slump structures in clay beds indicate liquefaction of sediments due to a large earthquake. The radiocarbon dating of a tree trunk found buried at 4 m depth with its roots firmly embedded in the clay sediments indicates that the tree died 1200 to 1300 years ago. The presence of earthquake-induced structures like the sand dykes, slump structures point to a strong possibility of a large earthquake rocking the ground about 1200 ± 100 years ago.

The high seismicity, in the belt of the Chedrang Fault, in fact in the whole Shillong Plateau as evident from seismicity monitoring for a period of several years indicate that the Chedrang Fault is quite active[5].

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Foraminifera and changing pattern of monsoon rainfall

Rajiv Nigam

National Institute of Oceanography, Dona Paula, Goa 403 004, India

The palaeomonsoonal history can be reconstructed utilizing climatically sensitive properties of marine microorganisms: foraminifera. The results show a major boundary at 3500 years B.P. and periods of rather low precipitation approximately at 420, 910, and 1680 years B.P. during the last 2000 years. A prominent association has also been observed between cyclicity (~77 years) in dry periods of monsoonal precipitation and Gleissberg cycle.

Need for record of past monsoon changes

ONE of the several consequences of global warming due to greenhouse effect is the likelihood of changes in the pattern of monsoonal precipitation[1]. To prepare the country for any eventuality of changes in rainfall pattern, predictive models are needed. To infer future behaviour of the monsoon, a study of monsoonal variations in the past (palaeomonsoons) becomes very important. Indian meteorologists have excellent records of rainfall over the last 100 years which help in climatic modelling and in understanding the factors influencing the climate. However, when we attempt to reconstruct long-term climatic changes, a record of climatic changes dating back far beyond hundred years is required. Such an ancient history of climatic changes is contained in layered sediments continuously deposited at the sea bottom.

Testimony of foraminifers

As far as marine sediments are concerned, under appropriate circumstances, some information concerning palaeomonsoonal precipitations can be derived from exclusively marine foraminiferal assemblages using indirect means. The few attempts that were made[2] to study changes in monsoonal pattern during the Pleistocene and Holocene used mainly planktonic foraminifera as a tool. It was inferred that climate was very arid about 22,000–18,000 years B.P. and that the Asian summer monsoon was weaker during the last Glacial Maximum (ca. 18,000 years B.P.) than it is today, whereas the winter monsoon was stronger. The climate changed from warm, with concomitant arid to warm and humid around 10,000 year B.P. and intensification of monsoon occurred[3]. An upper limit of about 7000 years has been placed[4] on the length of time during which the winter monsoon was stronger. The information derived from deep sea material suggests compressed climatic records due to low sedimentation rates. On the other hand, geological data from shallow nearshore areas where sedimentation rates are high, provide greater detail for a period covering the last few thousand years[5]. On the basis of foraminiferal studies by the author, supported by palynological observations[6] on shallow-water (22 m deep) cores from shelf region off Karwar, it was inferred that stronger monsoon condition existed prior to 3500 years B.P. and that subsequently monsoonal precipitation show a general deterioration. Archaeological records also show significant events at this time (approximately 3500 years B P.). According to Rao[7] 'the Harappans could not withstand the onslaught of a second great flood in some of the rivers in Kutch and Gujarat in circa 1500 BC'.

The study of climatic variations during the last 2000 years has acquired greater significance recently. The foraminiferal assemblages have been proved to be very sensitive to climatic changes. In a study on benthic foraminifera[8,9] it was observed (Figure 1) that the variation in 100-years rainfall in meteorological sector 31 of India can significantly be correlated inversely with the variation of angular asymmetric morphogroups of benthic foraminifera occurring in sediment that were deposited during last 100 years. Using this technique, the palaeomonsoonal precipitation history is reconstructed (Figure 2) for a period of the last 2000 years through a study of core (14° 49.43′ N, 73° 59.77′ E, water depth 22 m) subsampled at 5 cm intervals. This reconstruction is supported by planktonic foraminiferal variations as their increased abundance shows decreased runoff from rivers. The results show periods of rather high precipitation approximately at 280, 840, 1610 and 2030 years Before Present which are separated by three significantly dry climatic episodes approximately 420, 910 and 1680 years B.P. Considering the AMS date of 2020±40 at 145 cm in this core and assuming a uniform rate of sedimentation, the time resolution is approximately 70 years.

