30. *Mineralogical and Chemical Composition of the Kanto Loam from Turumi, Yokohama.*

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Introduction.

A conspicuous member of the Quaternary formations of interior Kanto is the upper Pleistocene deposit of clayey and sandy materials, which for want of a better formational name is known as "Kanto loam", and the greater part of which is popularly called "Akatuti" (red earth) after its characteristic red tint. The deposit is widely distributed on the uplands of the region (Tama hills, Musasino and Sagamino terraces, etc.), where it occurs as a surface mantle deposit, conforming closely to the general contours of the buried pre-Kanto loam topography, varying in thickness from a few meters to slightly more than ten meters. Where it is best developed, it is reddish-brown, fragile, and almost massive, without definite stratification, although in many localities it exhibits faint color-bands, suggesting variety of material. Thus, some yellowish beds of decomposed pumice are frequently interstratified within it.

Although the stratigraphic position of the Kanto loam has been almost unanimously settled, there still remains a divergence of opinion concerning the mode of its deposition and the source of the material composing it; some authors regard the Kanto loam as an eolian deposit of volcanic material, and others as a subaqueous (marine or lacustrine) sediment of either volcanic or detrital substance. When the writer studied, petrographically, the Kanto loam of Eno-sima, an islet lying near Kamakura on the northern shore of Sagami Bay, he came to the conclusion that the Kanto loam there is of detrital origin. According to Kuno,[2] who has studied the geology of Volcano Hakone, the Kanto loam that is developed in the southwestern part of Kanagawa prefecture, where Hakone is situated, consists practically of basaltic ejecta

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1) H. TSUYA, *Jour. Geol. Soc., Japan,* **37** (1930), 27~34; *Bull. Earthq. Res. Inst.,* **9** (1931), 98~106.

2) H. KUNO, *Jour. Geol. Soc., Japan,* **43** (1936), 225~229.

from Volcano Huzi (Fuji). From these evidences, it is natural to expect the presence there of several variations in the deposit to which the term "Kanto loam" can be applied in a comprehensive sense, and that various qualifications will arise. A detailed systematic study of the Kanto loam in every section of the Kanto region is desirable, in that it may probably reveal several horizontal and vertical subdivisions of the deposit, each exhibiting characteristics due to the modes of deposition with which they were formed, as well as to the original sources of their material.

For obtaining information on the origin, correlation, and differentiation of the Kanto loam, the composition of the deposit from any particular locality should be definitely ascertained through the methods of sedimentary petrography. In the present paper, the petrographic characters of four specimens of the Kanto loam, collected at Turumi, the northernmost ward of the city of Yokohama, are described, their stratigraphic relations noted, and their origin discussed, although the results obtained are by no means conclusive, more questions arising than can be answered.

Field relations of the Kanto loam in the vicinity of Turumi.

In the vicinity of Turumi, the Kanto loam is distributed on a terrace about 40 m above sea-level, lying close to the northern side of the Government railway of the Tokaido Line and a little northwest of Turumi station. The terrace, which is characterized by flat-topped interstream areas separated by broad and low-lying, esturine-like embayments, ends abruptly on its south and east sides with steep cliffs, facing respectively the coastal plain on Tokyo Bay and the alluvial flat of the Tama-gawa (river), while it extends northward and westward in a wide area including the Bluff and other uptowns in the southern part of Yokohama, and skirting on the west side the eastern margin of the higher Tama hills (an older dissected terrace), composed practically of Neogene formations. This low but extensive terrace is correlated, both geologically and geomorphologically, with the more extensive "Musasino terrace", on the southern part of which the uptown of Tokyo is situated, although the former is separated from the latter by the broad alluvial flat of the Tama-gawa.

The main lower part of the terrace consists of almost horizontal layers of sand, silt, and gravel of lower Pleistocene age, which are exposed everywhere in the scarps of the terrace, and which have been named the "Simo-sueyosi series" by Otuka[3] after the type locality, situated about 2 km north of Turumi station. The beds contain volcanic material (pumice, scoria, obsidian, etc.), besides pebbles of older rocks and marine fossil shells.

The upper one-fourth of the terrace, or less, is represented by the Kanto loam resting, usually with a slight unconformity, on the rocks of the Simo-sueyosi series, and contributing much to the even surface of the terrace. The loam bed, which, in its main part, is a massive, nonstratified accumulation of sandy and clayey materials of uniformly

Table I. Succession of different layers in the Kanto loam bed. After M. Harada.

	Kanagawa					Tokyo		Tiba	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	cm	cm	cm	cm	cm	cm	cm	cm	cm
Kanto loam	*L* 454	*L* 545	*L* 454	*L* 606	*L* 303	*L* 454	*L* 121	*L* 182	*L* 303
					S 6				
					L 364				
	P 24～30	*P* 24	*P* 24～30	*P* 55	*P* 21	*P* 5	*P* 21	*P* 3	*P* 8
	L 240	*L* 364	*L* 61	*L* 30	*L* 242	*L* 152	*L* 212	*L* 9	*L* 91
	P 3	*P* 24		*P* 15			*P* 24	*P* 3～6	
	L 212	*L* 91						*L* 15	
	P 6								
	L 30								
	P 9								
Base rocks	Sand Clay	Clay Sand	Clay Sand Gravel	Clay	Gravel	Sand	White silt	Clay	Sand

L: loam, *P*: pumice, *S*: scoria. The uppermost pumice layer is named "Tokyo pumice soil" after its type locality.

(1) Sinmei-maé, Namamugi-tyô, Turumi-ku, Yokohama (横濱市鶴見區生麥町神明前).
(2) Kami-sueyosi, Turumi-ku, Yokohama (横濱市鶴見區上末吉).
(3) Yamaté-tyô, Naka-ku, Yokohama (横濱市中區山手町).
(4) Yukôzi, Huzisawa-tyô, Kanagawa prefecture (神奈川縣藤澤町遊行寺).
(5) Odai, Koayu-mura, Aikó-gun, Kanagawa prefecture (神奈川縣愛甲郡小鮎村尾垈).
(6) Akabane-tyô, Ôzi-ku, Tokyo (東京市王子區赤羽町).
(7) Tamagawa-gakuen, Matida-mati, Minami-tama-gun, Tokyo-hu) 東京府南多摩郡町田町玉川學園).
(8) Turumai-tyô, Itihara-gun, Tiba prefecture (千葉縣市原郡鶴舞町).
(9) Kaizuka, Miyako-mura in the suburbs of Tiba (千藤市外都村貝塚).

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3) Y. OTUKA, *Bull. Earthq. Res. Inst.*, **15** (1937), 974～1040.

reddish-brown or tan color, shows a tendency toward vertical parting, where its thickness is greatest. But it is often accompanied by yellowish pumice, which occurs in distinct but thin beds, lying almost-horizontally at several horizons within it, with a fairly sharp line of demarcation between them. Although the pumice beds do not occur locally in the Kanto loam of the district under discussion, similar beds are frequently met with in the same formation of the wide region that includes Tokyo and district. The geographic distribution of these pumice beds has been well outlined by Harada.[4] Table I gives only a few of the many examples that were enumerated by him to show the order of succession of the different layers observed in the Kanto loam at a number of places in southern Kanto.

