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Geography of the Geomorphologic Surface in the Nasu-Fan Region, Tochigi Prefecture; Surface Geology as an Element Constituting Geomorphologic Region

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In this paper, surface geology means the character of the uppermost strata of the inner structure of the earth surface, while geomorphologic region signifies the geographical region established by taking geomorphologic surface into consideration. The areal variations in surface geology, which are found among different geomorphologic regions, are studied in the present paper, from the geographical viewpoint.

These variations, however, may be evaluated differently from different points of view. For example, for the purpose of researching surface geology, geomorphologic surfaces may serve as leading criterion, in order to find out the distribution areas of certain characteristic geologic profiles in question. On the other hand, for geomorphology surface geology may offer an indispensable key to an understanding of the genetic analysis of landform. In short, the concept of the genesis of surface geology and, in relation to it, the concept of landform development are fundamental to all the studies of this kind.

In contrast, in the field of geography, in which surface geology is considered as nothing but a constituent element of the geographic region, its areal differentiations being expressed in its interrelations among other phenomena of the region are essential. In the preceding paper (3)[2)] in which the geography of the geomorphologic surface in the Nasu-fan region was surveyed as a preliminary study, such areal differentiations of the surface geology were discussed, together with the areal variations of the soils, the ground-water and the land utilization, especially taking the geomorphologic regions as basic units which make up the fan as a geographic region. Regarding the interrelations among these items, the surface geology is considered as a

1) Nasu Agricultural High School
2) See the number of the title in the references at the end of this paper

leading phenomenon controlling the other features, directly as well as indirectly, to a certain extent. Although such interrelations or cause-and-effect relationships constitute only a certain part of the total interrelations composing geographic region, they are, nevertheless, regarded as an essential part of those total complexes.

In the preceding paper, however, because of the preliminary survey, the treatment of those aforesaid items were practised only in brief and bold outline, leaving all the details to future discussions. Consequently in the present paper, limiting the considerations to the problems of the surface geology, its varying manifestations, in relation to those of the ground-water and the soils with which the variations are most clearly interrelated, are compared and contrasted, as concretely and as minutely as possible, among the different geomorphologic regions. In this respect, this paper is supplementary to the preceding paper.

For this purpose all the available facts are analyzed, which were observed in the field survey by the present authors. These field data were obtained from the direct observations of the outcrops or from the observations in the well-holes, although not a few of them are the results of the electric-resistivity method practised for the ground-water studies especially by Sagehashi. The results obtained from the inspections using the hand-borer with a length of 1.5 m are also frequently referred to. These field data collected by such various methods, are expressed in the form of profiles showing the characteristic surface geology and are arranged systematically according to the geomorphologic regions delineated in the preceding paper (3). Among them certain representatives are illustrated in the present paper as typical examples.

(1) The Gongenyama-surface or the G-surface.

The G-surface is a group of maturely dissected isolated hills, ranging from 205 to 370 m in altitude and rising about 20 to 50 m when compared with the neighbouring N-surface. They extend from NW to SE, being arranged in five lines.

Fig. 1[3,4] shows typical profiles of the G-surface, observed by K. Watanabe and N. Sagehashi from the outcrops along a road crossing the Fujinidayama-hill which is a part of the above-mentioned isolated hills. The Ôtawara-pumice flow which is a massive volcanic tuff, gray white in color, with angular pebbles, is unconformably overlaid by the wind-

3) For the explanation of this and the following illustrations see the interpretation in the text. For the locations mentioned in the figures see the location map (Fig. 26) at the end of this paper.

4) Concerning the outcrops and the geologic profiles the depth is represented in meters. For the symbols see Basic Symbols A.

