Table 1.

Pollen grains		Fungal spores
Acanthaceae		*Alternaria*
Amaranthaceae		*Bipolaris*
Annonaceae		*Bispora*
Azadirachta	(Meliaceae)	*Curvularia*
Bignoniaceae		*Cercospora*
Cassia sp	(Leguminosae)	*Dendriphiopsis*
Casuarina sp	(Casuarinaceae)	*Dreschlera*
Cruciferae		*Fusarium*
Cucurbitaceae		*Helminthosporium*
Compositae		*Humicola*
Cyperaceae		*Nigrospora*
Cocos nucifera	(Palmae)	*Pithomyces*
Dalbergia sp	(Leguminosae)	*Spondylocladiella*
Eucalyptus sp	(Myrtaceae)	*Sporidesmium*
Euphorbiaceae		*Tetraploa*
Loranthus sp	(Loranthaceae)	Unidentified fungal spores
Liliaceae		Fern spores
Leguminosae		
Malvaceae		
Moringa sp	(Moringaceae)	
Mimoseae		
Papilionaceae		
Poaceae		
Ricinus sp	(Euphorbiaceae)	
Salmalia sp	(Bombacaceae)	
Solanaceae		
Umbelliferae		
Urticaceae		
Unidentified types		

biomass may in all probability be the source of food for the fishes. Thus, aerospora studies of the entire marine ecosystems are potent with newer directions of applications.

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Evidences of climatic variations during Late Pleistocene–Holocene in the eastern Bay of Bengal

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Based upon the variations of clay minerals, sediment texture, heavy mineral assemblage and ^{230}Th excess in the Late Pleistocene sediments of a hemipelagic core from the eastern Bay of Bengal (2713 m water depth), 35 cm and 73–78 cm levels are assigned as Holocene–Pleistocene Boundary and Last Glacial Maxima (LGM) respectively.

Two dominant arid phases and weak monsoon around LGM (73–110 cm) and at Holocene–Pleistocene boundary are identified from high concentration of chlorite, C/I ratio maxima (aridity reflector), decrease in characteristic clay mineral suites of humid climate, i.e. smectite and illite and a low K/C ratio. The intensity of monsoon between LGM and 15 ky^{-1} has been cyclic, and enhanced thereafter until the beginning of Holocene as deduced from high smectite, reduced chlorite and higher K/C ratio of sediments in 40–73 cm section (LGM–Early Holocene). Between 35 and 40 cm, at the beginning of Holocene, a significant reversal in the climate from humid to arid, and associated decrease in the monsoon intensity is interpreted. Clay mineral assemblage (high content of smectite, low chlorite) and their ratios, sediment texture and absence of heavy minerals between 0 and 35 cm, reflect the prevalence of stronger monsoon since 10 ky^{-1} BP. Angularity of quartz, characteristics of heavy and clay mineral suites and presence of glass shards have been utilized to determine the source of the sediments to this part of the Bay of Bengal.

THE Bay of Bengal has witnessed sedimentation since Early Eocene, and is a unique site which has archived the signature of palaeoclimatic fluctuations witnessed in the catchment area of different fluvial sources, i.e. Himalayas, peninsular India, Andaman Island group and Burma. Studies of palaeoclimatic changes in the Bay of Bengal are very few[1–4], and are mostly confined to the isotopic variations and sedimentology of selective sections of a few cores. As such, detailed palaeoclimatic studies in the Bay of Bengal are still in a state of infancy.

Liberation of the sediments and formation of clay suites depend upon climate, characteristics of source rocks and relief of the area[5]. If the geology and relief of the area has not altered significantly, the variations in the clay suites produced from a source will be climatic-dependent, i.e. formation of kaolinite and gibsite under a very humid climate, illite and smectite during moderate–humid climate and chlorite by physical weathering under arid cold climate[6–8]. The variations in allogenic lithogenic components, particularly in clay mineral suites in hemipelagic environment, thus, may effectively be applied to delineate the palaeoclimatic variations of an area.

The intensity of the southwest monsoon, which results due to heating of Indian Peninsula, has changed significantly during Pleistocene[2,9], and this monsoon controls the amount of rainfall over Himalayas, NE region of India, Andaman Islands and part of Burma coast. The fluctuation in the magnitude of monsoon and associated climatic changes will also influence the formation and liberation of clay minerals, the temporal variations of which will be recorded at a depositional site.

