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RIVER TERRACES ALONG THE MIDDLE KALI GANDAKI AND MARSYANDI KHOLA CENTRAL NEPAL

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ABSTRACT

River terraces along the middle Kali Gandaki and the Marsyandi Khola are all fill (filltop and fillstrath) terraces, and no strath (rock) terraces are distributed. Three valley-fill deposits are disinguished along the Kali Gandaki and two along the Marsyandi, and some of them are not normal fluvial deposits but mudflow ones in origin. The formative process of terraces along each river was strongly controlled by local and accidental geomorphic events, besides climatic change and other regional factors. Therefore the correlation of terraces between both rivers is very confused. Based on the longitudinal profiles of terraces, the tectonic movement along the middle Kali Gandaki is inferred that the region around Phalebas relatively subsided and the northern and southern regions were comparatively uplifted during the late Quaternary.

INTRODUCTION

The authors carried out a series of field surveys on geomorphology along the Kali Gandaki* between Kagbeni and Ramdi Ghat and the Marsyandi Khola** between Manang and Dumre for two months. In this paper the results are presented on the river terraces along the middle courses of both rivers. Glacial landform in the upper Kali Gandaki, Thakkhola region, is treated in Iwata *et al.* (1982) in this volume.

The authors have described the classification, distribution, and geomorphological characteristics of river terraces and their deposits in order to make clear the chronology of terraces and to compile their geomorphological developments during the late Quaternary. An attempt has been made to elucidate the correlation of terraces between both rivers and the morphogenetic relation between the formation of terraces in the middle courses and glacial phenomena in the upstream. Further, the tectonic movement along the middle Kali Gandaki has been discussed from the geomorphological viewpoint based on the deformation of longitudinal profiles of terraces.

The authors' investigation, however, was too restricted in term to treat the above subjects thoroughly. Some of them are left half-done, and much additional work is expected to be carried out.

In Nepali;

* "Gandaki" means large river.

** "Khola" means river smaller than "Gandaki"

PREVIOUS WORKS

Previous works on the river terraces along the middle Kali Gandaki and the Marsyandi Khola are few, other than Hiroshima (1972), Fort (1976) and Sharma *et al.* (1980), though there are some papers (e.g. Hagen, 1969) treating the geology of the regions. The whole aspects of the terraces and their geomorphological significance were not clear.

Hiroshima (1972) dealt with river terraces and glacial landform along the upper and middle Marsyandi, and he classified terraces into three; higher, middle and lower terraces. According to him, the middle and lower terraces are distributed along the middle reaches. The middle terrace rises 70 to 80 meters above the river bed and the lower 15 to 20 meters, and both terraces are accumulation ones. But his description is of preliminary in nature.

Fort (1976) studied three types of sedimentary basins along the Kali Gandaki: Kusma, Ghasa-Lete and Larjung-Jomosom basins, and only the first is situated in the midstream. She divided terraces around Kusma into five levels: levels (5), (4), (3), (2) and (1) in discending order. The level (4) terrace was regarded as a filltop one made up of thick conglomerate, and the level (3) as a fillstrath one that developed within the conglomerate. The former rises about 300 meters above the river bed and the latter about 200 meters. She touched the historical development of terraces briefly.

Sharma *et al.* (1980) classified terraces along the middle Kali Gandaki between Kusma and Behadi into three: T1, T2 and T3 terraces. The T1 terrace stands out at the height from 400 to 300 meters above the river bed, and the T2 is 25 to 60 meters lower than the T1. They are built up of unsorted, unstratified and consolidated conglomerates, which were considered to be attributed to one single sequence of accumulation. The T3 terrace rises 10 to 15 meters above the river bed, and it is made up of younger unconsolidated deposit. Sharma *et al.* (1980) considered that a large volume of the T1 and T2 material was provided as fluvioglacial deposit from the glaciated Himalayan Range and accumulated in lake-like stagnant water bodies which were caused by the damming of the river due to the uplift of the southern

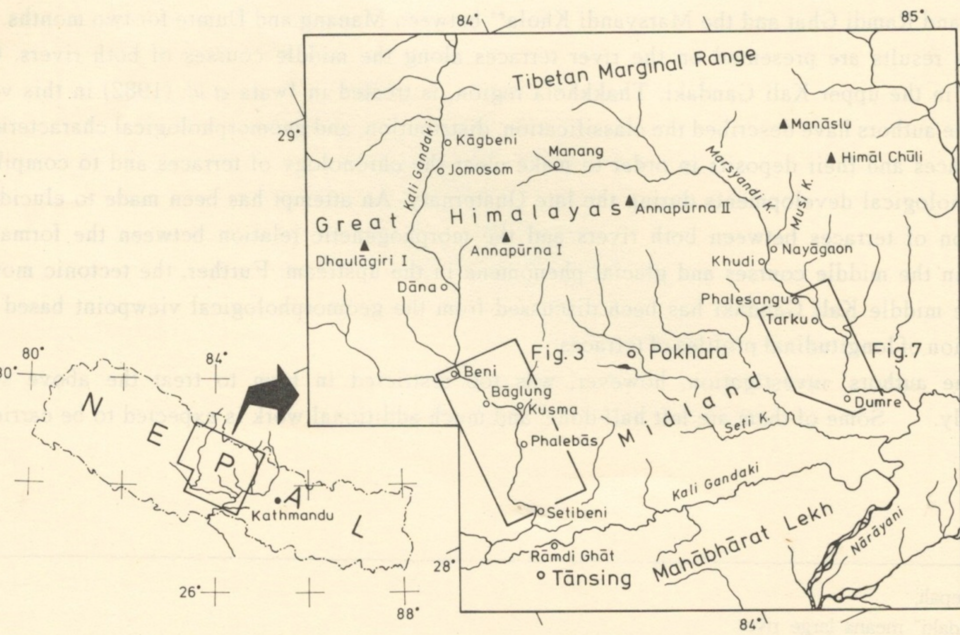

Fig.1. Index map of the study area.

