

Reworked Late Cretaceous microfossils in Late Pleistocene Baba Ghat Formation of southern Gangetic Plains of India and their implications in palaeodrainage

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ABSTRACT

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The alluvial deposits of southern Gangetic plains of Uttar Pradesh, in the absence of characteristic fossils from subsurface sediments have been correlated by earlier workers on the basis of lithology with Upper Siwalik of the Himalaya. The occurrence of *Stegodon insignis* from Prahladpur formed basis of such a correlation. However, detailed systematic study of exposed sections of Late Quaternary reveals that in several sections of Baba Ghat Formation (= Chitrakoot Formation of Verma & Mehrotra 1991, Bundelkhand Older Alluvium of Khan & Bhartiya 1995, Banda Alluvium or Chitrakoot Formation of Banda Group of Kumar et al. 1996a, b) of the area reveals presence of molluscs: *Caecilioides (Geostilbia) bensoni*, *C. (Geostilbia) sp.*, *Helicorbis sp.*, ostracodes: *Potamocypris sp.*, *Candona lactea*, *C. marengoensis*, *Candona sp. cf. C. paionica*, *Hemicypris battishi*, *Limnocythere franki*, etc. and charophytes: *Chara globularis globularis*, *Lychnothamnus barbatus* of Late Pleistocene age. *Boraginaceae* seeds (*Proboraginocarpus balasinorensis*) and ostracodes reworked from Late Cretaceous Lameta Group are also present in the assemblage. This find of reworked fossils provides evidence of presence of a river system which during Late Quaternary drained northward through Lameta sediments in this part of the peninsula. Therefore, correlation of these sediments and its vertebrate fauna with peninsular equivalents is more appropriate than with Upper Siwalik. One of the sections of Baba Ghat Formation exposed at Mendra (15°14'50"N, 81°03'30"E) has been dated 22670-20710 years B.P. (C¹⁴). This study shows that the Lameta were probably extended up to Chitrakoot during Cretaceous and were exposed for denudation up to as late as Late Pleistocene.

Keywords: Reworked Lameta microfossils, Late Quaternary, Uttar Pradesh

INTRODUCTION

The vertebrate fossils have been recorded from Quaternary deposits of Ganga-Yamuna alluvial plains of Uttar Pradesh since Lydekker (1882) first recorded mammalian bones belonging to *Elephas*, *Bos* or *Bubalus*, *Portax*, Antelope, *Rhinoceras*, *Equus* and

Felix from Yamuna (Jamna) tributaries in the Banda District. A Pleistocene age was suggested for the assemblage. Other records of vertebrates are from Jalaun and Kanpur Dehat districts by Dean (1833, 1835). A bed having 3.54 m long tusk of elephant *Elephas* beside other mammalian remains from Kalpi

has been recorded and dated around 30 ka (Singh et al. 1999). Similarly from Prayagraj District also, vertebrates have been recorded by Pilgrim (1904), Chakravarti (1935, 1938) and Mukherjee (1949). Record of *Stegodon insignis* by Mukherjee (1949) from near Naini on southern bank of Yamuna (Jamna) about 60 m from the surface has received much attention as Upper Pleistocene age has been assigned to these beds. *Stegodon insignis* was also recorded by Chakravarti (1932) from Older Gangetic Alluvium near Prahadpur, Varanasi District and assigned Upper Pleistocene age. Mathur (2001a, b) has discussed the status of Quaternary stratotypes of Gangetic plains of Uttar Pradesh and proposed Baba Ghat and Varanasi Formations as per code of stratigraphic nomenclature. Mishra (2001) has reviewed the vertebrate assemblages described from Ganga plains and has opined on their migration from cooler climates in the north due to rise of Himalaya.

Thus while penecontemporaneous presence of vertebrate fossils have received attention from palaeontologists, the records of other fossil groups such as molluscs, charophytes, ostracodes of the Late Quaternary are insignificant to be included here. In view of this lacuna one of us (AKM) took up study of Quaternary Stratotypes of Gangetic plains of Uttar Pradesh (Mathur 2001a, b). During this work, large number of sections were found to be rich in molluscs, ostracodes and charophytes. Through this study, it was revealed that in the upper part of Banda Group, i.e., in Baba Ghat Formation, the reworking of fossils from older Late Cretaceous Lameta sediments is common and characteristic in association with penecontemporaneous Late Quaternary fossils. Pirkenseer et al. (2011) while working on Upper Rhine Graben of Central Europe demonstrated how reworked microfossils provide insight into the palaeogeographic frame work of past sedimentary pathways. An attempt has been made to present palaeodrainage during Late Quaternary in southern part of Gangetic plains of Uttar Pradesh. A brief account of the molluscs and microfossil bearing sections is given in the sequel.

GEOLOGICAL SET-UP

The Quaternary deposits of Gangetic plains of Uttar Pradesh were studied previously in detail by several workers (Sastri et al. 1971, Rao & Ram Chandra 1973, Raiverman et al. 1983), yet certain lacuna remained. Pathak et al. (1978) and Baweja et al. (1980) recognized the Variegated Clays in subsurface and placed it on lithological considerations as equivalent to Tatrot Formation of Upper Siwalik. Agarwal et al. (1991) reviewed and also commented upon the problem of stratigraphy of the subsurface sequences comparing these with the Siwalik Group. In the absence of any record of fossils it is difficult to comment on correlatability of this formation with Tatrot Formation of the Upper Siwalik. Subsequently, Kumar et al. (1996 a, b) considered Variegated Clays as an older formation of Banda Group. Variegated Clay Formation is here treated as an entity separated from the overlying Late Quaternary sequence comprising Baba Ghat Formation (Chitrakoot Formation of Verma and Mehrotra 1991 which is a preoccupied stratigraphic name as discussed in Mathur 2001a, b) and Varanasi Formation. Gibling et al. (2005) have concluded that "Late Quaternary strata below the interfluves show a distinctive architectural motif of discontinuity-bounded sequences." In a more recent work, Dinkar et al. (2019) described geology of Uttar Pradesh. However, they did not take into account work of Mathur (2001b) wherein Banda Group was divided into lower, Variegated Clay Formation and upper Baba Ghat Formation (in gradational contact observed in borehole near Panki, Kanpur according to Kumar et al. 1996b). The distinct fossil assemblages and lithology permitted to replace informal terms Older Alluvium and Newer Alluvium by Baba Ghat Formation and Varanasi Formation. Therefore, the stratigraphic sequence followed here (Table 1) is after Mathur (2001a, b),

The distinguishing lithological characters of these two Quaternary formations is the dominance of pink medium to coarse sand/ *morrum* in the Baba Ghat Formation which is derived from the Vindhyan Supergroup of rocks and sporadic but significant

Table 1. Generalised Stratigraphy of Late Quaternary of Ganga Plains, U.P.

