A series of Micro-landform Units composing Valley-heads in the Hills near Sendai

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Toshikazu TAMURA

1. Introduction

In the analysis of hill landscape, different landform-components are treated with attention according to the orders of the viewpoints. Accordant-height summits are noticeable from the higher order viewpoint and valley features noticeable from the lower order viewpoint.

The accordant-height summits of the hills near Sendai are divided into four levels; level I, level IIa, level IIb and level III (Fig. 1) (Tamura 1965). Above the hill levels prevailing around Sendai up to 250 m above sea level, level I rises as isolated peaks or narrow ridges composed of Miocene volcanic and pyroclastic rocks. Level II, ranging 100 m to 250 m a.s.l., has rather smooth and undulating landscape in general and is subdivided into IIa and IIb. Level IIa is originated from the depositional surface of the fluvial gravels of middle Pleistocene[1] overlying unconformably Neogene or lower Pleistocene strata, and level IIb seems to present the denudational surface cutting Neogene strata. Level III, originated from denudational surface, has lower altitude and more rugged landscape than level II.

Smooth and undulating landscape in the level II area and rugged landscape in the level III area are concordent with distribution of shallower and steeper valleys[2] (Tamura 1965). Nakamura (1968) classified dissecting valleys into two types—shallow concave valley (*Muldental*) and V-shaped valley often accompanied with

1) These gravels, called the Futatsuzawa gravel member of the Aobayama formation (Nakagawa et al. 1961), are located separately on the north and the south sides of the Hirose river (Fig. 1). On the north side, they sit on round hill-tops (200 m–250 m a.s.l.) covering the red weathering crust unconformably and are weathered to red in color in some localities but are not covered by volcanic ash (Tamura 1965). On the other hand, the gravels on the south side of the river sit on rather flat surface called Aobayama upland, and have suffered selective red weathering in silty or clayey layers though degree of weathering of each gravel is varied in position, and the gravels are covered by weathered volcanic ash of a few meters in depth with yellow pumice. Besides, the upland (90 m–210 m a.s.l.) is divided into four surfaces which are the depositional surfaces of the gravels, and the lowest surface is obviously younger than the higher three surfaces whose differentiation was explained by Nakagawa et al (1961) being due to tectonic movement. As above mentioned, classification, correlation and identification of the gravel beds need to be reexmained.

2) It is without saying that rugged landscape is also seen in the area of level II.

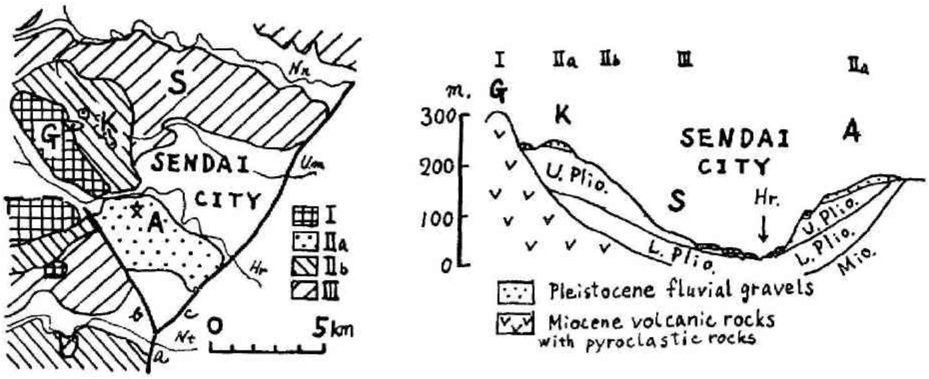


Fig. 1 Outline of landforms near Sendai
I-III: Hills (see the text)
blanc: Terraces and lowlands
G: Gongenmori, K: Kunimi-tôge, S: Sakuragaoka Danchi, A: Aobayama,
Nn: Nanakita River, *Um*; Umeda River, *Hr*: Hirose River, *Nt*: Natori River,
a-c: Main tectonic lines (a: Hisanohama-Iwanuma line, b: Kagitori-Okubushi line,
c: Nagamachi-Rifu line)
文: Inst. Geogr., Tohoku Univ.,

flat bottom (*Kerbtal* including *Sohlenkerbtal*)—and found the former type frequently even in the level III area[3] and along the deepest valley dissecting Aobayama upland (level IIa) in relatively small areas near the divides. He concluded that the distribution of the fomer type is due to a locational condition, where water is not concentrated enough to begin down-cutting which results in the making of the latter, and that the smooth undulating landscape is always maintained near the divides regardless of baselevel-change which induces development of rugged landscape or burying it along the downstreams.

The writer attempts to analyse more in detail the morphological composition of valley-heads including subsurface structure and investigate whether it differs or not according to origin, relief and lithology of summit surface.

2. **Method**—Continuity and discontinuity in landsurface—

Typology of micro-landforms is necessary for the purpose above mentioned. For this purpose, the scales of published topographical maps and air photos are not large enough and observation at the field are necessary. Neither it is adequate to depend on contour maps only even on large scale. Contour maps are not suitable to represent changes or breaks of slope forms because all landsurfaces are projected on level plane on contour maps. Landsurface is actually an assemblage

3) He called it the Nanakita hills in the north of Sendai.

