5. Division of terraces

A flat or gently inclined surface of hills and plateaus in the Kanto Tectonic Basin is called the terrace which is bounded along one edge by a steeper descending slope and along the other by a steeper ascending slope. The terrace occurs along the margin and above the level of a body of water making a former water level. The flat surface of the upper limit of gravel, sand and clay beds corresponds to the terrace plain. The terraces are mostly products of shallow marine and stream deposition. The surface of the terraces are former shallow sea floors, river floors, alluvial fans, deltas, marshes, floors of lake and pond. The terrace which is formed near the seashore is called the coastal terrace; and along the river, the fluvial terrace; and by the lakeside; the lacustrine terrace. Changes in sea level and climate shift the base level of erosion and deposition.

Investigation of the terraces in the Kanto Region was first done by Yabe (1920) who mentioned there are two terraces as upper and lower in the Chichibu Basin. Thence after Yabe and Aoki (1927) recognized three terraces as the upper, middle and lower terraces in Kumagaya and Yorii areas (Table 9).

Aoki and Tayama (1929 and 1930) divided the terraces in the Kanto Region into four terraces which were called the Pre-Tama Terrace (abbreviation; PN), Tama Terrace (abbreviation; T), Musashino Terrace (abbreviation; M) and Post-Kanto Loam Terrace (abbreviation; PL). It is not clear whether the terraces corresponds to those of today. The T Terrace corresponds to the "Tama Terrace", M Terrace corresponds to the Musashino Terrace (former Musashino Terrace included the Shimosueyoshi, Narimasu, Musashino, Tachikawa and Aoyagi Terraces) and PL Terrace corresponds to the Alluvial Terrace. Aoki (1930) reported the existence of the intermediate terrace between the T and M, and between M and PL. They correspond to the Shimosueyoshi and Tachikawa Terraces, respectively.

Tayama (1930) divided six terraces in the Boso Peninsulala and named them the X_1, X_2, T_1, T_2, M and PL Terraces. The X_1 and X_2 Terraces are denudational plane in the Boso Hills and is older than the Shimosa Group, and T_1 and T_2

Terraces correspond to the "Tama Terrace", and M Terrace corresponds to the Terrace of Musashino Plateau (Table 9).

Otuka (1931) divided the terrace of the Kanto Region into 8 stairs as P, Pd, Dl, Du Ia, Du I, Du II, A I and A II (Table 9) in ascending order.

After the IInd World War, the study of the terrace was continued from the view point of the relation between the terraces and age of the volcanic ash formations. The terraces were classified into the "Tama", Shimosueyoshi, Musashino, Tachikawa, Aoyagi and Haijima in ascending order by the Kanto Loam Research Group (1965). The terraces were subdivided more detail by stratigraphic succession in relation with the overlying tephras (Tsurumi and Ohmura, 1966; Kobayashi *et al.*, 1968a, b; Machida, 1971; Endo and Uesugi, 1972; Machida, H., 1973; Machida, M. 1973; Machida et al 1974; Kanto Quaternary Research Group, 1980).

The altitudes, gradient, dissection, and flatness in the Kanto Tectonic Basin were become more clear.

Kanto Loam Research Group (1965) divided the terraces in the southern part of the Kanto Region into the Tama I , Tama II , Shimosueyoshi, Musashino ("Toshima", "Hongo" and Naka-dai Terraces), Tachikawa, Aoyagi and Haijima Terraces in descending order based on the tephrochronology

There are the Sayama, Mine, Maeganuki, Oyama (these terraces belong to the "Tama Terrace Group"), Tokorozawa, Yodobashi, Omiya (these terraces belong to the Shimosueyoshi Terrace Group in a broad sense), Narimasu, Musashino, Naka-dai (these terraces belong to the Musashino Terrac Group), Tachikawa, Aoyagi and Haijima Terraces at present (Fig. 5-2). The geologic age of the Oyama Terrace in the "Tama Terrace group" (Board of Education of Yorii Town, 1983) is remain unknown. These terraces were formed by stream water which flowed across the alluvial fans where the deposition and the erosion were occurred.

The Sayama Terrace was built as a fill top terrace. Composite fans were formed from gravel transported by the rivers from the Kanto Mountains on the west. The Sayama Terrace was composed from the compound alluvial fan

(Kitabayashi and Saito, 1995) spread over north and south in the Musashino Plateau along the eastern margin of the Kanto Mountains. The Mine and Maeganuki Terraces were formed in the same way. These terraces were risen up at the present and were conserved as the hills.

