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NEOGENE VERTEBRATE PALEONTOLOGY AND STRATIGRAPHY OF NEPAL

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ABSTRACT

For the past 150 years, the Siwalik Group, a Miocene through Pleistocene molasse along the flank of the Himalaya has been studied intensively stratigraphically and paleontologically in both India and Pakistan. This work recently has been extended into Nepal, where a presumably complete Siwalik section is present, and a modest number of vertebrate fossils have been found. All but one of Nepalese Siwalik vertebrates have been collected along the southern edge of the Dang Valley in western Nepal. Two assemblages are now known. The older is of presumed Miocene age and likely equivalent to the fauna of the Chinji Formation in Pakistan. The other is of late Pliocene to early Pleistocene age and similar to the Indian Pinjor fauna.

In addition, Plio-Pleistocene vertebrates have been reported from fluvial intermontane deposits in the Kathmandu Valley.

As studies of radiometric dating, magnetostratigraphy, physical stratigraphy and fossil distributions are extended into Nepal, the place of the Nepalese Siwaliks and basin deposits will become increasingly clear.

INTRODUCTION

Critical to adequate interpretation of the Neogene geologic history of South Asia is an understanding of the sedimentary rocks derived from the Himalayan uplift. For the past 150 years numerous geologists and paleontologists have studied and collected Siwalik Group rocks in the foothills of India and Pakistan (Falconer & Cautley, 1846–1849; Lydekker, 1877; Colbert, 1935; and many others), as well as intermontane basin deposits such as the Karewas of Kashmir (DeTerra & Paterson, 1939; Tewari & Kachroo, 1977). Similar geologic settings in Nepal (both foothills and basins) have begun to receive scientific attention only recently. Nonetheless, both stratigraphic and paleontologic work since the 1950's now provide means by which Nepal's Neogene deposits can be placed within the overall South Asian context.

SIWALIK STRATIGRAPHY

The vast majority of Neogene rocks in Nepal are the molasse deposits of the Siwalik Group which makes up the Churia Hills or sub–Himalayas (Gansser, 1964; Sharma, 1973). This range of low hills, up to 1500 meters in elevation, parallels the Himalayas for the length of Nepal (West et al., 1978) The outcrop band narrows in the east and reaches a maximum width of 52 kilometers in the west. Siwalik Group rocks are situated south of the Main Boundary Fault which marks the southern limit of thepre–Cenozoic Himalayas.

In India and Pakistan the Siwalik Group traditionally has been divided into three units (Pilgrim, 1910, 1913; Lewis, 1937; Fatmi, 1973). The lower Siwaliks are the Chinji Formation, which consists of reddish claystones with minor sandstone. The overlying middle Siwaliks are the Nagri Formation, primarily multistoried sandstone sequences, and the Dhok Pathan Formation, largely sandstone with minor claystone. The upper Siwaliks, separated into the Tartot and Pinjor Formations in India, are lumped into the Soan Formation in Pakistan. They are relatively fine–grained at the base and become progressively more conglomerating upward. The lower Siwaliks conventionally are regarded as late Miocene in age, the middle Siwa–liks as Mio–Pliocene, and the upper Siwaliks as Plio–Pleistocene. Recent magneto–stratigraphic studies in Pakistan (Lindsay *et* al., 1980) have correlated the classic Siwalik units to the international calibrated magnetic polarity time scale.

This currently–used Siwalik terminology, developed early in the Twentieth Century and subsequently modified many times, does not serve to adequately differentiate lithostratigraphic, biostratigraphic and chronostratigraphic units (Pilbeam et al., 1977). The presumptions that each of the Siwalik formations is lithologically unique and temporally identical everywhere, and that a specific animal assemblage comes from that single lithology, have dominated research for the past seventy years. Recently, detailed mapping and carefully controlled fossil collecting in Siwalik and related rocks in Pakistan have shown the presence of substantial lateral facies variations. This indicates that the formations, which are lithologically recognizable and mappable units, do not everywhere represent the same time and should not be expected to yield the same fossil assemblage at all localities. Furthermore, it has been demonstrated (Pilbeam et al., 1979) that there are sedimentologic controls over the placement and quality of fossil localities.

There is now a move to restrict the old names to lithologic units only and to introduce new biostratigraphic and chronostratigraphic terminology.

