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Quaternary stratigraphy of Panchkhal valley, Central Nepal

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ABSTRACT

The Panchkhal Valley is one of intermontane basins in the Central Nepal east of Kathmandu with two sets of neo-tectonic lineaments sited from satellite imagery and aerial photographs. One extending NNW–SSE east of the valley results the old Panchkhal Valley uplifting along south during Plio-Pleistocene age and second one NE–SW has ultimately uplifted the old valley. The Panchkhal Clay, Ratopairo Formation, Rampur Formation and Tamaghat Formation are four depositional lithostratigraphical units. Similarly, Tamaghat, Rampur, Thumka, and Chisapani surfaces are depositional and Basukidada, Sano-Tinghare, Sumara-Thulo Tinghare, Dhulikhel, Koiralathumka and Bhamarkot surfaces are erosional morphostratigraphic geomorphic surfaces. Geomorphic terrace cutting level is around 1400–1440 m and all surfaces and deposits above and below are relatively young.

INTRODUCTION

The Panchkhal Valley, intermontane basin developed in the southeast of the Kathmandu Valley is located within the eastern flank of a synclinorium in Kavre District (Stocklin 1980). The Jhiku Khola, a tributary of the Sun Koshi River is characterised by development of geomorphic surfaces at different elevations formed after the last glacial retreat in the area. Glacial strand retreat and fluvial incision led to develop landscapes and evolve the area having a relief of about 122 to 750 m. This paper describes neotectonic framework and morphostratigraphic units of the Panchkhal Valley. Aerial photographs and satellite imagery of the valley were used to trace out the lineaments.

NEOTECTONIC FRAMEWORK

Geomorphic surfaces show low relief and continuous features. Terrace edges are considered as indicators for the detection of neo-tectonic units. The lineaments across the present basin cross-cut the existing tectonic discontinuity such as the Mahabharat Thrust (MT). Abrupt change in terrace elevation associated with observed lineaments at Khok Village and at Okhare Village signifies that they are neotectonic in origin.

Two type of lineaments were recognised, of which the first extends along NNW-SSE passing from the east of the Panchkhal Valley along the Cha Khola and eastern ridge. It has uplifted the southern block of the valley during the Plio-Pleistocene time resulting formation of an old Panchkhal valley with a thick black clay. Regionally, the fault is sinuous and is comparable with the Mahabharat Thrust (Stocklin 1980). The Mahabharat Thrust (MT) was active during the Middle Pleistocene. The axis of the elongated valley (NNW-SSE) is almost parallel to the MT that also supports its genetic relationship with the MT. The second group of NE-SE lineaments extends almost right angle to the MT (Fig. 1). Three major successive neo-tectonic lineaments, namely Okhre Khola, Dhulikhel Khola and Punyamati-Cha Khola Lineaments from south to north of Basukidada are found to be associated with identified geomorphic surfaces.

The Okhre Khola Lineament passes from the south of the present valley floor. The Dhulikhel Khola

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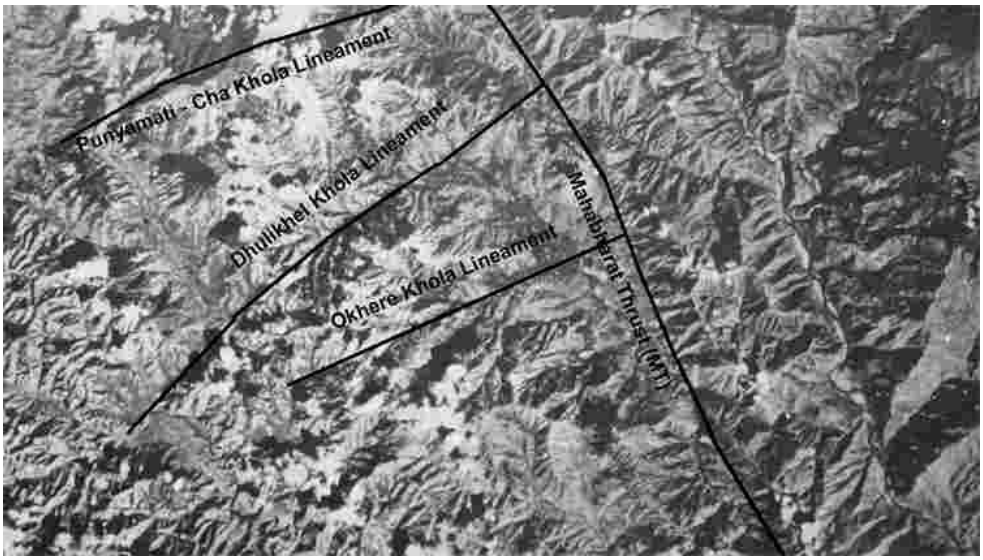