The present work addresses itself to decipher the changes in palaeoclimatic conditions, particularly the monsoon during Late Pleistocene in the eastern Bay of Bengal (Figure 1) derived from climatically induced temporal variations in the clay mineral suites, sediment texture and lithogenic component including heavy mineral suites of a box core. The sources of sediments in this part of the Bay of Bengal are also determined.

Keeping in view the physiography of the Bengal fan[10,11], a turbidity-free core from the eastern Bay of Bengal (Figure 1) was carefully selected from among 10 box cores collected during the cruise SK 31 of ORV *Sagar Kanya*. This core (5.4 m long) was subsampled at 5 cm intervals and salt-free dried (at 70°C) samples were subjected to grain size, lithogenic component and clay mineral analysis ($<2\,\mu m$ fraction) following standard procedures[6,12,13]. Repetition of analysis of 20 per cent duplicate samples suggests that the results are accurate within less than 8 per cent. Concentration of U and Th isotopes on top 40 cm (7 subsamples) was obtained[14,15], and the sedimentation rate estimated using a constant flux model[16]. As the Bay of Bengal has high rates of sedimentation the decay profiles may not show a perfect linearity and therefore, rates of sedimentation at three levels (0–10 cm, 10–20 cm and 20–35 cm) were computed. A rate for 0–35 cm level was obtained after averaging these results. In order to check whether the core top was preserved during sampling, ^{210}Pb analysis was also carried out on core top.

