geomorphology of the medeshima hills and its environs to the south of sendai, northeastern japan

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Geomorphology of the Medeshima Hills and its Environs to the South of Sendai, Northeastern Japan

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I Introduction

The geomorphological evolution of a coastal plain consisting of coastal lowland and hill areas will be studied not only by means of terrace chronology but also erosion surface chronology. A hill area is a geomorphological unit distinguished from both mountains and coastal lowlands, and is to be considered not only as an erosional feature, but as a complex product of Quaternary sea level fluctuation and a continuous tectonic movement since Tertiary in the sense of geomorphological development and geological history.

Concerning the hill area Shiki (1968) summarized following characteristics;
1. low height of summit level, lower than 300 meters above the sea level
2. accordant hill ridges
3. dissected form of complicated limbs
4. low relief, smaller than 100 meters
5. hill area was developed cutting Miocene and Pliocene rocks
6. hill surface is veiled partly with gravels, volcanic ashes and volcanic flow materials of Older Pleistocene
7. in general, the original surface of hill area was initiated in the original surface of mountains.

On the morphological aspect, Nakamura (1966, and others) studied the morphological elements characterizing the hill topography and investigated especially the locational and/or paleo-climatic conditions of the high-level valley formation.

On the geohistorical aspect, Nakagawa (1967) considered that the differentiation of hill area started after Pliocene sediments had deposited. He also considered that Pliocene and Early Pleistocene sediments are now preserved only within the hill areas and that the original surface of hill area is a graded surface denuded in a long period with unchanged base level near the highest coastal terrace plain.

However, some erosion surfaces characterized by the afore mentioned facts 2, 3 and 4 are lower than the Highest Terrace surface. Therefore the author has been interested in the process of the formation of the erosional surface of undulating summit level in the low hill areas representing the effects of base level fluctuation.
In the Iwai hills to the north of the Sendai coastal plain, undulating hill surfaces which were once considered a part of so-called Rikuzen peneplain were classified, and each surface was correlated to a respective terrace surface chronologically based on its formation process. The undulating surface was produced where terrace surface once existed and when it was dissected by subsequent valley linked with the base level of next lower terrace (Akojima 1968).

The author discusses in the following chapters the evolution of low level erosion surfaces in the southern part of the Sendai coastal plain. The erosion surfaces in this case approximate to the Middle Terrace surface in height and it is expected that the age and height of the base levels will be used as keys to explain the process of erosion surface evolution.

II General view of the area

The area is to the south of Sendai city and is characterized by the uplands of continuous hills lower than 350 meters a.s.l. and the lowlands along the Abukuma river and the coastal plain (Fig. 1).

The backbone range to the west is composed of Miocene sedimentary and volcanic rocks covered with Quaternary volcanoes.

Abukuma Mountains to the south are composed of Paleozoic and Mesozoic rocks and Miocene volcanic rocks overlying them.

The uplands are the Takadate hills, the Kakuda hills and the Watari hills. The first bevels the east flank of the backbone range and the second two the northern part of the Abukuma mountains. In the Takadate hills Miocene Takadate andesite, in the Kakuda hills Mesozoic granite and overlying Miocene volcanic rocks and in the Watari hills the Wariyama formation of unknown age and Mesozoic granite crop out.

Along the Abukuma river and its tributaries, there are small basins of Tsukinoki, Funaoka, Murata, Ogawara and Shiroishi. They make a chain of basins bordered each other with low hills. The low hills are less than 100 meters in height and generally exposing the Tsukinoki formation, the Miocene sedimentary rocks lying under the Takadate Andesite.

The Natori and Watari coastal lowlands to the south of Sendai are bordered on their western margin by steep slopes running straight north to south at the east flanks of the Takadate and Watari hills. The steep slopes represent the Hisanohama–Iwanuma tectonic line and its extention.

Lower Pliocene sediments making the low hills are located continuously from Sendai to far south on the east side of this line. Pliocene sediments are developed

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Fig. 1 Southern area of Sendai

The contour intervals in the restored map eliminated the valleys less than 500 meters in width are 100 meters in the part higher than 100 m a.s.l., and are partly 20 meters to represent the low level hill surfaces.

typically and are delimited to the east of the tectonic line at Sendai, but are not found in the inner basins along the Abukuma river and its tributaries.

Terraces are also developed at Sendai typically but are not found both in the coastal lowlands except in the Medeshima hills and in the inner basins to the west except in the Shiroishi and Murata basins. Therefore, the Medeshima hill is an important key area to explain the origin of the low-level hills marging these inner basins.

III The Medeshima Hills

A. The Medeshima Hills and the Pleistocene Masuda Gravel Bed

The Medeshima hills are tongue-shaped low rise lower than 50 m a.s.l. fringing
Fig. 2 Medeshima Hill and its environs

The contour intervals in the restored map eliminated the valleys less than 500 meters in width, are 50 meters and partly 10 meters. Highest terraces such as Aobayama surface, and Aobayama Gravel are mainly after Nakagawa et al (1961) and Okutsu (1967). Middle terraces such as Dainohara terrace in Sendai after Nakagawa et al (1960) and Masuda Gravel in Medeshima Hills by Akojima. Lower terraces are not shown.

In the Medeshima hills, the Masuda gravel bed is distributed covering the east flank of the Takadate hills in height of 100-250 m a.s.l. (Fig. 2 and Photo. No. 1)
Iwanuma formation which is correlated by its characteristic mollusca facies to the Lower Pliocene Tatsunokuchi formation in Sendai, and the hill surface is veiled with ash and pumice fall cover called the Medeshima (or Azukijima) volcanic ash.

It was once considered that the Medeshima volcanic ash covered the Masuda gravel bed in conformity* and the Masuda gravel bed was correlated to the Aobayama gravel bed distributed on the Aobayama upland (100–200 m in height) around Sendai city (Miki 1949 and Hanzawa et al 1954).

Nakagawa and others (1959, 60) considered that the Aobayama formation comprised two members; the Koeji volcanic ash upper member and the Futatsuzawa gravel lower member, and the Medeshima volcanic ash overlying the Aobayama gravel bed in unconformity rested on the next lower terrace, the Dainohara terrace in conformity. And at the same time, the Aobayama formation and the Masuda formation were correlated each other as the Koeji volcanic ash member was found in the upper part of the Masuda formation.

The Aobayama terrace was correlated approximately to the Tama terrace in Kanto district.