Terrace deposits T ₃ , T ₂ of Yamuna and Ganga River Systems (Late Holocene)		
----- Unconformity / Disconformity -----		
Late Pleistocene to Middle Holocene		Varanasi Formation ----- Disconformity -----
Late Pliocene to Late Pleistocene	Banda Group	Baba Ghat Formation Variegated Clays Formation
Pre-Quaternary	Vindhyan Supergroup/ Bundelkhand Gneissic Complex/?Upper Siwalik	

presence of borage fossil seeds recorded from Lameta Group (Late Cretaceous) of Kheda District, Gujarat by Mathur and Mathur (1985, 2011). On the other hand, appearance of mica bearing grey sand derived from Himalayan region is the distinguishing character of the Varanasi Formation. The geological map of the area based on Khan & Bhartiya (1995) is given in Figure 1. The sections where C¹⁴ dating (at Birbal Sahn Institute of Palaeosciences, Lucknow) of sample was carried out are also shown (Figure 1) to present the numerical dates of Baba Ghat Formation.

STUDY OF SECTIONS

The Baba Ghat Formation extends from Mirzapur District to Chitrakoot, Banda and Hamirpur districts mainly south of Yamuna in the southern Uttar Pradesh (Figure 1). A total of 19 sections of Baba Ghat Formation spread across this area were studied (Mathur 2001a) and have been described in brief to bring out significance of reworked Lameta microfossils in association with in-situ microfossils of Late Quaternary. A check list with location of sections is given in Table 2.

Sections of Baba Ghat Formation:

From the sections of Baba Ghat Formation listed above and described in Mathur (2001a), for the sake of brevity, only eight sections are briefly described below to show the distribution of reworked Lameta (Late Cretaceous) fossil seeds which form an important constituent of this stratigraphic unit and reflect on the erosion and deposition during Late Pleistocene in the southern part of Uttar Pradesh plains.

1. Baba Ghat Section: On the left bank of Paisuni River in the vicinity of Chitrakoot town east of

Baba Ghat about 500 m west of Nayagaon, the Late Quaternary Baba Ghat Formation is exposed. This section is designated as type section. The lithology comprises sand and gravel at the base followed by sandy silt and silty clay. Altogether, 17 samples were collected systematically (BG 1-17) from 16 m thick section (Figure 2). In the lower part, fossil *Boraginaceae* seed, *Proboraginocarpus balasinorensis* (Figure 6.i), derived from Lameta Group (Late Cretaceous) sediments has been recorded. In the middle part, gastropods *Caecilioides (Geostilbia) bensoni* and *Helicorbis* sp., imperfect borage seed (Figure 6.j) (BG 7), *Caecilioides (Geostilbia)* sp.1 (Figure 6.c) (BG 6) and Seed Type X (BG 5) have been found in the section. The molluscs are indicative of relatively cooler climatic conditions.

2. Mendra Section: On the left bank of Tons River near Mendra, Baba Ghat Formation is exposed comprising black humic clay at base followed by brown clay with lensoid sand bodies, mud, silt with ferruginous concretions, mud with calcrete and clay measuring 18.07 m in thickness (Figure 1). Though molluscs are present in the lower part (*Melanoides* sp., gastropod opercula), they are not significant for precise palaeoecological interpretations. Other fossils are ostracode *Limnocythere* sp. and fish vertebra. The ¹⁴C age for basal black humic clay (MN 14) determined by Birbal Sahn Institute of Palaeosciences, Lucknow (BSIP) is 22670-20710 years B.P. which correspond with Würm III – IV interglacial on global scale.

3. Anusuya–Chitrakoot Road Section: In a road cutting about 4 km from Anusuya, Baba Ghat Formation is exposed. This section measuring 7.0 m (Figure 3) in thickness and comprising brown, pink,