Fig. 1 Major tectonic lineaments in the Panchkhal Valley

Lineament passes through the Dhulikhel River. These lineaments have raised the Panchkhal Clay. After the depost of thick black clay, the fluvial sediments were deposited in the central part of the valley covering the clay, and debris flow deposited at the periphery. This gave rise to a wide intermotane basin between the lineaments. The lake would have drained momentarily along the Jhiku Khola gorge at the southern part of the valley. Punyamati-Cha Khola Lineament triggered rejuvenated fluvial incision which in its course led to headward nick-point migration very near to the water divids clearing the last glacial geomorphic surface. The neotectonic activities along the faluts sculptured the existing geomorphic surfaces. The activities continue even at present.

QUATERNARY STRATIGRAPHY

The quaternary stratigraphy of the Panchkhal Valley has been established based on field work focused on the northern area of the valley, however the stratigraphic units are also distributed in other parts of the valley. The deposit in the area is represented by terraces and debris flow at different elevations including thick buried black clay which does not form present-day landform. The geomrohphic higher elevations suffer intense erosion and mass movements erasing former evidences of landform development, which are difficult to date absolutely. These surfaces were dated relatively on the assumption that landform assemblages are a palimpset of superimposed part of different erosional cycles each initiated by a change of base level of tectonic or eustatic origin (Chorley et al. 1985). Geomorphic height of a particular surface can be dated relatively by morphostratigraphical criteria as described by Adhikary and Thapa (2001).

Morphostratigraphy

Morphostratigraphy units were first identified geomorphic surfaces in the aerial photographs (1:50,000) and topographical map (1:25,000) which was verified by field ground-truthing and were relatively dated on the basis of their absolute heights, general soil rubification, and terrace cutting levels. The geomorphic surface of 1400 m was considered as the terrace cutting level, a marker surface for the area, as other geomorphic surfaces above and below were relatively younger and were similar in composition and elevation with the oldest geomorphic surfaces of Middle Pleistocene age (?), which are represented by the erosional Kotol Formation and Swayambhu/Kirtipur Surface in the adjacent Kathmandu Valley (Adhikary and Thapa 2001).

Morphostratigraphic units of the Panchkhal Valley and its surrounding hills were broadly classified into the depositional and erosional surfaces (Fig. 2; Tables 1 and 2).

Depositional morphostratigraphy

Morphological depositional surfaces are represented by a series of terraces between 880 m

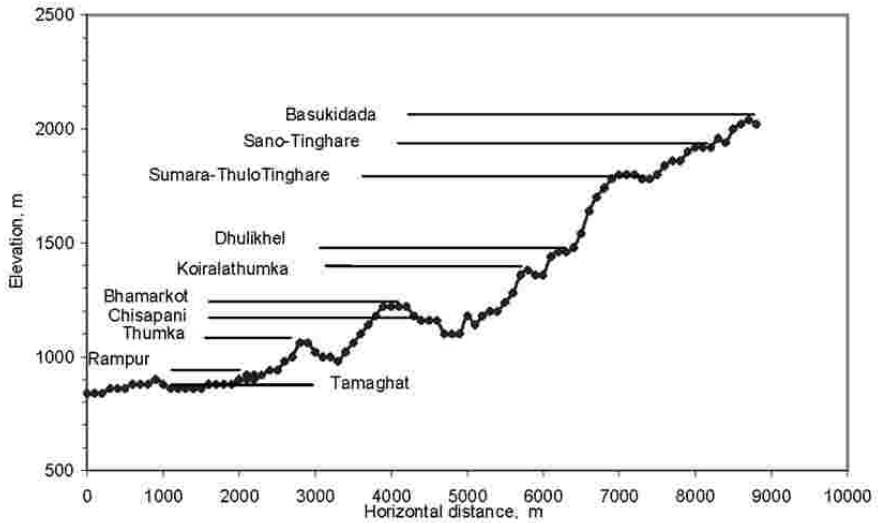


Fig. 2 Morphostratigraphic surfaces of the Panchkhal Valley

Table 1: Depositional morphostratigraphic units

Unit	Thickness (m)	Type	Probable age
Tamaghat Surface	<880	River terrace	Holocene
Rampur Surface	880-920	Old river terrace	Last glacial stage (?)
Thumka Surface	1000-1140	Debris deposit	Middle Pleistocene (?)
Chisapani Surface	1200-1220	Debris deposit	Middle Pleistocene (?)

