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Rocks, Kala Chitta Hills,
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**Geology and Vertebrate-Fossil Localities,
Tertiary Continental Rocks,
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Abstract: The most productive series of localities known for South Asian middle Eocene fossil vertebrates are in the Kuldana Formation along the southern side of the Kala Chitta Hills in Attock District, Punjab, Pakistan. The unconformably overlying lower Murree Formation is poorly fossiliferous, but has yielded a variety of identifiable fossil vertebrates. More than 300 fossil vertebrate specimens have been collected since 1976 by field groups working on the Howard University-Geological Survey of Pakistan project. This collection and allied geologic data substantially improve understanding of both middle Eocene (Kuldana Formation and Kohat Formation) and early Miocene (Murree Formation) rocks. All previously published vertebrate-fossil localities have been placed on maps and coordinated with the new Howard-Geological Survey of Pakistan localities.

INTRODUCTION

Most South Asian Eocene fossil-vertebrate localities are in a narrow band along the Himalayan foothills from the North West Frontier Province, Pakistan, to the headwaters of the Jumna River in Jammu and Kashmir, India (Gingerich 1977, fig. 1). The fossiliferous continental sedimentary rocks are known as the Kuldana Formation in Pakistan and the Subathu Formation in India. Despite the dual nomenclature, they appear to be part of the same depositional sequence. The principal fossil localities are a) between Fatehjang and the Campbellpur-Basal road in Attock District, Punjab, Pakistan (Pilgrim, 1940; Dehm and Oettingen-Spielberg, 1958; Gingerich, 1977; Buffetaut, 1977; Hussain *et al.*, 1978), b) north northwest of Chorlakkhi village, Kohat District, North West Frontier Province, Pakistan (Gingerich *et al.* a, 1979, *et al.* b, 1979), and c) near Kalakot in Jammu and Kashmir (Ranga Rao, 1972; Sahni and Srivastava, 1977). These areas cover approximately 350 km, while the entire region of

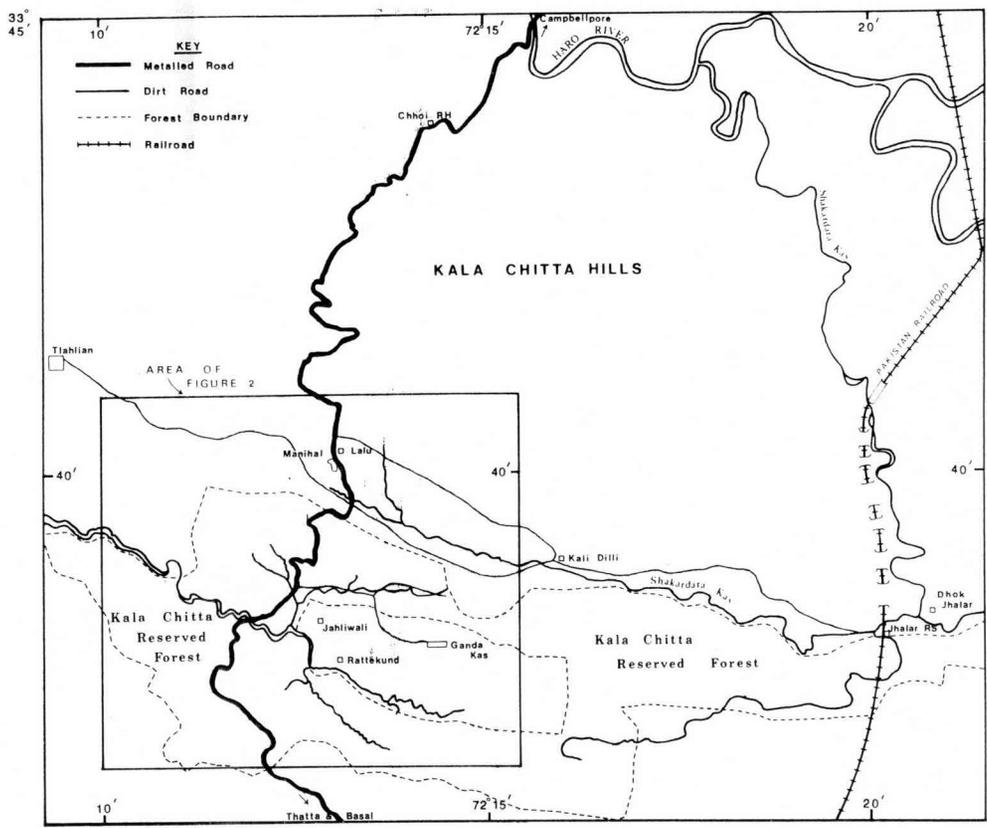


Figure 1. Study area along the south flank of the Kala Chitta Hills.

exposed continental Eocene deposits exceeds 600 km in east-west extent. Lithologic correlation of Indian and Pakistani localities is difficult; some fossil mammals from Kalakot may be younger than those found along the Kala Chitta Hills and in Kohat District. Within Pakistan, however, the general correlations are secure.

