

**Table 2.**  $\chi^2$  for 1:1 ratio on marginal totals to assess the relative mating propensity of high line and low line flies of both sexes of *Drosophila ananassae* (for pooled data of all crosses)

		Males		
		High line	Low line	Total
Females	High line	117	56	173
	Low line	54	51	105
	Total	171	107	
$\chi^2$ high line, low line females		16.64	$P < 0.001^*$	
$\chi^2$ high line, low line males		14.74	$P < 0.001^*$	

\*Significant (df = 1).

homogamic and heterogamic matings under the assumption of random mating. Although the  $\chi^2$  values show significant difference (one cross and pooled data) between homogamic and heterogamic matings and isolation estimate remains below one, there is no evidence for selective mating or sexual isolation between high and low lines for sternopleural bristles. Only one type of mating combination, i.e. H females  $\times$  H males is most frequent. The homogamic matings (L females  $\times$  L males) are more or less equally frequent to both heterogamic matings. High frequency of matings between high females and high males is due to higher sexual activity of high males and more receptivity of high females compared to low line flies. Table 2 shows the  $\chi^2$  values calculated on marginal totals (for pooled data of all crosses) to assess the relative sexual activity of two sexes of both lines. Differences are significant for females and for males. Females and males with high number of sternopleural bristles are more successful in mating than those with low number of bristles. Thus, our results indicate that flies of high line have greater mating success than those of low line and thus mating success in *D. ananassae* is influenced by sternopleural bristle phenotypes. However, there is no evidence for ethological isolation between high and low lines for sternopleural bristle number in *D. ananassae*.

Thoday and Gibson<sup>18</sup> found simultaneous divergence for a polygenic character and ethological isolation by disruptive selection for a morphological character (sternopleural bristle number) in *D. melanogaster*. Both homogamic matings (H  $\times$  H, L  $\times$  L) were significantly more frequent than heterogamic matings (H  $\times$  L, L  $\times$  H) and there was preference for homogamic matings. However, their data did not reveal difference in mating activity of flies with high and low number of sternopleural bristles. Unfortunately, attempts to repeat these experiments in a number of different laboratories have failed to confirm these findings of Thoday and Gibson<sup>18</sup> in *D. melanogaster*<sup>19</sup>. Our results in *D. ananassae* are also not in agreement with those of Thoday and Gibson<sup>18</sup> in *D. melanogaster* that divergence for polygenic character leads to reproductive isolation in the laboratory. On the other hand, there is clear evidence of the influence of sternopleural bristle phenotypes on mating success in *D. ananassae*.

1. Singh, B. N., *Nucleus*, 1985, 28, 169–176.
2. Singh, B. N., *Indian Rev. Life Sci.*, 1988, 8, 147–168.
3. Singh, B. N., *Indian Rev. Life Sci.*, 1991, 11, 205–231.
4. Chatterjee, S. and Singh, B. N., *Indian Rev. Life Sci.*, 101–135.
5. Singh, A. K. and Singh, B. N., *Indian Rev. Life Sci.*, 27–53.
6. Singh, B. N. and Chatterjee, S., *Heredity*, 1986, 57, 75.
7. Singh, B. N. and Chatterjee, S., *Genetica*, 1987, 73, 23.
8. Singh, B. N. and Chatterjee, S., *Behav. Genet.*, 1988, 369.
9. Singh, B. N. and Chatterjee, S., *Heredity*, 1988, 60, 26.
10. Singh, B. N. and Chatterjee, S., *Genet. Sel. Evol.*, 1989, 455.
11. Singh, B. N. and Chatterjee, S., *Can. J. Genet. Cytol.*, 405–409.
12. Singh, B. N. and Pandey, M., *Behav. Genet.*, 1993, 23, 239.
13. Singh, B. N. and Pandey, M., *Hereditas*, 1993, 119, 11.
14. Singh, B. N. and Mathew, S., *Biol. Res.*, Submitted, 1995.
15. Singh, B. N. and Mathew, S., *Evol. Biol.*, 1993, 7, 313–319.
16. Parsons, P. A., *Heredity*, 1961, 16, 455–473.
17. Merrell, D. J., *Evolution*, 1950, 4, 326–331.
18. Thoday, J. M. and Gibson, J. B., *Nature*, 1962, 193, 110–111.
19. White, M. J. D., *Modes of Speciation*, W. H. Freeman, San Francisco, 1978.