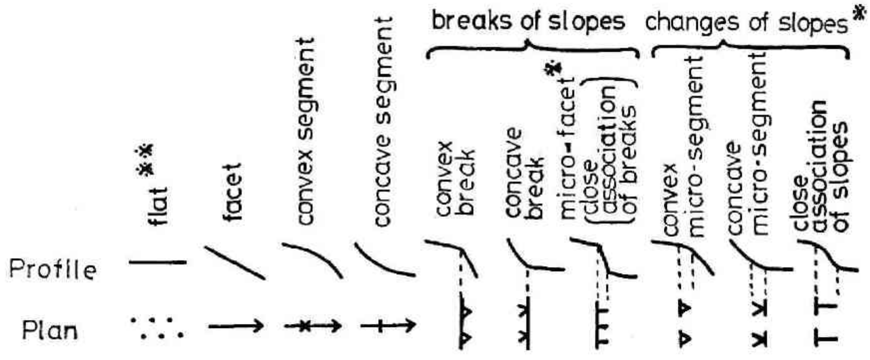


Fig. 2 Symbols of morphological map
A little revised by the writer after Savigear (1965) and Curtis et al. (1965).
* according to scale of the map
** less than about 3° (in this paper, tentatively)

of slopes of various inclination, curvature, length, width and so on, and the slopes contact each other rather discontinuously, but contour maps are apt to represent them as a continuous surface changing gradually except at cliffs. Discontinuity in landsurface is to be paid a particular attention for typology of micro-landforms.

Morphological mapping was devised by R.S. Waters (1958) to represent breaks and changes in landsurface such as convex and concave ones as well as convex, straight or concave slopes and flats between changes or breaks (Savigear 1965, Curtis et al. 1965) (Fig. 2). Accuracy of this morphological map increases by adding simple measurements. Any facet or segment on the map has only pure morphological meaning but no geomorphological significance. After comparison of many examples and with backing of processes, certain facets or segments are combined, or a single facet or segment is qualified, to a geomorphological micro-landform unit.

The writer drew morphological sketch maps of the valley-heads chosen as typical of respective areas (level I, level IIa, level IIb and level III) and observed surface geology and soil profiles of the places. Then six micro-landform units were discerned as geomorphic types composing valley-heads. He now continues to measure surface run-off and lateral subsurface water movement at a few sites with collaborators.[4)]

3. Description

1) At the north of Sahoyama (site 1)

Adjacent to southwest of the highest point of Aobayama upland (level IIa),

4) K. Sugawara, O. Miura, I. Ishikawa, K. Hosokawa, R. Kikuchi and H. Makita

Fig. 3 The environs of site 1. Dots represent the area covered with the middle Pleistocene fluvial gravels. (the Futatsuzawa gravel member).

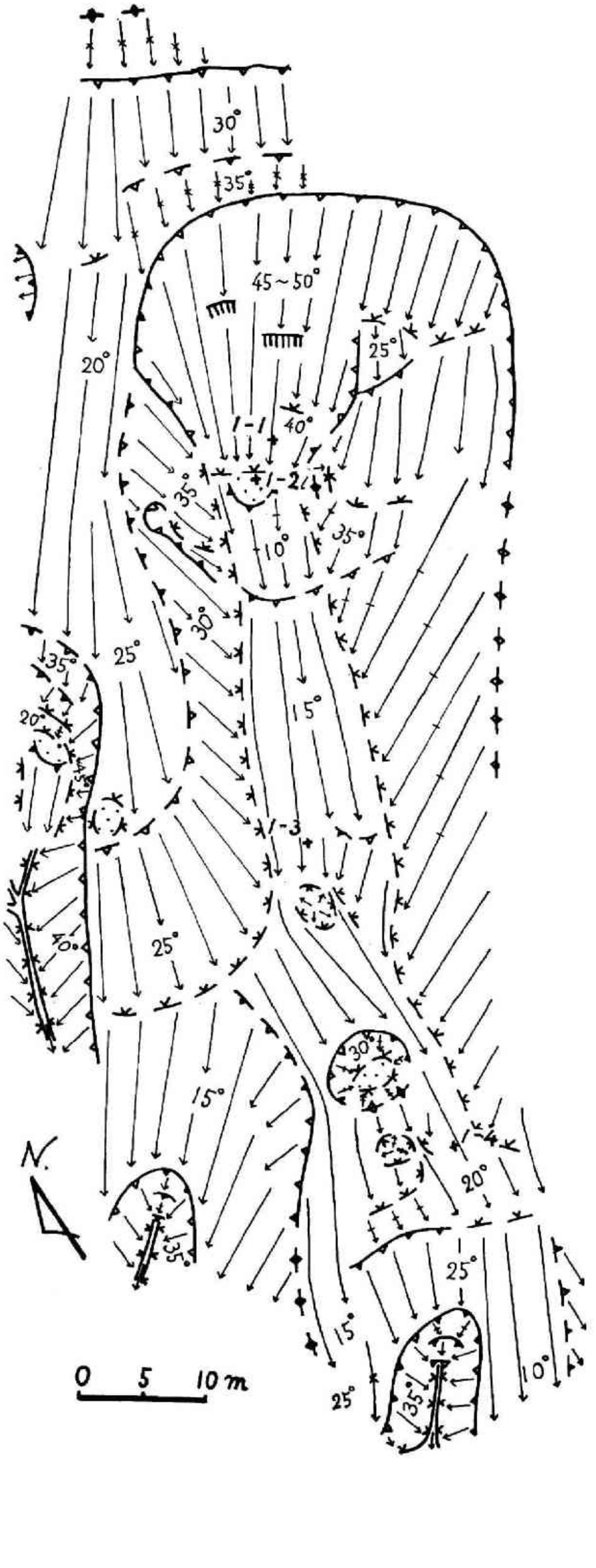
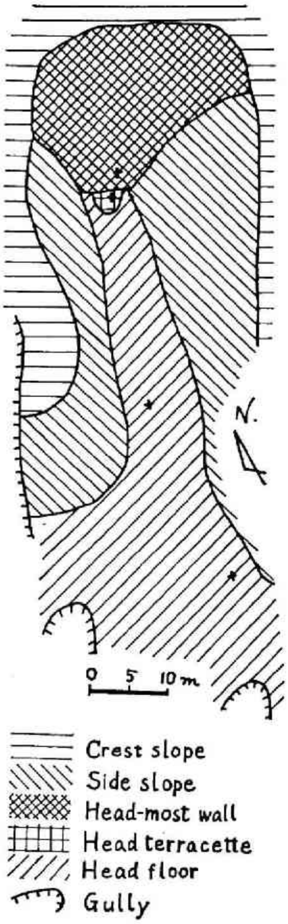