Three South Asian Eocene fossil-vertebrate localities occur far from the Sub-Himalayas. Pilgrim (1940) reported fossil mammals and reptiles from the Domanda Formation near Safed Tobah southwest of Dera Ghazi Khan, North West Frontier Province, Pakistan. Recent attempts to re-collect this area were unsuccessful (Gingerich, *et al.*, 1979). Middle Eocene marine mammals, cetaceans and sirenians, have been collected in Kutch, India (Sahni and Mishra, 1972, 1975). Late Eocene vertebrates have been known from the Pondaung Sandstone of Burma since the publication by Pilgrim and Cotter (1915). This fauna was reviewed by Colbert (1938) and several presumed primates from the Pondaung have been discussed in the recent literature (Szalay, 1970; Gingerich, 1976; Ciochon and Savage, 1979).

The survey work reported here is focused upon the small area which has, to date, produced the best records of middle Eocene fossil mammals in Pakistan. This area is near the village of Ganda Kas, about 10 km north of Basal, on both sides of the Basal-Campbellpur road, and extending east as far as the Jhalar railroad station (fig. 1). Previous reports on the fossil vertebrates from the Eocene rocks of this area are those of Pilgrim (1940), Dehm and Oettingen-Spielberg (1958), Gingerich (1977), Buffetaut (1977) and Hussain *et al.* (1978).

In addition to the fossils from the Kuldana Formation, the Howard University-Geological Survey of Pakistan (H-GSP) project has recovered a modest number of specimens from the lower part of the Murree Formation, probably of early Miocene age. No fossil vertebrates have previously been reported from the Murree Formation near Ganda Kas; the age of the lower Murree Formation (Fatehjang Member) was determined from fossils collected in the vicinity of Fatehjang (Pilgrim, 1910).

GENERAL GEOLOGY

The Kuldana, Kohat and Murree Formations lie in a structurally complex area at the southern edge of the Himalayan foothills. They were involved in intense compressional folding, probably during the Pleistocene (Gansser, 1964).

The lower Kuldana Formation appears to represent a period of dominantly fluvial and lacustrine deposition (Dehm and Oettingen-Spielberg, 1958), whereas the upper Kuldana Formation and the overlying Kohat Formation suggest a later marine transgression indicated by the presence of thin limestones with oyster beds and yellow shales with abundant

larger Foraminifera. Recognition of these two distinct depositional units goes back at least to Wynne (1874, 1875), who referred to the "Kuldana beds", "Nummulitic limestones", and "*Alveolina* beds". The history of terminology of these formations is given by Cotter (1933), Pascoe (1963), Meissner *et al.* (1974) and Fatmi (1974).

No large-scale geologic maps of the area along the southern flank of the Kala Chitta Hills have been published. Cotter (1938) included a 1:250,000 map covering the northwestern two-thirds of Survey of Pakistan topographic map 43 C, which shows Kuldana and Kohat Formation outcrops extending from Fatehjang on the east to the Indus River north of Kushalgarh on the west. Meissner *et al.* (1974) published a geologic map at a similar scale covering the Survey of Pakistan 38 0 sheet, the northern part of which adjoins Cotter's map. Together these encompass most of the known continental Eocene outcrops in Pakistan, though Eocene fluvial rocks extend north and east into Hazara and the Murree region, and south toward Banda Daud Shah.

Smaller areas within these two sheets have been mapped, largely by geologists exploring for mineral resources. In the late 19th century attention was called to the Eocene rocks approximately 8 km northwest of Fatehjang because of prominent oil seeps, now known to come from low in the Kuldana Formation. Pinfold (1918, pl. 5) mapped the Kuldana/Kohat Formation sequence along the stream east of Chharat village and noted the presence of crocodylian and chelonian bones in the Kuldana Formation.

In 1935 the Attock Oil Company assigned T.G.B. Davies to map an area near Ganda Kas. His map, at a scale of eight inches to the mile, was never published. It was used by Dehm's 1955-56 field group, and, through the courtesy of Mr. Z. N. Jafri of the Attock Oil Company, Rawalpindi, was made available to us. Davies recognized five mappable units: 1) the *Planorbis* beds; 2) the Kohat shales; 3) the nummulitic shales; 4) the Fatehjang beds; 5) the Murree Formation. In addition to the geologic map, Davies drew a detailed structural map which indicates measured and estimated attitudes, and which shows major faults and areas where the section is distorted due to extensive folding. Most of our fossil localities are on this map; those outside its limits are plotted on Survey of Pakistan topographic maps. Geological Survey of Pakistan mappers are preparing detailed geologic maps of the entire Kala Chitta Hills region.