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## Environmental variations in late Quaternary sequence of Kolaghat West Bengal, India

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**Paleoenvironmental analysis of late Quaternary sediment and their biotic contents from onshore of southern West Bengal reveals eight ecological phases. A climatic fluctuation for a short period has been noticed within the prolonged climatic**

# RESEARCH COMMUNICATIONS

Radiocarbon age data indicate the existence of mangrove swamps during ca. 32 ky (pre-Holocene) and ca. 7 ky (Holocene).

PALYNOLOGICAL, micropaleontological and sedimentological investigations were carried out from 30 m deep, continuous and undisturbed borehole samples from onshore Kolaghat (Lat. 22°27'N; 87°55'E), West Bengal (Figure 1). The top of the borehole was 4.0 m above the present sea level. Occurrence of plants and molluscs of mangrove ecology from upper 6.0 m of a 13.0 m deep excavation at Kolaghat had been reported earlier<sup>1</sup>. Incorporation of palynological, micropaleontological, sedimentological and radiocarbon age data in a single framework for the younger sediments of Southern Bengal had not been attempted so far. The present report is an initial outcome of such a study. Thirty palynomorphs, of which 2 were pteridophytes, 24 angiosperms, 3 fungi and 1 acritarch were identified from different levels of the 30 m deep sequence (Table 1). Of the recorded assemblages, 17 angiosperms were mangrove elements. This is in striking contrast to the total absence of mangrove from the same locality of present day Kolaghat. Micropaleontological study recorded a rich assemblage of 18 species of foraminifera from