Fig. 4 The morphological map of site 1
Keys are represented in Fig. 2.



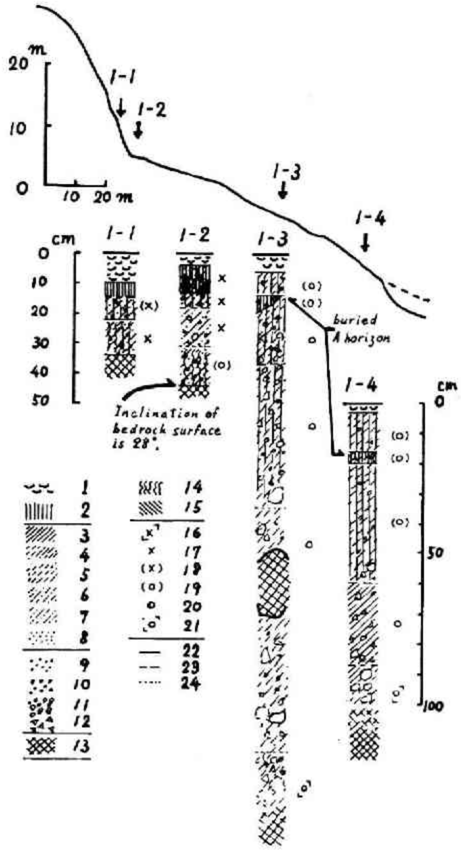


Fig. 5 (Left) The micro-landform classification map of site 1

Fig. 6 (Right) The soil profiles at some localities in site 1

1: Litter, fermentation and amorphous humified, 2: Visible humus, 3: Clay, 4: Clayey loam, 5: Silty loam, 6: Loam, 7: Sandy loam, 8: Sand, 9: Granule, 10: Pebble, 11: Cobble, 12: Breccia, 13: Rock, 14: Moist part, 15: Ferruginous part, 16: Very loose, 17: loose, 18: Slightly loose, 19: Slightly compact, 20: Compact, 21: Very compact, 22: Distinct, 23: Slightly distinct, 24: Indistinct or gradual,

there are rather rugged hills whose summits belong to level IIb where Miocene tuffaceous sandstone or tuff breccia are exposed inclining to northeast (Figs. 1 and 3). In the forest at the heads of deep valleys flowing to Sahoyama, firs (*Abies firmfa*) grow in relation to breaks or changes of facets or segments.[5)]

5) It is pointed out by a plant ecologist, T. Kikuchi.

At site 1 (Fig. 4) cliffs are sharply distinguished from somewhat convex crest slope at the top and very distinctive small flat at the foot. Downwards the flat follow moderately inclined facets for about eighty meters composing the valley floor with a little irregularity but without evident channel. Gullies with evident channels cut into the rather flat valley floor. The change from the interfluve to the rather flat valley floor is not so abrupt as at the headmost part of the valley. These facets and segments with flats at site 1 are arranged in a series of six micro-landform units, which are tentatively named as 'crest slope', 'side slope', 'headmost wall', 'head terracette', 'head floor' and 'gully' (Fig. 5).

The crest slope, composed of facets and scarecely convex segments, has shallow soil, most of which makes Ao horizon. On the headmost wall, especially at the micro-cliffs, bedrock (semiconsolidated medium or coarse grained tuffaceous sandstone) is exposed but thin soil layer with pebbles carried from the upper section is found at the lower section of the unit (Fig. 6, Loc. 1–1). A larger stump at the lowest edge of the head terracette holds a little thicker soil layer (40 cm+) abundant in gravels and breccia. The flatness of the terracette is resulted from this soil layer overlying directly the bedrock (Fig. 6, Loc. 1–2). The bedrock surface beneath the terracette is steeper than the ground surface of the same unit but is obviously gentler than the headmost wall. Then the head terracette is not a simple accumulation form. Holding of transported materials by stump occurs frequently on the fead floor in the form of mounds and small steps, larger ones of which are shown in Fig. 4. Such deep soil near the upper side of a mound seems to be not only transported but produced in situ (Fig. 6, Locs, 1–3 and 1–4). Short furrows just at the foot of mounds suggest the occurence of ephemeral linear stream on the ground there. Most of hollows on this unit seem to be orginated from falling trees. The gully, which cuts into the head floor, has a narrow but continuous channel which comes out as a spring and is covered with litter. Fresh bedrock under shallower soil is exposed at the gully wall.