Strike ridges of the Murree Formation are the dominant feature of the country between the south flank of the Kala Chitta Hills and the open plains of the northern Potwar Plateau. The Kuldana and Kohat Formations are considerably less resistant to erosion than is the well indurated Murree Formation, and make up the valleys and hillsides. Most Kuldana and Kohat Formation exposures are in the cores of breached anticlines. We have made no attempt at a structural synthesis other than to recognize

the complexity of the compressional origin. The compression is surely post-Murree Formation, as Murree rocks are structured identically to the Eocene units.

STRATIGRAPHY

Because of the intense folding and faulting (much of which is concealed by surficial deposits and vegetation) it is exceedingly difficult to unravel the stratigraphic details of the Ganda Kas region. The area in which most of the fossil-vertebrate localities are situated does not lend itself to section measuring because of structural complexities. On the other hand, the area near Jhalar railroad station (fig. 1) is relatively undisturbed (Hussain *et al.*, 1978) and shows a virtually continuous section from the Chor Gali Formation into the lower part of the Murree Formation.

The upper part of the Chor Gali Formation, according to Fatmi (1974), includes the "Passage Beds" of Pinfold (1918) who mapped the unit near Chharat. At Jhalar it is a massive, crystalline, light brownish gray limestone with modest numbers of larger Foraminifera. At some places the contact between the Chor Gali Formation and conformably overlying Kuldana Formation shows rubbly nodular pockets suggestive of a weathered surface on the Chor Gali Formation. Fatmi (1974) gave a 97 m (300 ft) thickness for the Chor Gali Formation at Chharat.

The predominantly fresh-water deposits of the Kuldana Formation are bright varicolored calcareous mudstones, fine-grained sandstones and minor amounts of coarser clastic rocks and limestones in shades of red, purple, brown and gray. Thin laterally-persistent beds of granular calcilithite (pellet rock) form minor ledges; many of the vertebrate fossils have been recovered from this lithofacies. Fibrous secondary gypsum is common, especially in the lower part of the formation. Although the Kuldana Formation is dominantly continental, thin beds containing Foraminifera are present; these do not appear to be reworked, but do substantiate the fluctuations of the regressing Tethys Sea.

The Kuldana Formation at Jhalar is estimated to be about 525 m (1625 ft) thick, which is substantially more than the 165 m (512 ft) thickness reported for the Kala Chitta area (Fatmi, 1974). The total thickness at Jhalar may actually be somewhat less, as it is likely that small amounts of structurally repeated section went unnoticed.

The continental deposits of the lower Kuldana Formation represent a regressive phase of the Tethys sea. We include sedimentary rocks intermediate between freshwater and marine environments in the upper Kuldana Formation. Fatmi (1974) reported the presence of similar beds, with abundant small oysters, in the topmost part of the Kuldana Formation near Kohat, and we record their presence in several prominent beds high in the Kuldana Formation throughout the Ganda Kas region.

The boundary between the Kuldana and Kohat Formations at Jhalar and Ganda Kas apparently is conformable. The Kohat Formation is a thin foraminiferal shale unit overlying the upper Kuldana Formation oyster beds; these Foraminifera weather out of the shale readily and cover broad surfaces. It is difficult to correlate the Ganda Kas region Kohat Formation with the sequence in the stratotype area; probably only a thin wedge of the lower Kohat Formation is present. Our interpretation of the Kohat Formation yields a unit about 13 m (40 ft) thick, much thinner than the 97 m (300 ft) in the Kala Chitta area and the 190 m (590 ft) in the type area cited by Fatmi (1974).

The deposition of the Kohat Formation was followed by a period of erosion indicated by the presence of reworked Eocene limestone pebbles and Foraminifera in the disconformably overlying continental deposits of the Murree Formation. Mammalian fossils from the lower Murree Formation (Fatehjang Member) near Fatehjang suggest an early Miocene age (Pilgrim, 1910). The Murree Formation is readily differentiable from the Kohat Formation by its coarseness, greater resistance to erosion, and red-brown coloration. No local thickness can be estimated, as the upper part of the unit is not present, but the Murree Formation is 3220m (10,000 ft) thick in the northeastern part of the Potwar Plateau (Fatmi, 1974). The Murree Formation is the youngest rock unit between the Kala Chitta Hills and the Potwar Plateau.

VERTEBRATE-FOSSIL LOCALITIES

Vertebrate fossils have been known to occur in the Eocene of northern Pakistan since Wynne's 1877 report of an occurrence in the North West Frontier Province near Kohat, and Pilgrim's (1910) mention of crocodilians and chelonians near Chharat. Additional fragments collected by Attock Oil Company geologists in the 1930's were described by Pilgrim (1940) and provoked Dehm's more detailed work in 1955-1956. Subsequent work by groups from the Geological Institute, Utrecht in 1966, the University of Michigan in 1975 and 1977 (Gingerich, 1977; Gingerich *et al.*, 1979), and the H-GSP project from 1976 to 1979 (Buffetaut, 1977; Hussain *et al.*, 1978) has added new vertebrate fossil localities in the Ganda Kas region (table 1 and figure 2). During the 1978 winter field season all known localities were visited and the accompanying correlation table was constructed (table 1). As of the end of 1979 winter field season there are 61 localities: 45 in the Kuldana Formation, 15 in the Murree Formation, and one of uncertain position (fig. 2).