They explained that the Medeshima hill surface under the Medeshima volcanic ash was an erosion surface of the Dainohara terrace stage. The Dainohara terrace in Sendai was correlated approximately to the Shimosueyoshi terrace in Kanto district.

Wako (1966) reported the red weathering crust and other surficial debris on the former ground surface under the Medeshima volcanic ash.

Tamura (1966), classifying the geomorphological surfaces in the Takadate hills, explained that the Medeshima hill surface lower than the Takadate upland surface was originated from the denuded flat surface and that the original surface was already lost.

However the author had presented two problems up to that time (1965);

1. The height of the Aobayama formation on the Aobayama upland (200–100 m) differs from that of the Masuda gravel bed in the Medeshima hills (lower than 50 m a.s.l.).

2. The Medeshima volcanic ash was explained to cover the Dainohara terrace (30 m at the lowest) of the Shimosueyoshi high sea level stage, but in its typical locality in the Medeshima hills, it is 10 m a.s.l. at the lowest near the level of the alluvial plain surface filling the former valleys.

On the contrary, Oide (1961) concluded that the Aobayama gravel was a fanglomerate deposit induced in tectonic background based on the distribution of

* So, the formation on the hill tops in the geological maps are not always the gravel bed member, but only the pumice shower.
the Aobayama gravel bed limited in the east of the Kagitori-Okubushi tectonic line, fan-shaped pattern of distribution and facies of the gravel bed. He also suggested that there was a uplift after the gravel deposition judging from base surface of both the Aobayama gravel and the basement Pliocene Hirosegawa tuff member.

Nakagawa (1961) reported that the Aobayama upland surface was divided into four blocks (from the upper to the lower; Surfaces I, II, III and IV) by the complicated tectonic movement. Each surface is not only tilted down from southwest to northeast in steps with small scale faultings, but also doubly warped from northwest to southeast joining the basement structure with faultings. Thereon Wako (1964) presented the time marks on each surface subdivided differently with remarks on the paleo-climatic agencies.

Recently different classification on the tephra covering the Aobayama upland surface is revealed (Geo-Science research group, Sendai branch 1968). The tephra are subdivided into three; Volcanic ashes A, B and C, and the lowest C cover the surfaces I and II, the middle B covers the surface III and the uppermost A covers the surface IV, and each tephra contracts conformably to each surface. Therefore, the problem afore mentioned 2 is still more complicated.

The steep slope bordering the east side of the Aobayama upland shows the Nagamachi-Rifu line (or Miyaginohara line) of flexure, which also delimits the east end of the lower terraces in Sendai from the coastal lowland and was considered to be active (Tayama 1933, 34, 36)*.

The Aobayama gravel is sliding down to the height less than 50 m a.s.l. on this steep slope at Dainenji (Okutsu 1967, p. 14, Fig. 5), and where the Aobayama terrace intersects the terrace correlative to the Dainohara terrace.

On the other hand, the hill surfaces of the Takadate upland were subdivided into two groups (Tamura 1966), and a decayed gravel bed was found on the lower surface (Tamura's H-II level) of the two (Akojima 1965).

In any case, it is not interpreted exactly that the Masuda gravel bed differs in height far from the Aobayama gravel bed as the Masuda gravel bed in the Medeshima hills rests on the lower Pliocene Iwanuma formation missing the middle and upper Pliocene sediments of the Sendai group (the Kitayama formation, and its

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* Tayama (1934, 36) noticed that the gravel bed consisting the steep slope at Dainenji was probably divided into two; the Aobayama terrace gravel bed on the upland surface and the gravel bed of the upper member of the Dainenji formation on the lower part of the slope. At the same time, the eastern steep slope may be explicable as not only the flexure slope but the terrace cliff cut by the lateral erosion of valley and obscured by the talus cover. But it is observed that the Aobayama gravel bed inclining down to the middle part of the slope in parallel with the slope.
Hirosegawa tuff member, the Yagiyama formation, and the Dainenji formation).

The eastward downwarping of the Iwanuma formation is pointed out, but it is not clear whether the origin of the marked steep slope on the east flank of the Takadate hills is formed by flexure. Oide (1955) considered that the Okubushi-Kagitori tectonic line which is the boundary between the Miocene rocks and the Pliocene rocks in Sendai extended southward on the border between the Takadate upland and the Medeshima hills.

B. The Iwanuma formation and the Masuda gravel bed

Pliocene Iwanuma formation is composed mainly of sandstone and partly of gravel bed, and is found up to the height of 70 meters a.s.l. on the steep slope to the west overlying the Miocene Takadate andesite.

Facies of the sandstone varies locally and vertically, but in the Medeshima

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**Fig. 3 Masuda Gravel Bed at Jusantsuka, Location No. 21**

1; Dark brown surficial soil and loamy volcanic ash (0.3-1 m in thickness)
2; Yellowish brown pumice layer (Pm-1, 4 m in thickness) of very large pumice particles and lapilli, contacting with distinctive and almost horizontal boundary to;
3; Yellowish brown pumice layer (Pm-2, 1.8-2 m in thickness) of upper 0.6-0.8 m: dark brown soil and loam, and lower 2 m: small granule pumice, interfingering with;
4; Sand and Gravel (Masuda Gravel, 10 m in thickness)
   The gravels are 0.2 m in diameter at the maximum and 1-10 cm generally, and subangular or subround.
   The upper part of the bed is sand and clay-silt and small pebbles. The bed is cut by 5 and 6, but cannot be distinguished from 7.
5 and 6; Upper white tuffaceous clay including the pisolite particles and lower white tuffaceous clay-silt with drift wood (Jusantsuka Tuff Bed, 4 m) overlying with very distinct boundary of lignity clay on;
7; Sand and gravel (1 m), contacting with distinct and horizontal boundary to;
8; Soft, fine granule sandstone (Iwanuma Formation) including much mollusca and sand pipes in some meters below horizon.
area each horizen is traced by means of mollusca bed, granules of the sand particle and hardness as the key (Fig. 5). At the location numbers 20-25, the typical localities of the Masuda gravel bed, it is cropped out newly that the Masuda gravel bed includes the pumiceous tuff and pisolite tuff layers filling the valleys cut into the gravel bed (Fig. 3).

This remarkable tuff layer is named the Jusantsuka tuff bed. At 20, 21 and 25, it rests on the thin sand and gravel layer 1-2 meters thick of the base of the Masuda gravel bed, and it contains the pisolite particles and the holes from which drift woods were gone.

