumiceous coarse sand, and are supposed as fluvial deposits perhaps supplied from dacitic mountains after their dissection. The terrace surface is traced continuously till Yanohara, where it makes swampy bottoms of dissecting valleys. Streamupward the terrace

A

Fig. 3 Scarps of Oashi Terrace
A: at the central part
B: at the northeastern corner
of Oashi Basin

B



transforms itself into present valley floor, covered with debris recently supplied from back slopes.

c) Basin Floor (660–550 m) — In the basin, Oashi Terrace is cut 8–10 m into the basin floor filled with alluvial deposits. Upstream, 2–3 km to Oashi, the height of the terrace scarps gradually decreases, and bottom plains disappear. Here the initial surface of Oashi "Terrace" is still being built. On the contrary, below the kinckpoint near the discharge point of the basin, the level changes to a lower terrace cut by the lowerstream of the Tamagawa River. This terrace is traced for 10 km along the Nojiri River, and probably it is identified with the "Higher Terrace" of the Tadami River (Fujiwara and Takahashi, 1960, Takahashi, 1962).

d) Valley Plain of the Nojiri River (600–400 m) — As above mentioned, this

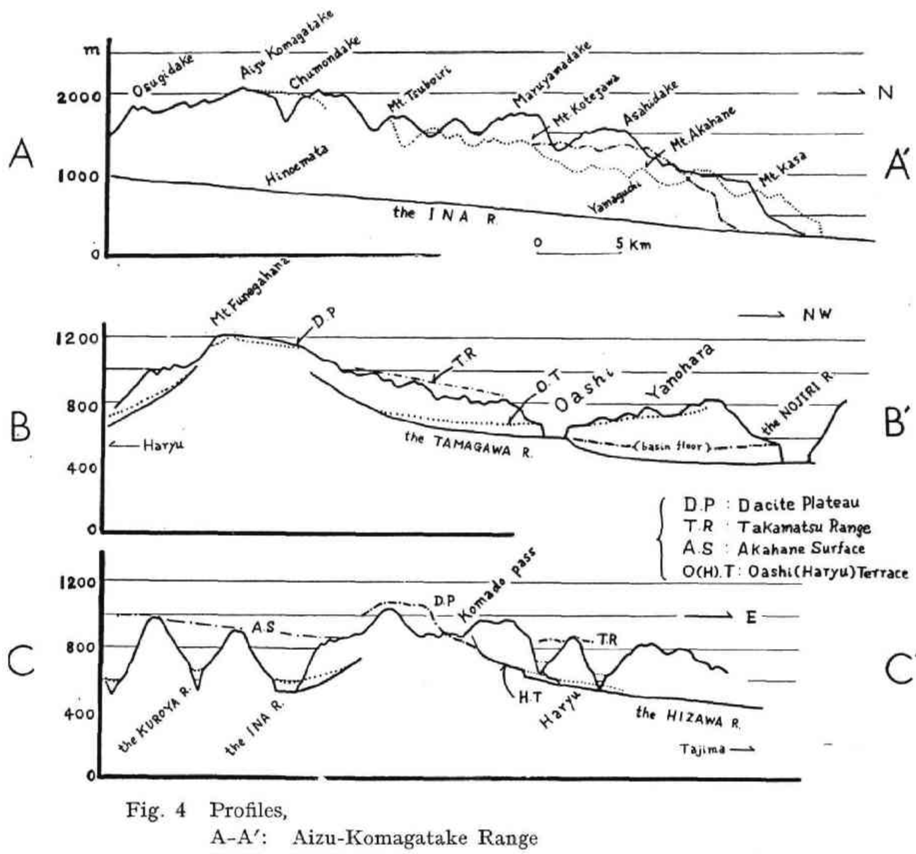


Fig. 4 Profiles,
A-A′: Aizu-Komagatake Range
B-B′: Dacite Plateau and Oashi Basin
C-C′: near Haryu Basin
(c.f. Fig. 2)

is cutting the basin floor, and the foot of mountains. As a base level of erosion it has no influence for Oashi except in a part lower than knickpoint.

