A SHORT REPORT ON THE GEOMORPHIC HISTORY AND THE PLEISTOCENE GEOLOGY OF THE MATSUMOTO BASIN AND IST ADJOINING MOUNTAINS (*1*)

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INTRODUCTION

For several years the writer's attention has been given to clarify the Pleistocene history in the district of the Matsumoto Basin and its adjoining mountain ranges. In the Hida Ranges (the so-called "North Japanese Alps") west of the Matsumoto Basin, generally with an altitude of more than 2,600 m, we can find a number of evidences of local glaciation. Not a few opinions have been hitherto published, on the age of glaciation in Japan (Otuka, 1931. pp. 80, 96; Shikama and Kobayashi 1949, and Shikama 1952). However, these opinions mainly based on indirect fossil records embeded in the deposits of coastal districts, suggested only the ages of the climatic deterioration in Japan. And yet we have not any persuasive proof of the age when the summits of the Hida Ranges were locally glaciated.

The principal reasons for the difficulties of age-determination of glaciation in Japan, are (1) During the Pleistocene the summits more than 2,500 m. high were sculptured by glacial ice, and evidences are mostly characterized by cirques, moraines, and a few morainic lakes. (2) Difficulties are due to the fact that the deposits at the foot of the mountains bear less emphasized glacial or fluvio-glacial features. (3) Such facts as the plurality of the species of the wind-pollinated plants, the less quantity of pollen produced by these trees and the rare occurrences of the bogs and standing water into which the pollen settles, present an inadequate condition for the solution of climatic fluctuations by pollen analytical method. Therefore we have not enough available data concerning the pollen history for discussing the climates during the later Pleistocene. (4) Geomorphic history has not yet been established in the district once glaciated and this has been a principal reason for the difficulties.

Owing to the scarcity of the fund for printing this journal, this manuscript was much shortened and only a conclusive interpretation concerning the geomorphic history and the deposits is to be presented.

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GEOMORPHIC AND GEOLOGIC SUMMARY

THE MATSUMOTO BASIN: The Matsumoto Basin is between the Hida Ranges and the mountain ranges occupying the western margin of the Fossa Magna. This is perhaps a structural basin bordered by the so-called "Hida Fault" (Tsujimura, 1926) along its western margin, and is filled up by the Pleistocene fanglomeratic deposit which is fairly thick (the thickness roughly estimated more than 200 m. at the center). In the western border of the basin, several consequent streams emerge from the western Hida Ranges and build a continuous apron of confluent fans along the mountain foot.

As the writer already noted (1953), it is difficult to presume that without any crustal deformation having taken place, such an enormous quantity of wastes occupies the mid-stream area of the river in the humid regions. Without fail, these fans are built up by the streams from the Hida Ranges during their young stage, however the deposition of such a vast volume of wastes must have been produced following the depressive movement of the base of the Matsumoto Basin. Each fan has been entrenched by a stream forming usually two or three steps of accumulation terraces along its course.

THE HIDA RANGES: The eastern mountains of the Hida Ranges, west of the Matsumoto Basin, rise about 2,000 m. and more in a space of about 10,000 m. and they are deeply drained by precipitous gorges. The mountains consist of granite, porphyrite, and palaeozoic sediments. The highest summit of the ranges reaches 3,190 m. On the east and north sides of the summits are a number of cirques which owe their origin undoubtedly to glacial sculpture. The cirque-bottoms are generally at an altitude of more than 2,500 m.

THE WESTERN PART OF THE FOSSA MAGNA

On the other hand, this section which is in the east of the Matsumoto Basin, comprises the so-called "Nakayama Ranges" and "Chikuma Ranges". The higest part reaches 2,034 m. among the Utsukushi-ga-hara plateau-like summits. 4 erosion surfaces ranging from 2,000 m. to 600 m. are emphasized by flat-topped crests and even-crested ridges. The area consists of dominantly Tertiary sedimentary and allied igneous rocks.

DIVISIONS OF EROSION SURFACES IN THE WESTERN PART OF THE FOSSA MAGNA

UTSUKUSHI-GA-HARA EROSTION SURFACE: Mt. Utsukushi-ga-hara plateau is a flat-topped mountains which is more than 1,900 m. high. The surface of the summit, is a level plain as wide as 4 km^2. The plateau consists partly of metamorphosed greenish rocks of igneous rock origin, dioritic rocks and other members of the Lower Uchimura complex, and partly of two-pyroxene-andesite which overlies the former complex (Matsuzaki, Kobayashi and Momose 1952). The correlative broad plains of erosion are recognized in the summits of Mt. Hachibuse (1,928m.) and Mt. Takeahi-mine (1,972 m.). Although the writer has not yet discovered any fluviatile deposit on these plateaus and although those surfaces are covered by the so-called aeolian "Loam", the writer holds an interpretation that the surfaces have been mainly denudated by the streams issuing from these mountains themselves. It is difficult to presume the numerous far-extended systems of streams from the Hida and other mountainland. It will be noted in the later chapter, that the Utsukushi-ga-hara erosion surface was slightly dissected and the deposition of the rounded fluviatile cobbles had taken place. Mt. Utsukushi-ga-hara has long been thought to be a volcano of *pedionite* type (Yagi, 1920, Homma, 1927 b) and accordingly the flat surface to be the indication of the andesitic lava flows. However the fact that supports this aspect is meagre. The flat surface consists of not only andesitic lava but also of other basal rocks which belong to the above mentioned Uchimura formation.