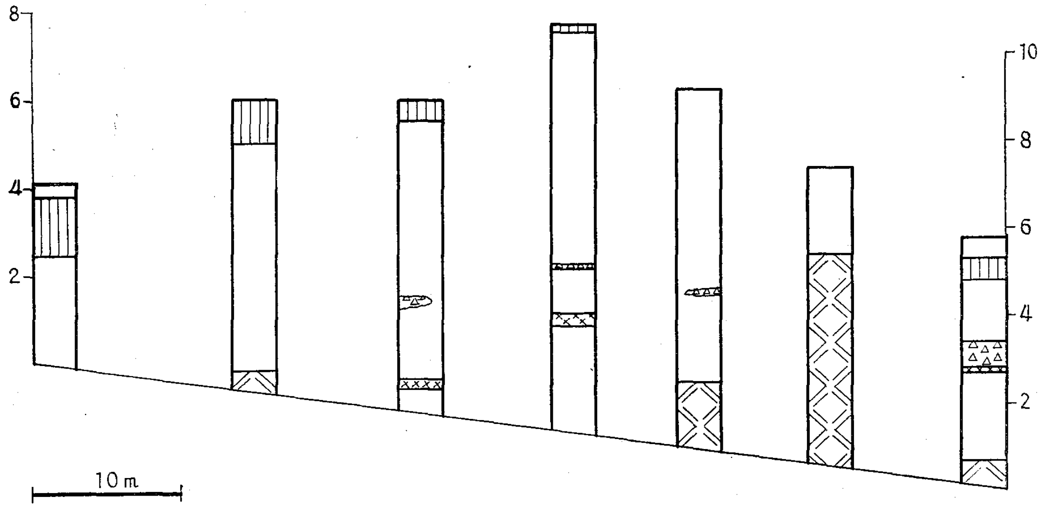
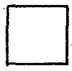
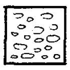


Fig. 1. Outcrop of the Fujinidayama-hill (G). After Watanabe and Sagehashi.

Basic Symbols A (For Geologic Profiles)

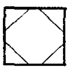
 Humus or Humus With Underlying Soil Horizons

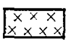
 Volcanic Ash or Mingled Type Volcanic Ash, Sometimes Including Soil Horizons

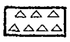
 Gravel Bed

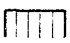
 Ôtawara-Pumice Flow or Takaiwa-Tuff

 Ainosawa-Pyroclastics

 Jôhôji-Mudstone

 Pumice

 Scoria

 Black Belt (Buried Soil)

f—g Fan-Gravel Bed

T—g Torinome-Gravel Bed

Y—g Yanagibayashi-Gravel Bed

deposited volcanic ash. Although the thickness of the ash layer is not definitely known, it probably represents a wide range of variation, within the limits of a small area. The soil which rests upon this ash layer is overlaid by the alluvial ash called the Fujinida-loam.

In connection with the G-surface south of Ôtawara, the Ainosawa-pyroclastics or the Yanagibayashi-gravel bed underlies as bedrock, instead of the Ôtawara-pumice flow.

Observed from the results inspected by the hand-borer survey being carried out on the G-surface just north of Ôtawara, where the Ôtawara-pumice flow is accompanied with numerous pumice-breccias, the depth of the humus layer lying directly upon the volcanic ash varies widely from place to place within a restricted area, ranging from few centimeters to more than one meter, presumably being affected by land surface inclination. Here the layer of the buried soil is not infrequently confirmed.

An example of the soil profile, which is illustrated in Fig. 2,[5] represents three layers lying under the humus, the first one grading downward from blackish brown to dark brown, the second one light brown and the

Basic Symbols B (For Soil Profiles)

(cross-hatched)	Black, Brownish Black, Blackish Brown or Dark Brown
(vertical lines)	Brown, Light Brown or Yellowish Brown
(short vertical lines)	Brownish Yellow
(dashes)	Gray
(dots)	Mingled With Sand, Gravel
(circles)	Gravel Bed
C	Clay
CL	Clayey Loam
L	Loam
S	Sand
SL	Sandy Loam
Si	Silt
SiC	Silty Clay

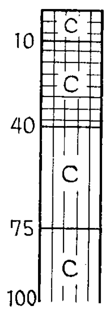


Fig. 2. Soil profile obtained by hand-borer on the hill north of Ôtawara (G).

5) For the soil profiles the depth is represented in centimeters. For the symbols see Basic Symbols B.

third one brown, respectively in color, all of which are composed of clay. The third and probably also the second layers are strata composed of the afore-mentioned wind-deposited volcanic ash. The humus layer is blackish brown and clayey texture. This kind of soil is classified as the Nasu upland black soil (hilly subtype) by Uchiyama and others (5).

Viewed from the landform development, the G-surface is formed by the ridges which are engraved upon the deposition surface of the Ôtawara-pumice flow or upon the surfaces of the other strata above-stated, and which rise above the level of the fan-gravel.

(2) The Kanemaruhara-surface or the K-surface.

The K-surface is a group of isolated flat uplands being sharply contrasted with the lowland of the N-surface. These surface adjoin each other with cliffs of 5–10 m in relative height. The K-surface extends from NW to SE, making seven lines, in the same manner as the G-surface.

