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The stratigraphic significance of vertebrate fossils from the Quaternary deposits of the Kathmandu Basin, Nepal

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with 4 figures

Abstract. Vertebrate fossils (*Elephas*, bovid, cervid, suid, and *Rhinoceros*) recovered from the intramontane basin sediment of Kathmandu Basin help to determine an early Pleistocene age of the basin fillings. The fossils are similar to the mammalian taxa of the Pinjor Formation of Upper Siwalik and Karewa deposits of Kashmir Basin.

Introduction

The Kathmandu Basin (Fig. 1) is Nepal's largest intramontane basin in the Lesser Himalaya. The basin fill consists of fluviolacustrine sediments which were deposited after tectonic damming of the prebasin drainage took place. Numerous studies have been made in this basin by different scholars in the past decade (GUPTA 1975, WEST & MUNTHE 1981 and YOSHIDA & IGARASHI 1984). However, no detailed information is available on its stratigraphic position and vertebrate palaeontology, as the sedimentary history of the Kathmandu Basin is poorly understood. I report here the discovery of *Elephas*, bovid, cervid, *Rhinoceros* and suid fossils of early Pleistocene age from the deep valley of the Bagmati River in the southern part of the basin (Fig. 1). All the localities are new and the stratigraphic position of the section parallels the Karewa deposits of Kashmir Basin and its mammalian taxa. This suite of fossils suggests a close relationship with the upper Siwalik Pinjor faunas (upper Villafranchian, lower Pleistocene) (OPDYKE et al. 1982, NANDA 1976).

Geologic setting of the Basin and its surroundings

The Kathmandu Basin is surrounded by metasediments and crystallines of the Kathmandu Complex which occupies the large core of the synclinorium a part of the Mahabharat synclinorium (STÖCKLIN & BHATTARAI 1977). To the north of the basin the outcrops are schists, migmatites and gneisses and to the east, west and south are phyllites, slates, metasandstones,

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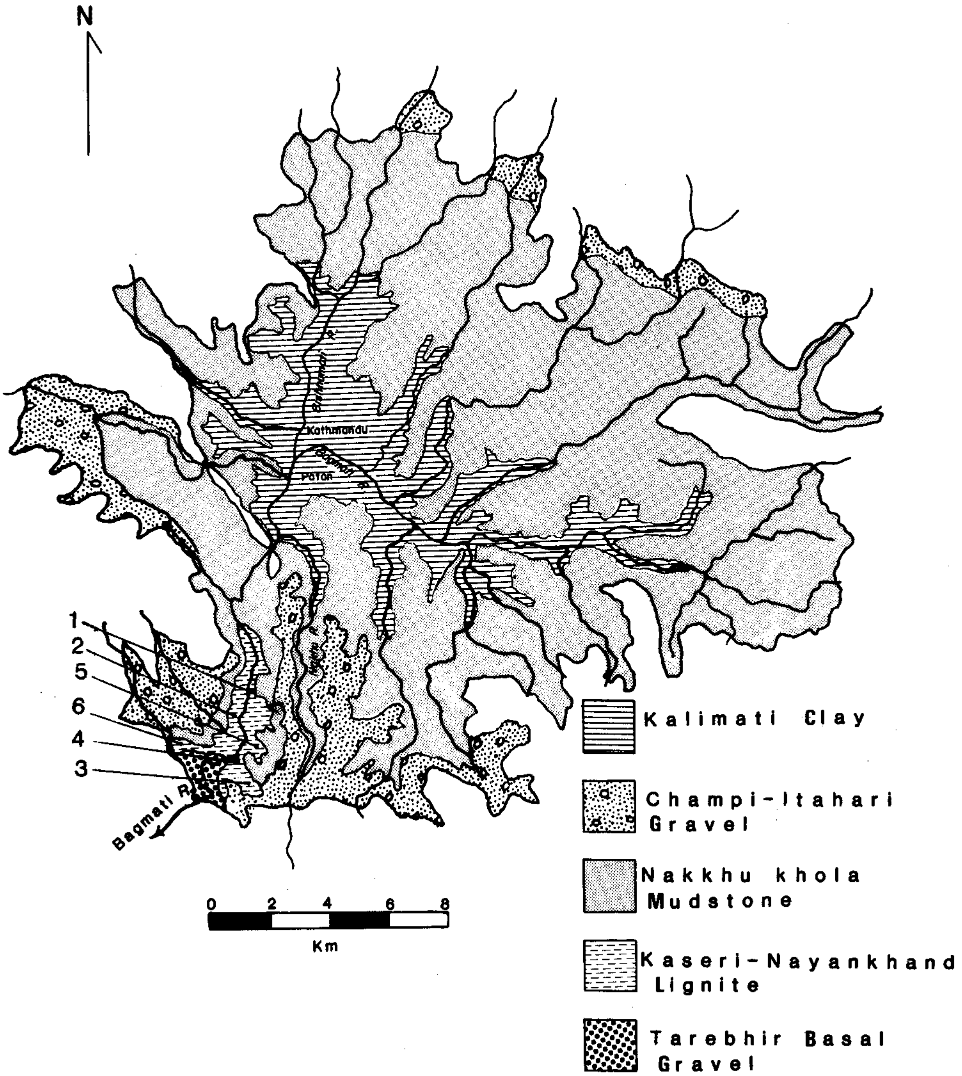


