Pleistocene Fauna of India

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COVER PHOTOGRAPH :

Mr. B. C. Verma (GSI), the author, Dr. S. N. Rajaguru (Deccan College) and Mr. P. C. Khanna (GSI) (left to right) view a reconstruction of Hippopotamus at National Fossil Park, Saketi, Dist. Sirmur, Himachal Pradesh. In the background is a section of the Tatrot Formation.

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WITH SPECIAL REFERENCE TO THE SIWALIKS

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SIWALIKS OF NORTH INDIA

INTRODUCTION

The Siwalik Group, extending from the Indus river in northwest to the Brahamputra river in northeast (Fig. 9) has yielded a rich assemblage of vertebrate fossils of great geological interest. Mammalian remains are the most predominant of the varied fossils and include a large number of proboscideans, ungulates, carnivores, primates etc.

The Siwalik deposits are composed of fluviatile sediments, the grain size of which ranges from a clay fraction to boulders, derived from the rising Himalayas and laid down in giant alluvial fans. This sub-aerial waste of alluvial detritus has been swept down the mountains by rivers and streams and deposited at their foot. The latest Himalayan upheaval subsequently folded, deformed and elevated these deposits as a result of which the pre-Siwalik rocks of Carboniferous-Lower Tertiary age were thrust over the younger ones of the outer ranges. The thrust plane, known as the Main Boundary Fault, the topographic expressions of which have not as yet been definitely established, forms a significant tectonic feature. This Main Boundary Fault is not a single fault but a series of more or less parallel faults of similar tectonic and stratigraphic affinity (Wadia, 1966).

Since 1832, when Falconer reported some vertebrate fossils from the Siwaliks for the first time, a few attempts have been made to classify the beds. But the classification proposed by Pilgrim (1913) has been accepted by subsequent workers except for some minor alterations. On the basis of palaeontological evidences, he recognized three main divisions of the Siwalik Group, viz., Lower, Middle and Upper, as follows :

Siwalik System	Upper Siwalik	Boulder Conglomerate Stage Pinjor Stage
	Middle Siwalik	Dhok Pathan Stage Nagri Stage
	Lower Siwalik	Chinji Stage Kamlial Stage

Attempts are still being made to precisely define these divisions and to classify the entire belt of the Siwalik Group either primarily on the basis of fossil finds or by taking into consideration the type area lithology.

In the present work, the author has described in detail the geology and palaeontology of the Upper Siwalik rocks exposed to the northeast of Chandigarh between Pinjore (30° 48′ 10″ : 76° 55′ 15″) and Nalagarh (31° 05′ 00″ : 76° 41′ 30″) (Fig. 10). The palaeontological study is based on collections made in the localities spread over an extent of about 500 sq. km (Survey of India topo sheet Nos. 53 B/9, 53 B/13 and 53 B/14, Scale 1″= 1 mile) but the detailed mapping has been done only of a part covering an area of about 80 sq. km (Fig. 11). The author has made a thorough study of some elements in the vertebrate fauna, namely, the perissodactyles, artiodactyles, proboscideans and reptiles. Whereas, other fossils have only been represented by illustrative photographs, the detailed morphological analysis of some perissodactyles and reptiles, included in the present work, is expected to go a long way in abridging the existing lacunae in regard to the morphology and taxonomy of these groups.

Location :

The area under study comprises a southern part of topo sheet No. 53 B/13 and a northern part of topo sheet No. 53 B/14 (scale 1″=1 mile) of the Survey of India.

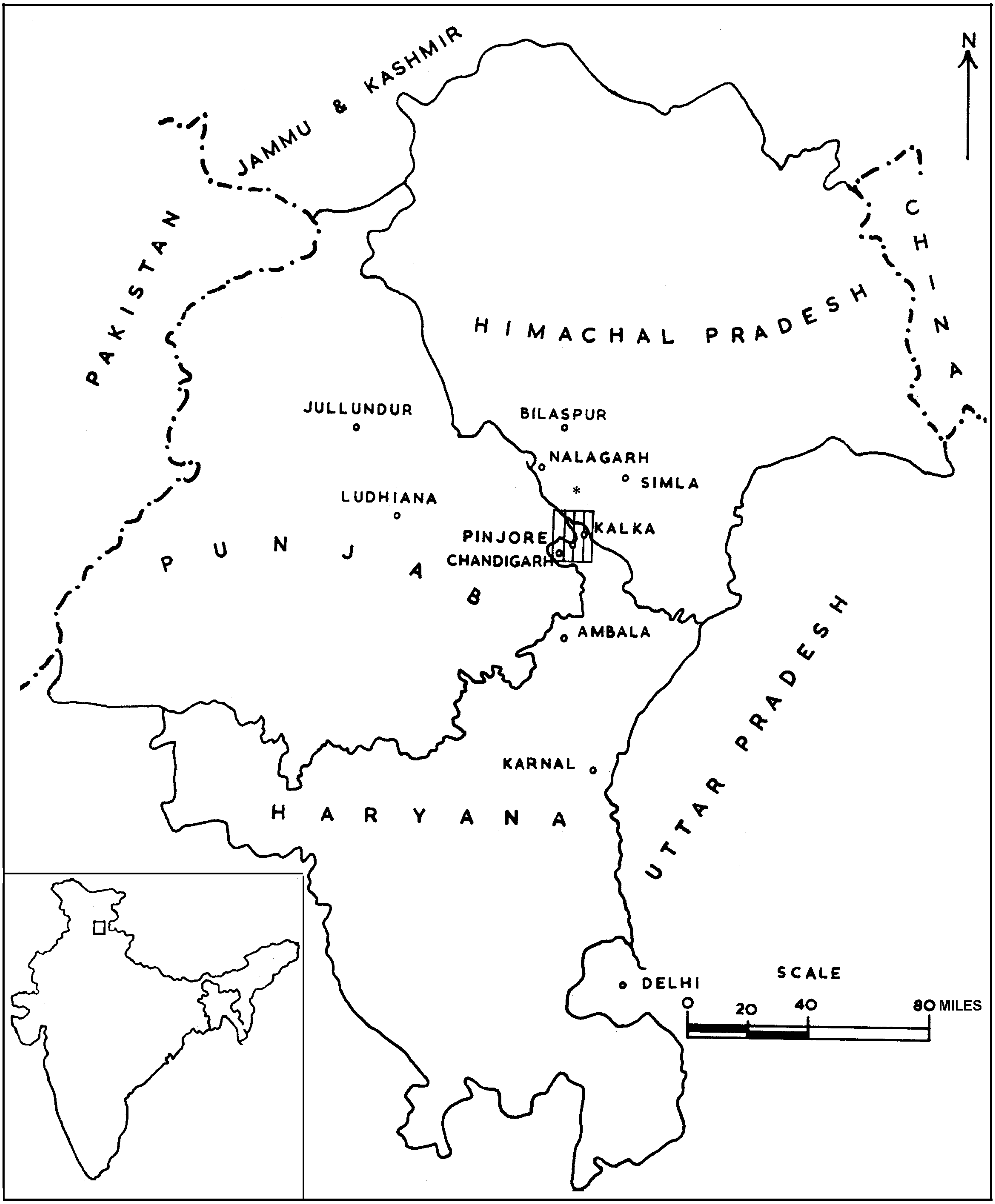

Fig. 10
Location map of the area.

(*See Fig. 11)

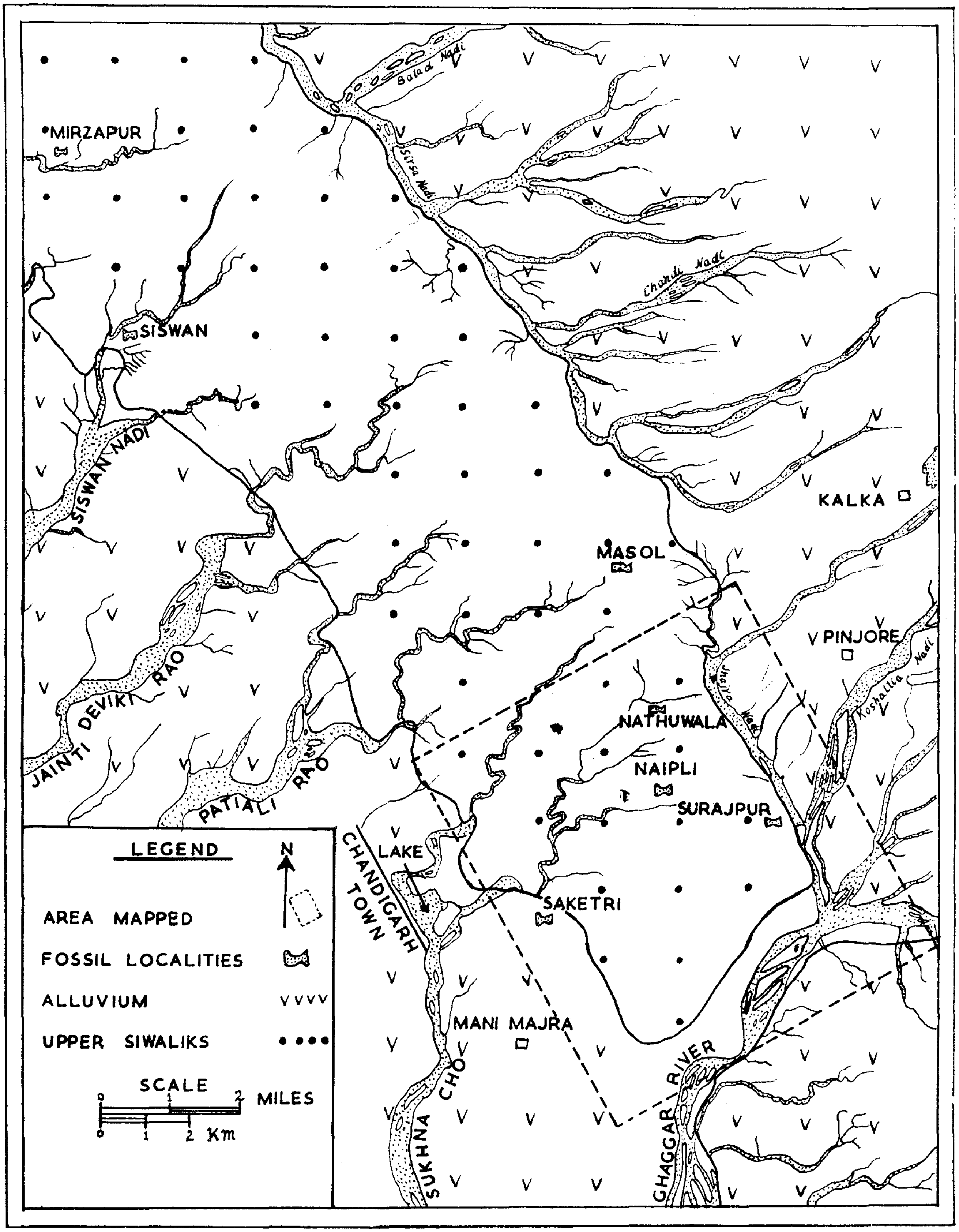

Fig. 11
Map showing fossil localities and the area mapped.

PREVIOUS WORK

Palaeontological investigations have been extensively carried out in the Siwaliks, well known for the wealth of fossil remains. The first serious effort to recover the remains of Siwalik vertebrates was perhaps made by W. S. Webb (geographer and explorer), who obtained fossils while exploring the heights of the Himalayan mountains (Colbert, 1935). These were later referred to by W. Buckland in the ' RELIQUIAE DILUVIANAE' published in 1823. Two army engineers, W.E. Baker and H. M. Durand, while working in the northern India also discovered fossils in 1836. H. Falconer, an English surgeon, found tortoise shells in 1832 in the Siwalik Hills of Dehra Dun. On the basis of these fossils, he referred to the beds around that area as belonging to the Upper Siwaliks. Falconer, who worked for many years in association with another civil servant, P. T. Cautley, an engineer, laid the foundation of vertebrate palaeontology in India. They made enormous collection from various localities in the Siwalik Hills and their commendable work provided the base for future palaeontologists. Their publications include a number of papers on various species of *Ursus, Felis, Camelus, Hexaprotodon,* etc., in ' ASIATIC RESEARCHES ' (1836a-f). Subsequently, Falconer and Cautley (1846-1849) brought out the most valuable and monumental work entitled ' FAUNA ANTIQUA SIVALENSIS ' consisting of illustrative photographs of several groups (Proboscidea, Equidae, Camelidae, Rhinocerotidae, Suidae, etc.) amply supported by explanations. Falconer's valuable contributions in ' PALAEONTOLOGICAL MEMOIRS' continued to pour in till his death in 1865. Finally, these memoirs edited by R. I. Murchison were published in 1868.

Medlicott (1864, 1873) and other officers of the Geological Survey of India engaged themselves in the study of Siwalik stratigraphy which subsequently proved to be of great help in the understanding of organic remains. On the basis of lithology, Medlicott gave a three-fold division of the Siwaliks, namely, Lower, Middle and Upper.

Lydekker, from 1874-1887, supplemented Falconer's work and published monographs on Tertiary and post-Tertiary vertebrates in various issues of ' PALAEONTOLOGIA INDICA '. His subsequent papers (1877, 1878, 1879, 1883) and also catalogues of fossil mammals in the British Museum (1885, 1886a) are indicative of considerable advancement over previous studies. On the basis of his finds, he classified the Siwalik rocks into lower and upper divisions and assigned a Pliocene age to them.

Our knowledge of Siwalik vertebrates was carried further by Pilgrim, another pioneer geologist, who contributed a great deal on this subject during the period from 1904-1944. He was the first person to establish a complete sequence of the Siwalik rocks on the basis of fauna (Pilgrim, 1913). There has so far not been any major change in his classification except for assigning different ages to the various rock units. Pilgrim (1911, 1926, 1932, 1939) produced a number of informative monographs in ' PALAEONTOLOGIA INDICA ' on fossil giraffids, suids, carnivores and bovids. His work on primates (1915, 1927) is of great importance and has considerably enriched the literature dealing with these highly evolved mammals.

Contributions in regard to Siwalik palaeontology by Matthew, Mook, Colbert, Osborn and Lewis are well known. Matthew's critical observations on Siwalik mammals (1929) is one of the significant contributions to Siwalik stratigraphy. Mook (1932, 1933) worked on some of the Siwalik reptiles housed in the American Museum. Colbert's monograph (1935) has been an excellent work dealing with almost all the groups of mammals excepting bovids and elephants. A list of fossils described by Colbert (1935) from some of the localities of the present study is given in Table 1. Osborn (1935, 1942) reviewed several notable contributions based on rich collections of Siwalik Proboscidea. The above mentioned contributions by Pilgrim, Matthew, Mook, Colbert and Osborn are mostly based on the collections made from the Siwalik Hills by Barnum Brown in

1921-1923. Gregory, Hellman and Lewis (1938) described, in a memorable monograph, primate remains from the Siwaliks which were collected by the Yale-Cambridge India Expedition in 1935. Lewis (1937), on the basis of his stratigraphic studies, also proposed a new correlation of the Siwaliks.

Chakravarty (1937, 1957) presented critical observations on the leading forms of Proboscidea. Further, contributions by Hooijer (1946, 1949, 1952, 1955a, 1958) describing various forms of horses, rhinoceroses, bovids, elephants, etc., have their own geological significance. Kurten (1957, 1958) has not only enriched our knowledge on the little known group of Siwalik hyaenas but also given his views about the age of the Siwaliks. Deraniyagala (1956, 1957) made important observations on fossil elephants and hippopotami of the Siwaliks.

In recent years, Sahni, Khan, Prasad and a few other palaeontologists carried out detailed and systematic investigations on the Siwalik fossil vertebrates. Sahni and Tripathi (1957) produced a monograph on Indian deinotheres giving therein descriptions of some new species apart from proposing a new classification . Sahni and Khan (1961a-e, 1964) described a number of fossils including those from some of the present localities. They also studied a part of the Upper Siwaliks in detail. A list of the fossils collected by Khan (1962) from some of the localities of the present investigation has been given in Table 2. Sahni and Mathur (1964), on the basis of detailed mapping of the Siwalik belt, gave a general account of the regional stratigraphy of the Siwaliks. Prasad (1962, 1964, 1968, 1969, 1970), who described a number of fossils including primates from various localities, has also made a detailed stratigraphical and palaeontological study of the Siwalik beds of Haritalyanagar, Himchal Pradesh.

Prasad and Satsangi (1964, 1966) described remains of *Hexaprotodon sivalensis* from the Pleistocene beds around Kalka and also reported a rare fossil hoof of a bovid from around Haritalyangar (H. P.). Verma (1969) described a new fossil primate *Procynocephalus pinjorii* from the Pinjor beds near Chandigarh. This is the first record of the genus from the Siwaliks. Khan (1971), who described a new genus of rhinoceroses, *Punjabitherium* from the Pleistocene beds suggested that this name should also be applicable to the fossil remains originally referred to *Rhinoceros platyrhinus*.

The present author's investigations of the Siwaliks have brought to light rich and varied fauna from these beds. Badam and Tewari (1968) and Tewari and Badam (in press) presented preliminary results of a statistical study of equid and bovid cheek teeth collected from the Pleistocene beds in the neighbourhood of Chandigarh. A new species of fresh water fossil turtle *Geoclemys sivalensis* from the Pinjor beds was also described by Tewari and Badam (1969). A preliminary account of the little known animals like *Ursus arctos* and *Sorex* sp. was also presented (Gupta and Badam, 1971 ; 1973). The author gave detailed morphological accounts of the skulls of some crocodiles—*Crocodylus biporcatus, Crocodylus palaeindicus* and of a partial skull of *Gavialis browni* (Badam, 1973; 1974; 1977). Observations made by Badam and Sharma (1973) on the milk dentition of *Stegodon insignis* have shown that this form does not warrant a specific distinction from that of *Stegodon ganesa.* A rich assemblage of vertebrate fossils from Kansil, a new locality near Chandigarh, has also been described (Badam and Sharma, 1975). The affinities of *Equus sivalensis* have been discussed in detail and it is thought that this form was zebrine in nature (Badam and Tewari, 1974). Fossils collected by the author from some of the present localities are given in Table 3.

Some meaningful contributions have recently been made on a part of the Siwaliks mainly based on the problems of stratigraphy and sedimentation of these beds (Halstead and Nanda, 1973; Nanda, 1973; Nanda and Halstead, 1975; Nanda and Tandon, 1976).

The author is aware that he may not have included all the works done on the Siwaliks, as it is not possible here to refer to the voluminous literature on these beds, in view of its extensive and diversified nature. However, only the more important works which have a direct bearing on the present study have been referred to.

GEOLOGICAL SETTING OF THE AREA

Introduction :

The present chapter describes the geological setting of the Upper Siwalik rocks, exposed northeast of Chandigarh and also gives in brief the salient features of the major structures in the area. Three stages, namely, Tatrot, Pinjor and Boulder conglomerate of the Upper Siwaliks have been recorded in the area.

The area is characterised by N-S trending open asymmetric anticline, the axis of which runs through the area west of Bhupindra Cement Works. The oldest rocks of the area, viz., the Tatrots, are exposed in the crest of the anticline both the limbs of which are in turn characterised by minor undulations. A major fault occurring in the south central part of the area trends in NNE-SSW direction and extends to a distance of about 7 km and disappears beneath the alluvium of the Jhajra river in the north and the terraces of the Ghaggar river in the south. Numerous minor faults have also been noticed.

The present area poses manifold problems regarding palaeontology, stratigraphy and sedimentation. The rocks are characterised by a shallow-water lagoonal facies. The sedimentary aspect governing the distribution of coarser and finer sediments has still remained a complicated feature (Raju and Dehadrai, 1962).

This area has yielded a good number of vertebrate fossils which provide ample clues for establishing the stratigraphic succession of the rocks. The importance of such palaeontological finds has already been acknowledged by the earlier workers. However, the work that has been done so far on the rich collection of fossils in relation to their detailed morphology and biostratigraphy cannot be considered to be adequate. It is hoped that this study will be helpful in giving a clear picture of the lacunae in the field of palaeontology and stratigraphy of the area.

