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The Ontake Pumice-Fall Deposit Pm-I as a Late Pleistocene Time-Marker in Central Japan

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Contents

Abstract

An extensive sheet of the pumice- fall deposit Pm-I erupted from Ontake volcano in central Japan covers the areal extent of over 1.5×10^4 km^2. At the type locality in the Ina valley, the pumice is situated in the lower part of the Middle Loam unit of Shinshu Loam formations, whereas in South Kanto it is embedded within the Shimosueyoshi Loam unit.

Though no absolute ages are yet available for this pumice-fall deposit, the Pm-I must be one of the most excellent time-markers and also a valuable long-distance key bed within the Late Quaternary sections in central Japan. Former interpretations as to the stratigraphic and topographic situations of the Musashino upland would more or less be improved by this time-marker.

I Introduction

In many regions of Japan, the Late Quaternary terrestrial sediments consist partly of tephra layers originated from various sources. So much tephra consisting of weathered finer ashes and having a similar lithological appearance, perplexes us to discriminate some definite horizon of tephra or trace it from an exposure to another.

In this connection, a layer consisting of such coarser materials as pumice or scoria may be employed as a time-marker, because their presence in the fields is easily perceptible even to the naked eyes, so that the samples may easily be brought to the laboratory scrutiny.

The extensive sheet of the Pm-I covers the areal extent of more than 1.5×10^4 km^2, spreading over a distance of more than 200 km from the source eastward beyond the environs of Tokyo (Kobayashi et al., 1967). Based on a rough estimation, volume of the Pm-I totals more than 3×10^9 m^3. The grain-size of the pumice in relation to distance from the source volcano was already presented in the previous paper (Kobayashi et al., 1967). The finding of the Pm-I in the Nobi and South Kanto plains, of which the latter district have a standard Quaternary succession in Japan, implies a serious significance upon the stratigraphic knowledges fomerly accepted. This work has been continued since 1963 by the staffs in our Department of Geology and by other collaborators to elaborate Late Quaternary chronology of central Japan.

Our gratitude is due to many persons who are, from all sides, engaged in the investigation of the nature of the Pm-I and especially to Dr. K. Momose whose works on the thermomagnetic analysis of ferromagnetic minerals powerfully support our works of identification. We are indebted to Mr. K. Watanabe for his X-ray analysis of clay minerals of weathered pumices, to Mr. S. Koshima of the Nagoya port managing co-operation for his presentation of samples, and to Mr. K. Kiuchi of the Minami Azumi Agricultural Sr. High School, for his helps for measurement of vesiculation of pumices. Our thanks are also extended to Mr. I. Inoue upon whom we have called for a presentation of some pictures in this paper.

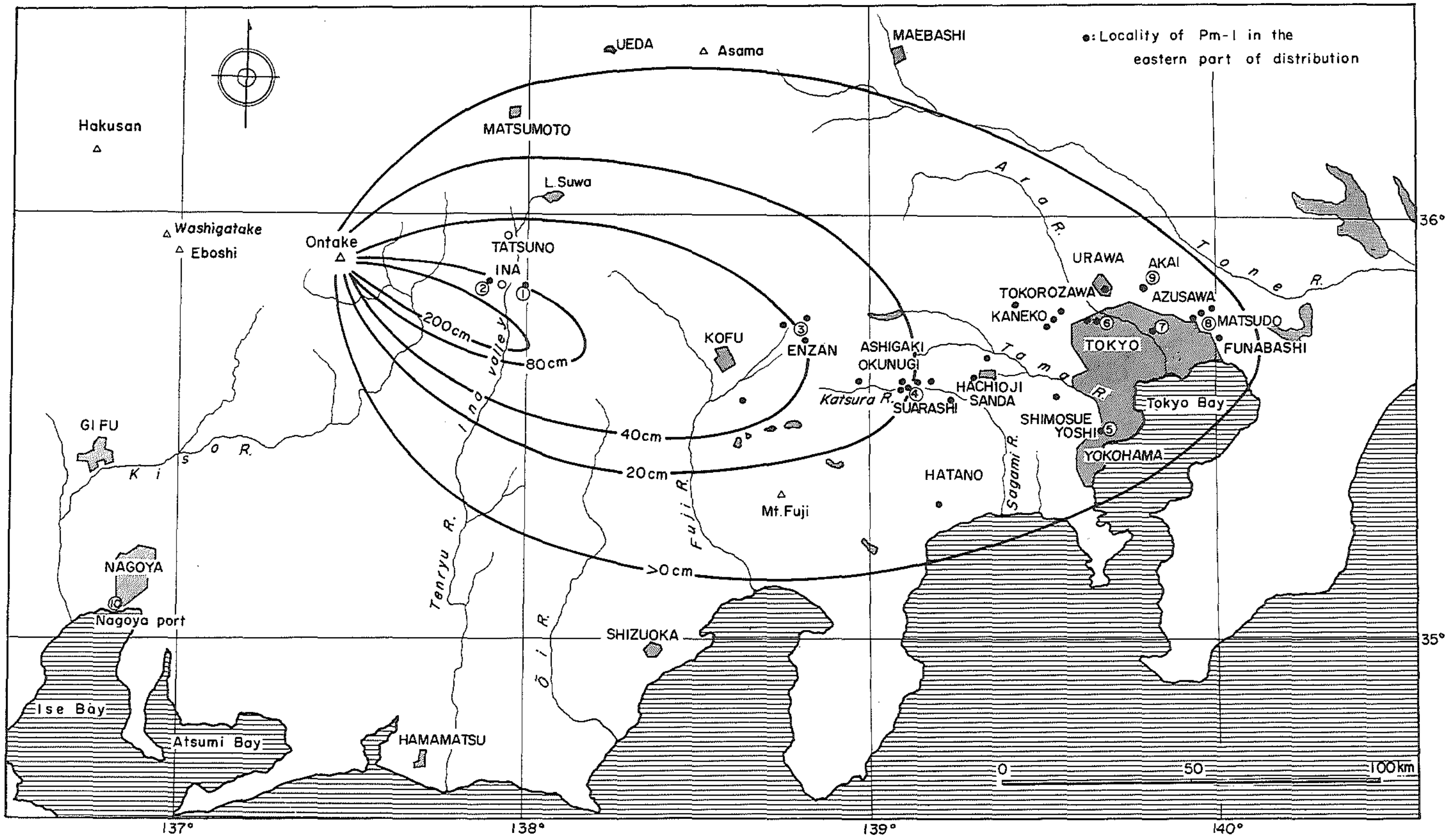

Fig. 1 Isopach map of the pumice-fall deposit Pm-I originated from Ontake volcano. *Loc. nos. 1–10 respectively correspond with the same number of columnar section in Fig. 3*

II Identification of the Pm-I

(1) *Lithology*

The pumice grains are usually clayed to a varying degree, according to the variety of depositional environment. At exposures, air-laid (AA type) Pm-I usually exhibits two types of lithological appearance. (i) The "Fox" type is buff or tan in color. In the western border of Yamanashi pref, it is popularly called "Fox" after its buff color. In the "Fox" type, glass component has mostly altered to allophane and hydrated halloysite. (ii) The "Mortar" (Kobayashi and Shimizu, 1963) or "Hakudo" (White earth) type of the Pm-I consists solely of hydrated halloysite. It is white, and sticky when it is wet, usually like mortar in appearance (Kurahayashi and Tsuchiya, 1967). Upon the Oizumi terrace in the Ina valley, the Pm-I is highly decayed, forming a thick kaolin layer which is at places mined for paper manufacture (Fig. 3–1). (iii) In rare cases, unweathered pumice of the Pm-I are found within beds of water-deposition (AW type). The Pm-I enclosed within the mudflow deposit of the Kisodani formation are fresh and hard seemingly having the least clay content.

Pumices which are not intensively decayed exhibit more or less fibrous structure with in parallel elongated vesicles. The apparent specific gravity (Da), true specific gravity (Dt) and the degree of vesiculation (P) were measured by Kiuchi on samples from Kashima near Nojiri on the Kiso river.

From four lump pumices, the average apparent specific gravity was obtained to be 0.712. Difficulty in estimation of porosity (P) is due to the fact that some vesicles or bubbles are completely confined within the glass and prohibit to evaluate the true volume of solid component. The pumice grains are pulverized into experimental grain-size fraction $\phi \leq 1$. Then the true specific gravity was measured to be 2.46. The porosity would then be $P=(1-Da/Dt)\times 100$ in percent. Calculation yields the average porosity or degree of vesiculation of 71.1 %. This will be discussed in detail by Kiuchi in another paper.

(2) *Mineral Composition*

At a distance from the source, the Pm-I layer becomes thinner and often imperceptible in other tephrogenetic region, or indistinguishable from other pumice layers. In South Kanto, the Pm-I is embedded within the Shimosueyoshi Loam and its correlatives; consequently the primary mineral assemblage is often adulterated to a varying degree in both air-laid and water-laid sediments, affected by contamination.

