GEOLOGY OF THE KATHMANDU FLUVIATILE LACUSTRINE SEDIMENTS IN THE LIGHT OF NEW VERTEBRATE FOSSIL OCCURENCES

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सारांश

काठमाडौं उपत्यकाको तालिय थिग्रीय चट्टानहरूको पुनः अध्ययन गरिएको छ। उपत्यकाको दक्षिण भागमा फेला पारिएका नयां जैविक अवशेषहरूले काठमाडौंको ज्ञात भौगर्भिक तथ्यमाथि थप प्रकाश पारेको छ। फेला पारेका अवशेषहरू प्लायोष्टोसिन युगका विभिन्न मेरू वण्डात्मक जिवहरू जस्तै हात्ती, मृग, गाईगोरू जातीका चौपायहरू र सुंगुरका अवशेषहरू छन्। यस लेखमा मुख्यत लुकुन्डोल संरचनाको स्तर विन्यास र काठमाडौंको थिग्रीनी चट्टानहरूको विकास बारे चर्चा गरिएको छ।

ABSTRACT

The fluviatile lacustrine sediments of the Kathmandu Valley have been restudied. New fossil discoveries in the southern part of the valley sheds light on the geology of the Kathmandu Valley.

The finds comprise, diverse vertebrate fossils represented by elephant, deer, bovine and pig belonging to Plio-Pleistocene age. The paper mainly deals with stratigraphy of the Lukundol Formation and evolution of the Kathmandu sediments.

INTRODUCTION

Kathmandu is an intramontane basin in the lesser Himalayas of Nepal. The basin consists of fluvio lacustrine sediments which were the result of tectonic damming in the south of the Katuwal daha.* The Bagmati River draining the valley with its tributaries has deeply dissected the continuous basin alluvium into terraces and gorges giving rise to the present geomorphic feature. The highest elevation of the valley deposits is approximately 1500m and the lowest elevation is 1220m both found along the Bagmati river valley near Katuwal daha. The best outcrops are exposed in the deeper cuts of the river valley in the south. To the north of the basin the outcrops are schists, migamatites and gneisses and to the east, west and south are mixtures of phyllitic slates, meta-sandstones, quartzites and limestones (Fig. 2).

* daha is the local term used for the pond.

Fig.1

Fluviatile Lacustrine Sediments of Kathmandu Lake

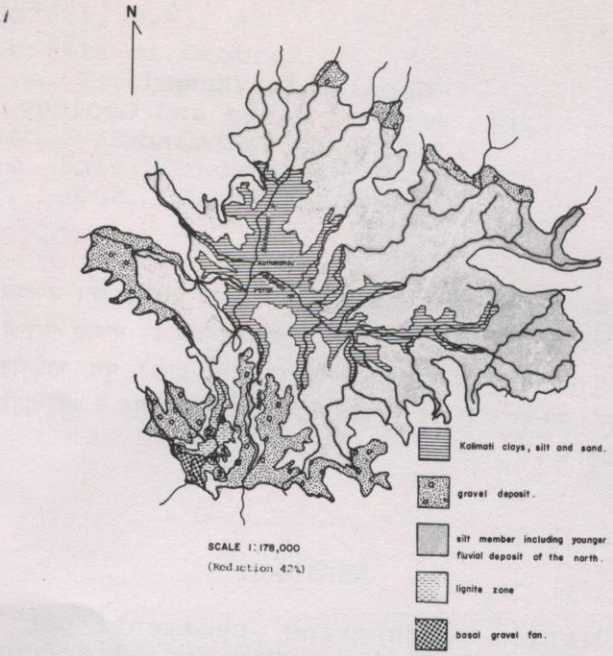
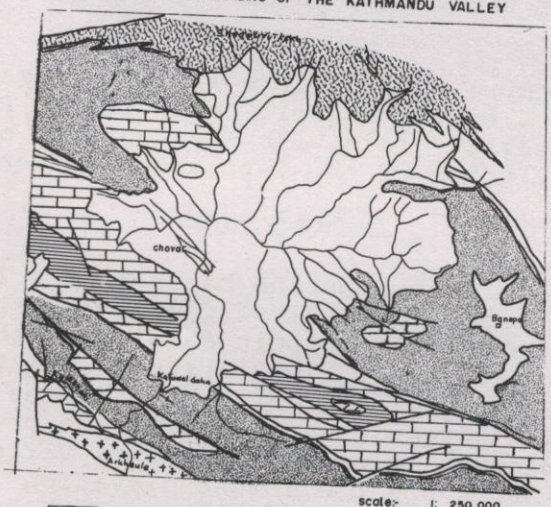