The Kanto Tectonic Basin was submerged by marine transgression. It is commonly accepted as the age of the maximum phase of the transgression, the age of the Shimosueyoshi Transgression. The age of the maximum phase of the transgression is 125,000±5,000 years ago (Penny et al., 1969; Chappel, 1974). The wave-cut bench was formed after the lowering of sea level. The Omiya Plateau was changed to a limnic area. On the eastern foot of the Kanto Mountains on the west of the basin, new fans were developed as mentioned in Chapter 3. As the sea retreated eastward, the fans were extended to the east. A part of the fan became to terrace which is called the Tokorozawa Terrace that belongs to the Shimosueyoshi Terrace in a broad sense. The Tokorozawa Terrace is a fill top terrace. The river area was shifted to the side of the Tokorozawa Terrace and extended to the sea. The lowering of sea level intensified the down-cutting of the rivers. The gravels were brought in down stream from the mountain areas along the valleys. The river floor left from the stream was converted to the terrace as the Narimasu Terrace. Thus, the Musashino, Naka-dai and Tachikawa Terraces were formed. The formation of new terraces were caused by the lowering of sea level.

It is well known that the lowering of sea level was contemporaneous with a climatic deterioration. The reasons for the increased supply of gravels in comparison with the present were originally due to the uplift of the Kanto Mountains against the lowland in Kanto Region, and probably the increased precipitation in those days.

During the formation of terraces, much gravels were constantly supplied to the river from the mountain area along the valley of upper stream of the Tama River, and at the apex deposits attained over 20 m thick. For example, the Tachikawa Gravel overlying the Musashino Terrace is recognized on the northwest

of the Sayama Hills. But the Tachikawa Gravel did not overlie the Kaneko-dai. The sand and gravel were supplied constantly by the streams over the fan, and the fan was gradually changed to the terrace. The fan which was formed in the plural ages was called the composite fan. The Musashino Plateau is the typical composite fan in Japan.

a) Sayama Terrace (Minagawa and Machida, 1971)(Figs. 5-2, 5-3 and 6-6)

The Sayama Terrace in the Sayama Hills is correlated with the Kamikayama Terrace in the Hanno Hills, and the Azuyama Terrace in the Azuyama Hills. The flat plain of the Kamikayama Terrace is the depositional surface of the Kamikayama Gravel. The flat plains of the Azuyama and Sayama Terraces are depositional surfaces of the Kanekozaka and Imokubo Gravels, respectively. The order in which the terraces were formed is the Kamikayama and Azuyama and Sayama Terraces. The gravels are the same in the composition and the degree of weathering. The Kap-1 (No.2 of Fig. 4-2) exists in the Hanno Hills but not in the Azuyama and Sayama Hills. Accordingly the age of the Kamikayama Terrace was formed in the early stage, and the Azuyama and Sayama Terraces in the final stage. These three Terraces are fluvial terraces, but marine terraces are not known in the studied area. The gravel of the Kanekozaka and Imokubo Gravels are 7 to 10 m in thickness. The lower limit of the Kamikayama Gravel is not exposed as shown in Pl. 1, fig. 2 of previous paper (Machida, M. 1973).

b) Mine Terrace (Figs. 5-2, 5-3 and 6-7)

The Mine Terrace has a small distribution on the eastern margin of the Kasumi Hills and belongs to the "Tama Terrace Group" together with the Sayama Terrace and the Maeganuki Terrace as mentioned in the following section. Kurakawa and Majima (1982) noticed that the existence of the Hodokubo Pumice Bed (Minagawa and Machida, 1971) in the middle part of the Tama I Volcanic Ash which is overlying the Mine Gravel forming the terrace in the Kasumi Hills. Kurakawa and Majima (1982) described the existence of the Hodokubo Pumice Bed in the basal part of the volcanic ash formation. The Mine Terrace is nearly

contemporaneous with the Maeganuki Terrace as mentioned in the following lines.

c) **Maeganuki Terrace** (Machida, 1986) (Figs. 5-2, 5-3 and 6-8)