Fig. 3 shows an outcrop illustrating the surface geology of the K-surface of Shiroyama along the river Sabi, just east of Ôtawara. The bedrock which is the Ôtawara-pumice flow is overlaid unconformably by gravel bed reaching about 5 m in thickness. This gravel bed which correlates probably to the Torinome-gravel under the fol-

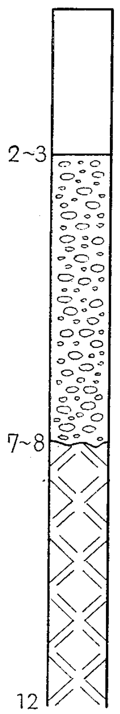


Fig. 3. Outcrop of Shiroyama east of Ôtawara (K).

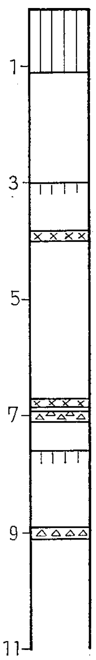


Fig. 4. Outcrop near Kitaôwaku (K).

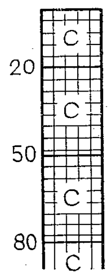


Fig. 5. Soil profile obtained by hand-borer at the same site as in Fig. 4 (K).

lowing N-surface, is composed of crudely sorted subrounded cobbles with boulders, the largest of which reaches about 30 cm in diameter. The wind-deposited volcanic ash rests unconformably upon this gravel bed. The surface horizons are, however, markedly changed by man in this part of the K-surface, where there was once the seat of the castle of Ôtawara.

A similar profile is found south of Akaze though no bedrock underlying the gravel crops out in this place. The bedrock in question, which is represented by the Ôtawara-pumice flow in the above-mentioned example of Shiroyama, may perhaps be the Ainosawa-pyroclastics or the Yanagibayashi-gravel bed in this southermost part of the fan.

According to the observation of an outcrop at Yuzaka being made by Akutsu (1), the depth of the volcanic ash layer resting upon the gravel bed attains about 12 m in thickness. In Fig. 4 an outcrop at Kitaôwaku which reaches a depth of about 11 m is represented, illustrating the volcanic ash layer which is brown in color, composed of clay and characterized by layers of buried soil, pumice and scoria.

On the rolling upland of the K-surface, the humus layer which is derived from the wind-deposited volcanic ash, develops, ranging some 50 to 100 cm in thickness, making a contrast with the above-mentioned G-surface. An example of the soil profile is represented in Fig. 5, where the humus resting upon the ash layer is divided into three strata, the upper one being black in color and somewhat loose, the middle one black and the lowest one grading downward from black to brownish black, all of these three strata being composed of clay. This profile probably represents the undulating subtype of the Nasu-upland black soil (5).

Considered from the point of view of ground-water, the K-surface, being characterized by the above-mentioned gravel bed, from which issue certain amounts of effluent seepage at the base of the cliff near Akaze and at other places, exhibits a contrast to the G-surface which is not endowed with such water-bearing stratum. Failing a field survey, however, nothing can certainly be known concerning the ground-water under the K-surface in general. At present, some parts of the K-surface are reclaimed as paddy fields by pumping up the ground-water from the adjoining L-surface.

The present day K-surface is considered as segments of a previous fan composed probably of the Torinome-gravel, which remained unworn down against the degradation of rivers, as isolated uplands being distributed from NW to SE.

(3) The Nasuno-surface or the N-surface.

The N-surface is the most extensive geomorphologic surface, extending continuously from the central to the terminal section of the Nasu-fan region, which is not only composed of the previous flood plains of the rivers Naka and Hôki but also composed of the previous and the present day flood plains of Sabi and Kuma. These present day flood plains are distinguished as the Intra-rivers-surface which includes the area between the rivers Sabi and Kuma and also the neighbouring areas in the central section of the fan.

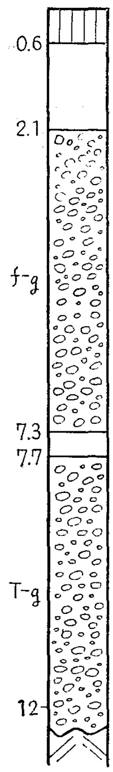


Fig. 6. Geologic profile observed in a well-hole northeast of the Karasugamori-hill (N). After Watanabe and Sagehashi (7).