Pilgrim (1940) reported on a suite of about 15 mammalian fossils from the Ganda Kas area which had been turned over to the British Museum (Natural History) by E. S. Pinfold of the Attock Oil Company. From this suite Pilgrim described a new anthracothere, *Anthracobune*, with several species, and a possible helohyid, *Khirtharia*, with a single species.

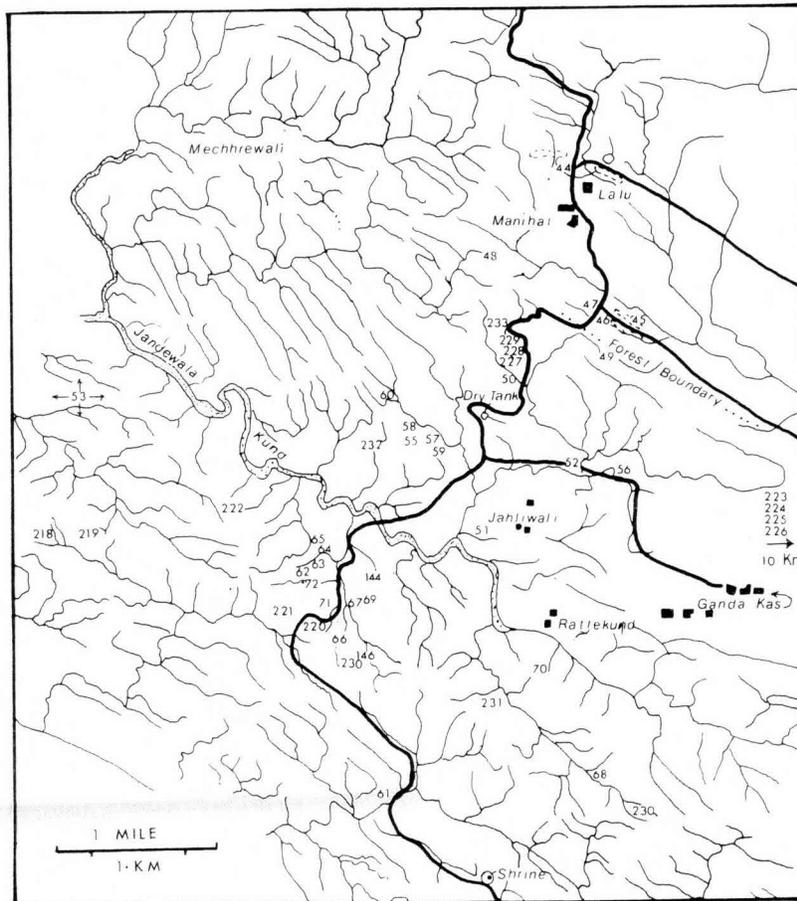


Figure 2. Area along the Basal-Campbellpur road which includes most of the fossil localities mentioned in this paper.

A much larger collection (303 fossil-mammal specimens of known provenance) was accumulated by Dehm and Oettingen-Spielberg (1958). They described five new genera (one taeniodont, two mesonychids, and two dichobunids) and eight new species. They referred Pilgrim's *Anthracobune wardi* to the new genus *Pilgrimella*.

Radinsky (1965) mentioned *Teleolophus*, and Szalay and Gould (1966) briefly considered *Gandakasia* and *Ichthyolestes* in their reviews of some groups of Asian early Tertiary mammals. Van Valen (1965) removed *Promioclænus* (?) *gandaensis* from the Hyopsodontidae and made that single tooth the type of *Dulcidon gandaensis*, considered by him to be a paroxyclaenid.

A small collection was made by Gingerich (1977; Gingerich *et al.* a, 1979) along the Basal-Campbellpur road. In 1977 he suggested reallocation of *Gandakasia* to the archaeocete cetaceans, and constructed the new genus *Lammidhania* for *Pilgrimella wardi* (Pilgrim). He also described several previously overlooked British Museum fossil-vertebrate specimens from the Ganda Kas area. More recently, in the first discussions of Eocene mammals from Kohat District (Gingerich *et al.* b, 1979) *Gandakasia* was placed provisionally in the Condylarthra, *Basalina* was transferred from the Taeniodonta to the Tillodontia, and a new artiodactyl, *Chorlakkia*, was described and tentatively assigned to the Dichobunidae.

Coombs and Coombs (1977a) confirmed *Anthracobune* as a primitive anthracothere and suggested that *Pilgrimella* is not an artiodactyl but rather a perissodactyl of uncertain affinities (Coombs and Coombs, 1977b and in press).