At 21, in the same outcrop, a yellow pumice layer (Pm-2) rests on the uppermost part of the Masuda gravel bed in conformity inter-fingering each other and the Pm-2 with the dark brown soil atop is veiled with the yellow pumice layer of large particles, the Medeshima volcanic ash (Pm-1). Here the relation of the gravel bed and the Pm-2 is a typical case of conformity.

The Jusantsuka tuff bed is distributed widely in 8, 34 and 39. At 8 and 34, it is in the same horizon as at 25, but at 39 it is covered under the thick sand and gravel bed including thin lignite beds of the Iwanuma formation. So the Jusantsuka tuff bed is possibly a member of the Iwanuma formation. Therefore, returning to 21 and 25, the Masuda gravel in the narrow sense is only a thin sand and gravel veneer overlying the tuff bed and it is 4-5 meters thick here. It is impossible to subdivide the gravel bed here and in the east where the gravel bed makes a flat hill top surface of 30 m a.s.l."

On the other hand, a 20 meters thick gravel bed of the Iwanuma formation is distributed in the west. This gravel bed is lying under the siltstone and tuffaceous sandstone at 14, and its base inclines to the east in parallel with the lignite bed in the Iwanuma formation from 13 to 15. The Pliocene gravel bed is found at the height of 60 m at 13 and of 70 m to the west of 5.

The distribution of two gravel beds is shown in Fig. 4. A tentative division of the gravels is discussed again in chapter F.

At 36 at the height of 120 m a.s.l. on the Takadate hill surface, a decayed sand and gravel bed lying on the Takadate andesite was found (Akojima 1965 and Tamura 1966), in which the gravels were weathered and in particular the andesite gravels were showing the onion weathering structure, and the upper part of which was a red clay layer. The same bed is not found in other places at present. The gravel bed may be neither a part of the Masuda gravel bed nor that of the Iwanuma formation as it is too far from the Medeshima hills and is separated by the steep slope. The surface underlying the gravel bed looks to continue to the Aobayama surface in height.
C. Facies of Masuda gravel bed

The facies of the Masuda gravel bed is generally fluvial and its thickness (20 m in the maximum) is equal to that of the alluvium of the surrounding alluvial plain (cf. chapter II). The gravels in the bed are subangular or subround and 0.2 meters in diameter at the maximum. The bed frequently includes lenticular sand and clay layers and has large scale false-bedding, and the fabric of the gravels is clear (Photo. No. 3).

The upper part of the bed is generally composed of sand and clay and small pebbles at 20-30, and is including poor peat layer in the upper clay at 30. The bed at 6 to the west is thin and the gravels are small, although the gravel bed in the Iwanuma formation to the west is thick and includes the horizons of large gravels and boulders. The pumice layer covering the gravels in conformity is found only at 21, one of the highest points of the hills, where the fill-top-level of the terrace deposits is remaining.

But at 22 and 25 on the ridges a few meters below the highest points, the pumice layer is already lost and stained tuffaceous clay and silt layers are exposed which look like a volcanic ash cover (Photo. No. 4).

D. Paleo-current in Masuda gravel bed

The gravel fabric was measured at nine locations, ranging less than 1 km, with the method after Schlee's (1957) "apparent dip direction measurement method", and in seven cases out of the nine come out clear orientation patterns. When the fabric structure was apparent originally, the orientation pattern of the rose diagram was clear in spite of small number of the sampled gravels (see Fig. 7, loc. 29).

But the judgement of the upcurrent direction of the paleocurrent will be misreading when only the direction of the dip of the gravels is taken into account. At 29, the concentrated direction of the gravel-dip is northward, but the actual upcurrent of the flow is southward judged from the depositional structure. It is as Johansson reported (1963, 65), because the gravels were arranged on the subaqueous slope by gravity.

Seemingly, all of the flow lines concentrate in the north-south direction in eight azimuths if the upcurrent and downcurrent directions are neglected, that is, the flow lines are generally parallel to the contour lines of the gravel base and look like those of drainage pattern on the alluvial plain off the hills.

E. Base of Masuda gravel bed and Tectonic movement

The heights of the Masuda gravel base, the Jusantsuka tuff bed and the
Iwanuma formation were measured in the Medeshima area covered by 1:2,500 topographic sheet and in the Iwanuma area of 1:50,000 sheet partly with the Barometer (Fig. 6).

The Masuda gravel base in the wide sense is even in large scale, but from 29 to 30, the base inclines gently and contacts with each horizon of the sandstone of the Iwanuma formation. (Fig. 5; 18-20-24-29-30-31-32) The base declines steeply 10 m in relative height from 26 to 28 and 30. The silt and clay layer is on each hill top, and at 26 on a hill top is the fill-top-level of the Masuda gravel bed. Therefore it is presumed that the terrace surface was warped down eastward after the deposition of the gravel bed.

A large fissure cuts the gravel bed at 29 and the upper-most silt and clay layer (Photo Nos. 5 and 6).

At 6, the gravel bed abuts on the sandstone of the Iwanuma formation in clinounconformity, which dips steeper than that of the gravel base. This means that the gravel bed deposited on the warped Iwanuma formation and tilted down eastward, when the inclination of the bedrock increased.

F. A tentative division of the gravel beds

It is difficult to distinguish the gravels by facies. The base surface of all the gravel beds directly on the sandstone of the Iwanuma formation and the Takadate andesite is shown in Fig. 6-A, when all the base gravels were assumed to be members of the Iwanuma formation. It is gently undulating in the east but ascending abruptly to the west.

The presumed base surface of the Masuda gravel bed in the narrow sense which covers the Jusantsuka tuff bed and other basement gravels is shown in Fig. 6-B. It is inclining steeply in the east and keeping the same level in the west, if all the gravels in the east are taken into consideration. And when the displacement of the gravel bed in the east is restored, the character in each case shows a tendency to be strengthened.

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Fig. 4 Geological map
mainly after Hanzawa et al 1954 and subdivided partly by Akojima 1967
Medeshima Volcanic Ash (pm-1) cover is taken off.