HAKAMAGOSHI-YAMA EROSION SURFACE: Hakamagoshi-yama (1,752 m.) is northwest of Mt. Utsukushi-ga-hara, and the area of distribution correlative to this erosion surface is less wide than that of the Utsukushi-ga-hara. The occurrence of the rounded cobbles at the pass of Takeshi-toge (1,760 m.) was mentioned by Homma (1,931). The occurrence of cobbles at the mountain pass, brings forward some tough problems to explain the condition of transportation and deposition. The cobbles are dominantly of palaeozoic chert and green rocks of the Lower Uchimura formation. Tertiary conglomerates are dominant in the place close to this locality. It is a question that the cobbles have been transported by a far extended stream issuing from the palaeozoic mountain area. Howerer the interpretation that the occurrence of the rounded cobbles indicates the past water-level of the stream may be acceptable.

DEMINE EROSION SURFACE: Demine Erosion surface includes the summits of Mt. Demine (1,487 m.) Mt. Toyamine (1,629 m.), Mt. Azumaya-san (1,387 m.), Mt. Obora-yama (1,315 m.) and others. They are all monadonocks above the Omine erosion surface and consist of resistant rocks, such as porphyritic sheets, metamorphic rocks of the Uchimura formation, andesitic rocks and silicified green rocks——"Murasame-ishi" originated from the Tertiary sediments. It is a question whether an even-crested ridges of Mt. Hachibuse with an altitude of about 1,600 m. may be comparable to this erosion surface or to that of the Hakamagoshi-yama erosion surface.

OMINE EROSION SURFACE: Topographic contrasts have been produced by the development of the Omine erosion surface with an elevation of 800—1,000 m. We can guess a landscape with the disappearance of strong relief over 1,000 $km.^2$ in area at least in the middle time of the Pleistocene (Kobayashi 1953). This area which is dominantly composed of Tertiary sedimentary rocks usually more liable to disintegration and crumbling than igneous rocks has been so rapidly eroded away that the reduction of relief of the mountains has been so conspicuous. Peaks projecting above the Omine erosion surface are all composed of above mentioned solidified rocks. Accordingly the interpretation that the projecting peaks above the Omine erosion surface have been resulting from the lateral corrasion, and that they are monadonocks, is undoubtedly correct. Cuesta topography is one of the charscteristic features of the monadonocks, such as shown in Mt. Omine, Mt. Minamitakagrai-yama (both composed of dacitic lava flows in the loose material of the Tertiary sediments) and Mt. Kokuzo (composed of prophyritic sheet that intruded into the Tertiary sediments.

Each cuesta has a steep inface and a gentle backslope. Homma (1931) and Yagi (1943) once mentioned that these straightened cliffs must have been originated from the faultlines. However it would be a mistake to interprete the steep cliff as an indication of fault-made scarp. With regard to the steep cliffs along the flanks of Mt. Omine, Mt, Hijiri, Mt. Utsukushi-ga-hara and Mt. Hachibuse (Tsujimura, 1943) the writer has not yet recognized any faultline by geological field works. These cliffs are the common products of lateral corrasion on the Omine erosion surface.

BOULDERS ON THE OMINE EROSION SURFACE: Fluviatile boulders on the mountain have been called "Yamazyari" or "Mountain gravel" in Japan (Nakamura 1927). It was mentioned by Nakamura (1927) that the mountain gravel was a past pluvial or torrential deposit. But we have no available description on the mountain gravel from the standpoint of the geological and topographical mode of occurrence. In this district also, Homma (1927 a) noted the occurrence of mountain gravel on the mountain near Mt. Omine and he interpreted, "they are the granitic boulders far traveled from the Hida ranges. They are named as "Omine gravel" by Hirabayashi and the writer (1954). The Omine gravel contains rounded rocks large and small, however, it is a tough work to discriminate them from the rounded cobbles derived from the basal conglomerate, as was previously noted (Kobayashi and Hirabayashi, 1950). For several years Hirabayashi and the writer have been trying to explain the occurrence of these boulders among the Omine gravel. Because the conclusive report will be published in the nearest future (Kobayashi and

Hirabayashi 1954), summarized inferences are to be offered. Some boulders among the Omine gravel reach up to 3 m. in diameter. It is noteworthy that the deposition of these boulders took place without strong previous dissection of the Omine erosion surface. But the localities of the boulders are on the comparatively lower part of the summit plateau. Boulders observed are almost granitic rocks, it is also noteworthy that although the granite is usually so crumbling in other places, the granitic boulders on the Omine erosion surface are firm and little weathered. Without any crustal movement or heavy precipitation, previous to or corresponding to the deposition of the Omine gravel, the large boulders could not have been transported by the stream on the Omine erosion surface. Because the erosion surface (not the deposition surface) previous to the deposition is represented by the small relief of the Omine erosion surface, and the stream gradient on this surface must have been considerably reduced. The deposition of boulders means that a new phase of stream regimen began, in other word the increase of the stream gradient took place. The scarcity of boulders which are more than 1 m. in diameter means that they have not been transported by normally flowing stream, but they have been transported by some occasional and accidental flood.

The rapid uplifting of the Hide Ranges took place and owing to the rejuvenation of the upper drainage of the river, the increase of the stream gradient resulted. The evidence of a fault movement along the eastern flank of the Hida Ranges has long been discussed by Tsujimura (1926), Yabe (1934—5) and the writer (Kobayashi, 1951 b). The straightened arrangement of the scarps and of the kernbut-like ridges constitutes a striking features along the foot of the mountain ranges. Gelogical discussion was made by the writer (Kobayashi, 1951 b). The suggested position of the faultline is densely wooded and covered by thick talusic wastes. There is yet an unanimity as to the actual occurrence of faultline, However, as shown in his preceding discussion, now the writer holds the standpoint to postulate the block movement along the eastern flank of the Hida Ranges. The great advantage of this hypothesis is that it provides a simple meachanism of the formation of the Matsumoto Basin, the elevation of the Hida Ranges, the formation of the Omine gravel, and of the glaciation of the summits of the Hida Ranges. The Omine erosion surface became an aggrading area by this block movement, however the time of the deposition of fluviatile wastes over there, did not last long. The uplifting began to take place perhaps accompanied by the faulting of NS trend, bordering the western margin of the Omine erosion surface.

