Signals of the change in monsoonal precipitation at around 2,000 years BP in a sediment core off central west coast of India

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A 4.80 m long shallow water sediment core, collected from the inner shelf (at 22 m water depth) off Karwar, near Kali river mouth is studied for foraminiferal tracers of palaeomonsoons. The climatic history of this core which represents the last 4,500 years approximately (^{14}C dates) revealed the evidences of a significant change in the intensity of the precipitation around 2,000 years BP.

THE main goal of palaeoclimatic research has been to describe variations in climate beyond the range of instrumental record. An inventory of events and trends in earth's climate in the past is preserved in marine sediments. To understand such changes a number of proxies have extensively been used. Earlier studies utilizing different proxy indicators have suggested that the monsoon (a climate-linked phenomenon) had not been a stable feature of the climate. A number of climatic aberrations/boundaries have already been witnessed in the long-term palaeoclimatic records throughout the world[1-6].

Palaeoclimatic records are required to assess the spatial pattern and extent of global warming, which may alter rainfall pattern[7]. Nevertheless, the period during the last few millennium has not received adequate attention. Our objective has been to fill up this gap. Foraminifera (an exclusively marine micro-organism and extremely sensitive towards climatic/environmental changes) could provide relevant clues to climatic changes during the concerned period.

In view of this, we studied down core (*SK 27B/8*) variations in the foraminiferal palaeomonsoonal tracers namely angular-asymmetrical morpho-group of benthic foraminifera[8,9] and total planktonic foraminiferal population in the above sediment core (4.80 m long; representing the last 4,500 years) collected from the inner shelf off Karwar (14° 49.43′N; 73° 59.37′E), near the mouth of Kali river (Figure 1). The water at the coring site was 22 meters deep. The core sample was subsampled at 5 cm intervals. All samples were dried at 60° C and washed using a 230 mesh (63 μm). About 500 specimens of foraminifera from each sample were separated. A total of 93 species of benthic foraminifera were identified. Earlier studies carried out on this core reported a major climatic boundary at around 3,500 years BP during the late Holocene, which is well supported by floral studies of the same core[10,11]. Furthermore, an increased precipitation was also noticed at a[…]d 4,000 years BP[12]. The time framework was provide[…]y ^{14}C dates.