1: Masuda Gravel Bed and its upper member of clay-silt and pumice layer (pm-2)
2: Pliocene Iwanuma Formation, sandstone, Jusantsuka Tuff member and Gravel member
3: Pre-Pliocene rocks mainly of Miocene Takadate Andesite
Numbers 1-43 are location numbers of outcrop column in Fig. 5 and letters A-G are locations of boring column of alluviums with the thickness in meter in parentheses.
G. Medeshima volcanic ash

The Medeshima volcanic ash in this area is 5 meters in thickness at the maximum and is consisted of upper brown volcanic ash and lower yellowish brown pumice bed.

The pumice bed comprises mainly large pumice particles of 2-3 cm in diameter
and includes lapilli and rock fragments.

The lowest part of the pumice bed is always soaked with ground-water and weathered into characteristic white clay layer with thick limonite band in the bottom of it. The weathered bedrock surface is very distinctive with soils and
Fig. 7  Paleo-current in Masuda Gravel Bed

Gravel fabric are measured at nearly basal part of Masuda Gravel in the broad sense, and as samples only apparent dipped disc-type pebbles are taken. In each location, more than 60 pebbles are measured which are sampled from more than one outcrop. Types of the orientation rose:
A; Concentrated type preferred in one direction.
B; Elongated type preferred in opposite two directions.
C; Relatively concentrated type in one direction and another.
D; Irregular type.

Type A, B, and C may give the paleo-current flow lines, if the direction of upcurrent or downcurrent is neglected. Notice the similarity between the flow lines of the base of the gravels and the drainage pattern on the alluvial plain.

muddy debris including gravels derived from the Masuda gravels.

At 11, the pumice layer (Pm-2) was found under the Medeshima volcanic ash (Pm-1) at the height of 20 m a.s.l. sliding down and filling the valley. Existence
Fig. 8  Cross profiles of the Medeshima hill
Key letters are same as the Column in Fig. 5.
The summit level is restored.

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of the red weathering crust on the gravels and the sandstone under the Medeshima volcanic ash was reported by Wako (1965).

The volcanic ash increased the evenness of the hill surface veiling the relief (Photo. No. 2). The shower reaches to the level of 10 m a.s.l. at the lowest at 18, 32, 41, 42 and 43.

The ash fell on the hill surface dissected almost to the present form. The aforementioned faulting did not cut the Medeshima volcanic ash cover.

As the pumice layer is not detected in the boring columns of alluvium surrounding the hills, it had been lost before the alluvium sedimentation.

H. Alluvial deposits around the hills

Close to the hills, the alluvium is very thin and is consisted of fine materials including poor peat.

Off the hills, the deposits are thicker up 20 to 30 meters and consisted of upper fine materials and lower gravels (Figs. 4, 9). The fine materials above 5-8 m in depth, i.e. about the sea level may have been the result of a minor transgression in the Jomon Earthenware age.

I. Topography and Rocks

On the flat hill top at 21, 26, 28, 29 and 30, the pumice layer or clay and silt layer contacting the gravel bed in conformity are the fill-top-level of the terrace deposits. In other places the hill ridges are narrow but accordant.

Terrace-like surfaces and accordant ridges beveling the Takadate andesite, the gravel bed and sandstones of the Iwanuma formation are dotted in the west at 1, west of 5, 13, 35 and 37.

As the Medeshima gravel in the narrow sense is always lower than 50 m a.s.l., the above mentioned ridges to the west were low inter-fluves at the deposition of the Masuda gravel.

They are remarkable in Fig. 2.

The ridges situated between the Medeshima terrace surface and the east flank of the Takadate hills are lower than 50 m a.s.l., and consisted of the gravel bed although the terrace deposits were worn away, and the these ridges made the accordant summit level like the terrace surface partially preserved in the east.

The evidences are not found that show the retarding base level lower than that level.

* The boring data are presented by the courtesy of Dr. Hase
The hills in Iwanuma are dissected into narrow ridges and have a complicated form cutting the sand and gravel bed of the Iwanuma formation, but they are remarkably accordant.

IV The Aobayama upland and the Natori upland

The upland surrounding the top of the Natori river fan is called Natori upland. (Noh and Nakamura 1967)

In this area between the Aobayama upland and the Takadate upland, a number of terraces were already reported (Nakagawa et al 1960, 61, and Nishitani 1965). Recently, engineering for housing made the outcrop observation much easier.
The terraces in this area are named temporally as follows;
Surface A 150-140 m
Surface B 130-120 m
Surface C 90-70 m, or Uenohara terrace surface
and other Lower terrace surfaces
The surface C was correlated to the Dainohara terrace.

The narrow but accordant ridges of the surfaces A and B were expected to be
the erosional surfaces which were eroded rapidly being deficient of gravel cap rock of
the Aobayama fanglomerate to be reversed the height. The structure of the
surfaces A and B is described here.

The surface A is lower than the upper surfaces of the Aobayama upland and
located around Mt. Taihaku (300 m), a small protuberance. On a part of the
accordant ridges, thin terrace deposits remain overlying the white pumice tuff of
the Miocene Hatatate formation.*

The surface B is not higher than 130 m a.s.l, and is cutting into the surface A
(Fig. 10). The distribution pattern and the structure of the surface B suggest that
it was made by lateral shifting of the Natori river channel. The surface is found
also to the south of the Natori river hanging on the flank of the Takadate upland.

The shallow hanging valleys are found cutting slightly in the surface A, where
the bedrock pumice tuff bed is exposed. The base level of the hanging valleys is
perhaps the same one as that of the terrace surface B.

The surface C is underlain by the 10 meters thick terrace deposits composed
mainly of boulders. At 104 and 108, the surface is veiled by the volcanic ash and
pumice layer, the tephra A of the Aobayama upland. At 108, the pumice layer
covers the soil veiled slope (Fig. 10), and within the pumice layer a greenish
gray volcanic sand layer is found, that is the key bed of the tephra A. The pumice
cover disappears at the downslope of the terrace surface cut by a shallow valley.**

Consequently, the tephra A covers the surface C of the Dainohara terrace stage un-
comformity, and also unconformably the surface IV of the Aobayama upland.

At 101, a typical exposure of the tephra A, the tuffaceous clay layer under the

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* At 106. At 107 are found also the gravel bed and tuffaceous clay layer including drift
woods and pisolite particles. It overlies both the hard sandstone including much
mollusca and the conglomerate bed of the Hatatate formation, and is located higher
than the pumice tuff bed. The gravels are well rounded and are generally smaller
than the terrace gravels of the lower terraces, but the beds are not consolidated yet.
It is to be reexamined as terrace deposits.