Lastly they concluded from the studies of the particle size-distribution of the present fan of the Takase that the large boulders among the Omine gravel were brought by the rapid stream, influenced by the increased gradient of the upper drainage of the river and by the occasional heavy rainfalls in the rainy season (summer time) whether it was during the glacial or interglacial age. Gage (1953) has discussed instructively the way of migration of boulders.

Flint, Demorest and Washburn (1942) once mentiond that boulders on the summit of Mt. Albert have been glacially transported. Howerer this is not the case with the Omine gravel, because our present knowledge concerning the scale of the growth of past glacier in Japan is that during the ice ages the climatic refrigeration was rather small and snowfall was not heavy, so only the summits above 2,500 m. were slightly glaciated. We can accept the opinion that the past occurrence of the glacier was only on the tops of the mountains in form of cirque and small valley glaciers. It is also difficult to explain that the transportation was made by the floating ice as was shown by Wentworth (1928) and others (see Flint's p. 135) in southern States. Wirtz and Illies (1951) in this manner explained the occurrence of the cobbles in the Kaolin-Sand of Island of Sylt, derived from the Scandinavia, as they had been transported over 1,000 km, by a rapid stream influenced by the increased increased gradient of the upper drainage of the river.

EROSION SURFACES IN THE HIDA RANGES

We can find a numerous flat-topped crests, even-crested ridges forming a summit level of an altitude of 2,600—2,500 m.——Otaki-yama erosion surface (2,614 m.). Below the Otaki-yama erosion surface, there are 2 steps of even-crested ridges and flat-topped crests at an altitude between 2,400—1,700 m. as shown in the summit of Mt. Nabekammuri-yama and other ridges branching off the main ridges. Ridges toward the east are truncated by steep flat scarps from an altitude of 1,700 m. to that of 1,200 m. The situation of the assumed "Hida fault", may be inferable from this characteristic topographical feature as has been pointed out by many geologists.

Mt. Karasawa-yama (1,371 m.), Mt. Fuji-yama (1,296 m.) and Mt. Kakuzo-yama (1,163 m.) which have been refered to kernbut may be the erosion surface down-thrown by this faulting from the even-crested ridges of an altitude more than 1,700 m. The kernbutlike mountains above mentioned are arranged in the pattern that modifies the ends of the eastward ridges with the rectangular plan of the valleys which follow the faultline. It is difficult to denote the time correlation of these erosion surfaces in the mountains of the western part of the Fossa Magna beyond the Matsumoto Basin. From the indirect evidences above mentioned, the writer's tentative correlation is to be shown in **Table 1**.

AZUSAGAWA FANGLOMERATE FORMATION

The Azusawaga fan is one of the most characteristic of all the confluent fans in this district. It is a magnificient fan with a radius of 15 km. The terraces along the stream was devided by the writer. The so-called aeolian "loam" covers the Hata and the Moriguchi terraces with a thickness of about 2 m. on the right bank, and the Yakeyama terrace with a thickness more than 2 m.

To the fanglomeratic deposits that fill the Matsumoto Basin, Yagi in 1928 applied the name "Anchiku formation". However the name "Anchiku" does not exist actually, therfore the name "Azusagawa fanglomerate formation" has been proposed (Kobayashi, 1951a). The fanglomerate has not been lithified, and loosely consolidated by coarse granitic sand. The pebbles consist of granite, porphyrite, andesite palaeozoic slate, chert, and sandstone, and generally are about 30 cm. in diameter near Hata oailway station. At the apex of the fan, there are found boulders with a diameter of 2 m. As the Azusagawa fanglomerate formation covers the "Hida fault", the fault movement had been active befor the deposition of the fanglomerate began.

LOAM

The significance of the so-called "loam" is important in the Pleistocene geology in Japan. An extensive literature has been published concerning the physical and geological characters especially on the so-called "Kwanto Loam" in the Kwanto districts. It is a striking mode of occurrence that the lowest or lower 2 steps of the river terraces are not mantled by the "loam". The so-called "loam" is not the loam in the strict sense, it ought to be called "loamy clay" as was dicussed by Wakimizu (See Nakao's paper). It is a brown or yellow coloured aeolian deposit consisting of particles of very small size originated from volcanic ash. Therefore "loam" must be "volcanic ash" in the geological sense, as was discussed by the writer (Kobayashi, 1951a). "Loam" is common in and outside of the volcanic districts. It is well recognized by Harada (1943) and Kuno (1936) that the "loam" in the Kwanto district originated from the volcanoes around the Kwanto plains.

However the loam in the district of the Matsumoto Basin has scarcely been discussed, although it is widely developed. The "loam" is strikingly uniform in general appearance and general composition throughout the western part of the Fossa Magna. The thickness varies in some extent but it usually has the thickness of about 2 m. on the river terraces of fans. In some cases the thickness is strikingly uniform, however on the slopes it usually exists in the colluvial, talusic or re-worked modes of occurrences. The materials of the loam in the western part of the Fossa Magna were supplied by the volcanoes west of the Matsumoto Basin,——the volcanoes belonging to the Norikura Volcanic zones. (Kobayashi, 1951 a). The present knowledge concerning the time of deposition of the loam makes us conclude that the loam was originated from the volcanoes that were active during the later Quaternary. On the basis of field evidences, also it can be said that the aeolian "Loam" is an excellent time indicater at least in some extent of space and time, and it roughly indicates 4th glacial age or the end of the Pleistocene. This aspect affords a correlation with the pleistocene chronological standard of Japan, as shown in **Tabe 1.**

SUMMARY OF GEOMORPHIC HISTORY

1) In the middle of the Pleistocene, the higher part of the Hida Ranges had an altitude of about 2,000 m. and consequent eastward streams had attained more or less profiles of equiliblium.

2) The monadonocks were the most remarkable of the landscapes above the Omine erosion surface.