The Kanto loam, together with the underlying Simo-sueyosi series, is exposed everywhere in the terrace-cliffs from Turumi station, southwestward, along the Government railway. One of the best exposures is found at Kisi, some 1·5 km southwest of the station, where, in addition to the natural terrace-cliffs, there are several cuts on the terrace recently leveled for laying out a residential section. One of these cuts is a single vertical section, exposing the Kanto loam as it is best developed, as shown schematically in Fig. 1. The different layers as observed in the section are from the top, downward, as follows:

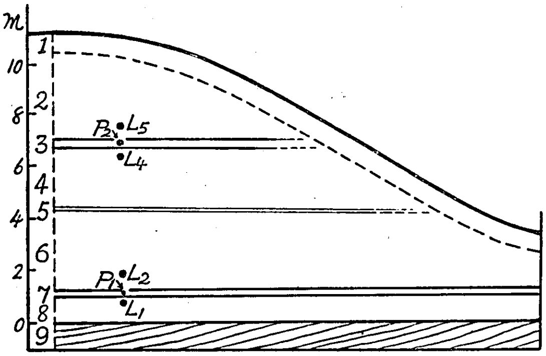

Fig. 1. Schematic sketch of a vertical section of the Kanto loam bed at Kisi, Turumi-ku, Yokohama (横濱市鶴見區岸). The black circles represent the sources of the samples selected for this petrographic study.

1.	Black humus soil	1 m.
2.	Reddish-brown loam	3 m.
3.	Light-yellowish pumice sand	30 cm.

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[4] M. HARADA, *Jour. Sci. Soil and Manure, Japan*, 7 (1933), 383∼406.

4.	Reddish-brown loam	2·5 m.
5.	Light-yellowish pumice	10 cm.
6.	Reddish-brown loam	2·5 m.
7.	Yellowish pumice	20 cm.
8.	Reddish-brown loam	1 m.
9.	Substratum (Simo-sueyosi series), more than 20 m in thickness.	

The uppermost part of the section, which is a black humus zone (1), about 1 m in thickness, is a continuous surface-mantle of the terrace. This humus zone grades downward into a reddish-brown loam (2), 3 m in thickness, which is in turn underlain by a horizontal bed, 30 cm in thickness, of light-yellowish pumice sand (3). The color of the pumice is largely determined by the extent of iron-staining, or weathering, which grows less with depth. Thus the pumice bed, which is clearly defined in the inner part of the section, when compared with the inner part, becomes indistinct at both sides of the section where the weathering action from the lateral slopes may have been more effective. Although, outwardly, the pumice bed has, consequently, the appearance of a wedge of local sediment, it virtually persists to a considerable extent as an index bed, correlating with Harada's "Tokyo pumice soil", which lies several meters beneath the surface of the Kanto loam in Tokyo and district (Table I).

The pumice bed (3) is underlain by a reddish-brown loam (4, 6), about 5 m in thickness. A light-yellowish pumice layer, 10 cm thick, lies in the middle horizon of the loam, although the boundaries separating them are rather indistinct. The loam (6) is underlain by a horizontal bed (7), 20 cm in thickness, consisting of closely-packed, flat fragments of yellowish pumice about 1 cm across. Beneath this pumice bed is a reddish-brown loam (8), 1 m in thickness, which represents the lowest part of the Kanto loam exposed in the section, and overlying a sand bed of the Simo-sueyosi series. The total thickness of the Kanto loam, inclusive of the pumice beds, is about 10·5 m.

Petrography of the Kanto loam.

The above-mentioned section at Kisi, Turumi, was selected for the present petrographic study of the Kanto loam, chiefly because suitable samples were available at short intervals from the top to the base of the formation. Four samples from the section were studied both microscopically and chemically, although several additional samples from the same section and from adjoining cuts were investigated microscopically in a less detailed manner. The following petrographic descriptions refer practically to the four samples that follow (cf. Fig. 1 and Table I).

L_5: Loam (2) just below the humus zone (1), sample 40 cm above the top of the pumice bed (3).
P_2: Pumice sand (3) just below the loam (2), sample from the middle horizon of the pumice bed.
P_1: Pumice (7) just below the loam (6), sample from the middle horizon of the pumice bed.
L_1: Loam (8) at the base of the section, sample just below the pumice bed (7).

Mechanical analysis. Because of its absorbtiveness, the Kanto loam in the field usually contains a large amount of moisture, although its presence does not cause any marked plasticity. Thus, the moisture contents as determined by the weight differences of the wet and air-dried samples L_1, P_1, P_2, and L_5, are 42, 57, 18, and 40 respectively in percentage weights of the original wet samples. Of the four samples, P_2, which is poorest in clayey material, shows the least moisture content. Compared with the wet samples, the air-dried materials are less intensely colored.

Samples L_1, P_1, P_2, and L_5, together with two additional samples L_2 and L_4, were subjected to mechanical analysis by the methods of decantation and sieving. L_2 is a loam 1 m above the pumice bed P_1, and L_4 another loam lying immediately below the pumice bed P_2. Each sample was first separated by settling and decantation into fraction *A*, which is the residual sediment containing grains coarser than 0·05 mm in diameter, and fraction *B*, which is the decanted suspended material containing all particles smaller than 0·05 mm in diameter and larger particles readily broken down to this size. The fraction *A*, after being dried, was further separated by sieving into five fractions containing grains of diameters[5] 0·05～0·074 mm, 0·074～0·177 mm, 0·177～0·42 mm, 0·42～2·0 mm, and exceeding 2·0 mm. The mechanical analyses are shown in Table II. Thus, no outstanding difference in mechanical composition exists in samples L_1, L_2, L_4, and L_5, all of which consist of less than 11 per cent of fraction *A* and more than 89 per cent of fraction *B*. Fraction *A* of these samples is composed practically of sand

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[5] The standard sieves, Type III, arranged by the Department of Home Affairs were used. They consist of four sieves, Nos. 10, 40, 80, and 200, having meshes 2·0 mm, 0·42 mm, 0·177 mm and 0·074 mm in diameter, respectively.

Table II. Mechanical analyses of successive layers in the Kanto loam at Turumi, Yokohama. (Percentage weight of air-dried sample)

	Fraction *A*					Fraction *B*
Grain-size in mm.	>2·0	2·0~0·42	0·42~ 0·177	0·177~ 0·074	0·074~ 0·050	0·050>
Sample L_5	2·4	0·3	1·8	2·5	1·0	92·0
P_2	—	22·3	30·5	8·5	0·9	37·8
L_4	—	1·8	3·6	3·9	1·2	90·5
L_2	0·2	0·2	1·3	2·2	0·6	95·5
P_1	0·5	0·6	1·5	1·4	0·2	95·8
L_1	0·2	1·8	4·2	3·8	0·9	89·1

grains smaller than 2 mm in diameter. Although some gravels are contained in L_1, L_2, and L_5, they are usually about 3 mm or smaller in diameter and negligible in amount, only one or two pieces of them being found in a 20 cc (about) portion of each sample. Sample L_5 carries very rarely gravels as large as 5 mm in diameter. Thus, that portion of the sample which was subjected to mechanical analysis, contained fortuitously a piece of such gravel, and consequently showed a relatively high percentage of gravel content. Sample P_1 is composed largely of pumice fragments up to 1 cm in diameter. Most of the pumice are, however, almost completely decomposed, so that they can be crushed with the fingers to a clayey mass which, after suspension in water and thorough washing by decantation, is included in fraction *B* of the mechanical analysis. Sample P_2, which differs markedly in mechanical composition from the rest of the samples mentioned above, contains a large amount of fraction *A*, consisting exclusively of rock and mineral grains of sand grade. Although the sample does not contain gravels of any hard rock or mineral, like P_1, it carries some pumice fragments of gravel grade.

The mechanical analyses of the Kanto loam from various parts of the Kanto region were made in detail by S. Nakao.7) Table III gives only a few of the many examples enumerated by him to show the mechanical composition of the Kanto loam. It is inferred from a comparison of Tables II and III that the Kanto loam varies in mechanical composition horizontally, even within a short distance. Thus the loams

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6) Gravels are defined as rock-fragments or mineral grains larger than 2 mm in diameter.