Stratigraphy :

The problem of nomenclature of the Siwalik strata is a complex one. Inspite of the work of Pilgrim (1913), Colbert (1935), Lewis (1937) and others, the nomenclature still lacks uniformity. After reviewing the codes of nomenclature advanced by the International Subcommission on Stratigraphic Terminology of the International Geological Congress (1961*), the American Commission on Stratigraphic Nomenclature (1961**) and the Code of Stratigraphic Nomenclature of India (1971***), the author has thought it proper to broadly follow the scheme adopted by Lewis (1937) which has a close bearing on the subject-matter dealt with in the present work. But in place of his term 'Tawi Formation,' the term 'Boulder Conglomerate' has been retained and used herein. As for classification, the scheme proposed by Pilgrim (1913) has been essentially adhered to excepting the ages assigned by him to various formations from time to time. However, the basis for determining the ages of different formations has been supported by palaeontological and lithological studies of the area.

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* International Geological Congress (International Sub-commission on Stratigraphic Terminology) 1961, " Stratigraphic Classification and Terminology." Part 25, edited by H.D. Hedberg.

** American Commission on Stratigraphic Nomenclature 1961. " Code of Stratigraphic Nomenclature. " *Bull. Amer. Assoc. Petr. Geol.* vol. 45, no. 5, pp. 645-665.

*** Geological Survey of India 1971. " Code of Stratigraphic Nomenclature of India. " Miscellaneous Publication no. 20, pp. 1-28.

The Pinjors in this section are highly fossiliferous especially towards the top. The fossils collected include *Bos, Hemibos, Leptobos, Bubalus palaeindicus, Camelus sivalensis, Cervus punjabiensis, Stegodon insignis, Archidiskodon planifrons, Hypselephas hysudricus, Chilotherium intermedium* and constitute a faunal assemblage different from the Tatrots.

The present discovery of *Chilotherium intermedium* has increased the range of this species to an extent of 55-65 m into the Pinjors. It may be mentioned that hithertofore the occurrence of this species was restricted only to the Lower and Middle Siwaliks (Colbert, 1935).

The Boulder Conglomerates in this section including the top alluvium are almost 220 m tnick and are apparently distinguishable into 11 successive units, as given below :

	Lithological Units	**Approximate thickenss in metres**
11	Sub-Recent alluvium and boulders	26
10	Variegated clays	9
9	Boulder bed	40
8	Red Clay	15
7	Red silty clay	10
6	Boulder bed	27
5	Reddish clay	14
4	Red sandstone	15
3	Boulder bed	42
2	Red sandstone	14
1	Conglomeratic bed	9

SYSTEMATIC PALAEONTOLOGY

Introduction :

Out of a very large collection of fossils made by the author during the present investigations, only the following forms have been taken up for a detailed morphological study:

1) *Hipparion antelopinum* (Falconer and Cautley), 1849

2) *Equus sivalensis* Falconer and Cautley, 1849

3) *Rhinoceros sivalensis* Falconer and Cautley, 1847

4) *Rhinoceros palaeindicus* Falconer and Cautley, 1847

5) *Chilotherium intermedium* (Lydekker), 1884

6) *Crocodylus biporcatus* Cuvier, 1807

7) *Crocodylus palaeindicus* Falconer, 1857

8) *Gavialis browni* Mook, 1932

9) *Geoclemys sivalensis* Tewari and Badam, 1969

10) *Colossochelys atlas* Falconer and Cautley, 1844

A suitable set of terms for the dental morphology of the equids has been selected for usage in the present work after consulting the contributions of Stehlin and Graziosi (1935), Romer (1945), Simpson (1951) and Forsten (1968).

The classification of mammals given by Simpson (The Principles of Classification and a classification of Mammals : 1945) has generally been adopted here. The data concerning the classification of reptiles have been taken from Romer (*The Osteology of the Reptiles :* 1956) and Kuhn (*Die Reptilien System und Stammesgaschichte* : 1966).

Unless otherwise stated, all the specimen numbers used in the morphological descriptions refer to the collections made mostly by the author himself and some by Dr. E. Khan and deposited in the museum of the Centre of Advanced Study in Geology, Panjab University, Chandigarh.

Remarks which have a direct bearing on the study of the present collection have also been made on some of the more important specimens examined at the Indian Museum, Calcutta.

In the pages that follow, the specimens listed under the head 'ADDITIONAL MATERIAL' have been described in detail whereas those falling under the head 'UNDESCRIBED MATERIAL' have not been described, although a reference to them was considered essential for necessary identifications.

Tables showing comparative measurements of the fossils are given in the end.

RHINOCEROTIDAE Owen, 1845

Diagnosis :

Characterised by the presence of stout horns borne on protuberances of the nasal bone or sometimes of the frontal bone, horns consisting of a bundle of hair glued together into a compact mass; skull large and low, sharp occipital crest on the occiput, orbits open posteriorly, temporal fossae unusually large, various skull bones greatly ossified; limbs short, femur with a marked third trochanter, radius and ulna well developed, carpals stout and short, metacarpals four, fifth digit of anterior foot lost, tooth structure generally complicated, premolars usually molariform, incisors and canines sometimes wanting.

(Zittel, 1925; Romer, 1945)

RHINOCEROTINAE Dollo, 1885

Diagnosis :

Skull elongated, posteriorly elevated, sagittal crest absent, a sharp occipital crest on the occiput; nasal bones long, with projections of different lengths, with or without horn pad; superior incisors and canines generally absent, superior cheek teeth with ectoloph and two oblique transverse ridges, metaloph with crochet, ectoloph usually with crista,superior and inferior premolars generally molariform; neck short; manus tridactyl or tetradactyl, pes tridactyl.

(Zittel, 1925)

Remarks :

Falconer and Cautley (1847) recorded for the first time fossil rhinoceroses from the Siwaliks. Subsequently, many workers have described a large number of species from various Siwalik formations on the basis of which they proposed a distribution of various species. The following is an up to date list of fossil species of rhinoceroses and incorporates the early data with fresh evidence collected by the author.

Rhinoceros sivalensis Falconer and Cautley, 1847 (Upper Siwaliks)
Rhinoceros palaeindicus Falconer and Cautley, 1847 (Upper Siwaliks)
Gaindatherium browni Colbert, 1934 (Lower Siwaliks)
Rhinoceros platyrhinus Falconer and Cautley, 1847 (Upper Siwaliks)
Synonym : *Coelodonta platyrhinus* (Falconer and Cautley) (Upper Siwaliks)
Rhinoceros perimensis Falconer and Cautley, 1847 (Middle Siwaliks)
Synonyms : *Aceratherium perimense* (Falconer and Cautley) (Middle Siwaliks)
Rhinoceros planidens Lydekker, 1880
Rhinoceros iravadicus Lydekker, 1876
Aceratherium lydekkeri Pilgrim, 1910 (Middle Siwaliks)
Aceratherium blanfordi Lydekker, 1884 (Lower Siwaliks)
Chilotherium blanfordi (Lydekker) (Lower and Middle Siwaliks)
Synonym : *Teleoceras blanfordi mihi* Pilgrim, 1910
Rhinoceros sivalensis intermedius Lydekker, 1884 (Middle Siwaliks)
Synonym : *Chilotherium intermedium* (Lydekker), 1844 (Lower and Middle Siwaliks)
The last species has also been reported from the Upper Siwaliks by the present author.

Matthew (1929) and Colbert (1935) have treated *Rhinoceros palaeindicus* as a synonym of *Rhinoceros sivalensis.* However, the skull of *Rhinoceros palaeindicus* has a different profile and is larger and broader, especially across the frontals. Moreover, the molars of *Rhinoceros palaeindicus* are without a parastyle buttress unlike those of *Rhinoceros sivalensis.* In spite of this difference, the two species have provisionally been treated as synonyms in this work for lack of sufficient reference material without which it is not possible at this stage either to accept or reject the concepts of previous workers. Consequently, while giving a morphological account of these species in the present work, the author has been obliged to treat them separately.

RHINOCEROS Linnaeus, 1758

Diagnosis :

Large rhinocerotid with an elongate skull and a high occipital crest; single dermal horn on the nose; nasal bones arched; teeth moderately hypsodont; occiput inclined forward; no postorbital process; posttympanic and postglenoid processes anchylosed.

(Zittel, 1925; Colbert and Hooijer, 1953)

Type species : *Rhinoceros unicornis* Linnaeus

Rhinoceros sivalensis Falconer and Cautley, 1847

Synonymy :

Rhinoceros indicus fossilis Baker and Durand, 1836; *Jour. Asiatic Soc. Bengal.*, vol. 5, pp. 579-584.

Rhinoceros sivalensis Falconer and Cautley, 1847; *Fauna Antiqua Sivalensis,* pt. 8, pl. 73, figs. 2 & 3; pl. 74, figs. 5 & 6; pl. 75, figs. 5 & 6.

Rhinoceros sivalensis, Falconer, 1868; *Pal. Mem.*, edited by Murchison, vol. 1, pp. 157-169, pl. 14, figs. 1 & 2; pp. 514-516.

Rhinoceros sivalensis, Lydekker, 1881; *Pal. Ind.,* ser. 10, vol. 2, pt. 1, pp. 28-42, pls. 5 & 6, figs. 2 & 3; pl. 7, fig 1; pl. 10, fig. 4.

Rhinoceros sivalensis, Matthew, 1929; *Bull Amer. Mus. Nat. Hist.,* vol. 56, pp. 444, 531.

Rhinoceros sivalensis, Colbert, 1935; *Trans. Amer. Phil. Soc.*, n.s., vol. 26, p. 180, figs. 78 & 79.

Rhinoceros sivalensis, Colbert, 1942; *Amer Mus. Novitates,* no. 1207, pp 1-6.

Diegnosis :

Unicorn and large species of the genus, with a big horn boss, deep saddle in the cranial profile; forwardly inclined occiput; cheek teeth characterised by a flat ectoloph, molars with a parastyle buttress, distinct crochet which may unite with the protolph to enclose a fossette, crista absent, if present incipient.

(Colbert, 1935, 1942b)

Type— (Lectotype)—Brit. Mus. No. 39626, part of a skull.

Cotypes— Brit. Mus. Nos.
39625— a skull;
39646— a mandibular symphysis;
39647— part of a skull.

Locality and Horizon—Siwalik Hills, Upper Siwaliks.

ADDITIONAL MATERIAL

G/397 — Skull, about 2.8 km south of Naipli ;
B/30 — Skull, about 1.6 km north of Masol ;
B/36 — Skull, about 4.8 km south of Beddi ;
B/35 — Occiput, about 3.2 km south of Beddi ;
S/5 — LM^3, about 0.8 km west of Naipli.

UNDESCRIBED MATERIAL

A/556 — Right maxilla, about 0.8 km north northeast of Siswan.

In addition to the above, there are a number of isolated teeth and fragmentary limb bones in the present collection which do not merit description.

All the specimens are from rocks of the Pinjor Formation except for the specimen A/556 which probably comes from rocks of the Boulder Conglomerate Formation.

DESCRIPTION

Skulls

G/397 — An almost complete skull (Pl. 15, figs. 1, 2, 3; Fig. 29, A, B)

The skull is massive, heavily built and fairly well preserved but the tip of the premaxilla is broken. On the whole, the skull is longer (measuring about 580 mm in length dorsally) than that of *Rhinoceros palaeindicus* but the latter is wider across the frontals. The maximum width of about 230 mm is at the frontals directly above the orbits. The minimum width of about 122 mm is at the tip of the nasals above P^2. The nasals are quite convex and transversely broad. The most elevated part of their upper surface is pitted for the attachment of a strong horn making the nasal boss rugose. Posteriorly the supraoccipital is elevated much above the level of the frontals almost in line with the arched nasals forming thereby a deep concavity along the frontals. Consequently, the cranial profile of the skull differs considerably from other species in being deeply saddle shaped. This is characteristic of the species.

The specimen is also characteristic in the absence of an ossified nasal septum. Anteriorly there is a small longitudinal elevation in the middle of the frontal which diminishes posteriorly.

Viewed dorsally, the cranium is essentially lozenge-shaped and more dolicocephalic than *Rhinoceros palaeindicus.* The two parietal crests converge posteriorly forming the dorsal boundary of the temporal fossa. The parietal crests are separated from each other indicating that the braincase was much expanded. The suture between nasals and frontal is ill-defined and the postorbital process is not as elevated as in other species.

The sagittal crest is absent. The parietals are elongated, receding and gradually merge with the squamosals with a marked depression between the two. The zygomatic ramus of the squamosal does not extend as far anteriorly as in other species of rhinoceroses and most of the arch is formed by the jugal. The jugals originate above M^1. The posterior angle of the zygomatic arch is more rounded than in other species.

The orbits are oval and open at the back and have a direct connection with the temporal fossa, there being no postorbital process to the frontal. The preorbital depressions on both sides are well marked and deeper than in other Siwalik rhinoceroses.The lacrymals cannot be easily made out. There is interlocking of the posterior end of the jugals, near their union with the squamosals. The distance between right jugal and frontal is less than on the left side. This is the result of compression of the skull on the right side.

The occiput is not well preserved and its compression has resulted in considerable deformation, though the general outline is still like a trapezium. The plane of the occiput is inclined anteriorly and the occipital condyles are elevated well above the level of the cheek teeth. The left occipital condyle is broken and the right one is represented by a fragment. The general shape seems to have been oval. A remnant of the foramen magnum is concave dorsoventrally and convex from side to side. Laterally, the paraoccipital processes are deformed but sufficiently preserved to indicate the triangular shape. The auditory bullae are represented by two oval cavities which are much below the level of the basioccipital.

The basioccipital is oblong and in the form of a V-shaped ridge. It is much elevated at its middle part and then slopes down to the basisphenoid. The basisphenoid is continued into presphenoid which forms the anterior-most part of the floor of the brain cavity, being followed by vomer. The hinder border of the palate is deeply excavated, the horizontal plates of the palatines being very narrow. Orbitosphenoids form an elevated ridge on either side of the presphenoid and this ridge is more prominent than in other species. The rest of the floor cavity is occupied by the presphenoid.

The alisphenoid, forming the two side walls of the basisphenoid are prominent and high. Palatines extend to the posterior part of M^2. The presphenoid starts at the commencement of M^3. The pterygoids are slender and placed more vertically.

The teeth are hypsodont. There are six pairs of well preserved cheek teeth, P^{2-4} of the premolar series and M^{1-3} of the molar series. Remnants of P^1 are also present. This is in contrast to most of the rhinoceroses where P^1 is usually absent. The third molar has a slightly triangular crown pattern, the other teeth assume a rectangular or squarish pattern. There is a gradual decrease in size from the molars to the premolars. However, M^1 is the largest tooth in the series. There is a complete fusion of all the folds of the teeth resulting in the formation of island-like spaces or fossettes which are oval and, though somewhat bigger in dimensions, similar to those of *Rhinoceros platyrhinus*. The median fossettes of P^4 are large and deep. The fossettes become successively narrower and shallower towards the anterior and posterior sides of P^4. Some other small, rounded accessory cavities are present in RM^1, RM^2 and LM^2. RM^3 and LM^3 are slightly broken so that the median cavities are partly visible. The spaces between the median fossettes and the outer walls are composed of dentine, covered by a coating of enamel. The folds of LM^1 are in the process of fusion. The intervening walls between the two successive teeth show occlusion facets. All teeth are fully erupted. Excepting P^2 the general pattern of premolars and molars is essentially the same indicating an increasing molarisation of premolars. The enamel is slightly plicate. The fusion of various folds in the teeth and the degree of wear indicate that the individual to which the skull belonged was mature.

B/30 — Part of skull (Pl. 16, figs. 1, 2, 3; Fig. 30, A, B)

The skull is well preserved but the premaxillae, nasals and the zygomatic arches are broken. In general, it is elongated and massive. The dorsal part of the skull measures about 350 mm in length. The maximum preserved width is about 230 mm at the frontals above the orbits, but this is not the true width of the skull. There is a deep saddle in the cranial profile. The sagittal crest is absent.

Anteriorly there is a small longitudinal elevation in the middle of the frontal. The two parietal ridges run backwards from above the orbits and narrow towards the posterior side being separated from each other by the posterior width of the frontal which is reduced to about 50 mm. This is an indication of the relatively advanced structure of the species in that the braincase is much expanded in contrast to some primitive rhinoceroses like *Gaindatherium* in which the parietal ridges come very close together. Posteriorly, these are connected by a flat elevation.

The parietals are exactly defined as in G/397. Remnants of the jugal are present above M^2.

The orbits are somewhat oval. There is no postorbital process to the frontal so that the orbit is not divided from the temporal fossa.

The occiput is in a better state of preservation than in G/397. Its general shape is that of a trapezium, and it is inclined forward and surmounted by a sharp occipital crest. The occipital condyles are not as elevated as in G/397 and are smaller in size. The internal cavity of the foramen magnum is circular in outline.

The auditory bullae are feebly represented by two oval cavities. They are much below the level of the basioccipital which is in the form of a V-shaped ridge sloping down anteriorly to the basisphenoid which is in turn followed by the presphenoid. The palatine becomes wider towards the anterior portion ; the orbitosphenoid is more prominent than in the first skull, i. e., G/397. The ridges of the orbitosphenoid converge more anteriorly towards each other unlike in the other specimens of the species. The alisphenoid is more prominent and placed higher than in G/397. Pterygoid process is present.

The teeth are hypsodont as in G/397. On the right side of the jaw P^{2-4} of the premolar series and M^{1-3} of the molar series are well preserved. On the left side, only P^4 of the premolar series and

M^{1-3} of the molar series are present. The teeth of the left side are not as well preserved as those of the right. The broken premaxilla makes it impossible to determine whether P^1 was present or absent. In most of the teeth, the enamel is well preserved. The third molar has a triangular crown pattern while in the other teeth it is either squarish or rectangular. In M^3 the ectoloph is bent backwards and fuses with the metaloph. There is a gradual decrease in size from the molars to the premolars. The largest tooth in the series is M^2. All the teeth are fully erupted. All the folds of the teeth have completely fused resulting in the formation of shallow oval fossettes smaller in size than those of G/397. Towards the anterior side, they become smaller and shallower. Other accessory cavities are also present in the molars of the right side. The median cavities of M^2 and M^3 are open. The ectoloph is flat in all the teeth. The parastyle fold of one tooth bends over the metastyle fold of another. In M^2 and M^3, the protoloph and the metaloph with their corresponding folds, viz., antecrochet and crochet are well defined though the former is slightly indistinct as is the crista. Though the premolars are less complex than the molars, both exhibit essentially the same pattern.

B/36 — A fragmentary skull

The skull is poorly preserved and fragmentary. The nasals, jugals, postglenoid processes, the right zygomatic arch and most of the teeth are broken. The demarcation between the various parts on the dorsal and ventral sides is difficult to make out because of the friable nature of the specimen. Consequently, it is difficult to attempt a complete description of the same.

The skull is elongated, being about 550 mm in length on the dorsal side. The maximum preserved width of about 240 mm is along the frontals.

The outline of the frontal is somewhat rhomboidal. The two parietal crests running towards the posterior side from above the orbits are separated from each other as in the two earlier skulls (G/397 and B/30).

As seen from the side, the cranial profile of the skull is saddle-shaped, with the nasals and occipital region rising considerably above the supraorbital portion of the frontal. However, the cranial saddle is not as deep as in G/397 and B/30.

Only the remnants of RM^2 and RM^3 are present. In RM^3 the crochet and antecrochet tend to unite but the median cavity is still open. The crista is ill-defined. The stubs of the other cheek teeth suggest their high-crowned nature.

The occiput is smaller but somewhat better preserved than the rest of the skull. It is like a trapezium and is inclined forward. The occipital crest is not prominent. The occipital condyles which are small, form an arcuate shaped structure, the concavity being somewhat deep. The basioccipital is in the form of a V-shaped ridge. The exoccipitals, which form the major part of the occiput extend out laterally into paraoccipital processes on either side. A depression is present in the upper part of the exoccipital on both sides.