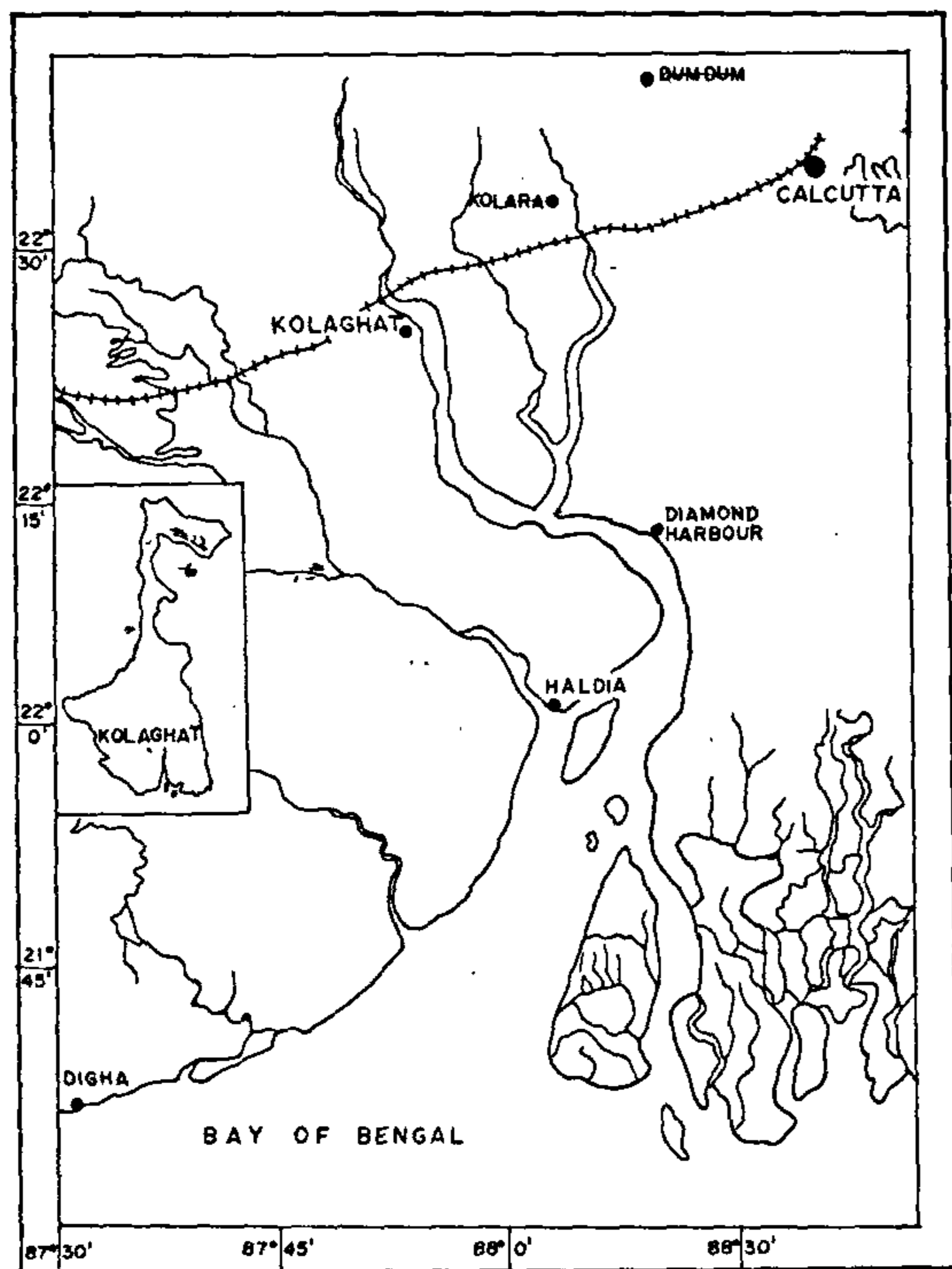


Figure 1. Location map.

Table 1. Palynomorphs recovered from Kolaghat bore hole under various ecological groups

Core mangrove	Back mangrove
<i>Avicennia alba</i> *	<i>Acanthus ilicifolius</i> *
<i>Avicennia marina</i> *	<i>Acrostichum aureum</i>
<i>Aegiceras corniculatum</i> *	<i>Heliotropium curass</i>
<i>Bruguiera gymnorhiza</i> *	<i>Pandanus fascicular</i>
<i>Ceriops decandra</i> *	<i>Suaeda maritima</i> *
<i>Excoecaria agallocha</i> *	
<i>Heritiera fomes</i> *	
<i>Kandelia candel</i> *	Non-mangrove
<i>Nypa fruticans</i> *	
<i>Phoenix paludosa</i> *	<i>Asteraceae</i> <sup>§</sup>
<i>Rhizophora mucronata</i> *	<i>Bombax</i> sp. <sup>§</sup>
<i>Sonneratia apetala</i> *	<i>Ceratopteris</i> sp. <sup>§</sup>
<i>Sonneratia griffithii</i> *	<i>Cyperaceae</i> <sup>§</sup>
<i>Xylocarpus granatum</i> *	<i>Polygonum</i> sp. <sup>§</sup>
<i>Potamogeton</i> sp. <sup>§</sup>	<i>Typha</i> sp. <sup>*,*</sup>
	Others (fungi and acritarch)
	<i>Cirrenalia</i> sp. <sup>§</sup>
	<i>Concentricystes</i> sp. <sup>§</sup>
	Foraminiferal inner lining <sup>§</sup> (cf. <i>Ammonia</i> )
	<i>Meliola</i> sp. <sup>§</sup>
	Microthyraceous fruit body <sup>§</sup>
	Poaceae <sup>§</sup>

\*Tropical; \*Temperate; §Cosmopolitan.