Interpretations of two groups of fossil vertebrates have been published as results of the present project. Buffetaut (1977) examined crocodylians from the Ganda Kas area and confirmed the presence of the Dryosauridae. He also identified numerous specimens belonging to the Pristichampsinae. Hussain *et al.*, (1978) described 163 isolated rodent teeth collected by screen-washing at H-GSP localities 57 and 144. They grouped the eight recognizable species into the new family Chapattimyidae. This family includes Indian materials described by Sahní and Khare (1973) as *Birbalomys*, which is considered a junior synonym of *Sakanomys* Shevyreva (1972).

In addition to the rodent localities (H-GSP localities 57 and 144) reported by Hussain *et al.*, (1978), several other localities have produced well-preserved larger-mammal specimens. H-GSP locality 62 is in a 30 cm thick granular calcilithite exposed as a northwest-facing vertical surface in the lower Kuldana Formation. The upper part is deeply weathered and crumbly, while the lower part of the exposure is less weathered and more compact. Spalling away of the face continuously reveals additional vertebrate fossils. Through the 1979 winter season ten fossil-mammal jaws

and jaw fragments, one virtually complete skull, and numerous isolated teeth have been collected from H-GSP locality 62; this is now the most productive large fossil-mammal locality in the Eocene of Pakistan. Several taxa are represented: at least two different cetaceans, and the artiodactyls *Anthracobune*, *Gobiohyus* and *Khirtharia* have been identified.

Another site which has yielded excellently-preserved larger fossil mammals is H-GSP locality 146, which is in a steeply-dipping gray-green marlstone in the upper Kuldana Formation. Two well-preserved specimens, a brontothere and an artiodactyl have come from this locality. Further new materials of *Anthracobune*, cf. *Eotitanops* and *Lammidhania* have been found at scattered surface sites in the Kuldana Formation. The 305 large fossil-mammal specimens now constitute a major addition to the Eocene faunas of South Asia, and will be considered in detail in a subsequent paper.

Forty-one mammalian fossils have been collected from the 15 lower Murree Formation localities in the Ganda Kas region. This small collection from near Ganda Kas is dominated by large perissodactyls and artiodactyls, although most of the specimens are indeterminate at the family level.

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TABLE 1
Correlation and Faunal Composition of Ganda Kas Area Localities

Formation	HGSP #	Dehm #	Gingerich #	Pilgrim
Murree	44 (1 TC)			
Murree	45 (6 C)			
Murree	46 (12 C)			
Murree	47 (5 C)			
Murree	48 (2 TC)			
Murree	49 (7 TCP)			
Murree	50 (2 TC)			
Murree	51 (1)			
Lower Kuldana	52 (11 TC)			
?	53 (1)			
Murree	55 (3)			
Lower Kuldana	56 (6 TCP)			
Lower Kuldana	57 (73 TC)	[29 (11 T)		
Lower Kuldana	58 (11 TCP)			
Lower Kuldana	59 (C)	30		
Lower Kuldana	60 (T)	29 (11 T)		
Murree	61 (1)		1 (TC)	

Formation	HGSP #	Dehm #	Gingerich #	Pilgrim	
Lower Kuldana	62 (45 TCPA)	9 (13 TC)			
Lower Kuldana	63 (2 T)				
Lower Kuldana	64 (5)		10,27,8 (23 TC)		
Lower Kuldana	65 (3 TC)		14,15,22 (37 TC)		
Lower Kuldana	66=145 (15 TC)				
Lower Kuldana	67=69 (5 C)	24 (11 TC)	5 (4 TCP)		
Lower Kuldana	68 (16 TCP)	25 (41 TC)			
Lower Kuldana	69=67 (4 TP)	24 (11 TC)	5 (4 TCP)		
Lower Kuldana	70 (2 T)	5,6 (9 T)			
Lower Kuldana	71 (22 TP)	2,11,12,20 (24 TC)	5 (4 TCP)		
Lower Kuldana	72 (28 TPL)	1 (36 TC)	11, 12 (5 TCP)		
Murree	121 (1)				
Murree	122 (1)				
Lower Kuldana	144 (116)	1 (10 TC)			
Lower Kuldana	145=66 (3 TC)	14,15,22 (37 TC)			
Upper Kuldana	146 (20 TC)				
Lower Kuldana	218 (4 TC)	19			
Upper Kuldana	219 (4 TCP)	13 (6 TC)			
Lower Kuldana	220 (3 TL)	21 (16 T)			
Upper Kuldana	221 (3 TCP)		10 (1 P)		