The structure of the teeth and the shallow concavity suggest that the skull belonged to a young individual.

Occiput

B/35 (Fig.31, A, B)

The shape of the occiput more or less resembles a trapezium. The occiput is inclined forward. There is a considerable amount of fusion of the elements which make up the occipital plate. The basioccipital lying below the foramen magnum seems to be fused with the exoccipitals as the demarcating line between the two is not traceable. The exoccipitals form a major part of the paired occipital condyles and extend laterally into the paraoccipital processes. The basisphenoid lies in front of the basioccipital, the former being bounded posterolaterally by the auditory region. The alisphenoid lies at the side of the basisphenoid. Anterior to the basisphenoid is the presphenoid whch forms the foremost part of the floor of the brain cavity. On either side is a plate of bone termed the orbitosphenoid. It is continuous with the presphenoid and essentially forms a part of it. The occipital condyles are convex transversely. The occiput is surmounted by a sharp occipital crest. The upper part of the occiput has two semicircular depressions separated by a vertical ridge.

Upper dentition

S/5 — Left M^3 (Pl.17, fig. 3)

The molar is large, hypsodont and exhibits a typical lophodont character, the cusps having fused into the ridges. It is triangular in outline. The ectoloph, the ridge formed by the two outer cusps, is thick and flat. Two obliquely and gently curved transverse ridges, known as the protoloph and metaloph are prominent. The former is big and the latter small. The parastyle buttress is prominent. The median valley is occupied by folds. The fold from the metaloph (crochet) tends to unite with that of protoloph (antecrochet) to enclose a fossette. The crista is incipient. The dentine is prominent and shining. Other characters cannot be deciphered for the molar is broken at one end.

Remarks :

In 1836, Baker and Durand working in the Siwalik Hills discovered a fossil specimen of rhinoceros which they named as " *Rhinoceros indicus fossilis* " on account of its similarities with *Rhinoceros indicus* Cuvier——a junior synonym of *Rhinoceros unicornis* Linnaeus. Falconer and Cautley (1847) investigated teeth of the Siwalik specimen in detail and stated that it had greater similarity to *Rhinoceros javanicus* Cuvier —— a junior synonym of *Rhinoceros sondaicus* Desmarest rather than to *Rhinoceros indicus.* This view was also held by Lydekker (1881). However, Falconer and Cautley (1847) concluded that the specimen referred to above was a new one and renamed it *Rhinoceros sivalensis.*

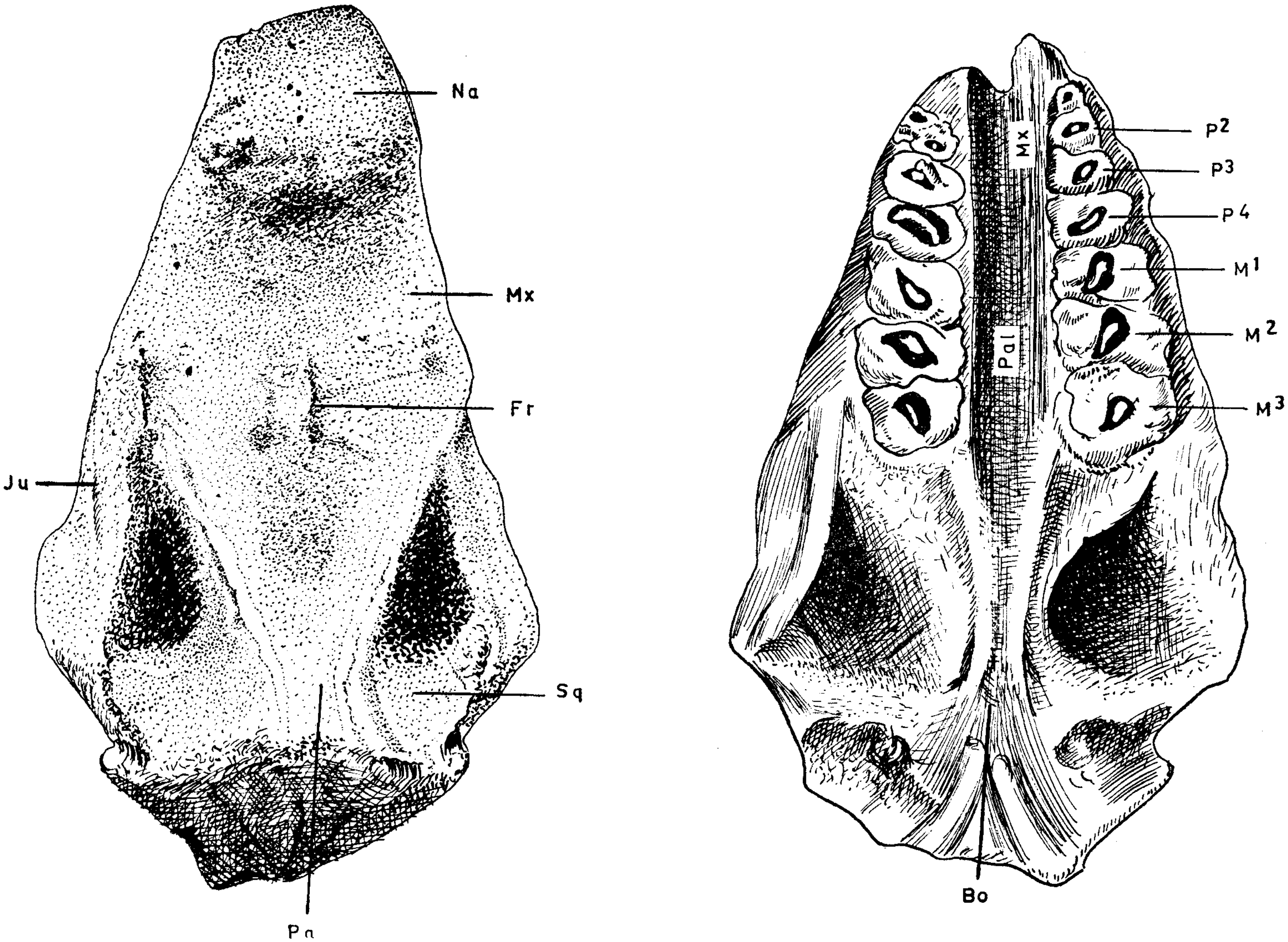
Rhinoceros sivalensis is a unicorn species and a dominant member of the Rhinocerotidae found profusely in the Upper Siwaliks. It is a large species with a single horn boss, deep saddle in the cranial profile and a forwardly inclined occiput. Its cheek teeth are characterised by a rather flat ectoloph and by the presence of the parastyle buttress (Colbert, 1942b). All these characters are discernible in the three skulls (G/397, B/30, B/36) under study.

The following table compares characters of these three species — *Rhinoceros sivalensis, Rhinoceros indicus* and *Rhinoceros javanicus* and demonstrates the degree of relationship of one form with the other.

	R. sivalensis	**R. unicornis* = *R. indicus*	**R. sondaicus* = *R. javanicus*
1.	Large	Large and robust	Smaller and lighter
2.	Nasals expanded into large rounded horn boss	Nasals expanded into large rounded horn boss	Nasals less expanded, horn boss pointed
3.	Deep saddle in the cranial profile	Deep saddle in the cranial profile	Shallow saddle in the cranial profile
4.	Occiput forwardly inclined	Occiput high and narrow	Occiput low and broad
5.	Skull considerably deep	Skull deep	Skull comparatively shallow
6.	Ectoloph of cheek teeth flat	Ectoloph of cheek teeth flat	Ectoloph of cheek teeth sinuous
7.	Parastyle buttress present	Parastyle buttress suppressed	Parastyle buttress prominent
8.	Well developed crochet and indistinct crista	Well developed crochet and crista	Crochet present but crista generally absent
9.	Teeth hypsodont	Teeth sub-hypsodont	Teeth less hypsodont
10.	Premaxillaries broad	Premaxillaries broad	Premaxillaries narrow

*Characters compiled from Colbert (1942b) and other sources.

It is evident that *Rhinoceros sivalensis* is more closely related to *Rhinoceros unicornis* than to *Rhinoceros javanicus* as has also been supported by Colbert (1942b). The views of Falconer and Cautley (1847) and those of Lydekker (1881), who regarded *Rhinoceros javanicus* as the descendant of *Rhinoceros sivalensis,* do not seem to be valid.



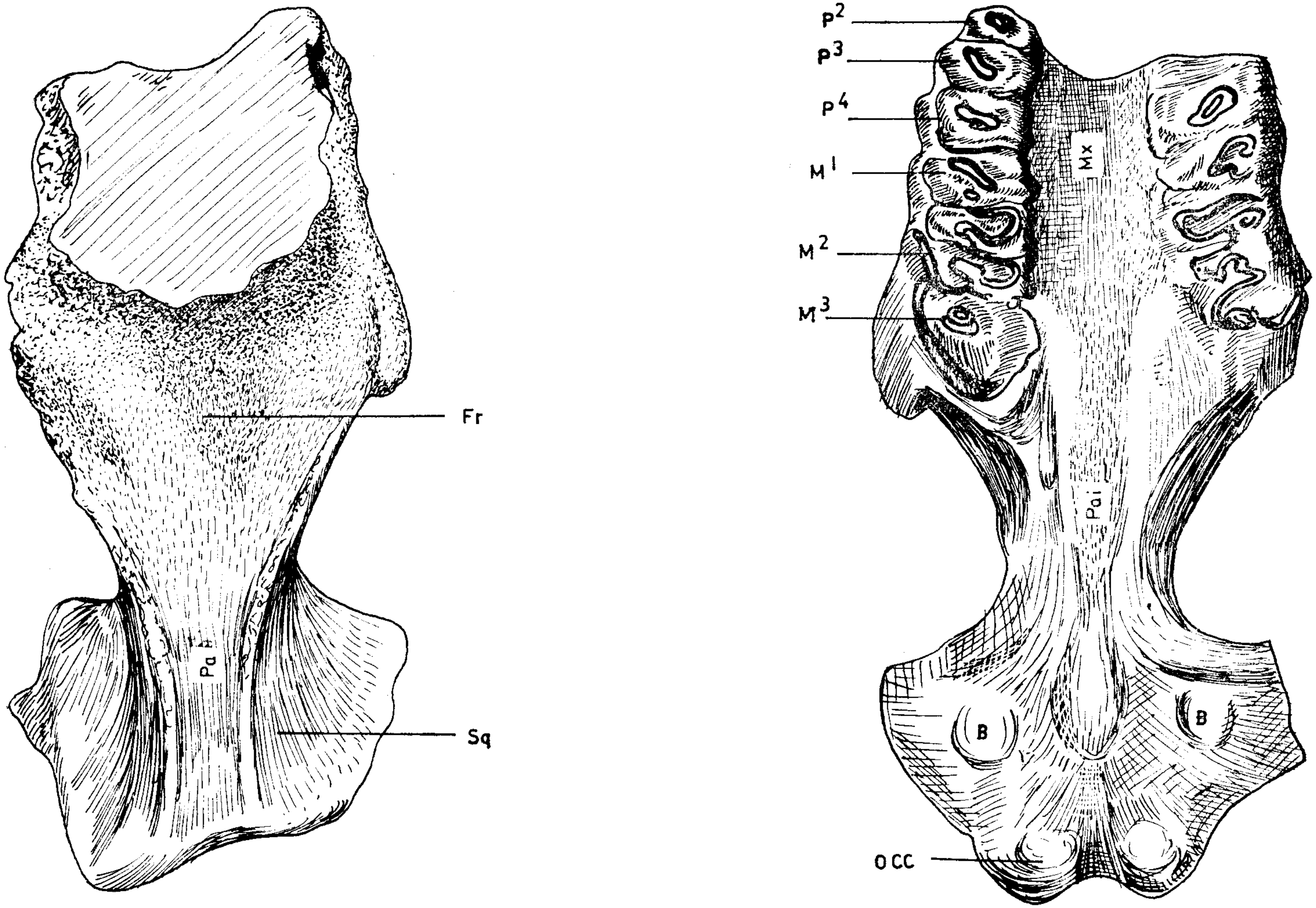
A : G/397, Dorsal view of skull

B : G/397, Ventral view of skull

Fig. 29

Skull of *Rhinoceros sivalensis* Falconer and Cautley

(All figures approximately one-fourth natural size).

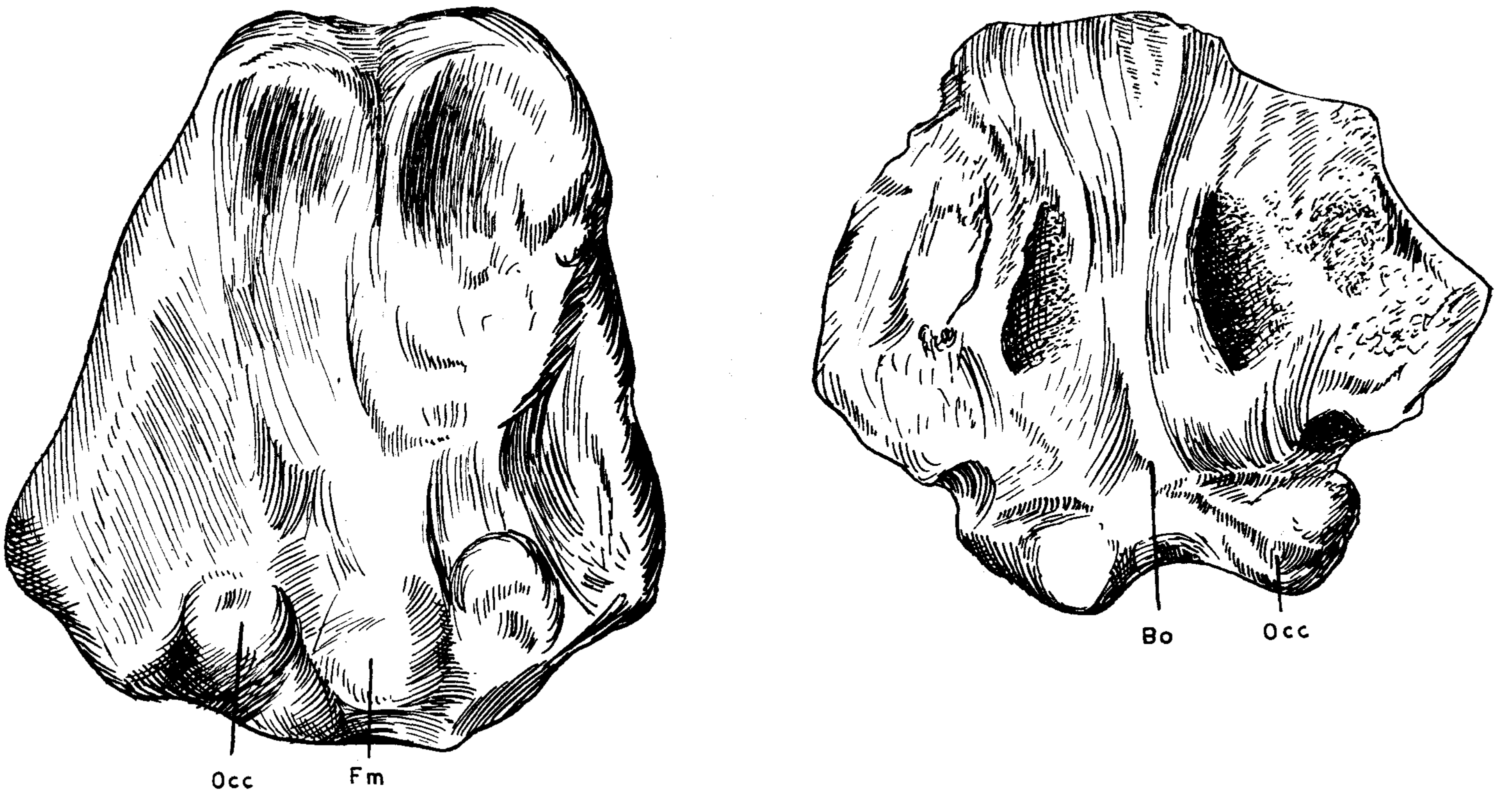


A : B/30, Dorsal view of skull

B : B/30, Ventral view of skull

Fig. 30

Skull of *Rhinoceros sivalensis* Falconer and Cautley
(All figures approximately one-fourth natural size).



A : B/35, Back view of occipital region

B : B/35, Basicranial view of occipital region

Fig. 31
Occiput of *Rhinoceros sivalensis* Falconer and Cautley
(All figures approximately one-third natural size).

Rhinoceros palaeindicus Falconer and Cautley, 1847

Synonymy :

Rhinoceros palaeindicus Falconer and Cautley, 1847 ; *Fauna Antiqua Sivalensis,* pt. 8, pl. 73, fig. 1 ; pl. 74, figs. 1-4 ; pl. 75, figs. 1-4.

Rhinoceros palaeindicus, Falconer, 1868 ; *Pal. Mem.,* edited by Murchison, vol. 1, pp. 157, 514-516.

Rhinoceros palaeindicus, Lydekker, 1876 ; *Pal. Ind.,* ser. 10, vol. 1, pt. 2, pp. 22-26, pl. 4, figs. 3 & 4.

Rhinoceros palaeindicus, Lydekker, 1881 ; *Pal. Ind.,* ser. 10, vol. 2, pt. 1, pp. 42-48, pl. 6, fig. 1 ; pl. 7, figs. 2 & 3 ; pl. 10, fig. 3.

Rhinoceros palaeindicus, Matthew, 1929 ; *Bull. Amer. Mus. Nat. Hist.,* vol. 56, pp. 444, 531-532.

Rhinoceros palaeindicus, Colbert, 1935 ; *Trans. Amer. Phil. Soc.,* n. s., vol. 26, pp. 180-182, fig. 79.

Diagnosis :

Unicorn and large, with a slightly different cranial profile, wider across the frontals, no parastyle buttress on molars, ectoloph flat, crochet distinct and frequently united with protoloph enclosing a fossette, crista indistinct or absent.

(Lydekker, 1881 ; Colbert, 1935)

Type — (Lectotype) — Brit. Mus. No. 16444, a skull.

Cotypes — Brit. Nus. Nos.

M 2727 — a skull ;
36740 — a skull ;
39644 — back portion of a left mandibular ramus ;
39645 — portion of a right mandibular ramus ;
39646 — mandibular symphysis :
39740 — a skull.

In addition to the above, the specimens figured in *Fauna Antiqua Sivalensis* (Pl. 75, figs. 1 & 2) are also cotypes.

Locality and Horizon —— Siwalik Hills, Upper Siwaliks.

ADDITIONAL MATERIAL

S/6 — Mandibular symphysis, about 0.8 km west of Naipli.

The specimen is from rocks of the Pinjor Formation.

In addition to the above, there are a number of vertebrae and parts of limb bones which have not been included for morphological study.

DESCRIPTION

Mandibular symphysis

S/6 — An almost complete mandibular symphysis (Pl. 18, fig. 3)

The specimen, which consists of a symphysis and two horizontal ramii, is on the whole well preserved. There are no median incisors. Only the roots of the outer incisors are present in this specimen. Their cross-sections indicate that the incisors must have been large and oval. There are four teeth on the left ramus, namely, P_2-$_4$ – M_1, while on the right, only the alveoli of the teeth are present. P_2 and P_3 are more worn than P_4 and M_1. P_4 is also slightly damaged on the buccal side. M_1 is not affected by wear indicating that the animal had just attained its full development at the time of death. The external faces of the teeth show no buttresses. The internal face of P_2 is straight. The row of teeth is not as straight as in the Indian rhinoceros nor as sinuous as in the Sumatran rhinoceros and is a diagnostic character of this species. The valley is open in all the teeth. The premolars are less molariform. The symphysis has a uniform channel sloping regularly from front to back as in the Javan rhinoceros. The specimen is devoid of P_1. This is in contrast to *Rhinoceros unicornis* where P_1 frequently persists.