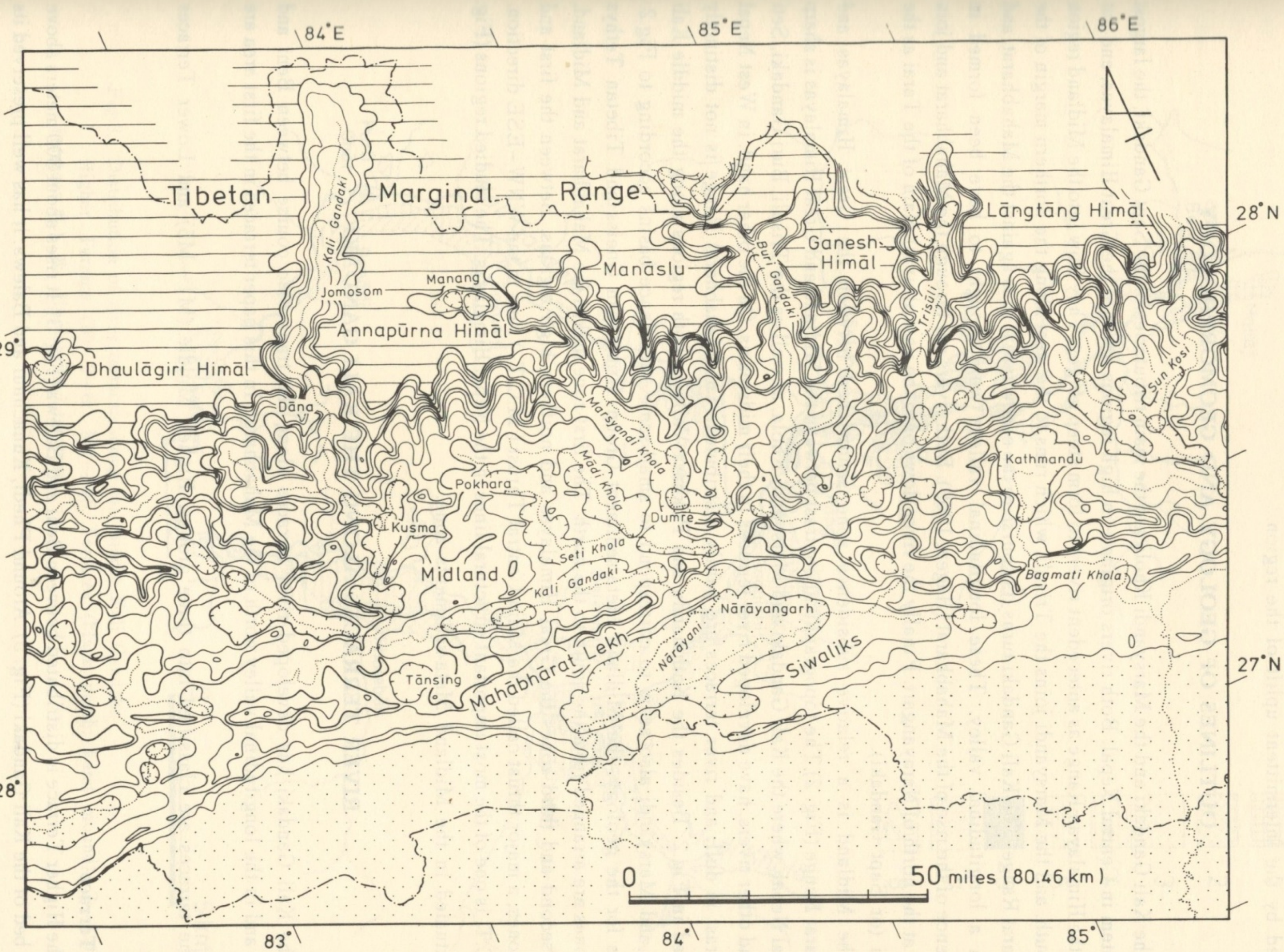

Fig.2. Restored contour map of Central Nepal.
Valleys less than 4 km across are eliminated. Contour interval: 1,000 feet (305 m). Hatched area: higher than 15,000 feet (4,570 m) above the sea level. Dotted area: lower than 1,000 feet.

Mahabharat Range. They also considered that the terracing was attributed to the rejuvenation of the river controlled by the intermittent uplift of the region.

OUTLINES OF GEOLOGY AND GEOMORPHOLOGY

The Kali Gandaki and the Marsyandi Khola are the main tributaries of the Sapt Gandaki, the largest river system in Central Nepal. Both rivers originate in high regions north of the Great Himalayas, and cut through the Himalayan Range as antecedent rivers to form steep gorges. They flow into the Midland region to the south, and the Marsyandi joins the Trisuli, which runs to the west along the northern margin of the Mahabharat Range. The Kali Gandaki turns its course to the east where it runs against the Mahabharat, and flows in a longitudinal valley. These longitudinal valleys were thought to have been formed in consequence of the rise of the Mahabharat (Hagen, 1969). Both rivers cut through the Mahabharat and join together at the north of Narayangart. Finally the river flows onto the vast alluvial plain of the Tarai as the Narayani (or Sapt Gandaki).

The Midland is a relative subsidence zone sandwiched between the Great Himalayas and Mahabharat Range (Fig. 2).The topographical contrast between the Midland and Great Himalayas is sharp in Central Nepal, where the Kali Gandaki and Marsyandi Khola, as well as the Trisuli, Buri Gandaki, Seti Khola and other rivers, have developed river terraces in their midsteams. On the other hand, in West Nepal the contrast is dull, and river terraces are hardly distributed. The Mahabharat Range is not distinctly repesented in Fig.2. Besides the Kathmandu and Pokhara Valleys, both regions along the middle Kali Gandaki and Marsyandi also seem to correspond to small-scale subsidence basins according to Fig.2.

As for the geology, the Midland Meta-sediment Group, Himalayan Gneiss and Tibetan Tethys Group zones are arranged from the south to the north. The first zone makes the Mahabharat and Midland, and the second and third zones the Great Himalayas and northern high regions. Between the first and second zones, a major thrust called the Main Central Thrust (M.C.T.) runs in the WNW–ESE direction. The M.C.T. is one of the most important structural lines in the Nepal Himalayas. The studied regions (Fig. 1) are situated in the Midland Meta-sediments zone.

RIVER TERRACES ALONG THE KALI GANDAKI

The Kali Gandaki has developed river terraces along the transverse course between Beni and Setibeni and in the longitudinal valley north of the Mahabharat. In this paper terraces in the first area are treated.

The terraces are classified into three groups: Higher, Middle (M1～M5) and Lower Terraces (Fig.3).

Higher Terrace

The Higher Terrace is distributed between Beni and Balewa (Fig. 3). It rises about 300 meters above the river bed of the Kali Gandaki (Fig. 5). Around Phedi, Kunachaur and Balewa, it has well preserved its flat terrace surface, on which reddish brown soil is sometimes found. But at other locations its original landform has been mostly lost; Terrace surface is covered with alluvial cone or talus deposits and terrace scarp is broken to turn into gentle slope.

The Higher Terrace is a filltop terrace made up of thick gravelly deposit. The deposit is more than 300 meters thick, and its base is situated below the river bed. It is roughly layered, firmly consolidated