Fig. 1. Geological framework of the Kathmandu Basin sediments with fossil localities.

quartzites and limestones. The tourmaline granite (Palung-Narayanthan Granite, STÖCKLIN & BHATTARAI 1977) is 10 to 15 km south of the basin. The Kathmandu Basin sediments are best exposed in the south, along the Bagmati River, which forms a centripetal drainage system in the basin. The sequence is divided into four informal stratigraphic members by the author, namely (from bottom to top): (1) Tarebhir Basal Gravel, (2) Kaseri-Nayankhandi Lignites, (3) Nakkhu khola Mudstone, and (4) Champi-Itahari Gravel. This sequence is shown in section 1 of Fig. 2. The new faunas described here are all from member 2.

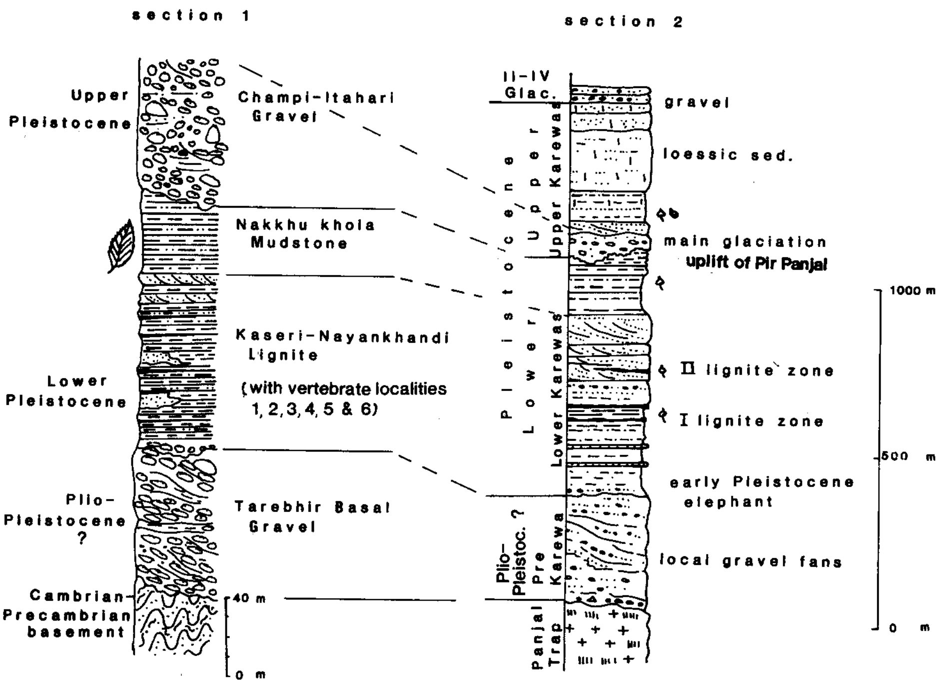


Fig. 2. Stratigraphic correlative chart of the Kathmandu Basin (section 1) by DONGOL (1985) and Kashmir Basin (section 2) by GANSSER (1964), (compiled after DE TERRA and DE CHARDIN (1936), WADIA (1951).