Table 2. Foraminifera recovered from Kolaghat bore hole ecological groupings

Environment	
Marginal sea	Marine inner s
<i>Ammonia</i> sp.	<i>Asterorotalia</i> sp.
<i>Elphidium</i> sp.	<i>Bolivina</i> sp.
<i>Glabratella</i> sp.	<i>Globigerina</i> sp.
<i>Pseudoeponides</i> sp.	<i>Neogloboquadr</i>
<i>Quinqueloculina</i> sp.	<i>Nonion</i> sp.
<i>Nonionella</i> sp.	<i>Triloculina</i> sp.
	<i>Uvigerina</i> sp.

Table 3. Textural analysis of Kolaghat bore hole

Lithology	Mean size (phi) <sup>*,*</sup>	Nature of size frequency curve
Grey silty clay	7.16 – 8.06	Platykurtic to leptokurtic
Greyish to yellowish silty clay	6.14 – 7.04	Platykurtic
Grey silty clay	6.5	Platykurtic

different strata of this locality. These include *tepida*, *A. soberina* (including a few inner palynological samples), *Pseudoeponides*, *Pseudoeponides* sp., *Elphidium minutum*,

Table 4. Phases and their diagnostic features

Depth (m)	Phases	Diagnostic features
0.0–5.3	VIII	Barren of biological remains. Sediments very poorly sorted. Representative curve platykurtic.
5.4–7.3	VII	Mangrove reappeared in the sedimentary succession. <i>Acrostichum</i> is the key mangrove element along with <i>Sonneratia</i> and <i>Heritiera</i> . Absence of foraminifera except foraminiferal inner lining (cf. <i>Ammonia</i> ) Sediments poorly sorted. Representative curve platykurtic
7.4–11.4	VI	Barren of biological remains. 'Kankar' is the characteristic lithounit. Sediments poorly sorted. Representative curve leptokurtic
11.5–16.8	V	Biologically barren. Sediments poorly sorted. Representative curve platykurtic
17.0–20.6	IV	Total absence of palynomorphs. Characterized by diverse foraminifera of shallow marine ecology, viz. <i>Ammonia</i> – <i>Globigerina</i> – <i>Neogloboquadrina</i> – <i>Elphidium</i> – <i>Glabratella</i> – <i>Bolivina</i> – <i>Uvigerina</i> – <i>Nonion</i> – <i>Fissurina</i> – <i>Triloculina</i> . Sediments very poorly sorted. Representative curve very platykurtic.
20.8–23.6	III	Core mangrove taxa dominated vegetational scenario, viz. <i>Rhizophora</i> – <i>Sonneratia</i> – <i>Avicennia</i> . Foraminifera present estuarine in nature. Sediments moderately sorted. Representative curve leptokurtic.
23.8–26.6	II	Appearance of mangrove palynomorphs. Dominant elements are <i>Sonneratia</i> – <i>Avicennia</i> – <i>Rhizophora</i> – <i>Bruguiera</i> – <i>Heritiera</i> – <i>Suaeda</i> – <i>Excoecaria</i> – <i>Acanthus</i> – <i>Xlycarpus</i> – <i>Aegiceras</i> and Poaceae. Estuarine salt tolerant foraminifera, viz. <i>Ammonia</i> – <i>Elphidium</i> – <i>Pseudoeponides</i> – <i>Quinqueloculina</i> – <i>Nonion</i> and <i>Triloculina</i> are present. Sediment moderately sorted. Representative curve leptokurtic.
26.8–30.0	I	Biologically barren. Sediments poorly sorted. Representative curve platykurtic.

*Elphidium* sp., *Glabratella* sp., *Uvigerina* sp., *Asterorotalia* sp., *Nonion* sp., *Fissurina* sp., *Globigerina bulloides*, *Neogloboquadrina pachyderma*, *Bolivina* sp., *Quinqueloculina* sp., *Nonionella* sp., *Triloculina* sp., and Ostracoda. These palynological<sup>2,3</sup> and micropaleontological<sup>4</sup> elements are grouped on the basis of their ecological affinity (Tables 1 and 2).