2) In the Botanical Garden of the Tohoku University (site 2)

The head of a small valley dissecting the eastern flank of Aobayama upland (level IIa) is shown in Figs. 7 and 8. This site is at the north end of the Botanical Garden[6] of the Tohoku University and is covered with forests of dominant firs (*Abies firma*) accompanied by shrubbery. Only on the ridge exists the fill of mid-Pleistocene gravels covering upper Pliocene tuffaceous silt- or sandstone intercalating lignite seams.

6) This upland surface has been highly transformed by artificial construction and such micro-landforms in their original feature hardly remain except in such area.

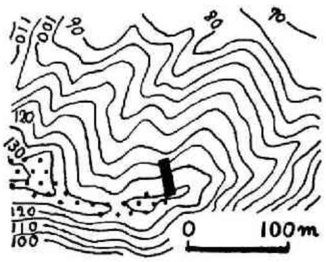


Fig. 7

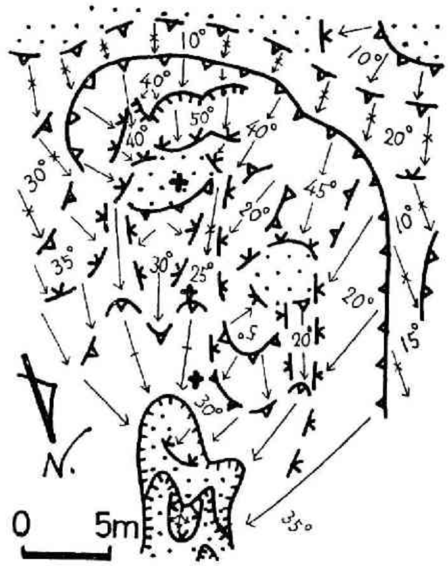


Fig. 8

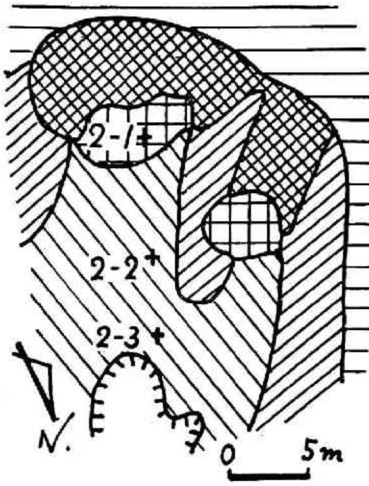


Fig 9

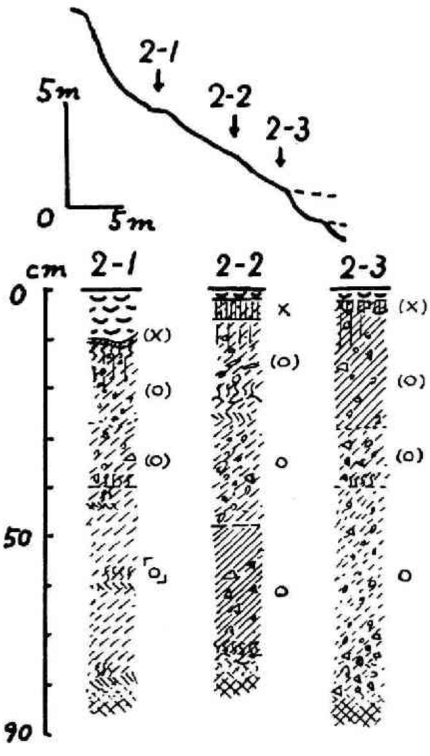


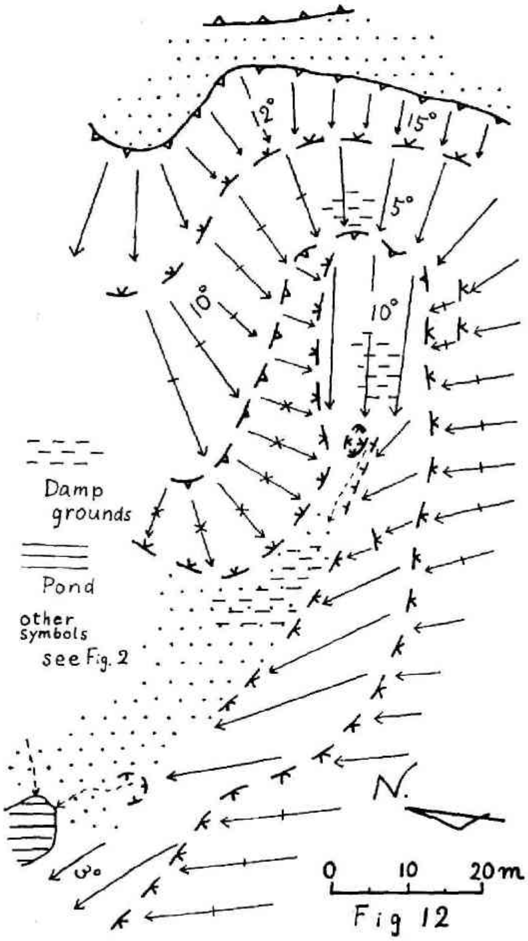
Fig. 10

Fig. 7 The environs of site 2.
Keys are represented in Fig. 3.