The specimen has suffered slight compression from right to left. There is no marked constriction in the mandibular symphysis which reaches back to the posterior end of P_3. A foramen on each side for the passage of the 5th and 7th nerves is filled with cementing material. The gap between the two opposite incisors is also small. All these characters agree fairly well with the type specimen of *Rhinoceros palaeindicus* figured in *Fauna Antiqua Sivalensis.* It may be mentioned here that most of the lower teeth and ramii of the different species of rhinoceroses are very similar. The shape of the mandible and the incisor formula seem to be the only distinguishing characters.

Remarks :

Rhinoceros palaeindicus was first described by Falconer and Cautley (1847) and its horizon was given as Mio-Pliocene. Lydekker (1883) opined that the species occurred in the Pliocene. Pilgrim (1913) did not place the Upper Siwalik species into any particular formation. However, the specimen under study (S/6) is from beds referable to the Pinjor Formation.

According to Lydekker (1881), *Rhinoceros palaeindicus* is wider across the frontals, with a slightly different cranial profile and with a flat ectoloph in the molars, without parastyle buttress. It has one large nasal horn. The crochet is frequently united with the protoloph forming a fossette. The crochet is distinct while the crista is absent or indistinct.

Matthew (1929) regards the species as synonymous with *Rhinoceros sivalensis* assuming that the supposed differences in dentition and skull really do not exist and that these may very well be within the bounds of individual variation. Consequently, Colbert (1935, 1942b) also treats the species as a synonym of *Rhinoceros sivalensis.*

In the present collection, there is no skull of *Rhinoceros palaeindicus.* In spite of the best efforts of the author, he could not find a complete skull of this species either in the Indian Museum, Calcutta or elsewhere in India, without which it was not possible to compare the skulls of *Rhinoceros sivalensis* of the present collection with those of *Rhinoceros palaeindicus.* However, a thorough comparison has been made between the skulls of *Rhinoceros palaeindicus* (Lectotype) and *Rhinoceros sivalensis* (Neotype), both figured in *Fauna Antiqua Sivalensis* (Pl. 21, figs. 1 & 3). This study reveals the following distinctions (see Fig. 32, A, B,) :

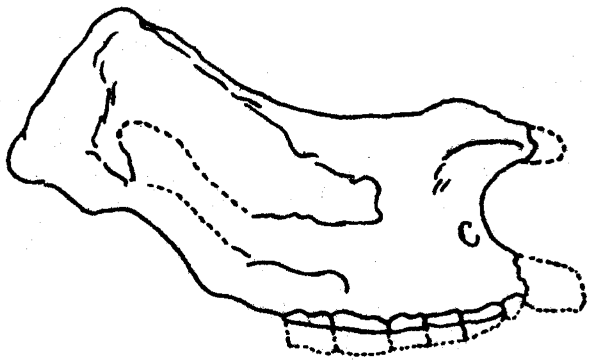
1) The cranial profile of *Rhinoceros palaeindicus* is less concave than that of *Rhinoceros sivalensis.*

2) The nasal cavity is deep and wide in *Rhinoceros palaeindicus* and deep but narrow in *Rhinoceros sivalensis.*

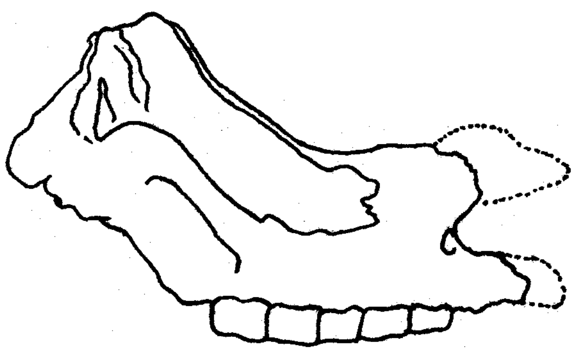
3) M^3 is situated about 10 cm from the end of the maxilla in *Rhinoceros palaeindicus* while in *Rhinoceros sivalensis* it starts only 3 cm away from the end of the maxilla.

4) The skull of *Rhinoceros palaeindicus* is higher than that of *Rhinoceros sivalensis.*

In addition to the above mentioned characters, there is no parastyle buttress on the molars of *Rhinoceros palaeindicus.* The species is also larger and wider across the frontals than *Rhinoceros sivalensis.* All these characters, in the view of the present author, do not seem to lie within the limit of species variation of *Rhinoceros sivalensis.* Due to the absence of a complete skull of *Rhinoceros palaeindicus,* the author has not been able to further justify his stand for the two different species. As such, he has been left with no choice but to treat the above two species as provisional synonyms of each other.



A : Brit. Mus. 16444, Lateral view of the Type skull of *Rhinoceros palaeindicus*



B : Brit. Mus. 39626, Lateral view of Neotype skull of *Rhinoceros sivalensis*

Fig. 32

Skulls of *Rhinoceros palaeindicus* Falconer and Cautley and *Rhinoceros sivalensis* Falconer and Cautley

(After Matthew, 1929 — showing differences in cranial characters)
(All figures approximately one-eighth natural size).

CHILOTHERIUM Ringstrom, 1924

Diagnosis :

Skull moderately large, frontal region slightly concave, horns absent, nasals straight and pointed, occiput vertical and large, orbits situated very high, postglenoid and post-tympanic generally separated ; premaxillaries short, cheek teeth hypsodont, upper incisors absent, lower incisors large, directed upwards and outwards, molars with strong crochet and antecrochet, protocone constricted ; mandibular symphysis transversely expanded ; manus and pes tridactyl.

(Colbert, 1935, Piveteau, 1958)

Type species : *Chilotherium anderssoni* Ringstrom

Chllotherium intermedium (Lydekker), 1884

Synonymy :

Rhinoceros sivalensis intermedius Lydekker, 1884 ; *Pal. Ind.*, ser. 10, vol. 3, p. 5, pl. 1, fig. 3.
Aceratherium gajense intermedium Pilgrim, 1910 ; *Rec. Geol. Surv. India*, vol. 40, p. 200.
Chilotherium intermedium, Matthew, 1929 ; *Bull. Amer. Mus. Nat. Hist.*, vol. 56, p. 508, fig. 32.
Chilotherium intermedium, Colbert, 1935 ; *Trans. Amer. Phil. Soc.*, n. s., vol. 26, pp. 201-226, figs. 91-93.

Chilotherium intermedium, Henshaw, 1942 ; *Car. Inst. Washington*, pub. 530, pp. 150-152.

Diagnosis :

A *Chilotherium* of medium size, very close to *Chilotherium blanfordi*, distinguished by its prominent parastyle fold and a slight constriction of the protocone.

(Colbert, 1935)

Type —— Ind. Mus. No. 34, a second right upper molar.

Locality and Horizon —— Sind ; Lower Siwaliks.

ADDITIONAL MATERIAL

A/555 — Maxilla, 1 km south of Bhupindra Cement Works ;
B/34 — Left ramus, 1 km south of Bhupindra Cement Works;
B/37 — Right ramus, 1 km south of Bhupindra Cement Works.

All the specimens are from rocks of the Pinjor Formation.

DESCRIPTION

Maxilla

A/555 — Part of left deciduous maxilla (Pl. 19, figs. 1, 2, 3)

The specimen is a part of the left maxilla of a juvenile skull with DM^3, DM^3 and DM^4. DM^2 is partly broken but the rest of the teeth are in excellent condition. DM^2 and DM^3 exhibit complicated crown pattern while DM^4 is simpler.

On DM^2, the ectoloph is convex outward. The protoloph is directed postero-medially which with the transverse metaloph gives the tooth an almost triangular outline. The parastyle fold is fairly strong. This tooth is characterised by a large anterior cingulum, separated by a valley from the protoloph and continuing round to the lingual side of the tooth enclosing the median valley. A number of transverse folds make the crown pattern rather complicated. A strong crochet and moderate antecrochet are present. The union of crochet and crista is not, however, complete. Prefossette and postfossette are open. The crochet of the metaloph joins the posterior crista from the ectoloph and closes off the median fossette. The enamel is rugose. The tooth is characterised by the inclined medial face of protoloph and the metaloph with the ectoloph.

DM^3 is similar to the permanent molars in general pattern. It is molariform and is more quadrate than the preceding tooth. It has a broad and almost flat ectoloph. Parastyle is strongly developed. The crochet is also strong. The protoloph and metaloph are somewhat oblique and of equal size. As in DM^2, the several transverse folds make the crown pattern very complicated. The protoloph remains separated from ectoloph. The strong crochet of the metaloph joins the posterior crista from the ectoloph and closes off the median fossette. The anterior and posterior fossettes are open.

DM^4 is also molariform, and is wider transversely than DM^3. It is larger and more nearly squarish in outline with a flatter ectoloph. The parastyle fold is larger than in the preceding teeth. The protoloph and metaloph are oblique. The protoloph is firmly joined to the ectoloph at one end The metaloph is slightly smaller than the protoloph and is connected with the ectoloph by the posteriorcrista. All the fossettes are open.

Ramii

B/34 — Part of left ramus (Pl. 20, fig. 1)

This specimen is a part of the left ramus of a juvenile skull with DM_2 and DM_3. The teeth show a typical rhinocerotid pattern, each being composed of two crescents. The specimen was found in the same horizon and only half a metre away from A/555. It probably represents the lower jaw of the same individual.

The mandible is quite slender, has very little depth, and thus may be ascribed to the youth of the individual. This character reflects in part a customary shallowness of jaw in *Chilotherium.*

DM_2 is long and narrow. It has a rectangular outline. The occlusal surface is marked by an elongate fossette which opens into a groove on the internal side of the tooth.

DM_3 is longer than DM_2. It is also narrow with a rectangular outline and lophid pattern. There is only one marked valley on the external wall of the tooth, while in DM_2 there is none. Both DM_2 and DM_3 consist of two lophids arranged as in typical rhinocerotids. There are no folds lying on the external walls of the teeth.

B/37 — Part of right ramus (Pl. 20, fig. 2)

This specimen is a part of the right ramus of a juvenile skull with DM_2, DM_3 and alveolus of DM_4.

The outline of the crown of both DM_2 and DM_3 is rectangular and there are no marked valleys on the external walls of the teeth. Both the teeth consist of two lophids each. The specimen seems to have come from a different individual and not from the one to which A/555 and B/34 belonged.

Remarks :

The type specimen of *Chilotherium intermedium* was described by Lydekker in 1884 as *Rhinoceros sivalensis intermedius.* Subsequently, after the establishment of the new genus, the species was renamed *Chilotherium intermedium.*

Colbert (1935) described in detail two species of *Chilotherium,* viz., *Chilotherium intermedium* and *Chilotherium blanfordi* from both the Lower and Middle Siwaliks. The present is, therefore, the first record of *Chilotherium intermedium* from the Upper Siwaliks. Matthew (1929) expressed his doubts in regard to *Chilotherium intermedium* being really separable from *Chilotherium blanfordi.* Cooper (1934) thought *Chilotherium intermedium* to be much more advanced in the evolution of the premolars, in the lesser development of the cingulum and in the development of a much larger crochet on the molars. He, therefore, treated it as a separate species. Colbert (1935) also treated *Chilotherium intermedium* as distinct on the basis of the following characters :

1) *Chilotherium intermedium* is smaller than *Chilotherium blanfordi.*

2) The antero-external pillar is prominent in *Chilotherium intermedium* while in *Chilotherium blanfordi,* the ectoloph is relatively flat.

3) In *Chilotherium intermedium* the protocone is much less cut off from the protoloph than is the case with *Chilotherium blanfordi.*

4) In *Chilotherium intermedium* the metaloph of the third upper molar is larger than the protoloph, while in *Chilotherium blanfordi* the two crests are more nearly equal in length.

Chilotherium bears such a close resemblance to *Aphelops* of the Ame ican Pliocene that it is rather difficult to separate them. A summary of some of the main points of distinction, mainly compiled after Matthew (1932), given below shows that *Chilotherium* makes the nearest approach to *Aphelops.*

	Aphelops :	*Chilotherium :*
1)	Hornless	Hornless
2)	Skull long	Skull long
3)	Frontal region strongly concave	Frontal region moderately concave
4)	Nasals much retracted	Nasals retracted
5)	Supraoccipital narrow	Supraoccipital broad
6)	Upper incisor vestigial or absent	Upper incisor vestigial or absent
7)	Premolars unreduced	Premolars unreduced
8)	Molars moderately high-crowned and of uniform size	Molars moderately high crowned and of uniform size
9)	Lower incisors less curved	Lower incisors less curved
10)	Lower limb segments long	Lower limb segments normal
11)	Feet slightly shortened	Feet slightly shortened
12)	Astragalus normal	Astragalus normal

It has further been suggested by Matthew (1932) that *Chilotherium* may be an immigrant into the Old World from America, and that it might represent a more progressive stage of *Aphelops.* He opines therefore that the name *Chilotherium* should be applied to the advanced species of *Aphelops*.

Remarks in Relation to the Indian Museum Collection of Rhinoceros Ssp. :

A brief account of the material of *Rhinoceros* Ssp. catalogued and housed in the Indian Museum Calcutta, has been given below :

Rhinoceros sivalensis

C 23 — Left upper second molars. ?
C 46 — Upper milkmolar. ?
C 40 — Upper first milkmolar.
C 37 — Upper molar.
C 36 — Right upper molar (*R. sivalensis var. gajensis*).
C 77 — Right M^2.
C 39 — Right upper premolar.
C 28 — Left P^2 and P^3.
C 34 — Right M^2 (*R. sivalensis var. intermedius*; Type for *C. intermedium*).
C 24 — Upper molar.
C 252 — Right DM^4.
C 38 — Right P^1.
C 56 — Mandible.

Rhinoceros palaeindicus

C 65 — Mandibular symphysis (cast).
C 66 — Mandible (cast).
C 67 — Lower outer incisor.
C 71 — Right DM^3.
C 25 — Last upper premolar.
C 274 — Left lower molar.
C 42 — Right M^3.

Rhinoceros unicornis

F 10 — Right upper molar.
F 113 — Upper molar.
F 114 — Upper molar.

Rhinoceros deccanensis

F 168 — Part of maxilla. (Pl. 22)

In addition to the above list, the following specimens were also examined but their specific identification is uncertain :

C 95 — Right ramus.
C 98 — Right ramus.
C 97 — Right ramus.
F 237 — Right ramus.
C 44 — Right lower molar.

The lower molar C 274 measuring 45/25/40 resembles the lower molars of the jaw S/6 of present collection. The crescents are touching and mildly folded in both. In the case of *Rhinoceros unicornis*, F 113, the crescents are deep and sharply folded.

In the mandibular symphysis, C 65 : cast (Pl. 18, figs. 1 & 2), the teeth are similar to those of S/6 of the present collection. The outer incisors in C 65 are big and somewhat oval in cross-section. Small remnants of the median incisors are also present.

Measurements (in mm) of C 65 :

Length of right tooth series P_2 - M_2	— 195
Length from tip of the outer incisors	— 300
Depth of jaw at P_2	— 110
Depth of jaw at M_2	— 140
Width transverse to incisors	— 115
Width of teeth varying from 15 to 25	

The position of the upper molars, C 23, cannot be ascertained with certainty because of their isolated nature. The smaller tooth of C 23 shows a lot of resemblance to S/5 of the present collection. However, in C 23, the ectoloph is differentiated into ridges and valleys and the median cavity is shallow. In the bigger tooth of C 23, the crochet is almost touching the metaloph and the median cavity is deep. The ridges are pointed. The bigger molar measures 60/50/60 and the smaller one 60/50/30.

The molar C 37 is quite different from S/5 of the present collection. There is a lot of variation in C 37 not within the limits of species variation. Hence in the opinion of the present author the identification of C 37 as belonging to *Rhinoceros sivalensis* is doubtful.

Neither of the teeth, C 39 and C 24, measuring 40/36/35 and 50/40/25, respectively, shows resemblance to S/5 of the present collection. In C 34, the second right upper molar, the type for *Chilotherium intermedium*, measuring 60/35/55, the ectoloph is concave and the parastyle buttress is prominent. The metaloph is smaller than the protoloph. The median cavity is deep and there is another rounded cavity at the posterior end.

PALAEOENVIRONMENT

Introduction :

According to Pascoe (1920) and Pilgrim (1919), the sediments constituting the Siwalik Formation were laid down in a single large river flowing from Assam to Kashmir. This single large river was named as 'the Indobrahm' by Pascoe and 'the Siwalik river' by Pilgrim.

Krishnan and Aiyanger (1940) postulated that the basin of deposition of the Siwaliks was in the form of a continuous lagoon or foredeep formed in front of the Himalayan range. Krishnan (1968) suggested that the Siwaliks are fresh water and partly continental deposits of lacustrine and fluviatile origin.

Sahni and Khan (1964) pointed out the cyclic or rhythmic characters of the deposits and also suggested a fresh water origin of the entire Siwaliks. But Sahni and Mathur (1964) opined that the sediments were also partly of lacustrine facies.

Glennie and Ziegler (1964) indicated a fresh water origin of the Siwalik beds on the basis of some laminated shell fragments of fresh water lamellibranchs and gastropods collected from these beds.

Fresh water ostracodes (*Candona candida, Hemicypris pyxidata* and *Ilyocypris bradyi*) described by Bhatia and Khosla (1967) and those described by Mathur (1972) (*Cypris subglobosa and Potamypris* sp.) from the Tatrots and Pinjors respectively in the neighbourhood of Chandigarh also support fresh water origin for these beds.

Besed on the study of petrogenesis, Chaudhri (1971) states that the Siwaliks were deposited in fresh water conditions in a shallow fast-sinking basin under conditions of rapid erosion, short transportation and rapid deposition.

From a detailed sedimentary analysis, Johnson and Vondra (1972) concluded that the entire Siwalik sequence was terrestrial. They also maintained that the differences in the abundance of fossil fauna reflect change in depositional regime within this environment.

Tewari and Sharma (1972), who described some charophytes (*Charites surajpurica, Charites indica,* and *Grambastichara bhatiai*) from the Tatrots and Pinjors of the Surajpur-Panchkula area, concluded that the sediments represent more or less lacustrine conditions. They further suggested that the water in which charophyte bearing sediments were laid down was more or less stagnant.

Present Observations :

The history of the physical environments under which the Siwalik fauna flourished can best be traced by studying the ecological habits of the animals which lived in the present area. It is to be noted that most of the fossils collected from the area include many related representatives of the recent fauna. For this reason, habits of similar living animals can form a basis for such a study. It can be safely inferred from the presence of fossil reptiles, viz., *Colossochelys atlas, Geoclemys sivalensis, Crocodylus biporcatus, Crocodylus palaeindicus* and *Gavialis browni* that the present area, traversed by a number of rivers, was occupied by lakes and swamps and was subjected to seasonal flooding indicating a rhythmic deposition. This fact is evinced by the alternation of coarser and finer sediments. By studying the habitats of the living fauna related to the above mentioned species, it can be taken for granted that the movement of water must have been rather slow. The presence of the fossil bovids (*Bos, Hemibos, Leptobos, Bubalus, Bison*) and those of *Cervus, Equus sivalensis* and *Hipparion antelopinum* indicates that the grounds surrounding the lakes and rivers were comparatively hard and dry but having pockets of rich vegetation here and there. The presence of *Rhinoceros sivalensis, Rhinoceros palaeindicus* and *Chilotherium intermedium* in the area support the fact that in addition to the hard grounds, the extensive swamps and water sheets that were present during the earlier phases of deposition of the Tatrots became fewer and shallower and gradually dried up as a result of which open plains dominated the area during the Pinjor times.

AGE OF THE UPPER SIWALIKS AND THE PLIO-PLEISTOCENE BOUNDARY IN NORTHERN INDIA

Different workers have offered different views in regard to the age of the Upper Siwaliks as also the boundary between the Pliocene and the Pleistocene. Although many of the authors including Pilgrim (1913, 1944), Matthew (1929), Colbert (1935, 1942a), de Terra and Chardin (1936), Lewis (1937) and Hooijer and Colbert (1951) have made meaningful attempts to define the Plio-Pleistocene boundary, their diverse approaches to and opinions on the problem of correlation of the Upper Siwaliks have made the whole issue all the more confusing. In order to have a better understanding of this complex problem, it is worthwhile to review, in brief, the different ideas expressed regarding the age of the Siwaliks.