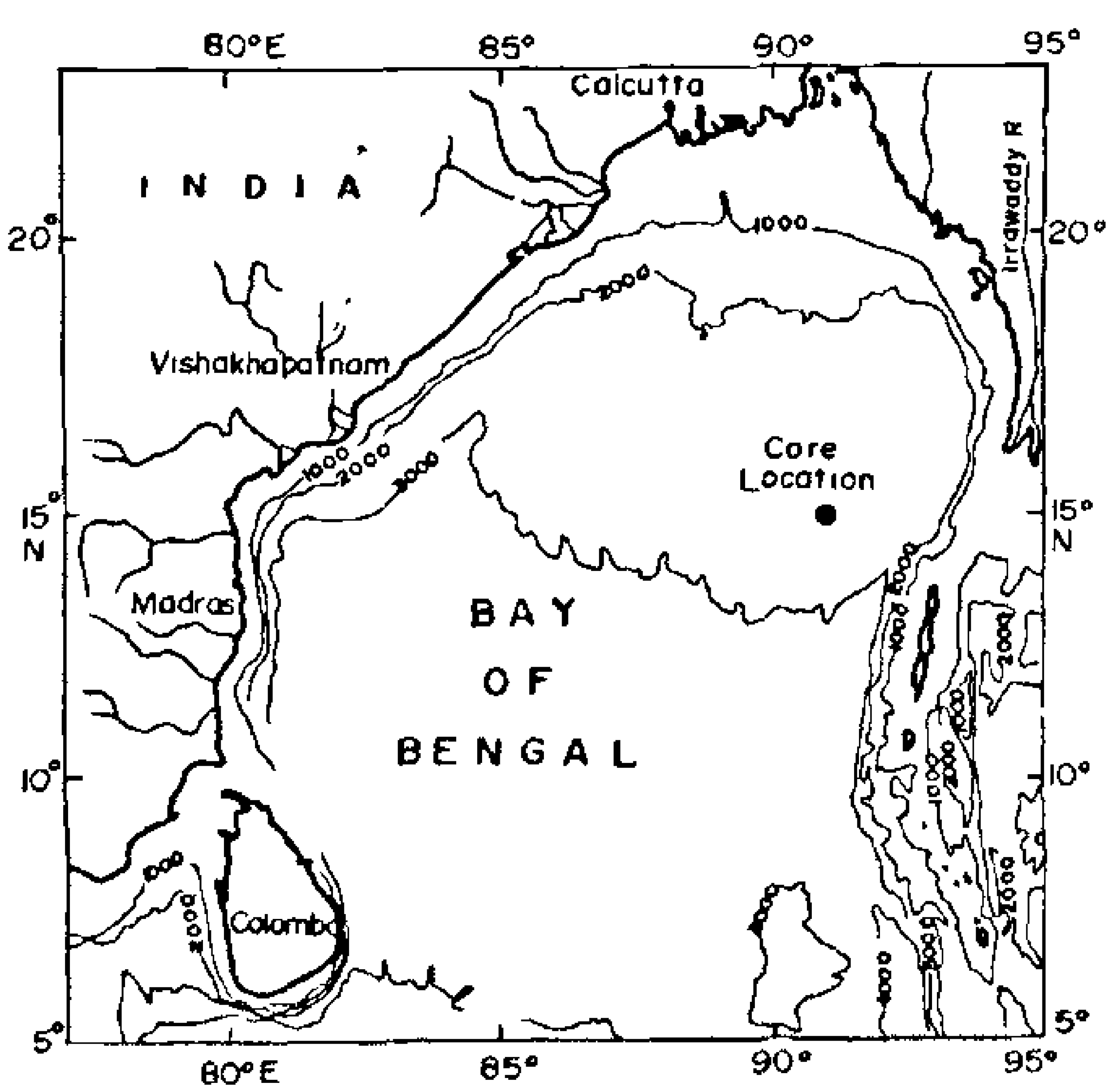

Figure 1. Core location map and generalized physiography of the study area

As chlorite is a characteristic product of physical weathering in arid cold climate, and illite and kaolinite are produced under humid conditions[8], the enhanced chlorite/illite (C/I) ratio will result from arid climatic conditions and kaolinite/chlorite (K/C) ratio will signify a prevalence of humid phase. With this postulation, the fluctuations of these ratios have been utilized to identify arid and humid phases.

The sediments of the core in general fall in medium silt-clay range. The clay minerals present are chlorite, illite, smectite and kaolinite. The temporal variations in texture, clay mineral assemblages, K/C and C/I ratio and lithogenic components are presented in Figures 2–4.

The ^{230}Th excess concentration (dpm/g) is shown in Figure 5. The average estimated rate of sedimentation is 3.5 cm ky^{-1} for the Holocene section.

The measured excess ^{210}Pb concentration in the surface section is 40 dpm/g which is excess over ^{230}Th (6 dpm/g), indicating that core top is preserved. The CM pattern[17] confirms deposition of the entire column under calm conditions[4]. These results confirm that sedimentation has taken place in a hemipelagic environment. There is a marked change in the temporal abundance of different clay minerals in the core. To determine whether these are climate-induced fluctuations, a correlation between kaolinite and smectite (the minerals reported to have preferential settling in low and high energy environments[18,19]) was obtained. These results confirm a poor correlation ($r = -0.276$, $p = 0.01$, $n = 63$) between these minerals which implies that the observed temporal variations in the clay mineral suites do not have any influence of depositional processes but reflect a climatic control.

The deduced rate of sedimentation is 3.5 cm ky in 0–35 cm, which implies that 35 cm would represent Holocene–Pleistocene boundary. The sediments of the core show a significant coarsening at 73–78 cm section. Several workers[2,4,9,10], have reported coarsening of sediments due to enhanced sediment input of sediments at Last Glacial Maxima (LGM). Based upon the Holocene sedimentation rates and coarsening of sediments, we demarcate 73–78 cm as the LGM.

In 73–110 cm, chlorite is high, but illite and smectite have reduced values (Figure 3). The aridity indicator C/I ratio (Figure 4) shows an increasing upcore trend