The geologic profile of a well-hole drilled into the N-surface (Fig. 6), located just northeast of the Karasugamori-hill, which was studied by Watanabe and Sagehashi (7), is presumably accepted as a standard representing the surface geology of the N-surface. Upon the Ôtawara-pumice flow rests unconformably a gravel bed which is about 5 m in thickness and composed of crudely sorted subrounded gravels of liparite, quarz porphyry, andesite and green tuff, materials which are found in the rocks along the upper streams of Hôki and Sabi. This gravel bed under the N-surface, lying unconformably upon the Ôtawara-pumice flow, is distinguished as the Torinome-gravel bed, although the lower part of which may correlate to the other gravel layer (the Nabekake-gravel) according to circumstances. The Torinome-gravel bed is overlaid by a thin layer of volcanic ash. This ash layer is defined as the Torinome-loam. Upon the Torinome-loam lies another gravel bed, i. e. the present-day fan-gravel which is a deposit of about 5 m in thickness and of which the degree of sorting, of rounding and the rock materials are exactly the same as those of the Torinome-gravel bed. The fan-gravel is covered by the upper volcanic ash layer or the Nasu-loam being about 1.5 m in thickness, which is overlaid by the soil.

Refering to this standard profile and the other profiles studied in the wells, Sagehashi analyses the ρ-a curves obtained by the electric-resistivity method, practised at some 2000 points, utilizing the difference in the electric-resistivity between the fan- and the Torinome-gravel beds, which results from the difference in the degree of consolidation. The Ôtawara-pumice flow and the Ainosawa pyroclastics, respectively in the central and the terminal section of the fan, are also discriminated, using the ρ-a curve, from the above lying Torinome-gravel bed. Although the Torinome-loam is commonly not exactly known by this method, the existence of both the fan- and the Torinome-gravel beds is presumed and their depth is estimated, under the numerous points of the N-surface.

It is characteristic of the N-surface that the thickness of these two gravel beds exhibits marked variations from place to place. For example, in the vicinity of the Fujinida-hill, an extreme case is found which has neither the Torinome- nor the fan-gravel. Here a thin

Fig. 7. Geologic profile obtained by electric-resistivity method near the Fujinidayama-hill (N).

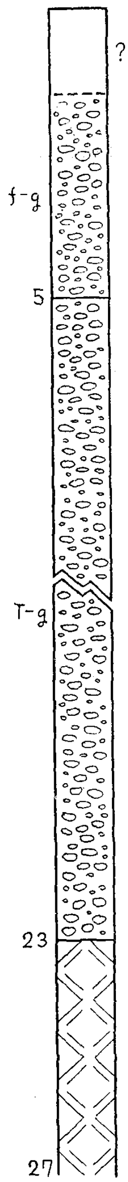


Fig. 8. Geologic profile obtained by electric-resistivity method at Ôtsukashinden (N).

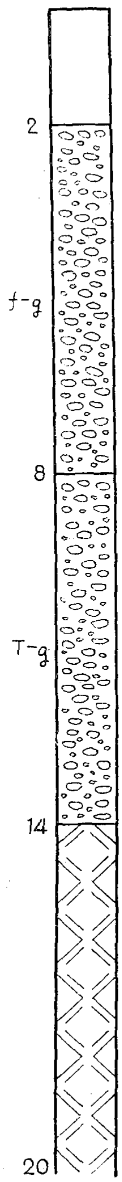


Fig. 9. Geologic profile obtained by electric-resistivity method at Nagakubo (N).

layer of angular andesite gravel derived from the underlying Ôtawara-pumice flow lies under the volcanic ash, and attains only about 40 cm in thickness (Fig. 7).

On the other hand Fig. 8 illustrates the fan- and the Torinome-gravel beds reaching 5 or less and 18 m respectively in thickness. The intermediate or the ordinary case is noticed in Fig. 9, where the two gravel beds attain a thickness of about 6 m each. Analyzing these and the other numerous observations Watanabe and Sagehashi conclude that there is a remarkable relief on the surface of the underground Ôtawara-pumice flow, made by the vertical erosion of the previous rivers corresponding to the present day Naka, Kuma, Sabi and Hôki. As a presumption they expect 9 or 10 underground valleys downcut into the Ôtawara-pumice flow, especially in the central section of the Nasu-fan, which extend from NW to SE almost parallel to the axis of the fan (8). Although the four largest among them reach to the depth of 20 to 30 m, the other five or six remain at the depth of more or less 15 m, respectively from the land surface. The underground ridges among these valleys, which stretch in the same direction, lie about 10 m under the surface.