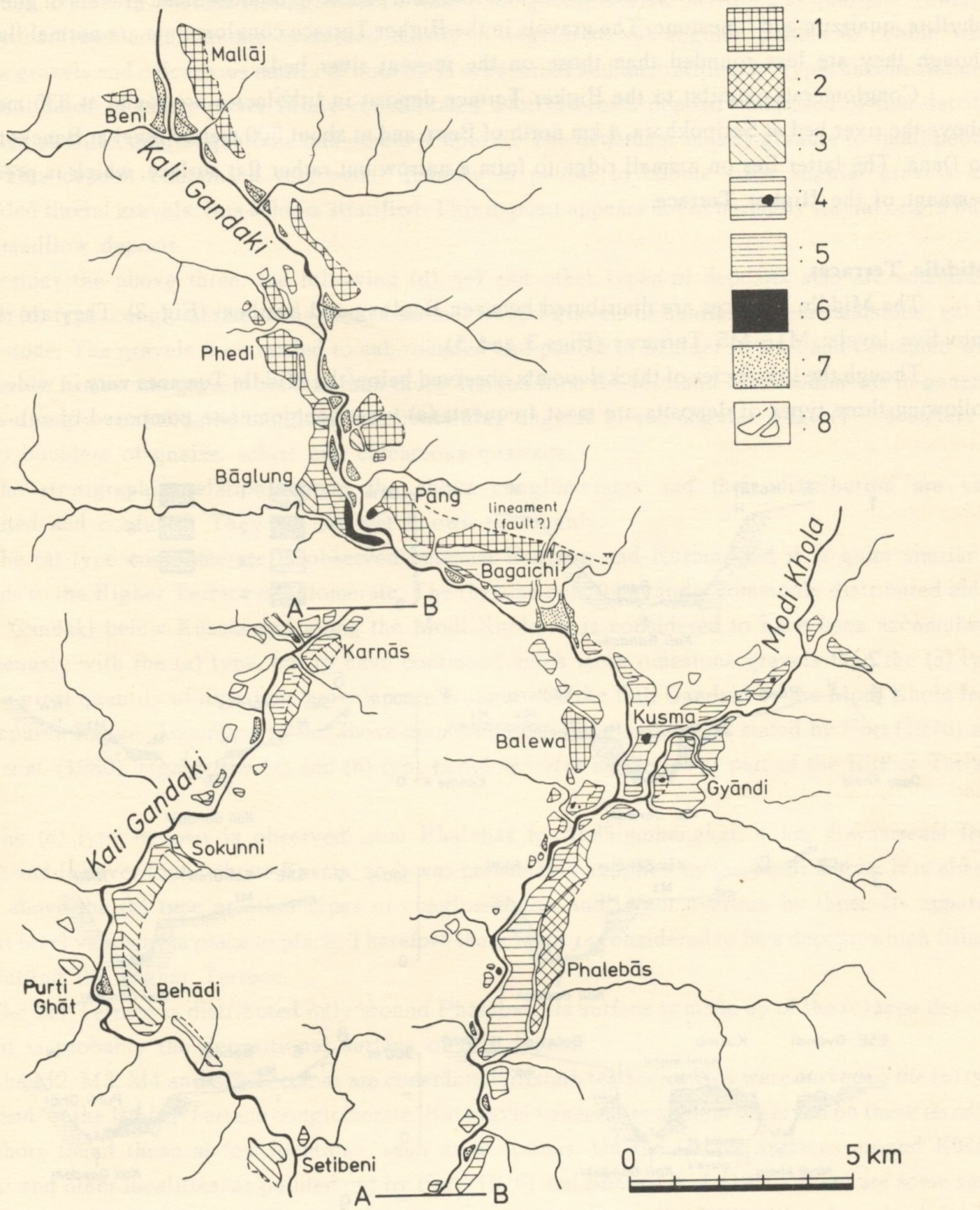

Fig.3. Distribution of river terraces along the middle Kali Gandaki.
1: Higher Terrace (H) 2~6: M1~M5 Terraces (black patch: karst mound) 7: Lower Terraces (L) 8: Unclassified terraces

conglomerate, and consists of sub-angular to sub-rounded, pebble to boulder sized gravels of gneiss, schist, phyllite, quartzite and limestone. The gravels in the Higher Terrace conglomerate are normal fluvial ones, though they are less rounded than those on the present river bed.

Conglomerates similar to the Higher Terrace deposit in lithofacies are found at 335 meters level above the river bed at Setipokhara, 4 km north of Beni, and at about 500 meters level at Banskot, opposite to Dana. The latter lies on a small ridge to form a narrow but rather flat surface, which is presumably a remnant of the Higher Terrace.

Middle Terraces

The Middle Terraces are distributed between Baglung and Setibeni (Fig. 3). They are subdivided into five levels: M1~M5 Terraces (Figs.3 and 5).

Though the lithofacies of thick deposits observed below the Middle Terraces vary in wide range, the following three types of deposits are most frequent; (a) type: conglomerate composed of sub-angular to

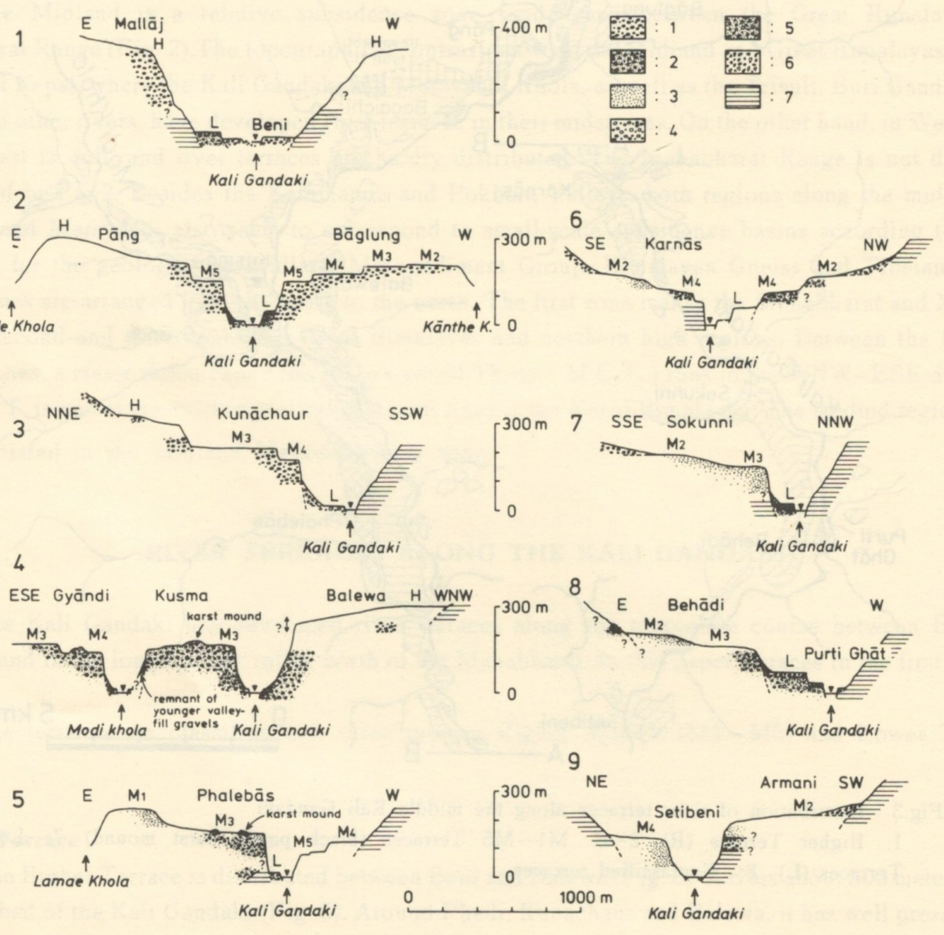

Fig.4. Cross-sections of terraces across the Kali Gandaki.
1: (a) type conglomerate 2: (b) type conglomerate (1 and 2: Higher Terrace deposit) 3: (c) type conglomerate (a kind of mudflow deposit) 4: Other types of conglomerates and veneer gravels 5: Younger valley-fill deposit (Lower Terrace deposit) 6: Fan, alluvial cone, talus or slope deposit 7: bedrock
Cross-sections are arranged from upstream to downstream.

sub-rounded, cobble to boulder sized gravels of limestone, gneiss, schist, phyllite and quartzite. (b) type: extremely hardened conglomerate composed mostly of angular to sub-angular, pebble to cobble sized limestone gravels and calcareous matrix (Photo 5). It is unsorted and unstratified. (c) type: unconsolidated, semi-consolidated or rarely rather firmly consolidated whitish brown deposit composed of fine detritus from schist, phyllite, gneiss, quartzite and others (Photo 6). The detritus is mostly granule to small pebble in size. This deposit contains a very small quantity of pebble to cobble sized angular gravels and sub-rounded fluvial gravels. It is seldom stratified. This deposit appears not of normally fluvial origin but a kind of mudflow deposit.