Fig. 8 The morphological map of site 2.
Keys are represented in Fig. 2.

Fig. 9 The micro-landform classification map of site 2.
Keys are represented in Fig. 5.

Fig. 10 The soil profiles at some localities in site 2.
Keys are represented in Fig. 6.



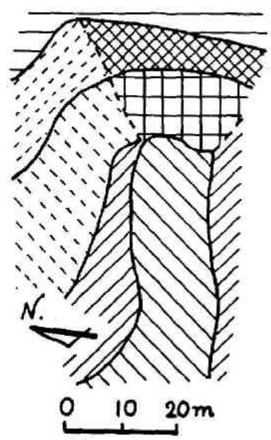


Fig. 11 The environs of sites 3, 4 and 5. Keys are represented in Fig. 3.
Fig. 12 The morphological map of site 3. Keys are represented in Fig. 2.
Fig. 13 The micro-landform classification map of site 3. Keys are represented in Fig. 5.

Micro-landform units composing the valley-head at the site (Fig. 9) is the same as, but smaller than, those of site 1 (Fig. 5). Arcuate cliffs and small troughs are noticeable on the headmost wall (Fig. 8), and the troughs are covered with litter and slightly decomposed material, but at the cliffs bedrock of tuffaceous siltstone is exposed. Most of the materials composing B horizon of soil on the head terracette seems to be originated from the headmost wall, but it is hard to distinguish transported materials and weathered products in situ stratigraphically, because andesitic gravels removed from the fill on the ridge mix in every horizon with breccia of siltstone which is the parent rock at the location (Fig. 10). Several seepage layers are recognized in the soil profile. A tall fir tree stands the lower margin of the terracette and holds the materials from the headmost wall. Two shallow channels are observed on the head floor though some small ephemeral furrows also exist in the unit. The heads of the gully is recurrence of small cliffs and terracettes as miniatures of the headmost wall and the head terracette.

3) In the vicinity of Kunimitôge (sites 3,4 and 5)

The undulating hills near Kunimitôge, northwest of Sendai, have round summits of 230 m–250 m a.s.l., which are partly capped with the mid-Pleistocene fluvial gravels (level IIa), and narrow summits of 200 m–210 m a.s.l. where underlying upper Pliocene or lower Pleistocene sedimentary rocks were exhumed (Level IIb) (Fig. 11).

The valley-heads shown in Fig. 12 is curved into gentle undulating hillslope leaving depositional surface of the mid-Pleistocene gravels on the crest. The slope equivalent to the headmost wall is too gentle (12°–15°) to discern. But the facet, gentler than the upper and the lower slopes, demonstrates the existence of the head terracette. The head floor is occupied by damp grounds and ephemeral furrows but there is no gully yet in the illustrated area. The gentle concave segment in the middle part of the side slope, which is composed of two sets of convex-concave slopes, looked like a terraced old floor. In spite of occupance by damp grassland, the head terracette and the head floor have only shallower soil, usually less than 30 cm in depth.

Fig. 14 represents a shallow depression situated on a gentle slope very close to the divide missing the fill of mid-Pleistocene gravels (Fig. 11). The bottom of the depression, occupied by grassland but invaded by shrubs from surrounding slopes, is equivalent to the head terracette of a valley flowing to the west. The headmost wall does not exist or is too gentle to discern from the crest slope. A terrace-like form in the head floor is noticeable.

The valley-head shown in Fig. 16 is carved into ridge missing the fill of mid-Pleistocene gravels, where the headmost wall is not discernible from the steep crest slope but the head terracette is evident. The head floor looks like a former gully. The uppermost section of the channel in the present gully is a small tunnel of several centimeters in diameter.

4) At the northeast of Sakuragaoka Danchi[7] (site 6)

The best example of valley-head in the area of narrower and lower ridges

7) The hills in the northern part of Sendai is severely destructed to construct large housing estates called "Danchi".

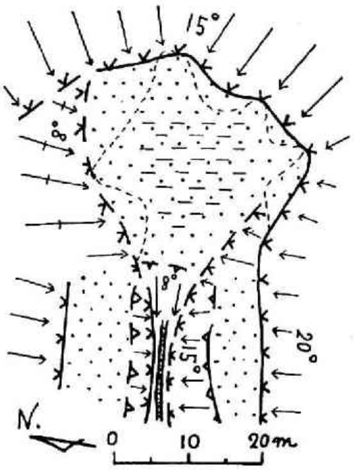


Fig. 14

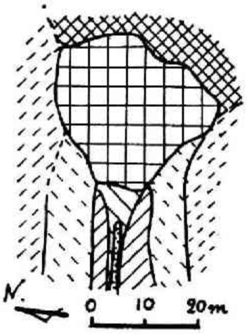


Fig. 15

Fig. 14 The morphological map of site 4. Inner area of short broken line is occupied by grasses and outer area by shrubs. Other symbols are explained in Figs. 2 and 12.
Fig. 15 The micro-landform classification map of site 4. Keys are represented in Fig. 5.