The mineral assemblage of the Pm-I is rather unique, so that it is effective to identify the Pm-I based on mineral composition of pumice grains by removing contaminants or finer materials which filled up the interstices. The Pm-I originally consists largely of glass with only a few amount of heavy minerals rarely

Table 1 Mineral composition of the Pm-I and associated pumices.
AA : Airborne and air-laid, AW : Airborne and water-laid, Tc: Curie temperature of ferromagnetic mineral
* Mixed with other pumices or finer tephra ** Splitted during pulverization

Sample				H/T %	biot.	horn.	aug.	hyp.	mag.	zircon	others	total	Tc °C
(1) a	Ina TJH 7	Pm-I	AA	—	+	18.8	1.0	10.1	57.7	10.1	2.4	100.1	450
b	7a	〃	〃	—	+	10.4	3.5	9.5	68.6	8.0	—	100.0	450
c	6	〃	〃	—	+	22.0	4.9	10.4	55.0	5.5	2.2	100.0	450
d	6a	〃	〃	—	+	19.3	1.2	8.3	60.0	9.8	1.6	100.2	450
e	5	〃	〃	—	+	28.5	1.1	9.5	54.0	4.2	2.6	99.9	450
f	5a	〃	〃	—	+	21.7	0.4	3.1	63.8	9.4	1.6	100.	450
g	4	〃	〃	—	+	25.2	1.8	3.3	60.0	8.4	1.5	100.2	450
h	3**	〃	〃	—	+	40.4	0.8	3.1	46.0	9.3	—	99.9	450
i	2	〃	〃	—	+	18.6	—	2.8	68.0	9.8	0.9	100.1	450
j	1	〃	〃	—	+	28.0	0.4	4.9	60.0	5.8	0.8	99.9	450
(2)	Hara-Jaya	?	AW	—	+	22.2	—	20.2	48.0	8.8	0.8	100.	60～440
(3) a	Kashima, Kiso	Pm-I	〃	0.6	+	24.3	—	1.6	65.5	7.1	1.5	100.	
b	〃	〃	〃	0.3	5.6	29.3	1.5	2.9	50.2	6.5	4.3	100.3	450
(4)	Nagoya port	〃	〃	—	+	30.8	3.2	5.1	53.8	3.8	3.1	99.8	450
(5)	Otsuki	〃	AA	4.8	+	25.6	4.8	13.5	43.6	7.9	—	100.2	
(6)	Uenohara-Hino	〃	AW	—	+	16.4	—	—	76.1	5.3	2.2	100.1	450
(7)	Okunugi-II	〃	AA	—	+	21.4	2.2	6.5	62.0	2.8	5.2	100.1	
(8)	〃 I-3	〃	〃	—	+	39.2	1.4	0.7	52.0	3.4	1.5	100.2	450
(9)	〃 IV	〃	〃	—	+	33.2	3.1	8.0	48.5	2.3	5.0	100.1	
(10)	Uenohara-III	〃	AW	—	+	9.9	0.4	1.2	82.2	5.1	1.2	100.	
(11)	Tozurahara-Ue 57g	〃	〃	0.9	+	22.8	1.1	1.1	62.0	11.3	2.2	100.	450
(12)	〃	〃*	〃	—	+	7.9	7.2	13.8	67.9	3.6	—	100.4	
(13)	Suarashi	〃	AA	—	+	25.7	2.6	3.8	63.7	3.4	0.8	100.	450
(14)	Tokyo-Hino	〃	〃	—	+	—	—	—	—	—	—	—	450
(15)	Tsurumi-M 17×6	〃	〃	—	+	29.1	1.3	3.4	59.5	2.1	4.6	100.	
(16)	Kajiyama	〃	〃	5.0	+	38.6	—	5.3	49.8	4.3	2.0	100.	450
(17)	Kanekodai-I	〃	〃	5.0	+	31.0	4.0	20.0	43.0	2.0	—	100.	
(18)	〃 (Shimofujisawa)	〃	〃	—	+	—	—	—	—	—	—	—	450
(19)	Nogami, Ome	〃	〃	—	+	32.0	4.0	10.0	50.0	4.0	—	100.	
(20) a	Tokorozawa-Hongo	KuP*	〃	—	—	6.0	4.0	22.0	52.0	—	16.0	100.	
b	〃	Pm-I	〃	—	+	30.0	2.0	8.0	50.0	6.0	4.0	100.	
c	〃	SIP	〃	—	—	—	2.1	10.6	81.6	—	5.7	100.	325
(21)	〃 -Wada	Pm-I	〃	—	+	31.0	3.0	13.0	45.0	4.0	4.0	100.	
(22)	Shirako-Minami	〃	〃	—	+	24.7	3.2	13.5	55.0	2.4	1.1	99.9	
(23)	Shirako-Sakaue	〃	〃	—	+	37.4	—	2.4	46.3	1.8	13.0	100.9	450
(24) a	Shirako-Ichiba	〃	〃	—	+	20.3	2.6	3.5	56.9	9.9	6.8	100.	
b	〃	〃	〃	—	+	19.5	0.6	—	63.5	6.5	9.9	100.	
(25) a	Narimasu-Hospital	〃	〃	3.0	+	25.0	—	6.0	59.0	4.0	6.0	100.	450
b	〃	〃*	AW	3.0	+	40.0	2.0	10.0	36.0	8.0	4.0	100.	
c	〃	〃*	〃	4.0	+	26.0	—	4.0	60.0	6.0	4.0	100.	
(26)	Narimasu-Daimon	〃	〃	1.0	+	22.0	4.0	6.0	60.0	6.0	2.0	100.	
(27) a	Kawaguchi-Akai	SIP	〃	4.0	—	—	4.4	52.8	40.9	—	2.0	100.	330
b	〃	〃	〃	5.0	—	—	8.3	46.0	43.4	—	2.3	100.1	
c	〃	〃	〃	6.0	—	—	12.3	51.7	32.8	—	3.2	100.	
d	〃	〃	〃	6.0	—	—	6.5	51.3	40.0	—	2.2	100.	
e	〃	〃	〃	6.0	—	—	6.6	61.3	29.9	—	2.2	100.	325
f	〃	Pm-I*	〃	—	+	47.0	4.0	6.0	39.0	2.0	2.0	100.	
(28) a	Kawaguchi-Nakago	〃	〃	5.0	+	18.0	2.0	4.0	71.0	2.0	3.0	100.	
b	〃	SIP*	〃	14.0	—	4.0	6.0	26.0	60.0	—	4.0	100.	
(29) a	Urawa-Negishi	Pm-I	〃	0.5	+	39.1	0.7	6.7	42.0	7.7	3.9	100.1	
b	〃	〃*	〃	1.0	+	28.0	10.0	20.0	26.0	3.0	13.0	100.	
c	〃	〃*	〃	1.0	+	12.0	5.0	16.0	59.0	2.5	5.5	100.	
(30)	Funabashi	〃*	AA	—	+	15.1	0.8	33.7	38.0	4.9	7.5	100.	450

(1) a-j Ina Tobu J. High School. See Fig. 2 (2) Harajaya near Fujimi. Problematic (3) a-b Kashima, Kiso valley. a : lump of pumice b : averagely containing 1.5 % apatite (4) Nagoya port. See the text (5) Iwadonoyama near Otsuki (6) Hino, W of Uenohara-machi (7) Upon Osawa terrace, SE of Okunugi, W of Uenohara-machi (8) Locality behind Kida's residence, Okunugi (9) NE of Okunugi, at a valley-head (10) 500 m E of the Uenohara Station (11) Type section of Tozurahara formation, S of Fujino-cho, on the Sagami river (12) The same locality Mixed. (13) Suarashi on the Doshi river, Kanagawa pref. (14) Hino upland, SW of Tachikawa city (15) Tsurumi, Yokohama. Collected by Kaizuka (16) Kajiyama, Yokohama (17) Kaneko upland near Kita-Nakano, Iruma city. (18) Shimo-Fujisawa, Iruma city (19) Nogami, Ome city (20) a-c Hongo, Tokorozawa upland, Saitama pref. (21) Wada, Tokorozawa upland (22) S of Shirako, Yamato-machi, Saitama pref. (23) Shirako-Sakaue, Yamato-machi (24) a-b Shirako-Ichiba, a : Upper yellow part (mixed) b : lower white part (25) a-c Narimasu Kosei Hospital. From upper (a) to lower (c) (26) Narimasu Daimon, Itabashi-ku, Tokyo (27) a-f Akai, Kawaguchi city. From upper (a) to lower (e) of the SIP. f : Pm-I (28) a-b Nakago, Kawaguchi city. a : Pm-I b : SIP (29) a-c Negishi, Urawa city. From upper (a) to lower (c) (30) N of Funabashi, Chiba pref. 140° E. Long. easternmost locality of the Pm-I ever recognized.

including apatite. With respect to unweathered pumice, the value H/T (in weight percentage) which denotes the relative amount of heavy minerals to the total, does never exceed 1 % in weight in fresh samples. Quartz is usually absent, rarely it is present in much small amount. Plagioclase belongs to andesine. Mineral assemblage in heavy fraction is specified by abundance of titanomagnetite averagely of 50% in number, and dark green hornblende attaining to more than 20 %. Augite and hypersthene are both less than 10 %; sometimes they are extremely rare. Hypersthene is usually greenish, yellowish or yellowish brown, rarely it is as light as nearly colorless, being very weakly pleochroic. In some sample, especially that from Kashima, Nojiri on the Kiso river, big crystal of apatite amounting to 1.5 % is present. Biotite is usually much less in amount than other heavy minerals, but it is present in much amount in some samples in South Kanto (i.e. Yasudo and Sanda near Hachioji, where it has altered to kaolinite). In the samples from Nakazato-I (Tokorozawa upland), and Shirako-Ichiba (upon the Narimasu terrace of the Musashino upland), biotite has usually altered also to kaolinite white or silver grey in color and in very peculiar form.