Besides the above three, the following (d), (e) and other types of deposits also are sometimes observed; (d) type: conglomerate composed of normal fluvial gravels of quartzite, meta-sandstone, gneiss and limestone. The gravels are rounded to sub-rounded and pebble to boulder in size, and cemented with sandy matrix. Limestone gravels are less than those derived from the Midland Meta-sediments in general. (e) type: strongly consolidated conglomerate containing angular to sub-angular, huge (1～ 4 meters in diameter) boulders of gneiss, schist and calcareous quartzite.

The stratigraphic relation among the above conglomerates and their distribution are very complicated and confused. They are not yet known thoroughly.

The (a) type conglomerate is observed between Baglung and Kusma, and it is quite similar in lithofacies to the Higher Terrace conglomerate. The (b) type conglomerate is commonly distributed along the Kali Gandaki below Kusma and along the Modi Khola. It is considered to have been accumulated simultaneously with the (a) type, but to have contained much more limestone gravels than the (a) type because a great quantity of limestone gravels were brought into the Kali Gandaki by the Modi Khola from the Annapurna Range. According to the above-mentioned facts, the authors, as stated by Fort (1976) and Sharma *et al.* (1980), regards the (a) and (b) type conglomerates as the lower part of the Higher Terrace deposit.

The (c) type deposit is observed from Phalebas to Andhimohanghat, 4 km downstream from Setibeni, and is never found above Kusma, so it was presumably supplied by the Modi Khola. It is always situated above the (b) type or other types of conglomerates, and is not overlain by them. Its apparent basement level varies from place to place. Therefore the (c) type is considered to be a deposit which filled a valley cutting the Higher Terrace.

The M1 Terrace is distributed only around Phalebas. Its surface is made up of the (c) type deposit, and so it is probably the depositional surface of this deposit.

The M2, M3, M4 and M5 Terraces are considered fillstath terraces which were carved in the (c) type deposit and/or the Higher Terrace conglomerate. But gravel veneers are seldom observed on these terraces. The authors found those at few locations, such as at Karnas. On the terrace surfaces around Kusma, Phalebas and other localities, as pointed out by Fort (1976) and Sharma *et al.* (1980), there are some small mounds built up of the (b) type calcareous conglomerate on which peculiar karst pillars have been formed (Photo 3). The mounds are regarded as a kind of residual hills which escaped from river erosion during the formative periods of terrace surfaces, and their existence itself becomes an evidence for the fillstrath origin of these terraces. The M2～M5 Terraces around Baglung and Bagaichi have very flat terrace surfaces and are bordered by nearly vertical distinct cliffs (sections 2 and 3 in Fig.4). But around Karnas, Sokunni and Behadi, the M2～M4 Terrace surfaces slope down gently toward the river, and terrace cliffs are indistinct (sections 6, 7 and 8). On the Middle Terraces, reddish brown soil is observed at some places, e.g. around Baglung, Sokunni and Behadi. It is usually generated on the (a) and (c) type conglomerates, and seldom formed on the (b) type.

Lower Terraces

The Lower Terraces are restricted in distribution. At Purti Ghat, a small terrace of 75 meters in relative height above the river bed is a fillstrath terrace which is carved in the underlying younger valley-fill deposit. The deposit has its base below the river bed, and consists of angular to sub-angular gravels. But the veneer gravels making the terrace surface are rounded to sub-rounded. There remains no filltop terrace around there.

Younger valley-fill deposits are also found in both the Kali Gandaki and the Modi Khola valleys around Kusma. These deposits are mostly composed of pebble to boulder sized, sub-angular to sub-rounded gravels of quartzite, meta-sandstone, gneiss and schist, and filled with loose or semi-consolidated coarse sand. No filltop terrace is distributed around there, too.

Longitudinal Profiles of Terraces

The relative heights of terraces above the present river bed of the Kali Gandaki were measured by means of an American Paulin type altimeter at as many localities as possible. The river bed profile in Fig.5 is based on the one inch/one mile topographic maps, and those of terraces are somewhat schematically shown on it.

According to Fig.5, the relative heights of the M2, M3 and M4 Terraces increase downstream from

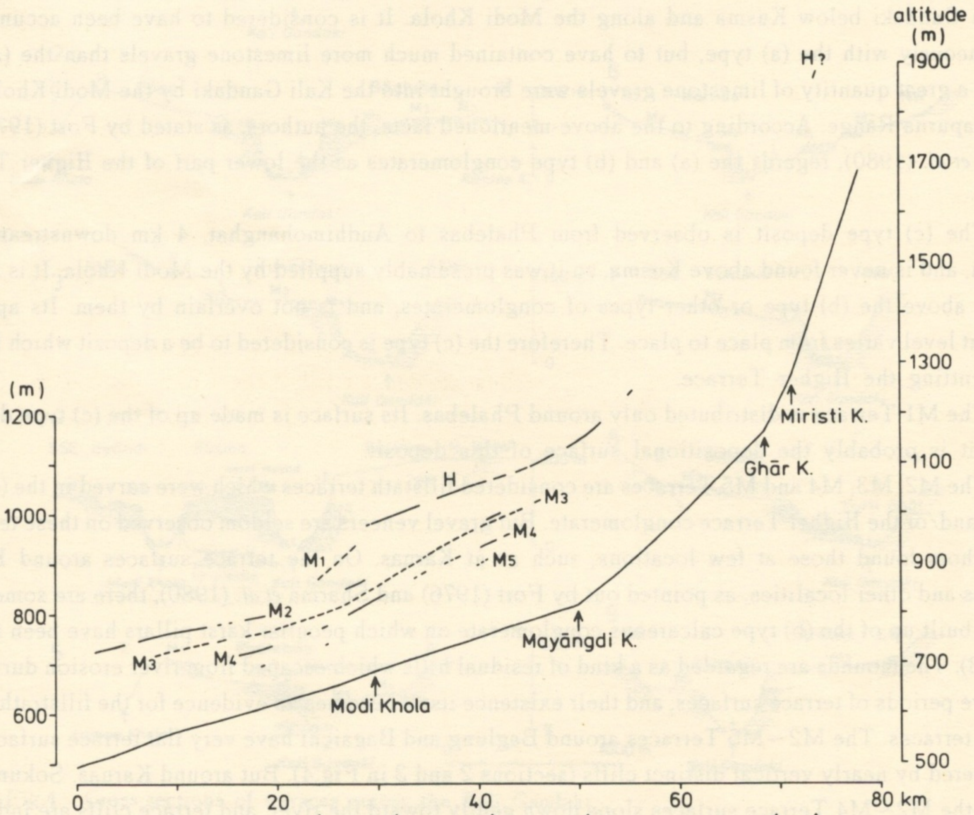

Fig.5. Longitudinal profile of terraces along the Kali Gandaki.
Terraces are projected to a general course of the Kali Gandaki. The fragmentary Lower Terraces are omitted.