Formation	HGSP #	Dehm #	Gingerich #	Pilgrim
Murree	222 (1)			Jhalar (4 CP)
Lower Kuldana	223 (-)			
Lower Kuldana	224 (-)			
Lower Kuldana	225 (-)			
Lower Kuldana	226 (1 P)			
Lower Kuldana	227 (7 TCPL)	34,35 (17 TC)		
Upper Kuldana	228 (3 TC)			
Upper Kuldana	229 (1)			
Lower Kuldana	230 (15 TP)		23 (9 T)	
Lower Kuldana	231 (4 TC)		5,6 (9 T)	
Lower Kuldana	232 (2 T)	28 (15 T)		
Lower Kuldana	233 (3 TC)	32,33 (T)		
Murree		17		
Lower Kuldana		Lalu 1		
Lower Kuldana		Lalu 2		
Lower Kuldana		3 (west) (5 T)	3 (TP)	
Lower Kuldana		7		
Lower Kuldana		26 (9 T)		
Lower Kuldana		36 (1 TC)		
Lower Kuldana		31 (1 T)		

Formation	HGSP #	Dehm #	Gingerich #	Pilgrim
Murree		16 (TC)		
Upper Kuldana		18 (8' TC)		
Upper Kuldana			2 (1 TC)	
Upper Kuldana			4 (2 TCP)	
Lower Kuldana				Lammidhan (8 C)
Upper Kuldana				Lammidhan (3)

number = number of identifiable mammals

P = Pisces

L = Lizards

C = Crocodilians

T = Turtles

A = Aves

APPENDIX

Ganda Kas Area Locality Descriptions

Localities collected by H-GSP group, 1976-1979

See Figures 1 and 2

- H-GSP Loc. 44. General locality within 200 meters south of uppermost Chor Gali Formation. Several hundred meters both east and west of Basal-Campbellpur road. Within .5 kilometer north and northwest of Lalu. Beds strike $N70^{\circ}W$ to $N80^{\circ}W$, and dip generally vertically. Fossils recovered mainly from sandstone, but some come from conglomerate. Murree Formation.
- H-GSP Loc. 45. General locality about 30 meters north of road to Kali Dilli paralleling the forest boundary for about .5 kilometer east of the Basal-Campbellpur road. Beds strike $N65^{\circ}W$ to $N70^{\circ}W$ and dip essentially vertically. Fossils recovered mostly from claystones, but some come from siltstones. Murree Formation.
- H-GSP Loc. 46. General locality for same area as H-GSP Locality 45, but about 30 meters south of Kali Dilli Road. Geologically similar to H-GSP Locality 45. Murree Formation.
- H-GSP Loc. 47. Between 20 and 50 meters west of the Basal-Campbellpur road, a few meters south of the Kali Dilli intersection. Stratigraphic interval the same as for H-GSP Locality 46. Fossils occur as float, probably from siltstones and claystones. Murree Formation.
- H-GSP Loc. 48. Approximately 1.3 kilometers $N70^{\circ}W$ of point approximately 50 meters north of forest boundary on Basal-Campbellpur road just south of Kali Dilli road, and about 20 meters south of H-GSP Locality 46. Almost due south of western edge of Manihal. Fossils occur as float from dark red siltstones and claystones adjacent to approximately 50 centimeters thick gray-red small pebble conglomerate. Murree Formation.
- H-GSP Loc. 49. Approximately 450 meters $S45E$ of point where Basal-Campbellpur highway crosses the forest boundary approximately 1 kilometer south of Lalu. Fossil bone found in place in a pebble conglomerate striking $N65^{\circ}W$, dipping $76^{\circ}N$. This bed pinches within 100 meters east-west, and reaches a thickness of approximately 2 meters near its west end. Murree Formation.
- H-GSP Loc. 50. Approximately 200 meters west of Basal-Campbellpur road at $33^{\circ}39'N$. Beds strike approximately $N75^{\circ}W$ and dip $80^{\circ}S$. Fossils occur as float on dark claystones and siltstones between gray-brown sandstones. The locality is approximately 15 meters vertically above the break in slope on a north-facing slope. Murree Formation.
- H-GSP Loc. 51. Approximately 500 meters southwest of Jahliwali and 200 meters east of the major drainage on the path to Jahliwali. Fossils collected from a pebble conglomerate between two gray sandstones. This conglomerate is approximately two meters thick and pinches out within 50 meters. It strikes $N60^{\circ}E$ and dips $48^{\circ}N$. Murree Formation.