3) When the uplifting of the Hida Ranges happened to take place, the increase of the stream gradient made the boulders migrate on the Omine erosion surface.

4) The relative depression between the Omine erosion surface and the Hida Ranges perhaps accompanied by the above mentioned "Hida fault" and by the fault along the western margin of the Omine erosion surface (the fault line is assumed along the western foot of the Mt. Omine) took place and thus the boulders which are quite foreign rocks on the mountains mear Mt. Omine, have come into existence.

5) The consequent streams flowing eastward began to detour southward and they have turned to flow again into the Sai-kawa has entrenched the Omine erosion surface by a rapid under-cutting. The pattern of the stream-courses may have been thus originated.

NOTES ON GLACIAL PROBELMS

The glaciation of the Hida Ranges appears to have originated from the emergence of the uppermost erosion surfaces above the snow line by the above mentioned uplifting during the later half of the Pleistocene. Otuka mentioned (1931) that the growth of the glacier in Japan antedated the volcanism of Mt. Norikura and Mt. Ontake, because they bear no trace of glaciation. However, the writer does not agree with this opinion as regards the Norikura Volcano. The volcanism of the Norikura

Table 1 Pleistocene Chronology by Means of Land Surfaces in the Hida Ranges and Western Part of the "Fossa Magna" (K. Kobayashi 1954)

Quarternary Chronological Standard of Japan (Ōtuka)			Topographic levels	Deposits & glava flows — Fossa magna	Levels of land surfaces — Ōmine-Utsukushi-ga-hara	" — Hida Ranges & Azusagawa fan	Glacial age & faulting (F)
			-AII		-Recent gravel l.	-Recent gravel l.	
Holocene	a	I	-AI		-Itoshiba l.	-Oshide l.	
		II			-Tatenouchi l.	-Kamikaido l.	
Pleistocene	duII	c		?			Würm
		b	-DuII	Brown ash	-Ōmachi park l.		
		a				-Moriguchi l.	F
	duI	c	-DuI	Fanglomerate		-Hata l.	
		b					Riss
		a	-DlII	Ōmine gravel	-Nakajima l. } Ōmine -Nokkoshi l. }	-1700 m l.	F
	dlII	b a			-Demine l.	-Nabekammuri l.	Mindel
			-DlI	Shiokawa f.	-Hakamagosi l.		F
	dlI						
			-Pd	Utsukushiga-hara lava	-Utsukushiga-haral	-Ōtakiyama l.	
	pd						
Late Tertiary	p		-P	?			

Volcano has been acive for far more than 10,000 years (B. P.) at least. The early volcanism which built the cones in the northern part of the Norikura Volcanic Chain, perhaps had been piled up before the Würm glacial age. The opinion denying the existence of cirque topography on the Norikura Volcano has been predominant. However the opinion that asserts the past growth of glacier on the northern peaks of the Norikura Volcano (Kano, 1937) can not be laughed away.

It has been said that from the studies of the morainic deposits in the cirques of Hida Ranges the cirques were twice glaciated (Tsujimura, 1913; Imamura, 1940; Minato, Hashinoto and Kobayashi, 1953). The writer agrees with the opinion that the glacial substages in the Hida glacial age are at least divided into two. However, the question is whether both of the substages could be correlated with Würm, or the former with the Riss and the latter with the Würm. Otherwise, it may be said that the two uppermost small sets of morains represent the evidence of the so-called post-glacial ice advance (Moss, 1951). The writer's present aspects on the interrelation of glaciation, climatic fluctuation and mountain lifting are shown in Fig. 3. The discussions on the correlation with the international geological time scale are omitted. Geological studies on the superfical deposits and the detailed discussion on the glacial problem will be published in the succeeding paper.

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EXPLANATION OF PHOTOGRAPHIC PLATES

Pl. IV

Fig. 1 Plateaulike summit of Mt. Utsukushi-ga-hara, with an altitude of more than 1900 m. View from Mt. Chausu (2006 m.) toward north.

Fig. 2 Mt. Utsukushi-ga-hara seen from Washi-ga-mine (1798 m.) toward north.

Fig. 3 Stone stripes on the summit of Mt. Hachibuse (1928 m.)

Pl. V

Fig. 4 Mt. Hachibuse seen from the Matsumoto Basin towrad east. The highest point shows the Utsukushi-ga-hara erosion surface. The lower ridge shows that of Demine.

Fig. 5-6 Mt. Hachibuse and even crested ridges seen from Yoko-mine toward north. The writer has discovered a numerous set of stone polygons and stone stripes. (infra-red photo.)

Pl. VI

Fig. 7 The eastern side of the Hida Ranges, seen from Matsumoto. (infra-red photo.)

Fig. 8 Mt. Jonen (2857 m.) and the Karasugawa fan, seen from Susado.

Pl. VII

Fig. 9 Fluviatile gravel bed on the ridge with an hight of 1150 m. (400 m. higher part above the present river floor) near Kawagishi, which perhaps may be referable to the Omine gravel in age.

Fig. 10 Rounded pebbles at the pass of Takeshi-toge (1760 m.)

Fig. 11 A Boulder of the Omine gravel on the ridge with on altitude of 1140 m. reaches 2.5 m. in diameter.

Fig. 12 Cuesta topography on the north side of Mt. Kokuzo (1136 m.) originated from the occurrence of the porphyrite sheet.

Pl. VIII

Fig. 13 Cuesta topography of Mt. Omine and the Omine erosion surface, the Omine erosion surface here is 800-860 m. high.

Fig. 14 Cuesta topograpty seen from Towari-bashi.

Fig. 15 Illustration of the geologic structure of Mt. Omine.

Pl. IX

Fig. 16 *Glacial topography in the Hotaka mountains.* 1) Kita-Hotaka-dake (3,100 m.), 2) Minami-dake, 3) Nakano-dake, 4) Dai-Kiretto-cirque, 5) Minamizawa-cirque, 6) Tengubara-cirque

Fig. 17 Sugoroku-cirque (2,750 m.)