Phalebas to Setibeni, while between Baglung and Phalebas these terraces constantly increase their relative heights upstream. The above tendency corresponds to the topographical feature represented in Fig.2; The region around Kusma makes a closed basin on the restored contour map. This tendency, in part at least, might be attributed to a local tectonic movement of this region. Namely, it is likely that the region around Phalebas subsided relatively, while both regions upsteam and downstream were comparatively elevated after the formation of the M2~M4 Terraces.

The Higher Terrace also slightly increases its relative height upstream from Balewa to Setipokhara. However, its increasing rate is much smaller than those of the Middle Terraces by unknown reason.By the way if the 500 meters level surface near Banskot (Dana) be really correlated with the Higher Terrace, it will indicate that the Higher Terrace around Dana was relatively uplifted about 150 meters as compared with below Beni. The region around Dana is close to the highest zone of the Great Himalayas, hence the region is evidently expected to have been greatly uplifted during the late Quaternary.

Geomorphological Development

1) Once the Kali Gandaki formed a deep valley, whose bottom was situated below the present river bed.

2) The valley was filled with thick gravelly deposit, and the Higher Terrace was formed as an accumulation terrace. Though Sharma *et al.* (1980) considered that the deposit was accumulated in lake-like water bodies, there are no evidences for their existence.

3) The Kali Gandaki cut the Higher Terrace to form a valley again. During this stage the Higher Terrace downstream below Kusma was eroded up. The river bed level at the end of this stage is not known, but it is unlikely to have been lower than the present level.

4) The (c) type deposit was brought into the newly deepened valley possibly by the Modi Khola as a kind of mudflow deposit, and filled it. The M1 Terrace around Phalebas was presumably formed as the depositional surface of this deposit.

5) The Kali Gandaki started downcutting, and eroded the (c) type deposit and the Higher Terrace conglomerate. On the way of downward erosion, the M2, M3, M4 and M5 Terraces were formed as fillstrath terraces during the stable periods of the river bed level.

6) The valley of the Kali Gandaki was deepened below the present level again.

7) Perhaps during the Holocene, small-scale valley-fill deposit filled the valley once more. But its depositional surface was lost soon. The Lower Terraces were formed as the fillstrath terraces carved in this younger deposit.

8) The Kali Gandaki continued deepening, and it reached the present level.

The above-mentioned development of terraces is not fully sure yet, because of the shortage of field observations. The ages of terracing and accumulation of deposits are unknown at all.

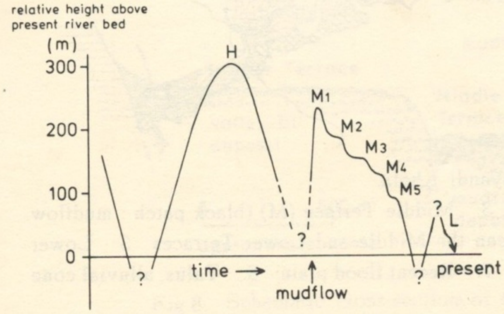

Fig.6. River bed level fluctuation of the Kali Gandaki at Phalebas.

Terrace surfaces were formed at the top and quiet stages of river bed level curve. Take care that the scale of time is unknown and not uniform.

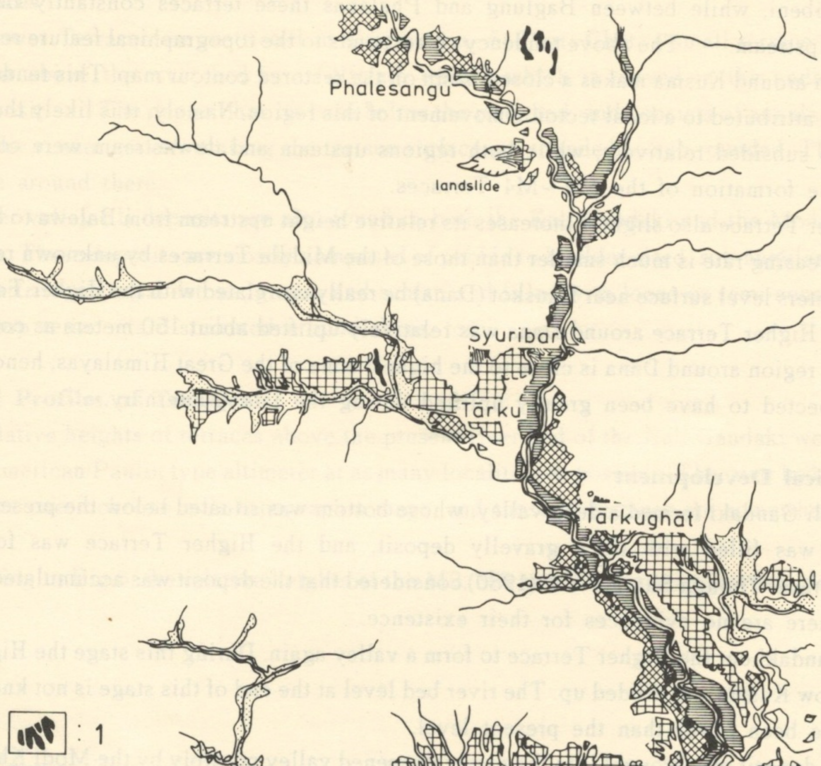

Fig.7. Distribution of terraces along the middle Marsyandi Khola.
1: Highest Terrace (HH) 2: Higher Terrace (H) 3: Middle Terrace (M) (black patch : mudflow mound) 4: Intermediate-level Terraces (M') between the Middle and Lower Terraces 5: Lower Terraces (L) 6: Stream and Lowest Terraces (L') 7: Recent flood plain 8: Talus, alluvial cone or fan

However, it is certain at least that the Kali Gandaki has never experienced constant lowering from the Higher Terrace level to the present level, but followed complicated process with some heavy fluctuations of river bed level (Fig. 6). It is also obvious that the terracing itself was not caused by the intermittent tectonic uplift of the region but it took place as the result of the change of river regime probably controlled by climatic change and some accidental events, e.g. a large-scale mudflow.

RIVER TERRACES ALONG THE MARSYANDI KHOLA

Along the middle Marsyandi, river terraces are distributed between Nayagaon and Dumre. They are widely spread especially in the downstream below Tarku. They are classified into six groups: Highest (HH), Higher (H) and Middle Terrace (M), Intermediate-level Terraces (M') between the Middle and Lower Terraces, Lower (L) and Lowest Terraces (L'). Among them, the HH, M' and L' Terraces are too limited in distribution to be described precisely.