Fig.2 GEOLOGY SURROUNDING OF THE KATHMANDU VALLEY



marble

Limestone

phyllite, meta,- sandstone, siltstone

granite

augen – gneiss, migmatites and schist.

PREVIOUS WORK

Many geologists have studied the Kathmandu valley sediments. Nautiyal and Sharma (1961), Sharma and Singh (1966) carried out detailed geological work in the valley. They gave much consideration to the type and origin of the sediments. Also their work indicates that the lacustrine fillings is locally deeper than 457m (Harisiddhi core) and they provide an in depth study of the available sedimentary description (lignites, sands, clays, etc.). Tandukar and Pandey (1969) carried out a magnetic survey of Kathmandu. They suggested north - south faulting through Kathmandu. Binnie et al. (1973) completed geological investigation in the valley in connection with the Water Supply and Sewerage Project for W.H.O. They gave a summary of the drilling carried out to date within the Kathmandu Valley and have shown a possible configuration of the bedrock underlying the lake deposits of the basin. Gupta (1975), West and Munthe (1981) reported vertebrate fossils from clay beds overlying the lignite beds near Lukundol adjoining Chapagaon at the head waters of Nakkhu Khola and correlated these occurrences with the Karewa Formation of Kashmir and Pinjaur Formation of the Siwaliks. The fossils include Hexaprotodon sivalensis, Archidiskodon planifrons, Stegodon ganesa, Crocodylus sp. of lower Pleistocene age. Yoshida and Igarashi (1984) also did paleomagnetic study and pollen analysis of the younger sediments of the valley.

KATHMANDU SEDIMENTS

The fluvio-lacustrine sediments of the Kathmandu basin consist mainly of fine and coarse sand, sandy loan, sandy silty clay and gravelly conglomerate. They cover approximately 200 sq. km. on folded and faulted Cambrian-Precambrian rocks. The deepest bore hole was 457 m deep in the south near Harisiddhi but did not reach bed-rock (Nautiyal and Sharma 1961). The sediments are nearly horizontal in the central part of the valley and are tilted up to 20 degree or more in the southern part representing the Champi-Katuwal daha, Dakshinkali area where they abut the Mahabharat Range.

This work is concentrated on the Lukundol Formation in the southern part of the valley exposed along the Bagmati River (Fig. 3). The detrital sediments in this part of the basin can be divided into four members from the bottom namely: 1.Basal Gravel, 2. Lignite, 3. Laminated Silt and 4. Upper Gravel (see Fig. 1 & Fig. 12). The upper three members are separated in the form of three fairly distinct terraces, and are slightly tilted indicating a good deal of upheaval in the south of the Kathmandu basin (see Fig. 3). The exposed thickness of the basin sediments in the south is nearly 300 meters.

1. Basal Gravel Member

The Basal Gravel exposed at Tare Bhir in the south of the

Bagmati Valley represented the oldest sediment consisting of conglomerates and bedded sandstones. Its exposed thickness is approximately 60 metres. The conglomerates are massive and disorganised consisting of pebbles and cobbles along with some floating boulders up to 3 metres. Individual pebble and cobble are generally rounded to well rounded meta-sandstone, phyllitic slate, pink quartzite, white quartzite, limestone and granite. Beds of 30cm to 1m silt and fine sand are also encountered within the conqomerates. These clastics have been derived from the Phulchawki-Chandragiri range in the southern rim of the valley. The presence of tourmaline granite boulders of up to 2 metre diameter show that the materials were supplied from the Narayanthan-Palung granite body. These lithofacies show viscous mass flow as the mode of sedimentation. The paleocurrent direction is towards west to northwest. This lithofacies grades into pebbly sandstone, crossbedded sandstone and siltstone. The pebbles are of migmatite, gneiss, quartzite and limestone and are derived from the north, east and west of the valley. The paleocurrent direction of this fluvial deposit indicates the southerly flow of the ancient drainage.