4) Haryu Basin

Here also four levels are recognized.

a) Ridge Top Surface (1000–900 m) — Below the dacite plateau, in U-shape open to NE, a level of accordant ridges and flanks of side slopes of the plateau are pointed out. This is clearly indicated by restored contours (Fig. 5). Lowerslopes of the surface have double curved profiles (Fig. 4) due to the recent downcutting of the streams. b) Haryu Terrace (740–670 m) — This is distributed along the tributaries into mountains, and the level is identified by the knicks (breaks) on the slopes by photo interpretation. Terraces correlated to this level are developed at Sawadahara (700–640 m), and at Hodokubosawa (820–740 m) outside the basin. The terrace is characterized by thick gravels and a cotinuous profile toward its back slope, so it seems to be conjugated with Oashi Terrace. c) Hizawa Terrace

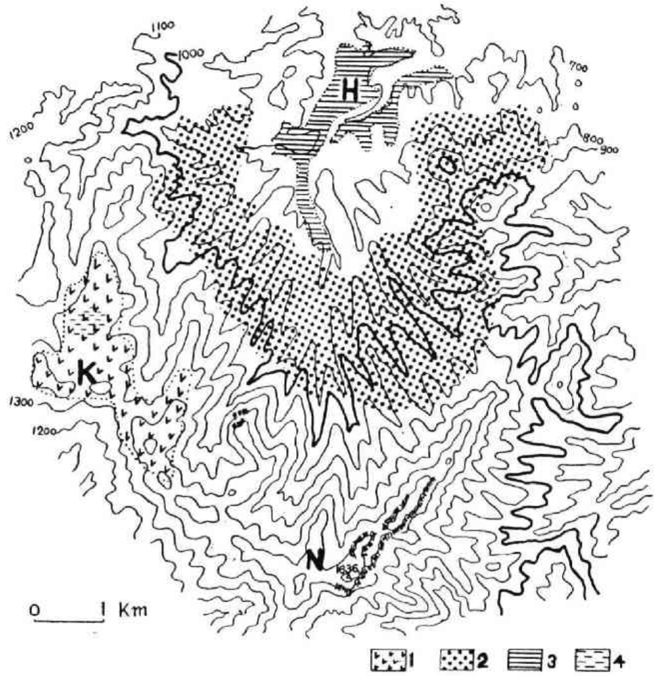


Fig. 5 Ridge top surface deduced from the restored contours at Haryu Basin
1. Dacite Plateau 2. Ridge top surface 3. Haryu Terrace 4. swamp
H: Haryu K: Mt. Kuroiwa N: Mt. Nanatsugatake

(below 680 m) — Haryu Terrace is cut by the lower terrace level with 5–6 m scarps. Downstream, along the Okawa River this terrace continues farther, probably to Aizu Basin. d) Valley Plain of the Hizawa River (below 670 m) — This level is present base level of erosion in the drainage basin of the Okawa River in the same way as the levels of the Nojiri and the Ina Rivers are in the drainage basin of the Tadami River.

5) Along the Ina River

Below the dacite Plateau, on the flanks or on the branching ridges 900–750 m high, a level is recognized. Though much dissected, there are a few swamps on gently descending surfaces. This level is identified with the Takamatsu Range and the 1000m level (Akahane S.) previously mentioned. River terraces are typically formed in the upstream area (south of Uchikawa) a valley plain develops extensively. Along the Hinoemata, a tributary to the Inagawa, the terrace (Yunohana Terrace) is divided into two levels. In the dissection of the mountains the level of this terrace played a predominant rôle, and the present valley level which cuts the terrace is no more important than modifying the previously formed slopes and reliefs. In this sense, the level of the terrace can be correlated to Oashi and Haryu Terraces.

III. Geomorphological development

Based on geological and morphological data the writer set up following evolutional process in the region (Fig. 6).