Higher Terrace

The Higher Terrace is widely distributed on both sides of the Marsyandi between Tarku and Dumre and along tributary rivers (Fig. 7). Its relative height above the river bed measures about 150 meters near Dhara and 115 meters near Dumre along the Marsyandi, while it is smaller along tributaries. The Higher Terrace is a filltop terrace made up of thick deposit. The deposit has its base below the river bed, and it is more than 150 meters thick. It consists of pebble and cobble sized gravels and silty material, which are stratified. Its top part is heavily red-weathered and thick (4~5 meters) red soil is generated. The Higher Terrace is much dissected and its surface is gently undulating. It seems to have been formed before the interstadial in the last glacial age at latest, though its absolute age is not known yet.

Middle Terrace

The Middle Terrace is distributed in a narrow valley of one or two kilometers in width, which cut the Higher Terrace. It rises about 90 meters above the river bed at Tarku and Dhara, and about 70 meters near Dumre. The Middle Terrace is the depositional surface of mudflow deposit, on which there are many mounds composed of angular gneiss blocks (Photo 7). These mounds are from 5 to 10 meters in height and from 20 to 60 meters in diameter in general, and they are regarded as mudflow mounds.

The mudflow deposit itself is often observed below the Lower Terraces. Its base lies below the present river bed. It consists of angular to sub-angular gneiss gravels and grey silty material, and is unsorted and not stratified. It sometimes contains huge boulders of two or three meters in diameter. The mudflow deposit is found upstream as far as the junction of the Marsyandi and the Musi Khola which originates in glaciers on the western side of the Manaslu Range. The mudflow presumably broke out in the

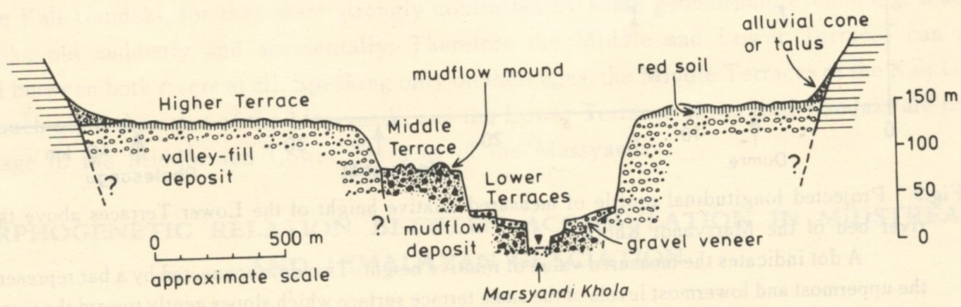

Fig.8. Schematic cross-section of terraces across the Marsyandi Khola.

Musi Khola valley and rushed into the Marsyandi.

The radiocarbon ages of wood samples collected from the deposit are 4,220 $\pm^{140}_{120}$ y.B.P. (TH-724) and 4,310 ± 130 y.B.P. (TH-725). The Middle Terrace is considered to have been formed at almost the same age as the deposit. The details of the dating will be reported in another paper (Yamanaka, 1982, in press).

Lower Terraces

The Lower Terraces are arranged along the channel of the Marsyandi as narrow strips with maximum width of 500 meters. They are subdivided with a distinct scarplet into two terrace levels at some localities, but at most places they forms a continuous terrace surface gently sloping toward the river (Fig. 8). Their relative heights were measured above the river bed, and shown in Fig.9. They are smaller in the downstream, and larger in the upstream. The relative height of the upper Lower Terrace is about 30 meters near Dumre and 70 meters at Phalesangu, and it becomes about 100 meters at Khudi, 12 km upstream from Phalesangu.

The Lower Terraces are the fillstrath terraces carved in the mudflow deposit. Gravel veneers are from 4 to 15 meters in thickness. They consist of sub-angular to sub-rounded gneiss gravels and sandy matrix. Although they sometimes contain lenses of well sorted sand, they are ill sorted and unstratified deposits in general.

Geomorphological Development

1) Once the Marsyandi Khola formed a wide and deep valley. Its bottom of those days was lower than the present level.

2) A large quantity of deposit was accumulated in the valley, and the Higher Terrace was formed as a

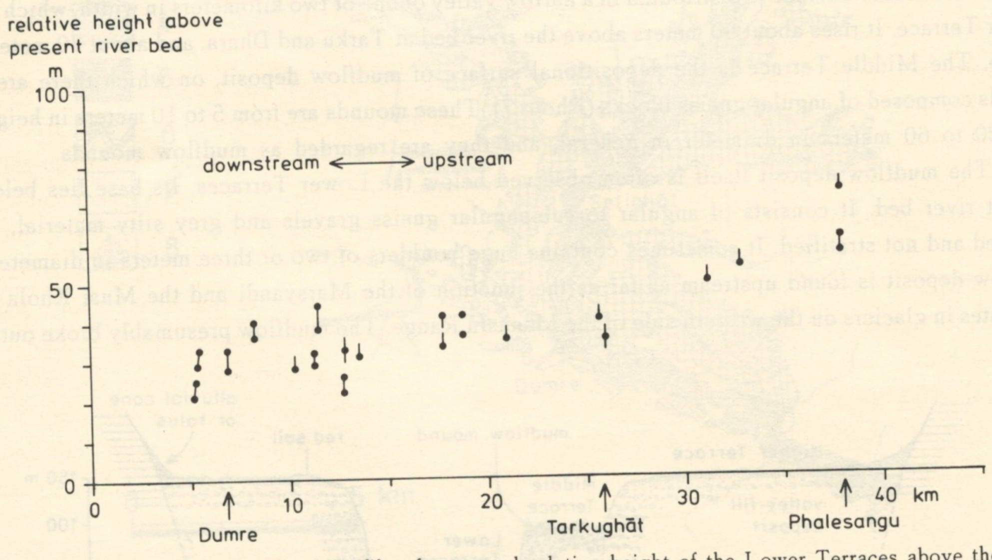

Fig.9. Projected longitudinal profile of measured relative height of the Lower Terraces above the river bed of the Marsyandi Khola.

A dot indicates the measured value of relative height. Two dots connected by a bar represent the uppermost and lowermost levels of the same terrace surface which slopes gently toward the river, and a dot with a bar above (or below) indicates the lowest (or uppermost) level.

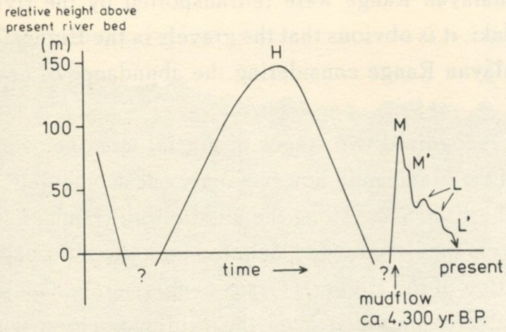

Fig.10. River bed level fluctuation of the Marsyandi Khola at Dhara. Remarks are the same as in Fig.6.

filltop terrace at the final stage of accumulation.

3) The Marsyandi started deepening to make a narrow valley, whose bottom reached below the present river bed level. The age of beginning of this erosional stage is unknown, but this stage lasted up to the middle of the Holocene.

4) About 4,300 y.B.P., the erosional stage 3 was broken off by a sudden event. A large-scale mudflow occurred possibly in the upper Musi Khola valley, and rushed into the Marsyandi. The mudflow flowed over a long distance to be deposited in the newly deepened valley. Its depositional surface with many mudflow mounds resulted in the Middle Terrace.