The Maeganuki Terrace was discovered recently as a fluvial terrace and the terrace plane is the depositional surface of the Maeganuki Gravel (Machida, 1986). The terrace was discovered at the Maeganuki Hills in Hanno City under the constructions of the Housing Development Corporation. Judging from the overlying volcanic ash, the Maeganuki Terrace is supposed to be near the upper terrace of the Gotentoge Gravel (Table 4) in the Tama Hills and the Odamaki Terrace in Chichibu City. The Maeganuki Terrace and its equivalents were discovered in same area but the distribution is small.

d) **Shimosueyoshi Terrace** (broad sense) **[Tokorozawa** (Machida, M. 1973) , **Yodobashi and Omiya Terraces]**(Fig. 5-2)

The depositional surface is called the Shimosueyoshi Terrace in a broad sense, and is coused by Shimosueyosh Transgression. The Shimosueyoshi Formation in the Yokohama area, the Tokyo Formation in Tokyo area and the "Narita Formation" in Chiba Prefecture were all deposited as a result of this transgression. The fluvial deposits of the Tokorozawa-dai Gravel is overlying the Tokyo Formation with unconformity at the Tokorozawa-dai.

The terraces which corresponded to the Shimosueyoshi Terrace, are distributed at the Kaneko-dai, Tokorozawa-dai, Yodobashi-dai, Ebara-dai, Iruma Plateau, Konan Plateau and Omiya Plateau (Fig. 5-2). The deposits is the Kaneko-dai Gravel at Kaneko-dai, Tokorozawa-dai Gravel at Tokorozawa-dai, Tokyo Formation in Yodobashi-dai, Ebara-dai and Omiya Plateau, Takahagi Gravel in Iruma Plateau and Konan Gravel in Konan Plateau. The Shimosueyoshi Terrace is the widest marine terrace distributed in the Kanto Region. The fluvial equivalents to the Shimosueyoshi Terrace are the Kaneko-dai, Tokorozawa-dai, Iruma Plateau and Konan Plateau, and of the marine terraces at the Yodobashi-dai, Ebara-dai and Omiya Plateau.

The SIP in the lower part of the Shimosueyoshi Volcanic Ash Formation just above the terrace deposits, indicates that the Yodobashi-dai and Ebara-dai were emerged at the same time as the Shimosueyoshi Plateau. The Shimosueyoshi Volcanic Ash was deposited in a fresh water at around the Iruma, Omiya, Shimosa and Hitachi Plateaus, and changed into bush warbler-coloured clay which are called the Kawaguchi and Joso Clays. Emergence of the area by subaqueous Shimosueyoshi Volcanic Ash was a little later than that of the Shimosueyoshi Plateau.

The Konan Plateau consisted by the fluvial terrace in the northern part of the studied area, was built by the Arakawa River. It is thought from the distribution of the terraces that there was a stream in the southeast trend on the Hiki Hills. The Hiki and Yoshimi Hills were surrounded by the Arakawa River and remained solitary like islands. The Arakawa River had flowed to the east and a distributary to the southeast (present Ichinokawa River; Fig. 7-4). Later, the main stream flowed along straight and wide river.

Consequently, the main stream of the river was cutting down the land; the stream which flowing down southeastward decreased and gradually separated from the main stream. Stream was changed into a stream scar by the time of the Musashino Terrace (Machida, 1986).

e) **Narimasu Terrace (= Toshima Terrace)**(abbreviation: M_1; Figs. 5-2 and 5-3)

The geologic columnar sections of the volcanic ash overlying the Toshima Terrace (Kaizuka and Toya, 1953; abbreviation: M_1) of the higher Musashino Terrace were regarded as same as those of the Hongo Terrace (Kaizuka and Toya, 1953; abbreviation: M_2) of the lower Musashino Terrace. Kobayashi *et al.* (1968a, b) clarified that there are the upper or the upper and middle parts of the Shimosueyoshi Volcanic Ash not only the Tachikawa and Musashino Volcanic Ashes on the Toshima Terrace (M_1). Only the Hongo Terrace is covered by the Tachikawa and Musashino Volcanic Ashes.

The Narimasu Terrace (M_1) was proposed by Kobayashi *et al.* (1968a) for the

former Toshima Terrace (M1) with the geologic columnar section. Only the Hongo Terrace is called as the Musashino Terrace (M2) from this time. Machida, M. (1973) defined the Hongo Terrace is same as the Musashino Terrace by overlying volcanic ashes.