7) S. Nakao, *Jour. Geol. Soc., Tokyo*, 38 (1931), 97~121.

shown in Table III are richer in sand fractions than the loams studied by the writer, although the locality of every one of the former lies within a short distance, less than 2·5 km, from the locality of the latter, and notwithstanding that both are much alike in having only a negligible proportion of gravels. Furthermore, it is inferred that the variation in the mechanical composition of the successive horizons of the Kanto loam, even assuming that it did occur, could never have been a regular one, seeing that loams (Nos. 69, 70, 71 in Table III) representing three different horizons of a vertical section of the Kanto loam vary in mechanical composition quite irregularly with depth.

Table III. Mechanical analyses of the Kanto loam from Yokohama. After S. Nakao.
(Percentage weight of original sample)

Grain-size in mm.	2·0 (gravel)	2·0~0·25 (coarse sand)	0·25~0·05 (fine sand)	0·05~0·01 (silt)	0·01 (clay)
Sample No. 21	0·13	4·11	13·55	12·48	69·73
No. 67	0·12	1·49	21·88	13·77	62·74
No. 68	0·52	3·97	17·32	14·02	64·17
No. 69	0·02	0·74	6·13	8·27	84·84
No. 70	0·57	3·24	12·28	9·14	74·77
No. 71	0·22	1·47	9·34	10·63	78·34

No. 21. Loam from the highest part of the terrace at Kagetu-en, Turumi.
No. 67. Loam, 1 m below the surface of the terrace north of Yokohama station.
No. 68. Pumice bed, about 30 cm below the surface, locality same as above.
No. 69. Loam, 3 m below the surface of the terrace, about 200 m south of the locality of Nos. 67 and 68.
No. 70. Loam, 2 m below the surface, locality same as above.
No. 71. Loam, 1 m below the surface, locality same as above.

Mineralogical composition. The coarser fractions (fraction *A* in Table II) in the samples of the mechanical analyses were first separated by means of bromoform (sp. gr. = 2·712) into a light and heavy fraction. The mineralogical composition of each of these fractions was then determined petrographically with the aid of oil immersion, with results as shown in Table IV.

The light fraction, which includes all material having a specific gravity lower than 2·712, consists exclusively of rock-fragments and colorless mineral grains. Most of the rock-fragments are lighter than the colorless mineral grains. The former were thus separated from the latter by means of a heavy liquid (a mixture of bromoform and bromnaphthaline, sp. gr. = 2·419), although a few rock-fragments heavier than

Table IV. Mineralogical composition of the coarser fractions (fraction *A* in Table II in the Kanto loam from Turumi).
(Percentage weight of the coarser fractions)

Sample No.		L_5	P_2	L_4	L_2	P_1	L_1
Light fraction (sp. gr. $\leqq$ 2·712)	Rock-fragments	13·6	23·2	8·5	20·4	18·9	6·5
	Quartz Orthoclase Plagioclase	28·6	45·6*	49·5	51·2	57·6*	83·6
Heavy fraction (sp. gr. $>$ 2·712)	Hornblende Hypersthene Olivine	43·8	24·3**	34·6†	13·0	8·3**	4·3
	Magnetite	14·0	6·9	7·4	15·4	15·2	5·4

* Quartz and orthoclase absent.
** Hornblende absent.
† Negligible biotite present.

the liquid were inevitably left in the sediment of the colorless mineral grains.

Although rock-fragments are present in all the samples, they vary in amount from the maximum 23·2 per cent in P_2 to the minimum 6·5 per cent in L_1. They occur as subangular or well-rounded grains of various sand grades, and besides as gravels which, however, are very rarely met with in any of the samples but in P_2 and L_4. So far as they have been examined microscopically in thin sections, as will be described presently, they are almost exclusively fragments of igneous rocks of either volcanic or plutonic origin, although many of them are highly altered. Pieces of colorless volcanic glass, which are but little weathered, may be seen in every sample, although they are evident more in P_1 and P_2 than in the others. Unlike basalt glass, they have a fairly low index of refraction (Table V), suggesting an intermediate or rather acid chemical composition.

The colorless mineral grains, which are all higher in specific gravity than 2·419, are more conspicuous in L_1 than the others, and least in L_5, therefore occupying more than 66 per cent of the light fraction in all the samples, or more than 45 per cent of the sand fraction in all but the L_5 samples, the proportion decreasing successively from 83·6 per cent in the sample of the lowest horizon to 28·6 per cent in the sample of the uppermost horizon. The mineral grains consist almost entirely of quartz and feldspars, although some of the feldspar grains are rimmed with colorless glass. Carbonates are absent, and it is in this characteristic that the loam differs most markedly from loess. Quartz grains, which are subangular to well-rounded, occur as sand of various grades in all the samples but P_1 and P_2, and appear to be more conspicuous in L_4 than the others, and least in L_5. Some of the quartz grains are almost colorless, while some are stained yellow. Although some fragments of a quartz-bearing rock were observed microscopically in a thin section of P_2, no isolated quartz grains were found in the sample. Neither fragment of quartz-rock nor isolated quartz grains were seen in P_1. The feldspar grains consist of both potash-feldspar and plagioclase. The potash-feldspar, which has been identified by its indices of refraction as orthoclase, occurs as subangular to rounded grains of various sand grades in all the samples except P_1 and P_2. Most of the orthoclase grains are stained dull yellow and, when examined microscopically, are spotted throughout with minute particles of alteration products. The plagioclase feldspars, which are usually clear and fresh, some forming well-shaped unbroken euhedrons, predominate over all the other minerals in every samples, except L_5, in which the colorless minerals are poorer in amount than the mafic minerals next to be mentioned. None of the plagioclase feldspars are so calcic as bytownite, which is common as phenocrysts in basalts and allied basic rocks from Volcano Huzi and a number of north Izu volcanoes. Thus many of them were identified by their indices of refraction as labradorite, and a few individuals in P_1 and L_1 as andesine (Table V).

Of the heavy fraction, which contains all material of specific gravity higher than 2·712, there is more in L_5 than in the others, and least in L_1, whence it occupies 57·8 per cent of the sand fraction in L_5 but only 9·7 per cent of the sand fraction in L_1, its amount in successive samples decreasing almost regularly from its maximum value in L_5 to its minimum in L_1. The heavy fraction consists almost exclusively of mafic minerals, including biotite, hornblende, hypersthene, augite, olivine, and magnetite. Biotite flakes, 0·5 mm in length, are present only in L_4, although the amount is negligible. Small amounts of prismatic crystals of hornblende, less than 1 mm in length, are found in all the samples, excepting P_1 and P_2, but appear to be more evident in L_4 than in the others. They are almost perfectly fresh and entirely of a greenish-brown variety. The hornblende from L_1 shows $n_2 = 1{\cdot}6838$ on (110). Hypersthene and augite are present, in fair abundance, in all the samples. Many grains of these minerals are fresh and euhedral, some of them almost perfectly so. The indices of refraction measured in the cleavage flakes of these minerals are shown in Table V. Olivine

Table V. Indices of refraction of the minerals and glass found in the Kanto loam from Turumi.

Sample No.	L_5	P_2	P_1	L_1
Orthoclase	1·5190	——	——	n.d.
Plagioclase	n_1=1·5630 1·5570 33,45% Ab	n_1=1·5564 46% Ab	n_1=1·5574 1·5505 45,56% Ab	n_1=1·5570 1·5510 45,55% Ab
Hornblende	n.d.	——	——	n_2=1·6838
Hypersthene	n_1=1·6980	n_1=1·7020	n_1=1·6975	n_1=1·6972
Augite	n_1=1·6900	n_1=1·6945	n_1=1·6934	n_1=1·6875
Olivine	n.d.	β =1·7070	n.d.	n.d.
Glass	n.d.	n =1·510	n =1·506	n =1·502

n_1 for plagioclase is the smaller index of refraction on (001) or (010).
n_2 for hornblende is the larger index of refraction on (110).
n_1 for hypersthene and augite is the smaller index of refraction on (110).

occurs as subhedral to unhedral grains in all the samples, except P_1 and P_1, particularly most abundantly in L_6. Many of the olivine grains are altered, either partially or completely, into a reddish-brown mineral, probably iddingsite. Although isolated grains of olivine were not found in P_1 and P_2, a few fragments of olivine-basalt were seen microscopically in thin sections of these samples. Magnetite grains, which were

Table VI. Mineralogical composition in percentage volume of the sand fraction in the Kanto loam from Yokohama.
After Nakao.