The diagnostic feature of mineral composition of the Pm-I is : (i) the existence of biotite and a notable amount of zircon, (ii) the paucity of hypersthene. These features are important for the identification, because most pumice layers stratigraphically close to the Pm-I horizon of the Shimosueyoshi Loam contains more than 20 % hypersthene, but lacks biotite and zircon.

In a broad area now we concern, pumice layers which are present at a little above or nearly at the same horizon of the Pm-I, trouble us to discriminate the true Pm-I layer, as have been known from such localities as Ogino(AA) and Ashigaki(AW) on the Nakama river, Kaneko-dai upland (Fig. 7-1) near Kita-Nakano(AA) in Iruma city, Tokorozawa upland(AA) and western part(AW) of Chiba prefecture. At several localities, an apparent single layer of pumice indicates that the Pm-I and other pumices containing more amount of orthopyroxene may have intermingled with each other, as suggested by the presence of biotite, a fair amount of zircon, green hornblende and hypersthene.

In Table 1, mineral compositions and Tcs of the Pm-I from many localities and from various horizons of a single layer at the Ina Tobu Junior High School (Kobayashi et al., 1967), indicate a comparatively uniform assemblage of heavy minerals. Those of other pumices at nearly the same horizon as the Pm-I are also indicated in Table 1.

(3) Curie Temperature of Ferromagnetic Minerals

Final testification of the Pm-I which was presumably identified in the out-door field is of basic importance. For this purpose, thermomagnetic analysis of ferromagnetic minerals in pumices has extensively been carried out. Most ferromagnetic minerals in volcanic rocks are said to have chemical composition in the magnetite (Fe_3O_4)-Ulvöspinel ($TiFe_2O_4$)-ilmenite ($TiFeO_3$)-hematite (Fe_2O_3) compositional field in a FeO-Fe_2O_3-TiO_2 ternary system (AKIMOTO and KATSURA, 1959; NAGATA, 1962). Most ferromagnetic minerals in pumices, according to our measurement so far made, prove that they belong to the titanomagnetite solid solution series (MOMOSE ET AL., unpublished).

The results of our examination are summarized as follows:

(a) Ferromagnetic minerals in pumices originated from an eruption seem to have a definite Curie temperature (Tc), implying that they consist solely of a solid-solution of some definite composition, sometimes accompanied by less amount of other kinds of ferromagnetics (MOMOSE ET AL., unpublished).

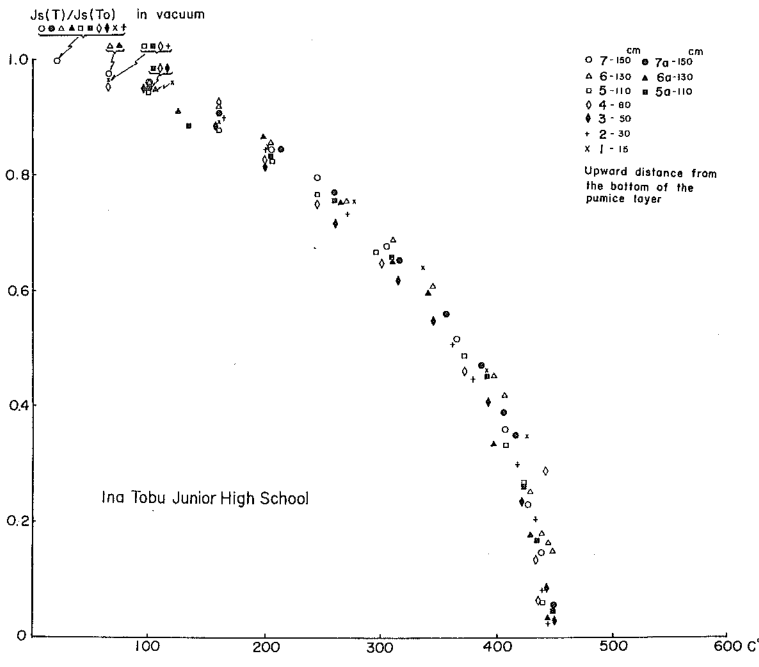

Fig. 2 Demagnetization curves (J-T curves) of ferromagnetic minerals in pumices taken from every seven horizons of a single layer of the Pm-I at Ina Tobu J. High School. Samples no. 5, 6, and 7 are respectively at the same horizons as the samples no. 5a, 6a, and 7a, but in lithological appearance differ from each other. —By courtesy of K. MOMOSE.

As for the Pm-I, most samples from many localities that stratigraphically or in mineral composition could be assigned to the Pm-I, show an extremely uniform Tc at 450°C.

(b) The value Tc of the Pm-I has no relation to the variety in the size of experimental grains extracted from pumices, although much finer grains are more or less apt to show, through heating process, an oxidation due to a partial vacuum of 10^{-3}mm Hg. The ambiguity of Tc caused by oxidation may be counteracted by avoiding to put too small grains to use. Ferromagnetic grains which are more than 0.25 mm across should preferably be used.

(c) Samples from various horizons of a single layer of the Pm-I provided a uniform value Tc at 450°C. This testification was practiced on samples from the Shinshu Loam at Ina Tobu (East) Junior High School (Fig. 2).

(d) When the thickness of the Pm-I reaches up to 1 m or more, its lower part is often intensively decayed and altered to hydrated halloysite (Kurahayashi and Tsuchiya, 1967), whereas other parts remain less weathered, as suggested by the co-existence of allophane with hydrated halloysite. All these pumices show that the Tc pertinent to each sample has a Tc being uniformly at 450°C, regardless of their varying degree of weathering. Ferromagnetic minerals in these pumices seem to be more stable against weathering than other mafic minerals.

(4) Radiometric Age

With respect to age of the Shinshu Loam formations, two dates of the Pm-III are available for the top of the Middle Loam unit. They are respectively 35,700 ±1,400 C^{14} years B. P. (GaK-1047) and 37,600±5,500 Ionium years (Kigoshi, 1967; Kobayashi, 1967). A wood sample enclosed within the pumice-fall layer Pm-II′ in the water-laid Mikoshiba gravels I was taken from a cliff at Yochi 7 km west of the town of Ina. By this wood an infinite date was obtained as being more than 34,600 C^{14} years ago (GaK-1048, unpublished). The upper part of a very thick pumice layer at Yochi was by mere observations misidentified to the Pm-I (Kobayashi and Shimizu, 1965), but the pumice from this part correlates with the Pm-II′ by a marked occurrence of ilmenite and by the mineral composition differring from the Pm-I. The Pm-II′ should in other exposures of air-laid tephra, have a stratigraphic position above the Pm-II lying above the Pm-I. The dating of the Pm-I has been tried by Kigoshi on fresh lump pumices from Kashima near Nojiri in the Kiso valley (Table 1).

III Pm-I in the Drainage Area of the Kiso River

(1) The Pm-I around the Source Vent

The Ontake volcano (N. Lat. 35°53′, E. Long. 137°29′) which is located on the border of Nagano (Shinshu) and Gifu (Mino) prefectures in central Japan, was active from Middle Pleistocene to Early Holocene times. The summit area consists of several volcanic cones and craters, of which the highest peak reaches up to 3,063 m above sea level. T. Kobayashi divided the history of its activity into four stages. The 1st stage reveals three cycles of magmatic activity from mafic to salic. The products during the 1st stage were subjected to a strong erosion, followed by eruptions of salic and viscous pyroclastic rocks consisting solely of pumices (2nd stage). The volcanic body built up during the 1st stage was destroyed by succeeding erutions of pumices which were well vesiculated, followed by a depression of the center of the initial volcanic body. The eruption of the Pm-I is ascribed to the earliest eruption of pumices during the 2nd stage.