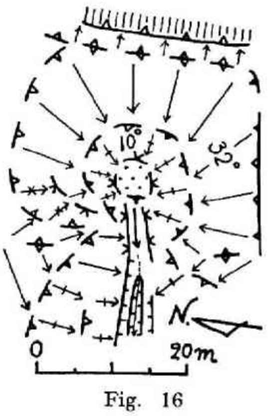


Fig. 16

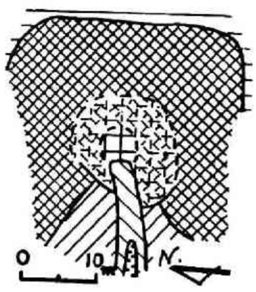


Fig. 17

Fig. 16 The morphological map of site 5. Keys are represented in Fig. 2.
Fig. 17 The micro-landform classification map of site 5. Keys are represented in Fig. 5.

belonging to level III in the north Sendai is seen at the northeast of Sakuragaoka Danchi. At site 6 (Fig. 18) is exposed lower Pliocene siltstone on the narrow ridge about 35 m above the level of Sankyô-dam reservoir, and on the gully-walls.

A large area of the site is occupied with very slightly sloping valley-bottom which seems to be equivalent to the head floor. The wide and long head floor

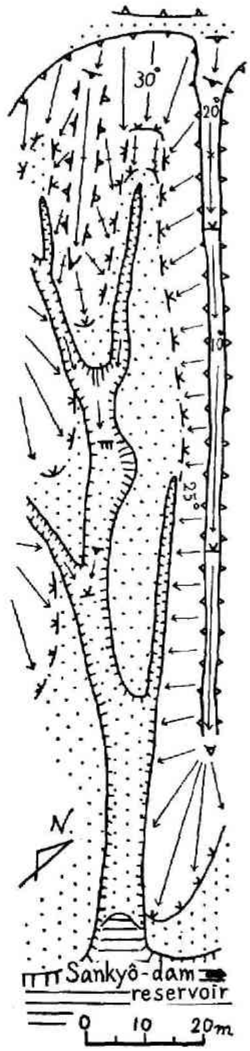


Fig. 18

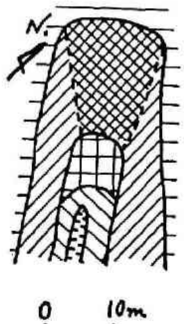
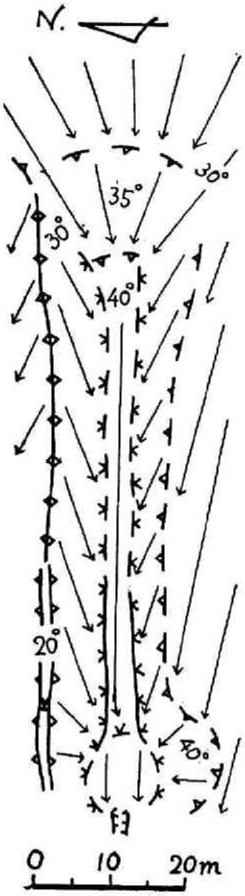


Fig. 19

Fig. 18 The morphological map of site 6.
Keys are represented in Fig. 2.

Fig. 19 The micro-landform classification map of site 6.
Keys are represented in Fig. 5.

covered by shrubs continues, without a break or change, to the erosion terrace along the main valley where Sankyô-dam is constructed. This terrace was correlated to the fluvial terrace buried under the Holocene alluvial plain along the lower course of the Nanakita river (Tamura 1965) but this correlation may have to be reexamied. The gullies of 0.3 m–3 m in depth break so far into the head floor as to reach the foot of the headmost wall. The head terracette is indistinct and is rather continuous to the head floor.



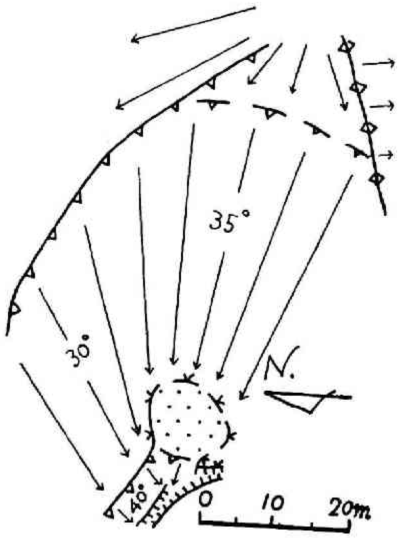


Fig. 20

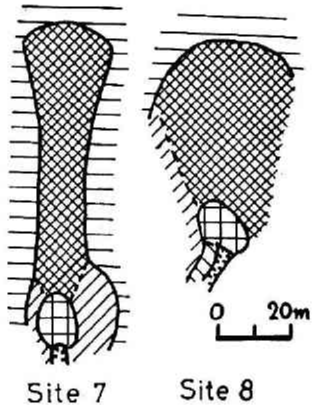


Fig. 21

Fig. 20 The morphological map of sites 7 (left) and 8 (right). Keys are represented in Fig. 2.