The upper three members are found (one per terrace) on three more or less distinct terraces along the Bagmati River in the south. These terraces are tilted slightly northward, indicating post-depositional uplift to the south of the Kathmandu Basin. The total exposed thickness of the basin sediments in the south is nearly 280 meters.

The Tarebhir Basal Gravel and Champi-Itahri Upper Gravel each indicate a period of intense uplift and erosion to the south of the Kathmandu Basin.

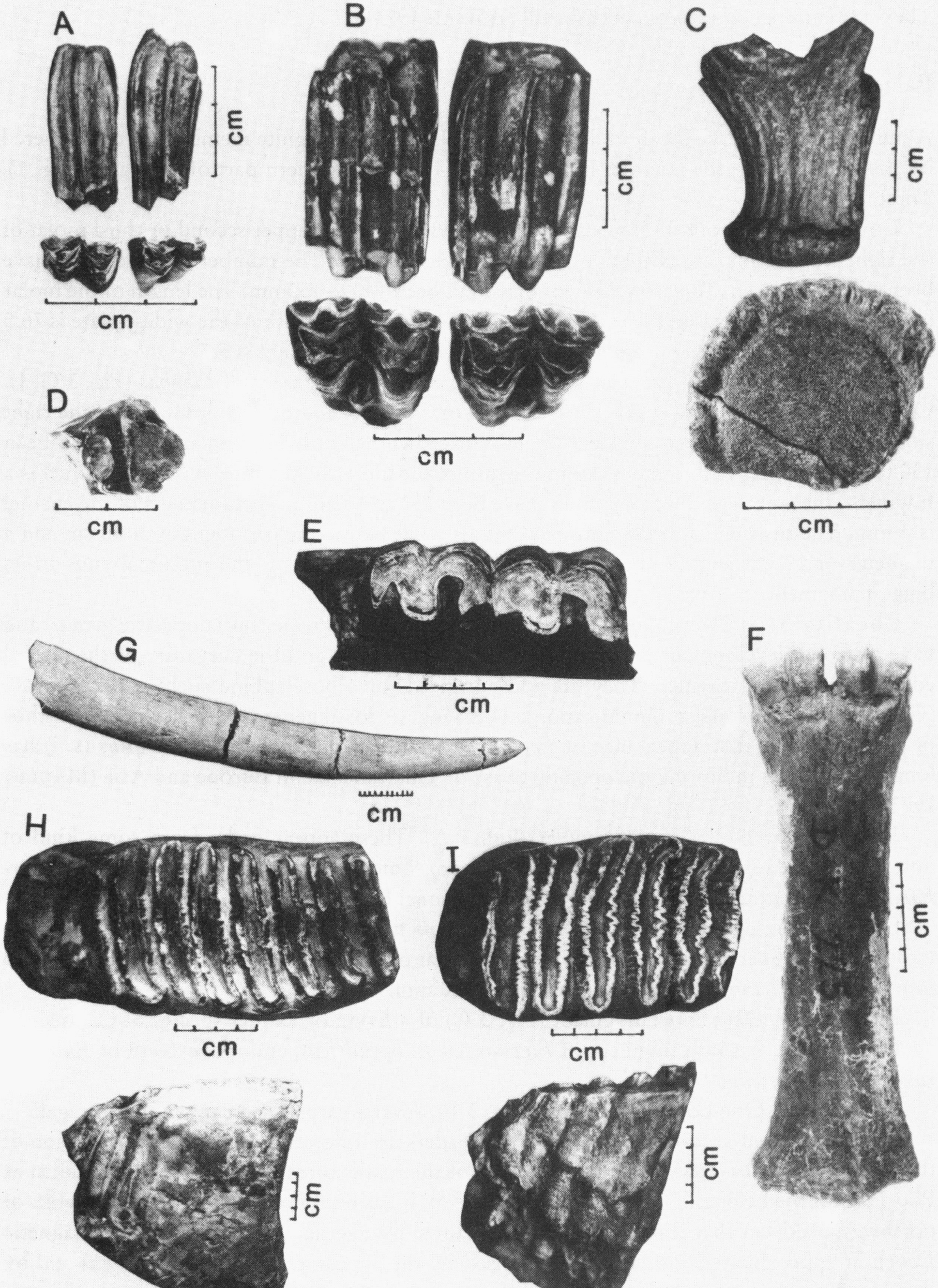
The Tarebhir Basal Gravel, the oldest sediment of the Kathmandu Basin, is exposed in the deep valley of the Bagmati River. Here the exposed thickness is 60 m. The clasts are commonly imbricated, and range from pebble- to cobble-size with some floating boulders up to 3 m in diameter. The clasts are rounded to well-rounded and are composed of metasandstone, phyllite, slate, pink quartzite, white quartzite, limestone and tourmaline granite, all originating from the southern rim of the basin. These fan deposits form a semi – conical landform with slope and transport direction (west to north-west) radiating from the mouth of the source valley. The grain size decreases rapidly down fan and roundness of gravels increases. The lowermost part of the fan is composed of conglomerates with clast supported framework and pebbly sandstone with clear stratification as a result of bedload deposition. In the middle portion, the conglomerates have a sheet-like form and are interbedded with finer sediment (sand and silt) probably from sheet floods. The upper portion represents the proximal part of the fan and is dominated by matrix-supported large size clasts (maximum 2 m) which lack internal structure. The mode of sedimentation appears to have been by viscous masas flow.