** As the cryopediment, a part of the Sendai Kamimachi terrace surface, was dated by C-14
method in Wurm Glacial age (Wako 1965), it is instructive that the tephra A is cut out
by the shallow valley here, which continues to the lower terrace surface correlative to
the Sendai Kamimachi terrace.
Fig. 10 Natori Upland

1: Surface A at 106 and 107, Surface B and Surface C at 108.
   Basement are the pumice tuff bed at 106, sandstone rich in mollusca and conglomeric at 107, hard pumiceous tuff at 108 (MioceneHatate Formation) and the hard sandstone at the cliff of the Natori river (Miocene Monisa Formation).

2: Details at 108
   1: Tephra A, I'; key bed of Tephra A
      a: Column of Tephra A; brown clay 2 m (volcanic ash). as the upper part is eroded out and lower part is saturated into dark brown in part, the total thickness is restored.
      b, c, d; (0.5 m in thickness); greenish yellow volcanic sand layer, laminating, and pumice layer of large particles and fine particles.
      e; fine granule pumice bed (1.5 m) rich in lapilli and quartz particles/contacting with very distinct boundary with limonite band to;
      f; clay layer, terrace deposit. Upper 0.2 m is stained and shows dark brown weathered zone.
   2: Terrace deposits of the surface C (or Uenohara terrace); upper; laminating pebbly sand layer and lenticular type clay layer originated in main from basement lower 1-4 m; gravel bed. gravel are generally 1-20 m in diameter and 40 cm at maximum, and are all polished.
   3: Terrace deposit of Surface B (130 m surface) more than 3 m in thickness
   4: Basement, hard pumiceous tuff (Hatate Formation)

3: Surface B at 105 and Surface C at 104
   Surface C; 1: Tephra A (1.5 m) covering with distinct boundary on;
   2: terrace deposit (5 m?). The upper surface of clay layer atop is weathered.
   Surface B; 3: terrace deposit (2 m at maximum)
   4: terrace deposit is lost at 110 m a.s.l., and basement with reddish brown weathering cover is exposed atop.

4: Details at 105
   a: Terrace deposits of upper sand and lower gravel (2m in thickness at the maximum). Gravels are generally 1-20 cm and at maximum 40 cm in diameter, overlying in clino-uncomformity with uneven boundary to;
   b: inclined basement tuffaceous sandstone with small scale faultings (Hatate Formation?)
pumice layer is thinned out in part. As the clay layer is the uppermost part of the
terrace deposits or the lowermost part of the tephra A, the relation of the contact
between the terrace deposit and the tephra A may be uncomformable here.
Wako (1964) suggested that the tephra filled the valleys that cut into the
Aobayama gravel and underlying bedrock. At 103, it is newly found that the tephra
(perhaps A) rests on the tilted Aobayama gravel lower than the upland surface.

V The Shiroishi basin

Terraces are developed well around the Shiroishi basin and they are classified
as follows (Furuya 1965);
Terrace surface 1 (Hara terrace) 150-180 m in height, 100 m higher than the
river floor
Terrace surface 2 (Nagano terrace) 130 m, 80 m
Terrace surface 3 (Nagahukuro terrace) 50-100 m, 40 m
Terrace surface 4 (New terrace) 75 m, 15 m
and the flood plain

The Hara terrace is typically developed near Shiroishi and is traced along the
Matsukawa river, and it was correlated to the Sendai Kamimachi terrace. But, a
terrace higher than the Hara terrace (the terrace 1) is newly found along the Shiroishi
river, and it is named the Nambuyama terrace (Terrace 0 in the Photo. No. 7).
Its relative height from the present river plain is 200-120 m and the height
from the sea level is 250-170 m. It is hanging along the gorge at the flank of a
mountain of the backbone range to the west of Shiroishi. The terrace surface
is wide but is engraved to make undulating surface. Although terrace deposits
are not found as the terrace 1, the Nambuyama terrace is surely a river terrace.

The cliff bordering the Nambuyama terrace slopes down to the terraces 1 and
2, and it is steep and high i.e. about 100 m in relative height.
Furuya presumed the existing of a tilting of the terraces based on the longitudinal
profiles of the terrace surfaces, and the Nambuyama terrace surface coincidently
descends steeply to the east.

To the east, this surface is bordered with a steep slope and faces on the
surface 3. This steep slope runs straight from north to south and its southward
extent conforms to the southern border of the terrace 2, from where the terrace
2 disappears*, and also to the steep slope making the flank of the mountains which
is explained as a fault-scarp (Fujiwara 1958), and its northward extension also
agrees with the steep slopes that border the hills from the lower terraces.

* The characteristic arrangement of the lower terraces was noticed by Tayama (1934).
This continuous steep slope is the Komatsuzaki-Shiroishi tectonic line, which was once pointed out by Furuya.

As the terrace 1 was correlated to the Sendai Kamimachi terrace, the Nambuyama terrace, the terrace O, is to be correlated to the Sendai Dainohara terrace. The higher terraces are not distributed to the cast of this line, and it is difficult to trace each terrace downstream along the Shiroishi river.

At any rate, it will be concluded that the base level graded to that of the Sendai Dainohara terrace stage extended to the Shiroishi basin.

The alluvial plain is lower than 50 m near Shiroishi and the subsurface deposits are 35 meters thick (Fig. 13-A).

It is presumed that the extending effects of the last maximum regression and of the following transgression reached upstream to this area.

VI The Ogawara basin and its environs

In the Ogawara and the Murata basins, Furuya (1965) noticed terrace-like hills 40-60 m high and hanging valley floors in corresponding height cutting into the upper hills.

Furuya concluded that the Sendai Dainohara terrace was submerged under the alluvial plain in this area because the terraces near Shiroishi descended downstream abruptly and were extinguished and because the height of red weathering crust in the hills 35 m at the lowest was too lower than he had expected. But it was not a necessary presumption as it was pointed out in the Medeshima hills (cf. III-G).

The low height of the red weathering crust is not ascribed to the absolute subsidence of the hills, and these hills 40-60 m in height are supposed to be same ones as the Medeshima hills.

The hill foot line is complicated but it is not due to the absolute subsidence of the hills, and is the drowned valley form at the Post-Glacial transgression, because the alluvium is 50 m thick in the center of the basin (Figs. 11, 12).

The hanging valley floor and the higher part of the alluvial plain surface which are slightly higher than the river floor is not yet dated.