Sample No.		21	67	68	69	70	71
A		72·0	81·5	68·5	73·5	74·0	50·0
B		28·0	18·5	31·5	26·5	26·0	50·0
C	(Glass)	—	0·5	11·0	0·5	1·5	15·5
	Quartz	2·5	9·5	—	1·5	—	—
	Feldspar	32·5	49·0	34·0	20·5	29·5	20·0
	Biotite	—	—	tr.	3·0	—	tr.
	Hornblende	0·5	3·0	1·0	1·0	1·0	1·0
	Hypersthene	12·5	6·5	8·0	8·0	11·0	15·5
	Augite	4·5	1·5	1·5	3·5	3·0	3·0
	Olivine	45·0	17·0	42·5	42·5	51·0	41·0
	Hematite(?)	tr.	9·5	—	12·5	—	tr.
	Magnetite	2·5	3·5	2·0	7·0	3·0	4·0

A: Rock-fragments and weathered material.
B: Mineral grains.
C: Each mineral as given in percentage of the volume of all the mineral grains.

present in all the samples, were separated from the other mafic minerals with the aid of a magnet, with results as given in the last line of Table IV.

S. Nakao[8] examined volumetrically, with the aid of an ocular net-micrometer, the mineralogical composition of the sand fractions that were separated from many loam samples. Table VI shows the mineralogical analyses obtained by him of the samples, the mechanical compositions of which are shown in Table III. As will be seen from the table, the sand fraction in each sample contains 50 per cent or more in volume of rock-fragments plus weathered material, the remainder being mineral grains, consisting of quartz, feldspar, biotite, hornblende, pyroxene, olivine, hematite (?), and magnetite. In all the samples, however, the mineral grains may exceed in percentage weight the rock-fragments plus weathered material, seeing that most of the former are probably higher in specific gravity than the latter. Of the mineral grains, the mafic minerals as a whole are decidedly more conspicuous in amount than the salic minerals, although in one sample (No. 67) the former fall but slightly in volume below the latter. In this respect, the whole of Nakao's samples resemble the writer's L_5 which, like the former, is a sample collected from a horizon that is within a few meters beneath the surface soil. Thus, a comparison of Tables IV and VI shows that, although there is no outstanding mineralogical difference in the samples from the various horizons, the samples obtained close beneath the surface differ from those taken from greater depths (those probably lying beneath P_2 horizon) in the proportion of the salic and mafic minerals in the sand fraction, the former when compared with the latter being usually poor in salic minerals but rich in mafic minerals, particularly olivine and pyroxene.

The finer fractions (fraction *B* in Table II) of all the samples from Turumi consist predominantly of an amorphous clayey material, although this material is accompanied with both mineral particles and rock-flour which, because of their very fine size (silt and clay grades in diameter) cannot be perfectly separated from the former by decantation alone.

Microscopic characters. Thin sections were cut from four samples L_5, P_2, P_1, and L_1, each hardened by impregnation with canada balsam. An examination of these sections shows that the mineral constituents that are of sufficient size to enable identification by the usual optical methods are essentially the same as those found in the sand fractions

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[8] Averages of the mineralogical analyses of coarse sand and fine sand as were calculated separately by Nakao.

separated from disintegrated samples, and that various rock-fragments are cemented, together with the isolated mineral grains, with a finer-grained matrix.

Sample L_5 (Fig. 2). Microscopically, this sample does not show any definite structure, stratification, or textural gradation. Thus it is a structureless mass consisting of mineral grains and rock-fragments, intermixed without order or system with a yellowish-brown matrix. The mineral grains, in order of decreasing abundance, are olivine, magnetite, augite, hypersthene, plagioclase, quartz, hornblende, and orthoclase. The olivine, which is subhedral to anhedral and up to 0·5 mm in diameter, is altered almost completely to a reddish-brown mineral, probably iddingsite, although a few olivine grains are partially left unaltered. The magnetite occurs as isometric grains, euhedral to subhedral, and up to 0·3 mm in diameter. The augite, which occurs either as euhedral individuals or angular fragments up to 0·3 mm in diameter, is pale brownish without any trace of alteration. A few grains of the mineral contain olivine inclusions. The hypersthene, which occurs either as prismatic crystals up to 0·3 mm long or angular fragment up to 0·2 mm in diameter, is pale greenish with a weak pleochroism (X'—pale yellowish-green, Z'—pale green). The plagioclase is found as fresh and clear crystals, euhedral to anhedral, up to 0·3 mm in diameter, and exhibiting the usual twin-lamellation and a faint zoning. The quartz is angular to rounded and up to 0·5 mm in diameter. The hornblende, which occurs as fresh, subhedral crystals, up to 0·2 mm long, and having the usual set of prismatic cleavages, is greenish-brown with a distinct pleochroism (X'—pale greenish-brown, Z'—dark greenish-brown). The orthoclase is found only sparingly as turbid and rounded grains up to 0·3 mm in diameter.

The rock-fragments contained in the sample are subangular to well-rounded, and mostly up to 1 mm in diameter, although a few fragments occur as gravels measuring 2～5 mm in diameter. Microscopically, they are of various petrographic types, chief among which are propylite and two-pyroxene-andesite. The propylite usually consists of plagioclase, chlorite, and iron-ores. The two-pyroxene-andesite, which occurs as subangular grains of gravel grade, besides smaller grains, is slightly porphyritic with a few phenocrysts of andesine (0·5 mm in diameter), hypersthene (0·8 mm long), and augite (0·3 mm in diameter), in a groundmass consisting of plagioclase laths (0·1 mm long), monoclinic pyroxene (0·05 mm long), and magnetite granules (0·01 mm in diameter), with interstitial colorless glass and some secondary hematite. Besides the propylite and two-pyroxene-andesite, pieces of medium-grained equigranular quartz-feldspathic rock and fine-grained silicified rock are observed in the same thin section, together with numerous decomposed rock-fragments stained dark brown to almost black with iron-oxide, some grains of black scoria, and a few pieces of colorless volcanic glass.

The yellowish-brown matrix with which the isolated mineral grains and rock-fragments are intermingled, is, microscopically, composed practically of an amorphous clayey material charged with very minute dust particles. No authigenous crystals are developed, most of the minute mineral grains (0·01 mm in diameter) found in it being fine powders of the allothigenous minerals just described. No fossils are seen, although there are not a few grains (0·01 mm in diameter) and rods (0·01∼0·2 mm long, rectangular in cross section) of an amorphous colorless material (opaline silica?), probably of organic origin.

Sample P_2 (Fig. 3). Microscopically, this sample consists of isolated mineral grains, pumice, and other rock-fragments, together with a little interstitial material. The isolated mineral grains, in order of decreasing abundance, are plagioclase, augite, magnetite, hypersthene, and olivine. The plagioclase (labradorite) is in euhedral to subhedral crystals, 0·1∼1 mm in diameter, and exhibiting the usual twin-lamellation and a distinct zoning. The mineral contains inclusions of brown glass. The augite, which is greenish-brown without sensible pleochroism, occurs as euhedral to subhedral crystals, 0·5∼0·1 mm in diameter, with a maximum extinction angle ($c \wedge Z'$) of about 52°. Small particles of brown glass are enclosed in the mineral. The magnetite, in euhedral to subhedral grains, 0·3∼0·1 mm across, is found either as isolated individuals or in association with the augite. The hypersthene occurs as euhedral to subhedral crystals, 0·1∼0·3 mm long and pale greenish-brown with very weak pleochroism. The olivine, which is fresh and almost colorless, occurs but sparingly as rounded crystals, 0·2∼0·3 mm in diameter.