Concerning the N-surface which occupies especially the central section of the fan, this characteristic configuration of the surface of the Ôtawara-pumice flow, which determines the thickness of the gravel beds, is decisive, as Watanabe and Sagehashi assert, viewed from the interrelation between the surface geology and the ground-water. Those limited parts of the Torinome-gravel bed deposited in the underground channels cut into the impervious Ôtawara-pumice flow, which are usually thick and as a general rule, composed of boulders and cobbles with a small quantity of cementing materials, satisfy one of the necessary conditions controlling the water-bearing strata which contain copious ground-water. In fact in the case of the wells which can supply more than 3000 m^3 of ground-water yield per day, the water is pumped up exclusively from those limited parts of the Torinome-gravel (8). On the other hand, those parts of the same gravel bed, which are deposited upon such sections of the Ôtawara-pumice flow which correspond to the aforesaid ridges or the interfluves between the neighbouring underground valleys, are usually thin being composed of pebbles cemented by fine materials. Consequently, these gravel beds can serve only as water-bearing strata with small water-yielding capacity.

Associated with the above-mentioned first necessary condition, the second which determines the water-bearing strata yielding copious supply is whether or not the abundant water can easily percolate into the thick gravel beds from such sources as the rivers Kuma, Sabi and Hôki and in addition from the Shimbori-cannal. These two conditions combined, provide certain limited ground-water veins under the N-surface (8).

Returning to the above-mentioned examples, the wells represented in Figs. 6 and 8 yield copious ground-water supply even in the drought period, in contrast to the well in Fig. 7, from which a very restricted amount of water can be pumped up all through the year. On the other hand, the well illustrated in Fig. 9 supplies a medium amount of water during the drought period when the water-table sinks into the Torinome-gravel bed, however, during the wet season when the water-table rises into the fan-gravel, it supplies abundant water comparable to the wells in Figs. 6 and 8.

As for the soil profiles, the uppermost strata observed from the outcrops or inspected by the hand-borer survey offer numerous data. In marked contrast to the K-surface where the thick volcanic ash layer which is deposited on the upland surface exclusively represents the stratum under the soil, the uppermost layers of the N-surface being inundated with previous and partly with recent floods, are rather heterogeneously composed of floodplain materials. In the present paper which deals primarily with the surface geology, the soil profiles of the N-surface are classified into the following four major types, owing to the materials composing the strata under the humus layer.

(a) This type is characterized exclusively by the stratum of the wind-deposited volcanic ash, being brown or yellowish brown in color and of clayey texture, similar to that associated with the G- and the K-surface, yet when compared with the upland type Nasu black soil of the K-surface, this layer of the volcanic ash is much thinner, probably attaining less than 2 m in thickness at the most and is underlain by the fan-gravel bed (Fig. 10). By the hand-borer survey which can reach only 1.5 m deep, this type is not exactly discrimi-

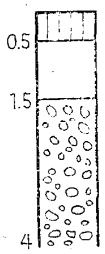


Fig. 10. Outcrop east of Mineshita (N).

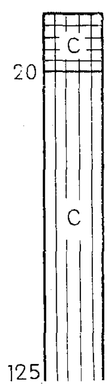


Fig. 11. Soil profile obtained by hand-borer south of Tayûzuka (N).

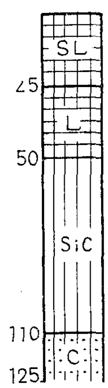


Fig. 12. Soil profile obtained by hand-borer west of Futatsumuro (N).

nated. Viewed, however, from many soil profiles accompanied by the wind-deposited volcanic ash lying directly under the humus, which are inspected by this method, the humus layer is generally blackish brown in color and of clayey texture. This type of soil is named by Uchiyama and others the Nasu black soil with cobble layer (5). In Fig. 11 the volcanic ash lying under the above-mentioned type of humus, changes downward gradually from yellowish brown to brown, the latter part being dotted with reddish pumice.

(b) This type is characteristically endowed with the strata of the volcanic ash mingled with river-deposited clay, sand or gravel, of which the color and the texture differ rather widely, depending perhaps partly upon the mixed ratio of these two kinds of materials, though usually being yellowish brown, grayish brown and yellowish gray changing from clayey to sandy texture, sometimes accompanied with gravels. The humus layer is generally blackish brown or dark brown in color and clayey, clayey-loamy or loamy in texture. Fig. 12 illustrates an example representing type *b*, in which the humus layer, blackish brown in color and composed of sandy-loam, is underlaid by three strata, of which the first is dark brown and composed of loam, while on the other hand, both the second and the third are yellowish brown and composed, respectively, of silty-clay and clay mingled with sand and gravel. Type *b* corresponds probably to the Nasu black alluvial soil named by Uchiyama and others (5).