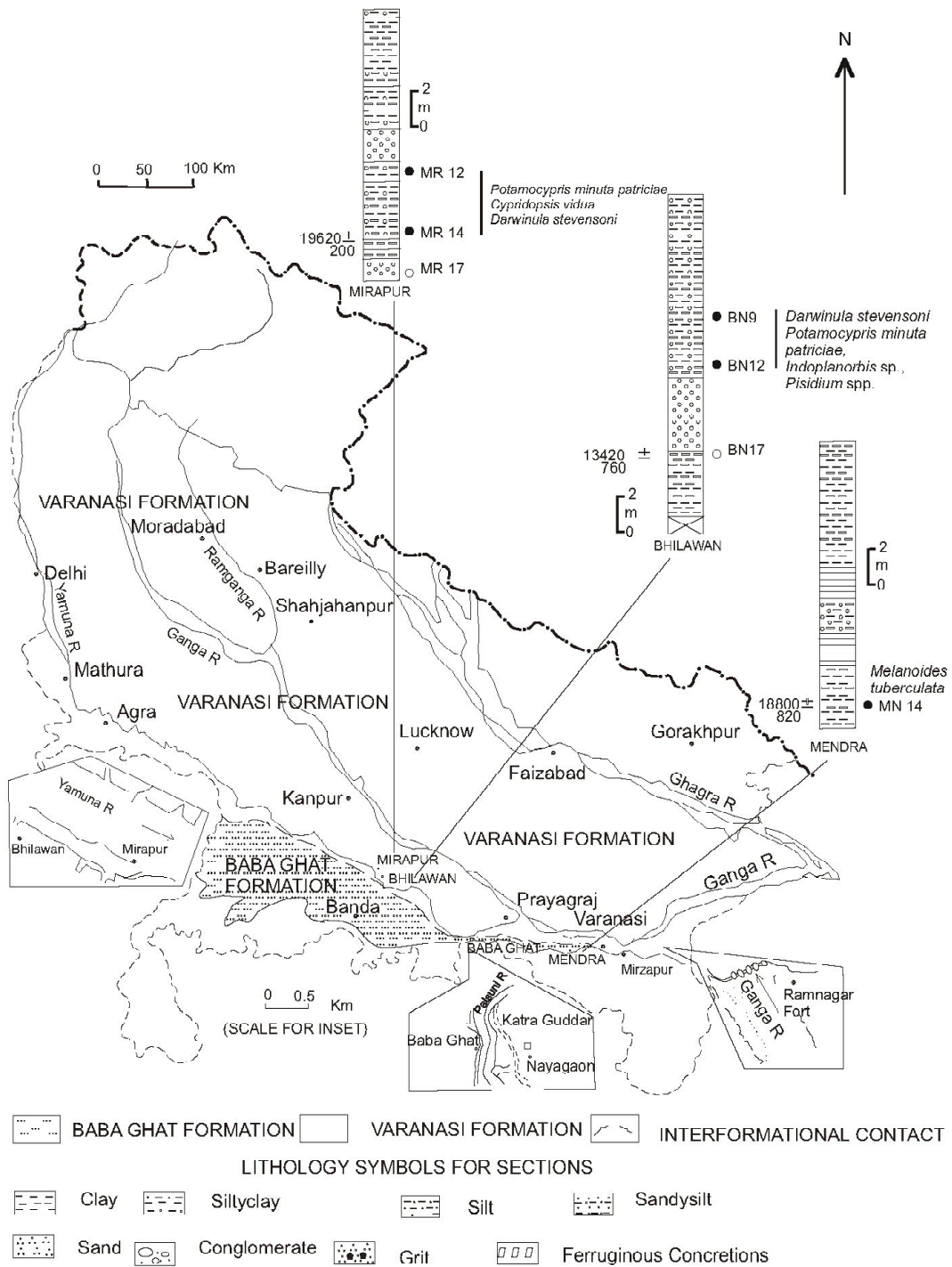


Figure 1. Quaternary geological map of plains of Uttar Pradesh with selected sections of Baba Ghat and Varanasi formations. (Based on Quaternary geological map of Khan & Bhartiya 1995).

grey brown sandy silt and grit was systematically sampled (AS 1-6). The upper part contains gastropods *Caecilioides* sp., and *Caecilioides* (*Geostilbia*) sp. 1 and shell fragments besides reworked borage seed

Proboraginocarpus balasinorensis (Figure 6.i) of Lameta Group (Late Cretaceous) and other fossils. The presence of reworked borage seeds of Late Cretaceous age in Late Quaternary sediments indicates denudation

Table 2. Check-list of sections of the Baba Ghat Formation (Late Pleistocene) of plains of southern Uttar Pradesh.

Section	Location		District	Sample No.	Total samples	Thickness (m)	Fossiliferous samples
	Latitude N	Longitude E					
1. Baba Ghat (Chitrakoot)	25°05'45"	80°54'30"	Chitrakoot	BG 1-17,	17	16.00	BG 5-7, 13
2. North of Ram Bagh (Chunar)	25°05'45"	82° 52'00"	Mirzapur	RB 1-9	9	9.0	RB 5 (stone implements)
3. Belan-Seoti (Bans Ghat)	24°54'50"	83° 05'00"	Mirzapur	BS 1-17	17	18.5	BS 12
4. Jadipur	24°56'30"	82° 04'45"	Mirzapur	JD 1-16, 7A	17	17.0	JD 16
5. Mendra	25°14'50"	82°00'33"	Allahabad	MN 1-16	16	18.07	MN 14, 16
6. Rajapur	25° 24'00"	81° 09'00"	Rajapur	RJ 1-21, 13A	22	20.50	RJ 3,10, 13A, 16-19
7. Anusuya	25° 04'30"	80° 52'45"	Chitrakoot	AS 1-6, 2A, 3A	8	7.00	AS 1, 2A, 3A, 4
8. Ainchwara	25°06'00"	81° 02'30"	Chitrakoot	AW 1-8	8	8.00	AW 1-4, 6-8
9. Hanumandhara I	25°09'30"	80° 53'00"	Chitrakoot	HD 1-10	10	8.00	HD 1, 6, 8-10
10. Hanumandhara II	25°09'30"	80° 53'00"	Chitrakoot	HN 1-2	2	5.50	—
11. Kanwara	25°30'32"	80° 18'20"	Banda	KW1-15	15	15.00	KW 11-15
12. Suharpur	25°53'30"	80° 03'31"	Hamirpur	SU1-11, 4A, B, C, D	15	11.00	SU 1-9, 4A, B, C, D
13. Badanpur 1	25°57'18"	80° 07'03"	Hamirpur	BD 1-4	4	1.00	BD 1-3
14. Badanpur 2	25°57'18"	80°07'05"	Hamirpur	BP 1-11, 9A	12	10.00	BP 1-6, 9-11, 9A
15. Mirapur	25°57'00"	80° 10'25"	Hamirpur	MR1-17, 3A, 7A, 10A, 15A	21	14.10	MR 1-16, 3A, 5A, 9A, 10A
16. Bhilawan	25°57'13"	80°09' 43"	Hamirpur	BN 1-19, 18	20	18.00	BN 1-4, 6, 7, 9-12, 10A
17. Daulatpur	26°08'15"	79°45'30"	Fatehpur	DP 1-5, 2A	6	15.00	DP 1-3
18. RayarDiwara	26°06'30"	79° 46'35"	Fatehpur	RD 1-2	2	3.10	RD 3
19. Kalpi	26°07'30"	79° 45'00"	Fatehpur	KL 1-21	21	19.30	KL 1, 5, 10

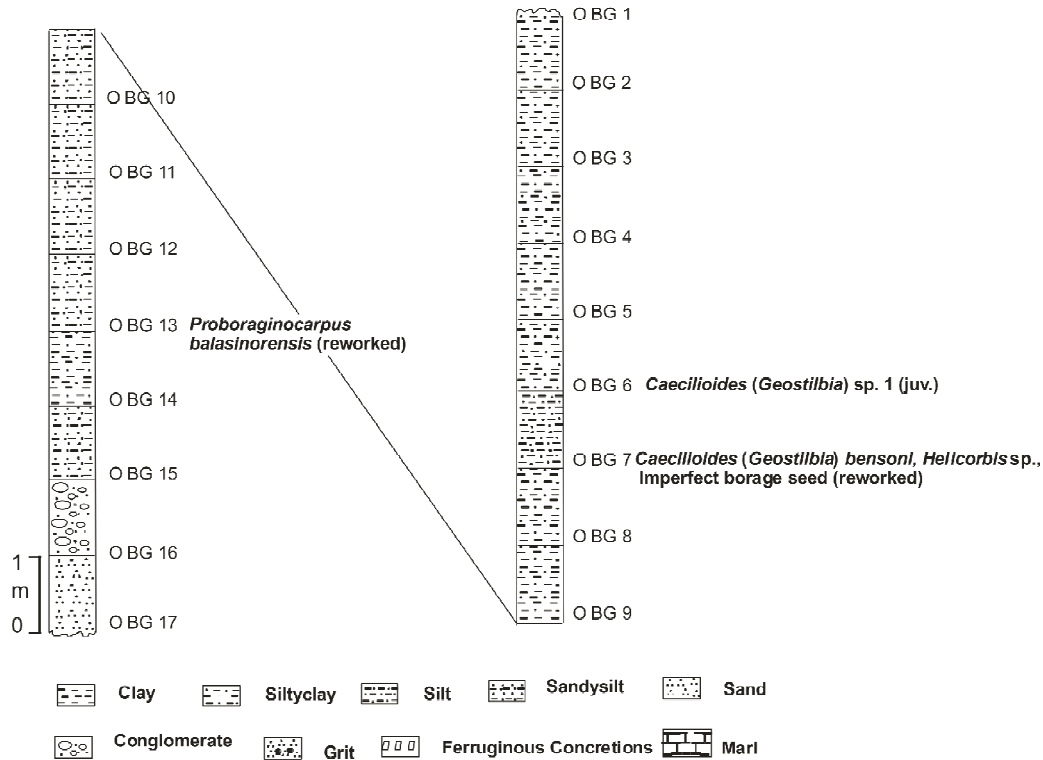


Figure 2. Lithocolumn of Baba Ghat Formation (Type Section) along right bank of Paisuni River opposite Baba Ghat in Chitrakoot town (Chitrakoot District) showing microfossil assemblage with presence of reworked Lameta boarage seed.