Textural analysis of sediments revealed three sets of data (Table 3). One clay sample from lower horizon (26.6 m) and one peat sample from upper horizon (7.0 m) were radiometrically dated depicting  $31,750 \pm 2030$  YBP (BS 1192) and  $6900 \pm 70$  YBP (PRL 1781) respectively<sup>5</sup>.

The sequence is divisible into eight phases (phases I–VIII), from bottom upwards, and integrates information from palynology, micropaleontology and sedimentology. The important features of the sedimentary succession are shown in Table 4 and Figure 2.

Phase I is biologically barren and deposited under fluvial environment. This phase is overlain by phases II, III and IV, which are deltaic estuarine and marine sequences. The fluvial terrain turned into an intertidal zone during the deposition of phase II at  $31,750 \pm 2030$  YBP (late Pleistocene) which facilitated mangroves to proliferate. Presence of these mangroves in the sequence may thus be considered to locate former sea levels<sup>6–8</sup>. The record of pre-Holocene mangrove swamp at Kolaghat (–22.6 m from present day insl), however, needs

special attention. During that time the global sea level was at least 55 m lower than the present mean sea level<sup>9</sup>. The difference of 32.4 m, thus appears to be due to local tectonism. Abundance of pollen grains of *Sonneratia*, *Rhizophora* and *Avicennia* in phase III indicates increase in tidal influx during the time of deposition. Phase IV is marked by sudden rise of the sea level which disturbed the intertidal character of the previous phase. As a result, the mangroves were exterminated and shallow marine conditions prevailed. Phase V represents similar conditions as of the Phase I, but for a longer duration. Lithologically this phase is represented by yellow silty clay; yellow colour of sediments indicate the presence of oxygenated agitated condition of deposition<sup>10</sup>. Phase VI is distinct and different from others by the presence of clay layers impregnated with kankar concretions formed possibly under relatively arid conditions for a prolonged period<sup>11,12</sup>. Phase VII is characterized by a peat layer, which indicates the existence of a thick forest and accumulation of partially decomposed matter in a wet humid swampy environment at about  $6900 \pm 70$  YBP, i.e. mid-Holocene. The mangrove elements in the peat and textural attributes of sediments suggested reappearance of intertidal mangrove forest, thus revealing transgression of the sea during the deposition of phase VII. The effect of transgression could be traced up to Kolara<sup>2</sup> and further up to Dum Dum<sup>8</sup> (Figure 1). Temporally this coincides with the mid-Holocene Flandrian Transgression