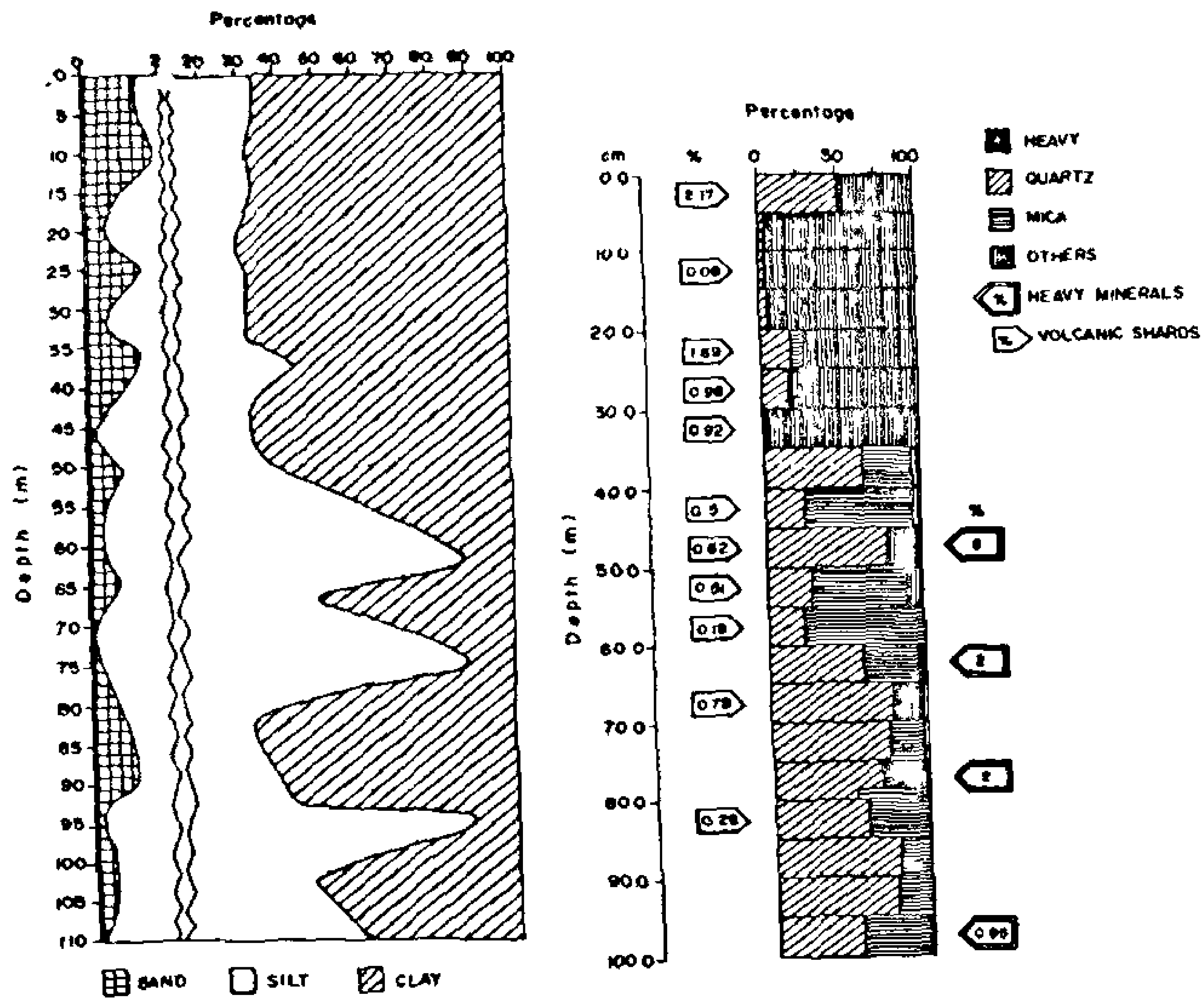

Figure 2. Sand, silt and clay size distribution and lithogenic components of the core. Note presence of heavy minerals at 40 cm, 65 cm and 73 cm levels and their absence in upper 40 cm of core. The presence of volcanic shards throughout the core is also recorded.

with a pronounced maxima at 73–78 cm level. The K/C ratio is also decreased. All these parameters suggest a prevalent arid phase between late Pleistocene and LGM with its culmination at LGM. This proposed aridity and a weak monsoon in the Indian subcontinent, Andaman Islands and Burma are in conformity with those reported earlier[2,9,21], which indicate a weak SW monsoon in the Indian Ocean during this period.

Enhanced illite and smectite (clay minerals formed under humid climate), high K/C ratio, a reduction in aridity indicator (C/I ratio) and chlorite, between 40 and 73 cm (LGM–Holocene), have been interpreted to be a product of a prevalent humid phase associated with initiation of monsoon in this region. C/I ratio and trends of different clay minerals at 60–65 cm also reveal a cyclic fluctuation in the intensity of this monsoon till around 15 ky^{-1} followed by a pronounced humid phase thereafter until the Pleistocene–Holocene boundary.