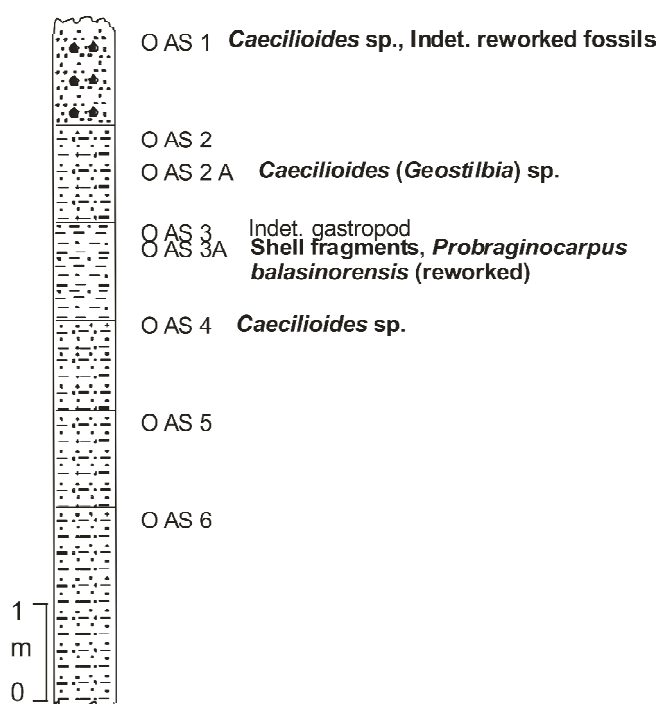


Figure 3. Lithocolumn of Baba Ghat Formation with fossil assemblages including reworked Lameta fossil borage seed about 4 km from Anusuya on Anusuya-Chitrakoot Road, district Chitrakoot.

of Lameta Group sediments present in near vicinity during Late Pleistocene.

4. Kanwara Section: On the right bank of Ken River near Kanwara about 2 km NNE of rail-road bridge, Bundelkhand Gneisses are unconformably overlain by Baba Ghat Formation comprising chiefly brown, yellow grey, pink clay having black blotches, buff grey sandy silt and silty clay measuring 15 m in thickness (Figure 4). In all, 15 samples (KW 1-15) were collected systematically from this section. The upper part yielded ostracodes, charophytes, reworked seeds (*Probraginocarpus balasinorensis*) of Lameta Group (Late Cretaceous). The ostracode assemblage comprises *Potamocypris* sp. cf. *P. minutapatriciae*, *Herpetocypris reptans*, *Candona* sp. cf. *C. paionica*, *C. lactea*, *C. marengoensis*, *Cypris* sp., *Cypridopsis* sp. 1, *Ilyocypris bradyi*, *Hemicypris battishi*, *Limnocythere franki*, *L. blankenbergensis*, *Limnocythere* sp. The charophytes include *Chara globularis globularis*, *Chara* sp. aff. *C. globularis*

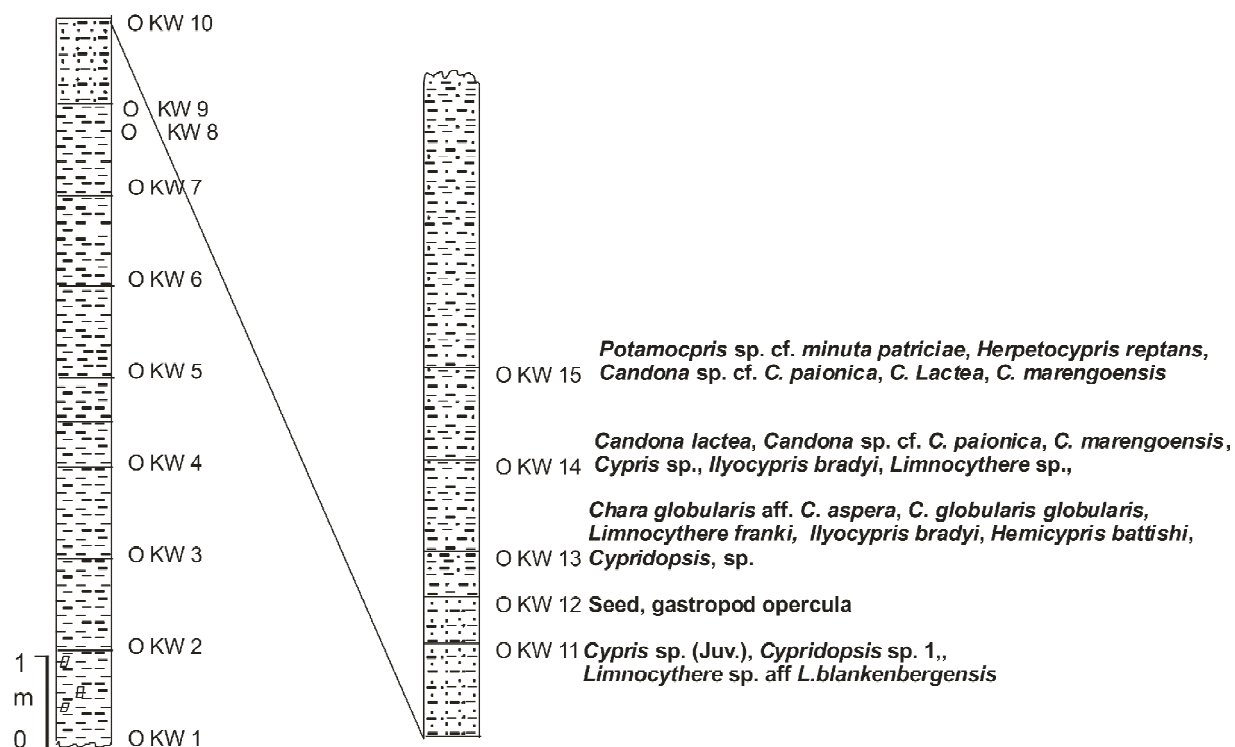


Figure 4. Lithocolumn of Baba Ghat Formation with fossil assemblages including reworked Lameta fossil borage seed Southeast of Kanwara on right bank of Ken River, district Banda.