Fig. 21 The micro-landform classification map of sites 7 and 8. Keys are represented in Fig. 5.

5) At Gongenmori (sites 7 and 8)

Gongenmori is a high (300 m–314 m a.s.l.) and narrow ridge belonging to level I and is composed of Miocene andesitic basalt. The steep southeast-facing slope (generally 30°–35°) of the ridge, recently deforested to shrubbery and bush, is slighly undulating along the general strike of the slope. A shallow depression upon the steep slope is guided to a small but distinctive terracette where a long gully is going to reach (Fig. 20). The shallow depression on the steep slope is equivalent to the headmost wall and the head floor is almost missing (Fig. 21). Boulders and dead branches are scattered on the head terracette which had, however, no boulders buried in or under shallow soil. On the crest slope closest to the divide, B/C horizon of 20 cm–30 cm rich in breccia is observed under shallow (5 cm) A horizon with litter.

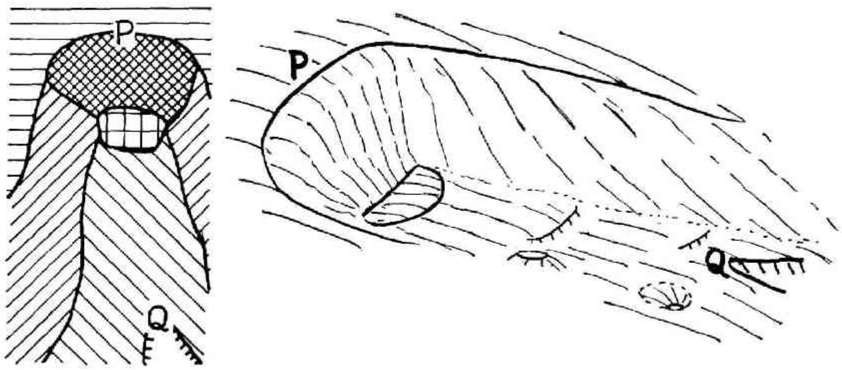


Fig. 22 The series of micro-landfrom units composing valley-head in the hills. Keys of the left figure are represented in Fig. 5.

4. Synthesis and discussion

It becomes clear that valley-heads in the hills around Sendai is composed of six micro-landform units: Crest slope, Side slope, Headmost wall, Head terracette, Head floor and Gully, and that they present the series schematized in Fig. 22.

The crest slope is composed of a facet, several facets or slightly convex segments reaching the divide, and has shallow soil. The following slopes below this unit are generally steeper.

The side slope is composed of facet (facets) or slightly concave segments changing smoothly to the head floor. This unit is inclined 20°–30° regardless of general inclination of the valley-head area.

The headmost wall is always the steepest unit and sometimes it is a cliff up to 50°. A convex break is the upper margin and a concave break or micro-segment is the lower margin of this unit. The soil is very shallow or missing and boulders are scattered on the ground surface of this unit. These facts, with the accumulation of boulders on the head terracette at the foot of the headmost wall, suggest the dominance of fall on this unit.

The head terracette is a small but the most conspicuous unit as well as the headmost wall in each valley-head. On this unit soil is thicker (about 30 cm–50 cm) and abundant in boulders and breccia which are brought from the headmost wall and sometimes held by a stump or a trunk at the lower margin of this unit. Moreover the bedrock surface under the soil inclines steeper than the present ground surface which is almost flat. Therefore the flatness of this unit is owing to the accumulation of materials derived from the headmost wall. But the fact that the bedrock surface of the head terracette is obviously gentler than the headmost wall suggests that certain denudational processes, different from the fall acting on the headmost wall, operated in the original formation of the head terracette.

The head floor includes several facets and segments which are long in proportion to their width and usually somewhat steeper than the head terracette. Many small breaks or changes and mounds kept at stacks, binding of lower parts of trunks and deep soil rich in gravels occasionally with buried A horizon, represent that soil creep is proceeding on this unit. But a transition at the lowest part of soil profile suggests that weathering in situ may also be proceeding. Small discontinuous furrows are the evidences of ephemeral stream or wash on this unit.

Generally speaking, several types of mass-movements controlled by stacks, roots or trunks are active processes in the five units above mentioned[8]. But it leaves much to be investigated concerning the processes which created them. Many informations about the problem seem to be presented in the slope failures occured at the Tokachi-oki earthquake after a heavy rainfall in May, 1968, in the vicinity of Hachinohe, Aomori prefecture (Hotta, Miura and Tamura 1968). Each failure site, especially of scauper type, has micro-landform units closely resemble to the headmost wall, the head terracette and the head floor (Fig. 23). The equivalent of the head terracette at the failure site was formed with rapid flowage of soaked materials to form the equivalent of the headmost wall. The equivalent of the head floor was only runway of collapsed materials accumulated at the bottom of the main valley.

Active and formative processes of the gully carved into the head floor is simpler; sapping and downcutting by linear stream flow accompanied with minor slumping or fall. At some sites, morphology of the gully-head is like as a miniature of headmost wall and head terracette. There are also two-storied head floors, the higher of which is terraced. Those facts may suggest the similarity between formative processes of initial form of the head floor and the present gully but it is assumed that some accidental factors intervene the formation of such small form as the gully-head.