2. Lignite Member

Overlying the Basal gravel is the well bedded siltstone best exposed along the Khare Khola and around Kaseri Naya Khandi area. It is composed of a 50m thick succession of sandstone, siltstone and mudstone. The contact with the underlying sand and gravel is erosional. In association with these are a number of coal seams, mainly lignites, with thickness ranging from 2cm to 1.5m. They are slightly tilted (5 degrees) but below Dukuchap they dip 20° to 40° towards the central depression of the valley.

The depositional environment as inferred from the lithostratigraphy of this zone shows partly a lacustrine and deltaic history. In these horizons fossil remains of Elephas, a pig, a bovid and a deer (?) or antelope (?) have been found. They have been described separately in this article.

3. Laminated Silt Member

The Lignite Member is overlain by a 40m, thick succession of Laminated Silt Member, well exposed in the upper Nakhu Khola, Bungmati and in the south of Chovar george. Some well preserved leaf imprints are encountered here. No granitic pebbles were present. It appears that this unit continues beneath the Patan Kathmandu alluvium. This facies represnts a lacustrine type of depositional environment.

The litho facies change to the south and show erosional intercalation ofpebble to cobblesized clasts which were derived from the southern rim of the valley.

Figure 3

4. Upper Gravel Member

A thick succession (50m or more) of Upper Gravel overlies the Laminated Silt Member capping the Champi-Itari ridge all the way to Bungmati. They are well distributed on the Pharping terrace, Chapagaon terrace, etc. These are conglomerates consisting mainly of pebbles and cobbles of meta-sandstone, quartzite, limestone and phyllitic slate. They were derived from the Phulchawki-Chandragiri range. The maximum clast size is 15 cm. The best exposure for this unit is just above Lukundol village.

The northern part of the valley is generally covered by fluvial deposits consisting mainly of coarse sand with some gravel which had been derived from the schists and gneisses of the north. Along the bank of the Bagmati River black silty clay and fine peat bands intercalated with sands are exposed.

The youngest sediments of the Kathmandu lake are below Kathmandu city centre as well as Patan along the Bagmati river in the central depression. There is a disconformity between the Lukundol Formation and the overlying recent deposits. These youngest sediments consist of Kalimati clay, silt and sand. They were entrenched into the former lake fillings (Boesch 1974). It seems that during the early period when the paleo-drainage in the south was blocked, the valley drained to the east down the Banepa-Panauti valley (see Fig. 2). Carson (1985) felt that the Banepa Valley was much larger than the present drainage might suggest, and that the paleo-drainage had captured a significant portion of the land that was once drained through Banepa (personal communication). Later the lake was completely drained by the Bagmati River due to the deepening of its outlet in the south leaving the youngest deposits.

NEW FOSSIL OCCURENCES IN THE SOUTHERN BAGMATI VALLEY

A number of vertebrate fossils have been discovered from the Lignite Member of the Lukundol Formation exposed along the bank of Bagmati River, south of Kathmandu Valley. Some vertebrate fragments are also collected from the talus near by the outcrops. The fossils and its localities are as follows:

Locality 1. : A tooth of Elephas (cf. hysudricus) (Fig. 4).

Locality 2. : Teeth of Elephas (cf. planifrons), and the upper part of a tusk in seven fragments (Fig. 5,6).

Locality 3. : 2 teeth of an Artiodactyla, a tooth of a pig (Fig. 7).

Locality 4. : 3 horn pieces (Fig. 8).