(c) This is the type which has both the strata of the wind-deposited volcanic ash and the above-mentioned mingled type volcanic ash. The humus layer is blackish-brown and of clayey or clayey-loamy texture in general. An example is illustrated from Fig. 13, in which the humus layer, blackish-brown and of clayey texture, is underlaid by characteristic stratum with the color grading downward from brownish-yellow to yellowish-brown and the texture, roughly

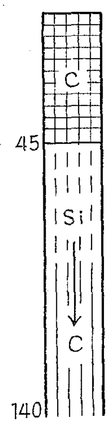


Fig. 13. Soil profile obtained by hand-borer at Nakatawara (N).

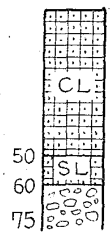


Fig. 14. Soil profile obtained by hand-borer at Ippongi (N).

speaking, from silt to clay.

(d) This type is characterized by the stratum of the river-deposited coarse sand and gravel lying directly under the humus layer. The humus is generally blackish brown in color and composed of clay, clayey loam or loam. In Fig. 14 the humus layer which is blackish brown, is divided into the upper and the lower strata, of which the former and the latter are composed respectively of clayey loam and sandy loam, both including gravels. The lower humus layer is immediately underlain by the gravel bed. Type *d* is included in the Nasu black alluvial soil.

In addition to the aforesaid four types, there exists the river-bed brown lowland soil of Uchiyama and others (5), which are most frequently found on the Intra-rivers-surface. As for the Intra-rivers-surface, failing a field survey, nothing, however, can be certainly concluded in the present paper concerning the soil profile.

(4) The Chikasono-surface or the C-surface.

This is the highest among a series of surfaces cut down into the N-surface, which is distributed mainly in the terminal section of the Nasu-fan region.

Fig. 15 illustrates a geologic profile of the C-surface, observed from the core obtained by drilling practised near Hiruhata, of which the depth reaches 43 m or more. From the depth of 8.8 m downward the profile is represented by the Jôhôji-mudstone, on which rest the Yanagibayashi-, the Torinome- and the fan- or terrace-gravel in the order of mention.

Similarly a cliff at Udagawa along the river Sabi, which is represented in Fig. 16, shows another example of the surface geology of the C-surface. The Ainosawa-tuffite is overlaid by gravel bed composed of crudely sorted gravels attaining a thickness of about 4 m. Perhaps the lower part of this gravel bed correlates to the Torinome- and the upper part to the fan-gravel bed or most probably to the terrace-gravel bed. Upon the latter rest two layers, the lower and the upper one being composed respectively of silt and the mingled type volcanic ash.

As for the C-surface the soil profiles are classified into the same types *a*, *b*, *c* and *d*, discussed for the N-surface, which are illustrated in Figs. 17, 18, 19 and 20, respectively in the order of mention.

In Fig. 17 the wind-deposited volcanic ash, which lies directly under the humus, is brown in color and dotted with red-brownish particles of pumice. Though, lacking the strata under this volcanic ash, nothing can be strictly said, this profile may perhaps be classified as type *a*. The humus layer of this type is generally blackish brown

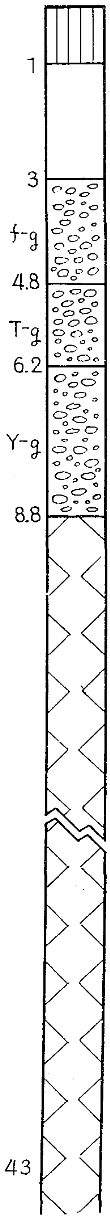


Fig. 15. Core obtained by drilling at Hiruhata (C).

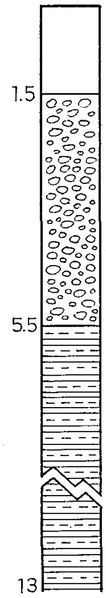


Fig. 16. Outcrop east of Udagawa (C).

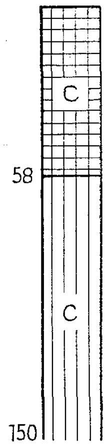


Fig. 17. Soil profile obtained by hand-borer northeast of Izumi (C).