Investigations of the Nepal Siwaliks have been based on the premise that the three major units identified in northern India are laterally persistent southeastward and recognizable throughout the length of the country. The first description (Auden, 1935) was of Siwalik rocks in eastern Nepal where lower, middle and upper Siwalik units were differentiated. Later, Hagen (1959) published a series of cross sections through the Siwaliks at numerous localities along the length of Nepal, indicated acceptance of the tripartite stratigraphic division, and suggested that most of the exposed Nepal Siwaliks are the middle unit.

Glennie and Ziegler (1964) reported on seven traverses through the Nepal Siwaliks. They divided the group into a lower sandstone facies and an upper conglomeratic facies, both of which show lateial variations and grade into one another. This was the first indication of the depositional complexity of the Nepal Siwaliks.

The Nepal Geological Survey has mapped numerous areas within the Siwaliks, but the individual reports are circulated internally only and not formally published. Some of the data are included in Sharma (1973). The mappers utilize the three-part subdivision of the Siwaliks, but for mapping purposes they recognize four to six lithologic units which do not correlate explicitly with the formations of India and Pakistan. They estimate the entire Siwalik Group within Nepal to have a thickness of 4250 to 8200 meters.

SIWALIK PALEONTOLOGY

Although occasional fossil materials had been reported from the Nepal Siwaliks (Mathur, 1972; Itihara *et al.*, 1972; Sharma, 1973; West *et al.*, 1975), only a single record was of a fossil vertebrate. Sharma (1973) discussed a jaw fragment of the hippopotamus *Hexaprotodon sivalensis* from presumed upper Siwalik rocks near Janakpur in eastern Nepal. The Siwaliks of eastern Nepal are poorly exposed since the Churia Hills there are densely vegetated. Most outcrops are stream cuts, landslide scars, and deeply weathered lateritic hilltops, and are unsuitable for effective searches for fossils.

It was not until 1976 that vertebrate fossils were found in the Siwaliks of western Nepal: these specimens are adequate for preliminary biostratigraphic correlations (West *et al.*, 1978; Munthe & Gupta, manuscript). Western Nepal receives much less rainfall than does eastern Nepal (Sharma, 1973) and, because of rapid increases in human activity, is now subject to systematic devegetation in parts of the Churia Hills. Rather extensive gently inclined badlands areas have developed in central western Nepal between Butwal and Nepalganj and along the southern side of the Dang Valley. At the present time, two suites of fossil vertebrates are known from the western Nepal Siwaliks; as shown below, these indicate the presence of both lower and upper Siwalik rocks there.

The Babai Khola Fauna

West *et al.* (1978) reported on a suite of 52 fossil vertebrates from 17 localities scattered along about 34 kilometers of the hills immediaely south of Babai Khola (Fig. 1). These specimens were collected from a 500 meter thick sequence low in the southward-dipping local section. The fossiliferous rocks in this part of the section are fine-grained, buff-purple to gray sandstone, siltstone, and marlstone. Little coarse sandstone or conglomerate is present, and channel deposits are not prominent. Marlstones make up many of the more resistant units. These rocks probably represent poorly drained areas, characterized by ponds and sloughs. In contrast, lower Siwalik rocks to the west in India and Pakistan are almost entirely fluvial and indicative of much better drainage.

The specimens found along Babai Khola and reported by West et al. (1978) were found as surface lag fragments; only one specimen was in place. The fragmentary nature of the specimens plus the relative infrequency of fossils suggested that the Babai Khola area is not as productive as exposures of equivalent size farther west in India and Pakistan.

The Babai Koola fauna includes the following (Fig. 2):

- Pisces
  - Teleostei indet.
- Reptilia
  - Crocodilia indet.
  - Chelonia
    - Trionychidae, gen. indet.
  - Squamata
    - Ophidia indet.
- Mammalia
  - Carnivora
    - *Amphicyon palaeindicus*
  - Proboscidea
    - *Deinotherium pentapotamiae.*
    - Gomphotheriidae, gen. indet.
  - Perissodactyla
    - *Brachypotherium perimense*
  - Artiodactyla
    - *Hemimeryx pusillus*
    - *Dorcatherium* sp.