The whole fan sequence with an erosional contact is overlain by 6 m. thick bed of conglomerates with pebbly sandstone and cross-bedded mica sand. The clasts consist of gneiss and mica schists originating from the Sivapuri Gneiss zone. The sedimentary structure shows southerly flow of the ancient drainage. This portion of the sediments is very similar to the sediments of the present day Bagmati River bed load deposition. Unconformably overlying the basal gravel are the Kaseri-Nayakhandi Lignites. Along the Bagmati River this member is composed of a 50 m thick succession of alternating, unconsolidated sandstones, siltstones and mudstones. A number of coal seams, mainly lignites, with thicknesses ranging from 2 cm to 1.5 m occur within these sediments. They are slightly tilted (5 degrees) towards the central depression of the valley to the north. These sediments indicate a marshy environment with frequent ponding of the pre-existing drainage. The Kaseri-Nayakhandi Lignites are overlain by 40 m of Nakkhu khola Mudstone, consisting mostly of laminated grey silt and Mudstone and indicating a lacustrine environment. Some well-preserved leaf impressions occur within this stratigraphic member.

A widespread succession of conglomerate, the 50 m thick Champi-Itahari Gravel, overlies the Nakku khola Mudstone. The gravel consists of pebbles and cobbles of metasandstone, quartzite, limestone, phyllite, and slate, all derived from the southern part of the basin. The maximum clast size is 15 cm. Unlike the Tarebhir Basal Gravel, this gravel contains no granitic material. Apparently the source of granitic clasts (probably the Palung – Narayanthan granitic body far to the south of the Kathmandu Basin) was cut off before the Champi-Itahari Gravel was deposited, due to rapid uplift in the southern part of the Kathmandu Basin.