5) Soon after the stage 4, the Marsyandi began deepening. On the way of deepening, the Lower Terraces were formed as fillstrath terraces carved in the mudflow deposit when the river bed stayed once or twice at comparatively quiet levels. Their formative periods were probably between 3,000 and 2,000 y.B.P.

6) The Marsyandi has continued erosion and reached the present level.

CORRELATION OF TERRACES BETWEEN THE KALI GANDAKI AND MARSYANDI KHOLA

Both the Higher Terraces are the highest of all the widely distributed terraces along the Kali Gandaki and Marsyandi Khola. These terraces were preceded by deep valleys which lowered their bottoms below the present levels, and are built up of very thick gravelly deposits filling the former valleys. Considering these similarities, the periods of such heavy deepening of the former valleys, accumulation of deposits and formation of the Higher Terraces are roughly correlatable respectively between the Kali Gandaki and the Marsyandi, though some slight differences remain; the Higher Terrace of the Marsyandi is more dissected and has much thicker red-weathering crust on its surface than that of the Kali Gandaki.

The formative process of the Middle and Lower Terraces of the Marsyandi was quite different from that of the Kali Gandaki, for they were strongly controlled by some geomorphic events, e.g. mudflows, which broke out suddenly and accidentally. Therefore the Middle and Lower Terraces can not be correlated between both rivers at all. Speaking only on their ages, the Middle Terraces of the Kali Gandaki must be much older than that of the Marsyandi, and the Lower Terraces of the Kali Gandaki are possibly close in age to the Middle and Lower Terraces of the Marsyandi.

MORPHOGENETIC RELATION BETWEEN ACCUMULATION IN MIDSTREAMS AND HIMALAYAN GLACIATION

It can be expected that vast volumes of morainic material brought into the Thakkhola and Manang basins by the ice age glaciers from the Great Himalayan Range were re-transported by the rivers and deposited in the lower courses. As for the Kali Gandaki, it is obvious that the gravels in the Higher Terrace conglomerate were provided mostly from the Himalayan Range considering the abundance of gravels of Himalayan Gneiss and Dhaulagiri limestone.

In the Thakkhola region, Iwata *et al.* (1982) recognized two stages of glacial moraines which fall possibly into the last glacial age. In the midstream of the Marsyandi, however, only one accumulation stage was recognized besides the mudflow deposition in the Holocene. Along the middle Kali Gandaki also, the accumulation which is likely to have been resulted from the Himalayan glaciation took place probably only once during the late Pleistocene; it is the accumulation of the Higher Terrace conglomerate. Considering the kinds of detritus rocks, the (c) type deposit clearly provided from the Midland region where no glaciation occurred even during the glacial age. The younger valley-fill deposit making the Lower Terraces seems to be of the Holocene.

As a result, the number of aggradation in the middle courses of both rivers, namely in the Midland region, conflicts with that of the glaciation in the Great Himalayas during the late Pleistocene, although the possibility that the Higher Terrace deposit might be separated into two different sequences of accumulation cannot be denied thoroughly. Furthermore, the topographical continuity between river terraces in the midstreams and glacial landforms in the upper valleys is cut off by long steep gorges, and few radiometric ages have been obtained so far. Therefore the precise chronological and morphogenetic relationships between them are yet hardly clear and left for future work.

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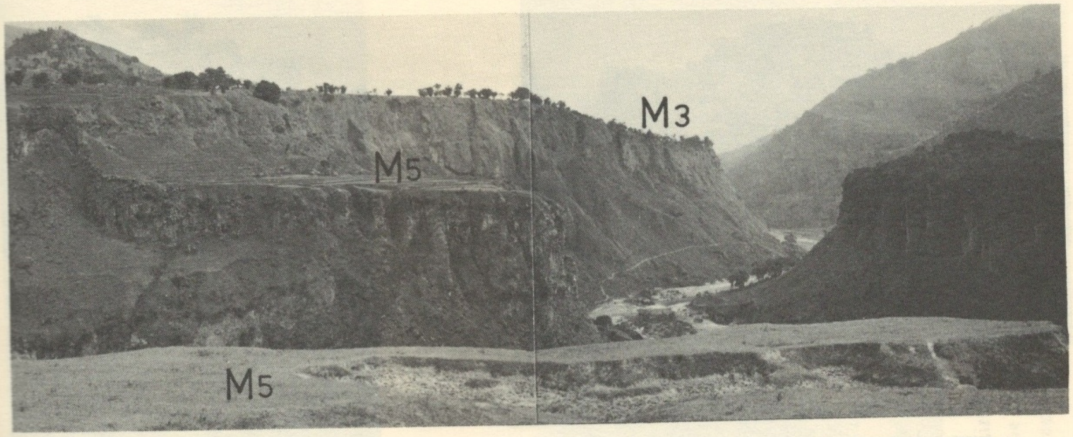

Photo 1. M3 and M5 Terraces near Pang, looking from Baglung side. The relative heights of the M3 and M5 Terraces above the river bed of the Kali Gandaki are 215 and 150 meters respectively. The nearly vertical terrace cliff is made up of the consolidated (a) type conglomerate.

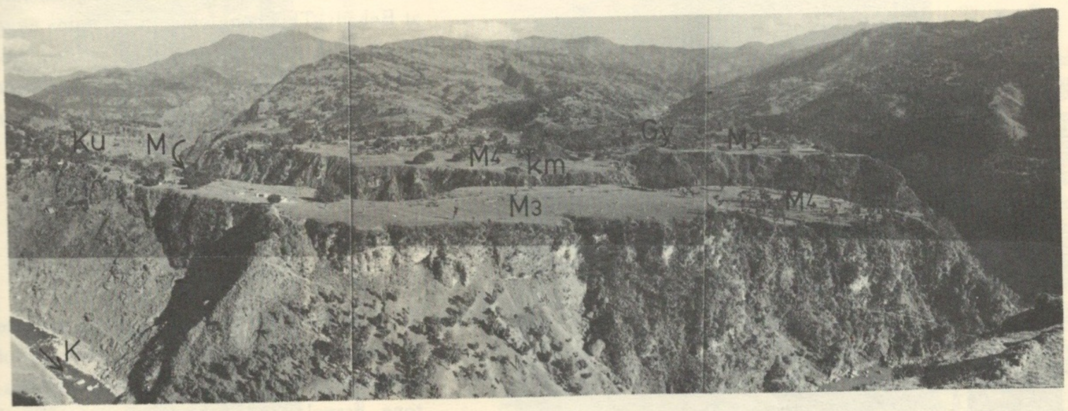

Photo 2. View of terraces around Kusma (Ku) and Gyandi (Gy), looking from Balewa. A karst mound (km) is observed on the M4 Terrace at Gyandi. The M3 Terrace between the Kali Gandaki (K) and Modi Khola (M) rises about 170 meters above the river bed. It is built up of the thick (b) type conglomerate.