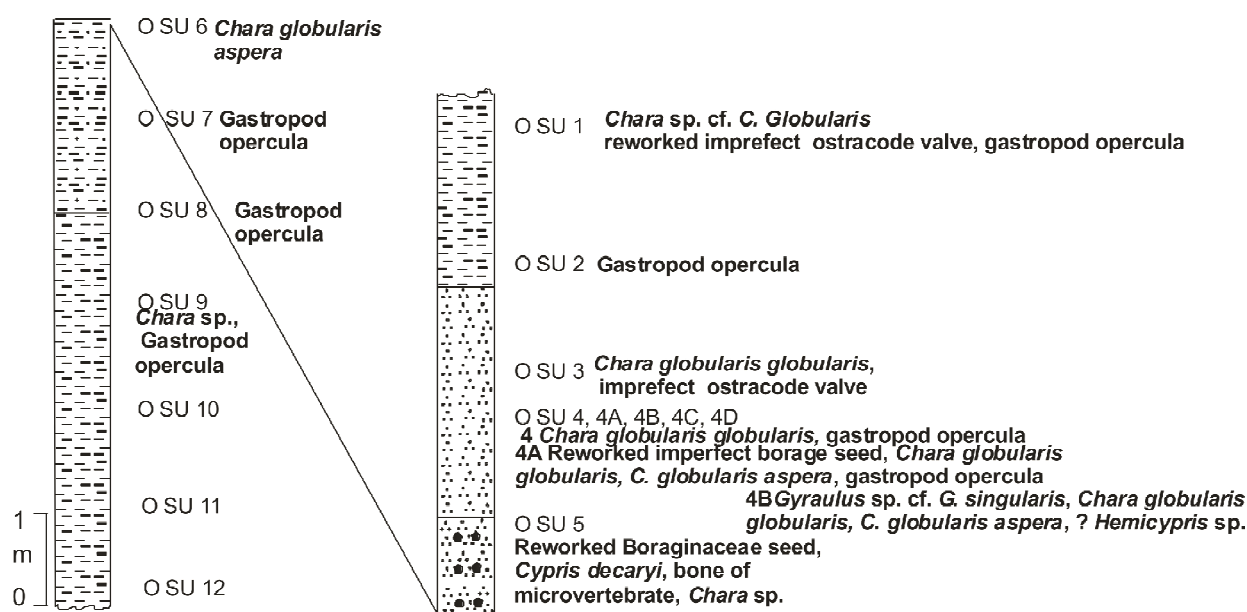


Figure 5. Lithocolumn of Baba Ghat Formation in a nala 1km NW of Suharpur, on the left bank of Betwa River, Hamirpur district.

aspera. Among the ostracodes, *Limnocythere franki*, *L. blankenbergensis*, *Potamocypris minutapatriciae* are known from Karewa Group of Kashmir and indicate cold water bodies. *Candona paionica* is a Late Pleistocene taxon from Czechoslovakia. The assemblage thus suggests cool climatic conditions. The presence of Late Cretaceous Lameta Group borage seed in these sediments indicates extension of these older sediments in this area during Late Pleistocene.

5. Suharpur Section: In the Betwa River section, upstream of Suharpur, Baba Ghat Formation comprising brown to buff clay at the base, followed by silty clay, gravel and ferruginous sand and chocolate marl at the top has a thickness of 11.0 m (Figure 5). In all, 16 samples (SU 1-12, 4 A, B, C, D) were collected systematically. In this section, charophytes *Chara globularis globularis*, *Chara* sp. are present in the middle and upper part (SU 1, 3, 4, 4A, B, 5, 6, 9) besides gastropod opercula, ostracode ?*Hemicypris* sp. (SU 4 A, B), *Cypris decaryi* (SU 5). Reworked ostracode valve ?*Eucypris* sp. (Figure 6.h) and borage seed *Proboraginocarpus balasinorensis* from Lameta Group (Late Cretaceous) are also present indicating presence of Lameta Group sediments in the near vicinity during Late Quaternary.

6. Mirapur Section: On the right bank of the Yamuna River at Mirapur village close to Hamirpur town, Baba Ghat Formation is exposed. From this 14.10 m (Figure 1) thick section, comprising gravel and sand at the base with shell fragments followed by silty clay, sandy silt and sand (*morrum*) alternations, a total of 21 samples were collected systematically (MR 1-17, 3A, 7A, 10A, 15A). The beds dip 8° in S20°E direction. The entire section is rich in fossils. In the lower part (MR 12-15) mostly ostracodes are present which include *Candona rawsoni*, *C. candida*, *C. lactea*, *C. neglecta*, *C. marengoensis*, *Candona* sp., *Cypridopsis vidua obesa*, *C. vidua vidua*, *Cypridopsis* sp., *C. aculeata*, *Cypridopsella* sp., *Virgatocypris* sp., *Cypris* sp. cf. *C. subglobosa*, ?*Cypris pubera*, *Potamocypris minutapatriciae*, *Potamocypris* sp. cf. *P. nealei*, *Potamocypris* sp., *Stenocypris major*, *Stenocypris* sp., *Hemicypris* sp., *Darwinula stevensoni*, *Microdarwinula* sp., ?*Herpetocypris reptans*, *Ilyocypris bradyi*, *I. gibba*, *Limnocythere* sp. The presence of *Darwinula stevensoni* indicates permanent water bodies which seem to have been filled with sand (MR 10, 10A) and silty clay (MR 8, 9) clay (MR 1-6) where molluscs dominated. The molluscs comprise *Caecilioides*