Falconer (1968) considered the Siwaliks, now constituting the Upper Siwalik division, to contain a single unit fauna, and assigned Miocene age to these beds on the basis of fossils (tortoise shells) found by him in 1832 from the Siwalik Hills near Dehra Dun. According to Lydekker (1883), the Siwalik remains do not represent a single unit fauna and as such he divided the Siwaliks into Lower and Upper horizons assigning them a Pliocene age. It may, however, be mentioned that the fauna which Lydekker referred as relating to ' Lower Siwaliks ' actually belongs to Middle Siwaliks as we know them today.

Pilgrim (1913) classified the Siwaliks into Lower, Middle and Upper divisions, each comprising a distinct fauna. He traced the relationship of one unit fauna with that of the other. On the basis of a comparison of the Siwalik faunas with those of Europe, he (Pilgrim, 1934) assigned Middle Pliocene to Lower Pleistocene age to the Upper Siwaliks, Upper Miocene to Lower Pliocene age to the Middle Siwaliks and a Middle Miocene age to the Lower Siwaliks.

Further, he included in the Tatrots all the lower beds of the Upper Siwaliks which do not yield remains of *Equus* and *Elephas.* The tentative ages given by him are tabulated below :

Upper Siwaliks	Boulder Conglomerate zone	— Lower Pleistocene
	Pinjor zone	— Upper Pliocene (Val d'Arno)
	Tatrot zone	— Middle Pliocene (Montpellier)
Middle Siwaliks	Dhok Pathan zone	— Lower Pliocene (Pontian)
	Nagri zone	— Upper Miocene (Sarmatian)
Lower Siwaliks	Chinji zone	— Middle Miocene (Tortonian)
	Kamlial zone	— Middle Miocene (Helvetian)

Matthew (1929) modified Pilgrim's correlation and placed the Siwalik Group somewhat higher in the geological time scale. On the basis of an extensive study on Equidae (migration of *Hipparion* and *Equus* to India) supplemented by further studies on Camelidae and Giraffidae, he placed the Lower, Middle and Upper Siwaliks in Lower Pliocene, Middle Pliocene and Lower Pleistocene, respectively. According to him, the presence of *Equus* and *Camelus* is indicative of the Pleistocene age while that of *Hipparion* and giraffids a Pliocene age. Matthew compared the Siwalik faunas not only with those of Europe and Asia but also with those of North America. He laid more emphasis on the appearance of new elements in a fauna to be recognized as a safer guide for its correlation than the disappearance of the old ones.

Colbert (1935, 1942a) supporting the views of Matthew on the migration of Equidae adopted the following correlation :

SIWALIK SERIES	Upper Siwaliks	Boulder Conglomerate zone	Lower Pleistocene
		Pinjor zone	
		Tatrot zone	Transitional
	Middle Siwaliks	Dhok Pathan zone	Middle to Upper Pliocene
		Nagri zone	
	Lower Siwaliks	Chinji zone	Lower Pliocene
		Kamlial zone	Upper Miocene

de Terra and Chardin (1936) while studying the Pleistocene deposits in India, placed the Tatrots and Pinjors in the Lower Pleistocene and the Boulder Conglomerates in the Middle Pleistocene.

Lewis (1937), on the basis of his studies both on stratigraphy and *Hipparion* suggested the following correlation of the Siwalik Group :

SIWALIK SERIES	Upper Siwalik Group	Tawi Formation (new name for Boulder Conglomerate zone)	Middle Pleistocene
		Tatrot Formation (including Tatrot and Pinjor zones)	Lower Pleistocene
		Break	Upper Pliocene
	Middle Siwalik Group	Dhok Pathan Formation (Dhok Pathan zone)	Middle Pliocene
		Nagri Formation (Nagri zone)	Lower Pliocene
	Lower Siwalik Group	Chinji Formation (Chinji zone)	Upper Miocene
		Kamlial Formation (Kamlial zone)	Middle Miocene

As a result of discovery of *Equus* and *Elephas* in the Tatrot Formation, Lewis combined Tatrots with Pinjors and equated them to Lower Pleistocene. Later Studies, however, reveal that *Equus* has by mistake been stated to be found in the Tatrots (Pilgrim, 1940; von Koenigswald, 1950; Stirton, 1951). This correlation differs from the ones proposed by Matthew (1929) and Colbert (1935) in as much that he placed the Lower Siwaliks still lower on the geological time scale than suggested earlier by them. He further extended the range of the Upper Siwaliks still higher into the Pleistocene than it stood previously. Again, he proposed a stratigraphic break between the Dhok Pathans and the overlying Upper Siwaliks. The Tatrot Formation considered by Colbert to be a transitional one between Upper Pliocene and Lower Pleistocene also includes Tatrots and Pinjors as suggested by Lewis.

Pilgrim (1938), in the light of subsequent evidences, modified his own views in connection with the correlation maintaining that the Tatrot Formation is truly a distinct and independent horizon which has nothing to do with either of the correlations given by de Terra and Chardin (1936) and Lewis (1937). This is clear from his revised correlation of the Siwalik Group given below :

Upper Siwaliks	Boulder Conglomerate	Post-Cromerian	Pleistocene
	Pinjor zone	Villafranchian	
	Tatrot zone	Astian	Pliocene
Middle Siwaliks	Dhok Pathan zone	Pontian	
	Nagri zone	Sarmatian	Miocene
Lower Siwaliks	Chinji zone	Tortonian	
	Kamlial zone	Tortonian	

Pilgrim (1944), who continued his studies on this aspect, ultimately put Tatrots and Pinjors as equivalent to Upper Pliocene separating the Lower Pleistocene by Bain boulder beds.

At the International Geological Congress held in Great Britain in 1948*, several papers were presented on the problem of the Plio-Pleistocene boundary and there was a consensus that the Tatrots be considered as equivalent to the Upper Pliocene, Pinjors as equivalent to the Lower Pleistocene and Boulder Conglomerates as equivalent to the upper part of the Lower Pleistocene.

Hooijer and Colbert (1951), on the basis of a statistical survey, asserted that because of the emergence of nine holdovers from the Dhok Pathan Formation as also the appearance of six new genera, the Tatrots should be kept as purely transitional between the Pliocene and the Pleistocene. They have further confirmed that *Equus* in the Siwaliks made its first appearance in the Pinjors.

Hooijer (1955b) holds the Tatrot Formation of the Upper Siwaliks to be of early Villafranchian age on the basis of a molar of *Archidiskodon planifrons* collected by Lewis in 1932 from the Upper Siwaliks southeast of Tatrot village. Later, in 1957, Hooijer suggested that "....the Tatrot zone should be included in Lower Pleistocene just as the Pinjor zone, and that the Plio-Pleistocene boundary should be placed at the base of the Tatrot zone.. . ".

Sahni and Khan (1964) put the Tatrots as equivalent to the Upper Pliocene and the Pinjors to that of Lower Pleistocene supported by the evidence of absence of *Equus* and *Bubalus* in Tatrots and the absence of *Hipparion* and *Proamphibos* in the Pinjors.

From the Siwaliks, northeast of Chandigarh, the following fossils were collected by the present author at different levels from the Pinjor Formation :

> *Equus sivalensis, Rhinoceros sivalensis, Rhinoceros palaeindicus, Chilotherium intermedium, Bos, Bubalus, Hemibos, Leptobos, Bison, Cervus, Camelus, Archidiskodon planifrons, Geoclemys sivalensis, Crocodylus biporcatus, Crocodylus palaeindicus* and *Gavialis browni.*

The Tatrots in the area have yielded the following fossils :

> *Hipparion antelopinum, Proamphibos, Leptobos* and *Colossochelys atlas.*

It may be emphasized that the presence of *Equus, Rhinoceros, Camelus, Bubalus,* and Bos indicates a Pleistocene age for the Pinjors (Lydekker, 1882 ; Pilgrim, 1913 ; Matthew, 1929 ; Hopwood, 1936). The absence of *Hipparion* and *Proamphibos* in these beds further confirms this contention. The presence of the two in the Tatrots is indicative of a Pliocene age. The Boulder Conglomerate Formation in the area has yielded scanty and fragmentary remains of *Bos, Equus* and *Rhinoceros.* The scarcity of fauna in the Boulder Conglomerate Formation and presence of widely spread over heavy boulders derived from the rocks of earlier ages indicate a definite change in climate and environment including those of water and vegetation. Consequently, there could have been a partial extinction and migration of animals. The skeletons left behind were broken into numerous small fragments as a result of high energy environment evidenced by the transportation of the larger boulders. Most probably, there was a long time interval between the deposition of the Pinjors and that of the Boulder Conglomerates. Some of the fauna which survived during this process are represented in the Boulder Conglomerates on a much lesser scale. In view of the foregoing, the present author is inclined to assign Upper Pliocene (Astian) to the Tatrots, Lower Pleistocene (Villafranchian) to the Pinjors and probable Middle Pleistocene (Cromerian) to the Boulder Conglomerates.

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* Int. Geol. Congress, Rep. 18th Session, Great Britain, 1948, pt. 9, London, 1950, p. 6.

In the area studied by the author, Tatrots are distinguished from the Pinjors by the frequent occurrence of grey clays, predominance of fine sandstones and presence of only minor conglomeratic bands. It will not be out of place to mention that there is a comparative decrease of the bright grey beds towards the top of the Tatrots which pass almost conformably into the Pinjors. The lithological contact between upper part of the Tatrots and lower part of the Pinjors is generally marked by boulder bed. The lower beds of the Pinjors are throughout predominantly marked by grey silty clay. This particular characteristic together with the faunal evidence has led the author to regard it as the marker horizon for the lower Pinjors. There is, however, a definite faunal break between the Tatrots and the Pinjors as is evident from Table 21. The absence in the Pinjors of index fossil *Hipparion* — characteristic of the underlying Tatrots — supported by a relative change in lithology, marks the boundary between the Tatrots and the Pinjors (Badam, 1971). The beginning of the Pleistocene in India, therefore, coincides with the appearance of *Equus, Rhinoceros and Bos*. Similar fossils collected by de Terra and Paterson (1939) and the present author (Badam, 1968, 1972) from the Lower Karewas of Kashmir (Lower Pleistocene) lend further support to this occurrence. According to Hopwood (1935), *Equus, Bos* and *Elephas** form guide fossils for distinguishing the Pleistocene from the Pliocene. He further states that the presence of any one of the above mentioned fossils is a sufficient proof for assigning a Pleistocene age to the bed yielding the same. Similarly, the disappearance of *Hipparion* marks the upper limit of Pliocene (Matthew, 1929 ; Colbert, 1935 ; Kurten, 1958).

It can be concluded that the absence in the Pinjors of *Hipparion* and *Proamphibos* on the one hand and the first appearance of *Equus, Rhinoceros, Bubalus, Bos and Elephas* on the other not only amply distinguishes the Pinjors from the Tatrots but also assigns a Lower Pleistocene age to the former. Along with the disappearance of the archaic groups, the Plio — Pleistocene transition was contemporaneous with the emergence of progressive forms, some of which had a long history in the Pleistocene.

Comparative views on the correlation of the Upper Siwaliks are summarized in Table 22.

Incorporating the different schools of thought, most of which are based on interpretations of mammalian fauna discussed above, the status of the Plio—Pleistocene boundary in the northwest India is as follows :

1) At the base of Tatrot — on palaeontologic and palaeoclimatic considerations (e. g., Matthew 1929 ; Lewis, 1937 ; de Terra and Paterson, 1939 ; Colbert, 1951).

2) Between Tatrot and Pinjor — on palaeontologic considerations (e. g., Sahni and Khan, 1964 ; Badam, 1977).

3) Pinjor as transitional passage between Pliocene and Pleistocene — on sedimentary, stratigraphic and tectonic considerations (e. g., Wadia, 1951).

4) Between Pinjor and Boulder Conglomerate — on palaeontologic, stratigraphic, tectonic and palaeoclimatic considerations (e. g., Pilgrim, 1944; Gill, 1951; Balasundaram and Sastry, 1972).

Thus, there is no single agreement on the placement of the Plio-Pleistocene boundary in India since the selection of basic criteria for placing this boundary is still in a fluid stage as in man parts of the world. According to Sastry and Dutta (1977) the recognition of this boundary is based on the precise correlation of the Siwalik faunal zones with that of European stratotypes where the boundary is much better defined and chronologically established (see Table 23).

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* The presence of *Equus, Bos* and *Elephas* as marking the beginning of the Pleistocene has also been recommended at the London (1948) International Geological Congress. This faunal element in part or in toto is present during the Pleistocene in many parts of Europe (Gabunia, 1972) and Japan (Minato *et al.,* 1972).

A number of international colloquia on the problem of the boundary between the Pliocene and the Pleistocene in many parts of the world have been held in various countries and a clearer picture of the basic criteria on which this boundary should be based is gradually beginning to emerge. The current picture of the status of this problem has been reviewed ably by Nikiforova (1972).

The author feels that a complex method is necessary for establishing the lower boundary of the Quaternary in India. Until then, it would continue to be one of the most debatable problems in Indian stratigraphy. In this connection, application of palaeomagnetic dating technique may provide a firm basis for correlation of the Siwalik beds with the dated standard palaeomagnetic column. With the recently formed "International Union of Quaternary Studies" and the co-ordinated efforts put by scientists from various disciplines, new and valuable information on the problem of the Plio-Pleistocene boundary is expected to emerge throughout the world.

SUMMARY AND CONCLUSIONS

The area explored by the author lies to the northeast of Chandigarh in between Pinjore and Nalagarh. Here all the three stages of the Upper Siwaliks, viz.,Tatrot, Pinjor and Boulder Conglomerate are exposed in the following order :

Boulder Conglomerate Formation —	— Middle Pleistocene (Cromerian)
Pinjor Formation —	— Lower Pleistocene (Villafranchian)
Tatrot Formation —	— Upper Pliocene (Astian)

The Tatrot Formation comprising grey sandstone, siltstone, and clay is, at places, interbedded with red clay and red sandstone. Skeletal remains of *Hipparion antelopinum, Proamphibos, Leptobos* and *Colossochelys atlas* have been collected from these beds. The Pinjor Formation, extensively exposed in the area, consists generally of friable red clay and red siltstone. One of the conspicuous characters of this formation is the presence of conglomeratic bands exposed at irregular intervals. The author believes that on the basis of further exhaustive lithostratigraphic investigation it may be possible to divide the Pinjors into two units, the lower and upper, the former representing grey rock types and the latter red ones. But palaeontologically the above contention can only be confirmed if two distinct faunal assemblages are established by future studies.

The richly fossiliferous Pinjors, have yielded the following forms :

Equus sivalensis, Rhinoceros sivalensis, Rhinoceros palaeindicus, Chilotherium intermedium, Bos, Bubalus, Hemibos, Leptobos, Bison, Cervus, Camelus, Archidiskodon planifrons, Geoclemys sivalensis, Crocodylus biporcatus, Crocodylus palaeindicus and *Gavialis browni.*

The Boulder Conglomerate stage is characterised by thick conglomeratic horizons interbedded with thin red silty beds. The author has not been able to locate any fossils except for scanty and fragmentary parts of bovids, equids, and possibly rhinocerotids from these beds (see Table 25).

The area mapped by the author is generally marked by an open asymmetric anticline the axial plane of which trends in N-S direction. The only major fault present in the area almost trends NNE-SSW, the extent of which is not traceable beyond 7 km. A number of small flexures of local importance do exist in the area as evidenced by rapid changes in dip direction.

The following conclusions can tentatively be drawn as based on the present study.

1) The teeth of *Hipparion* found by the author reveal a close affinity to those of N. American species. However, the mixed characters observed in some of the teeth can be attributed to the effects of evolutionary changes during the process of its migration from N. America to the Old World.

2) In absence of the remains of *Hipparion theobaldi* in the present collection, it has not been possible to establish its existence in the area.

3) The detailed study of *Equus* from the Siwaliks reveals that there is only one species, namely, *Equus sivalensis.* The author is not agreeable to the views of Hopwood (1936) in regard to establishing another species, namely, *Equus cautleyi* on the basis of its size alone, disregarding other factors like age, sex and effects of environment. As such the author has a strong conviction that *Equus cautleyi* lies within the limit of species variation of *Equus sivalensis.*

4) As for the study made about *Equus namadicus* of the Narmada Pleistocene, the author is in full agreement with the views of Matthew (1929), Colbert (1935) and Hooijer (1949) that it is a junior synonym of *Equus sivalensis.*

5) An examination of the skulls of *Rhinoceros sivalensis* in the present collection and those of *Rhinoceros palaeindicus* from the published material reveals that both species have different and distinct cranial characters. As such the author is of the opinion that the two species cannot be considered as synonyms as stated by Matthew (1929) and Colbert (1935, 1942b). However, in absence of any complete skull of *Rhinoceros palaeindicus* in the present collection or elsewhere in India, the author has not been able to assert his point of view in favour of the two different species.

6) The range of *Chilotherium intermedium*, hitherto considered to be restricted only to the Lower and Middle Siwaliks (Colbert, 1935) extends up to the Pinjors.

7) It is for the first time that the author has been able to make a systematic study of *Crocodylus biporcatus* (a synonym of *Crocodylus porosus*) though a cursory account about this species was given by Falconer and Cautley in 1836.

8) The fact that *Gavialis browni* has now been found from the Pinjor Formation lends support that the species ranges in age from Lower Pliocene (Mook, 1932) to the Lower Pleistocene.

9) A new species of fresh water fossil turtle (*Geoclemys sivalensis*) has been reported from the Pinjor Formation.

10) The ' Upper Boulder Conglomerate ' as described by Sahni and Khan (1964) belongs to the oldest phase of terrace T1 deposit and there is no ground to justify the statement that it is a separate and distinct stage. The study made by the author reveals that the said T1 terrace deposit is of local importance present in the form of two outliers in the northern part of the area towards the west of Surajpur Railway Station. These outliers constitute an aggregate of haphazard boulders distributed horizontally within a loose clayey matrix.

11) The statement by Sahni and Khan (1964) that the ' Quranwala zone ' is a separate entity is rather questionable. The present study has revealed that the lower part of Pinjors in the area has yielded comparatively large number of fossils as against the top of the Tatrots as claimed by Sahni and Khan (1964).

12) It is also felt that the boundary between the Pliocene and the Pleistocene lies at the base of the Pinjors.

13) The present study supports the theory that the Tatrots and the Pinjors which are distinguishable both on the basis of lithology and fossil content, can definitely be considered to be valid formations.

14) The Tatrots and Pinjors are fresh water deposits. The lower one, i.e., Tatrots, are predominantly lacustrine while the Pinjors have been laid down in valley and open savannah grassland by river sediments arising from the adjacent rising hilly region. The Boulder Conglomerate deposits are the result of coalescence of vast boulder fans emanating from northern rising Himalayas.

15) On the basis of palaeontological evidence the Pinjor Formation of the Upper Siwaliks and the lower parts of the exposed Karewas (Lower Karewas) are of Lower Pleistocene age.

16) The climate during the Lower Pleistocene appears to be in general warm tropical. The upper parts of the Upper Siwaliks (represented by conglomerates and boulder beds) and of the Karewas (represented by conglomerates and semi lacustrine fluvial beds, known as the Upper Karewas) and glacial and glaciofluvial deposits and fluvial formations — all suggest a distinct change in the depositional environment after the Lower Pleistocene. Tectonic movements must certainly have played a major role in bringing about this change. As rightly pointed out by de Terra and Paterson (1939), the uplift of the Pir Panjal by about 1700 to 2000 metres brought a change in the climate of the Kashmir Valley.