The stratigraphical equivalent to the Nakkhu khola Mudstone in the northern part of the Kathmandu Basin is dominated by fluvial deposits consisting mainly of coarse sand with some gravel interbedded with mudstone and siltstone. The fluvial deposits were derived from the schists and gneisses to the north. The youngest deposits of the Kathmandu Basin consist mainly of clays, silt, and sand collectively known as the Kalimati Clay. They are exposed

Fig. 3. Selected specimens of fossil vertebrates from Kathmandu Basin.
A Antelope molars, side and crown view; B *Bos* molars, side and crown view; C Deer antler fragment, side and basal view; D Part of suid molar cf. *Potamochoerns palaeindicus,* side view; E Molar teeth of *Rhinoceros* cf *sivalensis,* crown view; F Bovid metacarpal, side view; G Tusk fragments of *Elephas,* side view; H *Elephas* cf. *hysudricus,* upper second or third molar, crown and side view; I *Elephas* cf. *hysudricus,* front part of upper second or third molar, crown and side view.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between Kathmandu and Patan along the Bagmati River in the central depression (Fig. 1). They are entrenched into older basin fill (BOESCH 1974).

Palaeontology

A number of new fossil localities in the Kaseri-Nayankhandi lignite member were discovered by the author along the Bagmati River (see Fig. 4) in the southern part of the basin (Fig. 1). These are:

Locality 1. A tooth of *Elephas,* cf. *hysudricus* (Fig. 3 H) (upper second or third molar of the right side). The plate is worn out and thickened closely. The number of plates may have been at least thirteen. The crown height may have been 140 to 150mm. The length of the molar is 120 mm, originally it could have been 130 to 140 mm. The width of the widest plate is 76.5 mm. The thickness of the enamel is 3 mm. The lamellar frequency is 5.7.

Locality 2. Teeth of *Elephas,* cf. *hysudricus* and tusk fragments of *Elephas* (Fig. 3 G, I). One of the specimens (Fig. 3 I) is the front part of the upper second or third molar of the right side. The plate is worn out at a steep angle. The crown height is 107 mm and must have been 130 to 140 mm originally. The maximum width of the molar is 80.5 mm. As this specimen is a fragment, the length of the molar could have been 150 to 160mm. The thickness of the enamel is 3 mm. The tusk which broke into four pieces while extracting has a length of 96 cm and a diameter of 12 cm and 10 cm both horizontally and vertically at the proximal ends of its biggest fragment.

Locality 3. a) Two upper molars(Fig. 3 B). These are bovine (buffalo, cattle group) and have a strong development of labial ribs between the styles and the curvature of the lingual edge of the central cavities. They are too advanced for a boselaphine such as *Pachyportax* (GENTRY 1986, personal communication). This suggests fossil genera no earlier than Hemibos or *Leptobos.* The first appearance of *Leptobos* together with *Elephas* (s. l.), *Equus* (s. l) has long been used as indicating the opening phase of Villafranchian in Europe and Asia (MAGLIO 1973).

Locality 3. b) Two upper molars(Fig. 3 A). These appear to be from some kind of antelope (Bovidae). Most probable they come from some member of Caprinae such as *Nemorhaedus* or an extinct relative (GENTRY 1986, personal communication).

Locality 3. c) Suid molar, cf. *Potamochoerns palaeindicus* (PILGRIM 1926) (Fig. 3 D) (front part of upper second, or possibly third, molar of the right side). The specimen is of 20.5 mm length, 19.7 mm width and crown height 20 mm.

Locality 4. Deer antler fragment (Fig. 3 C) of a living or extinct species of Cervus.

Locality 5. A tooth fragment of *Elephas,* cf. *E. hysudricus,* and molar teeth of *Rhinoceros,* cf. *sivalensis* (Fig. 3 E).

Locality 6. One bovid metacarpal (Fig. 3 F), several carpals, phalanges and astragali.