Table 2: Erosional morphostratigraphic units

Unit	Thickness (m)	Type
Basukidada Surface	2053	Debris deposit
Sano-Tinghare Surface	1960	Debris deposit
Sumara-Thulo Tinghare Surface	1865	Debris deposit
Dhulikhel Surface	1505-1600	Debris deposit
Kairalathumka Surface	1400-1420	Debris deposit
Bhamarkot Surface	1340-1360	Debris deposit

and >1160 m. Three depositional morphostratigraphical landforms of the Pleistocene age and the remaining one of the Holocene age were observed as shown in Table 1. The Tamaghat Surface (present-day floodplain and braided channels of the Jhiku Khola) below 880 m above mean sea level (amsl) represents the lowermost and the youngest geomorphic surface in the valley (Fig. 3). The next Rampur Surface represents the first raised old river terrace forming prominent geomorphic surface at an elevation 880-920 m and is distribtuted around Tamaghat, Rampur and Takadihi Villages (Fig. 3). The Thumka Surface represents the next surface at 1000-1140 m amsl. The uppermost surface is represented by the Chisapani Surface at 1200–1220 m amsl. The Chisapani surface is underlain by debris flow deposit.

Erosional morphostratigraphy

Erosional surfaces of Pleistocene age are widely distributed at different elevations from 1360 to 2053 m on hills surrounding the Panchkhal Valley. They represent patchy remnants of gently slopping to almost flat surfaces and are occupied by debris flow deposits of varying age. Six erosional geomorphic surfaces were identified in the area and are as shown in Table 2.

Fig. 3 Rampur Surface and Tamaghat Surface north of Tamaghat

Basukidada and Sano-Tinghare surfaces are made up of Basukidada morrains, eskers, kames and debris flows exhibiting U-shaped trough and glacial arrets above 2000 m. U-shaped troughs on the surface at the higher elevations in the Himalaya are the good evidences of the last glacial stage (Adhikary 1993). The age of the Basukidada geomorphic surface is estimated to be of the last glacial stage. Widespread Sumara-Thulo Tinghare and Dhulikhel geomorphic surfaces respectively at 1865 m and 1505–1600 m, are covered by Nala and Dhulikhel debris flow deposits. Similarly, Koiralathumka and Bhmarkot geomorphic surfaces between the Basukidada geomorphic surface and the terrace cutting level are estimated to be of the Middle Pleistocene age.

Depositional lithostratigraphy

Quarternary depositis distributed in the study area were classified into seven units of formation level (Fig. 4; Tables 3a and b).

Panchkhal Clay

West of Tamaghat, the Phanchkhal Clay is represented by weakly consolidated thick black clay with thin silt and fine sand layers in a dug well of more than eight meters. The Panchkhal Clay is buried and does not crop out on the surface. It also does not make significant relief but forms a basal stratigraphic unit that can be compared to the Lukundol Formation of age ranging from the Late Pliocene to Early Pleistocene (Tuladhar 1982; Yoshida and Igarashi 1984).

Ratopairo Formation

The ratopairo Formation is an unconsolidated debris flow deposit that overlies the Panchkhal Clay. At present it lies at the toe often covering the top of the low hills. It is primarily represented by the slopping debris flow terraces distributed at the lower elevations north of the Pachkhal Valley. The type locality of the formation is located at Ratopairo about 2 km north of Tamaghat. About 5 m thick debris and mud flow deposits cover the low-lying hilly areas around Ratopairo. The formation comprises deeply weathered red soil at top and matrix-supported angular rock fragments at bottm (Figs. 5 and 6). The formation has been severely eroded and intensely rubified. The Ratopairo Formation is older than the Rampur Formation because the former is more rubified. The age that could be attributed to the Ratopairo Formation could be Middle Pleistocene to Early Pleistocene (?) and could be correlated to Middle Pleistocene Champi Formation in the Kathmandu Valley (Adhikary and Thapa 2001).