Upon the eastern slope of Ontake volcano lump pumices have a maximum size of 20 cm across; at exposure of Jūni-Gongen (altitude, 1,400 m. a. s. l.) a thick layer of the Pm-I contains large accidental blocks of dacitc rocks assignable to the so-called "Nōhi rhyolite". In the nearby area east of Ontake volcano, the layer attains a thickness more than 5 m, nearly 1 m even in the Kofu basin (Fig. 6-1) about 80 km east of the source (KOBAYASHI ET AL., 1967; KOFU BASIN PLEISTOCENE RESEARCH GROUP, 1967)

(2) *The Pm-I in the Atsuta Formation*

A vast quantity of the Pm-I grains supplied in the upper drainage area of the Kiso river were transported by the stream downward to Ise Bay. Its occurrence is traceable within the Kiso-dani formation along the Kiso river down to the Atsuta formation in the Nobi plain, which once was believed to be a marine sediment deposited during the Eemian transgression. The Atsuta formation in the environs of Nagoya city, whose deposition surface ranges from 20 to 5 m above sea level, has been studied in detail, along with the Pleistocene and Holocene marine sediments, so that numerous informations are now available (e. g. MATSUAZAWA and KUWABARA, 1964; TAKEHARA ET AL., 1964). Recent studies indicate that the upper 30 m of the Atsuta formation consists mainly of sand originated from pyroclastic materials and lacks marine fossils, whereas the underlying part (Lower member of the Atsuta formation) with a similar thickness contains mollusc shells. The Upper member which contains numerous pumice grains is doubtlessly an equivalent of the Kisodani formation (QUAT. RES. GROUP KISO RIVER, and KIGOSHI, 1964).

By courtesy of Mr. S. KOSHIMA, recently we had an opportunity to study some borehole samples raised by drillings made on a reclaimed ground (West II Square of the Nagoya port) off the mouth of the Nikko river pouring into Ise Bay.

The 30.3-m core extends downward through the base of the Nan'yo (Pleisto-Holocene) formation into the Upper member of the Atsuta formation (Fig. 3-10). Some segments of the core apparently reveal the existence of pumices: the core registered West 2-16 exhibits a marked inclusion of pumice grains within a segment from 28.15 to 28.20 m in depth (22.45 to 22.50 m below sea level). Heavy mineral composition and Curie temperature (Tc) of associated ferromagnetics of the pumice prove to be identified to the Pm-I (Table 1). The overlying deposit with a thickness of about 23 m and involving marine molluscs should be the Na-n'yo formation which through postglacial time was deposited as a consequence of uprise of sea level. All the values N in the penetration test practiced at various depths above the level of 23 m, do not exceed 20, regardless of variety in lithology, whereas the most values approximate 50 below this level where the intervening of unconformity is expected. The information from the depth of ca. 28 m justifies that Upper member of the Atsuta formation should be correlative of the Upper part of the Kisodani formation which exhibits a series of terraces along the Kiso river. Thus it has been confirmed that the Upper member of the Atsuta formation can be correlated to the upper half of the Shimosueyoshi Loam unit which conformably overlies the marine Shimosueyoshi formation in South Kanto region.

IV The Pm-I in South Kanto District

(1) General Remarks

The South Kanto district as a classical type locality of the Japanese Quaternary succession has long afforded leading conceptions in the Quaternary researches in Japan. After the World War II, stratigraphic studies along with pedological and mineralogical studies have especially been advanced by individuals and by the members of the Kanto Loam Research Group.

As scores of papers have been published on these subjects, now we are to present brief accounts of terraces and associated sediments in order of the time when each definition was given. Stratigraphic succession of the Late Quaternary sediments in the northern part of the Musashino upland is expressed as shown in the right column of Fig. 4.

(a) The term "Loam" does not imply genetical meaning, so it is undesirable to use this for the Pleistocene weathered tephra. Since the days of Brauns' stay in Japan, this term has popularly been misused. The term "Loam" was used first by Brauns (1881) for the so called "Loam" in South Kanto. After discussions, Brauns stated that the lithology of his "Upper diluvial brownish layer" upon the upland in South Kanto was similar to that of "loam", but he emphasized that this material might be compared to loess, except for the meager content of Ca. He made efforts further to discuss the reason for the paucity of Ca in this material, based upon an assumption that the material could be of loess-like origin. Though he could not have attained any conclusion, he used the term "Loam" in his paper of 1882.

(b) In this district as elsewhere in South Kanto, terraces usually carry tephra-covers with various thicnesses. An attention should be directed to that a terrace name indicates strictly the deposition surface of the associated gravel bed, when it is used to indicate a surface as time-topographic surface. Accordingly, the height of terrace does not concern the actual height of a terrace modified by tephra-cover – in other word "topographic terrace".

(2) *Pm-I in the Drainage Area of Katsura and Sagami Rivers*

The Quaternary of the drainage area of the Katsura and Sagami rivers was studied by MINAGAWA (1968). The Katsura river which is the name of the upper part of the Sagami river flows eastward through mountainous area west of the South Kanto plain. Tephra in this environs which should be assigned to the South Kanto tephrogenetic region is divided, from younger to older, into four stratigraphic units, namely "Tachikawa", "Musashino", "Shimosueyoshi", and "Suarashi" Loams. The terraces on which Tama Loam lies, are not recognized upon terraces along the stream course in this mountainous area.

Along the Katsura river, the Pm-I are found to be embedded within the lower part of the Tozurahara formation which formerly was correlated to a sediment deposited during the Tama Loam stage (KANTO LOAM RES. GROUP, 1965). The air-laid Pm-I lies upon the Osawa terrace, and terraces older than the former as known from Okunugi, Ogino, Naramoto, Tsukui Golf links, and Suarashi (Fig. 6–2). In the water-deposited Tozurahara formation exposed at many cliffs on the Katsura and Sagami rivers, and on their tributaries, is found a layer of the Pm-I which sometimes attains a thickness of about 1 m or more and containing unweathered pumice grains with a maximum size of 4 mm (Fig. 3–4).

As noted in the foregoing lines, at nearly the same horizon as that of the Pm-I, some pumices originated from some unknown sources are recognized. Some pumice which contains much amount of hypersthene, and lacks biotite and zircon is found immediately above the Pm-I, and some other one which is characterized by abundance of hornblende and a fair amount of big crystals of apatite, but by lack of biotite and zircon is found in the lowest part of a thick layer of the Pm-I. These pumices are unweathered within the water-laid Tozurahara formation and often are intermingled with the Pm-I (Table 1).

(3) *Shimosueyoshi Terrace and Shimosueyoshi Loam*

The Shimosueyoshi terrace and the Shimosueyoshi Loam have been established from exposures at type locality of Shimosueyoshi, Tsurumi in the northeastern part of Yokohama city. A typical section of the Shimosueyoshi Loam is exposed to view at a man-made cliff about 500 m south of Kajiyama near Shimosueyoshi (Fig. 5–2). There the Shimosueyoshi terrace surface with the tephra cover barely 10 m thick, is 40 to 43 m above sea level. The deposition surface of the Shimosueyoshi formation which is at the level of ca. 30 m, has long been believed to be an indication of the highest sea level during the Shimosueyoshi transgression assignable to the Eemian transgression (Fig. 3–5).

The Shimosueyoshi Loam conformably overlies the deposition surface of the Shimosueyoshi formation, at this level of which lies a variegated laminated pumice layer called the "Sanshoku aisu pumice" (Symbol : SIP), which is traceable over a wide area even within water-laid sediments (Fig. 3–8?, 9, Fig. 6–3, 8–2?). Accordingly the horizon of the SIP should be employed as the lower demarcation of the Shimosueyoshi Loam unit. The section of the Shimosueyoshi Loam at type locality near Kajiyama exhibits five or six pumice layers, of which some are faint and discontinuous (Fig. 3–5, 5–1, 2). At a level below the middle horizon of the Shimosueyoshi Loam is the Pm-I with a maximum thickness of about 15 cm (Fig. 3–5, 5–2). Despite that the upper limit of this Loam unit is often lithologically indistinct and problematic, the boundary between the Shimosueyoshi Loam and the Musashino Loam has been placed at the top of the chocolate-colored cracky zone (Fig. 3–5, 7–1) which in many cases appears at a level a little below the Tokyo pumice (Symbol : TP) and the Miura pumice (Symbol : MP). In the picture Fig. 5-1, however, is not shown any marked lithological boundary seemingly suggesting a demarcation of stratigraphical hiatus between the Shimosueyoshi and the Musashino Loam units.

A considerably big stratigraphic hiatus was once placed at the top, otherwise in the inner part of chocolate-colored cracky zone; accordingly a stratigraphic break was postulated to intervene between Shimosueyoshi and Musashino Loams (KANTO LOAM RESEARCH GROUP, 1965). This inference was, however, rejected by KOBAYASHI (1965 a), who stressed that generalization was hazardous if based upon only apparent unconformity revealed in the air-laid tephra deposit upon slopes and at the margin of uplands or terraces. This type of cracky zone which is usually chocolate-colored and dirty in lithology, is empirically inferred to have been produced caused by mass-wasting once having taken place upon land surface consisting of less coherent deposits of young geolgic ages.