The pumice, of which the bulk of the sample is composed, is found, microscopically, as angular fragments, up to 3 mm in diameter. Although most of the pumice fragments are altered more or less to a clayey material stained pale yellowish-brown, the original pumice-structure is well preserved in them. Thus they contain a few phenocrysts of plagioclase in a highly vesiculate groundmass which, in the freshest pumice, consists of colorless glass carrying plagioclase and pyroxene microlites and magnetite granules.

The rock-fragments other than the pumice just mentioned are of various petrographical types, being chiefly propylite and two-pyroxene-andesite. The propylite shows the same microscopic characters as those found in the preceding sample L_5. The two-pyroxene-andesite, which forms angular grains of 0·5∼1 mm in diameter, occurs in two types that differ from each other in the groundmass structure. Thus one type of it, microscopically, is exactly the same as the two-pyroxene-andesite found in L_5, while the other type differs from the former in that its groundmass is a finer-grained, highly crystalline aggregate of plagioclase laths (0·03∼0·1 mm long), minute grains and prismoids of monoclinic pyroxene, magnetite granules, and interstitial tridymite. A few phenocrysts of both plagioclase and pyroxene are found in both types. So far as has been examined, the small gravels (2∼5 mm in diameter) that occur rarely in the sample under consideration, are entirely of one of the two types of the two-pyroxene-andesites. Besides the propylite and two-pyroxene-andesites, subangular grains (0·3 mm in diameter) of both a medium-grained equi-granular quartz-feldspathic rock and a diabasic rock are found in the same thin section, together with a few fragments of decomposed material impregnated with iron-oxide.

The fine matrix in which the isolated crystals and rock-fragments are enclosed, consists practically of finely divided pumiceous material of the same nature as the larger pumice fragments.

From the foregoing microscopic characters, sample P_2 is identified as a pumice-tuff of the nature of a two-pyroxene-andesite, although it contains a few accessory and accidental materials.

Sample P_1 (Fig. 4). Microscopically, this sample consists practically of pumice-fragments, almost closely packed together, with a little interstitial material. The pumice, which is angular to subangular, and up to 10 mm in diameter, is altered largely to an amorphous clayey material, stained pale yellowish-brown, and having an index of refraction that is higher than canada balsam, although the original structure of many of the pumice fragments is clearly indicated by their being full of elongated vesicular cavities. A few phenocrysts of a faintly zoned plagioclase (labradorite∼andesine), 0·2∼1 mm long, are found in the pumice, together with smaller and fewer phenocrysts of augite, hypersthene, and magnetite.

The interstices between the pumice fragments are occupied by isolated mineral grains and rock-fragments other than pumice. The isolated mineral grains are plagioclase, augite, hypersthene, and magnetite, all in euhedral to subhedral crystals up to 1 mm in diameter, and showing almost the same optical characters as the respective minerals found as phenocrysts in the pumice. The rock-fragments other than pumice occur as angular to subangular grains up to 1 mm in diameter, many of which are of an andesitic nature, although there are a few fragments of a silicified rock impregnated by a chloritic material. One of the andesitic fragments carries olivine phenocysts, 0·2 mm in diameter, in a groundmass of plagioclase, pyroxene, and magnetite.

From the microscopic characters aboved outlined, sample P_1 is identified as a pumice tuff of the nature of a two-pyroxene-andesite, although it contains a few accessory and accidental materials.

Sample L_1 (Fig. 5). Microscopically, this sample consists, like L_5, of mineral grains and rock-fragments, both scattered, without any definite structure, in a yellowish-brown matrix.

The isolated mineral grains contained in the sample are plagioclase, quartz, orthoclase, hornblende, olivine, and magnetite, in order of diminishing abundance. Augite and hypersthene may be present, but only negligibly, seeing that, although a few pieces of these minerals were found in the sand fraction mechanically separated from a large volume of the sample under consideration, none of them were recognized in the thin section that was cut from the same sample. The plagioclase (labradorite∼andesine), which is almost always fresh and clear, occurs as euhedral to subhedral crystals, up to 1 mm in diameter, exhibiting the usual twin-lamellation and a faint zoning. A few inclusions of colorless glass are present in the mineral. The quartz occurs either as isolated individuals, subangular to well-rounded and up to 0·5 mm in diameter, or in granular aggregates of two or more individuals. Some of the quartz grains exhibit an undulatory extinction between crossed nicols. The orthoclase in subangular to well-rounded crystals up to 0·5 mm in diameter, is clouded almost completely by impregnation with alteration-products (sericite and chlorite). Besides the orthoclase, there are a few grains of microcline showing the usual lamellar twinning. The hornblende, which occurs as euhedral to subhedral crystals up to 0·3 mm in diameter, is almost perfectly fresh and green with distinct pleochroism (X'—pale green, Z'—dark green). The olivine, which is found as rounded anhedral crystals up to 0·5 mm in diameter, is almost completely altered to a reddish-brown mineral, probably iddingsite, although the cores in a few grains of the mineral remain unaltered. The magnetite is in subhedral to anhedral grains up to 0·2 mm in diameter.

The rock-fragments contained in the sample are subangular to rounded and mostly up to 2 mm in diameter, although gravels 2∼3 mm across are present, but sparingly. They are largely of altered andesitic lavas and tuffs, both impregnated with chlorite, epidote, and iron-ores.

Besides these, there are a few pieces of an olivine-bearing basaltic rock, in which the olivine occurs as phenocrysts in a chloritized groundmass.

The yellowish-brown matrix in which the isolated mineral grains and rock-fragments above described are enclosed, is, microscopically, almost the same as that of sample L_5. Thus it is composed of an amorphous clayey material containing fine rock-flour and minute mineral grains, both of which are nothing but fine powder of the same materials as the larger mineral grains and rock-fragments found in the sample. Neither fossils nor authigenous crystals are found in it, although there are, as in the matrix of sample L_5, not a few minute grains and rods of an amorphous colorless material (opaline silica?), with very low index of refraction, and probably of organic origin.

Chemical composition. Four samples L_5, P_2, P_1, and L_1, after being air-dried, were chemically analyzed by S. Tanaka, with results as shown in Table VII, in which two old published analyses of a loam sample from Tokyo have been added for comparison.

The variation in the mineralogical composition of the four samples

Table VII. Analyses of the Kanto loam from Turumi.
S. Tanaka, analyst.

	L_5	L_1	P_2	P_1	A	B
SiO_2	36·04	43·83	41·58	38·63	69·885	65·15
Al_2O_3	23·87	25·13	23·03	26·77	15·285	19·20
Fe_2O_3	11·23	8·74	4·66	8·18	8·645	7·76
FeO	1·57	0·70	3·01	0·44	—	—
MgO	1·43	0·55	2·33	0·29	tr.	0·12
CaO	0·57	1·03	4·63	0·75	1·875	1·49
Na_2O	0·47	0·92	1·71	0·49	—	—
K_2O	0·27	0·40	0·11	0·06	—	—
$H_2O\ (+)$	12·41	10·63	10·30	11·17	—	6·03*
$H_2O\ (-)$	10·75	6·58	7·75	12·16	—	—
TiO_2	1·26	1·06	0·95	1·23	—	—
P_2O_5	0·07	0·08	0·11	tr.	—	2·20
MnO	0·23	0·25	0·12	0·14	—	—
Total	100·17	99·90	100·29	100·31	95·690	99·95

* Loss on ignition.