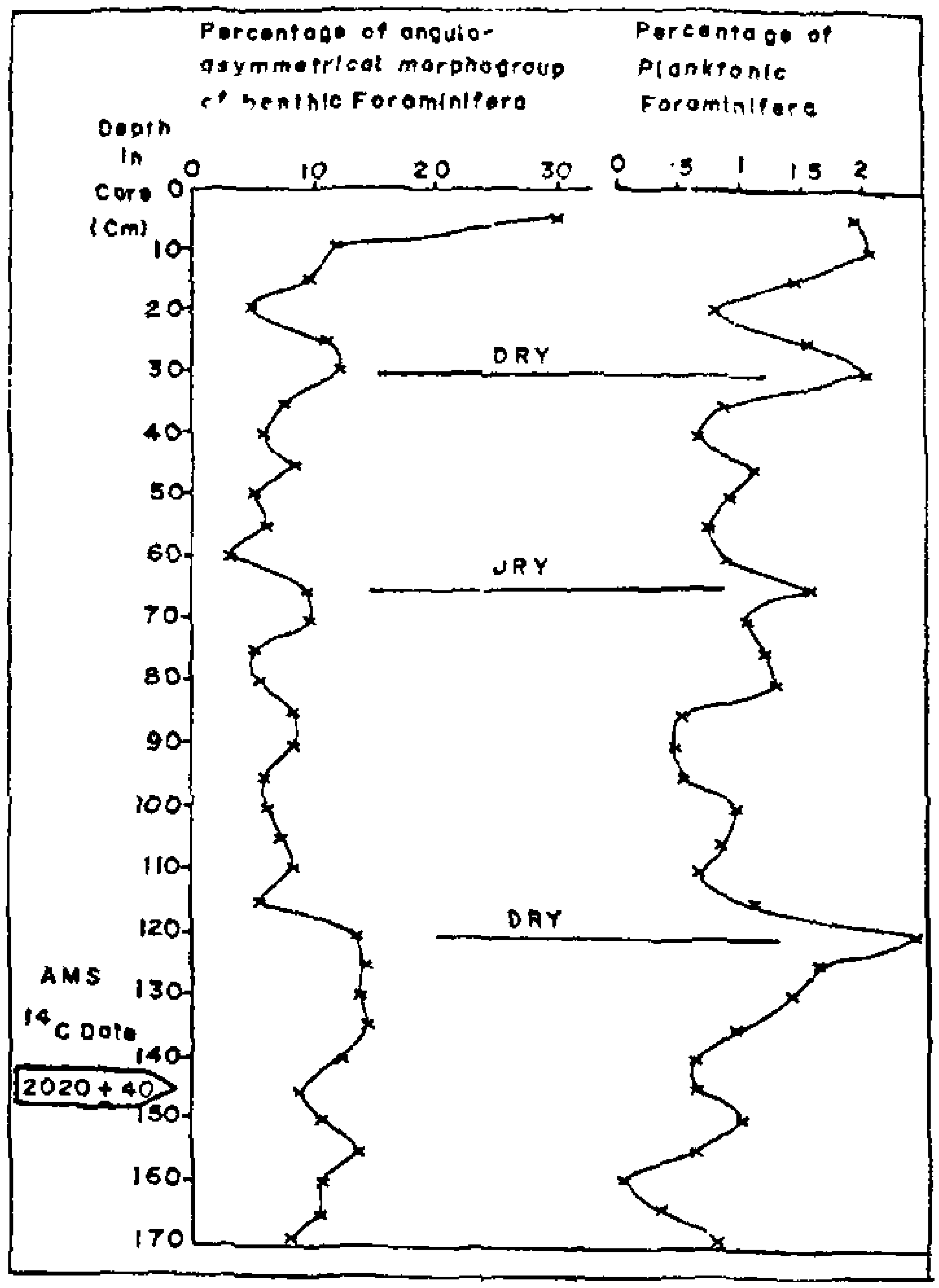

Figure 2. Fluctuations in palaeomonsoonal precipitation during the last 2000 years using angular asymmetrical morphogroup of benthic foraminifera and planktonic foraminiferal variations in a core, off Karwar as proxy data.