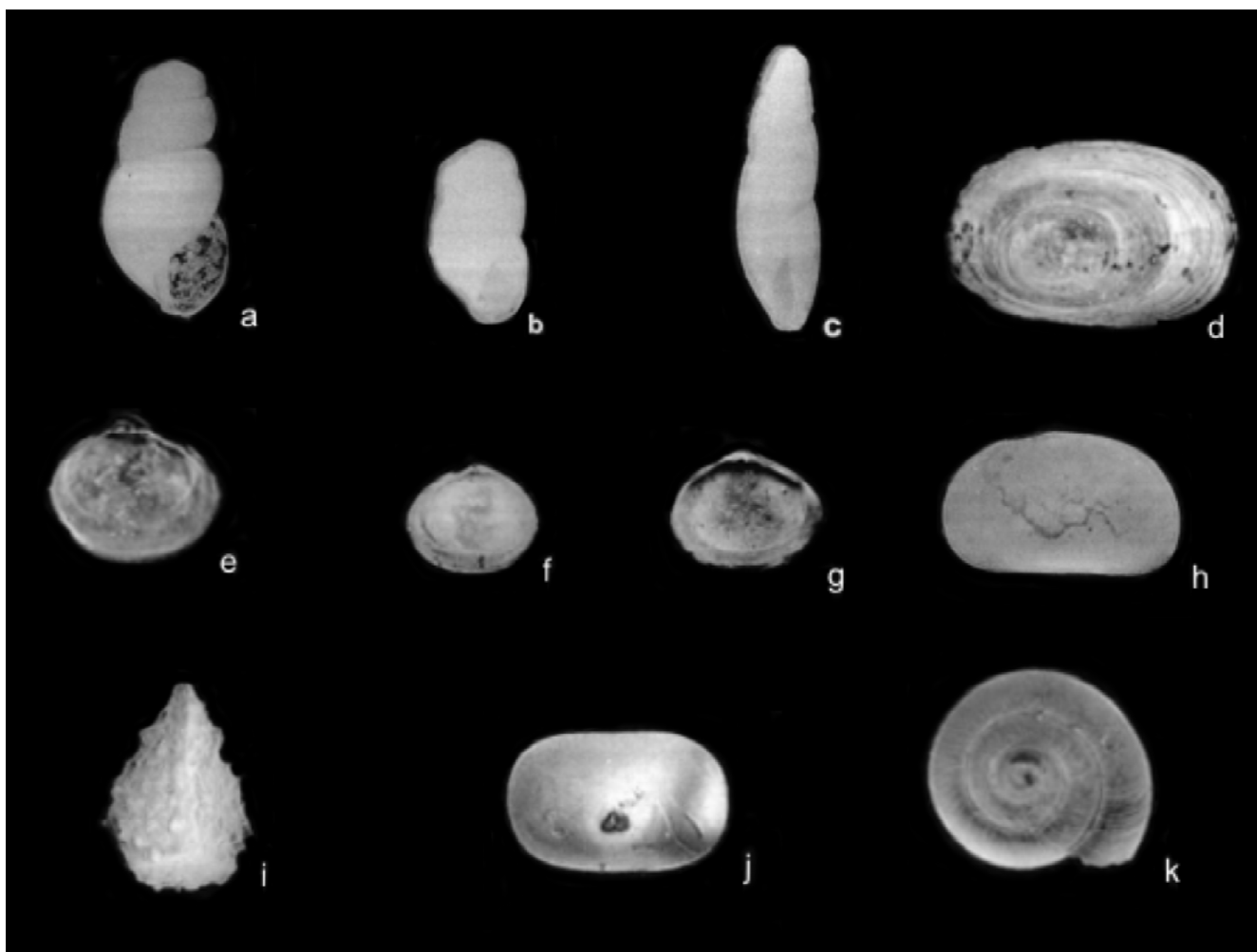


Figure 6. Photographs of selected in situ and reworked fossils in Baba Ghat Formation (Late Pleistocene) of Uttar Pradesh. **a.** *Tricula montana* Benson H: 2.6 mm. **b.** *Gulella (Huttonella) bicolor* Gude H: 1.2 mm. **c.** *Caecilioides (Geostilbia) sp. 1* H: 1.5 mm. **d.** *Ferrissia* sp. cf. *F. viola* Annandale & Prasad L: 1.8 mm. **e.** *Pisidium (Pisidium) mitchelli* Prasad L: 1.0 mm. **f.** *Pisidium (Afropisidium) clarckeanum* Nevill & Nevill L: 1.1 mm. **g.** *Pisidium (Neopisidium) nevillianum* (Theobald) L: 0.9 mm. **h.** Ostracode ?*Eucypris* sp. (reworked from Lameta Group) L: 1.5 mm. **i.** *Probraginocarpus balasinorensis* Mathur & Mathur (reworked from Lameta Group) L: 1.8 mm. **j.** Seed (reworked from Lameta Group) L: 1.5 mm. **k.** *Philalanka micromphala* Benthem Jutting Max Dia.: 2.0 mm.

(*Geostilbia*) *bensoni*, *Caecilioides (Geostilbia)* sp. 1 (Figure 6.c), *Tricula montana* (Figure 6.a), ?*Tricula* sp., *Gulella (Huttonella) bicolor* (Figure 6.b), *Helicorbis* sp., *Philalanka micromphala* (Figure 6.k), *Gyraulus stewarti*, *Gyraulus singularis*, *Pisidium (Afropisidium) clarckeanum* (Figure 6.f), *Pisidium (Neopisidium) nevillianum* (Figure 6.g), *Pisidium (Pisidium) mitchelli* (Figure 6.e) and gastropod opercula. The ostracodes include *Hemicypris* sp. 1, *Hemicypris* sp. 2, *Stenocypris* sp. cf. *S. major*, *Ilyocypris bradyi*, *I. gibba*, *Ilyocypris* sp. The charophytes include *Chara globularis aspera*

and *Chara* sp. and Seed Type A1, Seed Type A2, Seed Type A3 and ?seed. Besides coaly matter, burnt vegetal matter and pottery pieces are also present in the upper part of the section. The presence of *Pisidium (Pisidium) mitchelli* and *Tricula montana* are indicative of cool environment. Sample MR 14 has been dated by BSIP, Lucknow as 23.03-22.20 ky B.P. which corresponds to Würm III-IV interglacial on global scale.

7. Bhilawan Section: In a section along right bank of Yamuna River upstream of Mirapur near Bhilawan, Baba Ghat Formation is exposed. In this section