At 35–40 cm, a conspicuous reversal in the clay mineral assemblages, with dominant chlorite, and reduced smectite and illite has been noted (Figure 3). K/C ratio also decreases, and aridity reflector (C/I ratio) has a most conspicuous maxima at this level (Figure 4). These parameters collectively point towards a reversal in the climatic phase from humid to arid and a reduction in the intensity of monsoon around 10 ky^{-1} During Younger Dryas, which terminated at 9 ky^{-1}, the world climate was dominantly arid[22,23]. We also propose that this reversal in the climate observed in the present study is associated with global climatic variations and archives the Younger Dryas event.

During Holocene (0–35 cm), smectite, the most dominant clay mineral, shows an upward increasing trend with a well-defined high at 15 cm, whereas chlorite is low and has a minima at 15 cm (Figure 3). The C/I ratio also indicates a decreasing trend; but K/C ratio is high. These results clearly imply that during early Holocene, after Younger Dryas, stronger monsoon with a humid climate prevailed.

Angular transparent quartz, glass shards and angular-to-subangular heavy minerals have been observed in sand-coarse silt fraction at LGM (Figure 2). The angularity of these minerals suggests that sediments have not been subjected to reworking or long duration transport. Silt content at this level is also maximum (Figure 2). The global sea level during LGM was at − 100 m (refs. 24, 25). Along the east coast of India, the evidences of Pleistocene sea level still stands at − 100 m have been documented[26]. Such a low sea level, with river mouth much closer to shelf edge (also to the core site), and continental margins of India, the Andaman and Burma exposed to the subaerial erosion, has led to an enhanced supply of terrigenous sediments to the bay.