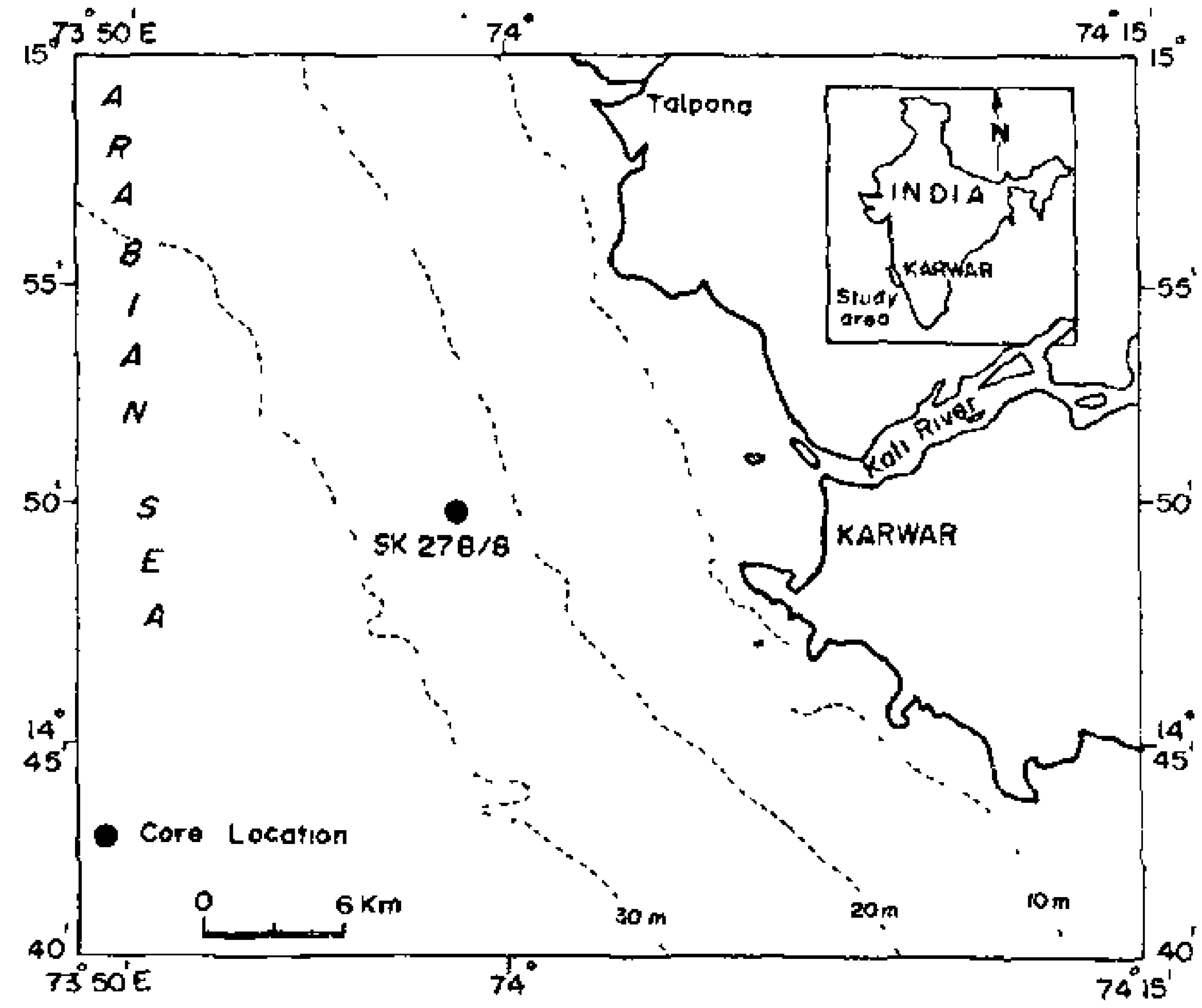

Figure 1. Location of the core *SK 27B/8*.