Rampur Formation

The Rampur Formation exhibits old gentle slopping river terrace widely distributed at Rampur, Dwaredhihi, Takadihi and northeast slope of Lamdihi and east of Tamaghat. The formation comprises thick and loose sand deposit with more than 8 m thickness overlying the lower portion of debris deposit of the Ratopairo Formation (Fig. 7) at west of Tamaghat in newly dug well which was more than 8 m deep. The

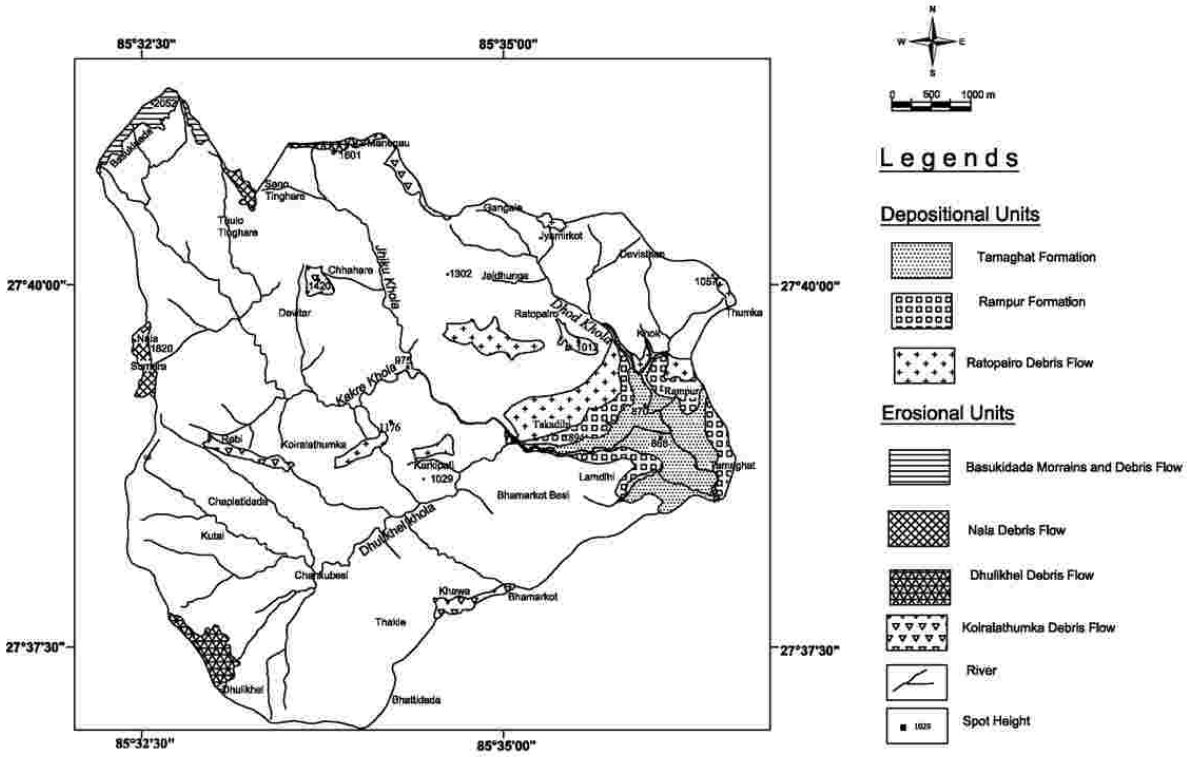


Fig. 4 Quaternary geological map of northwester region of the Panchkhal Valley

Fig. 5 Debris deposit of the Ratopairo Formation

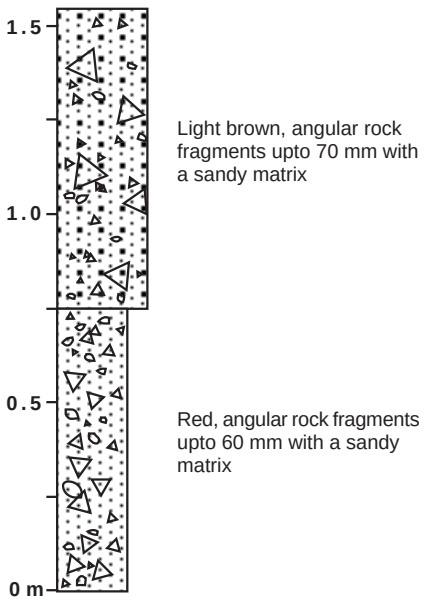
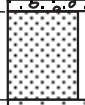
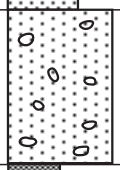
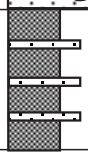