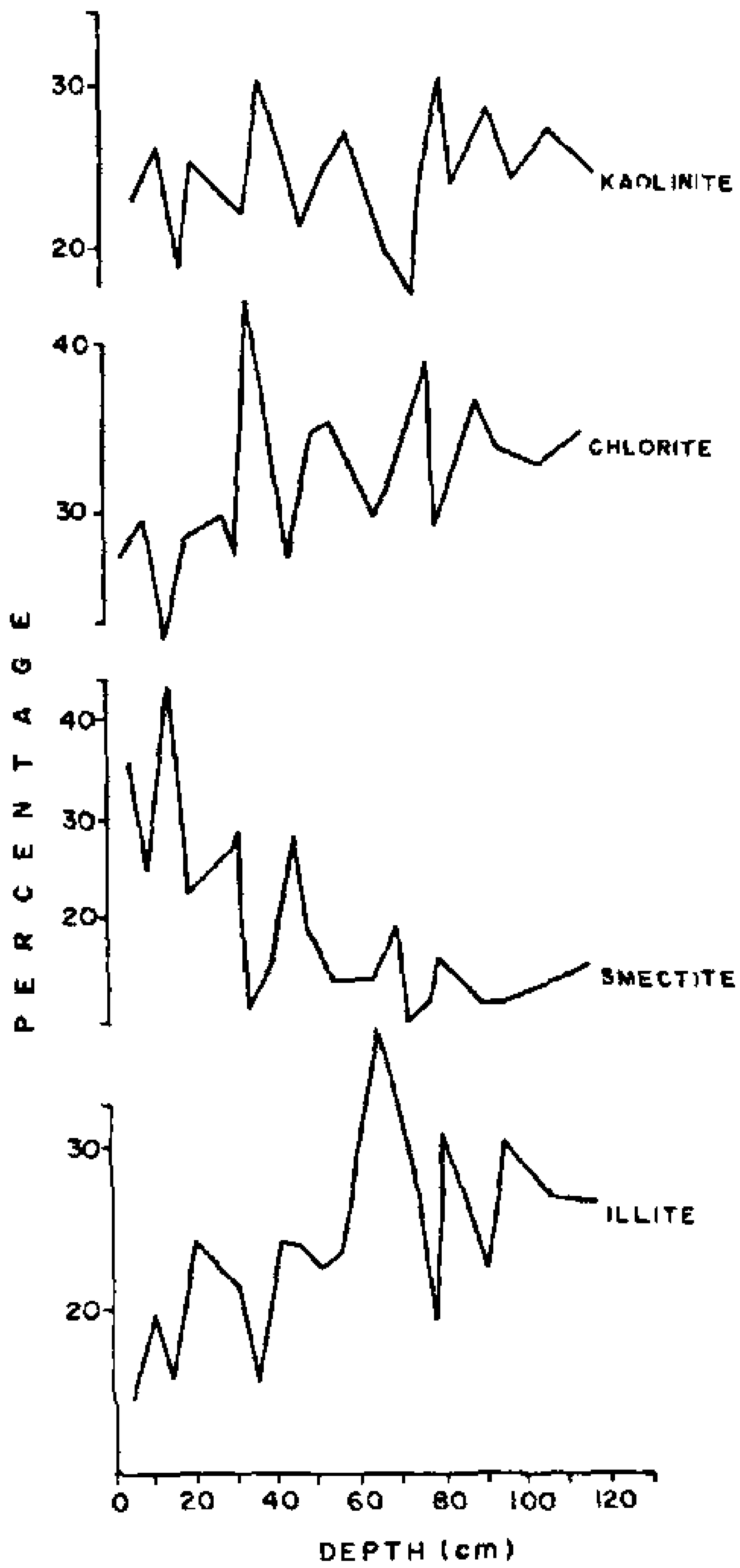

Figure 3. Variations in smectite, chlorite, illite and kaolinite in the core. Note high content of smectite in upper 35 cm section and variations in chlorite and kaolinite contents at 35–40 cm and 73–78 cm levels.