For the detailed sections of the localities, readers are referred to an earlier publication of the author (DONGOL 1985). The inferred ages of the fossils mentioned above can be taken as Plio-Pleistocene belonging to Pinjor faunal interval. It has been noted in the Upper Siwaliks of northwest Pakistan that there is a significant faunal change near the top of Gauss Magnetic Epoch at approximately 2.5 m.y. characterised by the appearance of *Equus, Elephas* and by the appearance of cervids with antlers (OPDYKE et al. 1982). *Elephas* cf. *hysudricus, Rhinoce-*

rous, *Equus*, suid, *Bos* and cervids have been reported by various scholars from the Karewas of Kashmir Basin (GODWIN-AuSTEN 1864, DE TERRA & PATERSON 1939, WADIA 1941, BADAM 1968, 1972). Also in the Upper Siwalik Subgroup of Ambala (India) *Elephas planifrons* and *Elephas hysudricus* are confined to the Pinjor Formation (NANDA 1976). The recent recovery of *Elephas* cf. *hysudricus*, suid cf. *Potamochoerns palaeindicus* (PILGRIM 1926), *Bos* sp., cervid with antler and *Rhinocerous* cf. *sivalensis* in the Kathmandu Basin suggest close relationship with the Upper Siwalik Pinjor faunas.

Fig. 4. View of one of the *Elephas* localities in the Bagmati River valley.

Correlation

Fig. 2 shows the similarity between the proposed stratigraphy of the Kathmandu Basin by DONGOL (1985) and that of the Karewa beds (Kashmir, India) as compiled by GANSSER (1964), mostly after DE TERRA & CHARDIN (1936), and WADIA (1951). It is apparent that the deposits of the Kathmandu Basin are similar in sedimentology, structure and palaeontology to the Karewa deposits of Kashmir. The Tarebhir Basal Gravel might be correlated with pre-Karewa deposits of Kashmir. The Kaseri-Nayankhandi Lignites could be correlated with the lower Karewas in which similar vertebrate fossils are found. The development of the Kashmir Basi~ started with pondings of pre-existing drainages (BURBANK & JOHNSON 1983) as was the case in the Kathmandu Basin.

Sedimentary history of Kathmandu Basin

Large scale folding after large scale thrusting created the Mahabharat synclinorium involving steeping the thrust plane on both flanks (STÖCKLIN & BHATTARAI 1977). The renewed intensive folding and overthrusting related to movement on the Main Boundary Thrust caused the recent upheaval of the Mahabharat rocks. This in turn, caused tectonic damming in the Chandragiri-Phulchawki range south of the Katuwal daha and led to northward drainage on the southern side of the Kathmandu Basin. This is shown by the vertical dipping of the basement rock near Katuwal daha and the presence of huge southerly-derived boulders of Palung Narayanthan granite in the Basal Gravel of Tarebhir together with other rock types of the Phulchawki – Chandragiri range.

This uplift of the Phulchawki-Chandragiri range also blocked the ancient drainage which maintained a stagnant water body to the north. This formed the sedimentary basin for the Kaseri-Nayakhandi and Nakkhu khola members consisting mainly of sandstone, siltstone and lignite.

It appears that the original lake was slightly bigger including the area of the present Chovar gorge. The areal extent of the lake was later reduced because of the uplift of the southern part of the valley at the close of mid-upper Pleistocene. This is well represented by the northward tilting of the lower group. The decrease in the areal extent of the lake was also due to stream down cutting through the rising mountain and completely draining out the lake south of the Chovar barrier. Renewed thrusting related to the Main Boundary Thrust south of the Kathmandu Basin was responsible for the development of the incipient drainage of the Bagmati River after it flows out of the basin. 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.

The sedimentary history of the Kathmandu Basin has a wider implication in the chronological study of the intermontane basin developments along the Himalayan front. During the late Cenozoic the formation of the Kashmir Basin and Peshawar Basin resulted from the transfer from the north of the locus of thrusting and uplift to the southern margin of the basin (BURBANK 1983). The similarity in Plio-Pleistocene histories of the widely separated Kashmir Basin, Peshawar Basin and Kathmandu Basin indicates nearly synchronous movements on the Main Boundary Thrust and possibly other Himalayan thrusts and resulted in upliftment of the ancestral Pir Panjal, Attock Range and Phulchawki-Chandragiry Range along the southern margins of the three basins respectively. This greatly affected the sedimentational pattern and has important implications for Himalayan tectogenesis and uplift.

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