From many exposures are known the cracky zone (Fig. 7–1), of which the top horizons are far less than 1 m below the Tokyo pumice. In other exposures, however, any kinds of cracky zone are not recognized at this level, especially in some newly cut sections (Fig. 3–5, 5–1). A horizon marked by the upper limit of joints or cracks shown in Fig. 5–1, is at the level just below the Kuriyokan pumice (KuP) that tentatively we named from its lithological appearance, has generally been accepted as being involved in Shimosueyoshi Loam. It is important that the aeolian KuP overlies the Narimasu terrace or the Ml terrace as observed from exposures at Shirako-Ichiba (Fig. 7–3,) and Shirako-Sakaue on the margin of the Musashino upland.

(4) *Musashino Terraces*

(AOKI and TAYAMA, 1929, 1930).

(Redefined by KAIZUKA and TOYA, 1953)

Definition : The term "Musashino terrace" was first given by AOKI and TAYAMA (1929, 1930) collectively to a group of flat topographic surfaces of the Musashino upland. These flat surfaces of deposition were later dismembered into two groups of terrace : i. e. the Shimosueyoshi (S) and Musashino (M) terraces, of which the latter was again dismembered by KAIZUKA and TOYA (1953) into the Toshima and Hongo terraces. The Yodobashidai terrace on which the Shinjuku Railway Station (altitude 36–40 m. a. s. l) is located, is tephrochronologically identified to the Shimosueyoshi terrace, but its exact extension is not known. By KAIZUKA and TOYA (1953), the Toshima terrace was named for the area around Ikebukuro with an actual altitude a little more than 30 m a. s. l. At a level 5 m below the Toshima terrace, there lies the Hongo terrace (20–25 m. a. s. l.) on which, for instance, Ueno park is situated. This classification has, since that time, been used for more than a decade ; moreover two terraces have been designated in another way respectively as the M1 (meaning higher Musashino terrace) and the M2 (meaning the lower Musashino terrace) terraces (SHIMBORI, 1965).

Comments : KAIZUKA and TOYA (1953) also presented an ideal schematic section of strata building the terraces in Fig. 4 on page 62 in their paper of 1953. The term "Yamate formation" was by these authors applied collectively to the gravels respectively building the Toshima and Hongo terraces.

These two terraces as time-topographic surfaces have not, however, been detailed in respect of their stratigraphic relation to such air-laid tephra as Musashino and Shimosueyoshi Loams. The lack of information about the tephrostratigraphic situation of these terraces have caused a growth of generally accepted conception that the Toshima terrace is characterized by the covering of Musashino Loam but by the absence of the Shimosueyoshi Loam. Our recent study provides a suspect that in reality even some terraces which are grouped as belonging to the Hongo terrace, might possibly carry some of the upper part of the Shimosueyoshi Loam, though further examination has yet to be made.

Omiya upland : A wide terrace of the Omiya upland has been correlated by FUKUDA (1954) to the Musashino terrace ; later by many workers it is correlated to the Shimosueyoshi terrace (KANTO LOAM RESEARCH GROUP, 1965). The surface of the Omiya upland is highest in the northwestern part, dipping gently to the northeast and southeast until it becomes 10–15 m in the northeast and 20 m a. s. l. in the southeast. Our tephrochronological study also justifies that the southern part of the Omiya upland should have been an area of subsidence through Quaternary

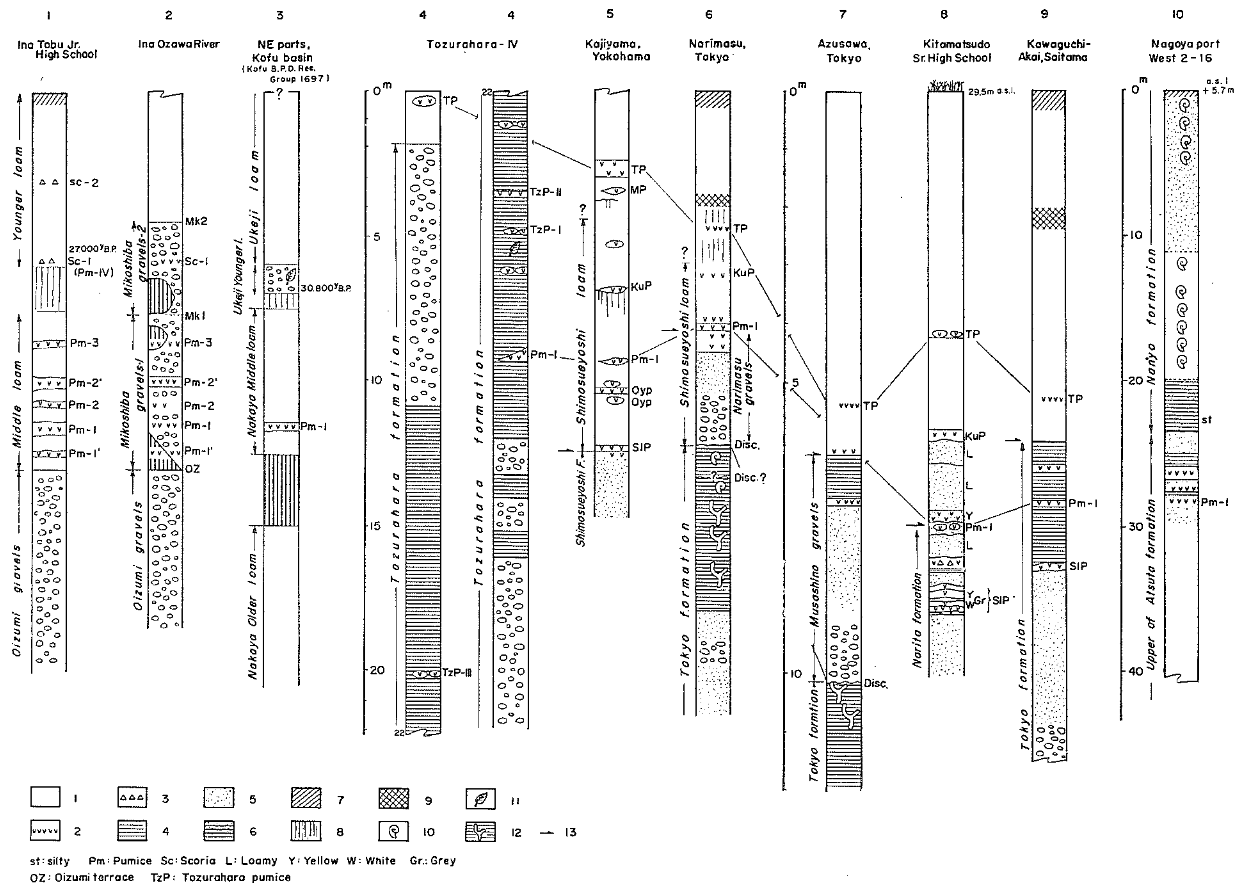

Fig. 3 Columnar sections of tephra at various localities in the Ina valley, Nobi plain and South Kanto. Legend: 1 Loam (ash) 2 Pumice 3 Scoria 4 Silt 5 Sand 6 Sandy silt 7 Top soil 8 Crack 9 Dark band 10 Fossil shells 11 Plant fossils 12 Sand-pipes 13 Depositional surface of water-laid sediment.

3-1 Schematic profile of Shinshu Loam at the type locality 3-2 Schematic presentation of tephra layers within the gravel beds exposed along the Ozawa river west of the town of Ina 3-3 Schematic profile of tephra in the northern part of the Kofu basin (redrawn from the source) 3-4 Profile of the Tozurahara formation at the type locality Loc. Tozurahara-IV near Fujino, Kanagawa pref. 3-5 Type section of Shimosueyoshi Loam at Kajiyama (Mitsuike park), Yokohama 3-6 Narimasu (M1) gravels and overlying tephra at the type locality near Narimasu Kosei Hospital, Itabashi-ku, Tokyo 3-7 Profile of the Musashino (M2) gravels and overlying tephra at Azusawa, Akabane, Tokyo 3-8 Profile of the Narita formation and overlying tephra at Matsudo Senior High School 3-9 Profile showing the occurrence of water-laid Pm-I below the air-laid Tokyo pumice (TP). 3-10 A boring log from the Nagoya port near the mouth of the Nikko river (See Table 1).

time. Thereby, the strata below the TP is continuous, exhibiting no stratigraphic break (Fig. 3–9, 6–3). At an exposure near Akai of Kawaguchi city on the Omiya upland, below the air-laid TP follow, from upper to lower, water-laid layers of the Pm-I, the SIP, and sandy facies of the Narita formation. These facts indicate that here both the correlatives of the Narimasu gravels and Musashino gravels are continuous within a section below Kanto Loam. The fact that the top of these water-laid deposits or shortly the desiccation level being a little below the air-laid TP, clearly indicates that the terrace surface of the Omiya upland is assignable to the Hongo (M2) terrace, instead of the Shimosueyoshi (S) terrace.