- H-GSP Loc. 52. .55 miles from Basal-Campbellpur road on south side of dirt road to Ganda Kas, between the road and a major stream, approximately 100 meters west of a north-south stream bed. Fossils collected from purple and red siltstones with gray-green foraminiferal limestone and marls to the north and more resistant gray marl lacking foraminiferans to south. Abundant gypsum on the surface. The producing unit is approximately 10 meters thick, and produces for approximately 40 meters along strike. Lower Kuldana Formation.
- H-GSP Loc. 53. "3 miles west" of Basal-Campbellpur road west of Jahliwali, according to the local man who brought in the specimen. Attached matrix is green gray foraminiferal shale, like the Kohat Formation. Formation uncertain.
- H-GSP Loc. 55. Near top of 1st ridge south of the dirt road to Ganda Kas and west of the Basal-Campbellpur highway approximately 500 meters west of the highway along the ridge. Altitude approximately 1660; S67°W of the dry tank northwest of Jahliwali. A thin pebble conglomerate, similar in most respects to that at H-GSP Locality 49, caps the locality. Specimens occur as float a few meters downslope from the indurated sandstones and conglomerates. Murree Formation.
- H-GSP Loc. 56. Approximately 300 meters east of H-GSP Locality 52 and 150 meters west of the point where dirt road turns south to Ganda Kas. N87°W to intersection with Basal-Campbellpur road. Locality is in a major east-west nala one ridge north of the main drainage, in the middle of an approximately 50 meter thick claystone-marlstone sequence. The fossils come from a deep purple, almost black claystone, approximately 1 meter thick and lensey, extending perhaps 20 meters along strike. Lower Kuldana Formation.
- H-GSP Loc. 57. Ferungi Pocket. Approximately 100 meters east of locality 55 and 400 meters west of Basal-Campbellpur highway. It is on the south side of the large nala which is bridged at the 58/6 milepost. There are several concentrations of bone here, including one bone bed in gray mottled claystones approximately 10 centimeters thick, which contains well-preserved but broken and fragile bone. The locality is S65°W from the dry tank northwest of Jahliwali. Lower Kuldana Formation.
- H-GSP Loc. 58. Same level as H-GSP Localities 57, 59, and 60 but approximately 100 to 150 meters west and slightly upslope of Locality 57. Bone found weathering out of purple claystones, but most of these specimens were collected as float downslope. Lower Kuldana Formation.
- H-GSP Loc. 59. Same level as H-GSP Localities 57 and 58. It is slightly upslope and approximately 100 meters east of H-GSP Locality 57. Lower Kuldana Formation.
- H-GSP Loc. 60. 100 to 150 meters west and slightly downslope of H-GSP Localities 57 and 59. The purple claystone exposure ends approximately 75 meters west of this locality. Lower Kuldana Formation.
- H-GSP Loc. 61. Fossils found as float below a thin conglomerate partway up slope west of Basal-Campbellpur road at approximately the 23 mile sign. Murree Formation.
- H-GSP Loc. 62. Approximately 350 meters west of the Basal-Campbellpur highway at about 59/6 milepost. A sequence of dark red claystones and yellow-gray marls. The main producing bed is a 30 centimeter thick reddish granular calc-

lithite which dips vertically and strikes approximately northeast in the center of the locality. Specimens found either as float on slopes below or *in situ* in the granular calcilithite. Lower Kuldana Formation.

H-GSP Loc. 63. Approximately 100 meters northeast of H-GSP Locality 62 on the southeast side of the same stream bed. Most or all of the specimens come from a thin granular calcilithite similar to or the same as at H-GSP Locality 62. Lower Kuldana Formation.

H-GSP Loc. 64. Approximately 50 meters northwest of H-GSP Locality 62. Fossils found as float from dark red claystones immediately adjacent to and on both sides of the footpath. The strike is nearly east-west and the dip vertical. A thin granular calcilithite cuts through the locality just south of the path and contains much mammal bone but no obvious teeth. Lower Kuldana Formation.

H-GSP Loc. 65. Approximately 50 meters west of H-GSP Locality 64 and apparently involving the same approximately 30 centimeter thick granular calcilithite which cuts thru Locality 64. Small area in east-facing bank in lateral nala south of footpath. Most of the fossils come from a granular calcilithite, but some also come from red claystones with gypsum. Lower Kuldana Formation.

H-GSP Loc. 66. Approximately 150 meters east of Basal-Campbellpur highway at the 60/2 milepost at a break in slope on the south side of valley. Fossils appear to be coming from a dark red claystone. Lower Kuldana Formation.

H-GSP Loc. 67. Approximately 15 meters N70°E of 60/1 milepost on Basal-Campbellpur road, at the southwest base of a steep slope in a small northwest draining nala. Bone occurs as float on red and gray claystones below a coarse gray-green sandstone with some bone in place. Lower Kuldana Formation.

H-GSP Loc. 68. 3-4 kilometers from highway, precisely 2.5 kilometers southwest of Ganda Kas on the north bank of the major nala. Beds strike N67°N, nearly vertical dip. Fossils produced from a dark red claystone sequence 30 meters thick and yielding bone from at least two levels. Lower Kuldana Formation.

H-GSP Loc. 69. Approximately 10 to 15 meters northeast of Locality 67. Sequence of dominantly gray-green clays. Bone found *in situ* in a granular calcilithite, and is much more abundant than in the coarse sandstone at top of Locality 67. Lower Kuldana Formation.

H-GSP Loc. 70. Low exposures several hundred meters south of Rattekund in a red claystone sequence. An interbedded conglomerate strikes N45°W, and dips 65°SW, but is exposed for approximately 5 meters along strike. Lower Kuldana Formation.

H-GSP Loc. 71. General locality in a small valley west of Basal-Campbellpur road between 60/2 and 60/3 mileposts. Red claystones crops out on both sides of the stream bed from approximately 100 meters to 300 meters west of the highway. The beds strike approximately east-west and dip steeply north. Lower Kuldana Formation.