APPENDIX B

TYPE SPECIMENS OF THE SIWALIK FAUNA

S. No.	Order	Species	Reference	Type	Horizon	Locality
144.	Perissodactyla	*Aceratherium iravadicus* (Lydekker), 1876.	*Pal. Ind.*, (10) 1,pp. 36-41, Pl. 5, figs.1-4.	G. S. I. C74, left M^2; C73, portion of a skull; C75, right M^2; C76, fragmentary maxilla.	Irrawaddy beds (Middle Siwaliks)	Irrawaddy river, Burma.
145.		*A. lydekkeri* Pilgrim, 1910.	*Rec. Geol. Surv. Ind.*, 40, pp. 65-6.	G. S. I. C1,C2,C3, C4,C7,C14,C18, C238(indefinite designation).	Middle Siwaliks	Near Hasnot, West Pakistan.
146.		*A. perimense* (Falconer and Cautley), 1847.	*Fauna Antiq. Siv.*, Pl. 75, figs. 13-16,Pl. 76, figs. 14-16.	Pl. 75, 76, (cotypes).	Middle (?) and Lower Siwaliks	Perim Island, Gulf of Cambay.
147.		*A. planidens* (Lydekker), 1876.	*Pal. Ind.*, (10) 1,pp. 41-3, Pl. 4, figs.7,9.	G. S. I. C13, 2 imperfect upper molars.	Middle Siwaliks	Padri, West Pakistan.
148.		*Chilotherium blanfordi* (Lydekker), 1884.	*Pal. Ind.*, (10) 3,pp.2-11, figs. 1-3; Pl. 1, figs. 1, 2, 6; Pl. 2, figs.1-3.	G. S. I. C268, left maxilla with M^{1-3}, (lectotype).	Bugti beds	Dera Bugti, Baluchistan (Pakistan).
149.		*C. intermedium* (Lydekker), 1884.	*Pal. Ind.*, (10) 3, p. 5, Pl. 1, fig.3.	G. S. I. C34, right M^2.	Lower Siwaliks	Sind, Pakistan .
150.		*Coelodonta platyrhinus* (Falconer and Cautley), 1847.	*Fauna Antiq. Siv.*, Pl. 72, figs.1-7;Pl.75, figs.9-12.	B. M. 33662, battered skull.	Upper Siwaliks	Not known.

S.No.	Order	Species	Reference	Type	Horizon	Locality
151.		*Equus namadicus* Falconer and Cautley, 1849.	*Fauna Antiq. Siv.*, Pls. 81-82.	B. M. M2683, skull, (lectotype).	Upper Siwaliks and Upper Pleistocene (Narmada Valley)	Not known.
152.		*E. palaeonus* Falconer and Cautley, 1849.	*Fauna Antiq. Siv.*, Pls. 82, figs.9,10, 11.	B. M. M2685, premaxilla; M2686, premaxilla; M2689, left ramus,(cotypes).	Upper Pleistocene (Narmada Valley); Siwalik Hills	Not known.
153.		*E. sivalensis* Falconer and Cautley, 1849.	*Fauna Ant. Siv.*, Pls. 81-85.	B. M. 16160, cranium.	Upper Siwaliks	Not known.
154.		*Gaindatherium browni* Colbert, 1934.	*Amer. Mus. Novit.*, 749.	A. M. 19409, skull.	Chinji zone	Near chinji Rest House, West Pakistan.
155.		*Hipparion antelopinum* (Falconer and Cautley), 1849.	*Fauna Antiq. Siv.*, Pls. 82-85.	B. M. M2647, right maxilla with P^2-M^3 (lectotype).	Dhok Pathan zone	Not known.
156.		*H. chisholmi* (Pilgrim), 1910.	*Rec. Geol. Surv. Ind.*, 40, P. 67.	—	Middle Siwaliks	Near Dhok Pathan, West Pakistan.
157.		*H. perimense* Pilgrim, 1910.	*Rec. Geol. Surv. Ind.*, 40, p. 66.	Ref. Lydekker, *Pal. Ind.*, (10) 3, pp. 11-14, Pl. 3, figs. 1,2.	Middle Siwaliks	Perim Island, Gulf of Cambay.
158.		*H. theobaldi* (Lydekker), 1877.	*Rec. Geol. Surv. Ind.*, 10, p.31.	G. S. I. C153, left maxilla with milk molars.	Dhok Pathan zone	Keypar, West Pakistan.
159.		*Macrotherium salinum* Cooper,1922.	*Ann. Mag. Nat. Hist.*, 9, 10, pp.542-4, figs.1-3.	B. M. M12239, left M^3.	Lower Siwaliks	Near Chinji, West Pakistan.
160.		*Nestoritherium* (?) *sindiense* (Lydekker), 1876.	*Pal. Ind.*, (10) 1, p. 64, Pl. 8, figs. 11-14.	G. S. I. D 99, median phalanx.	Manchar beds (Siwaliks) of Sind	Sind, Pakistan.
161.		*N. sivalensis* (Falconer and Cautley), 1843.	*Proc. Geol. Soc. London*, 98, Pl. 2.	B. M. 15366, right and left maxilla with left P^2-M^3 and right P^4-M^3.	Upper Siwaliks	Not known.
162.		*Rhinoceros palaeindicus* Falconer and Cautley, 1847.	*Fauna Antiq. Siv.*, Pl. 73, fig. 1,Pl.74, figs. 1-4, Pl. 75, figs.1-4.	B. M. 16444 skull, (lectotype).	Upper Siwaliks	Not known.

S. No.	Order	Species	Reference	Type	Horizon	Locality
163.		*R. sivalensis* Falconer and Cautley, 1847.	*Fauna Antiq. Siv.*, Pl. 73, figs. 2,3 ; Pl. 74, figs.5-6 ; Pl. 75,figs.5,6	B. M. 39626, part of a skull, (lectotype).	Upper Siwaliks	Not known.

TABLE - 3

DISTRIBUTION OF FOSSILS REPORTED FROM THE AREA BY THE AUTHOR

FOSSILS	Beddi			Bhupindra Cement Works			Darra Kharuni			Masol			Mirzapur			Naipli			Nalagarh			Nathuwala			Siswan		
	T	P	BC	T	P	BC	T	P	BC	T	P	BC	T	P	BC	T	P	BC	T	P	BC	T	P	BC	T	P	BC
Hipparion antelopinum (Falconer & Cautley), 1849				X			X			X						X			X			X					
Equus sivalensis Falconer & Cautley, 1849		X									X?			X	X		X			X			X			X	
Rhinoceros sivalensis Falconer & Cautley, 1847		X									X						X										X?
Rhinoceros palaeindicus Falconer & Cautley, 1847																	X										
Chilotherium intermedium (Lydekker), 1884					X																						
Crocodylus biporcatus Cuvier, 1807																	X										
Crocodylus palaeindicus Falconer, 1859																	X										
Gavialis browni Mook, 1932																	X										
Geoclemys sivalensis Tewari & Badam, 1969																	X										
Colossochelys atlas Falconer & Cautley, 1844																X											
Bos									X					X			X									X	
Hemibos															X?		X			X							
Bubalus					X																		X				
Leptobos											X					X									X		
Bison																	X						X				
Proamphibos	X			X																					X		
Cervus		X															X			X							
Camelus																	X									X	
Archidiskodon planifrons											X						X						X				

T — Tatrot P — Pinjor BC — Boulder Conglomerate

TABLE - 12

COMPARATIVE MEASUREMENTS (in mm) OF SKULLS AND UPPER TEETH OF RHINOCEROS SIVALENSIS

(Present Collection)

DIMENSIONS	Skulls			Occiput
	G/397	B/30	B/36	B/35
Length of skull (dorsally)	580	350	550	—
Length of skull (ventrally)	600	520	—	—
Width of skull (across zygomatic arches)	370	—	—	—
Width of skull (across the frontals)	230	220	240	—
Height of skull (top of orbits to M^3 alveolus)	212	170	200	—
Height of skull (at frontals)	240	240	250	—
Width at tip of nasals	122	—	—	—
Preorbital length	208	—	—	—
Postorbital length	240	—	—	—
Width of condyles	132	—	—	—
Maximum width of occiput (along exoccipital)	260	—	230	244
Maximum width of occiput (anterior and (along supraoccipital)	110	—	—	130
Height of occiput (interior border of foramen magnum to occipital crest)	200	—	200	207
Length of occipital condyles	—	—	110	135
Width of palate at M^2	65	—	—	—
Width of palate at P^1	72	—	—	—
Length of molar series	275	—	230	—
Length RM^1—RM^3	134	—	—	—
Length LM^1—LM^3	141	—	—	—
Length RM^3—RP^4	177	—	—	—
Length LM^3—LP^4	176	185	—	—
Length RM^3—RP^2	—	240	—	—

UPPER DENTITION	Skulls				Molar
	G/397		B/30		S/5
	Left	Right	Left	Right	
Anteroposterior diameter P^1	27	30	—	—	—
Transverse diameter P^1	25	24	—	—	—
L/W P^1	1.08	1.2	—	—	—
Anteroposterior diameter P^2	29	27	—	30	—
Transverse diameter P_2	37	42	—	44	—
L/W P^2	0.78	0.64	—	0.68	—
Anteroposterior diameter P^3	37	37	—	35	—
Transverse diameter P^3	54	57	—	55	—
L/W P^3	0.68	0.65	—	0.63	—
Anteroposterior diameter P^4	38	38	44	45	—
Transverse diameter P^4	68	64	65	60	—
L/W P^4	0.55	0.58	0.69	0.75	—
Anteroposterior diameter M^1	41	42	50	50	—
Transverse diameter M^1	72	70	60	60	—
L/W M^1	0.56	0.6	0.88	0.88	—
Anteroposterior diameter M^2	48	45	50	54	—
Transverse diameter M^2	70	72	50	70	—
L/W M^2	0.68	0.62	1.0	0.77	—
Anteroposterior diameter M^3	52 ?	49 ?	30 ?	50	64
Transverse diameter M^3	62 ?	68 ?	40	60	47
L/W M^3	0.83 ?	0.72 ?	0.75 ?	0.82	1.3

TABLE - 13

COMPARATIVE MEASUREMENTS (in mm) IN MANDIBULAR SYMPHYSES OF RHINOCEROS Ssp.

RAMII	F.A.S. (1847) Pl. 75, fig. 10 *R. palaeindicus*	F.A.S. (1847) Pl. 74, fig. 1 *R. platyrhinus*	Lydekker (1881) Pl. 6, fig. 3 *R. sivalensis*	Lydekker (1881) p. 39 *R. javanicus*	P. U. Specimens *Rhinoceros palaeindicus* A/553	P. U. Specimens *Rhinoceros palaeindicus* A/557	Present Specimen *R. palaeindicus* S/6
Anteroposterior diameter P_2	17	29	32	27	23 ?	29 ?	33
Transverse diameter P_2	11	19	—	—	17	20	21
L/W P_2	1.55	1.52	—	—	1.35 ?	1.45 ?	1.57
Anteroposterior diameter P_3	34	29	—	—	39	42 ?	40
Transverse diameter P_3	21	25	—	—	33	29	25
L/W P_3	1.62	1.16	—	—	1.18	1.44 ?	1.60
Anteroposterior diameter P_4	42	42	—	—	43	—	43
Transverse diameter P_4	27	28	—	—	39	—	26
L/W P_4	1.55	1.5	—	—	1.10	—	1.65
Anteroposterior diameter M_1	36	39	—	—	42	53	53
Transverse diameter M_1	26	32	—	—	39	—	30
L/W M_1	1.38	1.21	—	—	1.08	—	1.76
Anteroposterior diameter M_2	50	47	—	—	51	—	—
Transverse diameter M_2	29	33	—	—	38 ?	—	—
L/W M_2	1.72	1.42	—	—	1.34?	—	—
Anteroposterior diameter M_3	—	—	52	43	64	—	—
Transverse diameter M_3	—	—	—	—	39?	—	—
L/W M_3	—	—	—	—	1.64?	—	—
Depth of ramus at M_1	—	89	83	69	93	—	90
Width between second premolars	87	50	—	—	—	54	73
Length of symphysis	136	—	85	—	—	151	100?
Width of symphysis	106	—	85	—	—	106	97
Greatest diameter of incisor	36	42	42	40	—	27	33
Shortest diameter of incisor	17	—	27	22	—	22	27
Depth of ramus at P_2	—	—	—	—	—	—	60
Length P_2–M_1	—	—	—	—	—	—	170

F. A. S. — *Fauna Antiqua Sivalensis*

TABLE - 14

COMPARATIVE MEASUREMENTS (in mm) IN THE DENTITION OF CHILOTHERIUM Ssp.

MAXILLAE	Colbert (1935) p. 206 Amer. Mus. 19690 *Chilotherium intermedium*	Colbert (1935) p. 206 Amer. Mus. 26340 *Chilotherium anderssoni*	Present Specimen *Chilotherium intermedium* A/555
Length of DM^2 - DM^4 series	109	133	145
Anteroposterior diameter of DM^2 (L)	34	38	37
Transverse diameter of DM^2 (W)	27	33	44
L/W DM^2	1.2	1.15	0.81
Crown height of DM^2	25	28	39
Anteroposterior diameter of DM^3 (L)	35	43	49
Transverse diameter of DM^3 (W)	31	39	53
L/W DM^3	1.1	0.92	1.10
Crown height of DM^3	28	34	43
Anteroposterior diameter of DM^4 (L)	40	52	53
Transverse diameter of DM^4 (W)	33	44	59
L/W DM^4	1.2	1.18	0.89
Crown height of DM^4	31	43	38

MANDIBLES	Colbert (1935) p. 206 Amer. Mus. 19689 *Chilotherium intermedium*	Colbert (1935) p. 206 Ringstrom (1924) p. 37 Amer. Mus. 26341 *Chilotherium anderssoni*	Present Specimens *Chilotherium intermedium*	
			B/34	B/37
Length DM_2 - DM_3 series	58	68	91	88
Anteroposterior diameter of DM_2 (L)	27	30	39	41
Transverse diameter of DM_2 (W)	14	16	20	20
L/W DM_2	1.9	1.87	1.9	2.05
Crown height of DM_2	18	—	22	18
Anteroposterior diameter of DM_3 (L)	31	38	51	48
Transverse diameter of DM_3 (W)	16	20	25	24
L/W DM_3	1.9	1.9	2.04	2.0
Crown height of DM_3	20	—	33	26

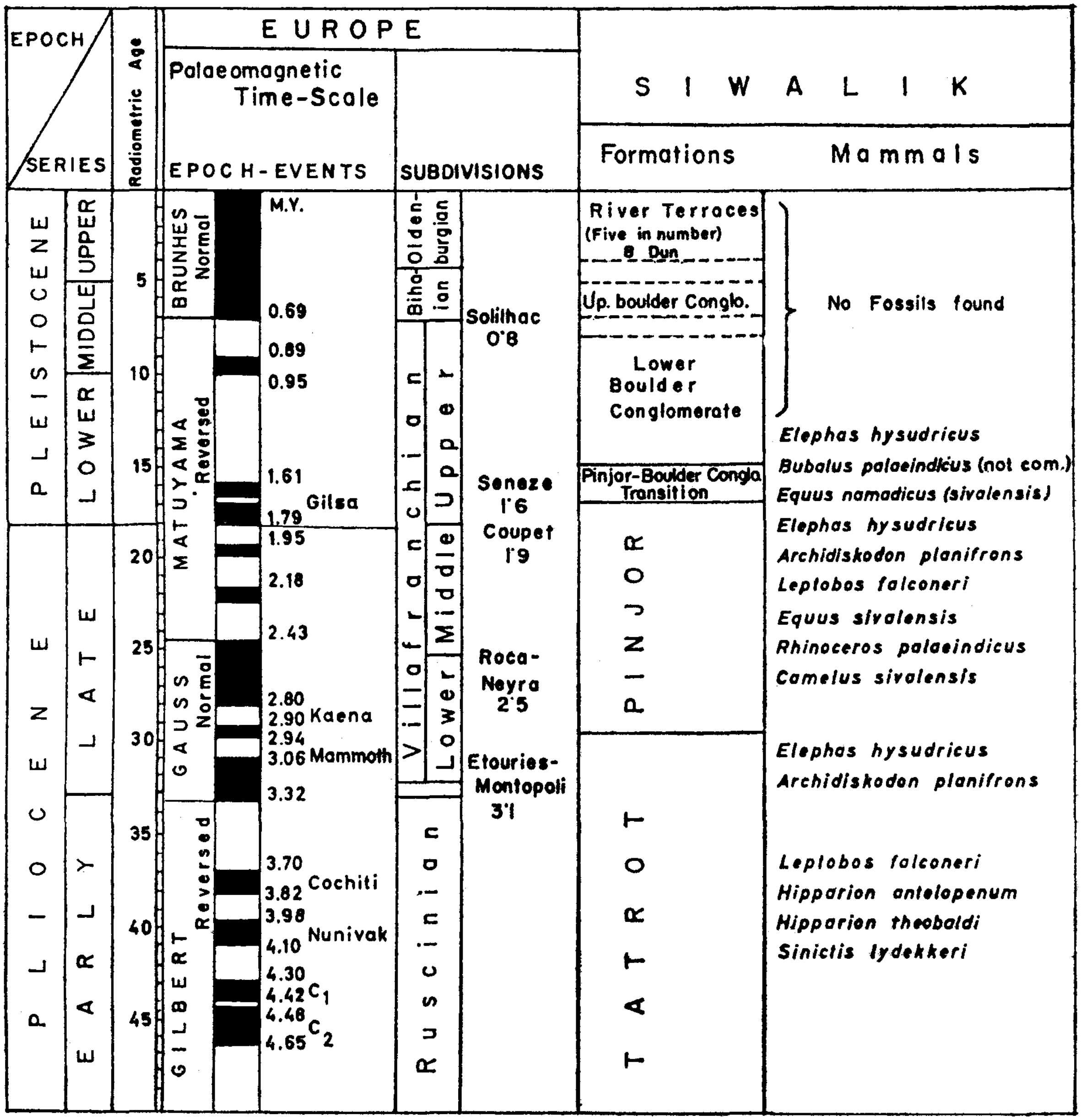
TABLE - 21

UPPER PLIOCENE — LOWER PLEISTOCENE FACIES AND FAUNA AROUND NAIPLI

Stratigraphical Unit	Facies			Fauna
		Western Part of Naipli (Along AB, Fig. 12)	Eastern Part of Naipli	
Lower Pleistocene (Villafranchian)	Alternation of Sandstone with Clay and Grit	Sandstone Siltstone Conglomerate Clay Grit (Thickness 500—550 m)	Sandstone Siltstone Clay Conglomerate (Thickness 85—100m)	*Equus sivalensis* *Rhinoceros sivalensis* *Rhinoceros palaeindicus* *Chilotherium intermedium* *Geoclemys sivalensis* *Crocodylus biporcatus* *Crocodylus palaeindicus* *Gavialis browni* *Bubalus* *Hemibos* *Cervus* *Leptobos* *Camelus* *Bison* *Bos* *Archidiskodon planifrons*
Upper Pliocene (Astian)	Alternation of Sandstone and Clay with Gravel		Sandstone Clay Siltstone Gravel (Thickness 390—400 m)	*Hipparon antelopinum* *Colossochelys atlas* *Leptobos* *Proamphibos*

TABLE - 23

PLIO-PLEISTOCENE CORRELATION



(After Sastry and Dutta, 1977)

TABLE - 25

TABLE OF FAUNAL OCCURRENCES
(In the Area Studied by Author)

Species	Tatrot	Pinjor	Boulder Conglomerate
Hipparion antelopinum	+	—	—
Equus sivalensis	—	+	+
Rhinoceros sivalensis	—	+	?+
Rhinoceros palaeindicus	—	+	—
Chilotherium intermedium	—	+	—
Crocodylus biporcatus	—	+	—
Crocodylus palaeindicus	—	+	—
Gavialis browni	—	+	—
Geoclemys sivalensis	—	+	—
Colossochelys atlas	+	—	—
Bos	—	+	+
Hemibos	—	+	?+
Bubalus	—	+	—
Leptobos	+	+	—
Bison	—	+	—
Proamphibos	+	—	—
Cervus	—	+	—
Camelus	—	+	—
Archidiskodon planifrons	—	+	—

PART THREE

THE FOSSILIFEROUS LOCALITIES OF PENINSULAR INDIA

THE KRISHNA VALLEY

Introduction :

The river Krishna is one of the major easterly flowing rivers in Peninsular India. Originating on the eastern slope of the Mahabaleshwar Plateau, at an altitude of about 1,337 m above sea level, it flows across the entire breadth of the Peninsula from west to east through the states of Maharashtra, Karnataka and Andhra Pradesh before debouching in the Bay of Bengal. Its total length is about 1,400 km and the total drainage about 2,59,000 sq. km.