VII The Tsukinoki basin and the Watari lowland

Dissected low hills and drowned valleys are main features in the Tsukinoki basin, which is a part of coastal lowlands because the upper part of the alluvium includes oyster shells and the base of the alluvium is more than 40 m meters below the sea level along the Shiroishi river (Figs. 11, 12).

The hills of loose sedimentary rocks of the Miocene Tsukinoki formation un-
Fig. 11 The low level hills along the Kakuda, Tsukinoki and Ogawara basins and the dissecting base level.

The numbers are depth of bed rock in meter from the sea level, the numbers in parentheses are the thickness of alluvium in meter and enclosed numbers are that of alluvium where the bedrocks was reached.
derlying the Takadate andesite are dissected but have an accordant summit level, and Tamura (1966) classified it as the level-III (his H-III) including the Medeshima hill. At present no terrace deposits and no volcanic ash fall covers are found on the hill tops.

The hills on the east foot of the Watari hills, the narrow rise of the Wariyama formation develop bevelling both the Takadate andesite and the Iwanuma formation, which deposited intricately on the border between the Wariyama formation and the Takadate andesite.

The Medeshima volcanic ash (pumice fall cover) is found on the lower hill side.

VIII  The Kakuda basin

Similar to the case of the Tsukinoki basin, the Kakuda basin is bordered by the lower hills of the sedimentary rocks of the Miocene Tsukinoki formation, and is
surrounded with the higher hills of the andesite, the granite and the consolidated rocks more than 100 m a.s.l.

In a part of the low hills, a terrace was proposed (Suzuki et al. 1968). They may have considered the gravel bed at Kitane as the terrace deposits (Fig. 1). The gravel bed is at 70 m a.s.l. and is 10 meters thick and are composed of sand and gravels mainly originated from the granite, and the bed is overlying the wavy bedded lignite containing sandstone. But it is traced that the gravel bed is underlying the bedrock tuffaceous sandstone and is inclining together with it. Therefore, the gravel bed may not be terrace deposits but a part of the bedrock.

The thickness of the alluvial deosits is shown in Fig. 11, and it is for the first time in the gorge between the lower and middle reaches of the Abukuma river that the alluvium base reaches to the depth of the sea level. Therefore it is natural to understand that the sea level fluctuation in the last maximum regression and the following transgression affected to produce the lowland in the Kakuda basin. The sediments filling the drowned valleys around the hills are so fine granule and make up the feeble ground (Figs. 11, 12).

VIII Summary and Discussion

A. Tectonic movement and Correlation of the terraces

In the Medeshima hills, it is presumed that the eastern part of the hills tilted down eastward after the deposition of the terrace gravels and prior to the fall of the Medeshima volcanic ash (III-E). The tilting is correlative to some part of the tectonic movements along the Miyaginoohara line in Sendai. But the presumed amount of the tilting is not large, and the terrace gravels are found always lower than 50 m a.s.l. Therefore, the tectonic movement does not explain the gap in height between the Aobayama gravels and the Masuda gravels.

Nakagawa (1961) concluded that the uplift of the Aobayama surface accompanied with a tilting that made the surface I in the westmost part the highest. However the author knows that the terraces lower than the surface I of the Aobayama upland surfaces are developed to the south of them and are corresponding to the lower ones of the Aobayama surfaces in height.

As the contemporaries with these surfaces are found also at the south side of the Natori river hanging on the flank of the Takadate upland, so both the Aobayama upland and the Takadate upland were not be differentiated in tectonic movement.

Therefore, the terrace surface of the Medeshima hills is correlated to the 90-70 m terrace surface (the Uenohara surface) of the Natori upland around the Natori river fan top, and also to the Sendai Dainohara terrace surface.

The tephra A, perhaps identical to the Medeshima volcanic ash, covers the
Medeshima hill surface in uncomformity but it does not cover the Aobayama upland surface in conformity as once reported.

The correlation of the pumice layer (Pm-2) lapping comformably on the Masuda gravel bed with the tephra on the Aobayama upland surfaces is not conclusive. It is difficult to make it clear whether the relation of contact between tephra and terrace surface is conformity or uncomformity, because the scale of outcrop is limited. The author points out two cases for example; the Pm-2 in the Medeshima hills contacts the Masuda gravel bed comformably, but in a location it is filling the valley in the hill side and it seems to have deposited on the dissected hill surface. It shows that the fill-top-level, the Pm-2 once occupied behind there, was lost.

On the contrary, the tephra A in the Natori upland covers the 90-70 m surface uncomformably, but it is not found on the 130 m surface and in the main part of the 150 m surface, where it was eroded out.

B. Evolution of the low-level hill area

The low-level hills at the margin of the basins are separated peacemeal and are dissected so much to show the complicated form, but the restored summit level is accordant.

1) Accordant summit level evolution

The flat hill surface, 30-40 m in height to the east of the Medeshima hills is a depositional surface covered with at least a thin veneer of sand and gravel.

The ridges which are more than 50 m a.s.l. and make up the flank of the Takadate upland were the low inter-fluves when the Masuda gravel deposited. They were composed of the Pliocene sand and gravel bed and were not differentiated in lithology against the erosion from the depositional surface of Masuda terrace gravel to the east, and they preserve almost the original levels.

In the middle part of the hills and perhaps in the Iwanuma area, the thin gravel veneer was worn out, and the basement sand and gravel bed of the Iwanuma formation were exposed forming the narrow but accordant ridges a little lower than 50 m a.s.l.

The accordant hill top level in the Medeshima hills and Iwanuma hills indicates the existence of a surface in a past stage. This case is complicated due to the deformation of the surface by the lowest level of the last maximum regression (Fig. 13-B), but the most simple case is known.

The Nanakita hills, the hills behind the Sendai Dainohara terrace, are formed at the height between the Dainohara terrace surface and the upland surface around
Fig. 13 Boring Column of Alluvium

Location A (Shiroishi) is in Fig. 1 and Locations B (Ogawara), C (Marumori), D (Kakuda), E, F (Tsukinoki) and G, H, I (Kakuda) are in fig. 11. A, B and E are along the Shiroishi river, C, D and F along the Abukuma river, and G, H and I are in the drowned valleys.