(5) *Yamate Formation*

(MAKIYAMA, 1930; Redefined by FUKUDA, 1950 : KAIZUKA, and TOYA, 1953)

Definition : Early in 1930, MAKIYAMA assigned the name "Yamate formation" to the fluviatile sand and gravels at exposures along northeastern scarp of the Musashino upland (Fig. 4). It underlies his "Akatsuchi Loam" (meaning the so-called "Kanto Loam formations") and rests unconformably upon the "Micaceous brackish clay". Upon the Yamate formation below his "Akatsuchi loam", he placed the layer "Light grey clay" which is stratigraphically continuous with the Yamate formation. But he gave little accounts to this clay layer which later acquired the name "Itabashi clay" (Fig. 4).

The term "Yamate formation" was redefined by FUKUDA in 1960 to include the "Light grey clay" of MAKIYAMA; accordingly it consists of two members of which the upper is the Itabashi clay.

Comments : The term "Yamate formation" as a collective term of deposits underlying the Kanto Loam, was employed by KAIZUKA and TOYA (1953) for two sorts of deposit respectively underlying the Toshima and the Hongo terraces. This nomination is, however, ambigous because both MAKIYAMA and FUKUDA gave this term to a deposit apparently pertinent to the Hongo terrace. The upper part of the Yamate formation of FUKUDA is overlain by the Kanto Akatsuchi formation which he divided into two members, of which the upper is doubtlessly of subaerial deposition, but the clayey lower part containing decayed plant remains was ascribed by him to fresh-water deposition. One of the most problematic conclusion of FUKUDA's conception that this part of fresh-water deposition should unconformably overlie the Itabashi clay which is doubtlessly a ater-laid tephra layer 0 to 4 m thick. As was already discussed by KOBAYASHI (1965), loose materials originated from tephra-fall, for instance, on slopes are easily mass-wasted even through a short span of time of tephpra showering. In the evaluation of the stratigraphic hiatus of subaerial deposit, hasty generalization is hazardous if based upon single or a few obervations. We hope that more concrete evidences will later be presented for our critical discussions.

(6) *Yamate Gravels*

(FUKUDA, 1950)

Definition : The lower member of the Yamate formation redefined by FUKUDA; the equivalent of MAKIYAMA's Yamate formation (1930, 1931). FUKUDA described a stratigraphic succession of the Upper Pleistocene section of the Musashino upland from exposures north of the Tobu-Nerima Railway Station. The localities of exposures observed by him may be very near to those we have concerned at Tokumaru area. His classification of the strata illustrated in Fig. 4, indicates that his Yamate formation lies unconformably below the Kanto Loam and unconformably upon the Tokyo formation which consists of marine sand and silt and being characterized by abundant occurrence of sand-pipes.

Comments : The Yamate gravels (lower part of the Yamate formation) are graveliferous in the lower part but becomes more sandy upward grading into clay facies called the Itabashi clay. The erosion surface below the Yamate gravels were once thought by FUKUDA (1950) and AKATSUCHI RESEARCH GROUP (1959) to be of insignificant value probably of conformable or nearly conformable relation.

The lower part of the Yamate gravels with frequent cross-lamination is pumiceous and contains in the basal part breccias derived from clay layers of the directly underlying Tokyo formation. They were apparently derived from clay or silty clay which are penetrated by numerous sand-pipes and containing fossil shells. This apparent erosion surface at the base of the Yamate gravels is even and horizontal, suggesting that a slight lowering of sea level had taken place. Doubtlessly it should demonstrate, in all means, an existence of a significant stratigraphic break.

(7) *Itabashi Clay*

(FUKUDA, 1950; KANTO LOAM RESEARCH GROUP, 1950)

Definition : FUKUDA first in 1950 gave the name "Itabashi clay" to the clay layer above the fluviatile graveliferous beds that he named the "Yamate gravels", from exposures north of the Tobu-Nerima Railway Station. It is not so thick in Tokumaru area but elsewhere it has been said to attain the maximum thickness of 4 m or so. In this area it is represented by a small thickness of fresh-water clay which marks the upper part of the Yamate formation.

Comments : It is bluish, in many cases Uguisu-colored (light yellowish green), and sometimes yellowish or light brownish owing to limonite stain. In lithology, it appears to be tuffaceous and clayey but in reality it contains much amount of sand, and also pumice grains indicating that it consists mainly of tephra materials. At Nakai north of the Nakai Railway Station of the Seibu-Shinjuku Line, an excavation made on the M2 terrace revealed a section of the Itabashi clay which attains a thickness more than 3 m. Here, the top of the Itabashi clay is situated at a horizon about 1 m below the Tokyo pumice (TP). At the top horizon of the Itabashi clay is recognized a somewhat peaty layer that by SAKAI in our Department found that it contained the least amount of pollen grains.

It is important to bear in mind that the Itabashi clay as a whole ranges stratigraphically from nearly the base of the Musashino gravels closely to the TP. Accordingly the clay layer should be believed to adhere to the building of the M2 gravels. The clay layer was once called by FUKUDA and ANDO (1951) the "Itabashi bentonite bed" but later by SUZUKI and KITAZAKI (1953) it has been identified to endellite (hydrated halloysite), instead of bentonite. The Joso clay named by NAKAMURA and FUKUDA (1953) may partly be correlated to the Itabashi clay, more safely to the Shimosueyoshi Loam unit.

(8) *Musashino Gravels*

(FUKUDA and HATORI, 1952)

Definition : The Musashino gravels have been defined as the terrace gravels with a thickness 3 to 6 m unconformably lying below the Kanto Loam, based upon exposures near Kami-ishiwara and Osawa along the Kokubunji terrace-scarp line. The gravels have been correlated by FUKUDA (1950) to the Yamate formation which includes the Itabashi clay. At many localities in the western part of the Musashino upland, the sections do not always exhibit clay layer correlatable to the Itabashi clay at the top of the Musashino gravels. The tephra between the TP and the surface of the Musashino gravels is usually less than 2 m thick, and the lower half of the tephra is highly clayed and sometimes peaty suggesting that the depositional environment was not dried up at the time of tephra showering.

Comments : The Musashino gravels were believed by FUKUDA (1950) and by AKATSUCHI RESEARCH GROUP (1959) to be a correlative of the Yamate gravels. If so, the terms Yamate and Musashino gravels should only be used for the gravel beds underlying the Hongo or the M2 terrace, because the so-called Musashino gravels typically exposed at the valley-side of Todoroki, SE of Futago-Tamagawa, are tephrochronologically identified to be a deposit pertaining to the M2 terrace. At the exposure of Todoroki, is found a 1 m thick Itabashi clay (NARUSE 1966). Also the Yamate formation should be restricted to indicate the deposit pertaining to the M2 terrace.

(9) *Narimasu Gravels and Narimasu Terrace*

(Newly proposed)

The terms Narimasu gravels and Narimasu terrace were first introduced by KOBAYASHI and others (KOBAYASHI et al., 1968) for those near the Narimasu Kosei Hospital north of the Narimasu Railway Station. In the environs of Narimasu, Itabashi-ku in Tokyo, and adjacent Shirako, Saitama prefecture, a part of the

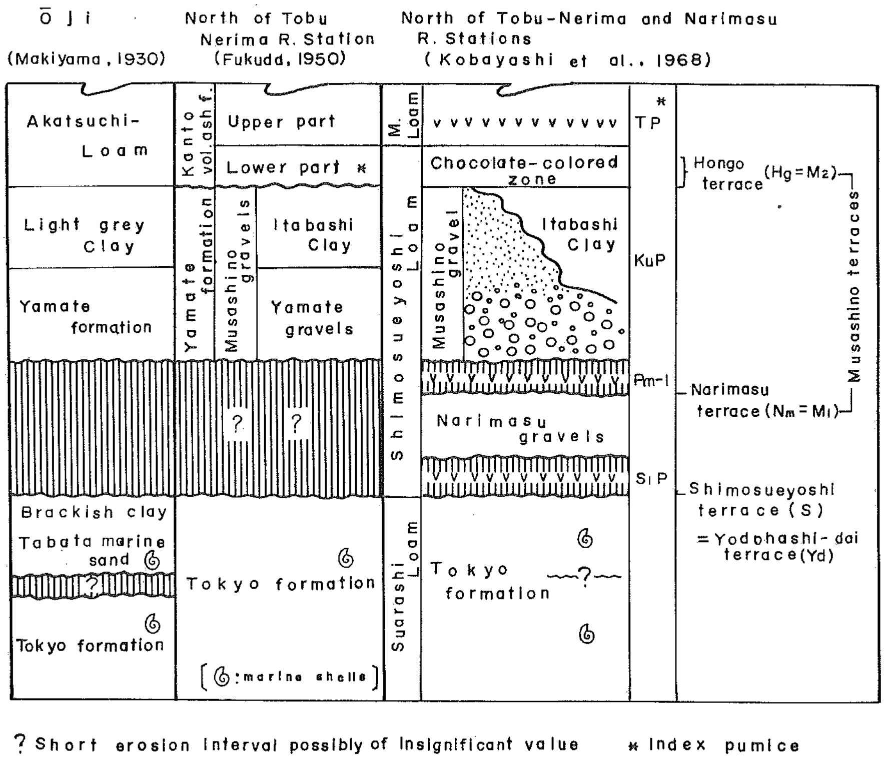

Fig. 4 Correlation chart of the Late Pleistocene stratigraphic succession exhibited at the northern marginal cliff of the Musashino upland. Revised classification is illustrated in the middle and right columns. TP : Tokyo pumice KuP : Kuriyokan pumice SIP : Sanshoku aisu pumice

Musashino upland has altitudes from 30 to 40 m, and about 50 m in the east of Higashikurume, and is apparently higher by about 5 m or more than the lower Musashino terrace with an altitude of about 20 m in Tokumaru area. The type locality of the Narimasu terrace (just 30 m above sea level) and its associated gravels are observed at a big cliff near the Narimasu Kosei Hospital. Here, the Narimasu gravels are about 4 m thick and at the base is a distinct erosion surface upon the Tokyo formation with numerous sand-pipes. At the top of the Narimasu gravels is a 70 cm thick white clay altered from pumices including the Pm-I, and overlying thin and yellow pumice layer (Fig. 3-6, 7-3, 4). Below these clayed pumice layers is a thin sand layer which forms the upper part of the Narimasu gravels. The lower 2 m of the Narimasu gravels is graveliferous and highly cross-laminated.