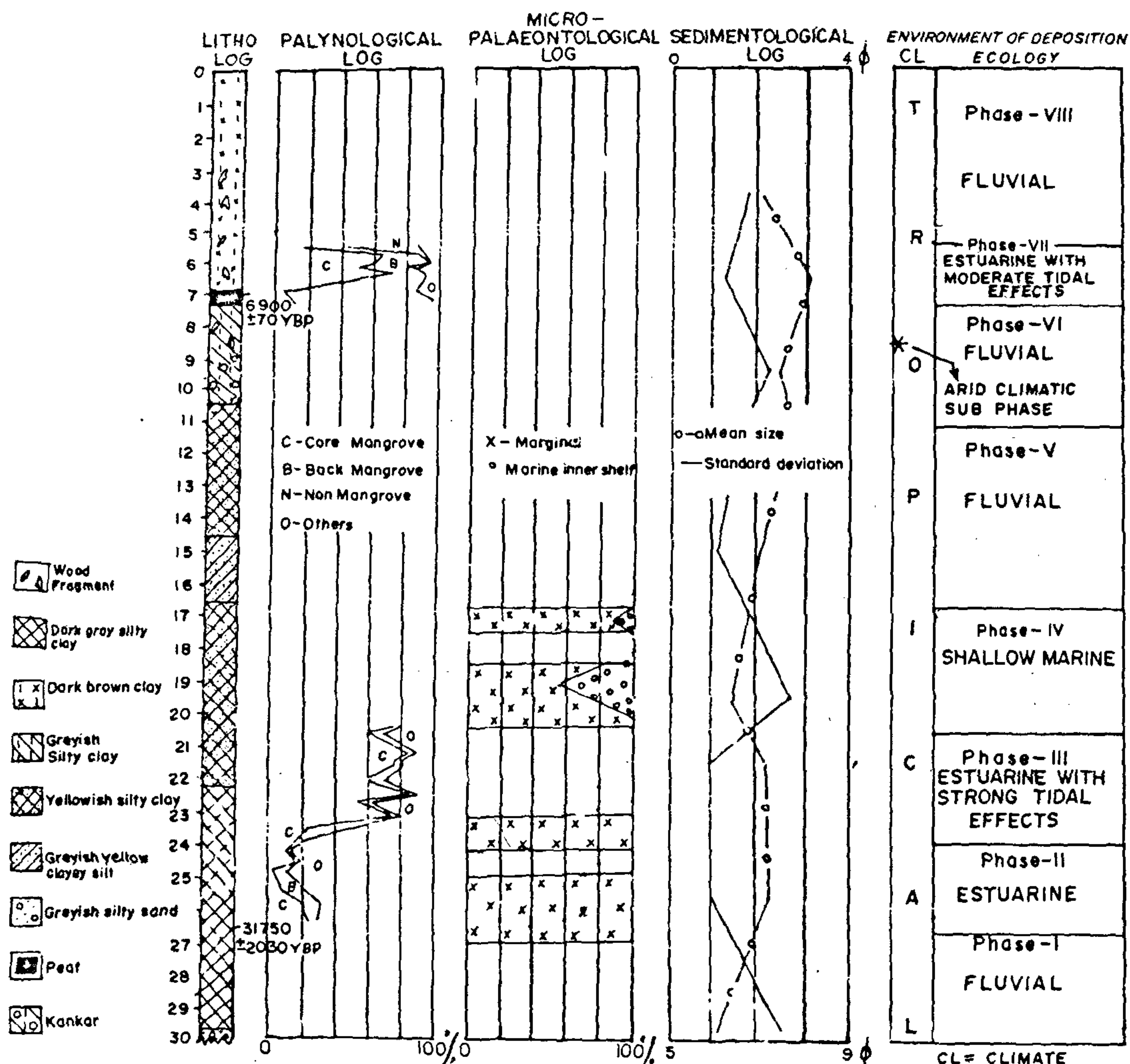


Figure 2. Late Quaternary environment of deposition of Kolaghat bore hole based on palynological, micropaleontological and sedimentological records.

as reported elsewhere<sup>7,13,14</sup>. Phase VIII developed with a regression of the sea. Thus, phases VII and VIII demonstrate emergence and stabilization of a mangrove swamp during the last stage of sea-level rise during 5900 ± 70 YBP followed by choking of the swamp due to continued siltation, leading to the development of modern plains. Apparently this vertical succession, recapitulates vertically the spatial distribution from lower intertidal mangrove vegetation to plain land vegetation.

The following points of interest have emerged out of the results:

1) Late Pleistocene mangrove swamps (31.750 ± 2030 YBP) are recorded from the then existing coastal area of South Bengal.

2) Rich and diverse foraminifera-bearing horizons of marginal to marine environment of deposition are recorded from the lower part of the sedimentary sequence of onshore Kolaghat.

3) The presence of kankar suggests climatic fluctuations, perhaps indicating an arid subphase within a wet humid tropical set-up.

4) Flandrian Transgression is located from paleobiological evidences towards the top of the studied sequence.