(all was taken by the writer).

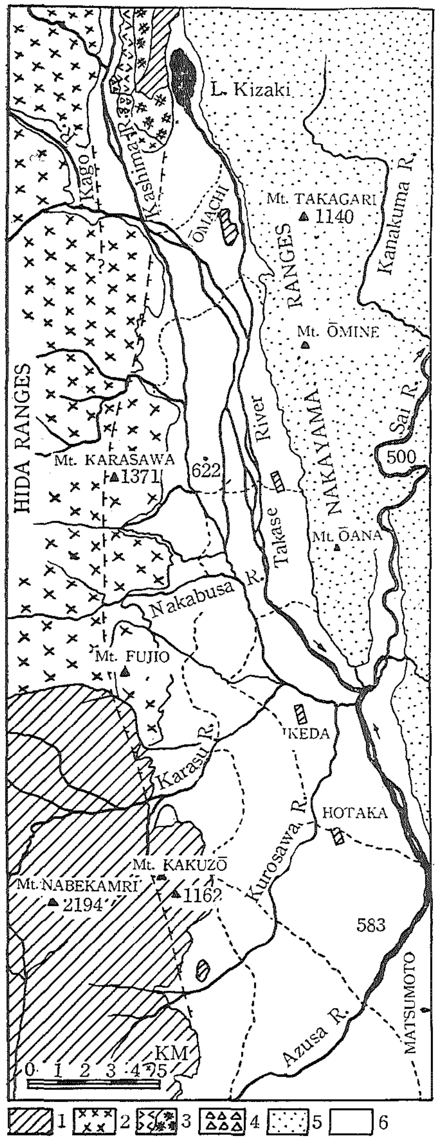


Fig. 1 **Geological Sketch map of the Matsumoto Basin and its Adjoining mountains.**

1. Palaeozoic rocks including a little Mesozoic rocks, 2. granitic rocks, 3. quartz-syenite and monzonite, 4. agglomerate, 5. Tertiary rocks, 6. fanglomerate

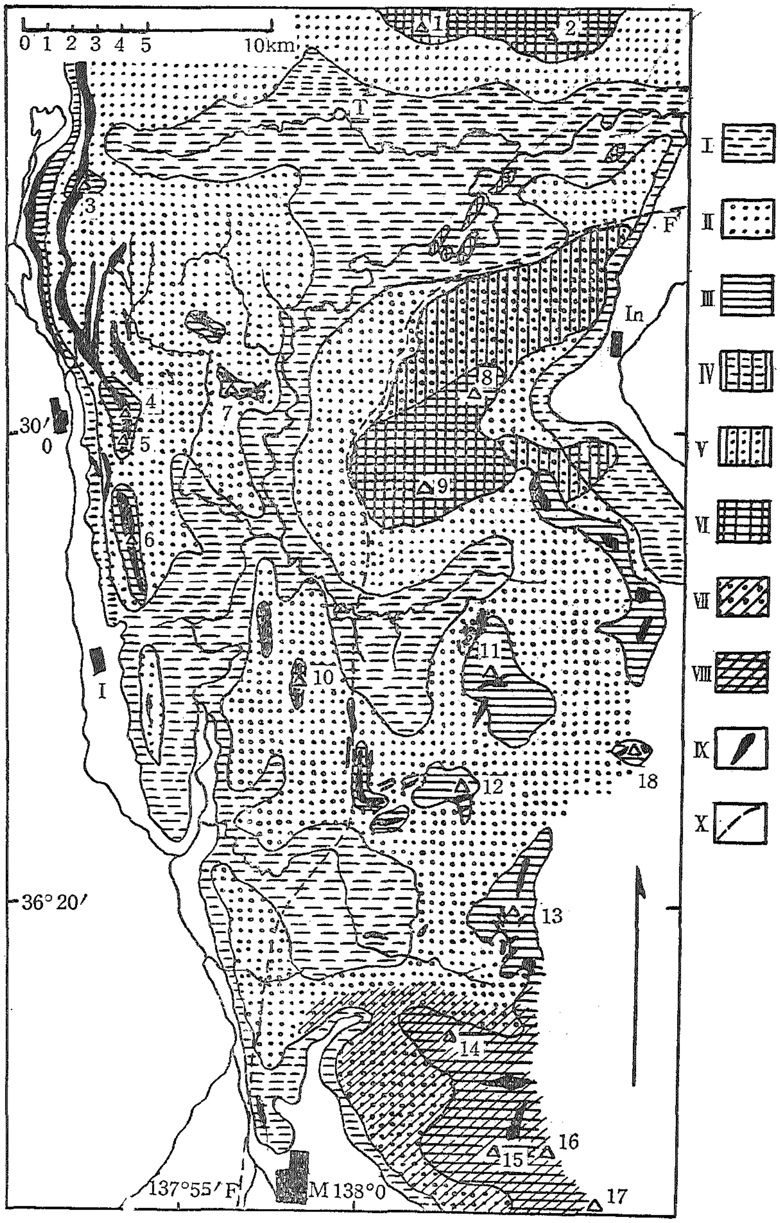


Fig. 2 **Sketch-Map showing the 3 Levels of the Remnant Erosion Surfaces and the Distribution of Resistant Rocks in the Western Part of the "Fossa Magna"**

I=Ômati park level (lower); II=Ômine levels (upper); III=Monadnocks (horizontal line indicates the monadnocks on the Ômine levels); IV, V, VI=resistant rocks (vertical line indicates the area consists of andesite flows or volcanic pyroclastics, both embedded in the Tertiary formations); VII, VIII=resistant rocks (oblique line indicates the area where a very numerous set of prophyritic sills is found); IX=resistant rocks (black part marks the distributions of various sorts of resistant rocks, i. e. conglomerate, dacite flow, andesite, prophyritic sill, diorite, the so-called green tuff, etc.); X=broken line across the map (F-F′) marks the western limit of the area of the unfolded Tertiary formations and also that of the area embracing many plutonic or hypabyssal intrusives.