Heavy mineral composition of sample from every horizon of these white and yellow pumice layers was surveyed by MACHIDA (Table 1). Some samples contain considerable amount of biotite, green hornblende, and zircon, indicating that they are identified to a nearly unmixed Pm-I. At the same horizon in an exposure at Shirako, Yamato-machi in Saitama pref., a white micaceous Pm-I underlying a yellow micaceous pumice seam proves, in mineral assemblage and in Tc of ferromagnetic minerals, to be the Pm-I. It seems somewhat unreasonable that the clayed pumice layer with its total thickness of 70 cm at Narimasu might consist wholly of the Pm-I, because in South Kanto the air-laid layer of the Pm-I is usually less than 10 cm in thickness. The pumice layer of water-deposition naturally does not always reflect the amount of tephra-fall in situ. At the type locality, the depositional surface of the Narimasu gravels is covered by an air-laid tephra which is about 2 to 3 m thick below the TP.

The air-laid Pm-I is just above the depositional surface (desiccated surface) of the gravel bed at an exposure near Shirako-Ichiba (Fig. 7–3). At Sakaue in Shirako, the Pm-I is nearly at the deposition surface of 1 m thick clay layer upon the gravel bed, and overlain by 4 m thick air-laid tephra below the TP. From Yotsuba-cho in Itabashi-ku are found the water-laid Pm-I grains which are unweathered and probably, at the time of deposition, mixed with pumice grains originated from some other source. The higher one of the two Tcs of ferromagnetic minerals of sample from Yotsuba is at 450°C. At a locality south of Shirako and upon the terrace 40 m above sea level, the Pm-I 10 to 20 cm thick is situated 3 m below the TP. Here, the deposition surface of the underlying gravel bed is unexposed, but at least 1 m thick tephra is, by hand boring, recongnized to lie below the Pm-I and upon a gravel bed.

Conclusion : We have discussed the modes of occurrence of the Pm-I and the overlying air-laid tephra below the TP, and it may be concluded that;

(a) The Pm-I lies nearly at the top of the Narimasu gravels, otherwise at a level a little higher than the deposition surface of the Narimasu gravels.

(b) In the northeastern part of the Musashino upland, the Narimasu terrace carrying air-laid tephra is 30 (at the type locality) to 40 m above sea level. The highest portion in this environ is a narrow elevation on which Heirinji temple is located, but it is not clear to what topographic category this may belong.

(c) As both the air-laid TP and KuP are recognized in every section of tephra upon the Narimasu terrace (deposition surface of the Narimasu gravels), the upper half of Shimosueyoshi Loam is confirmed to mantle the higher member of the Musashino terraces.

(d) The tephrochronological situation of the M1 terrace was formerly not clear in detail, but our efforts which solely concern the identification of pumice layers, elucidated that the Narimasu terrace should represent the M1 terrace. KAIZUKA (1964, p. 31, p. 37–38) once predicted that in the environs of Narimasu, although the terrace surface has the same altitude as the Toshima terrace; the former being more dissected might probably be assigned to the Shimosueyoshi terrace, instead of the Musashino terrace.

(e) Correlative topographic surfaces of the Narimasu terrace are widely recognized upon the Musashino upland north of the Seibu-Ikebukuro line, on the Hino upland, and on the 30 m terrace in Chiba prefcture (Fig. 3–8).

(f) The building of this terrace is apparently younger than the Shimosueyoshi (S) terrace, and older than the Hongo (M2) terrace. This is the reason why we propose to establish a new terrace name "Narimasu terrace".

V Conclusion

In this paper, results of our tephrochronologic investigations made especially in the eastern and northern suburbs of Tokyo are discussed rather in detail, because the recognition of the Pm-I has to change the former correlation and reconstruct a correlation of the late Quaternary sediments and terraces in this district.

Identification of the Pm-I has been carried out by both stratigraphic and mineralogical investigations, of which the latter includes a method of identification by measuring the Curie temperature of ferromagnetic minerals of pumices. Because of a fair stability of ferromagnetic minerals against weathering of tephra, thermomagnetic features are helpful for the identification of the Pleistocene tephra.

In the Musashino upland, the Pm-I overlies the Shimosueyoshi and Narimasu terraces, of which the latter carries the air-laid or water-laid Pm-I at the top of the Narimasu gravels. In the areas (NE, E and N of the Musashino upland) where subsidence has taken place through late Quaternary time, the Pm-I is found to be embedded within the successive water-laid sediments from the Narita formation.

Through Late Pleistocene time having followed the time of the Shimosueyoshi transgression are recognized three stages recorded by minor uprise of sea level, and these should respectively be called the Narimasu, Musashino and Tachikawa transgressive stages.

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Fig. 5-1 Tephra profile at the type locality of Shimosueyoshi Loam at Kajiyama, Yokohama. See also Fig. 3-5. The boundary between Musashino and Shimosueyoshi Loams is indistinct. Cracky zone just below the KuP is vaguely indicated.

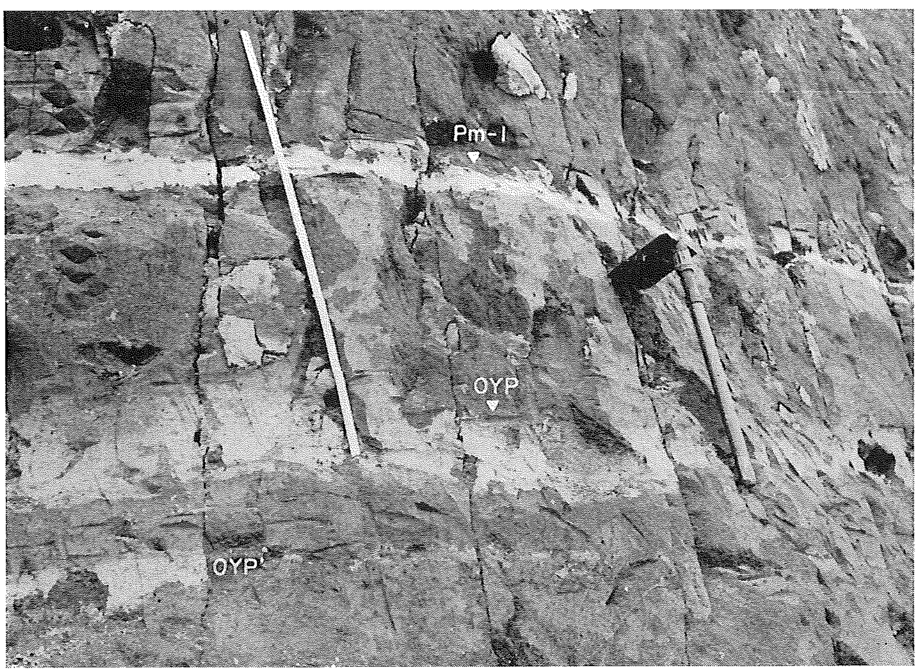

Fig. 5-2 Pm-I layer at Kajiyama near Shimosueyoshi, Yokohama. Maximum thickness of the Pm-I measures 15 cm.

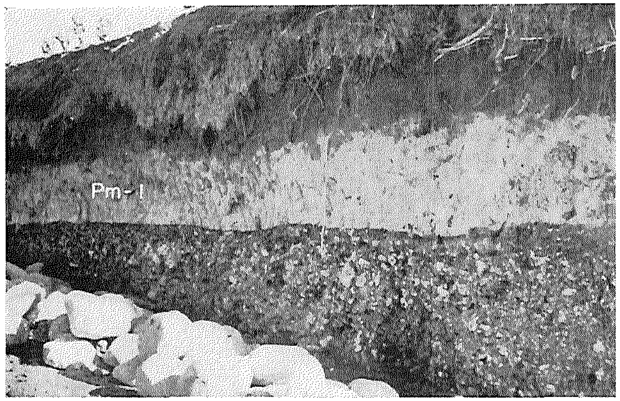

Fig. 6-1 Pm-I layer (70 cm thick) at Ushii-zawa (Loc. U-IV) near Fujinuta, on the Sone Hills, SE of Kofu city. The pumice lies unconformably on the Terao gravels.