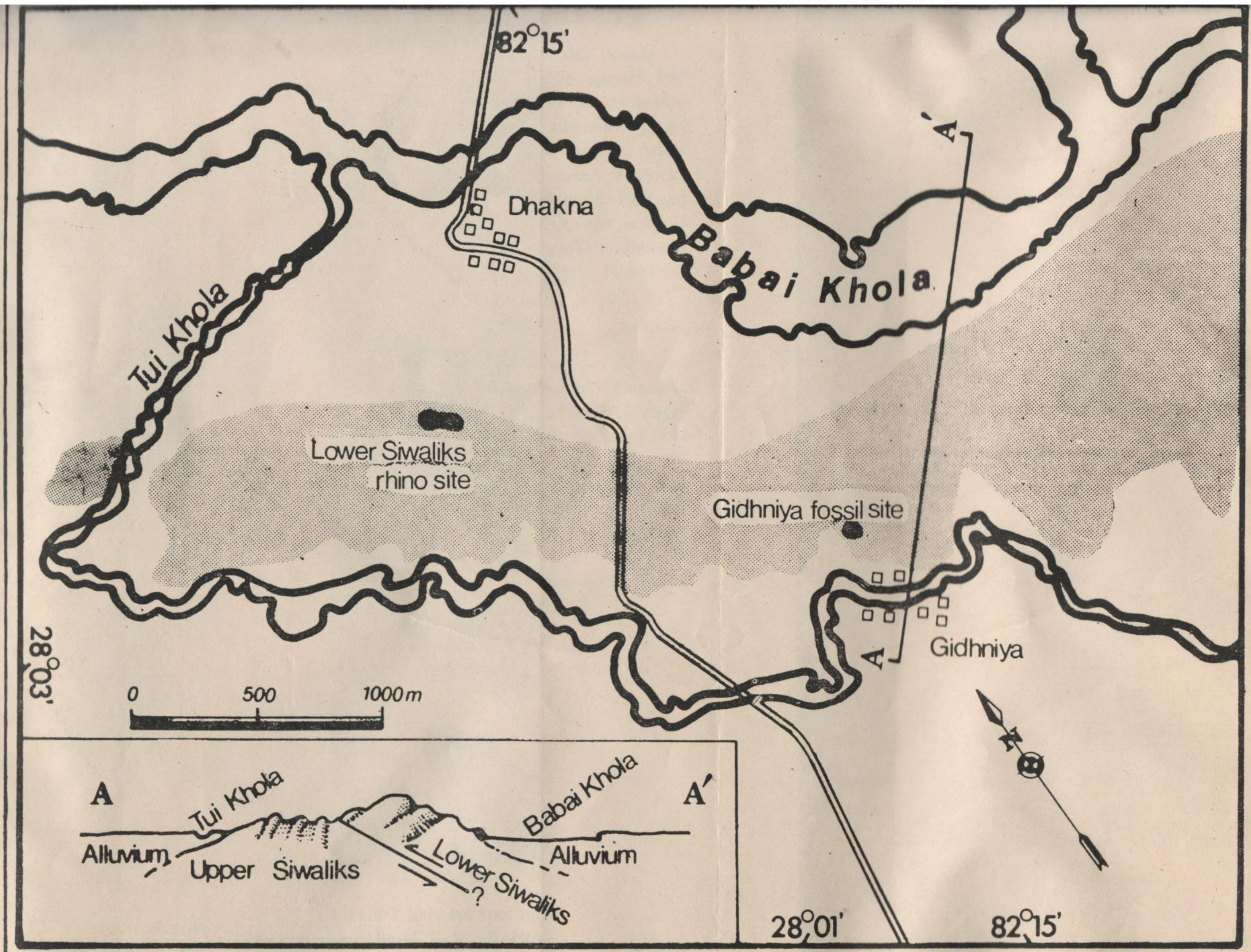

Figure 1. Sketch map of the southwestern end of the Dang Valley, western Nepal. Shaded area shows the outcrop of Siwalik rocks, with a