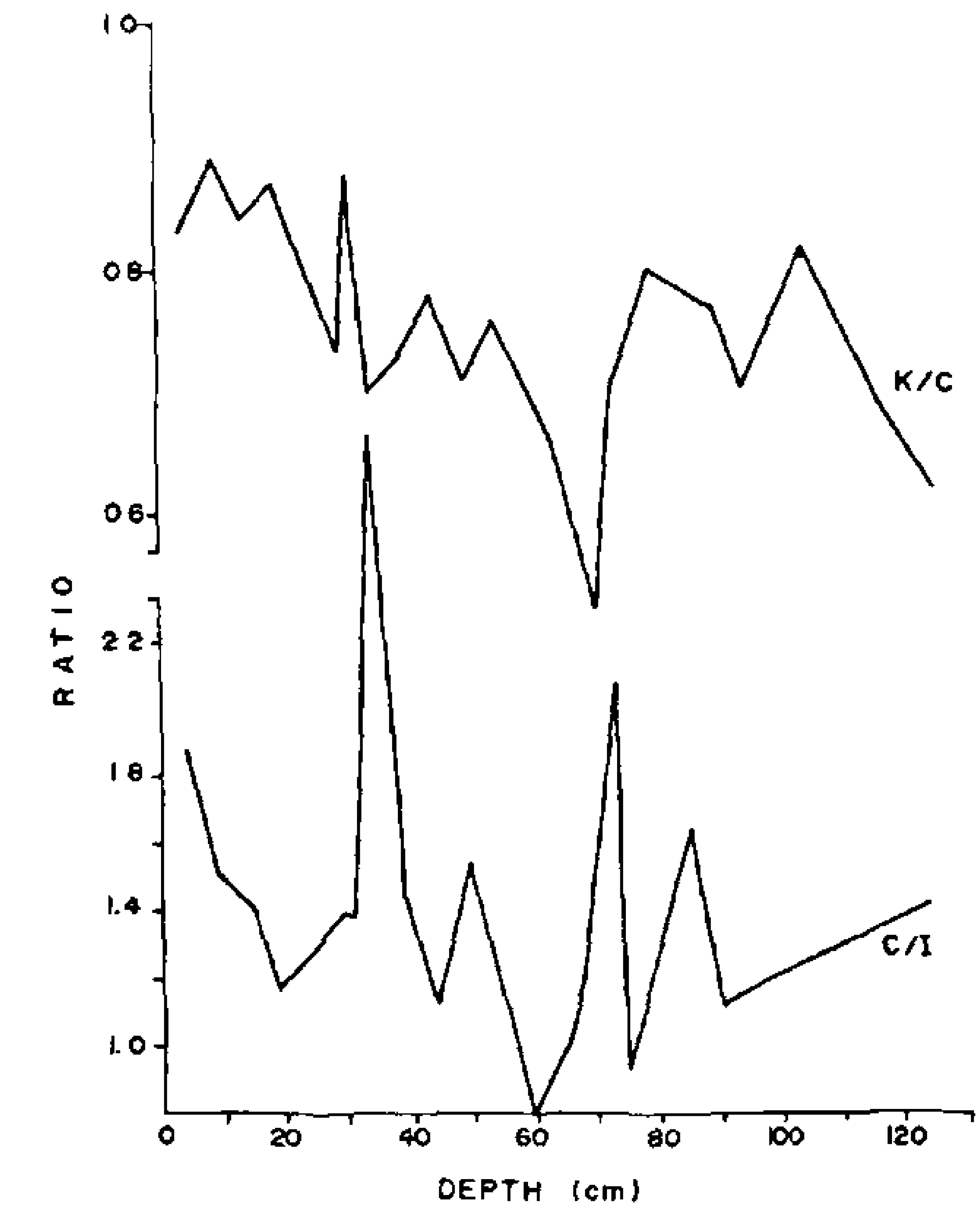

Figure 4. Variations in the C/I (aridity reflector) and K/C ratio with depth in the core. The two conspicuous maxima of C/I ratio at 35–40 cm and 73–78 cm, and related reduced K/C ratio are the conspicuous features of the distribution.

Since the 73–78 cm section represents LGM, the rate of sedimentation during LGM-Holocene is 4.75 cm ky^{-1}, which is higher than Holocene rate (3.5 cm ky). This is a further reflection of enhanced terrigenous input during LGM-Holocene, as observed by Fontugne and Duplessy[2] also. Furthermore, the observed heavy mineral suites (garnet, kyanite, hornblende, zoisite and tourmaline in diminishing order) at 73–78 cm, 65 cm and 40–45 cm, and angular quartz point to metamorphic or basaltic and volcanic sources. The catchment area of the River Irrawaddy and Salween (which discharge from Burma and have catchment in the NE Himalayas) comprises metamorphic and intrusive rocks. The Andaman Islands and Burmese arc are reported to have basaltic rock and active volcanic sources such as Toba Volcano and Barren Island[27,28] in the vicinity. The characteristics of clay mineral suites of Ganga–Brahmaputra system (illite 80%, kaolinite 6%, chlorite 8%[29,30]) are also markedly different from