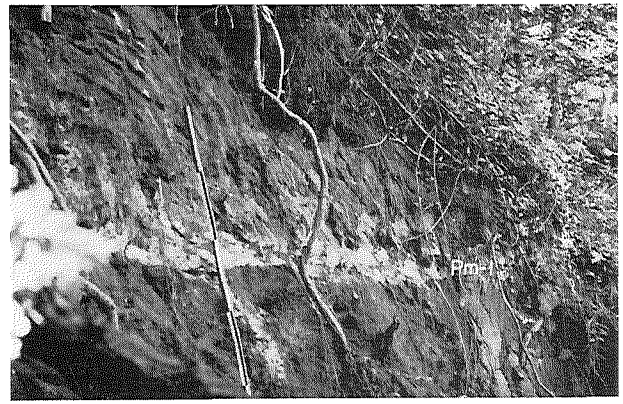

Fig. 6-2 Pm-I layer (15 cm thick) at a big cliff of Suarashi (Loc. I), on the Doshi river-a tributary of the Sagami river. See also Table 1.

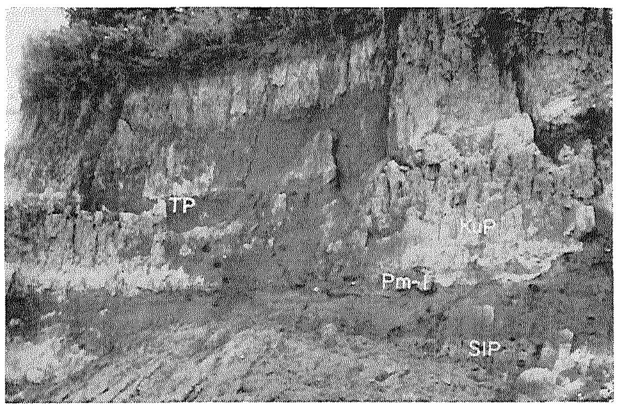

Fig. 6-3 Water-laid Pm-I layer at Akai, Kawaguchi city, Saitama pref. The TP is 45 to 50cm above the water-laid deposit, but the SIP (Tc : 325-330 °C) is water-laid.

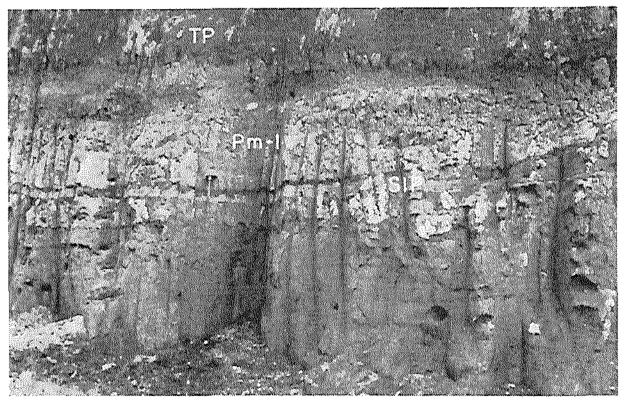

Fig. 6-4 A big cliff near Matsudo Senior High School, Kita-Matsudo, Chiba pref. Pm-I lies immediately above the deposition surface of the water-laid sediment of which the lower part is the Narita formation. See Fig. 3-8.

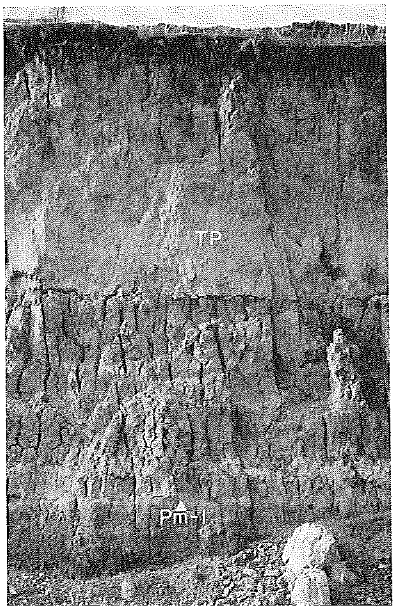

Fig. 7-1 Pm-I layer (20 cm thick) at the edge of the Kaneko upland near Kita-Nakano, Iruma city.

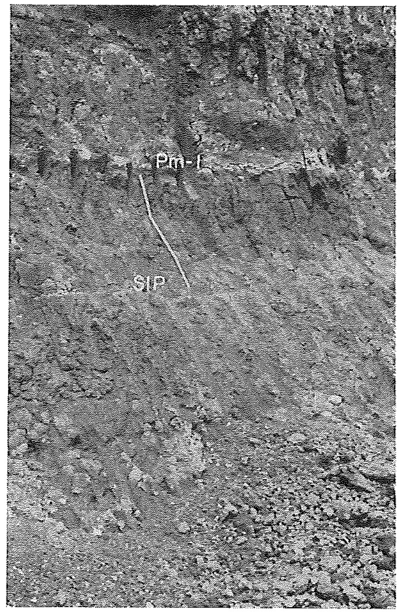

Fig. 7-2 Pm-I and SIP (Tc : 325°C) pumice layers at Hongo, Tokorozawa upland. 70 cm thick air-laid tephra lies between the SIP and Tokorozawa gravels.

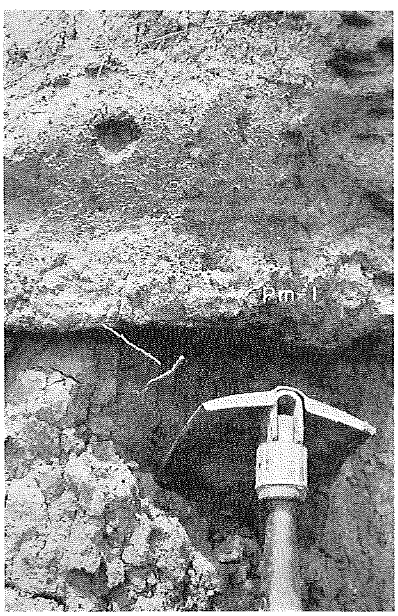

Fig. 7-3 The Pm-I rich in biotite, Yamato-machi, Saitama pref. Yellowish upper part of air-deposition, 20(−) cm thick; white lower part 10(−)cm thick.

Fig. 7-4 Pm-I layer mixed with other pumice grains, at a big cliff near Narimasu Kosei Hospital, Itabashi-ku, Tokyo. See also Table 1 and Fig. 3-6

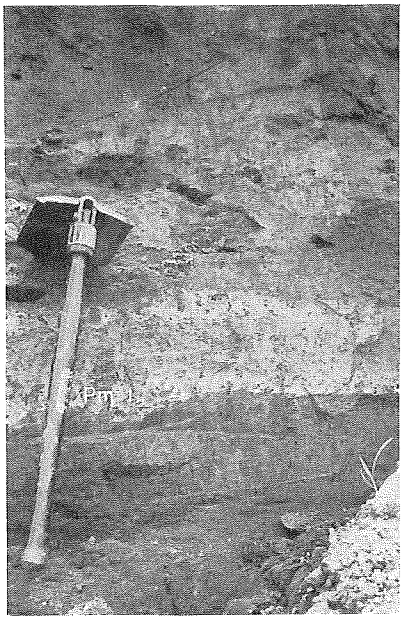

Fig. 8-1 Pm-I layer at Matsudo Sr. High School, Kita-Matsudo. The white lower part is the Pm-I just overlying the water-deposited sediment. The air-laid and yellowish upper part is not the Pm-I.

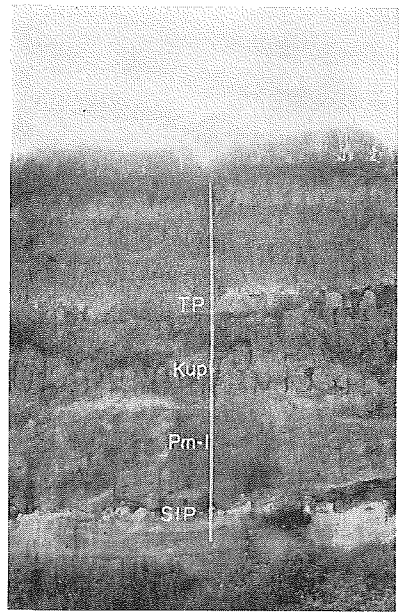

Fig. 8-2 Tephra profile north of Mabashi, Kita-Matsudo. The KuP is just above the water-laid sediment. The Pm-I and the SIP? are both water-laid. A measure hanging on the cliff is 9 m long.