Locality 5. : A tooth fragment of Elephas (cf. planifrons)

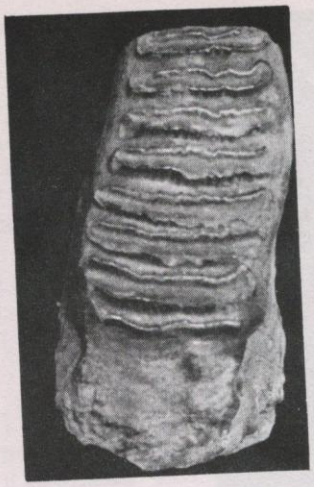


Fig. 4.

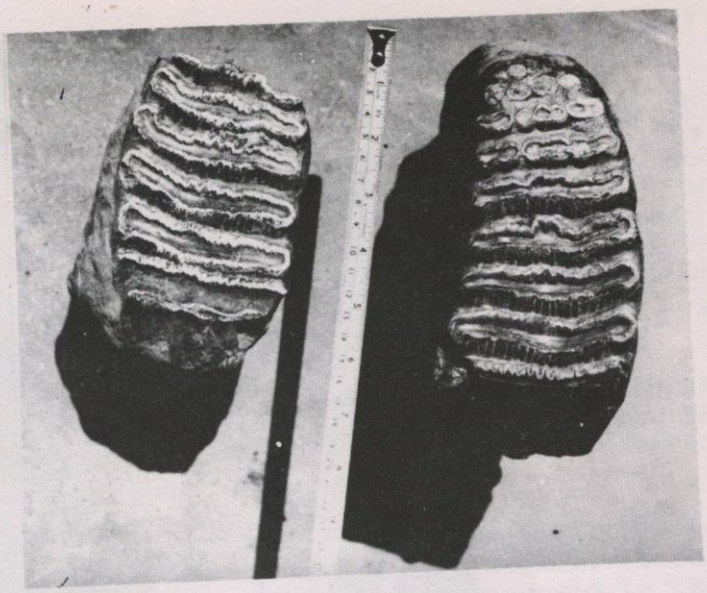


Fig. 5

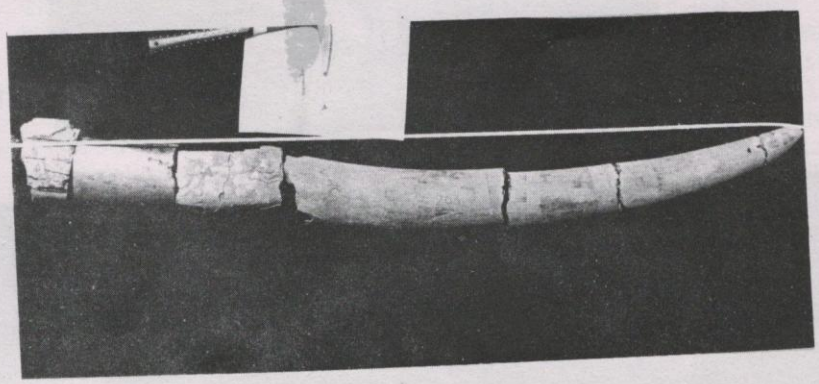


Fig. 6

Fig. 7

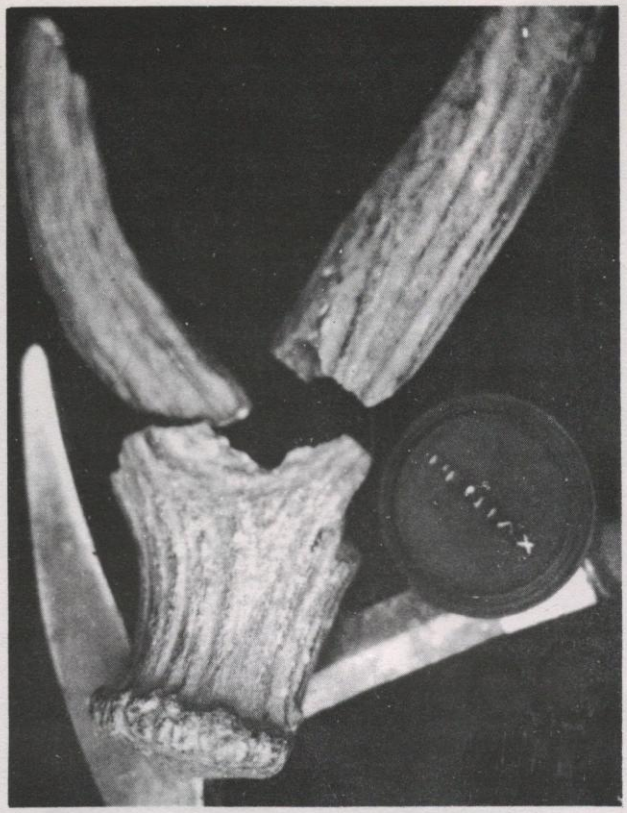


Fig. 8

Fig. 9

Locality 6. : A number of bovid metacarpals (or tarsals) astragali and foot bones (Fig. 9).

Locality 1. (Figs. 1 4 & 10): The fossil area is located near Hatiban in the eastern bank of the Bagmati valley. The outcrop exhibits a succession of lignite, silt and sand. The Elephas tooth was found in the lignite band exposed in a 1.5m deep trench dug by farmers at the eastern side of the Bagmati River. This lignite band is 0.9m thick. There are other 7 lignite bands observed in the same outcrop. They are from the bottom 0.6m, 0.20m, 0.40m, 0.90m, 0.45m, 0.30m, 0.90m, (see Fig 10).

The elephant tooth is well preserved. It has a length of 17 cm and a width of 9.5cm, at its centre. It is interesting to note that this area is traditionally called Hatiban meaning Elephant Forest.

Locality 2. (Figs. 1, 5,6 and 10): This locality is situated in the western terrace slope of the Bagmati River adjacent to the Pharping Power House. The rocks exposed in the outcrop are silty clay, silt and sand along with four lignite bands. The silty clay yielded a tusk and a tooth in good condition. Three more tusk pieces and a tooth were found in the talus just below it which must have been derived from the same horizon. The tusk broke into four pieces while extracting it. These