A, *B* are the old analyses of a loam sample, referred to by Brauns.[9]

A. Coarser part of the sample, amounting to 75·52% of the whole.

B. Lighter part of the same sample after levigation, amounting to 24·40% of the whole.

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[9] D. Brauns, *Mem. Sci. Dep., Univ. Tokyo*, 4 (1881), 17.

is reflected in their chemical composition. Thus samples L_5 and L_1, both of which contain large amounts of clayey material, are rich in silica, alumina, ferric oxide, and water, but extremely poor in the other oxides, including ferrous oxide, magnesia, lime, and alkalies, together with minor constituents. The presence of large amounts of alumina and combined water indicates the clayey character of these samples. Sample L_5 is richer in iron-oxides and magnesia and poorer in silica, lime, and alkalies than sample L_1, in accordance with the mineralogical difference that the former is richer in mafic minerals and poorer in salic minerals than the latter. Sample P_2 also shows the same tendency as the preceding two in containing large amounts of alumina and water, although it is not so poor in ferrous oxide, magnesia, lime, and alkalies, as the latter. Since this sample is a tuff composed almost exclusively of pumice fragments, without admixture of any noticeable amount of decomposed detrital material, the presence of large amounts of alumina and combined water in it suggests that the pumice fragments have decomposed, partially, at any rate, to a clayey material. Although sample P_1, which also consists almost exclusively of pumice fragments, is similarly rich in alumina and water, it differs from P_2 in its smaller contents of ferrous iron, magnesia, lime, and alkalies. While the difference in composition between P_1 and P_2, is of course due in part to certain differences in the composition of the rocks at the time of deposition, it may be taken as largely showing a variation according to the extent of subsequent alteration, seeing that the decomposition of the pumice fragments to a clayey material has progressed farther in P_1 than in P_2. From a comparison of the analyses of P_1 and P_2, it is inferred that the decomposition of these rocks might have been accompanied by several chemical changes—loss of the soluble bases (magnesia, lime, and alkalies) by leaching, oxidation of the iron compounds, absorption of water, and concentration of the slightly soluble alumina and ferric oxide in the residual substances—many of which are regarded as the process known as kaolinization.

The norms for the foregoing analyses were calculated by the usual method of obtaining the norm of a fresh igneous rock, with results as shown in Table VIII. Although the results, of course, differ considerably from the actual mineralogical composition of the analyzed samples, they show with a fair degree of accuracy the relative proportion of the mineral grains (plus unaltered rock-fragments) to the clayey material in these samples. As will be seen from the table, the norm for each analysis consists of several minerals, which may be divided into two groups, *A* and *B*. Group *A* contains feldspars, pyroxenes, iron ores, and other minor constituents, many of which actually occur in the analyzed samples either as isolated fragments or as the constituents of rock-fragments. In the norm, after calculating the minerals of group *A*, there is an excess of silica and alumina, which is included, together with water (+), in group *B*. The excess of silica and alumina is conspicuous in all the analyses, particularly of L_5, L_1, and P_1. Although samples L_5, L_1, and P_2 contain quartz and other silica minerals, the excess of silica in their norms considerably exceed the total amount of these silica minerals. Sample P_1 is practically destitute of any silica mineral to which the excess silica in its norm may be attributed. It is therefore evident that an appreciable part of the excess silica in L_5, L_1, and P_2, must occur, together with the excess alumina and the water, either as a hydrous silicate of aluminium, or in a colloidal mixture, constituting the bulk of the clayey material that is present in the respective samples.[10] As to P_1, it may be assumed that the whole of the excess silica that is contained in the clayey material resulted from an almost complete decomposition of former pumice fragments, so that by combining it with the excess alumina and the water (+), it is possible to get a material of the composition,

Table VIII. Norm composition of the Kanto loam from Turumi.

			L_5	L_1	P_2	P_1
A	Orthoclase		1·67	2·78	0·56	0·56
	Albite		4·19	8·39	15·73	4·72
	Anorthite		2·23	4·73	23·82	4·17
	Enstatite		4·02	1·51	6·22	0·80
	Ferrosilite		—	—	0·26	—
	Ilmenite		2·73	2·12	1·97	1·37
	Rutile		—	—	—	0·64
	Apatite		0·33	0·33	0·33	tr.
	Magnetite		2·32	—	7·41	—
	Hematite		11·02	9·42	—	9·26
B	Free silica plus hydrous silicate of aluminium	SiO_2	32·97	36·46	19·58	37·96
		Al_2O_3	24·77	23·04	12·95	27·83
		H_2O	13·88	11·40	11·13	12·67

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[10] The excess alumina, which is possibly included in the clayey material, may be present for the most part as a silicate, but not as a hydrate, seeing that the clayey material usually shows a relatively low index of refraction (n=1·535~1·580). *Winchell, Elements of Optical Mineralogy,* 2 (1927), 241.

SiO_2 48·5, Al_2O_3 35·6, H_2O 15·9 (wt. %), approaching fairly closely the composition of kaolinite, $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O = SiO_2$ 46·5, Al_2O_3 39·5, H_2O 14·0. So far as microscopic observations go, however, the clayey material in P_1 is unlike the usual kaolinite, being decidedly amorphous. Although the evidences are rather meagre, it may presumably be identified as halloysite, a hydrous silicate of aluminium like kaolinite, but amorphous, and having the composition $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O + aq. = SiO_2$ 43·5, Al_2O_3 36·9, H_2O 19·6.11), 12) Further detailed analyses, optical as well as chemical, of the clayey material contained in the Kanto loam may throw more light on the mineralogical and chemical properties of the material.

Origin of the Kanto loam.

The origin of the Kanto loam is a subject to which not a few geologists, in dealing with the Cenozoic geology of the Kanto region, have referred, from either the stratigraphical or the petrographical point of view, but in regard to which there are yet several unsettled questions. For example, although it is generally accepted that the Kanto loam is an upper Pleistocene deposit containing a large amount of volcanic material, opinion is not agreed on the source of the material of which the deposit is composed, nor regarding the agency that carried and distributed the material to where we now find them; some believing it to be wind-borne, others that it is of volcanic origin, while still others think it is detrital in origin. Although the writer, in this paper, does not attempt to settle these questions, some of the data given above of the mineralogical and chemical compositions of the Kanto loam from Turumi may be pertinent to the problems.

So far as the locality studied is concerned, the Kanto loam is practically a formation composed of beds of two different rock-types whose origin must be examined separately. One of these is a reddish-brown sandy clay, which forms the bulk of the formation, and to which the term "loam" is specially applied, and the other a light-yellowish pumice found in several horizons of the formation in relatively thin beds, sharply bounded above and below by the loam beds.

The loam that is the subject of our study is represented by four samples L_1, L_2, L_4, and L_5, collected from four different horizons in

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11) E. S. DANA and W. E. FORD, *A Text-Book of Mineralogy*, 1922, 579.

12) Seki has assumed that the main part of the argillaceous substances in the Kanto loam is a clay resembling allophane. T. SEKI, *Proc. Imp. Acad.*, 2 (1926), 65. According to Dana and Ford, allophane is an amorphous hydrous silicate of aluminium, $Al_2O_3 \cdot SiO_2 5H_2O = SiO_2$ 23·8, Al_2O_3 40·5, H_2O 35·7.

a single vertical section of the formation. From the mechanical and mineralogical analyses of these samples, the following, points may be summarized:

(1) The loams from the various horizons are all similar to one another in mechanical composition as well as in texture; there is no appreciable definite vertical variation in their grain size.