Before the eruption and deposition of dacitic welded tuff, a vast flat land with low relief developed. This is presumed from the existence of K-Surface and the ridge top level, both of which are not covered with dacite and are higher than the dacite plateau. The period in which K-Surface was formed is considered to be Pliocene, because bed surface of the dacite is an erosion surface cutting Neogene Tertiary strata. When the dacite erupted, and drainage system on K-Surface had been maturely developed in adjustment to geological structure as main valleys prevailed in N - S direction, and relief must have been about 500 m or less.

Thereafter the dacite plateau and K-Surface underwent a surfacial denudation upon a slightly lower base level (1000–800 m, equal to Akahane Surface and Takamatsu Range), coming to produce concave sloped and open valleys on the plateau. Where the dacite was denuded out, Tertiary bedrock emerged at this level. On the other hand a selective denudation worked in K-Block during whole period, so that the Paleozoic section of K-Surface was preserved in location higher than the Tertiary section. The writer's assumption that the erosion process during

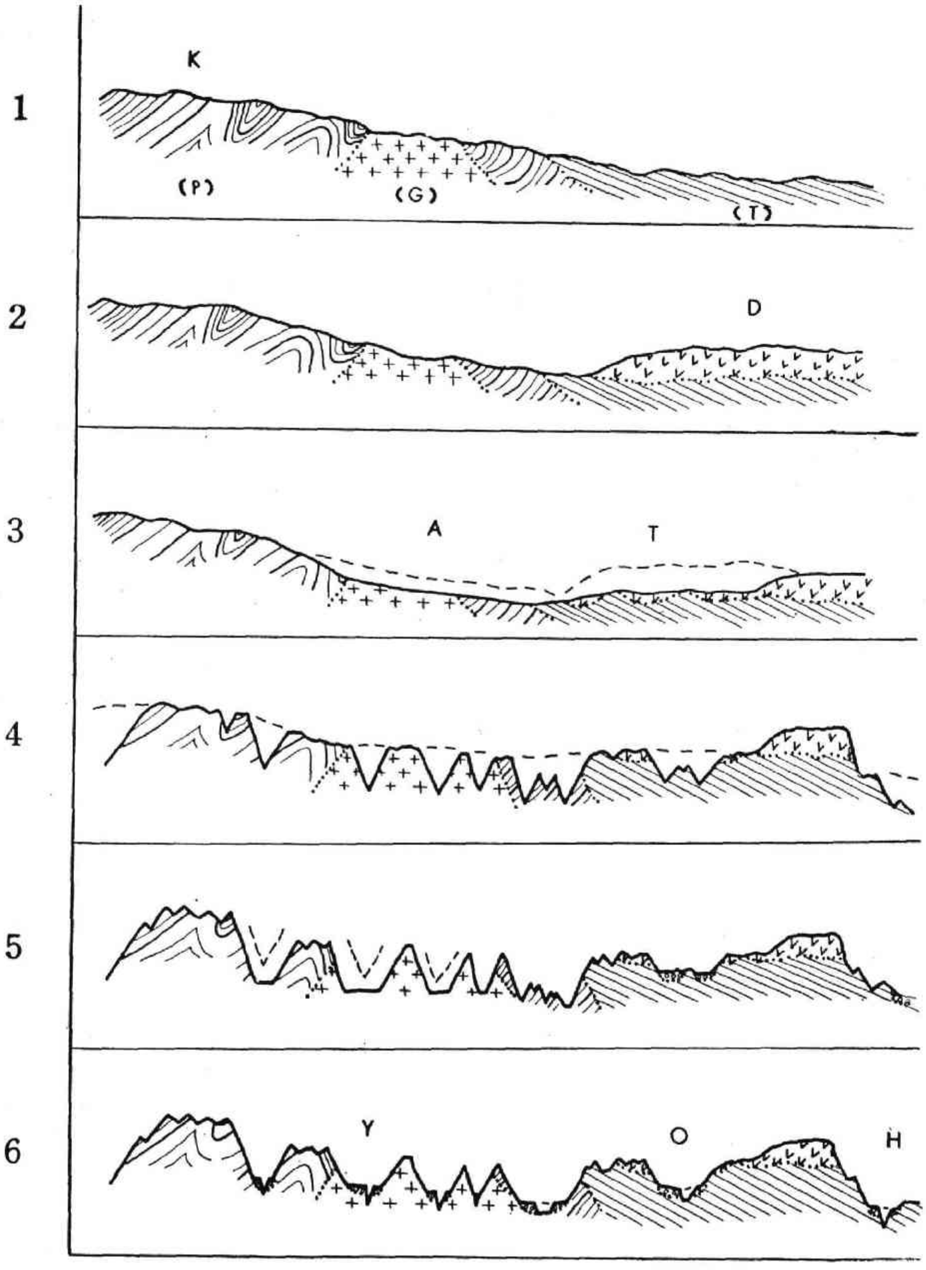


Fig. 6 Schematic profile of geomorphological development
1. *erosion surface*; Komagatake Surface (K) 2. (*late Pliocene~early Pleistocene*) Dacite Plateau (D) 3. *surfacial denudation*; Akahane Surface (A), Takamatsu Range (T) 4· *large uplift, valley developing, relief increasing* 5. *valley developing, gravel deposition* 6. *small uplift, terrace formation, relief increasing a little*; Oashi (O), Haryu (H), and Yunohana (Y) Terraces
(P): Paleozoic (G): granite (T) Neogene Tertiary

this period was a surfacial denudation is deduced from two facts, that is, concave sloped valleys on the plateau, and a remarkable flatness of the ridge top surfaces in 1000m level in K-Block (Louis, 1964).

