In the Suvarnavati valley, samples collected from depths of 20 and 140 cm at Homma (Figure 2) yield ages of 3540 ± 170 yr BP and 7850 ± 140 yr BP, respectively. The Muguru and Chelukavadi dates of the Kaveri sediments fall in the isochron of the Vaddarakuppe samples. From the calibrated age range it seems that the end of the lacustrine phase in the Kaveri Valley was sometime between 4860 and 5290 yr BP, and in the upper reaches of the Suvarnavati around 2600 to 3900 yr BP. In the Arkavati valley, the Manchenabele lake vanished around 1900 yr BP and the Mosalehosahalli lake south-east of Hassan dried up around 1300 yr BP.

It seems that these lakes did not dry up during the same period. Although substantial draining out of the impoundments could have been caused by revival of movements on the active faults, it was the growing aridity in the later Holocene that was responsible for the drying up of the lakes. Presence in abundance of calcareous nodules including rhyzocretions in the black clay succession implies growing aridity in the climate as was the case in the dryland of western Rajasthan[13]. The Indian subcontinent had experienced a spell of dryness beginning around 3500–4000 yr BP and ending at about 2000 yr BP[14–16]. The lakes of the Kaveri basin dried up possibly during this period. Revival of movements on active faults must have helped in the draining out of the impoundments as stated earlier in the article.

The expanse of the lacustrine clay deposit in the Kaveri valley has been dismembered and vertically displaced by the NNE-SSW trending fault that is traceable through Talakad (where the east-flowing Kaveri suddenly swings SSW) (Figure 2), and then past Malavalli to the straight N–S course of the Shimsha near Maddur. Not only is there a difference in the elevation of the order of 15 m but also the black lacustrine clay is sharply juxtaposed against brown fluvial sediment west of Talakad. In the Hulu Halla and Shimsha valleys, the elevation difference of the black clay surface is 15 m where the eastern side was downfaulted. Upstream of Maddur the black clay is considerably truncated, there being none on the eastern side. Likewise in the Antargange and Rayatmala valleys later movements have faulted up the black clay and exposed the sheared gneisses of the floor at Sitalavadi.

Ponding of these and other streams in some segments cut by the active faults suggests that the fault movements are continuing in the present.

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Occurrence of pteropods in a deep eastern Arabian Sea core: Neotectonic implications

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This paper reports pteropod shells (aragonitic) at 100, 200, 270–277 and 470 cm sediment depths in a core (EAST) recovered from 3820 m deep water from the eastern Arabian Sea. Ages of the four stratigraphic levels showing pteropod presence are estimated as 29, 52, 70–72 and 127 kyr. In normal circumstances microfaunal assemblages of this core are expected to be devoid of pteropod shells because the site is situated far below (~ 3.5 km) the Aragonite Compensation Depth. Therefore, the recorded pteropod shells are exotic to the location and may have been transported from the shallower depths by the turbidity currents. The plausible reason for the preservation of aragonitic shells at such greater depth appears to be quick burial of pteropods resulting from large-scale vigorous slumping triggered by neotectonic activity.

PTEROPODS are marine holoplanktic micro-gastropods having aragonitic shells. Living pteropods are abundant in pelagic environment, but rarely preserved in deep-sea sediments because of their dissolution-prone shells. Well

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preserved pteropod shells are limited to the marginal seas and tropical to subtropical shallow areas and continental margins[1–6]. In deep ocean, decreasing carbonate saturation results in selective and substantial dissolution of the aragonitic shells[7]. The level of Aragonite Compensation Depth (ACD) is shallower by about 3 km on an average, than Calcite Compensation Depth[8]. ACD in the eastern Arabian Sea has been estimated approximately at 0.3 km water depth[8]. Therefore, bottom sediments of the eastern Arabian Sea below ACD are expected to be devoid of pteropod shells. Hence, the occurrence of pteropod shells in deep-sea sediments is a rare and unusual event that is worth examining.