1. Banerjee, M. and Sen, P. K., Proceedings of the National Symposium on Biol. Util. Conserv. Mangrove, Shivaji Univ., Kolhapur, 1986, pp. 393-397.
2. Gupta, H. P., *Palaeobotanist*, 1981, **27**, 138-160.
3. Hait, A. K., Das, H. K., Chakrabarty, S., Ray, A. K. and Chanda, S., *Indian J. Earth Sci.*, 1994a, **21**, 192-198.
4. Murray, J. W., *Ecology and Palaeoecology of Benthic Foraminifera*, Longman Scientific and Technical, Longman Group, UK, 1991, pp. 397.
5. Hait, A. K., Das, H. K., Ghosh, S., Ray, A. K., Saha, A. K. and Chanda, S., *Indian J. Earth Sci.*, 1996, **23**, 79-82.
6. Hait, A. K., Das, H. K., Ray, A. K. and Chanda, S., *J. Palynol.*, 1994b, **30**, 73-78.

7. Geyh, M. A., Kudras, H. R. and Streif, H., *Nature*, 1979, **278**, 441-443.
8. Banerjee, M. and Sen, P. K., *Indian J. Earth Sci.*, 1987, **14**, 307-320.
9. Chappel, J. and Shackleton, N. J., *Nature*, 1986, **324**, 137-140.
10. Chakrabarty, A. and Niyogi, D., Proceedings of the Seminar on Geomorphology, Geohydrology and Geotectonics of the Lower Ganga, IIT, Kharagpur, 1972, pp. 135-139.
11. Poddar, B. S., Chakrabarti, C., Banerjee, S. N. and Chakrabarty, P., *Geol. Surv. India Rec.*, 1992, **121**, 47-53.
12. Coulson, A. L., *Mem. Geol. Surv. India*, 1940, **76**, 1-150.
13. Thom, B. G., Wright, L. D. and Coleman, J. M., *J. Ecol.*, 1975, **63**, 203-232.
14. Umitsu, M., *Sed. Geol.*, 1993, **83**, 177-186.

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## Breakup of Gondwanaland and the Jurassic record of the Kachchh Basin, Gujarat, Western India

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The pericratonic Kachchh basin of Gujarat, western India, hosts a succession dominated by siliciclastics punctuated by oolitic limestone horizons. The two horizons occur in distinct time frames, the older in the Bathonian and the younger in the Oxfordian. The younger horizon the Dhosa Oolite, Member of the Jumara Formation forms an important lithostratigraphic marker horizon. These two horizons are re-interpreted as ironstone horizons based on iron sequestration observed at field outcrop and petrographic scale. It is suggested that the iron content in the ironstones is on account of hydrothermal plumes of a magnitude similar to the infrequent Event hydrothermal plumes observed in the case of Juan de Fuca ridge off the western coast of Canada. Therefore the ironstones could represent two phases of increased sea-floor spreading activity related to the breakup of Gondwanaland. The older ironstone known as Golden Oolite documents the formation of a mid-oceanic ridge system after a period of continental stretching, while the Dhosa Oolite is the manifestation of the migration of Greater India as a discrete continental landmass, from Gondwanaland.

THE breakup of Gondwanaland began about 180 million years ago with the formation of the Karoo Basalt Province of South Africa<sup>1</sup>. This resulted in the formation of several smaller plates, each of which underwent its own

tectonic evolution. The breakup of Gondwanaland led to the formation of Greater India<sup>2</sup>; a conjoined land mass comprising India, Madagascar and the Seychelles. In the context of the Indian plate there is no direct evidence of the early Jurassic breakup in the form of oceanic crust remnants or associated igneous activity (on the Indian subcontinent). Therefore, as a working hypothesis, it is assumed that the breakup might be manifested in the stratigraphic record as a distinct facies/facies associations. With this assumption the Kachchh basin sediments have been analysed with a binary aim: i) Reinterpretation of a iron oolitic facies observed at two stratigraphic