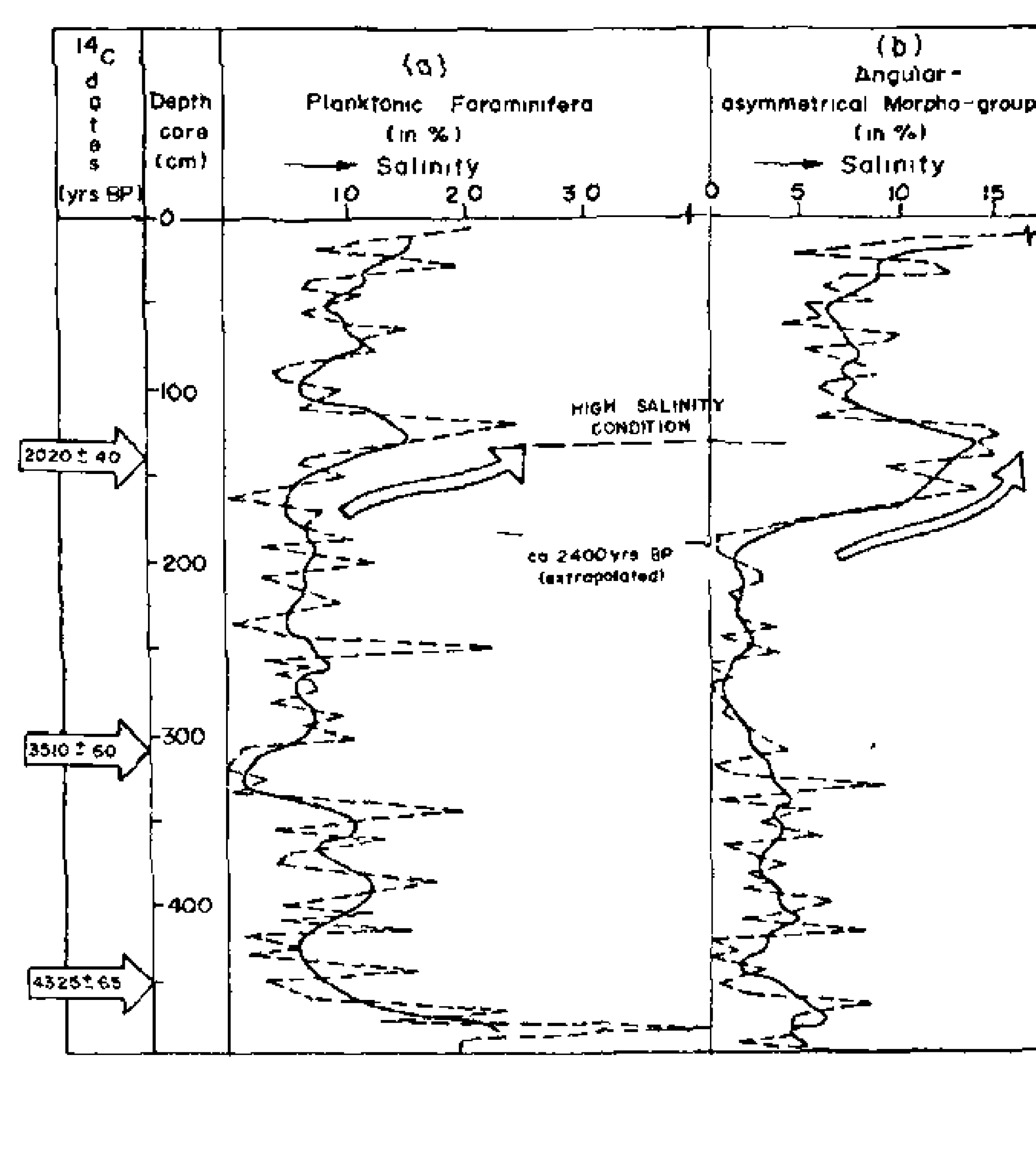

Figure 2. Down core profiles of the frequency variations of planktonic foraminifera and angular-asymmetrical morpho-group of benthic foraminifera (Thick arrow indicates c[…]ge in the monsoonal precipitation towards dry phase after a goo[…])

Table 1. Climatic conditions/inferences noticed at around 2000 yrs BP in different parts of the world

Area	Climatic conditions/inferences ca. 2000 yrs BP	Reference
Lunkaransar lake (India)	Scanty monsoon rains and complete desiccation of the lake	Bryson & Swain[20]
Pacific coast of United States and other widely separated localities (Pacific)	Cooling	Griggs *et al.*[21]
Sahel (Africa)	Modern Sahelian semi arid conditions in lake Niayes, lake Guiers/fluvial inputs of Ferlo river into lake Guiers cease.	Lezine[22]
Wald Sea lake (south-central Saskatchewan) (Canada)	Lake returned to a stratified deep water environment	Last & Schwegen[23]
Lake Rudolf (East Africa)	Low lake level	Butzer *et al.*[24]

The objective of the present study was to highlight the signals of extreme drought conditions around 2,000 years BP clearly seen in the variations of morpho-groups of benthic foraminifera in the same core.

Following the opinion of Sahni (see Nigam[13]) that reliance should not be only on single species but efforts should be made to recognize an indexing assemblage, a technique was recently developed which utilizes the morpho-groups of benthic foraminifera. The whole benthic foraminiferal population was clubbed into two morpho-groups (i.e., angular-asymmetrical and rounded-symmetrical), which were complimentary to each other. The study of these morpho-groups in the surface sediment samples off the central west coast of India revealed that angular-asymmetrical group shows abundance in the region of less river influence and thus suggested that these forms are adversely affected by the river-borne turbulence in the coastal regions[8]. This river discharge indirectly reflects the intensity of the monsoonal precipitation over the catchment area of the river. In view of this, an attempt was made to establish the relationship between these morpho-groups and average rainfall record of the meteorological sub-division no. 31 (Karnataka). This comparison exhibited a significant inverse relationship between angular-asymmetrical morpho-group and rainfall during the last 116 years[9]. Similarly, the sensitivity of planktonic foraminifera towards salinity changes is already well established[14-17].

Therefore, the down core variations in angular-asymmetrical morpho-group along with the planktonic population in a core off Karwar, are expected to reflect changes in the salinity conditions and thus, monsoonal precipitation over catchment area of Kali river.

The results revealed that the percentage abundance of the foraminiferal angular-asymmetrical morpho-group varied from 0 to 28.85%, whereas the variation in the planktonic foraminifera ranges from 0 to 4.1%. In order to highlight only major climatic boundaries, small-scale variations (noise) were suppressed by taking five points moving average in the percentage distribution of these two parameters (Figure 2). After the abrupt change at around 3.00 m down the core (corresponds to 3,500 years BP), the profiles of these parameters show a low value up to 1.80 m (ca. 2,400 years BP). Above 1.70 m (ca. 2,200 years BP) in the core both components exhibit a general increase which peaked at around 1.30 m (ca. 1,800 years BP). In view of their ecology it may be inferred that from 2,200 years BP to 1,800 years BP the intensity of the monsoonal precipitation reduced significantly. However, within this increase the average period of the high salinity conditions may be considered more or less around 2,000 years BP. Our inference of the onset of drier conditions around 2,000 years BP appears to be interesting in the light of speculations made by Wadia[18] that 'the Thar before the Christian era was a well-watered and cultivated country'[19].