A 5.19 m long core (EAST) recovered from 3820 m deep water of the eastern Arabian Sea (lat. 15°35.52′N, long. 68°35.09′E) was taken for the study (Figure 1 *a*). The main characters of down-core variation in lithology are shown in Figure 1 *b*. Core samples at 10 cm regular intervals were used for the study. The qualitative and quantitative microfaunal analyses (planktic foraminifers and pteropods) were carried out on 1 g of > 250 µm in size fraction. Ages of the samples were estimated based on the stable oxygen isotope (*G. ruber*) stratigraphy established by correlating $\delta^{18}O$ record of the core with time scale of Martinson *et al.*[9] (Figure 2).

Pteropod shells were recorded from four stratigraphic levels, viz. 100 cm, 200 cm (Stage 3), 270–277 cm (Stage 4/5) and 470 cm (Stage 5). The number of specimens of aragonitic shells varies from 3562 to 6400 per gram. The assemblage comprises *Limacina inflata*, *L. trochiformis*, *Creseis acicula*, *C. virgula*, *C. chierchiae*, *Clio convexa*, *Cavolina* sp. and *Dicaria quadridentata*. *C. acicula* (an epipelagic form) dominates the assemblage. The question arises as to how the well-preserved aragonite shells occur in core sediments approximately 3.5 km below the ACD. There can be two probable reasons: (i) considerable deepening of the ACD during certain periods resulting in favourable conditions for the aragonite preservation or (ii) transportation of the pteropod shells from the shallow areas. The first possibility is ruled out because the ACD variation with amplitude of 3.5 km and that too for very short interval seems to be impossible. Moreover, the available data on the fluctuations in the Aragonite Compensation Level during Quaternary do not reveal such a wide range of variation. Therefore, the plausible cause appears to be the transportation of pteropod shells from the shallow areas to the deeper sites. Presence of shallow benthic foraminifers along with the pteropods in the microfaunal assemblages supports this view. A significant reduction in total planktic foraminifers noticed in the samples containing shallow microfaunal elements further suggests dilution of autochthonous sediment concentration due to carbonate as well as non-carbonate input to the deeper regions (Figure 2).