four pieces together have a length of 96 cm, with a diameter of 12 cm and 10 cm both horizontally and vertically at the proximal ends of its biggest fragment. One of the Elephant teeth is 16 cm long and is 8.5 cm wide in its centre. The second tooth is a fragment which has 13 cm length and 8 cm width.

Locality 3. (Figs. 1, 7 & 10): The fossil area islocated at the right bank of Khare Khola (just near the confluence of another stream from the left) below Lukundol village. It exposes a section containing a number of lignite bands (average 2cm to 1m thick), silty clay, sand and gravel. The thickest coal seam is 1m which has flattened dip of 5 to 10 degrees to the north. Two teeth of an Artiodactyla were found in situ in 2.5 cm thick lignite band which overlies 4 metre thick silty clay and a metre of another lignite band. A tooth of a pig was found in a silty clay horizon below 2 cm thick lignite band.

Locality 4. (Figs. 1, 8 & 11): is situated near the confluence of the Khare Khola with the Bagmati River below the Tokalmath villages. The section exposes a succession of silty clay, sand and silt with four lignite band of 0.1m to 0.3m thickness. The basal part of the horn-core of a deer (?) or antelope (?) was found in the talus of locality 4. The diameter of the horn-core at the proximal end is 6 cm.

Farmers said that they found some more bone pieces in a silty clay horizon indicated by a cross in the section. The other horn core pieces, a part of scapula and some pieces of fossils wood were found near by in the same talus.