Fig. 6 Columnar section of the Ratopairo Formation

Table 3a: Quaternary stratigraphic divisions of Panchkhal area and correlation with the Kahmandu Valley after Adhikary and Thapa (2001)

	Panchkhal Area, present study							Kathmandu Valley, Adhikary and Thapa (2001)					
	Geochronology	Lithostratigraphy		Morphostratigraphy		Neotectonism		Lithostratigraphy			Morphostratigraphy		
Age Yr. BP		Erosional Formation	Depositional Formation	Erosional	Depositional			Erosional Formation	Depositional Formation	Member	Erosional	Depositional	
10,000	Holocene		Tamaghat		Tamaghat				Tundikhel			Thapathali	
13,000	Upper Pleistocene?			Basukidada Sano-Tinghare	Rampur	The upliftment of the watershed along the Punyamati-Cha Khola Lineament, existing rivers entrenched forming the Rampur Formation and deposited the Tamaghat Formation along the valley axis	KAREWAS GROUP			Tilangatar Dhapasi Tokha	Sheopuri Manichur Nagarkot Indrasthan	Tundikhel Tilingatar Dhapasi Tokha	
24,000		Basukidada	Rampur						Gokarna				
30,000	Middle Pleistocene?	Nala Dhulikhel Koiralathumka		Sumara-Thulo Tinghare Dhulikhel Koiralathumka Bhamarkot	Tumka Chisapani	The Okhre and the Dhulikhel Lineaments uplifting the Panchkhal Clay and resulting the deposition of the Ratopairo Debris Flow		Dalkap Tharthok Kotol			Nagarjun Kirtipur		
120,000			Ratopairo						Chunikhel				
900,000	Lower Pleistocene?		Pachkhal Clay (not exposed to the surface			Upheaval of the Mahabharat Range along the MT and southeast and south of the present valley resulting the formation of old Panchkhal basin			Champi Lukundol				

Table 3b: Stratigraphic divisions of the Quaternary sediments in the Panchkhal Valley

Age Yr. BP	Geochronology	Formation	Thickness	Lithology	Neotectonism
10,000	Holocene	Tamaghat	Thin ?		The upliftment of the watershed along the Punyamati-Cha Khola Lineament, existing rivers entrenched forming the Rampur Formation and deposited the Tamaghat Formation along the valley axis
13,000 24,000	Upper Pleistocene?	Rampur	20 m		
30,000 120,000	Middle Pleistocene?	Ratopairo	5 m		The Dhulikhel Lineament uplifted the Panchkhal Clay and resulting the deposition of the Ratopairo Debris Flow sediment
900,000	Lower Pleistocene?	Pachkhal Clay (not exposed to the surface	?		Upheaval of the Mahabharat Range along the MT and southeast and south of the present valley resulting the formation of old Panchkhal basin

formation is represented by old river terace and fan deposits at the foothills. The soil profile is poorly developed. The formation lies upto about 20 m above the present riverbed with higher terraces than of the Holocene terraces in the area. This leads the most suitable age for the Rampur Formation is the Late Pleistocene (?) comparable to the Gokarna Formation of the Kathmandu Valley (Adhikary and Thapa 2001).

Tamaghat Formation

The Tamaghat Formation is represented by Holocene deposits, present floodplain, channels and minor natural levee just above the present Jhiku Khola. The series of Holocene fluvial terraces of height less than meters are characterised by alternate layers of loose gravel and coarse to fine sand from the bottom to the top. The gravel is matrix-supported with lithology of quartzite, gneiss, granite and few schists fragments. Holocene deposit is not differentiated during this study and included in a single unit.

Erosional lithostratigraphy

Debris flow deposits are widely distributed at the gentle hill slopes and capping low-lying surrounding hills around the Panchkhal Valley. They are found as patches of hanging elongated bodies over steep hillslopes and isolated hummocky hills. The debris flow deposits contain matrix-supported poorly sorted rock fragments distributed as wide extensive hanging terraces.