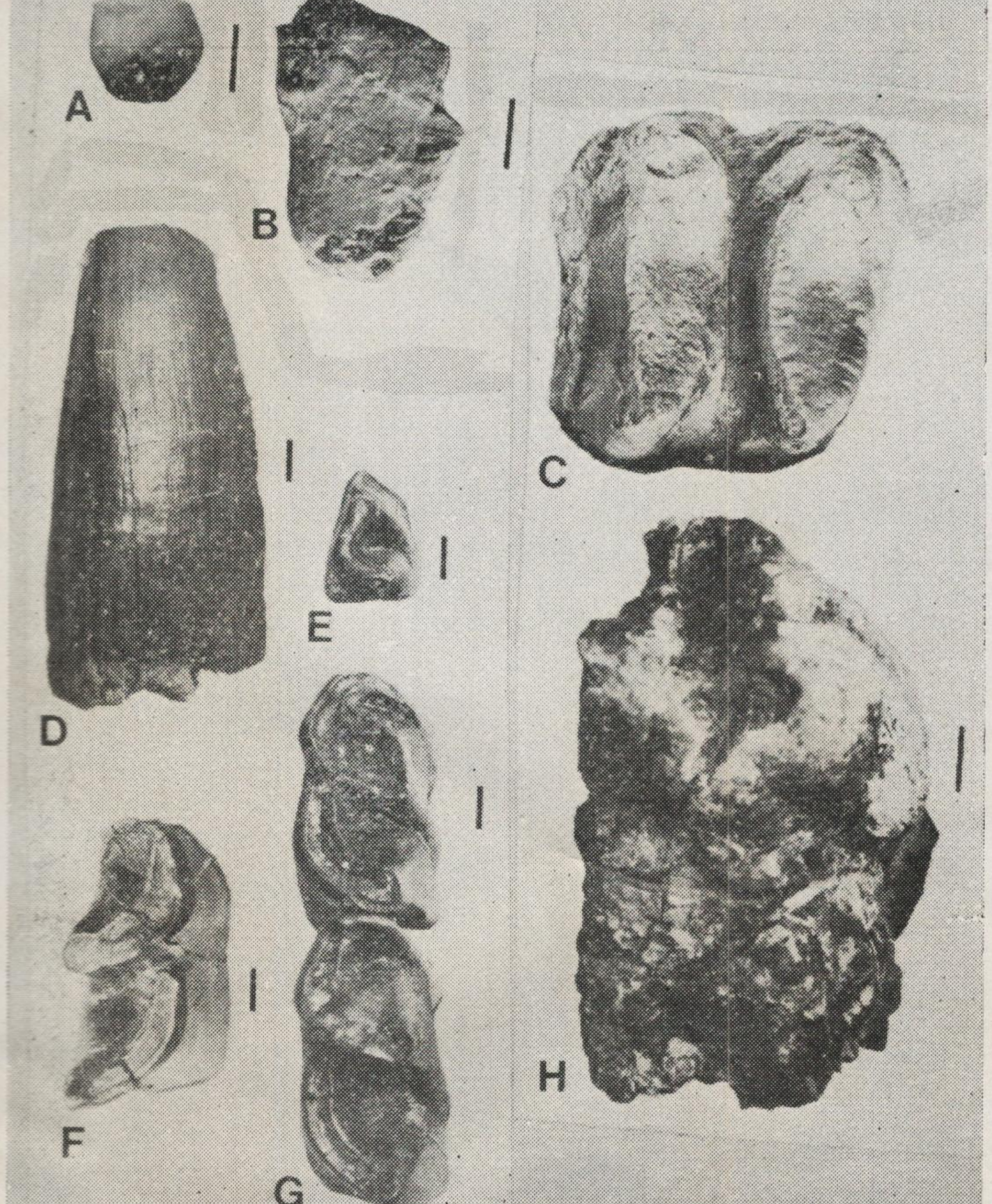

Figure 2. Vertebrate fossils from the Babai Khola fauna. A. Amphicyon palaeindicus molar trigonid, MPM N-76-6; B. Hemimeryx pusillus mandibular fragment, MPM N-76-4; C. Deinotherium pentapotamiae upper second molar, MPM N-76-5; D-G. Brachypotherium perimense, MPM N-76-48; D. Incisor; E. Right lower second premolar; F. Right lower second molar; G. Left lower first and second molars; H. Gomphothere molar fragment, MPM N-76-12. Scale lengths represent 1cm. Specimen numbers are Milwaukee Public Museum field numbers.

Figure 3. Selected specimens from the Gidhniya fauna. A. Hexaprotodon sivalensis skull, V/1, lateral view; B. Hexaprotodon sivalensis skull, V/1, palatal view; C. Elephas planifrons, lower third molar, v/10; D. Stegodon insignis, lower third molar, V/29; E. Bovid, left metacarpal, anterior view, V/31; F. Equus sivalensis, upper cheek tooth, V/5; G. Cervus sp., left lower first molar, occlusal and labial views, V/14; H. Antilopine, left lower third molar, occlusal and labial views, V/23; I. Cervus sp., left deciduous lower fourth premolar, occlusal and labial views, V/40. Specimen numbers from Centre of Advance Studies in Geology, Panjab University, Chandigarh, India.