H-GSP Loc. 72. General locality in a small valley running approximately S65°W from the Basal-Campbellpur road between mileposts 60/1 and 60. The productive exposures are a lense of dark red claystone and granular calcilithite extending

from approximately 100 meters to 250 meters west of the highway which ends essentially at the break in slope at the head of the valley. Lower Kuldana Formation.

- H-GSP Loc. 121. Red sandstone and interbedded mudstones north of Charmtra railroad station. Bone from coarse lenses. Murree Formation. Not on map.
- H-GSP Loc. 122. North of Maryla, on the road from Thatta to Nara, several miles west of Basal-Campbellpur road. Sandstone and mudstone sequence. Murree Formation. Not on map.
- H-GSP Loc. 144. Approximately 200 meters east of the 60/1 milepost on the Basal-Campbellpur road. Immediately southeast of a major footpath to Ganda Kas village. Fossils collected by washing a poorly indurated grayish-red granular calcilithite which crops out in the middle of a red claystone sequence. Lower Kuldana Formation.
- H-GSP Loc. 145. Identical to H-GSP Loc. 66. Lower Kuldana Formation.
- H-GSP Loc. 146. About 75 meters east of H-GSP Locality 66, in a steeply-dipping gray-green marlstone making up the south wall of a stream bed. Abundant *Planorbis* in place, as well as well-preserved bones. Upper Kuldana Formation.
- H-GSP Loc. 218. At western end of the prominent strike valley which extends west from milepost 60/4. Bone found as debris on rubble on slope of brown-red mudstone with several layers of interbedded granular calcilithite. Lower Kuldana Formation.
- H-GSP Loc. 219. North northeast of strike vally containing Loc. 218 and about two miles north northwest from milepost 60/4 on Basal-Campbellpur road. Locality is 125 meters N35°W from forest boundary marker (white square) #355. Upper Kuldana Formation.
- H-GSP Loc. 220. 50 meters east of Basal-Campbellpur road and E30°S from 60/4 milepost. Primarily red mudstones with some greenish siltstones. Erosion gulleys reveal dark red beds. Lower Kuldana Formation.
- H-GSP Loc. 221. On north-facing slope of the first prominent hill south of Locality 71, and 150 meters due west of 60/4 milepost on Basal-Campbellpur road. Yellow-green siltstones with occasional lenses of grey siltstones and mollusc beds. Upper Kuldana Formation.
- H-GSP Loc. 222. About 500 yards west of Basal-Campbellpur road, on second major ridge south of Jandewala Kund, N10°W from Rattakund. Northeast of 1959' hill. Murree Formation.
- H-GSP Loc. 223. Approximately 500 meters northwest of Jhalar railroad station. Poorly indurated granular calcilithite. Lower Kuldana Formation.
- H-GSP Loc. 224. Approximately 500 meters northwest of Jhalar railroad station. Poorly indurated granular calcilithite. Lower Kuldana Formation.
- H-GSP Loc. 225. Approximately eight meters east of Locality 226, with same description. Lower Kuldana Formation.
- H-GSP Loc. 226. 10 meters west of road to Jhalar railroad station due east from north end of railway bridge and E25°N from the Jhalar railroad station. Grey-

blue granular calcilithite of varying thickness and induration. Lower Kuldana Formation.

H-GSP Loc. 227. Valley on north bank of main stream bed. W15°N from halfway point between mileposts 57/6 and 57/5. 75 to 100 meters west side of Basal-Campbellpur road. Lowest local exposure in core of anticline. Flat covered with numerous thorn bushes. Lower Kuldana Formation.

H-GSP Loc. 228. About 25 meters due north of Locality 227, on flats just below lowest mollusc (non-nummulitic) bed. Upper Kuldana Formation.

H-GSP Loc. 229. 50 meters north of Locality 228; bone actually weathering out of mollusc bed. Upper Kuldana Formation.

H-GSP Loc. 230. About 175 meters upstream (east southeast) of Locality 68 and at same level. It is directly southeast of Locality 68 where the trail crosses a high ridge on the side of a stream bed, just before the stream bed cuts through a massive limestone. Most bone comes from a granular calcilithite. Lower Kuldana Formation.

H-GSP Loc. 231. A low lying area just southeast of the main drainage divide and due north of high point at 2031'. Locality is due south of Rattekund village. Bone is derived primarily from the red siltstones. Lower Kuldana Formation.

H-GSP Loc. 232. About 250 meters southwest from Locality 55. Low red beds exposed in the middle of a northwest-southeast trending strike valley. Lower Kuldana Formation.

H-GSP Loc. 233. 150 meters due west of Basal-Campbellpur road at the sharp curve just north of 57/5 milepost. Locality is two meters north of a trail in a blue-gray conglomeratic lens in a red siltstone. Lower Kuldana Formation.