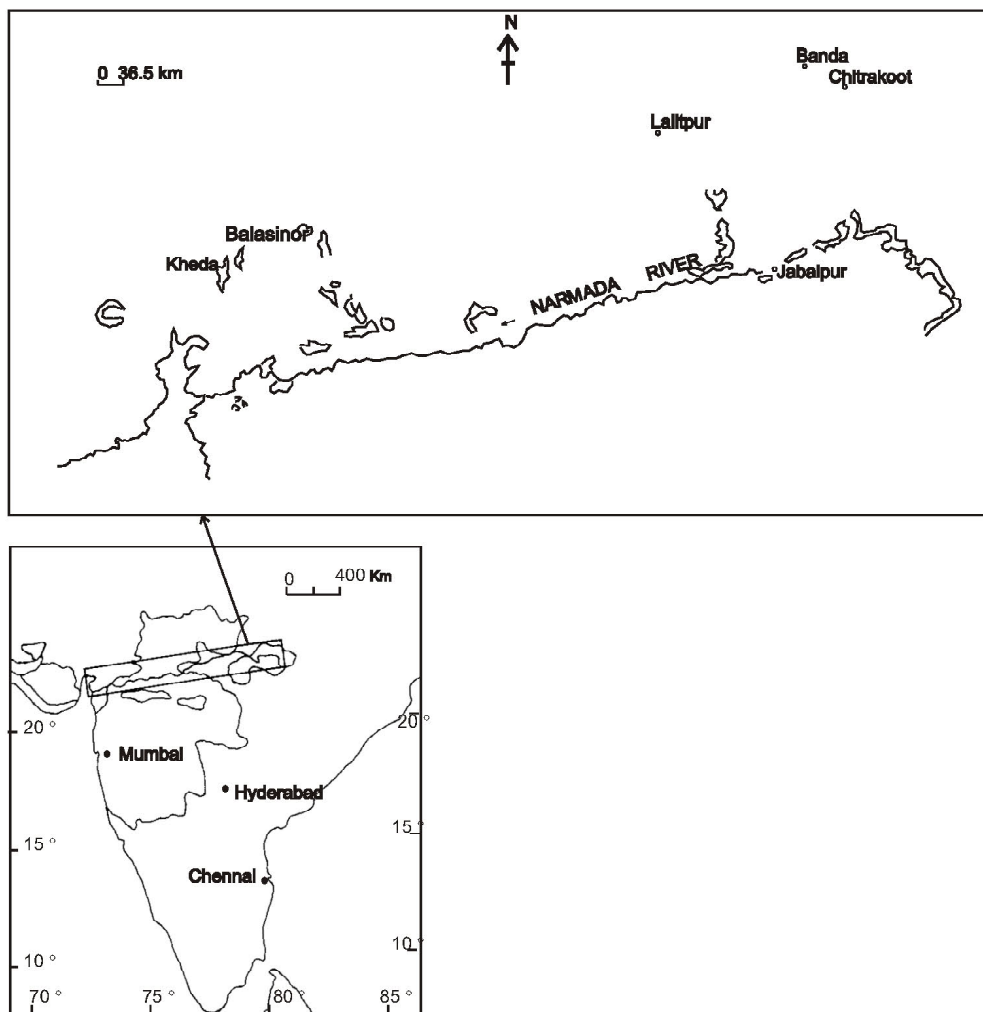


Figure 7. Showing present outcrop distribution of Late Cretaceous Lameta Formation in Central India (after Sahni 1983) northern-most of which is in Lalitpur. The Late Pleistocene Baba Ghat Formation exposed at Chitrakoot, near Banda contains reworked Borage seeds of Lameta Group.

measuring 18 m in thickness (Figure 1) the humic clay with sand lenses at the base is followed by sand with clay lenses which are in turn overlain by silty clay. A total of 20 samples (BN 1-19, 10A) were collected systematically. The beds dip at 8-10° in southerly direction. Except for imperfect gastropod shells, lower part (BN 13-19) has not yielded fossils. The middle part is rich in molluscs and ostracodes. The molluscs comprise *Caecilioides (Geostilbia) bensoni*, *?Euaustenia* sp., *Ferrisia* sp. cf. *F. viola* (figure 6.d), *?Indoplanorbis* sp., *Pisidium (Afropisidium) clarckeanum* (Figure 6.f). The ostracodes include *Candona compressa*, *Candona neglecta*, *C.*

marengoensis, *Candona* sp. cf. *C. paionica*, *C. lactea*, *Cypridopsis vidua*, *Stenocypris major*, *Parastenocypris* sp. cf. *P. nealei*, *Hemicypris* sp. cf. *H. battishi*, *Hemicypris* sp., *Hemicypris* sp. cf. *H. pandei*, *?Cyprinotus* sp., *Cypris subglobosa*, *Potamocypris minutapatriciae*, *Ilyocypris bradyi*, *Limnocythere* sp. aff. *L. franki* and *Darwinula stevensoni*. In addition, fish scales are also present. The molluscs such as *Ferrisia* sp. cf. *F. viola*, *Euaustenia* sp., *Pisidium (Afropisidium) clarckeanum* together with ostracode *Limnocythere franki* are indicative of cold water lacustrine conditions. The shift in climate or depositional regime is inferred

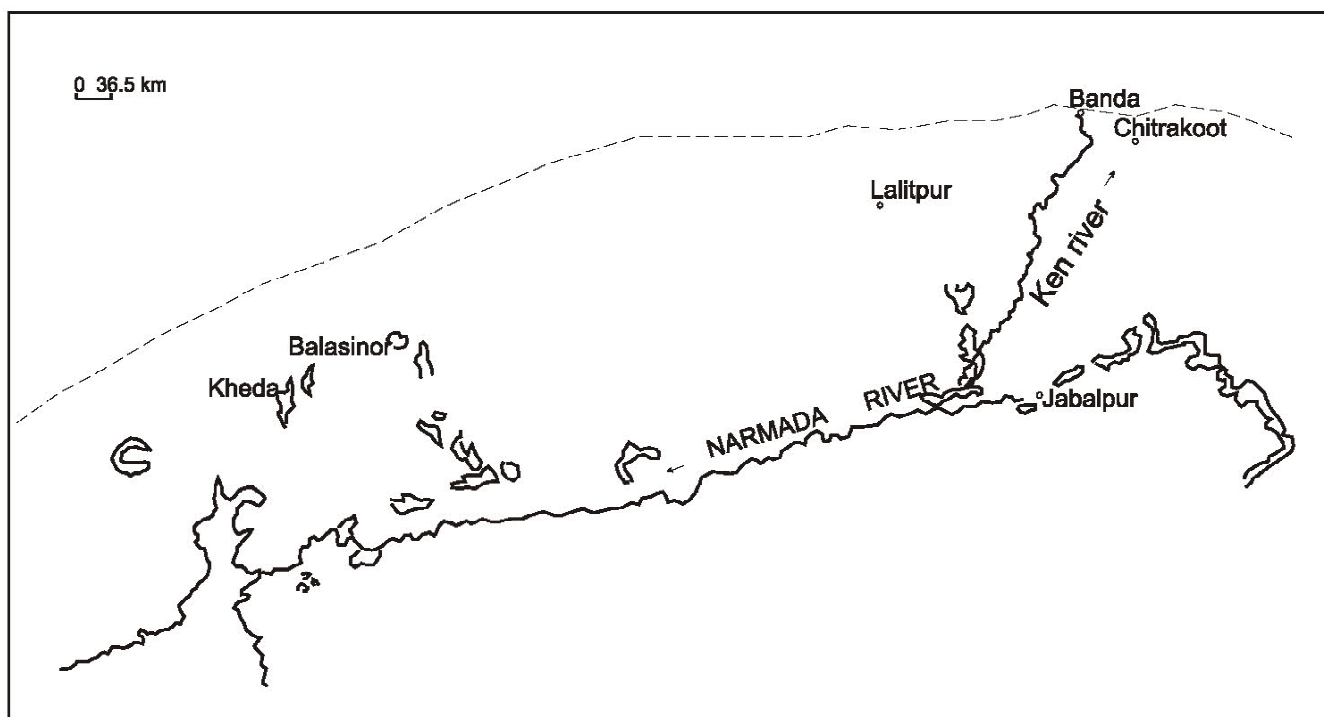


Figure 8. The possible extension of Lameta Formation during Late Pleistocene. The present direction of Ken River is suggestive of palaeodrainage pattern which eroded Lameta Formation during Late Pleistocene and deposited Baba Ghat Formation of Banda Group.