This small assemblage was compared with the extensive Siwalik faunas of India and Pakistan and, despite the presence of only six mammalian species, was found to compare well with both the typical Chinji fauna and the Nagri fauna. The absence of the horse *Hipparion,* exceedingly common in all known Nagri faunas, led West *et al.* (1978) to consider this Nepal fauna as approximately equivalent to the Pakistan Chinji assembage and thus of late Miocene age. Rocks containing the Chinji assemblage have been dated paleomagnetically in Pakistan (Lindsay *et al.*, 1980); if the biostratigraphic correlation is correct, the animals of the Babai Khola fauna lived 11 to 12.5 million years ago. The marked difference in lithologies between the Babai Khola localities and typical Chinji Formation rocks makes a direct lithostratigraphic correlation impossible.

The Gidhniya Fauna

Recently Munthe & Gupta (manuscript) reported a second Nepalese Siwalik vertebrate fauna. Thirteen mammalian fossils were obtained near Gidhniya village (Fig. 1), only two kilometers from the most productive of the Babai Khola sites of West *et al.* (1978), and in the same outcrop band. The specimens are fragmentary, having been collected as surface float. One specimen, however, is a substantially complete hippopotamus skull and mandible. Subsequent aerial examination of the Siwalik outcrops between Babai Khola and Tui Khola suggest a major structural break between the two fossiliferous areas, with the lower Siwaliks thrust up over the upper Siwaliks. If this is the case, it can account for the time differential between the two faunas, as suggested below.

The Gidhniya fauna includes the following (Fig. 3):

- Mammalia
  - Proboscidea
    - *Stegodon insignis*
    - *Elephas planifrons*
  - Perissodactyla
    - *Equus sivalensis*
  - Artiodactyla
    - *Hexaprotodon sivalensis*
    - *Cervus sp.*
    - Antilopini, gen. indet.
    - Bovinae, gen. indet. (probably *Bubalus)*

Comparison of this suite of fossils with those from India and Pakistan suggests closest relationship with the Pinjor fauna. Opdyke *et al.* (1979) recently studied the magnetic reversal stratigraphy of upper Siwalik rocks in northeastern Pakistan. They related the first and last occurrences of the common Plio–Pleistocene mamm-

-alian taxa to the paleomagnetic record and, thus, to an absolute time scale. If the first occurreces in western Nepal are approximately the same as in northeastern Pakistan, the presence of *Equus, Cervus* and *Elephas* indicates a maximum date of 2.9 million years before present for the Gidhniya assemblage. Similarly, if the last occurrences are also coincident, *Hexaprotodon* and *Elephas* disappeared about 1.5 million years ago. Thus the upper Siwalik fauna from western Nepal may be regarded as having lived between 2.9 and 1.5 million years ago, and as being temporally equivalent to the Pinjor and Karewa faunas of India.

INTERMONTANE BASINS

Two of Nepal's prominent intermontane basins also contain fluvial sedimentary rocks. Both the Pokhara and Kathmandu basins have been mapped in detail (Sharma, 1973; Fort & Gupta, manuscript) and the extent of the Plio-Pleistocene basin fill rocks relineated.

The Pokhara Basin is the smaller of the two and contains sediments of predominantly fluvio-glacial origin. No means of precise dating (e. g. fossils, magnetic reversal stratigraphy, or radiometric stratigraphy) are available as yet, so the dating of the sediments is by correlation of depositional events with a similar sequence in the Kashmir Basin. Fort & Gupta (manuscript) regard the Pokhara Basin as having been filled more recently than was the Kathmandu Basin and showing more pronounced glacial influences.

The Kathmandu Basin is much larger and contains extensive fluvio-lacustrine deposits, up to 500 meters in thickness (Fig. 4). The finer-grained sediments, the so-called Kalimati clays, which are associated with local peat and lignite deposits, fill the central part of the basin. Several vertebrate fossils have been collected from these clays in the vicinity of Lokundol, near Chapagaon at the upper end of Nakhu Khola in the eastern part of the Kathmandu Basin (Gupta, 1975).