The sharp change in climate around 2,000 years BP has already been noticed in the continental and marine records from various regions elsewhere (Table 1), whereas, from the Indian region it was noticed in continental records[20] alone as marine sediments were not studied over this time framework.

In conclusion, our study provides signals of poor monsoonal precipitation at around 2,000 years BP. The coincidence of this boundary in the palaeoclimatic records of other regions could be a matter of interest. Confirmatory results from many marine sediment cores, coupled with additional continental records and a detailed reasoning in this direction may provide the regional scenario of the paleao-climates.

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Record of microgastropod from the Arenaceous Member of the Tal Formation, Garhwal Syncline, Lesser Himalaya, India

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Lower Cambrian microgastropod *Pelagiella* sp. is recorded from the upper part of the Arenaceous Member of the Tal Formation, Garhwal syncline, Uttar Pradesh. It was earlier known from the overlying Calcareous Member.

THIS note records the Lower Cambrian microgastropod *Pelagiella* sp. from the greyish siltstone unit forming the upper part of the Arenaceous Member of the Tal Formation exposed in a section southeast of Kauriyala

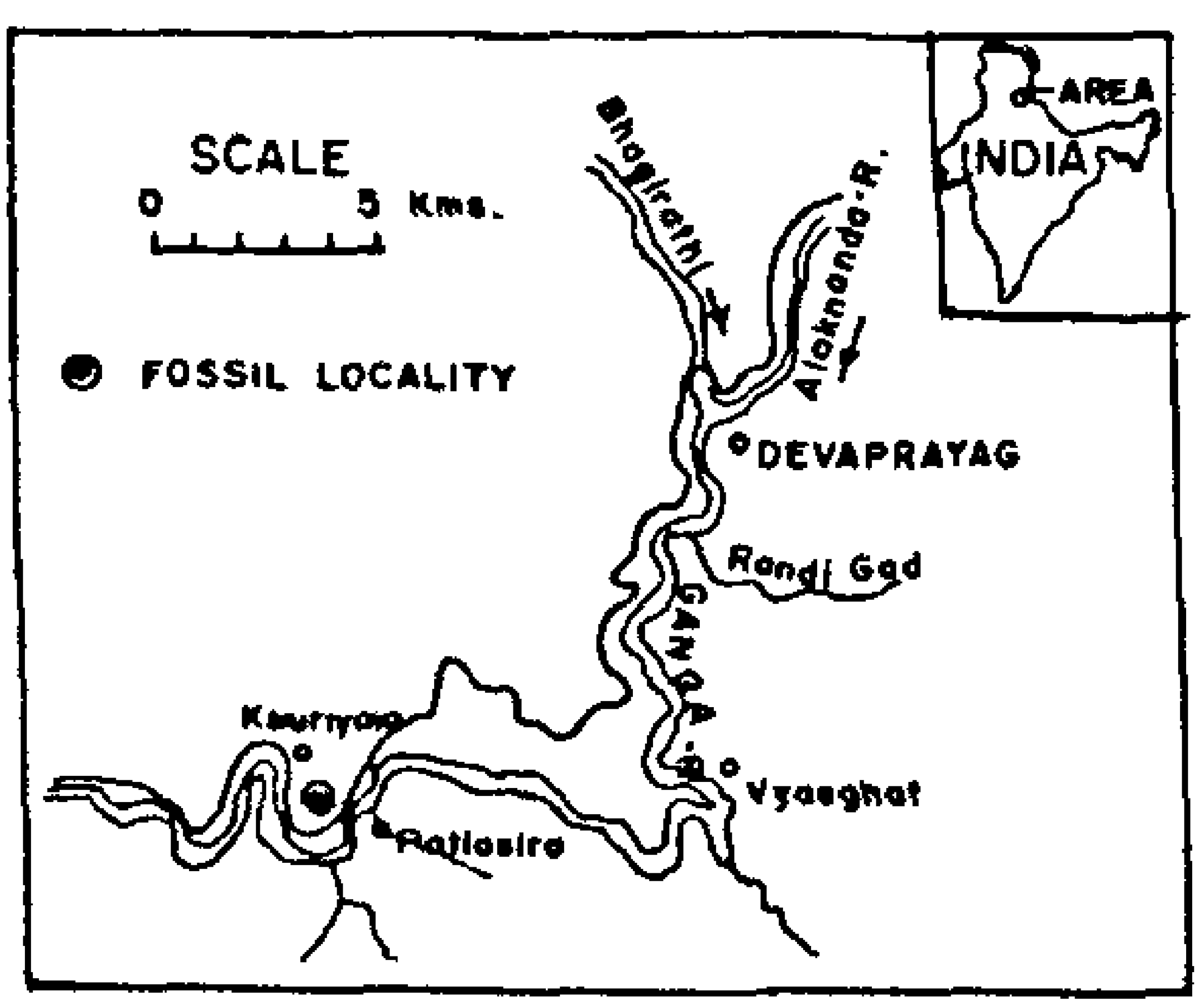

Figure 1. Location map showing fossiliferous bed.