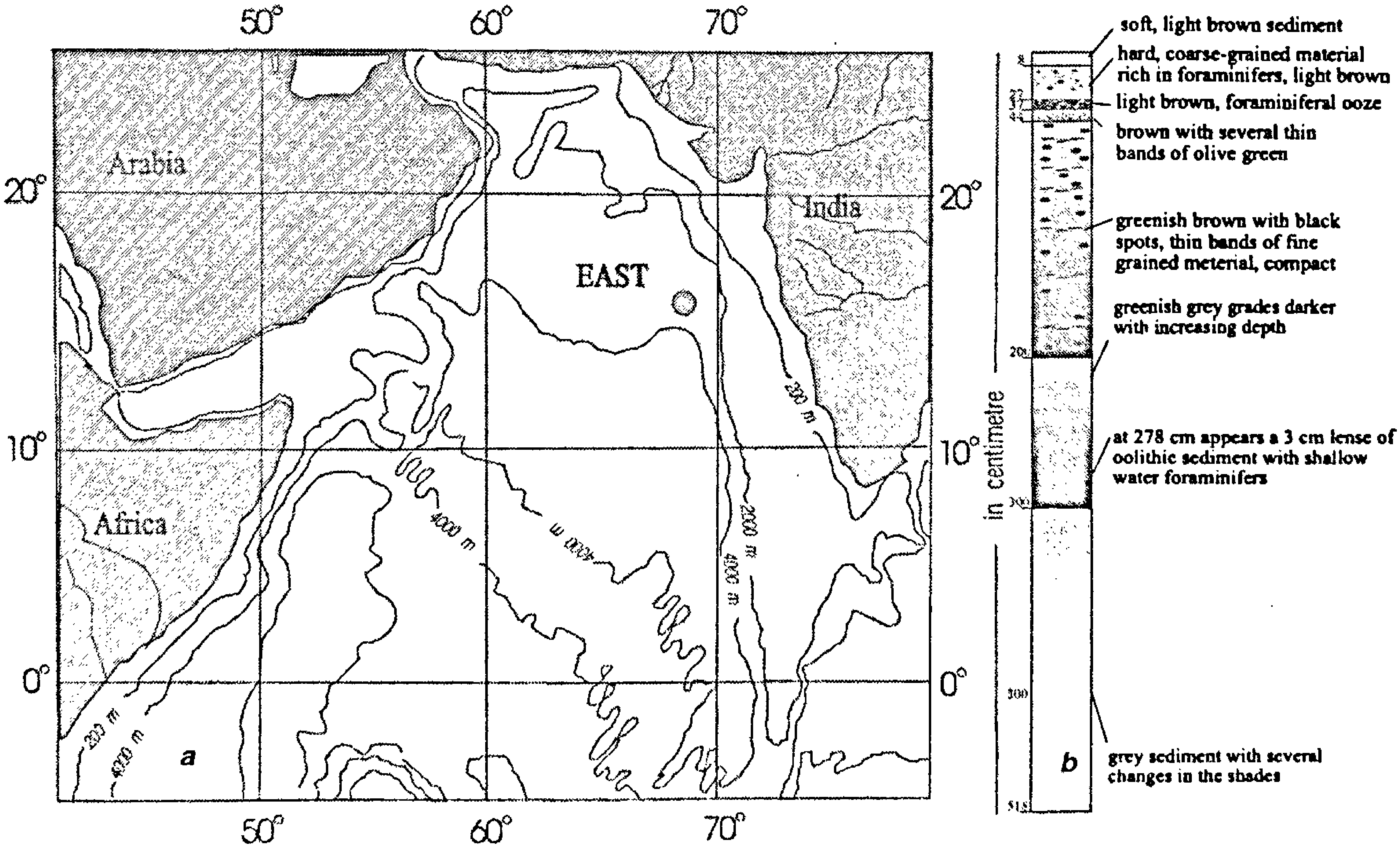

Figure 1. *a*, Location of the core (EAST) site; *b*, Core description (drawn from *Meteor Cruise-33* Report, 1996).