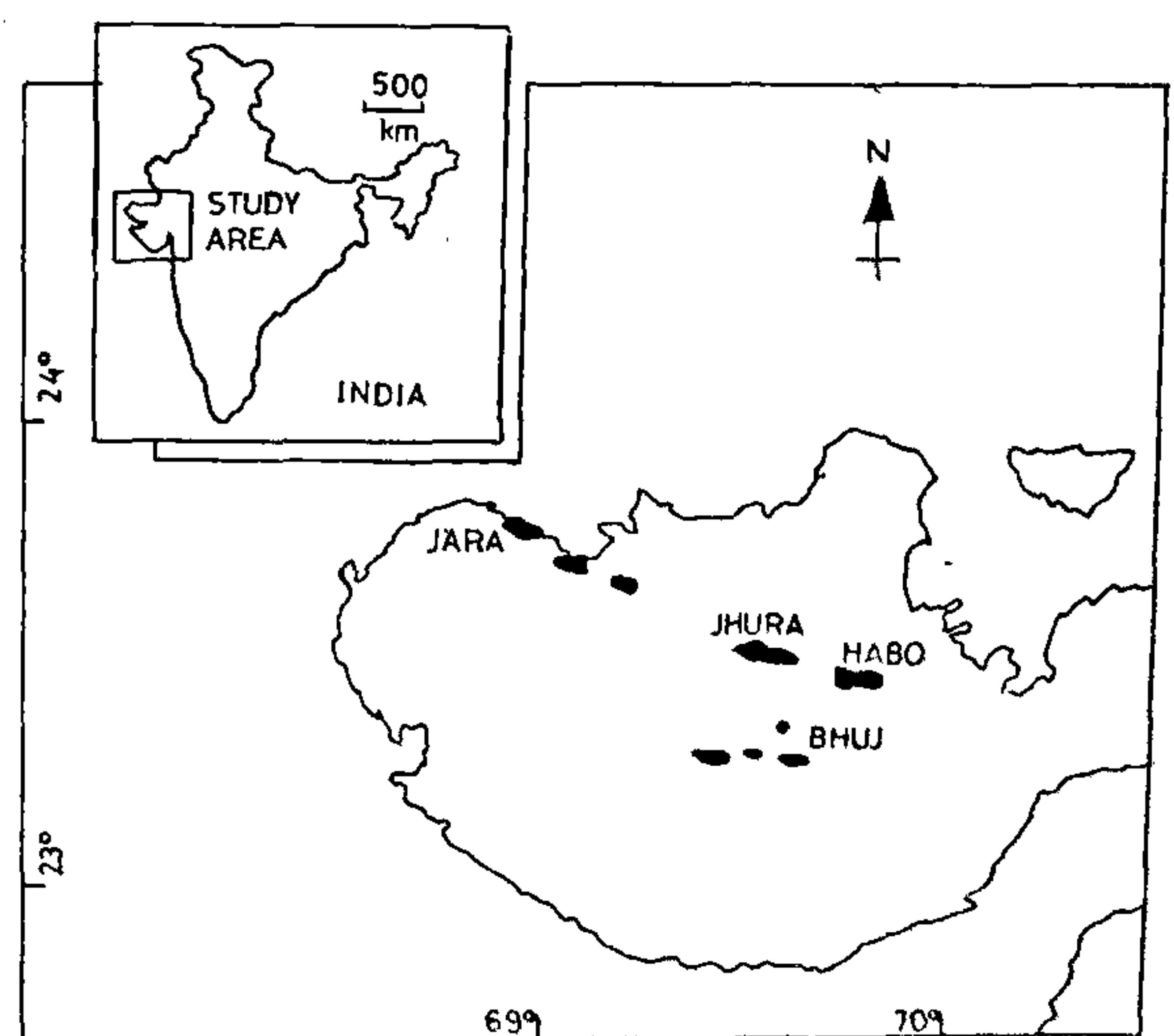


Figure 1. Geological map of the Kachchh Basin showing Mesozoic exposures in black.