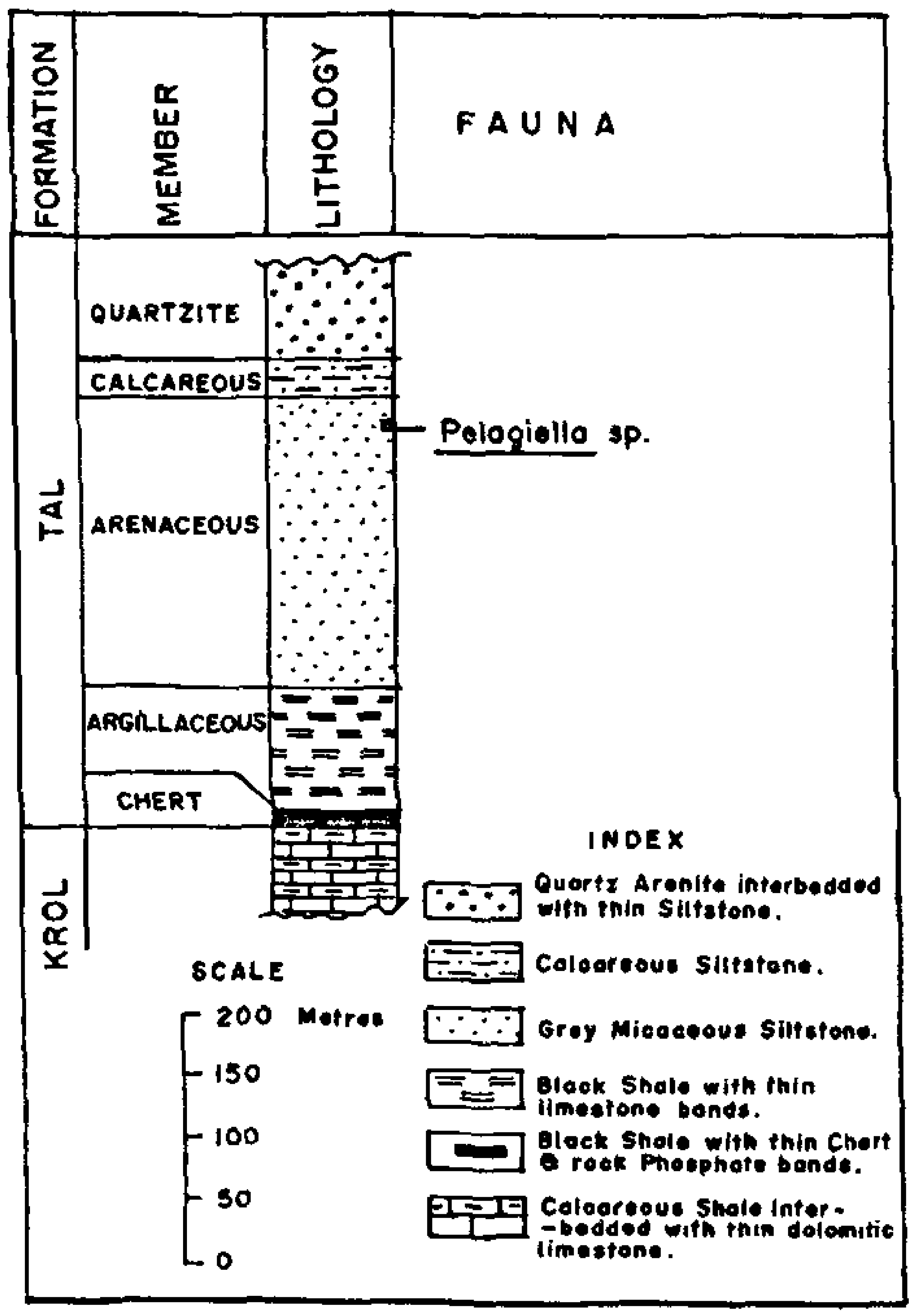

Figure 2. Stratigraphic section at fossil location showing position of fossils.