1. Musikura-yama, 2. Zimbadaira-yama, 3. Gongen-yama, 4. Takagari-yama, 5. Minamitakagari-yama, 6. Omine, 7. Ouba-yama, 8. Takao-san, 9. Hiziri-yama, 10. Iwadono-yama, 11. Azumaya-san, 12. Ohorayama, 13. Iri-yama, 14. Toyamine, 15. Hakamagoshi-yama, 16. Takeshi-mine, 17. Ogatô, 18. Komayumi-dake

T/Takahu; O/Omati, Ikeda; M/Matsumoto; In/Inariyama

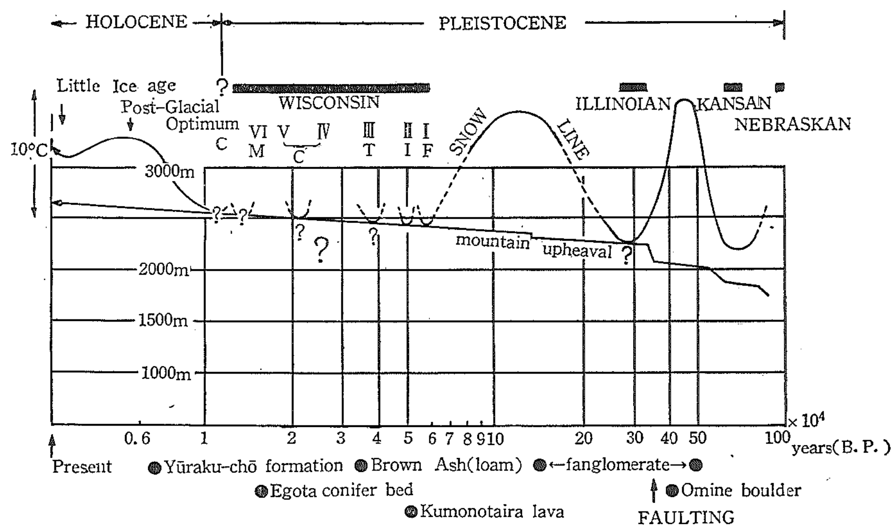


Fig. 5 **Assumed glacial ages in relations to mountain uplifting, deposits, and to climatic fluctuations.**

Dates are shown according to those by W. D. Urry and J. L. Hough. [Hough, J. L. (1953) Pleistocene climatic record in a Pacific Ocean core sample. J. Geol., Vol, No. 3, pp. 252-262]