Columns are after the published data by Planning Agency of Miyagi Prefecture (1968) and the Economic Planning Agency of Japan (1963), and are presented newly by the Marumori Railway Line Construction Office, Japanese National Railway.
Kunimitoge which is contemporary to the Aobayama upland surface, and the hill top surface is undulating (Fig. 2).

The geomorphological details of the Nanakita hills were analyzed (Tamura 1965, Nakamura 1966, 67) but the hill top level is explained roughly on the chronological viewpoint; there was once a flat surface related to the base level of the Aobayama surface, and when it was dissected on the basis of the base level of the Dainohara terrace, the undulating surface between the two levels was natural result. It is reasonable to conclude that the terrace deposits suggesting the original level were already eroded out because the hills are at the present remarkably dissected to shift the divide of the hills southward as Tamura pointed out* (Fig. 12-1).

The highest terrace of the Natori upland (IV) is well preserved as the narrow but accordant hill ridges, and this case may fit the same one. Especially in this case, the relative height, i.e., the potential relief, between the surface A (150–140 m) and the surface B (130–120 m) was small and the dissecting valleys which drained to the surface B were small and gentle-profiled. So the original level of the surface A was not lost when it was dissected on the basis of the base level of the surface B, but was denuded to an undulating surface. Then the tributaries cut down according to the relative drop of the base level related to the lower terraces, but the undulating surface which had originated from the surface A was preserved by the same reason** as that which preserved the lower terrace surface such as the Uenohara terrace surface.

The evolution of the low-level hill surfaces in the inner basins may be the most complicated case through the multiple stages (Fig. 12-3).

The accordant hill top level continuing along the chain of basins is concluded to have been affected by the base level of the Medeshima terrace stage, because the base level of the terrace extended upstream to the Shiroishi basin and perhaps to the Kakuda basin (V–VIII). Their original surfaces were formed as valley floor surfaces and as low erosion surfaces. In addition, the hanging valleys in corresponding height to it were pointed out in the upper hills (VI).

These low-level hills were developed commonly cutting the Miocene loose sedimentary rocks, and were presenting the topographic unconformity to the upper hill surfaces of the andesite, the granite and the consolidated sedimentary rocks.

* Along the Nanakita river, to the north of the hills, there is no wide terrace surface correlative to the Dainohara terrace. (Miura 1964, Noh and Nakamura 1967) Seemingly it was lost when the base level dropped, and the base level of the northward valleys which are graded to the Nanakita river was lower than that of the southward valleys, which are graded still to that of the Dainohara terrace surface.

** And possibly with the help of its lithology, i.e., the underlying pumice tuff bed possibly shows the resistance against the erosion by its permeability.
The differential resistance of the rocks was not the only reason. Nakamura (1964) noticed the existence of high level valleys above 80-160 m a.s.l. in the Kakuda hills, and he assumed that they were originated from a former base level. It can be surmised that the wide valley plain acted as a base level of some of the afore mentioned high level valleys. Once the flat surface was formed as the valley floor surface, the former surface of the low-level hill surface were to be easily formed like in the case of the Sendai Nanakita hills and the Medeshima hills.

Thereafter they were dismantled again to the lowest base level of the last maximum regression. As they were beveled at the height between the two levels probably remaining the former level in part, they were still undulating although the slope of the hill tops increased.

The present feature of the hills are the upper part of them free from the submergence.

2) Isolation of the hills

The low-level hills are separated piecemeal. That may have been splitted by the extending valleys cutting down the plain according to the drop of the base level.

Perhaps the steep slopes on the northeast and east sides of the Medeshima hills were formed by the shift of the Natori river channel. The flow lines on the alluvial plain are read as the drainage pattern of the rivulets in Figs. 2 and 7. The outline of the Medeshima hills was dicided by the lateral erosion of the valleys. Therefore, the arrangement and the scale of the valleys extending from the upper land behind the low hills decided the range or scale of the low hills and then the slope of the hill top level.

The low hills were located at the foot of the highly dissected and massive upperlands in the basins of Kakuda, Tsukinoki, Funaoka and Ogawara, as well as in the coastal lowlands of Natori and Watari. They were taken to pieces. But in Sendai area, the terraces of the Dainohara terrace stage were surrounded by the lower terraces afore and the small hills back. They were not dissected and remained their fresh cliffs and wide surfaces. In Shiroishi area too, the Nambuyama terrace correlative to the Sendai Dainohara terrace and the Medeshima terrace was uplifted and it was isolated in the surrounding lower terraces, then it remained as the undulating but wide surface.

3) Complicated forms of the hills and the base level of dissection

The terraces in Shiroishi and Sendai are located delimited by the tectonic lines from the lowlands and the present river floor, and some ones of which newer
look higher than the low-level hills along the lower reaches of the rivers. The Sendai Kamimachi terrace is dated in the Würm glacial age. The lower Sendai Nakamachi terrace and the lowest Sendai Shitamachi terrace are extinguished to the east of the tectonic line.

Each of the three is correlated to each horizon of the submerged sediments under the coastal plain (Hase 1967). Along the Shiroishi river the case is the same (Furuya 1965).

On the contrary, the hills in the lowlands of Natori and Watari and along the rivers of Shiroishi and Abukuma face directly on the alluvial plain and coastal plain. They were affected directly by the drop of the sea level in the last maximum regression.

Therefore the former was remained not dismantled but the latter was dissected to present very complicated form.*

The fine granular sediments filled the intricately valleys of the dissected hills far from the main river channel. The bottom of the sediments may be denuded in the air at the last lowest base level and drowned rapidly according to the later accelerating stage of the transgression.

X Conclusion

1. The surface of the Medeshima hills is partly the remnant of terrace and partly the erosion surface denuded to the base level of the terrace.

2. The base level of the Sendai Dainohara terrace and/or of the Medeshima terrace extended up to the inner basins along the Shiroishi and Abukuma rivers. The effects of the last regression and the post-glacial transgression also extended upstream and formed the lowlands of the Shiroishi and Abukuma rivers.

3. The low-level hills bordering the chain of basins were originated from the couple of surfaces such as the Medeshima hill surface, the subaqueous valley floor surface and the subaerial denudation surface.

The outline of the basins which decided the distribution of the low-level hills had been drawn perhaps in the former stage (probably 100 m level stage).