On the next stage an epeirogenic uplift occurred, consequently valleys developed in the way of deep downcutting to produce 600–1000 m relief in K-Block and 300–400 m in the dacite plateau. This stage continued so long that the potential relief in K-Block appeared as real relief in mature stage of erosion, but in the dacite plateau, dissecting valleys could not sculpture the surface and remained in higher level.

It is just later than this period that a lot of gravels was supplied into valleys in Oashi Basin and at Sawadahara, etc., as a result of the deposition of gravels and volcanic ash, at the same time as detrital deposits, steep slopes behind side slopes of mountains become gentler and continuous to valley floors in many places. The supply of such a large quantity of gravels may indicate the presence of certain climatic changes (more arid?).

Then, more recently, an uplift in smaller scale occurred here, and the valley plains became terraces. Mountain-side slopes were modified at their foot to double cruved form. This movement is divided into two stages as is shown in two stepped terraces in Oashi Basin and in Haryu Basin etc. In areas of large relief this subdivision is not recognized because streams could not complete the cutting of the potential relief since the foregoing period.

IV. Relief distribution

There are five levels as surfaces providing the upper limit of relief; 1) K-Surface, 2) dacite plateau, 3) ridge top surface, 4) Oashi Terrace and corresponding surface, 5) lower terraces, and other local levels due to special conditions. On the other side, valley levels providing the lower limit of relief are classified as follows; a) concave valley on K-Surface and the dacite plateau, b) Oashi Basin, c) valley floor directly corresponding to the present level of the Tadami and the Okawa Rivers. Altitudes of surfaces and valley floors are variable within this large area, so their absolute values mean little in the correlation of far distant places. As a whole, however, they are distributed orderly, and to compare each element of one group with each of the other we are able to clarify the state of relief distribution as a result of the geomorphological evolution in this region (Fig. 7, 8).