Sections of

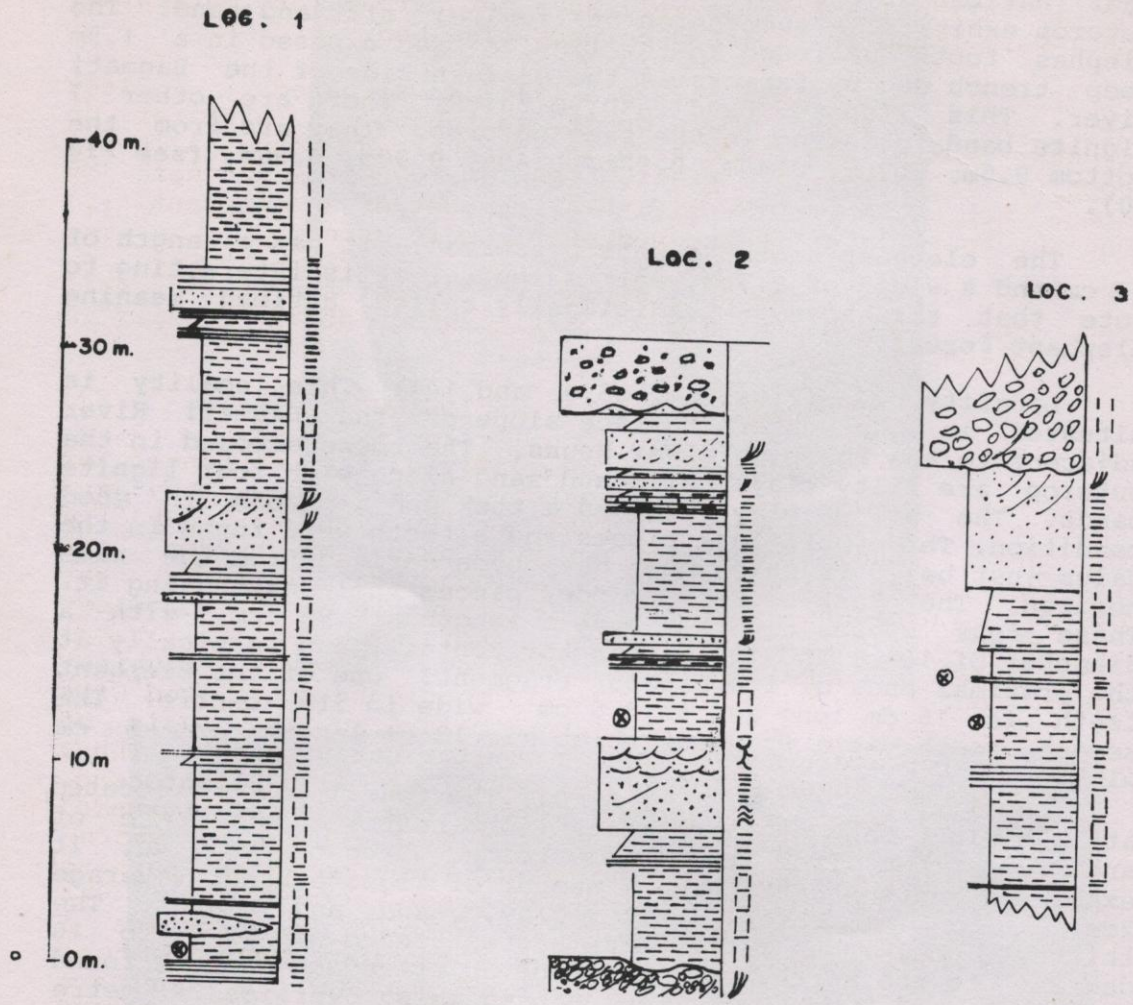


Fig. 10

Locality 5. (Figs. 1, & 11): is situated at the left bank of the Mai Khola near Euntiki village where some excavation were done by the villagers. The section exposes 4 metre of silty clay, hard clay and 1m of lignite. A number of foot bones and an astragalus bone as well as a metacarpal (or metatarsal bone) were found in the hard compact clay bed.

Locality 6. (Figs. 1, 9 & 11): is situated just north of the Khare Khola on its left bank. A part of an elephant tooth was found here in a reworked young alluvial deposit. This fossil must have been derived from the near by exposed rock. An unidentifiable fragment of an elephant (?) bone was found later in the bed of the same stream.