Koiralathumka Debris Flow

Koiralathumka Debris Flow, the oldest debris flow in the Panchkhal Valley, is located at elevation 1420 to 1460 m amsl at the toe of surrounding hills as a blanket of elongated bodies. The deposits are highly weathered with intense rubification with reddish colour. The deposits comprise poory soted boulders. The Koiralathumka Debris Flow forms the oldest deposit in the valley as evidenced by its distribution around the distinct terrace cutting around the elevation 1400 m. The type locality is proposed at Koiralathumka along the Rabi-Opi road. The deposit is also exposed around Bhamarkot and Khewa Villages. The Koiralathumka Debris Flow is interpreted as an evidence of extensive glaciations in the Himalayas representing the Gurkha Glacial Stage (Adhikari 1993). It is correlated with the Kotol Debris Flow of the Kathmandu Valley (Adhikary and Thapa 2001).

Dhulikhel Debris Flow

The Dhulikhel Debris Flow maintains an elevation between 1550 and 1700 m amsl particularly at foothills surrounding the Panchkhal Valley and comprises poorly sorted sediments with less intense rubification. The sediment includes sandy matrix-supported boulders. The type locality of the formation is

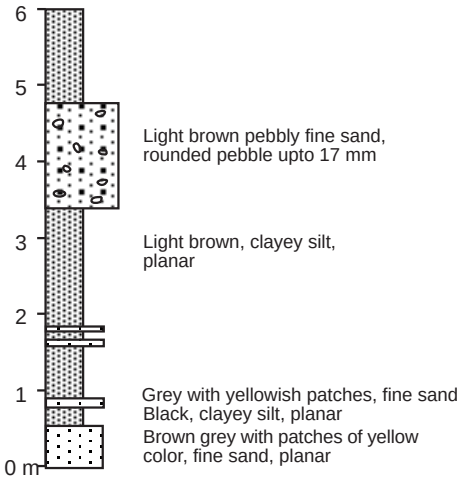


Fig. 7 Columnar section of the Rampur Formation

proposed at Dhulikhel and is widespread in Thakla, Thadagau, Kalthumki Bhanjyang and Manegau.

Nala Debris Flow

Nala Debris Flow is widely distributed at an elevation from 1820 to 1990 m amsl. It is distributed in the upper part of the Jhiku Khola watershed at the toe of Basukidada. The debris flow has similar lithology as the earlier two deposits, but shows no soil profile and rubification. The type locality is proposed at Nala where the the dissected flat erosional terrace at 1840 amsl represents the deposit.

Basukidada Morrains and Debris Flow

The Basukidada Morrains and Debris Flow occupies the highest elevation in the valley above 1994 to 2053 m amsl. It covers the hill tops of the valley. The unit contains sandy and gravely eskers and kame glacial deposits with almost no soil profile. The landscape reflected by U-shaped smooth glacial valleys at the ridges surrounding the Panchkhal Valley holds evidence of the last glacial stage. These strong glacial evidences represent the last glaciation, the Sherpa Glacial Stage in the Himalaya (Adhikary 1993). It is comparable to the Sheopuri Debris Flow of the Kathmandu Valley (Adhikary and Thapa 2001).

CONCLUSIONS

The Panchkhal Valley is one of the intermontane basins in the Central Nepal forming its landscape by the Quaternary sediments. The area bears two sets of tectonic lineaments, one extends NNW–SSE east of the Panchkhal Valley, while the second group of NE–SW lineaments has uplifted southern part of the valley forming old valley at the beginning of Plio-Pleistocene. The basin drained after activation of the second group of lineaments and started to deposit river sediment and raised river terraces above the present floodplain accompanied by retreating hillslopes, and therefore erasing the Pleistocene signatures. Geomorphic terrace cutting level in the area is around 1400–1440 m amsl and all surfaces and deposits above and below are relatively younging (?). The Panchkhal Clay, Ratopairo Formation, Rampur Formation, and Tamaghat Formations are depositional lithostratigraphic units. Tamaghat, Rampur, Thumka and Chisapani surfaces are depositional morphostratigraphic units while Basukidada, Sano Tinghare, Sumara-Thulo Tinghare, Dhulikhel, Koiralathumka and Bhamarkot surfaces are erosional morphostratigraphic units.

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