(2) The loams contain not more than ten per cent (wt.) of sand fractions, the remainder consisting of clay fractions. The sand fractions of all these loams do not show any outstanding mineralogical difference; they are a rich assortment of minerals and rock-fragments, each containing isolated crystals of quartz, orthoclase, plagioclase, hornblende, hypersthene, augite olivine, and magnetite, together with fragments of two-pyroxene-andesites (with or without olivine), and various altered rocks including propylites, diabase, tuffs, silicified rocks, and granitic or quartz-dioritic rocks. But the sand fractions differ in the proportions of the various minerals present in them, the relative abundance of the mafic minerals (hypersthene, augite, olivine, and magnetite) increasing as one goes upward.

(3) Many of the grains of plagioclase, pyroxenes, and hornblende are only slightly altered, those just beneath the surface being equally as fresh as those at greater depth, some forming well-shaped unbroken euhedrons. Most of the grains of quartz and orthoclase, however, are subangular to well-rounded, many of the latter mineral being greatly altered. Of the rock-fragments, those of the two-pyroxene-andesites are mostly angular, whereas some of the altered rocks are subangular to well-rounded.

(4) The clay fractions of the loams contain minute rock-flour and mineral grains in an amorphous clayey material Both the rock-flour and the mineral grains are nothing but the same materials as the coarser grains composing the sand fractions, only that these two are finely pulverised. The bulk of the amorphous clayey material, judging from the chemical analyses, is regarded as a hydrous silicate of aluminium of halloysitic composition, although it is impregnated with dust particles, probably of iron oxide.

(5) The clayey material in these loams does not show the ash-structure that would suggest either a pumice or scoria ancestry.

From the facts just outlined, it is inferred that, although the loams evidently contain appreciable amounts of volcanic material, they are by no means a pure volcanic ash. The most distinctive characteristics of the loams, and that which must be accounted for in any satisfactory explanation of their origin, is their content of quartz, orthoclase, and many fragments of altered rocks, most of which are genetically foreign to the fresh volcanic material. The wide distribution of these mineral grains and rock-fragments in the loams and the more or less rounded shape exhibited by many of them may be arguments against the view that they are accidental ejecta derived, together with juvenile volcanic material, from a volcano in the course of its paroxysmal eruptions. An alternative concept, and that which is most favored by the writer, is that the loams as a whole are a mechanical mixture of relatively little altered volcanic material and of much more altered detrital material, although, judging from the decomposition of the pumice intercalated in the loams, some weathering may have taken place more or less selectively in the loams themselves after their deposition, while some of the resistant mineral grains remain untouched. Under this interpretation, the fresh volcanic material might be derived directly from a volcano, and the detrital material from another source, or sources, capable of supplying a wide variety of rocks, particularly igneous, but probably sedimentary as well.

The fresh volcanic material in the loams is represented by isolated crystals of plagioclase, hypersthene, augite, some olivine, and magnetite, together with some rock-fragments containing these minerals. A few grains of hornblende also may be volcanic, although no fragments of volcanic rocks carrying this mineral are found in the loams. As a possible source of these volcanic products, we may mention a number of Quaternary volcanoes lying close to the southwestern and northwestern parts of Kanto—Huzi, Asitaka, Hakone, Taga, for example, in north Izu and vicinity, and Asama, Sirane, etc., in Sinano and vicinity. H. Kuno, who identified the loam-like ash bed that extensively covers both the somma and the central cones of volcano Hakone, with basaltic ejecta (ash and lapilli) from volcano Huzi, believes that the ash bed passes without any change in the material to the Kanto loam that covers the hills in the Oiso district, adjoining the northeastern foot of Hakone, and consequently concludes that the bulk of the Kanto loam from Kanagawa prefecture, eastward beyond Tokyo, may be composed of basaltic ash ejected from Huzi. The writer, upon examining, microscopically, several samples from the ash bed that is typically exposed in a road-cut called Kiridoosi at the northeastern foot (Sekimoto) of Hakone, and for which Kuno, without any questions, adopted the name "Kanto loam", found that unlike the loams studied, in textural and mineralogical characters, they are composed exclusively of volcanic material (ash, sand, and lapilli) of a basaltic nature. As Kuno had noted, the loam-like ash bed at Sekimoto and similar beds on Hakone and on the mountainous land (Tanzawa) that adjoins the northern part of the volcano may all be ejecta from Huzi, it being possible that similar ejecta may be incorporated locally in the Kanto loam, but so far as the loams here studied are concerned, most of the fresh volcanic material in them cannot be considered as ejecta from Huzi. Thus, the mineralogical character of this material suggests that it might have come from an andesitic volcano, or volcanoes, that supplied the two-pyroxene-andesites (with or without olivine in one case, and hornblende in another case). If some basaltic ejecta from Huzi are present in the Kanto loam of Turumi and vicinity, there is a liklihood of their being found in the loams not more than a few meters below the present surface that are not represented by any of the samples here studied.

Most of the detrital materials in the loams studied closely resemble some of the lower Miocene rocks (Misaka series and other contemporaneous formations), which in Izu form the base of several Quaternary volcanoes, and which in districts adjoining the northern part of Izu, occur in the mountains of Tanzawa, Dosi, Misaka, etc. It is possible, therefore, that the detrital materials may have been derived, partially, at any rate, from some parts of these mountains. Further detailed studies of the aerial distribution, thickness, and petrographical variations of the Kanto loam, as well as of its relation to any underlying formation, may supply more definite information regarding the source or sources of the material.

The mode of deposition of the Kanto loam therefore remains an open question. On the one hand, it forms the low-lying terraces (Sagamino-terrace and Musasino-terrace) within the Kanto basin, while on the other, it is believed that the same deposit occurs on the hills (Tama hills) and mountains (Tanzawa-yama and vicinity) as veneers of varying thickness. Because of these reasons, and because there is no positive evidence for a subaqueous deposition, an eolian origin of the Kanto loam is supported by many writers. Although an eolian origin appear to be the most plausible explanation for the loam that occurs at high levels on the hills and mountains, it is a question whether or not the theory could be invoked for the whole of the terrace-forming, low-lying loam to which the loam at Turumi belongs. In the writer's opinion, the Kanto loam presumably consists of two types according to the mode of deposition or to the mode of transportation of the material: the high-level loam of wind-borne origin, consisting almost exclusively of volcanic ash, and the low-lying terrace-forming loam of fluvial origin, consisting of detrital material and wind-borne volcanic ash. While the term "Kanto loam" may be applied in a stratigraphical sense both to the low-lying terrace-forming loam and the high-level loam, yet when it is desired to be more precise from the genetical point of view, we must recognize and distinguish these two types.[13]

Although the terrace-forming loam is a mechanical mixture of detrital material and wind-borne volcanic ash, there may be some true volcanic ash or lapilli beds within it that are represented at the locality studied by means of the pumice beds P_1 and P_2. These beds which, as already stated, practically consist of pumice fragments of the nature of two-pyroxene-andesite, show a wide distribution, suggesting rather extensive paroxysmal eruptions that might have taken place intermittently during the doposition of the loam at the volcano, or volcanoes, that yielded them. According to Harada, the "Tokyo pumice soil" (pumice bed P_2) thickens as one proceeds from Tokyo and vicinity toward the southwestern part of Kanagawa prefecture. As a possible source of the pumice, therefore, we may mention several volcanoes lying close to the southwestern part of the prefecture, of which Hakone is the most prominent.[14] Assuming that pumice P_1 and P_2 were originally of the same chemical composition as the lava of the Hutago-yama twin-domes on Hakone, and that the alumina contents in them have remained constant, the writer calculated the percentage of each constituent lost by the original pumice during weathering, with results as shown in Table IX, in which the result of decomposition of a diorite is also given for comparison. Although the calculation is based upon somewhat uncertain

Table IX. Percentage of each constituent lost by the original pumice during decomposition.