4. The complicated form of the hills is resulted both from the isolation of the hills by the shifting of the extending tributaries from the upper lands, and

* There is little evidence suggesting the retarding base level at the height between the level of the Medeshima hill surface and the level of the alluvium base, i.e. at the height between the level of so-called Middle terrace and the lowest level of the last maximum regression (except the case of the Ogawara basin). The lower terraces at Sendai and Shiroishi perhaps affected mainly by the tectonic uplifting. That is instructive of the mechanism of terrace formation in that time, namely the superposition of the tectonic movement and the sea level fluctuation.
from the dissection to the lowest base level of the last maximum regression extended directly to the basins.

5. When the original surface comes into shape, the undulating surface is to be formed between the original level and the dissecting base level, if the potential height of the two is small. The presumption of the original surface and the later base level change will be instructive of the formation of the erosional surface of accordant summit level in the low hill area.

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References (*in Japanese)

Akajima, I., (1965); Geomorphology of the hills near Natori and Iwanuma* Promotion Thesis (Geography) Tohoku University (unpublished)

——— (1968); Geomorphology of Iwai Hills* Annals of the Tohoku Geographical Association V. 23-3 181 (Abstract)


Furuya, T., (1958); Geomorphological developments of the eastern foot of the Zao Volcanoes and its environs* Geographical Review of Japan v. 38-2 57-73

Geo-science research group, Sendai Branch, (1967); Geo-science of Sendai* Tohoku Education Library co. ltd., 96ps

Hanzawa, S., et al. (1953); The geology of Sendai and its environs Sci. Rep. Tohoku Univ. Ser. 11 (Geology) No. 25 1-50

Hase, K., (1967); Geology of Alluvial Plains of Miyagi Prefecture* Contributions from the Institute of Geology and Paleontology, Tohoku University No. 64 45 ps


——— (1965): Structural studies of Sedimentary Deposits ibid No. 32 61ps

Miki, K., (1949); Geology of the southern part of Sendai* Promotion Thesis (Geology) Tohoku University (unpublished)

Miura, O., (1965); River terraces in the middle and lower reaches of the Nanakita river* Promotion Thesis (Geography) Tohoku University (unpublished)
Nakagawa, H., et al. (1959); Quaternary geology of Sendai area* Journal of the Geological Society of Japan v. 65 460 (Abstract)

--- (1960); Quaternary geology and geomorphology of Sendai* and its environs (1)* Quaternary Research v. 1 219–227

--- (1961) Quaternary geology and geomorphology of Sendai and its environs (2)* Quaternary Research v. 2 30–39

Nakagawa, H., (1961); Terraces bordering the Pacific coast of the Southern Tohoku Region, Japan* Journal of the Geological Society of Japan v. 67 66-78

--- (1967); Development of Hilly Lands* Jubilee Publication in the Commemoration of Professor Y., Sasa, Dr. Sc. Sixtieth Birthday

Nakamura, Y. (1964); Geomorphology of the Kakuda Hills* Annals of the Tohoku Geographical Association v. 16–3 168

--- (1966); Relief distribution and Morphological Development of the Sasamori Hills, Akita Prefecture Sci. Rep. Tohoku Univ. 7th Ser. (Geography) No. 15 95–116

--- (1968); Dissection features in the Hills near Sendai City, viewed from the valley forms Sci. Rep. Tohoku Univ. 7th Ser. (Geography) No. 17 19-30

Nishitani, K., (1965); Geomorphological development of South-western part of Sendai* Promotion Thesis (Geography) Tohoku Univ. (unpublished)

Noh, T., and Nakamura, Y. (1967); Geomorphological land classification ‘Sendai’ quadrangle 1:50,000 map,* National land survey, Economic Planning Agency, Japan 29ps

Olde, K., (1955); Geology of South-western Area of Sendai City — On three Problems—* Journal of the Geological Society of Japan v. 61 388-395

Okutsu, H., (1967); Subsurface geology of ‘Sendai’ 1:50,000 quadrangle map.* National land survey, Economic Planning Agency, Japan 43ps


Schlee, J., (1957); Fluvial Gravel Fabric Journal of Sedimentary Petrology v. 27-2 152-176

Shiki, M., (1968); Geomorphology of hill area* Geography v. 13-10 6

Suzuki, K., et al. (1968); Quaternary geology in Fukushima and Koriyama* Quaternary No. 13 10-29

Tamura, T., (1965); Geomorphology of the hills in the northern part of Sendai City* Promotion Thesis (Geography) Tohoku Univ. (unpublished)

--- (1966); Geomorphological study in the Takadate Hills, Miyagi Prefecture* Annals of the Tohoku Geographical Association v. 18–2 75–82

Tayama, R., (1933); River terraces in the Sendai District, Geomorphological study on the Kitakami Mountains*; Pt. 1 River terraces: A. Saito Ho-on Kai Museum Research Bull., No. 17 84ps

--- (1934) Surface and Subsurface Deformation of Ground in Sendai and its vicinity* Bull. Earthq. Res. Inst., v. 12-1 76-95

--- (1936); Landslide in Dainenji Hills, Sendai* ibid, v. 14–2 271-284

Wako, T., (1964); Geomorphological surfaces and Red Weathering Crust in Northeast Japan* Quaternary Research v. 3–4 197–211

--- (1965); A Cryopediment, Jutokuji Surface, in Sendai City* Annals of the Tohoku Geographical Association v. 17–3 164

Photo No. 1 A distant view of the undulating hill top level of the Medeshima Hills from the Takadate Upland. The flat surface in this side is the contemporary of Medeshima Hill surface.

Photo No. 2 Medeshima volcanic ash on the hill top at 5.

Photo No. 3 Upper part of Masuda Gravel, at 29.

Photo No. 4 Upper horizon level of Masuda Gravel, almost horizontal but a little lower than the fill top level.

Photo Nos. 2–4 Masuda Gravel Bed and Medeshima Volcanic Ash.

Pm-1: Medeshima volcanic ash Ma; Masuda Gravel Bed I; Basement Iwanuma Formation

Photo Nos. 5, 6 Fissure cut the uppermost clay layer and the gravels at 29.
Photo No. 7 Relief model of Shiroishi Basin
S; Shiroishi City, H; Mt. Hachimori (557 m)
Terrace surfaces;
O; Highest terrace surfaces newly found  Oa; Nambuyama terrace, Ob; Kokubodaira
1; Hara terrace, 2; Nagano terrace, (in Shimohara)
3; Nagafukuro terrace 4; New terrace 5; Flood plain
Notice the scarp line running south to north along the foot of Mt. Hachimori and its
tention.