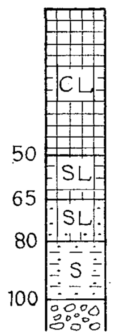


Fig. 18. Soil profile obtained by hand-borer southwest of Karikiri (C).

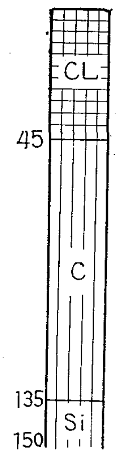


Fig. 19. Soil profile obtained by hand-borer at Udagawa (C).

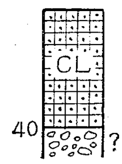


Fig. 20. Soil profile obtained by hand-borer at Nabekake (C).

or brownish black in color and composed of clay or clayey loam.

Type *b* is most commonly found under the C-surface. An example in Fig. 18 shows two layers between the humus and the gravel bed, of which the upper and the lower one being respectively brown and gray in color and composed of sandy loam and sand, both including gravels. The humus layer being blackish brown is divided into two strata of clayey loam and sandy loam. As a general rule, however, the humus layer of type *b* is blackish brown and composed of clayey loam or clay. Strata including gravels are frequently found in the soil profile and often the underlying gravel bed lies at the depth of more or less 1 m.

The profile which is illustrated in Fig. 19 may perhaps be classified as type *c*, viewed from the layer under the humus, being light yellowish brown in color and composed of clay, which is presumed as the wind-deposited volcanic ash. This bed is underlaid by the layer composed of silt being whitish-yellowish brown in color. The humus is blackish brown and clayey-loamy texture.

Reliable examples illustrating type *d* characterized by the gravel bed lying immediately under the humus are not yet definitely known for the C-surface, although Fig. 20 may represent one of these cases, in which the humus layer being brownish black and composed of clayey loam accompanied with gravels, rests upon a layer which is presumed in all probability as the gravel bed.

In connection with the interrelations between the surface geology and the ground-water, the C-surface is somewhat different from those interrelations found concerning the N-surface in the central section of the fan.

In the terminal section where the C-surface most widely develops, the Torinome-gravel is more or less consolidated and becomes half impervious. The fan-gravel, on the other hand, plays a role of the principal water-bearing stratum. Accordingly the water-table, though undergoing some range of fluctuation, remains as a general rule shallow below the land surface all through the year. From the head of small valleys downcut into the water-bearing fan-gravel bed, moreover, a large amount of ground-water issues continuously even in the drought period though restricted in quantity, making a number of springs, especially in the area of the C-surface lying west of the river Sabi.

(5) The Lower-surface or the L-surface.

The L-surface is a series of erosion surfaces formed upon the C-surface by the river degradation. A greater part of these surfaces forms a set of lower terraces along the rivers Naka and Hôki. The uppermost among these lower surfaces lies 2 to 3 m lower than the C- and 6 to 7 m lower than the N-surface.

The L-surface has a characteristic surface geology in general, being illustrated by the examples in Figs. 21, 22 and 23, all of which are observed from the outcrops exposed at the terrace cliffs. As for the bedrock the Ainosawa-pyroclastics, the Takaiwa-tuff and perhaps the Yanagibayashi-gravel crop out respectively, in connection with the above-mentioned examples in the numerical order. The terrace-gravel

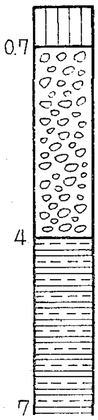


Fig. 21. Outcrop west of Takizawa (L).

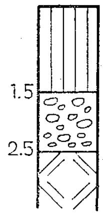


Fig. 22. Outcrop near Ômameda (L).

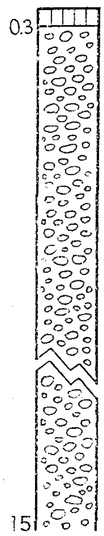


Fig. 23. Outcrop west of Katabuda (L).

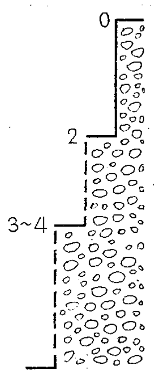


Fig. 24. Outcrop west of Ônuki (L).

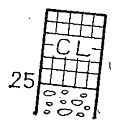


Fig. 25. Soil profile obtained by hand-borer west of Nakadawara (L).

bed which lies under the soil strata, rests directly upon the bedrock, although not infrequently there exists almost no soil on the surface. In Fig. 24 three steps of terraces are illustrated, each being composed of gravel bed.