As to the existence of large relief in K-Block, the writer seeks the explanation in the evidence that downcutting went on only in N-S direction and K-Surface was preserved as ridges without changing to isolated peaks, and that this was due to the non-existence of the dacite deposition which, after dacite eruption, made

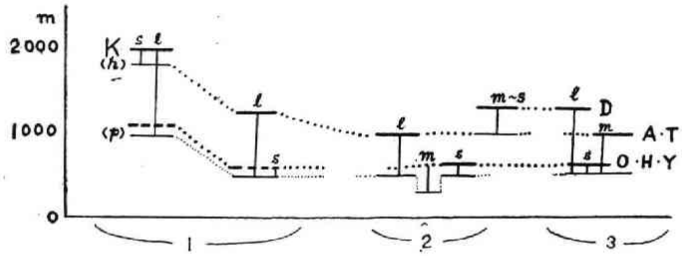


Fig. 7 Relief in relationship between the surfaces and the valley levels
l: large relief area m: moderate relief area s: small relief area
K: Komagatake Surface D: Dacite Plateau A.T: Akahane Surface and Takamatsu Range O.H.Y: Oashi, Haryu, and Yunohana Terraces (h): high leveled concave valley (p): present valley floor
1: along the Ina River 2: Oashi Basin 3: Haryu Basin

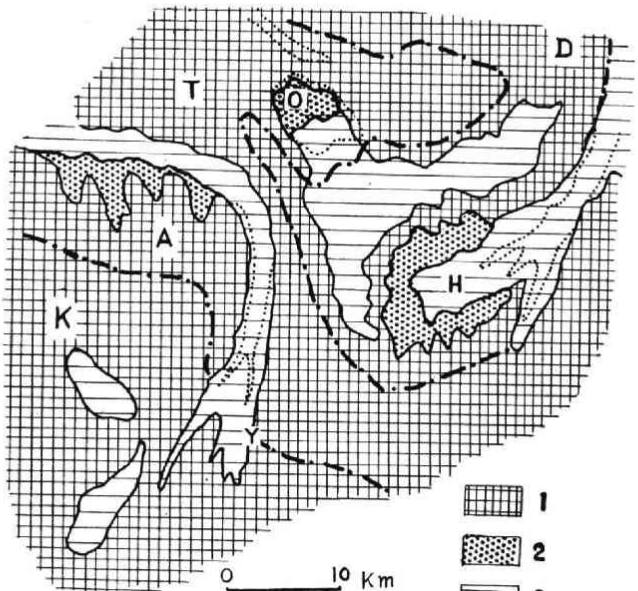


Fig. 8 Relief distribution
1: large relief area 2: moderate relief area 3: small relief area
K: Komagatake Surface D: Dacite Plateau A: Akahane Surface
T: Takamatsu Range H: Haryu O: Oashi Y: Yunohana

a new drainage system with no relation to bedrock structure.

Compared with Kitakami and Abukuma Mountains, the ridge top surface is well preserved in accordant height, while high leveled valleys are less preserved in Aizu Mountains, and consequently there is a conspicuous different in relief distribution in spite of analogous background in both regions. As examples of the mountains like this, there are Asahi, Iide, and Echigo Mountains, and the some of small relief surfaces on their tops are described recently (Yonechi, 1964).

Now some problems remain to be solved, such as the relationship between the terraces in this area and fan-like dissected hills to the east of Tajima (Jumonjihara), correlation of terraces in the upstream area of the Tadami and the Okawa Rivers, and how to obtain evidences of the influence of climatic change in the geomorphological development.

V. Conclusion

1) The difference of relief distribution between the western part and the northeastern part of the region was caused because in the latter area the dacite plateau was built in late Pliocene or early Pleistocene renewing the development of the valley, while in the former, the drainage system had been maintained since before the great uplift.

2) Seemingly the erosion process after the building of the dacite plateau was a surfacial denudation, deducing from the concave form of the valleys on the plateau and, in a few exmaples, on Komagatake Surface.

3) In Oashi Basin a high potential relief is preserved by the presence of high leveled valley, and with an advance of incision by the streams the potential relief will turn into real relief in the same way as in Haryu Basin.

4) After the great uplift and the accompanied valley development, there was a period characterized by producing and supplying a lot of gravels, and it was before the recent volcanic actions and terrace building by rejuvenation of the rivers.

5) The whole area was affected by the recent small uplift, shown in terrace development in upstream area of the Tadami and the Okawa Rivers.

The relief distribution is summarized in Fig. 7, which at the same time explains the development of the region.

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