The series above mentioned is common in every valley-head regardless of origin or lithology of summit surface cut with the valley. But proportion of each unit to the valley-head as a whole is variable by site. Where the local relief[9] is higher and general slope is steeper as sites 7,8,1 and 2, the headmost wall is high

8) The whole of the units is represented *Muldental* by Nakamura (1968).

9) Local relief in such scale of area (per about 0.02 km^2) may reflect shallower and steeper valleys described by the writer (Tamura 1965). Valley features by Nakamura (1968) is lower order components of hill morphology than the features described previously by the writer (Tamura 1965) and higher order components than the features treated in the present paper.

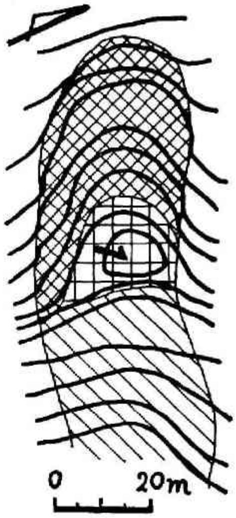


Fig. 23

Fig. 23 An example of the scauper-type failure at the Tokachi-oki earthquake, 1968. The head area of the failure site at Daibutsu, west of Hachinohe.
Contour line interval is 2 m. An arrow indicates the depression. Other symbols are explained in Fig. 5.

Fig. 24 Changes of proportion of micro-landform units composing valley-head
Keys are represented in Fig. 5.

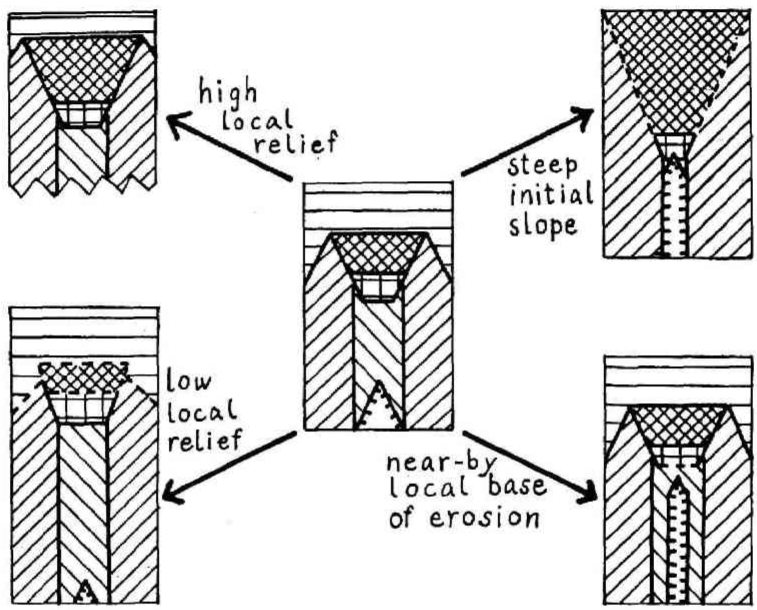


Fig. 24

and steep in proportion to the valley-head as a whole. At those sites the head terracettes are small but conspicuous. It is considered that vigorous fall caused by high and steep initial slope produces the high and steep headmost wall and consequent active accumulation facilitates the forming of the distinct head terracette. On the contrary where local relief is lower and general slope is gentler as sites 3, 4 and 6, the headmost wall is lower and is often indistinguishable from the crest slope. But at such sites the head floor or the head terracette is long in proportion to the valley-head as a whole. Where the local base of erosion exists close by, as site 6, headward gullying reaches close to the headmost wall. Where initial slope is steep and long as sites 7 and 8, also, the gully develops well, but it is different from the site of low local relief and near-by local erosion base in that the head floor is almost missing. Trend of development of each unit in the series observed at the site of low and high local relief in the hills may suggest the trend of it in the plains (uplands) and the mountains respectively.

Is each unit controlled only by such locational conditions as discussed above or as maintained by Nakamura (1968) ? Didn't it occured in the history of valley-head evolution that some processes were intensified or some processes were declined through total environmental change ? What does it mean that the gully incises into the head floor at every site ? It seems to offer a key to the chronological problem that the head floor at site 6 continues to the fluvial terrace along the main stream, as well as the two-storied head floors at sites 3 and 4, and buried shallow valleys on the summits of hills reported by the writer (Tamura 1965) and Wako (1966).

5. Conclusion

Valley-heads in the hills around Sendai are composed of the series of six micro-landform units; crest slope, side slope, headmost wall, head terracette, head floor and gully. Each unit is characterized with different processes, for example, the headmost wall by fall, the head terracette by temporary accumulation of materials from the headmost wall, and head floor by weathering in situ with creep, wash and ephemeral linear flow. But those are present processes and certain type of slope failures may have influenced the initiation of present form of valley-head. This series is common to the whole valley-head areas in the hills near Sendai, though each area is different in relief, origin and lithology of summit surface. Differences in proportion of each unit to the valley-head as a whole is related to initial slope and local relief near divides and distance from local base of erosion through intensity of processes concerning development of each unit. Further research on each unit from viewpoint of chronology and of exact processes is neccessary.

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