Some of the important tributaries of the Krishna river are the Malaprabha, the Ghataprabha, the Tungabhadra and the Bhima. The river, in general, follows the south easterly course and seems to have shifted its course at a few places. However, the changes in the course of the river are not major as those observed in the rivers of the Indo-Gangetic plain.

The phenomena of aggradation and erosion and the rejuvenation of streams are the conspicuous geomorphic features observed in the Krishna Valley. These have resulted in response to either eustatic, tectonic or climatic changes during the Pleistocene. That the climate was previously wetter than it is at present is suggested by

1) the misfit condition of the streams in their broad valleys with thick alluvium,

2) the presence of relatively greater proportion of kaolinite clay in the silty alluvium of the present day semi-arid region,

3) the coarse nature of the older gravel deposits as compared to modern fine grave bodies at a number of places.

In its upper reaches, the Krishna river has a moderately meandering course cutting through the Deccan Trap and further down it flows through Precambrian Kaladgi sediments, comprising conglomerates, sandstones, quartzites, chert, limestone and shales. In the latter region, laterites are found capping the surfaces at elevations of 550 - 600 m above mean sea level. The Krishna and its tributaries have cut their valleys in these lateritised surfaces. In its middle and lower reaches, the river cuts through the Archaean Formation.

Previous Work :

Unlike other fossiliferous localities in India, work on these alluvial deposits has received little attention. During his survey of the northern portion of the present Karnataka state, Foote (1876) discovered numerous stone artefacts in Belgaum, Bijapur and Dharwar districts. Among the late Tertiary and Recent deposits, he recognised five distinct groups as follows :

a) Konkan laterite,

b) Ancient fresh water unfossiliferous lacustrine deposits,

c) Ossiferous deposits of fluviatile or fluviolacustrine origin containing mammalian fossils,

d) Older and newer river alluvia,

e) Newer marine alluvia of Konkan.

After a big lull lasting well over 75 years, Joshi (1955) carried out intensive geologic peomorphologic and prehistoric survey of Malaprabha basin for a stretch of nearly 160 km in Belgaum and Bijapur districts and located 20 Lower Palaeolithic sites. The artefacts comprise handaxes, cleavers, choppers and scrapers, and display Acheulian characters. Malwad and Sankalia (1956) and Banerjee (1957) also discovered a number of Stone Age sites on the Krishna and its tributaries.

In recent years a number of Lower, Middle and Upper Palaeolithic sites have been discovered by Paddayya (1969), Ansari (1970), Pappu (1970) and Corvinus *et al.*, (1972/73) on the Krishna and its tributaries.

The radio-carbon dates for the Older Alluvium yielding tools of Middle Palaeolithic Culture suggest an age of about 30,000 - 39,000 years B. P. Hence the Middle Palaeolithic Culture is of Upper Pleistocene period. The Black Soil that caps the terrace of the Older Alluvium has been dated to 7000 B. P. (early Holocene). The younger sub-Recent alluvium belongs to post - Black Soil formation.

Faunal Material :

The Krishna river has yielded scant faunal material and less Stone Age tools than other Peninsular rivers despite similar ecological and geological conditions. There are only a few reports of fossils mostly from the tributaries of the Krishna. Perhaps, the earliest record of fossils from the valley is by Foote (1876). He discovered fossils of *Bos namadicus* (?) and an upper jaw of rhinoceros, which he described as a new species, *Rhinoceros deccanensis,* from the ossiferous deposits near Gokak in district Belgaum on the Ghataprabha river. The fossils mentioned above and numerous molluscan shells were recovered from a section exposed on the bank of a stream near the village Chikdauli, situated 5 km east of Gokak. There was almost no report of fossils from the Krishna for nearly a century, when Paddayya (1969) discovered a fossiliferous Middle Palaeolithic site near Hagargundi, on the left bank of the river Bhima. The course of the river here is characterised by many sinuous curves and the site of Hagargundi is located at the height of one such meander.

THE KURNOOL CAVES

Introduction :

The Kurnool Caves are located around Betamcherla, a small town in the Kurnool dist. of Andhra Pradesh (Fig. 48). These have attracted the attention of geologists and archaeologists since their first discovery by Newbold (1844) at Billa Surgam, about 4.5 km southeast of Betamcherla. Subsequently, a number of other caves (Yaganti, Yerrazari Gabbi, Sanyasula Gavi and Krishnammokona Gavi) in the neighbourhood of Billa Surgam, were brought to light by Foote (1884) and Cammiade (1927). However, the most important of the Kurnool caves are those of Billa Surgam. Three of these caves were excavated by Robert Bruce Foote and subsequently by his son Henry Bruce Foote ; they have been named Charnel House Cave, Purgatory Cave and Cathedral Cave.

Recently, Murty (1974, 1975) excavated two caves — Muchchatla Chintamanu Gavi and Pedda Pavuralla Badde Gavi — both located within a radius of 5 km from Betamcherla. The first one is situated about 5 km southwest of Betamcherla in the escarpment of a small canyon, through which a streamlet flows into the stream Muchchatla Vagu, while the second one is located about 1 km south of Betamcherla.

A number of streamlets flow around Betamcherla. Those flowing into Muchchatla Vagu originate south of Betamcherla and flow in a north to south direction. Muchchatla Vagu itself arises from streamlets in the Betamcherla Reserve Forest near the village Papasanikottala, about 10 km west of Betamcherla. It flows from west to east and then to the southeast for a total distance of about 35 km before joining the river Jureru near Banaganapalle.

All the caves mentioned above are endogenous caves which developed due to Karst activity and most of them are located in the limestone escarpments of short canyons with streamlets flowing through them. Subterranean tunnels can be noticed in the interior of most caves and tunnel passages are known to lead about 1 km inside. All the caves are characterised by enormous sediments comprising clays, stalagmites, stalactites and limestone block forming breccias. The thickness of the sediments as revealed by the excavation of Foote appear to be more than 10 m. While the plateaus and hills are characterised by a grass cover and occasional xerophytes, the hilly slopes, the talus slopes on the sides of the limestone escarpments, and the streamlets support the scrub jungle. The vegetation cover, which is of dry deciduous type, is often thin in this semi-arid country. The living fauna includes mainly the game animals *Hystrix indica, Viverricula indica, Hyaena hyaena, Lepus nigricollis, Felis chaus and Manis crassicaudata*. Among these, *Hystrix indica* and *Lepus nigricollis* form favourite meat for local people.

Previous Work :

Foote's* (1884) excavations brought to light some 3000 dental and osteological remains of late Pleistocene fauna representing mammals, aves, reptiles and amphibians. In addition to this, several hundred bone implements comprising awls, barbed and unbarbed arrowheads, spear or harpoon heads, daggers, scrape-knives, scrapers, chisels, gouge, wedges, axe heads and sockets were also reported. Thus Foote's excavations confirmed the existence of man in these caves and also threw light upon the former geographical distribution of some animals, no longer existing wild in South India at the present time. However, these caves were not continuously inhabited either by man or animals because indications of man's continued residence (ash, charcoal and bone fragments) were missing.

The Muchchatla Chintamanu Gavi cave excavated by Murty (1974, 1975) is situated at a height of 10 m in the limestone escarpment whose total height is 32 m. The cave sediment is a heterogeneous ill-sorted material.

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*Subsequently this collection was lost and therefore no comments can be offered.

The *Viverra* and *Hystrix* of Kurnool probably provide an evolutionary stage between the Siwalik representatives and existing forms of those genera. Possibly the existing *Sus cristatus* was derived from the Siwalik *Sus falconeri* which may have given rise to extinct *Sus karnuliensis.* This group of pigs has also extended into Africa.

Rhinoceros karnuliensis and *Rhinoceros deccanensis* have no representatives at present in India. According to Lydekker (1886) the Kurnool species appears to show characters connecting it on the one hand with *R. etruscus* (European) and *R. deccanensis* and on the other with *R. bicornis* (African).

The above account supplements the evidence, also afforded by the Siwalik fauna, that there was a faunal link between India and Africa.

As mentioned earlier, the distribution of the Kurnool fauna throws interesting light on the palaeoecology of the area as a whole during the late Pleistocene. Flocking animals like *Antilope cervicapra, Gazella gazella, Cervus unicolor* and *Boselaphus tragocamelus* indicate a scrub to tree jungle in the hilly and plateau country and a tall grass cover in the plains. *Bos/Bubalus* which usually inhabit less densely forested regions, broken up by streams/streamlets, with open-expanses of grass, suggest that the plateaus and streamsides might have provided a plentiful supply of grass while the hilly slopes had a tree cover. The occurrence of *Presbytis entellus,* the arboreal langur, which moves in packs that can live on rocks and cliffs (provided there are shady groves and accessible water) also points to a small forest-type vegetation (Murty, 1975).

Rhinoceroses which have totally disappeared from southern India, must have inhabited this area when the low hills were forested with swamps in the short canyons surrounded by grass. The presence of *Ursus* also indicates a forest cover. The presence of *Tragulus meminna, Tetracerus quadricornis, Sus cristatus, Hystrix crassidens, Lepus nigricollis, Felis chaus* and *Viverra karnuliensis* also suggests a scanty bush jungle around in this rocky and hilly country. The faunal evidence on the whole, therefore, suggests a thicker vegetation cover in this region during late Pleistocene times. This also indicates that the climate was relatively more humid than at present.

Most of the ungulates with the exception of domesticated forms (ox, sheep, goat and pig) have disappeared from this region. However, some of the antelopes and cervids even now inhabit the forested regions of Nallamalai and other neighbouring ranges. This may be attributed to the changed floral pattern during the present times, the plateaus except in monsoons are devoid of grasses and only the hilly slopes, canyons, and surroundings of streams have a scrub jungle vegetation. The deterioration of forest vegetation may be due to human interference (by clearing the land for cultivation) or/and the dessication of sub-surface drainage systems. If the onset of neothermal climate is the cause of semi-aridity in the region during the present times then it can be inferred that the climate during the late Pleistocene must have been more humid than at present. The chemical analysis of the cave sediments from Muchchatla Chintamanu Gavi has also revealed that they were deposited under somewhat humid conditions. The animals known in the late Pleistocene and inhabiting the cave areas to this day include *Felis chaus, Hyaena hyaena, Viverricula indica, Herpestes edwardsi, Hystrix indica, Lepus nigricollis, Golunda* sp., *Mus* sp., *Rattus* sp., *Bandicoota* sp., and *Manis crassicaudata.* Changed ecology does not threaten the survival of these animals.

The total evidence (archaeological, faunal and geomorphical) suggests that these sites (both open-air and cave) represent Upper Palaeolithic way stations or transit camps.

The fauna listed by Lydekker (1886) and Murty (1975) is given in the table below :

FAUNA OF THE KURNOOL CAVES (after, Murty, 1975) (see Pls. 53-56)

	Ellerman Morrison-Scott	Lydekker	
MAMMALIA			
Primates	*Presbytis entellus* Dufresne, 1797*	*Semnopithecus entellus* (Dufresne)	langur
	Papio sp.	*Cynocephalus*, sp.	baboon
Carnivora	*Panthera tigris* L. (or *? Leo*)*	*Felis tigris* (or ? *Leo*) Linn.	tiger or lion
	Panthera cf. *pardus* L.	*Felis* (?) *pardus*, Linn.	leopard
	Felis chaus Guldenstaedt, 1776*	*Felis chaus*, Guldenst.	jungle cat
	Felis rubiginosa Geoffroy, 1831*	*Felis rubiginose*, Geoffr.	rusty-spotted cat
	Crocuta crocuta Erxleben, 1777	*Hyaena crocuta* (Erxl.)	spotted hyaena
	*Viverra karnuliensis** (new fossil species, Lydekker, 1886a)	*Viverra karnuliensis*, nobis	civet
	Prionodon sp.	*Prionodon* (?), sp.	linsang
	Herpestes edwardsi Geoffroy, 1818	*Herpestes griseus*, Desm.	Indian grey mongoose
	Herpestes fuscus Waterhouse, 1838*	*Herpestes fuscus*, Waterh.	Indian brown mongoose
	Melursus ursinus Shaw, 1791*	*Ursus labiatus*, Blainv.	sloth bear
Insectivora	*Sorex* sp.	*Sorex* sp.	shrew
Chiroptera	*Taphozous saccolaimus* Temminck, 1838	*Taphozous saccolaemus*, Temm.	pouch-bearing bat
	Hipposideros diadema Geoffroy, 1813	*Phyllorhina diadema* (Geoffr.)	large Malay leaf - nosed bat, not found in India at the present day
Rodentia	*Sciurus* sp.*	*Sciurus macrurus*, Hardw.	squirrel
	Tatera indica Hardwicke, 1807	*Gerbillus indicus* (Hardw).	Indian gerbil
	Bandicota indica Bechstein, 1800*	*Nesokia bandicoota*, (Bech).	large bandicoot rat
	Bandicota bengalensis Gray & Hardwicke, 1833*	*Nesokia kok*, Gray	lesser bandicoot rat
	Millardia meltada Gray, 1837	*Mus mettada* (Gray)	soft-furred field rat ; metad
	Mus platythrix Bennett, 1832	*Mus platythrix*, Sykes	Indian brown spiny mouse
	Golunda ellioti Gray, 1837*	*Golunda ellioti*, Gray	Indian bush rat
	Hystrix crassidens (new fossil species, Lydekker, 1886a)*	*Hystrix crassidens*, nobis	porcupine
	Atherura karnuliensis (new fossil spcies, Lydekker 1886a)	*Atherura karnuliensis*, nobis	porcupine
	Lepus cf. *nigricollis* Cuvier, 1823*	*Lepus* (cf. *nigricollis*, Cuv.)	black-naped hare
Perissodactyla	*Equus asinus* L.*	*Equus asinus*, Linn.	ass
	*Rhinoceros karnuliensis** (new fossil species, Lydekker, 1886a)	*Rhinoceros karnuliensis*, nobis	rhinoceros

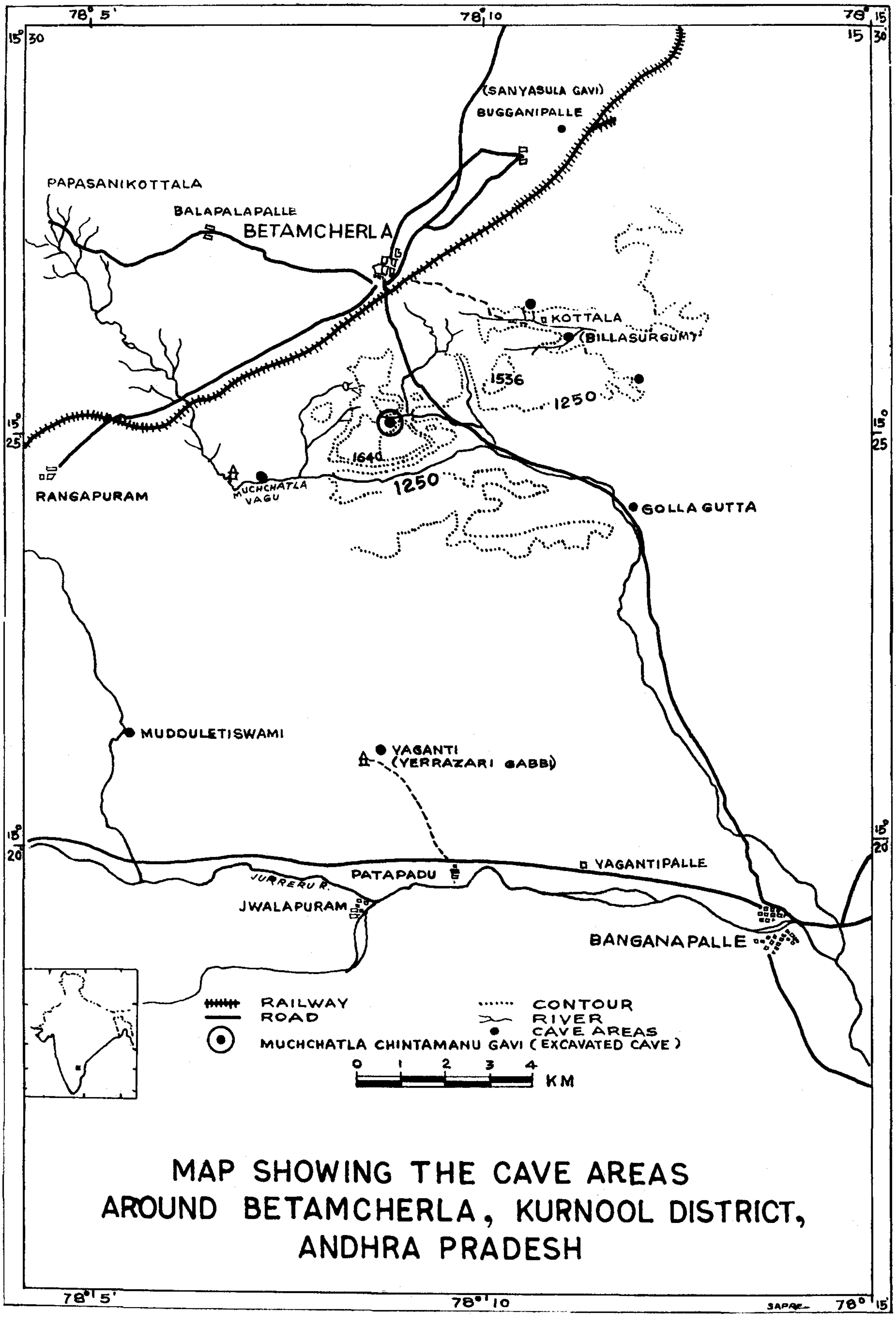
78° 5'
78° 10
78° 15
15° 30
15° 25
15° 20
(SANYASULA GAVI)
BUGGANIPALLE
PAPASANIKOTTALA
BALAPALAPALLE
BETAMCHERLA
KOTTALA
(BILLASURGUM)
1536
1250
1640
RANGAPURAM
MUCHCHATLA VAGU
1250
GOLLA GUTTA
MUDDULETISWAMI
YAGANTI
(YERRAZARI GABBI)
PATAPADU
YAGANTIPALLE
JURRERU R.
JWALAPURAM
BANGANAPALLE
RAILWAY
ROAD
MUCHCHATLA CHINTAMANU GAVI (EXCAVATED CAVE)
CONTOUR
RIVER
CAVE AREAS
0 1 2 3 4
KM
MAP SHOWING THE CAVE AREAS
AROUND BETAMCHERLA, KURNOOL DISTRICT,
ANDHRA PRADESH

Fig. 48

SUMMARY AND CONCLUSIONS

No geological system in India has a more varied development than the Pleistocene which represents every aspect of the last chapter of earth's geological history. The study of the Pleistocene is one of the most important subjects not only to the geologist and palaeontologist but also to the prehistorian.

Though the Pleistocene fossil localities have come to light in India during the last hundred years or so, great strides have been taken in such studies only during the last nearly forty years when the prehistoric archaeologists and palaeontologists developed interest in these deposits and started search for the remains of Early Man and his tools and the contemporary fauna.

The broad feature of the Pleistocene fauna, was the absence of certain groups which had become conspicuous in the Upper Pliocene times. Along with the disappearance of the archaic groups, the Plio-Pleistocene transition was contemporaneous with the emergence of progressive forms that have persisted to the present day or at least had a long history in the Pleistocene. The differentiation of the mammalian faunas seems to have become more pronounced in Middle and Upper Pleistocene times, almost contemporaneous with the uplift of Cenozoic mountain ranges and topographic and climatic changes coupled with it. All the major dispersals of mammals were complete before the close of the Pleistocene.