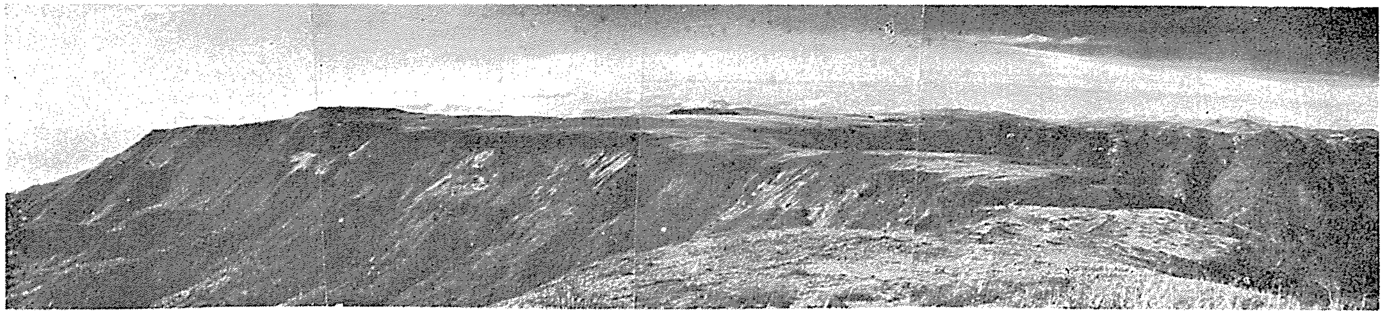


Fig. 1

Fig. 2

Fig. 3

Fig. 4

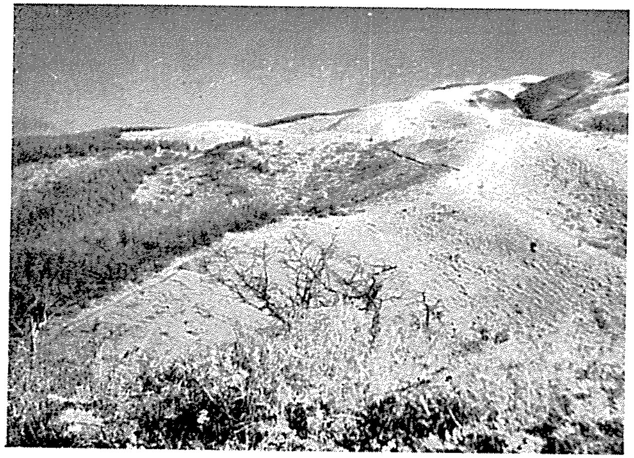


Fig. 5

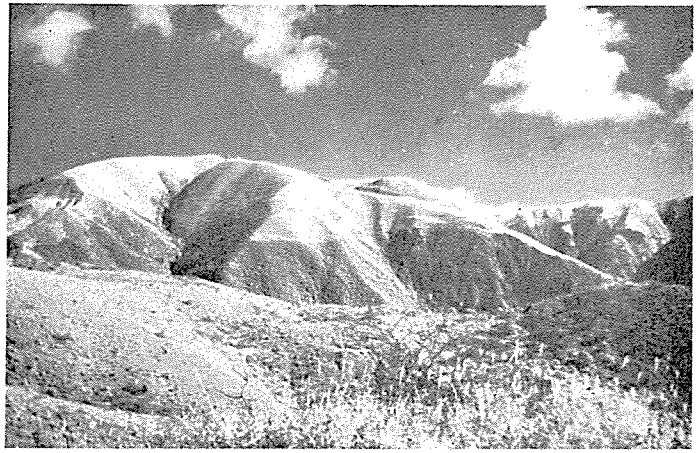


Fig. 6

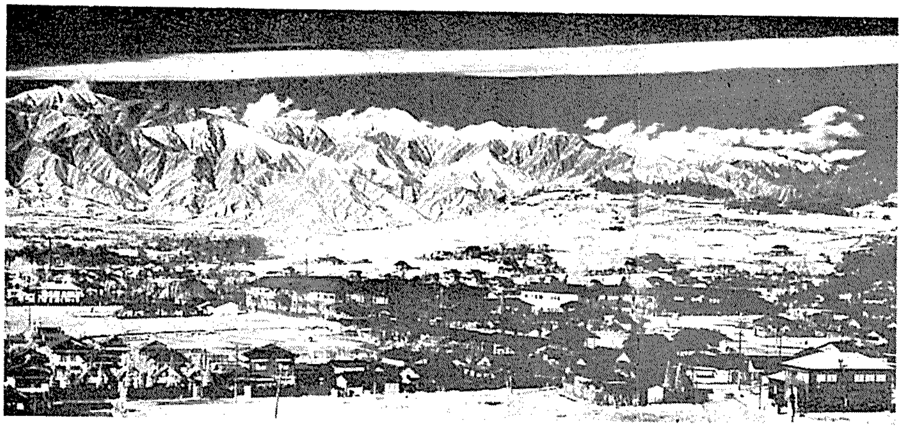


Fig. 7

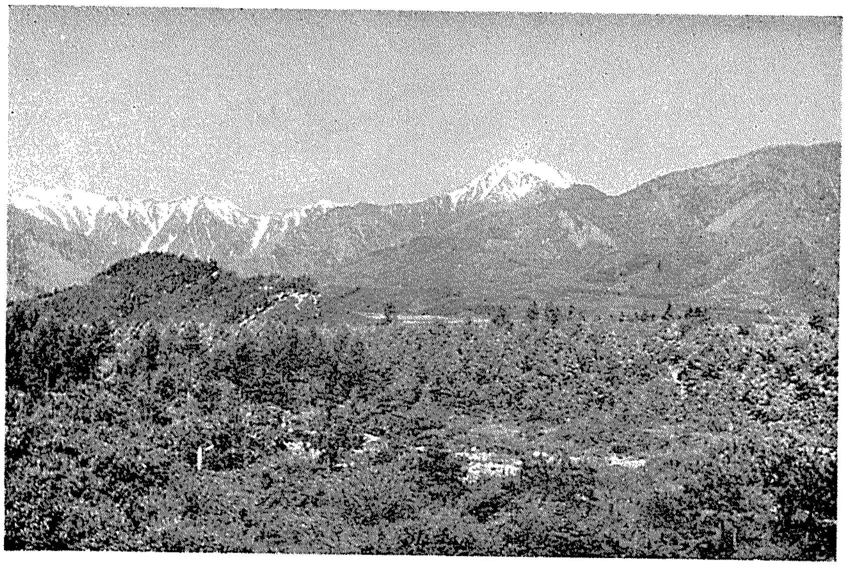


Fig. 8

Fig. 9

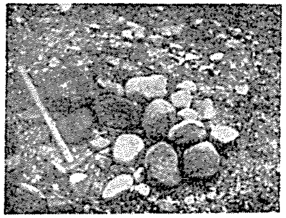
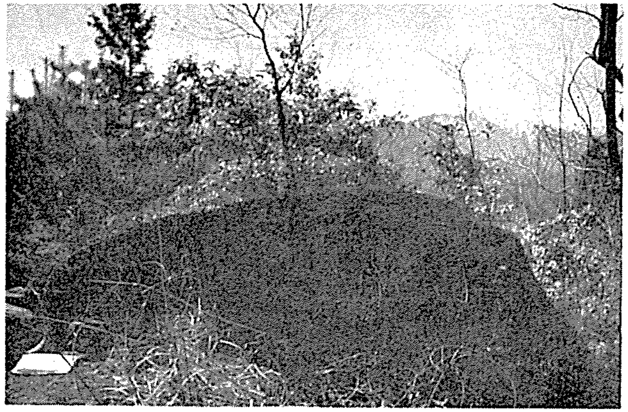


Fig. 10



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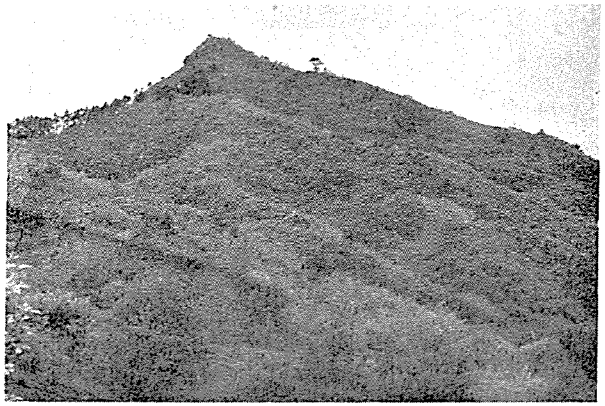