for the upper part (BN 1-8) from its meagre fossil assemblage comprising *Caecilioides* sp., *Polypylis* sp., imperfect gastropod shells, Seed Type A, Seed Type B and Seed Type C. The basal black humic clay (BN 17) has been ^{14}C dated by BSIP, Lucknow as 16500-14290 years B.P. This corresponds to Würm IV Late glacial on global scale.

8. Kalpi Section: About 800 m west of right bank end of road bridge on Yamuna near Kalpi, Baba Ghat Formation comprising calccrete bearing silty clay at base followed by gravel, silty clay, sandy clay alternations measuring 19.30 m in thickness is exposed. In all, 21 samples (KP 1-21) were collected systematically. The basal silty clay (KL 1) and gravel bed (KL 5) contain vertebrates and gastropods. The section yielded poor fossil assemblage viz. *Melanoides tuberculata*, *Succinea* sp. and gastropod opercula, besides indet. equid molar, limb bones.

DISCUSSION

In Late Pleistocene, during the deposition of Baba Ghat Formation in the type area Baba Ghat

(Chitrakoot), Kanwara, Anusuya and Suharpur, in southern Uttar Pradesh, there is dominance of argillaceous sediments laid down in shallow freshwater bodies formed by the prevailing drainage system in Vindhyan ranges. The in-situ faunal assemblages suggest climatic fluctuations during deposition of these sediments. Salient palaeoclimatic inferences drawn from these assemblages are: in the lower part of Baba Ghat Formation in sections such as Kanwara and Hanumandhara, Anusuya, the presence of ostracodes *Potamocypris* sp. cf. *P. minutapatriciae*, *Herpetocypris reptans*, *Candona* sp. cf. *C. paionica*, *C. lactea*, *C. marengoensis*, *Cypridopsis* sp. 1, *Ilyocypris bradyi*, *Hemicypris battishi*, *Limnocythere franki*, *L. blankenbergensis*, *Cypris decaryi*, *Cypris* sp. cf. *C. pubera*, gastropods *Caecilioides* (*Geostilbia*) sp.1, *Tricula* sp. and *Gulella* (*Huttonella*) *bicolor* (juv.) (Figure 6.b) and charophyte *Lychnothamnus barbatus* represent an interglacial phase where fauna is rich and diverse. The cold dry conditions result in an increase in total dissolved solids raising the pH as indicated by charophyte

Lychnothamnus barbatus. Though no ^{14}C dates for these sections is available, their stratigraphically lower position (older than Mirapur section giving an age range of 23030-22200 years B.P.) suggest its placement in the Late Pleistocene.

In the middle part of Baba Ghat Formation, in sections such as Mirapur, Bhilawan (age range 16500-14290 years B.P.) there is again proliferation of fauna as represented by ostracodes *Candona rawsoni*, *C. candida*, *C. lactea*, *C. neglecta*, *C. marengoensis*, *Cypridopsis vidua obesa*, *C. vidua vidua*, *C. aculeata*, *Cypridopsella* sp., *Virgatocypris* sp., *?Cypris pubera*, *Potamocypris minutapatriciae*, *Potamocypris* sp. cf. *P. nealei*, *Potamocypris* sp., *Stenocypris major*, *Darwinula stevensoni*, *Microdarwinula* sp., *?Herpetocypris reptans*, *Ilyocypris bradyi-gibba* and *Limnocythere* sp., gastropods *Caecilioides (Geostilbia) bensoni*, *Caecilioides (Geostilbia) sp.*, *Tricula montana*, bivalves *Pisidium (Afropisidium) clarckeanum*, *P. (Pisidium) mitchelli* and charophytes *Chara globularis aspera* suggest development of relatively cooler freshwater bodies along the drainage system. Some selected in-situ and reworked microfossils are shown in Figure 6.

Insofar as the direction of drainage during the deposition of Baba Ghat Formation is concerned, the presence of *Boraginaceae* fossil seed *Proboraginocarpus balasinorensis* recorded by Mathur and Mathur (1985, 2011), from Lameta Group (Late Cretaceous) of Kheda District, Gujarat as reworked in Kanwara, Suharpur, Anusuya, Baba Ghat sections indicates that the drainage was emerging from southern source in northerly direction. It was cutting across the Lameta Group sediments exposed in Vindhyan range during Late Quaternary.

The river system denuded the Late Cretaceous calcarenite sediments in the above sections and Bundelkhand Gneisses in other sections of Baba Ghat Formation that are rich in *morrum* or ferruginized quartz. The present northern most extension of Lameta Group is near Lalitpur. Sahni (1983) had shown

extension of nonmarine Lameta Group north of Jabalpur (Figure 7) but how far these must have extended remains to be ascertained. The fact that Baba Ghat Formation exposed north and east of the above Lameta borage seed bearing sections are rich in derivatives of Vindhyan Supergroup/ Bundelkhand Gneissic Complex. This shows that in Mirzapur District the drainage no more passed through the Lameta sediments as either these had been eroded previously and deposited at greater depths and not exposed any more or that the Lameta Group did not extend in this direction during Late Pleistocene. The possible northern extent of Lameta Group in Late Pleistocene on the basis of above discussion can be close to Banda and Chitrakoot as shown in Figure 8.

However, the drainage continued in southwest-northeast direction similar to the flow direction of present day Ken River.

CONCLUSIONS

1. Reworking of Late Cretaceous Lameta Group sediments during Late Pleistocene in southern Uttar Pradesh is conclusively proved by the presence of borage seeds (*Proboraginocarpus balasinorensis*) among the in-situ molluscs, ostracodes and charophytes of Baba Ghat Formation.
2. Drainage direction during the deposition of Baba Ghat Formation in Late Pleistocene in Vindhyan ranges was from south towards northern part of southern Uttar Pradesh, similar to the course of Ken River near Banda and Paisuni Stream near Chitrakoot.

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