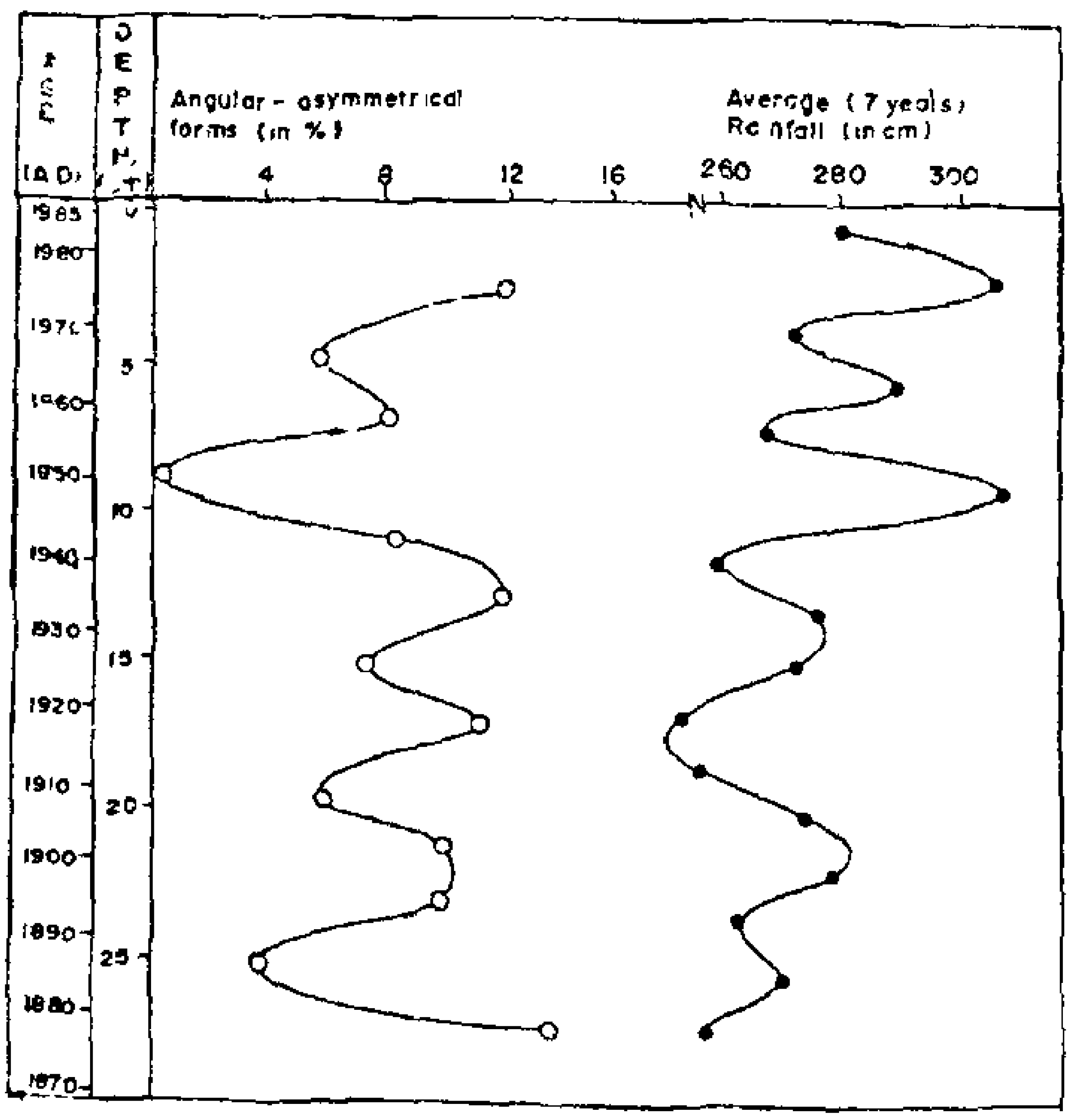

Figure 1. Inverse relationship between angular asymmetrical morphogroup of benthic foraminifera and average rainfall in the meteorological subdivision no. 31.