The Lokundol fauna includes the following:

Reptilia
- Crocodilia
  - *Crocodylus sp.*

Mammalia
- Proboscidea
  - *Archidiskodon (=Elephas) planifrons*
  - *Stegodon ganesa (=insignis)*
- Artiodactyla
  - *Hexaprotodon sivalensis*

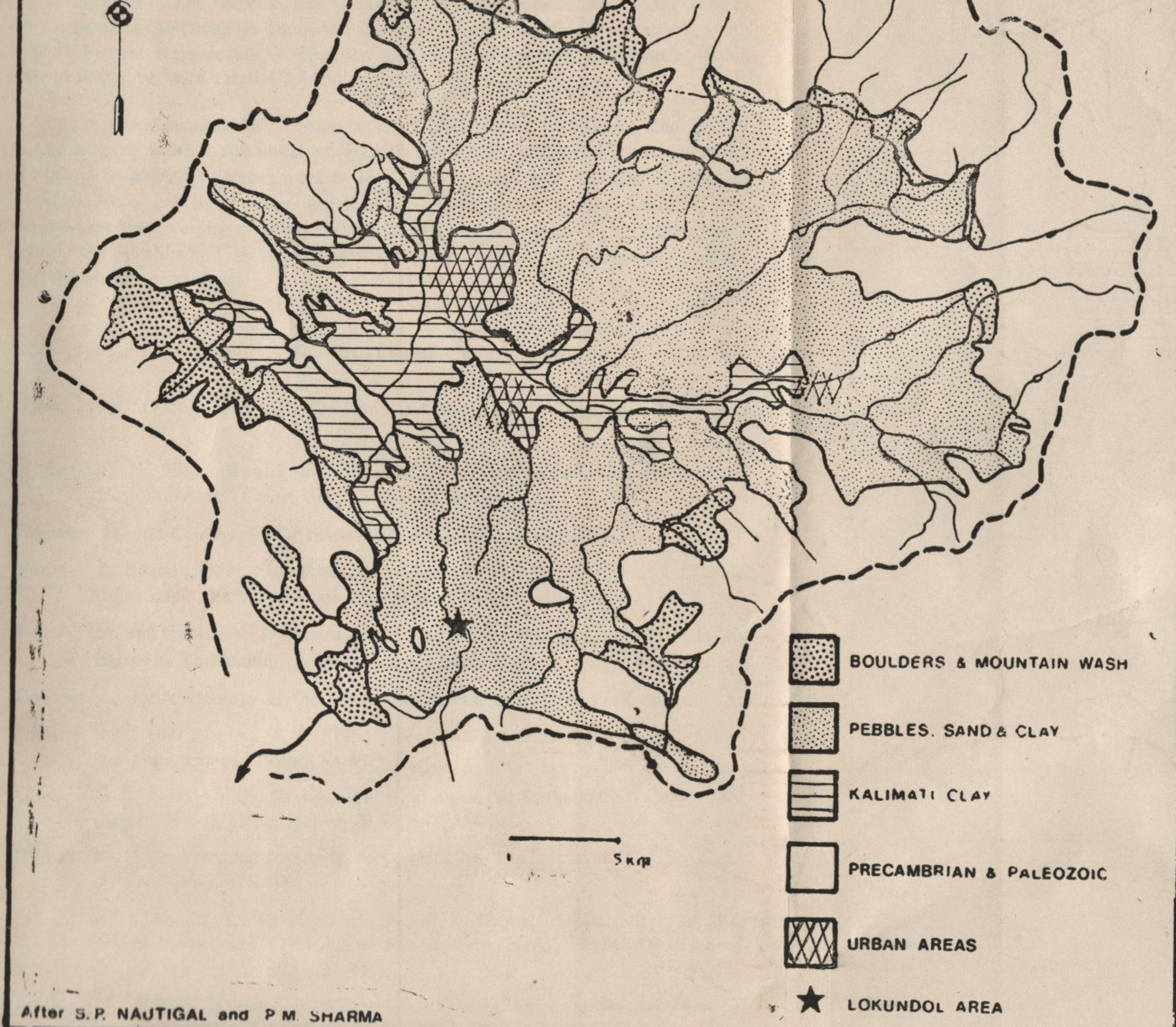

Figure 4. Sketch map of the Kathmandu Valley with the Lokundol area indicated by the dark star. From Fort and

Although it is not diverse, this assemblage contains some of the same taxa as are present in the Gidhniya fauna and therefore may be correlated tentatively with the Pinjor and Karewa faunas. Thus the Kalimati clays of the Kathmandu Basin are probably between 2.9 and 1.5 million years old.

It is now clear that the Neogene rocks of Nepal are fossiliferous and potentially of great value in the understanding of Himalayan geology and the evolution of life in South Asia. Further work by the authors is planned for the Siwaliks of western Nepal and the Pokhara and Kathmandu Valleys. Attempts will be made to increase the diversity of all the known faunas, to discover fossils at other levels within the Siwaliks and the basin deposits, and to develop a paleomagnetic standard for the Neogene in Nepal.

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