At the same time, the Obara-dai Terrace was discovered by the careful observation of the pumice beds at Obara-dai Plateau in the Miura Peninsula (Machida, 1971). The Narimasu and Obra-dai Terraces were contemporaneous and they were confirmed as the intermediate terrace between the Shimosueyoshi and Musashino (= Hongo) Terraces (Kobayashi *et al.*, 1968a, b; Machida, 1971). The Narimasu Terrace was formed by fluvial process (Kobayashi *et al.*, 1968b) and Obara-dai Terrace by marine process (Machida, 1971). This was the result of the trace of Pm-I and OP in the Shimosueyoshi Volcanic Ash.

By reexamination of terraces in the Kanto Region, the distribution of the Narimasu Terraces and its equivalents were ascertained well in the southern parts of the Kanto Region (Machida, 1971).

It became clear that the Narimasu Terrace is distributed along the Tokyo Bay on the south side of the Shimosa Upper Terrace (an equivalent to the Shimosueyoshi Terrace) from Ichikawa to Kisarazu Cities in Chiba Prefecture.

The Hino Plateau (Machida, 1984; Fig. 4-8) in Tokyo Metropolis was correlated with the Narimasu Terrace covered by the Shimosueyoshi Volcanic Ash. The OP is definitely intercalated in the Shimosueyoshi Volcanic Ash. The lower (marine to deltaic deposit) and the upper (fluvial deposit) parts of the Anegasaki Formation which is 20 m thick (Arai *et al.*, 1977) belongs to the Narimasu Gravel. This means that the sea level was lowered 20 meters or less.

f) Musashino Terrace (= Hongo Terrace)(abbreviation; M2)

Kaizuka and Toya (1953) pointed out the Hongo-dai on the east margin of the Musashino Plateau is 5 m higher than that of the Toshima-dai. Both areas consist of gravel, sand, silt and volcanic ash (Tachikawa and Musashino Volcanic Ashes) overlying the Tokyo Formation. The cross section of the Tokyo Formation

is clear. The upper or the upper and middle parts of the Shimosueyoshi Volcanic Ash is distributed in the Toshima-dai as mentioned in the section of the Narimasu Terrace and is named as the Narimasu Terrace (Kobayashi *et al.*, 1968a,b and Machida, M. 1973).

The Hongo-dai is the standard area of the Musashino Terrace (Machida, M., 1973). The river was flowed to the south when the Hongo-dai was the river floor (Togi, 1928). The Chiba Terrace Sand and Gravel (Nakagawa, 1960; Kanto Loam Research Group, 1965) which is equivalent to the Musashino Gravel in Chiba Prefecture distributes in the down stream side of the Miyako, Murata, Yoro and Obitsu River Valleys. It shows that sea level was lowered after the formation of the Narimasu Terrace, and marine deposit of the equivalent to the Musashino Gravel is not exposed.

g) Naka-dai Terrace (abbreviation; Ms)

The Naka-dai Terrace is distributed only along the Tama River Basin and is overlain by the air-borne TP and the upper volcanic ashes. The Naka-dai Terrace is narrowly exposed at Naka-dai (present Wakaba-cho and Irima-cho) in Chofu City. The area of the southern bank of the Yanase River along the southern margin of Tokorozawa City is reffered to be the Naka-dai Terrace (Regional Geology of Japan, Kanto, 1986). But the volcanic ash of about 20 cm thick corresponds to the part below the TP is existing. This area is correlated with the Musashino Terrace. Juen (1966b) correlated the terrace extended in front of cliff from Zanbori-cho in Musashimurayama City to Sunagawa-cho in Tachikawa City with the Naka-dai Terrace. The terrace distributed from Den-enchofu 1-chome to Unoki-cho in Ota-ku, and one step lower terrace than the Musashino Terrace, is correlated with the Naka-dai Terrace. Yamazaki (1978) reported that the former is a cliff of the Tachikawa Fault (Matsuda and Hatano, 1975) and denied the recognition of the Naka-dai Terrace in this area. The latter is thought to continue the Naka-dai Terrace in stereoscopic view of the aerial photograph. The latter is not recognized and the detailed succession is not published. The latter may be a

terrace between the Musashino and Tachikawa Terraces. The present author correlates the latter with the Naka-dai Terrace.

h) **Tachikawa Terrace** (Fukuta and Hatori, 1952)