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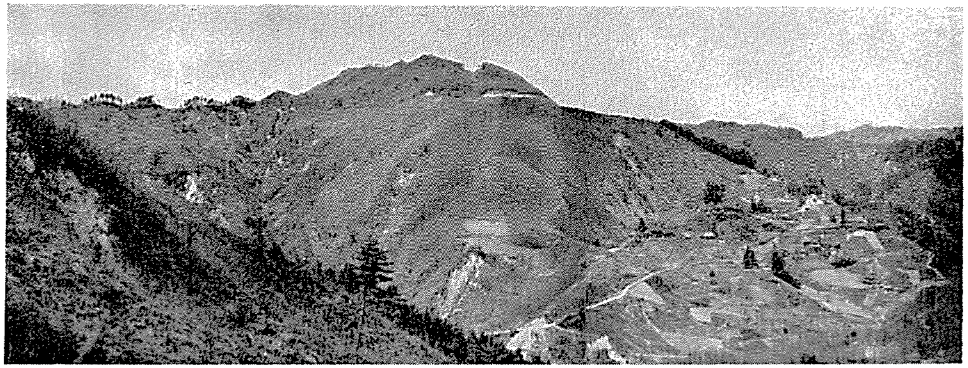

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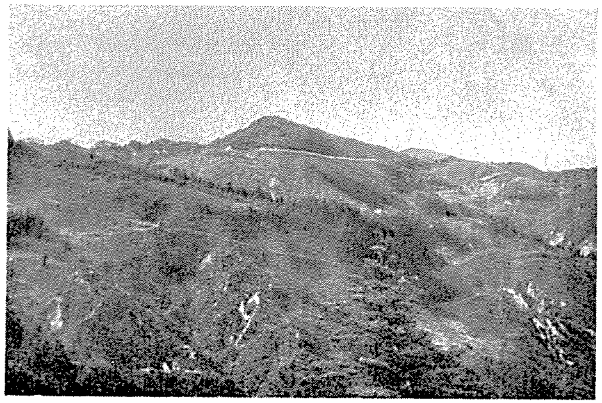

Fig. 15

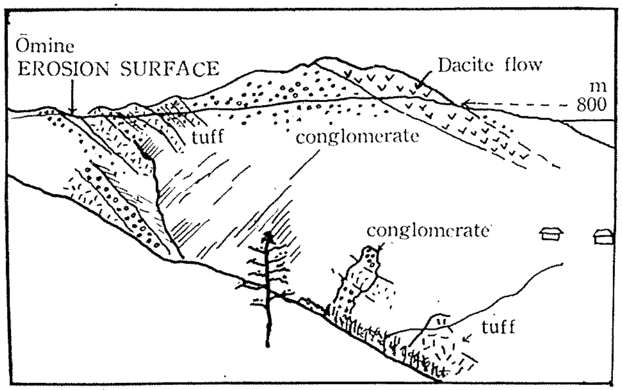

Fig. 14

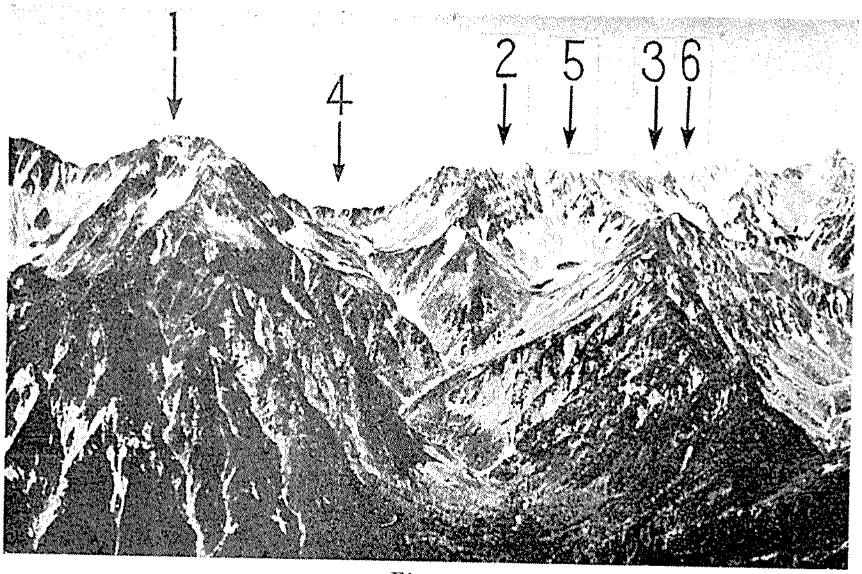

Fig. 16

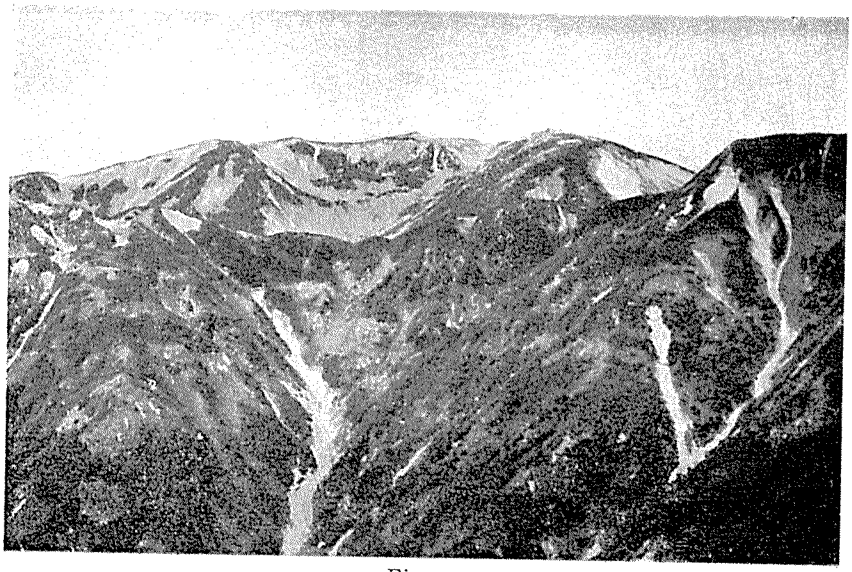

Fig. 17