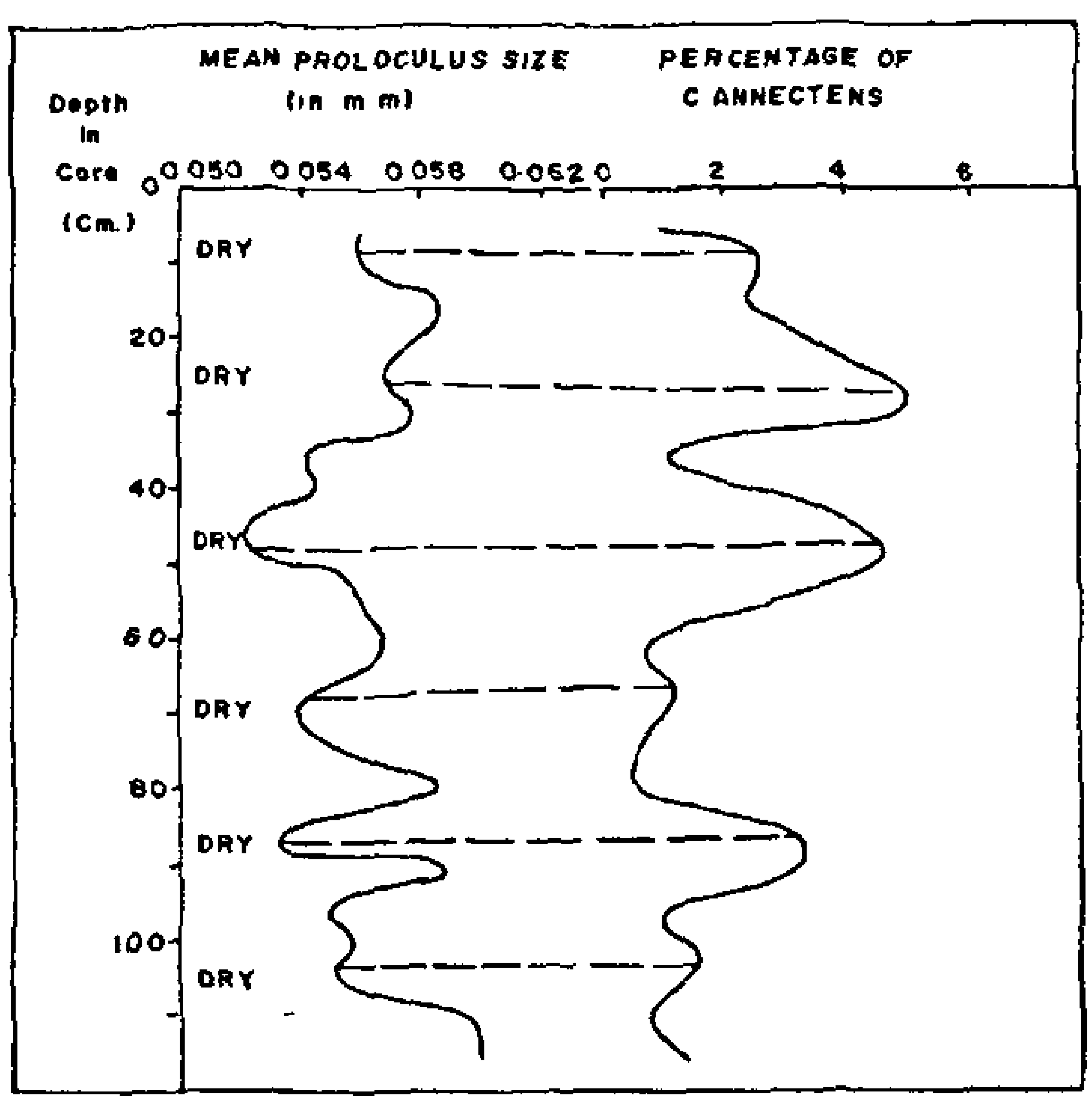

Figure 3. Cyclicity of approximately 77 years in dry periods revealed by proxy data of palaeomonsoons, i.e. abundance and mean proloculus size variations of *Cavarotalia annectens* in a short core (representing approx. 400 years), off Kali River, West Coast.

To get still finer time resolution another core (14° 53.1′ N, 73° 57.9′ E, water depth 20 m) showing 2.6 mm/year rate of deposition as measured by the ^{210}Pb method was investigated. Assuming a uniform rate of sedimentation, this core contains approximately a record of 400 years. We have used the down core variations in abundance and mean proloculus size of benthic foraminiferal species *Cavarotalia annectens* as proxy data, which have already been established as parameters[8,9] for determination of palaeomonsoons. The results show significant variations in monsoonal precipitations and the existence of cyclicity of approximately 77 years (Figure 3).

A possible association between the solar output received on the Earth and the weather has been investigated by many workers. A prominent association has been observed between cyclicity in dry periods in monsoonal precipitations and Gleissberg cycle of sun[10]. Evidences of almost similar cycles are also witnessed in many palaeoclimatic records from many parts of the world[11,12]. This finding is significant in view of the conclusions that 'droughts are natural, cyclical events which we may eventually be able to predict using astronomical analysis'[13].

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