These are only the preliminary records of the new fossil find. Work is continuing and detailed study of the fossils is forth coming.

THE AGE OF THE BASIN FILLING

The present investigation has confirmed the occurences of vertebrate fossils in the Kathmandu lake sediment. They are teeth, tusk and other bone fragments of the Elephas; tooth of a pig, ankle bone, lower limb and bone pieces of bovid; horn pieces of a deer (?) and teeth of Artiodactyla. It shows that the region presents similarities in strucutre and paleontology with the Karewa fillings of Kashmir, India. The Tare Bhir Basal Gravel might be correlated with pre-Karewa deposits. Lignite member containing vertebrate fossils should be correlated with the lower Karewas of the Kashmir Himalaya on the basis of similar vertebrate remains and the similar stratigraphy. Thus, the age of the Lukundol Formation could be Plio-Pliestocene. According to West and Munthe (1981) the age of Lukundol Formation is between 2.9 and 1.5 million years. The upper Gravel deposit including the Chapagaon-Pharping terrace might be correlated with the upper Karewas. The C - 14 age compiled by H. Yamanaka and M. Yoshida (in Yoshida & Igarashi, 1984) shows the Gokarna Formation consisting of laminated arkosic sand, silty clay and peat (in the northern part of the Kathmandu lake) as 29,390 - 2040.year B.P.and 24,420 + 1960 yr.B.P. The age of the youngest deposit of the Kathmandu lake according to them at Koteswor is 11,070 1,480 yr. B.P.

The location of Lukundol adjoining Chapagaon at the head water of Nakhu Khola as the fossil source mentioned in the older publication (Gupta 1975, Fort and Gupta 1981, West and Munthe 1981, Yoshida and Igasashi 1984) must be corrected. Lukundol lies in the Khare Khola cut adjacent to the Bagmati river. The vertebrate yielding horizon is probably not exposed along Nakhu Khola and other places except around Nayakhandi-Kaseri including Lukundol. It lies beneath younger sediments.

Fig. 12 Composite Sketch profile of the Plio-Pleistocene deposits of the Southern Kathmandu Valley in the Lukundol area.

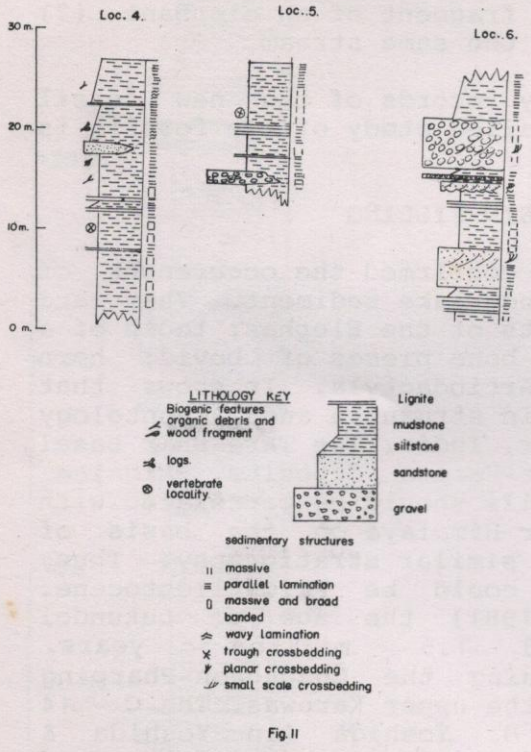
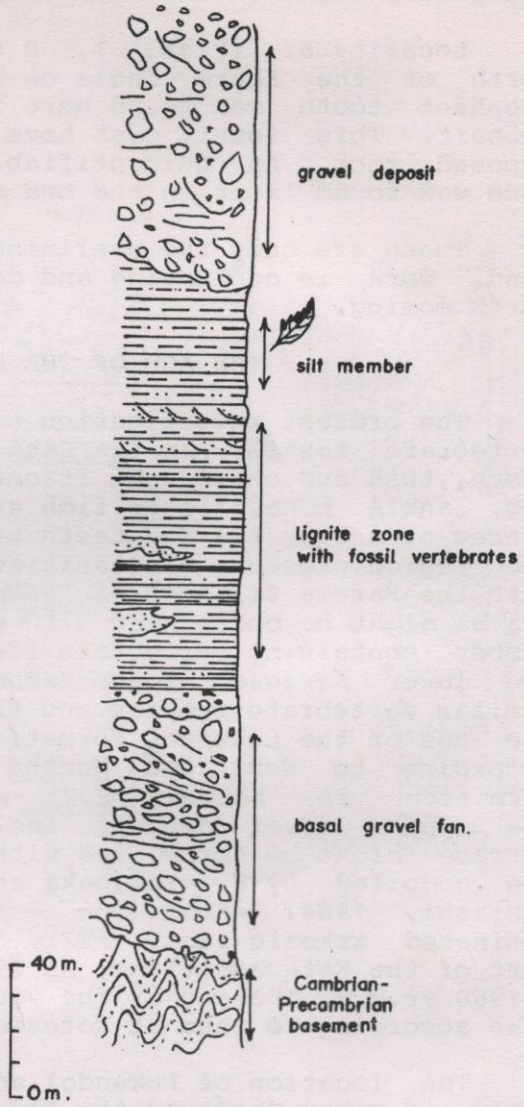