As a result of lithological, palaeontological and climatic changes, the separation of the Pleistocene from the underlying Pliocene deposits has now been established in many parts of the world including India. In the Indian sub-continent, the various sub-divisions of the Pleistocene period, viz., Lower, Middle and Upper are based mainly on vertebrate palaeontology and Palaeolithic archaeology. The Lower Pleistocene from northwest India is characterised by the presence of ***Equus, Rhinoceros, Elephas*** and ***Bos.*** The late Upper Pleistocene is well dated by a score of C-14 dates in western India. But the Middle and early Upper Pleistocene are not precisely dated due to lack of proper index fossil assemblage and non-availability of radiometric dates.

Apart from the Karewas of Kashmir and the Siwalik formations of the Punjab and Himachal Pradesh, large collections of fossils have been made from the alluvial deposits of Indo-gangetic plains, the Narmada basin, the Deccan river valleys and the Kurnool caves. However, keeping in view the fact that the Pleistocene deposits in the Indian sub-continent cover roughly an area of 500,000 sq. km, the percentage of the fossiliferous deposits is meagre. In the Himalayas, the poor preservation of fossils or their absence in the post-Villafranchian deposits is on account of torrential rivers and high energy environment while in the Peninsular India there are very few sedimentary troughs suitable for better preservation of fossils. This is also due to strong erosive forces operating on the plateaux of Peninsula during vigorous monsoons.

Though sufficient light has been thrown on the environment of deposition of the Peninsular rivers during the last twenty years or so, our knowledge regarding the chronology of various lithic industries in these regions is still inadequate. Our studies show that the major part of the exposed alluvia is not older than the Upper Pleistocene and that the Middle Pleistocene patches may be confined to some parts of the Narmada Valley only. It must be admitted that the Middle Pleistocene deposits have so far been vaguely dated on palaeontological basis and not a single absolute date is available until now.

Until recently, the Narmada alluvium and the fossils therein were considered as a standard for the post-Villafranchian deposits in India. During the last decade, however, palaeontological studies in the Narmada, the Godavari, the Bhima and the Pravara valleys have shown that fossils hitherto considered as index for the Middle Pleistocene (*Equus namadicus, Bos namadicus, Elephas hysudricus, Stegodon insignis-genesa*) in fact range from Middle to Late Pleistocene. *Stegodon insignis-ganesa* and *Elephas hysudricus* are also present in the Lower Pleistocene of the Upper Siwaliks of N. India. There are reports of the occurrence of even *Equus namadicus* in the Lower

Pleistocene of the Upper Siwaliks. *Bos namadicus* survives late enough and is also reported from Mohenjodaro and Langhnaj. Species like *Elephas maximus, Cervus duvauceli* and *Rhinoceros unicornis* range from Late Pleistocene to Holocene. Their presence in the late Pleistocene deposits of the Deccan river valleys is confirmed by several C-14 dates. The author is of the opinion that only *Hexaprotodon namadicus* and *Sus namadicus* may today be considered as index fossils for the Middle Pleistocene. The latter resembles Middle Pleistocene suids described from China, Burma and Java (Hooijer, 1963).

Traditionally, the Lower Palaeolithic tools have on faunal associations, been assigned a Middle Pleistocene age while the Middle Palaeolithic tools have been well dated by C-14 method to the late Pleistocene or upper part of the Upper Pleistocene. The Upper Palaeolithic is considered as transitional between the Upper Pleistocene and Holocene. The Boulder Conglomerate zone (Lower Narmada Group) has yielded so-called Middle Pleistocene fauna along with Lower Palaeolithic tools. The dating of the Lower Palaeolithic industry discovered from the Boulder Conglomerate has posed certain problems due to the complex nature of the geomorphological and palaeontological data.

Recent geomorphological and palaeontological investigations in the Central Godavari Valley indicate that the antiquity of Middle Palaeolithic tools goes beyond the range of 40,000 B. P. In West Asia similar evidence for a higher antiquity of Middle Palaeolithic (~50,000 B. P.) (Agarwal and Kusumgar, 1974) and in parts of Africa (~100,000 B. P.) (Clark, 1976) has been obtained. These geo-archaeological findings have great bearing on palaeontological research as they raise doubts regarding the established dating of Boulder Conglomerate on the basis of palaeontological evidence alone. Furthermore, the age of the Karewa gravels and that of the Boulder Conglomerate of the Siwalik zone, which is generally taken as Middle Pleistocene (Cromerian) on the basis of the dating of Narmada Boulder Conglomerate, seems to be still disputable in view of the absence in it of *in situ* organic material or other data for radiometric dating.

The upper part of the Upper Pleistocene of the Narmada can be correlated with the deposits of the Godavari, the Ghod and the Pravara valleys from where we have a score of C-14 dates more or less of the same range along with identical fauna. Morphologically, the fauna from the Lower Narmada Group, which is associated with Boulder Conglomerate, appears to be older than that recovered from the Ghod, the Pravara and the Manjra valleys.

The wide distribution in time and space of some fossils is on account of similar ecological niches, climatic conditions and geographical history prevalent in most of the parts of Central and South Indian regions. The animals seem to have had zonal distribution in these parts without any definite ecological barriers between them. Most of the forms appear to be the late survivals from the Siwaliks, having migrated to other suitable areas in India (especially the Narmada-Godavari complex) when the conditions in northwest became unfavourable an account of glaciation.

The ice sheet as a result of Pleistocene glaciation pushed out repeatedly from the northwest. It acted as a physical and climatic barrier to the movement of animals northwards and made the southward migration of most of the animals possible. Many of the species became extinct in course of such migrations due to adverse climatic conditions and allied factors like non-adaptability and hence are not represented in these deposits in such profusion or are totally absent. A few evolved into advanced forms in the Holocene.

The Kurnool cave fauna appears to be younger than that recovered from the Deccan river valleys and may belong to the terminal phase of Pleistocene.

The climate during the Pleistocene was at times more warm and humid and at other times much more drier and cooler than today. The existence of such widely diverse phenomena gave rise to profusion of large and varied fauna. However, this mangificent assemblage of animals was not totally indigenous to India. Progressive groups possibly of local origin were the primates, many giraffe-like forms, musk-deer, goats, buffaloes, bovids and pigs. The mammals which were shared by the contemporary fauna of Europe were the sabre-toothed cats, the hyena, wolves, rhinoceroses, horses of the genus *Equus*, various deer, antelopes and hippopotami. The migratory routes lay east and west of the Himalayas (Pilgrim, 1925) and most of the larger animals migrated from Egypt, Arabia, Central Asia and N. America through passes across Alaska, Siberia and Mongolia. *Hippopotamus* and elephants had their early origin in Central Africa from where they radiated out and entered India during Tertiary period through Arabia and Iran. *Rhinoceros*, horse and Camel, all originating in North America, evolved in some countries of central and western Asia before migrating to India. The elephant and horse have been a world traveller and peopled to almost every country of the world except Australia.

It is well known that the migration of mammals chiefly occurred in the Tertiary, starting vigorously in the Lower Eocene and continuing mildly till the Pleistocene. The Himalayan range began to be elevated as early as Eocene. In the Miocene it must have acted as a formidable barrier to the free migration of mammals between India and Central Asia. However, the migratory routes lay between Burma and China and through Baluchistan into Persia. Intercommunication also took place between India and N. America & Mongolia.

Between India and Africa, the interchange of faunas probably took place more easily. There is sufficient evidence for the existence of land-bridge across the straits at the entrance of the Persian Gulf. A corresponding bridge across Red Sea would have opened up ready means of communication between India and Africa through Arabia.

Many species of European and Central Asian origin migrated to India during glacial periods and survived into modern times or became extinct.

India's population of higher mammals was far greater in the past than it is today. The sudden and widespread reduction of the vertebrates is a most startling event for the geologist and the biologist. Large carnivores, varied races of elephants and numerous hoofed animals which inhabited the Indian jungles are no longer found. The sudden disappearence of the vertebrates in northwest India is attributed to the effect of intense cold of the glacial age while anthropogenic factors may have been responsible for the reduction of animals in Central & Peninsular India. Some species were able to move to warmer regions eg., the giraffes which were profusely abundant in the Upper Siwaliks are now found only in Africa. Of the nearly thirty species of elephants that were present in India, only one is found living today.

The complete absence, so far, of the remains of pre-*Homo sapiens* man in India is undoubtedly the biggest lacuna in Indian prehistoric archaeology. Though the handiwork of man in the form of stone tools and other artefacts is available in profusion, the absence of physical remains of the architects of these tools has been a puzzle alike to palaeontologists, geologists, archaeologists and anthropologists. Primitive man who certainly lived here must have left behind his bones and teeth somewhere and it is certain that with patience and luck they will come to light one day. As rightly pointed out by P.T. de Chardin, between Africa and Java, India happens to hold an exceptionally critical place as far as the origins of man are concerned. The discovery of the physical remains of Early Man will certainly make the most significant contribution to prehistory and palaeontology and fulfil the long cherished dream of the Indian palaeontologist.

The author feels that the evidence of fossils and tools in the Narmada and its tributaries, the presence of a number of rock shelters in the vicinity of the Narmada river and the well preserved terraces make the Narmada Valley an ideal place for the hunt of the primitive man.

In conclusion, Pleistocene studies in India offer a challenging field of investigation to natural scientists, particularly geologists, palaeontologists and anthropologists. Some of these deposits are fairly well dated and important from the view point of prehistory.

Distribution of important fauna in the Indian Pleistocene deposits (see also Fig. 51) along with their ages and the associated cultural material is tabulated below :

DISTRIBUTION OF FAUNA IN INDIAN PLEISTOCENE DEPOSITS AND THEIR PROBABLE AGES

Locality	Important Fauna	Associated Cultures		Probable Age	Environment
Kurnool, Ghod, Manjra, Pravara, Godavari	*Canis* sp., *Bubalus* ssp., *Cervus* ssp.,*Bos namadicus, Elephas hysudricus, Elephas maximus, Rhinoceros unicornis, Bos indicus, Hexaprotodon palaeindicus.*	Bone tools, Burins, Blades, Points. Scrapers, Flakes, Blades, Points, Borers.	Upper Palaeolithic late Middle Palaeolithic	late Upper Pleistocene (also dated by C-14 : 40,000-15,000 B. P.)	Savannah type with pockets of forests and swamps (Humid in Kurnool).
Central Narmada (Upper group) ; Paimar	*Equus namadicus, Bos namadicus, Hexaprotodon palaeindicus, Elephas hysudricus, Stegodon insignis-ganesa, Cervus* ssp.	Scrapers, Flakes, Flake-blades, Points, Borers, Handaxes, Cleavers, Polyhedrals, Discoids, Choppers.	Middle Palaeolithic Late Acheulian	early Upper Pleistocene	Savannah grassland interspersed with swamps.
Central Narmada (Lower group)	*Equus namadicus, Bos namadicus, Hexaprotodon namadicus, Sus namadicus, Elephas hysudricus, Stegodon insignis-ganesa.*	Choppers, Handaxes, Cleavers, Flakes.	Acheulian (Lower Palaeolithic)	Middle Pleistocene (not well established)	Savannah grassland interspersed with swamps.
Lower Karewa ; Pinjor of Upper Siwaliks	*Equus sivalensis, Rhinoceros sivalensis, Rhinoceros palaeindicus, Elephas hysudricus, Bos sp., Archidiskodon planifrons, Sivatherium giganteum.*	No Stone Age Tools.		Lower Pleistocene	Valley and open savannah grassland with lakes and swamps.

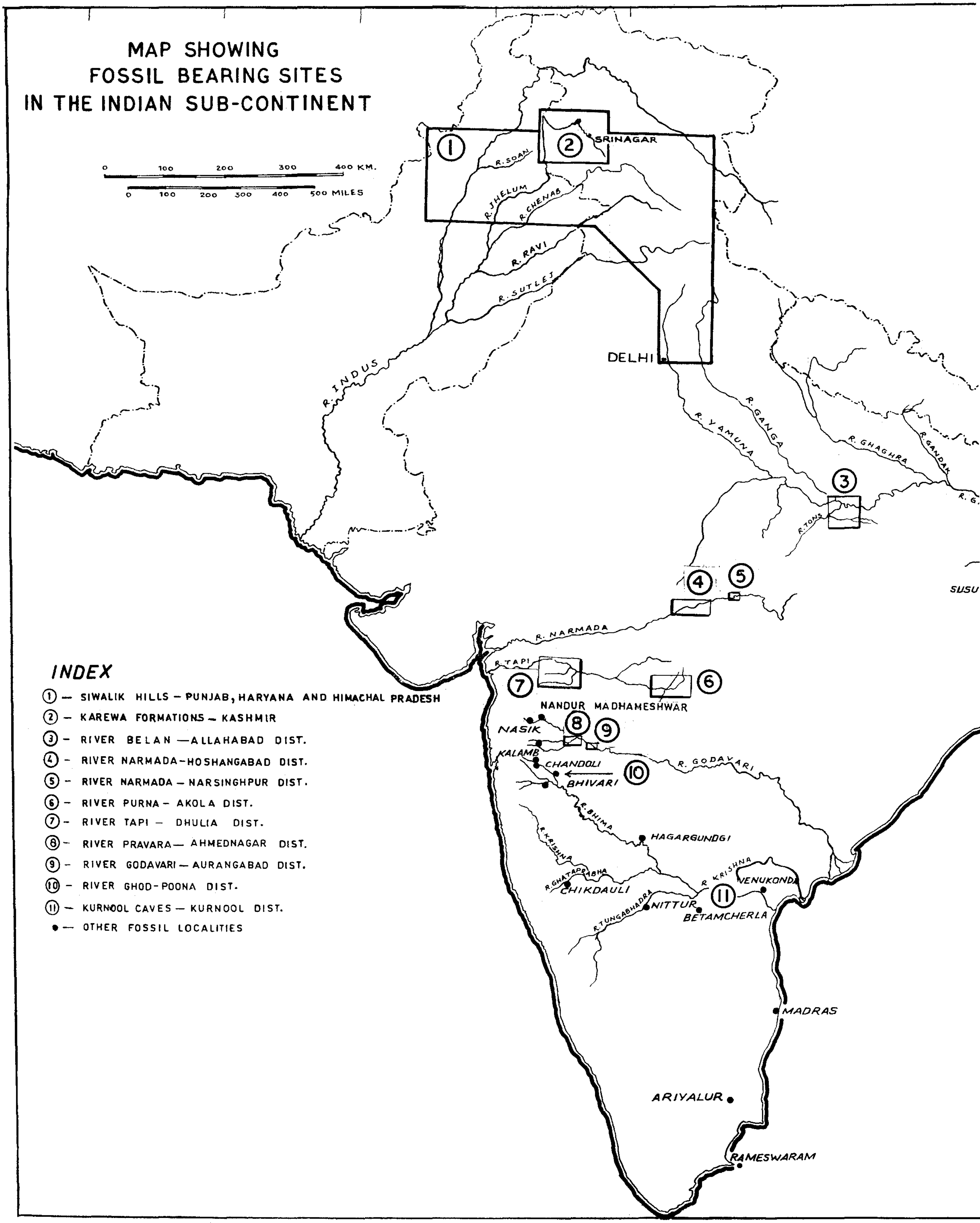
MAP SHOWING
FOSSIL BEARING SITES
IN THE INDIAN SUB-CONTINENT
0 100 200 300 400 KM.
0 100 200 300 400 500 MILES
INDEX
1 — SIWALIK HILLS — PUNJAB, HARYANA AND HIMACHAL PRADESH
2 — KAREWA FORMATIONS — KASHMIR
3 — RIVER BELAN — ALLAHABAD DIST.
4 — RIVER NARMADA—HOSHANGABAD DIST.
5 — RIVER NARMADA — NARSINGHPUR DIST.
6 — RIVER PURNA — AKOLA DIST.
7 — RIVER TAPI — DHULIA DIST.
8 — RIVER PRAVARA— AHMEDNAGAR DIST.
9 — RIVER GODAVARI — AURANGABAD DIST.
10 — RIVER GHOD-POONA DIST.
11 — KURNOOL CAVES — KURNOOL DIST.
• — OTHER FOSSIL LOCALITIES
SRINAGAR
R. SOAN
R. JHELUM
R. CHENAB
R. RAVI
R. SUTLEJ
R. INDUS
DELHI
R. GANGA
R. YAMUNA
R. GHAGHRA
R. GANDAK
R. TONS
SUSU
R. NARMADA
R. TAPI
NANDUR MADHAMESHWAR
NASIK
KALAMB
CHANDOLI
BHIVARI
R. GODAVARI
R. BHIMA
HAGARGUNDGI
R. KRISHNA
R. GHATAPRABHA
CHIKDAULI
R. TUNGABHADRA
NITTUR
R. KRISHNA
VENUKONDA
BETAMCHERLA
MADRAS
ARIYALUR
RAMESWARAM

Fig. 51

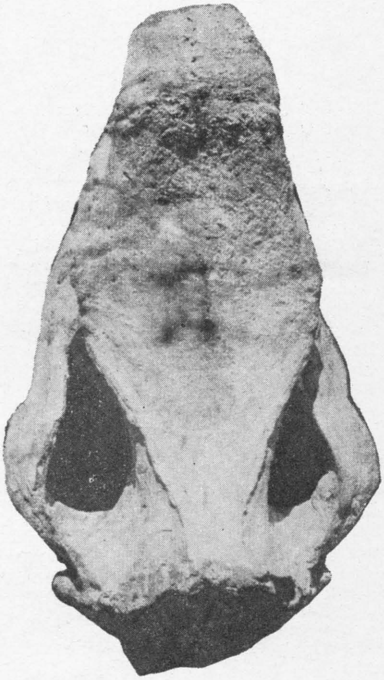

fig. 1 : G/397, Dorsal view

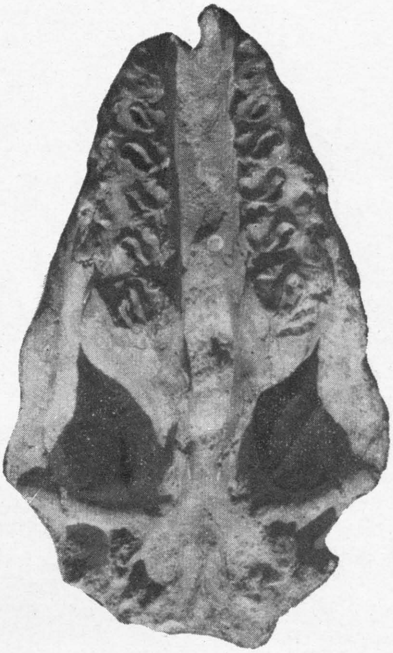

fig. 2 : G/397, Ventral view

fig. 3 : G/397, Lateral view

Skull of *Rhinoceros sivalensis* Falconer and Cautley
(All figures approximately one-sixth natural size).

fig. 1 : B/30, Dorsal view

fig. 2 : B/30, Ventral view

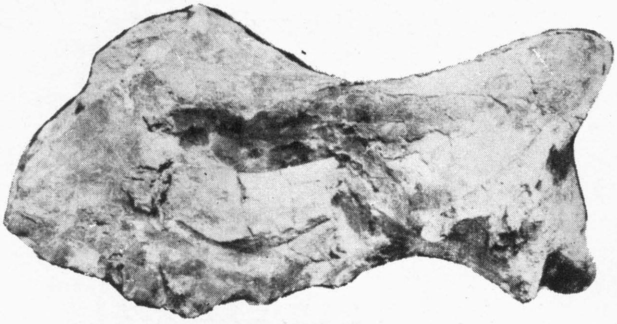

fig. 3 : B/30, Lateral view

Skull of *Rhinoceros sivalensis* Falconer and Cautley
(All figures approximately one-sixth natural size).