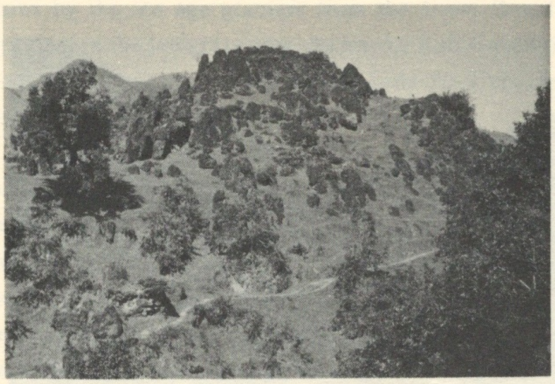

Photo 3. A karst mound on the M3 Terrace at Phalebas. The mound is made up of the (b) type calcareous conglomerate, and numerous karst pillars have been formed on it.

Photo 4. Terrace cliff of the (e) type conglomerate at Behadi. This conglomerate contains huge (1~3 m in diameter) sub-angular boulders. The upper terrace is the M3, and the lower flat on which a man is walking is the Lower Terrace.

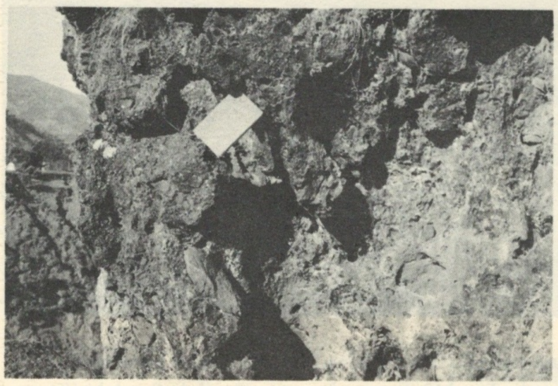

Photo 5. Lithofacies of the (b) type conglomerate at Kurgha, just below Phalebas. This type of conglomerate is mostly composed of limestone gravels and calcareous matrix, and consolidated very hard.

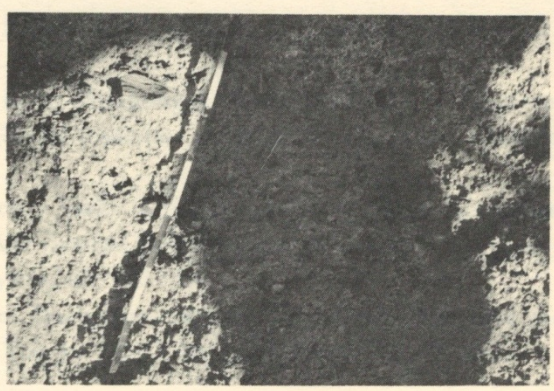

Photo 6. Lithofacies of the (c) type conglomerate at Phalebas. This conglomerate consists of fine detritus from schist, phyllite, quartzite, gneiss and others, and contains a very small quantity of pebble to cobble sized gravels.

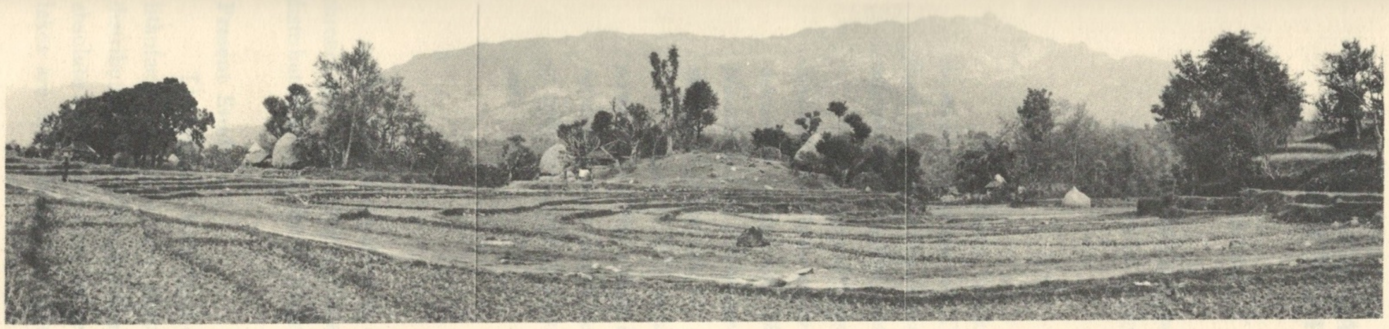

Photo 7. Mudflow mounds on the Middle Terrace of the Marsyandi Khola near Khalpani, between Tarku and Dhara. These mounds are 5 to 10 meters in height and 20 to 60 meters in diameter.

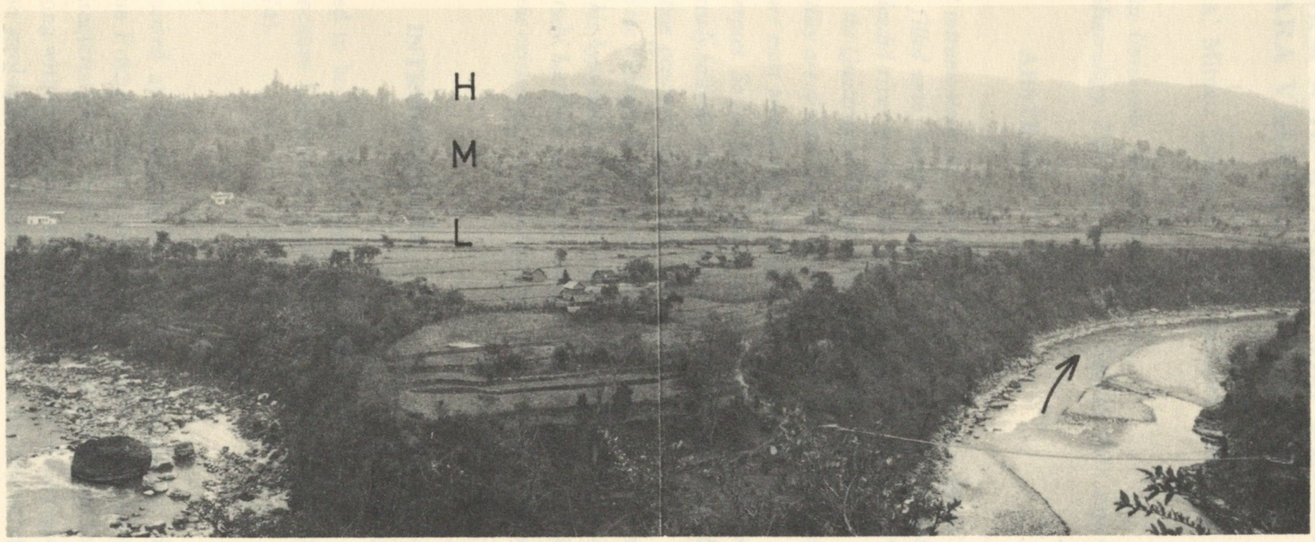

Photo 8. Higher (H), Middle (M) and Lower (L) Terraces around the Gorkha Airstrip, opposite to Dhara. These terraces rise about 150, 85 and 40 meters respectively above the Marsyandi Khola bed. The Higher Terrace is much dissected and its surface is gently undulating, while the Lower Terrace is very flat and the airstrip is situated on it.