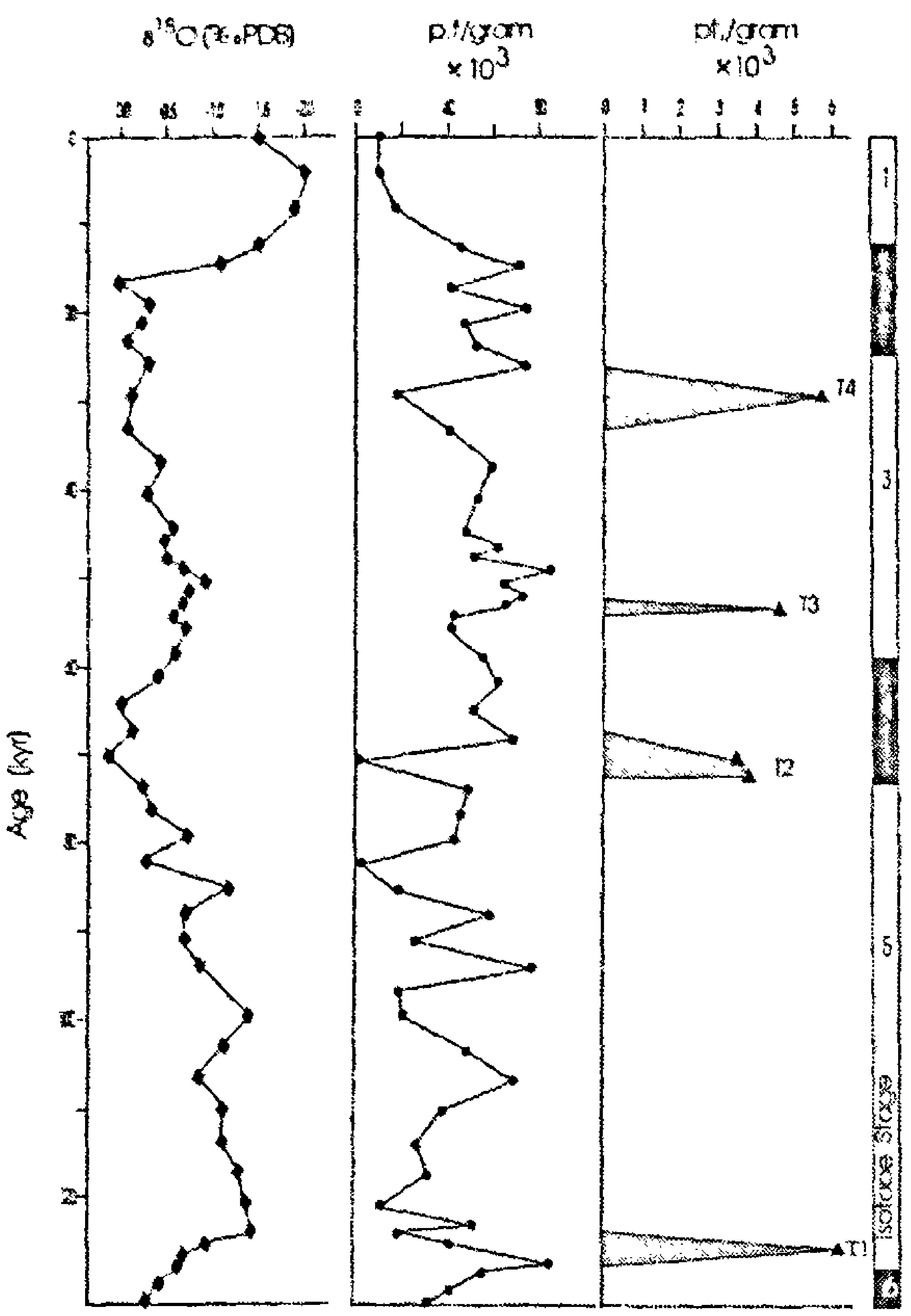

Figure 2. Stable oxygen isotope record of *G. ruber* (white > 250 μm). Isotope stages are determined following Martinson *et al.*[9], and total number of specimens of planktic foraminifers (p.f) and pteropods (pt) in one gram of dry sediment (> 250 μm). T1, T2, T3 and T4 indicate turbidites in chronological order.

Deposition of bioclastic sediments consisting of aragonite component at greater depths (below ACD) has been reported from the Columbus Basin[10], Blake Basin[11], Mediterranean Sea[12] and Sargasso Sea[13]. Occurrence of pteropods along with ooids was also observed in the late Pleistocene–Holocene deep-sea cores from the continental rise/abyssal plain of the Bay of Bengal[14]. In the Arabian Sea, ooid turbidites consisting of pteropods and shallow marine microfauna have been recorded from the deep western continental margin of India[15–17]. Previous documentation of turbidites from the eastern Arabian Sea was mainly limited to the sedimentary records representing last glacial and Holocene periods. The present study enables to document four layers of pteropod turbidites (T1, T2, T3 and T4) formed approximately during 127, 70–72, 52 and 29 kyr BP (Figure 2). Ooids were also found in turbiditic layer T2 (Figure 1). The preservation of pteropods at such greater depths can be possible if the rate of deposition of bioclastic sediments is rapid. It appears that the large-scale vigorous slumping triggered by neotectonic activity would have resulted in quick burial of pteropod shells at present site. Earlier workers[16,17] have suggested sediment transport by slumping from the outer shelf-slope region of western continental margin of India during the late Pleistocene. Stackelberg[18] has also reported slumping all along the central western continental margin of India.

Data on the pteropod occurrence in deep sedimentary records are crucial for determination of ACD in the eastern Arabian Sea. The study reveals that the depths to which pteropods occur in surface sediments may not always represent actual Aragonite Compensation Level. Redeposition can introduce pteropod assemblages into depths even far below the ACD. A detailed study on composition, chronology and source area of the pteropod turbidites based on more sediment cores will provide better understanding of the depositional history of the eastern Arabian Sea.

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