	P_1	P_2	Diorite		P_1	P_2	Diorite
SiO_2	31·72	25·46	17·43	MgO	3·70	2·11	4·97
Al_2O_3	Standard.	Standard.	Standard.	CaO	8·31	5·25	9·20
Fe_2O_3	−2·82	−0·97	3·53	Na_2O	2·48	1·50	2·17
FeO	2·55	3·15		K_2O	0·49	0·45	0·21

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13) In the loam-like deposits developed in the valley of the Katura-gawa, the writer recognized two forms at Otuki and vicinity—a pure volcanic ash type and a detrital variety. The volcanic ash type, which consists exclusively of basaltic ejecta from Huzi, occurs as a veneer covering the mountain-slopes on both sides of the valley; while the other type, which consists of basaltic ash and detrital material including rock-fragments from the Misaka series that are exposed extensively on both sides of the valley, occurs as a terrace deposit near the bottom of the valley and covering a lava-flow (the Enkyo lava) from Huzi.

14) M. Harada, *loc. cit.*

assumptions, the results indicate that the pumice P_1 and P_2 might originally have been similar in chemical composition to the Hutago-yama lava,[15] and that they have been altered to their present compositions through the ordinary processes of rock-decomposition, involving oxidation of ferrous oxide and leaching of soluble bases (magnesia, lime, and alkalies).[16]

The two-fold origin for the Kanto loam is only tentatively offered here until it is possible to obtain further data both from the field and from the laboratory.

30. 横濱市鶴見にて採集せる“關東ローム”の鑛物成分と化學成分

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横濱市鶴見區岸の臺地（花月園の南西隣）に露出する關東ローム層は約 10 m の厚さをもつて，下部洪積層（末下吉統）を蔽ひ，赤褐色の所謂ロームと其間に二三の略水平の薄層をなして夾まる淡黄色の輕石とから成つてゐる．此論文で，筆者は之等のローム層と輕石層との機械的組成，鑛物構成，顯微鏡的性質，化學成分等を研究した結果を述べ，且つ其結果に基づいて同地の關東ローム層の起源に就いて若干の考察を試みた．

赤褐色のロームは，層の上下を通じて，10%（重量）以下の砂（粒の直徑 0·05～2·0 mm）と殘餘の粘土（直徑 0·05 mm 以下）とから主として成り，極めて稀に礫（直徑 2·0～5·0 mm）を含む．砂は石英，正長石，斜長石，黑雲母（稀），角閃石，斜方輝石，單斜輝石，橄欖石，磁鐵鑛等の單獨結晶粒と複輝石安山岩（橄欖石を含むもの及び之を含まざるもの），變質安山岩類，凝灰岩類，輝綠岩，珪質岩，花崗岩（或は石英閃綠岩）等の岩片とから主として成り，稀に輕石と無色乃至單褐色の火山岩玻璃の破片とを含む．上位のロームには有色鑛物の砂粒が比較的多く，下位のロームには無色鑛物の砂粒が多い．斜長石，輝石，角閃石等の單獨結晶粒と複輝石安山岩の破片とは殆ど大部分新鮮で，斜長石は曹灰長石或は中性長石の成分を有する．

ロームの砂を除いた殘餘は上に擧げた結晶及び岩石片の微細な粉末の他に黑色不透明の分解物（酸化鐵？）を含むが，其大部分は非結晶質の粘土物質で，輕石或は岩滓を多く含む火山灰に特有の火山灰組織を示さない．ロームの總化學成分から判斷すると，此非結晶質の粘土物質は恐らくハロイサイトに近い成分を有するアルミニユームの含水珪酸鹽である．

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15) Hutago-yama, which is a central volcano composed of twin lava-domes, lies near the southern foot of Komaga-take (the highest central cone of Hakone). The Hutago-yama lava is an olivine-bearing hypersthene-augite-labradorite-andesite. Composition: SiO_2 57·07, Al_2O_3 17·53, Fe_2O_3 2·59, FeO 5·44, MgO 3·87, CaO 8·77, Na_2O 2·80, K_2O 0·52, $H_2O(+)$ 0·27, $H_2O(-)$ 0·12, TiO_2 0·77, P_2O_5 0·08, MnO 0·14, Total 99·97.

16) F. W. CLARKE, *The Data of Geochemistry*, 1924, 492.

ローム層中に夾まれてゐる特に明瞭な二枚の輕石層の中，上位の輕石砂層（原田正夫氏の“東京浮石土”）は複輝石安山岩質の輕石，熔岩片，火山岩玻璃等と斜長石，斜方輝石，單斜輝石等の單獨結晶粒とから主として成る．下位の輕石層は同様に複輝石安山岩質であるが，主として扁平な輕石礫と輕石砂とから成り，少量の結晶粒と他の火山岩片とを含むのみである．斜長石は，何れの場合にも，曹灰長石或は中性長石の成分を有する．下位の輕石は上位の輕石に比較して，著しく分解して粘土質となり，總化學成分に於いてアルミナと水とに富んでゐるが，顯微鏡下で見ると輕石の構造を明瞭に殘してゐる．

鶴見附近のロームは，其鑛物構成から見て，純粋な火山灰ではなくて，火山灰と種々の舊い岩石の碎屑との混合物である．火山灰は中性或は稍基性の複輝石安山岩，含橄欖石複輝石安山岩等を主として產する火山から抛出されたものであるに相違ないが，其火山が現在の火山の何れに當るかは未だ明かでない．舊い岩石の碎屑の多くは御坂層を構成する岩石に類似してゐて，同層或は夫に類似する地層から來たものと推定される．然し，其量，分布，粒の形等から，此岩屑が火山灰中の異質抛出物であるとは考へられない．

種々の事實を綜合して考へると，鶴見附近のロームは恐らく河成の堆積物で，御坂層或は夫に類似する地層の露出する山地から運ばれた岩屑及び粘土が廣い河成平原に堆積しつゝある時に，安山岩質の火山から噴出した多量の火山灰が夫に雑つて生じたものと解釋される，然し，此解釋を所謂關東ロームの凡てに適用する事は勿論許されないのであつて，丹澤山地或は多摩丘陵上の高位の所謂ロームが關東ロームの一部であるとすれば，之に對しては別の解釋が必要である．現在の筆者の考へでは，丹澤山地や多摩丘陵上の高位のロームは火山から直接運ばれた純粋の火山灰の風成堆積物で，武藏野臺地や相模野臺地の低位のロームは火山灰と水蝕岩屑との混合した河成段丘堆積物であると解釋される．

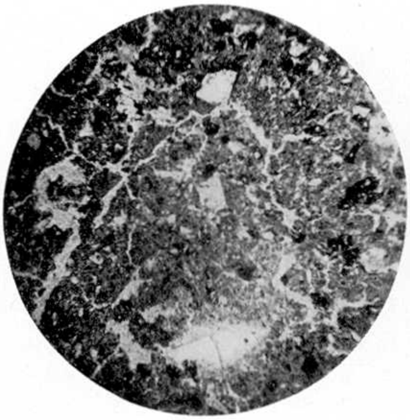

Fig. 2.

Fig. 3.

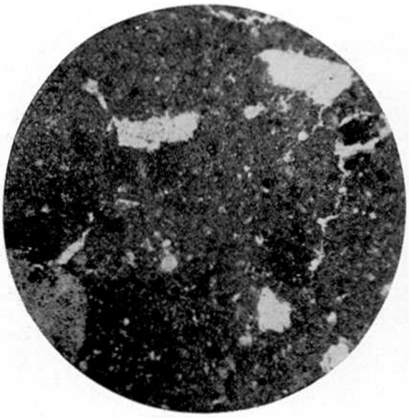

Fig. 4.

Fig. 5.

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