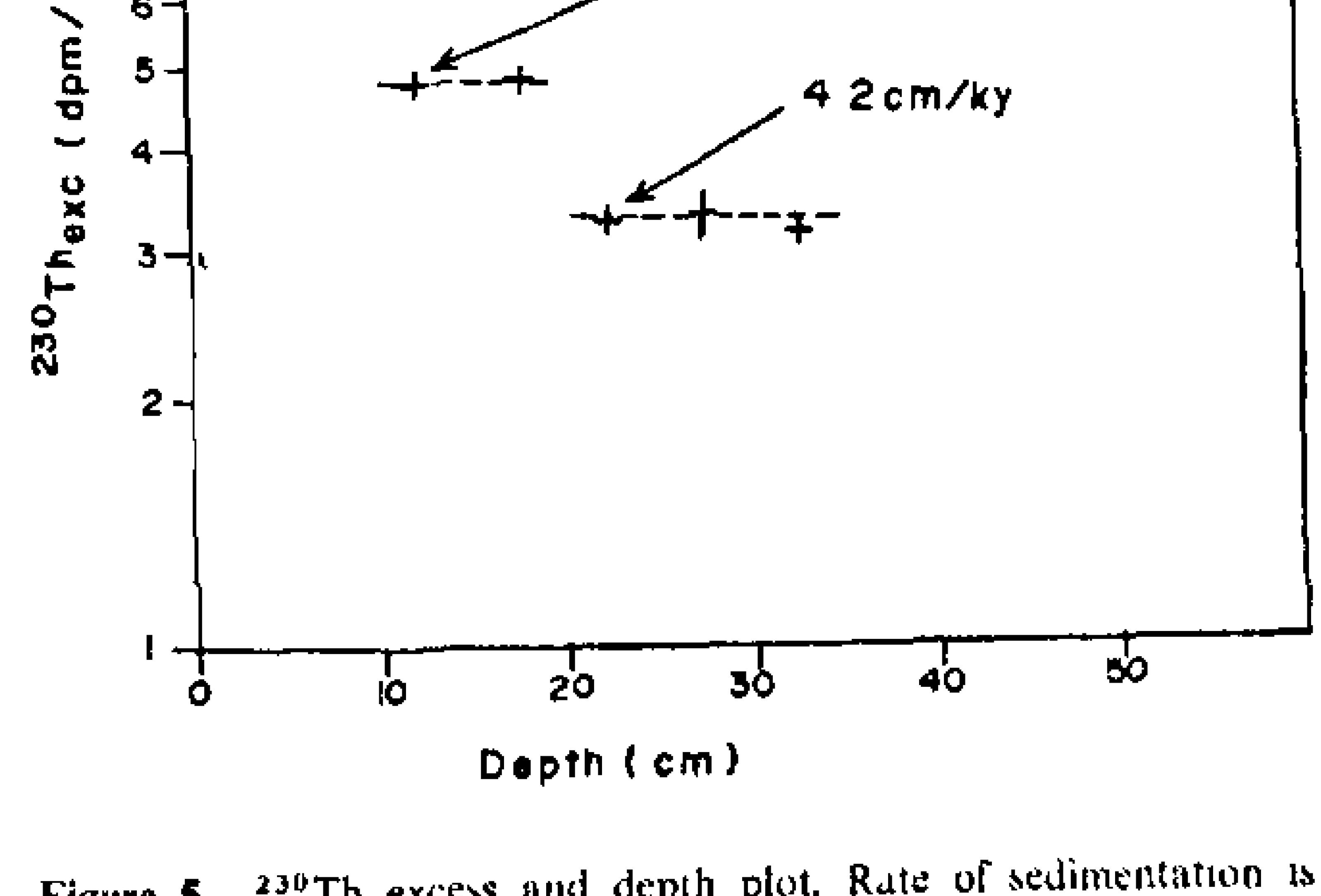

Figure 5. ^{230}Th excess and depth plot. Rate of sedimentation is based upon constant flux model at 0–10 cm, 10–20 cm and 20–35 cm segments. See Krishnaswami[16] for the terminology used.

the core site which is enriched in chlorite, smectite, illite and kaolinite in diminishing order (Figure 3). Based upon the above observations, we propose that the sediment supply to the eastern Bay of Bengal, close to Burma and the eastern Andaman sea, was dominantly from the east (NE Himalayas, northern Burma and Andaman region) rather than from north (Ganga–Brahmaputra system). The abundance of smectite in these sediments, a characteristic product of volcanic rocks, source of which lies in proximity (the Burmese arc and Andaman Islands) further gives credence to our proposition of proximity of the source.

The silt contents at 60–65 cm and reappearance of heavy minerals at 40 cm (at 14 and 10 ky^{-1}) may be related to the oscillating sea level still stands during this time[25,31]. As the content of the clay size component is uniformly high in Holocene section, we interpret an enhanced humid phase associated with stronger monsoon and rapid sea level rise, resulting in a landward recession of sources after Younger Dryas, and corresponding reduction in the gravity-induced sedimentation to the depositional basin.

In conclusion, (i) significant variations exist in the intensity of the monsoon since Late Pleistocene and at least two dominant arid phases at Pleistocene–Holocene boundary and LGM are identified. During Holocene, the intensity of monsoon was stronger over NE India, part of Burma and Andaman Islands, and (ii) the terrigenous input to the eastern Bay of Bengal is dominantly from NE Himalayas, Andamans and Burma.

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Plant regeneration from internode segments of *Cucurbita maxima* Duch. × *Cucurbita moschata* Duch.

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High frequency shoot formation from internode explants of a hybrid (*Cucurbita maxima* × *C. moschata*) squash was achieved on Murashige and Skoog's medium. Explanted internodal sections were induced to develop multiple shoots through direct regeneration without intervening callus phase. Maximum frequency of shoot bud formation was obtained when MS medium was supplemented with 4.4 μM BA and 0.54 μM NAA. Only one subculture of shoot bud producing explants to the same nutrient combination was required for development of shoots from shoot buds. Rooting of *in vitro* regenerated shoots was obtained in half strength MS medium with 0.54 μM NAA.

Differentiation leading to the formation of plantlet in tissue cultures derived from plants of many families has been reported. The plants of Cucurbitaceae provide a major portion of vegetables and they need to be investigated for maximum utilization. In *Cucurbita*