Fig. 11



KATHMANDU BASIŃ EVOLUTION

The intensive folding and overthrusting of the Mahabharat rocks related to the M.B.T. action caused the tectonic damming in the Chandragiri-Phulchawki range south of the Katuwal daha by creating a relief that resulted in strong northward erosion. This is shown by the vertical dipping of the basement rock near Katuwal daha and the presence of huge tourmaline granitic boulders of Arkhaule (extension of Palung-Narayanthan granite) in the Basal Gravel of Tare Bhir together with other rock types of the Phulchawki - Chandragiri range.

The ancient drainages started to migrate to the newly created low topographical depression near Katuwal daha which created a breach and were drained out. This ancient southward drainage was responsible for the deposition of sand and gravel of the Phulchawki - Chandragiri range which blocked the ancient drainage and maintained a stagnant water body to the north.

This formed the semidentary basin for the lower group consisting mainly of sandstone, siltstone and lignite. It was this group that yielded the new vertebrate finds described in this article. The new fossils were derived from the Lukundol formation representing the Lignite Member. Similarly the development of the Kashmir basin also started with ponding of pre-existing drainages (Burbank & Johnson 1983). This shows the similarity of the development history in the early stage of the Kathmandu basin evolution to the Kashmir basin.

It appears that the original lake was slightly bigger including the area of the present Chovar gorge. The areal extent of the lake was reduced later partly because of the upift of the southern part of the valley at the close of mid-upper Pleistocene. This is well represented by the northward tilting of the Lukundol Formation. The decrease in the areal extent of the lake was also due to the breaching of the lake by cutting through the rising mountain and completely draining out the lake south of the Chovar barrier. The Bagmati River flowing through a gap near the present Chovar started to cut into the newly emerged broad alluvial flat. In process it formed the Chovar gorge and drained the entire lake during the Holocene.

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Fig. 4 Tooth of Elephas (cf. hysudricus) from Loc. 1. (the tooth is 17 cm. in length).

Fig. 5 Two teeth of Elephas (cf. planifrons) from Loc. 2.

Fig. 6 The elephant tusk of locality 2.

Fig. 7 2 teeth of Artiodactyla and a tooth of a pig from loc. 3.

Fig. 8 Horn core pieces from Loc. 4.

Fig. 9 Foot, ankle bone and meta-carpal (or tarsal) of a bovid from loc. 5.

Fig. 10 Sections of Loc. 1,2, and 3.

Fig. 11 Sections of Loc. 4, 5 and 6.

Fig. 12 Composite Sketch Profile of the Plio-Pleistocene Deposits of the Southern Kathmandu Valley in the Lunkundol - area.

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