The type locality of the Tachikawa Terrace is located along the Tama River and distributed narrowly in the central area of the studied area. The distribution area becomes wide from Ome to Tachikawa Cities along the Tama River in the southern part and in the Honjo Plateau and Yorii Town of the northern parts of the studied area. In these areas, the Tachikawa Terrace is the upper surfaces of the fans. The relative heights between the river floors and the Tachikawa Terraces at Ome City along the upper stream of the Tama River is about 40 m and is about 25 m at Yorii Town along the upper stream of the Arakawa River. The heights are decreasing to down stream. The Tachikawa Terrace is extended beneath the alluvial plain, Futagotamagawa along the Tama River. And it is not exposed along the down stream of the Arakawa River to the south of the Yoshimi Hills on the south of Kumagaya City along the Arakawa River.

The Tachikawa Terrace is 2 to 5 m high in the alluvial plain along small valley incised in the northern part of the Musashino Plateau and open into the Arakawa Lowland. The Tachikawa Terrace is buried beneath the alluvial plain below the entrance of these terraces in the Arakawa Lowland. The buried terrace is known also in the Nakagawa Lowland. This terrace was subdivided into two topographic steps (Machida, M. 1973).

The Tachikawa Terrace is the depositional surface of the Tachikawa Gravel. The Kaneko-dai and Tokorozawa-dai Gravels were deposited thickly in the western part of the Musashino Plateau (apex area of the Musashino fan), and the upper part of the both gravels were partly eroded. The Narimasu Gravel was deposited on the partly eroded surface of the Kaneko-dai and Tokorozawa-dai Gravels. The Narimasu Gravel were partly eroded and deposited on the Musashino Gravel. Degradation and aggradation had been repeated many times during the age of late Pleistocene. Finally, the Tachikawa Gravel had been

accumulated. As a result of the intermittent deposition of each gravel that was eroded or not, the thickness of the gravel reached over 20 m in the Ome City area. The deposition was occurred along the upper stream, and the erosion was occurred along the down stream of the Tama River Basin, and the gravel was deposited thick along the upper stream and thin along the lower stream.

If the gravel was deposited intermittently along the upper stream of a river, the relative height between the old and new terrace gravels became small, and finally, the new gravel covers the old gravel. This phenomenon is called as the convergence of the terraces. The example of the Ome City area is mentioned in the earlier lines (Fig. 7-3). Reports about the convergence are rarely existed, but the phenomenon was occurred in many times. For example, the alluvial deposit is spread over the upper stream from Konosu City in the northwestern part of the Omiya Plateau. The assumed cross sectional view is shown in Fig. 5-1.

The Tachikawa Terrace was formed by the extended river of steep gradient which resulted from the lowering of sea level. The gradient of the Tachikawa Terrace is larger than that of the above mentioned terraces and is particularly steep in the southern part of the Musashino Plateau. The rivers in the northern part of the Musashino Plateau had flowing toward the Arakawa Lowland in the maximum inclination trend. The flowing of Tama River to the southeastward along the southern border of the Musashino Plateau is uncertain. Whether a fault exists along the Tama River, or the subsidence of the southern side of the fan occurred in Musashino Plateau are still under consideration. Sea level was rised since the formation of the Tachikawa Terrace. The Tachikawa Terrace is buried beneath the alluvial plain along the down stream of the Tama and Arakawa Rivers.

i) Aoyagi Terrace (Fukuta and Hatori, 1952)

The Aoyagi Terrace is overlain by the upper most part of the Tachikawa Volcanic Ash whose thickness is an average of 50 cm (Kanto Loam Research Group, 1965). The volcanic ash on the terrace is mixed with granules of overflow deposits

in many places. During the formation of Aoyagi Terraces along the river floor was proceded, the river was flooded many times. The air-borne volcanic ash fell on the flood plain.

j) Haijima Terrace

The type locality of the Haijima Terrace is along the left bank of the Tama River. The Haijima Terrace is distributed in the Tama, Iruma and the middle stream of the Arakawa and not covered by the volcanic ash. This terrace was formed in the Holocene Epoch.

The Haijima Terrace was formed according to rising of sea level after the maximum phase of regression, but was not affected by the rising of sea level because the Haijima Terrace was distributed in the upper stream. Distribution of the Haijima Terrace at the down stream is below the surface as well as the Aoyagi and Tachikawa Terraces.