As a general rule the soil profile is classified into the above-mentioned type *d*, of which an example is represented in Fig. 25 where the gravel bed is overlaid directly by the humus layer being blackish brown in color and composed of clayey loam. This kind of humus is most commonly found concerning the L-surface.

Finally the terrace-gravel bed of the L-surface contains shallow lying copious ground-water in general, although those terraces along the river Hôki which borders the Nasu-fan on the west are presumed as exceptions because of no water effluents from the terrace cliffs in this part of the L-surface.

(6) Comparison among the geomorphologic regions, viewed from the surface geology as a constituent element.

The geomorphologic regions G-, K-, N-, C- and L-surface are compared and contrasted as follows, by taking the surface geology which is interrelated with the ground-water and the soils into consideration. As for the G-surface of which the surface geology is characterized by the wind-deposited volcanic ash lying unconformably upon the bedrock, no water-bearing stratum can generally be found, making a striking contrast to the other surfaces. The K-surface which is provided with a gravel bed composed probably of the Torinome-gravel, possesses undoubtedly a certain amount of ground-water, the general character of which, however, is not yet surveyed. On this flat surface, the Nasu upland black soil develops more perfectly, which is derived from the underlying thick volcanic ash layer which rests upon the above-mentioned gravel bed, when compared with the same type of soil on the G-surface where the surface inclination interferes with the soil making processes.

The N-surface which is the largest of all surfaces, is at the same time most complicatedly differentiated, viewed from the areal variations of the ground-water and the soils which are interrelated with the surface geology. In connection with this surface, the Torinome-gravel bed which rests upon the unpermeable Ôtawara-pumice flow, plays the role of principal water-bearing stratum, especially in the central section of the fan. During the drought season the ground-water is concentrated chiefly into those parts of the Torinome-gravel, which lie in the underground channels cut into the Ôtawara-pumice flow, making conspicuous ground-water veins limited in numbers. Considered from the soils which are classified into the already-mentioned four principal types of *a*, *b*, *c* and *d*, representing complicated areal variations, the N-surface as a whole is, however, sharply contrasted with the K-surface covered with the Nasu-upland black soil which has no gravel bed within few meters from the land surface nor has sand and gravel in either the humus layer or in the underlying volcanic ash as Uchiyama and others pointed out (5). Although the wind-deposited volcanic ash underlying the humus layer is also frequently found on the N-surface, this volcanic ash is far thinner compared with that on the K-surface.

The C-surface which is the erosion surface cut down into the N-surface, has certain similarities and differences compared with the N-surface, concerning the surface geology interrelated with the ground-water and the soils. With regard to the C-surface being located chiefly in the terminal section of the fan, the fan-gravel bed instead of the Torinome-gravel represents the water-bearing stratum.

providing the shallow lying ground-water, the concentration of which into the water veins being not so conspicuous when compared with that part of the above-stated C-surface, which covers the central section of the fan. The soils on the other hand, is more or less analogous to that of the C-surface, though definite conclusions must be expected from future studies.

In connection with the L-surface, the terrace-gravel bed which lies directly under the humus and rests immediately upon the bed-rock, determines the *d* type soil profile. The gravel bed plays the part of water-bearing stratum, furnishing permeating water from the terrace cliffs.

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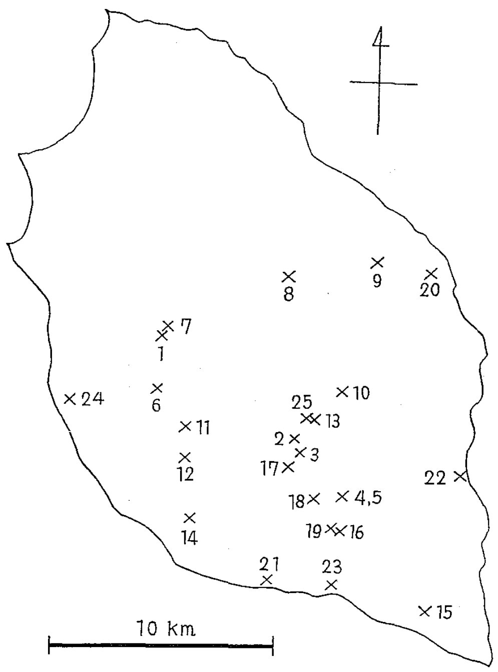

Fig. 26. Map showing the locations mentioned in the figures.

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