Palaeoseismicity studies in Meghalaya

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The Chedrang Fault, which developed during the great earthquake of 1897 and follows the Krishnai river has been deduced through the study of terrace deposits and by magnetic surveys. From sample seismicity and measuring radon emission the Fault seems to be active. Four trenches were dug to investigate seismites with sand dykes and slump structures in soft sediments. A decomposed tree trunk with roots reaching a depth of 4 m in the sandy-clay sediments at the base of buried river channel is dated 1220 ± 100 years. Evidence points to a possible pre-historic earthquake in the region about 1200 years ago.

Introduction

LARGE earthquakes commonly produce surface faulting, folding, slump structures and the sand blows and sand dykes (seismites) due to liquefaction of sediments during shaking of the ground. Dating of different seismites at different levels allows the related events to be included in the record of past earthquakes, thus permitting extension of the earthquakes record beyond the historical period and consequently, resulting in better evaluation of the repeat times of large earthquakes[1].

In India, the northeast region comprising the eastern Himalaya is one of the most seismically active regions in the world. Here, two great earthquakes of magnitude greater than 8 have occurred in 1897 and 1950. A seismic gap between the places of 1897 and 1950 earthquakes is identified,[2] where a major earthquake can be expected in future. Since there is no knowledge of the occurrence of great earthquakes prior to the event of 1897 in this region, the study of palaeoseismicity was undertaken in the region.

Geological setting

The study area encompassing Mendipathar and Jira in East Garo Hills of Meghalaya (Figure 1) lies on the northern extension of the Chedrang Fault, mapped by Oldham[3] after the great Assam earthquake of 1897. The Archaean rocks comprising gneisses, granulites, migmatites, amphibolites, and banded ferruginous quartzite, occupy about 60% of the Garo Hills, the Tertiary sediments are confined to the southern parts while the northern fringe is covered with the Quaternary alluvial deposits.

Chedrang Fault

The N to NNW trending Chedrang Fault was traced by Oldham[3] up to Dilma along the Chedrang River (Figure 1). The area north of Dilma was flooded in the 1897 earthquake as the ground north of Gangdubi was uplifted, blocking the flow of river Krishnai. Its northern extension is traced along the straight course of Krishnai river. On the eastern side are two terraces, at a height of about 10 m above the river bed. These terraces imply two phases of uplift of the terrain along the Fault. East-west magnetic profiling, using a proton precession magnetometer, between Mendipathar and Jira confirmed existence of the Fault.

Monitoring geophysical changes

The present activity of the Chedrang Fault was tested by monitoring for 5 days the micro-seismicity and measuring emission of radon gas for 8 days. The instrument at Gangdubi Lake near Dilma Aphal recorded 13 shocks of magnitude 0.1 to 2.3 at an average of 3 shocks per day at distances of 4 to 135 km between March 18, and 23, 1982. Radon gas in well water was measured for eight days from March 24, 1982 near Mendipather[4] and from hot water of Bakrapar hot spring. It was observed that the emission was high for 1 to 2 days prior to the events of magnitude 2 or above. It was reported that the temperature of the spring water was higher on 20.3.82, just prior to the shock of magnitude 2.3.

Trenches observation

Four trenches (Figure 1) were dug along a possible northern extension of the surface rupture that took place in the 1897 earthquake. The trenches are 5–10 m long, 4-5 m wide and 5 m deep, cut into the quaternary deposits comprising sandy silt interbedded with clay. Trench no. 4 exposed a buried river channel with fresh sand. Trench no. 1, near Jira (Figure 2) is close to a place where the river Krishnai changed its course after the 1897 earthquake or an earlier earthquake. Emplacement of sand dykes took place due to liquefaction during an earthquake. The sand from the

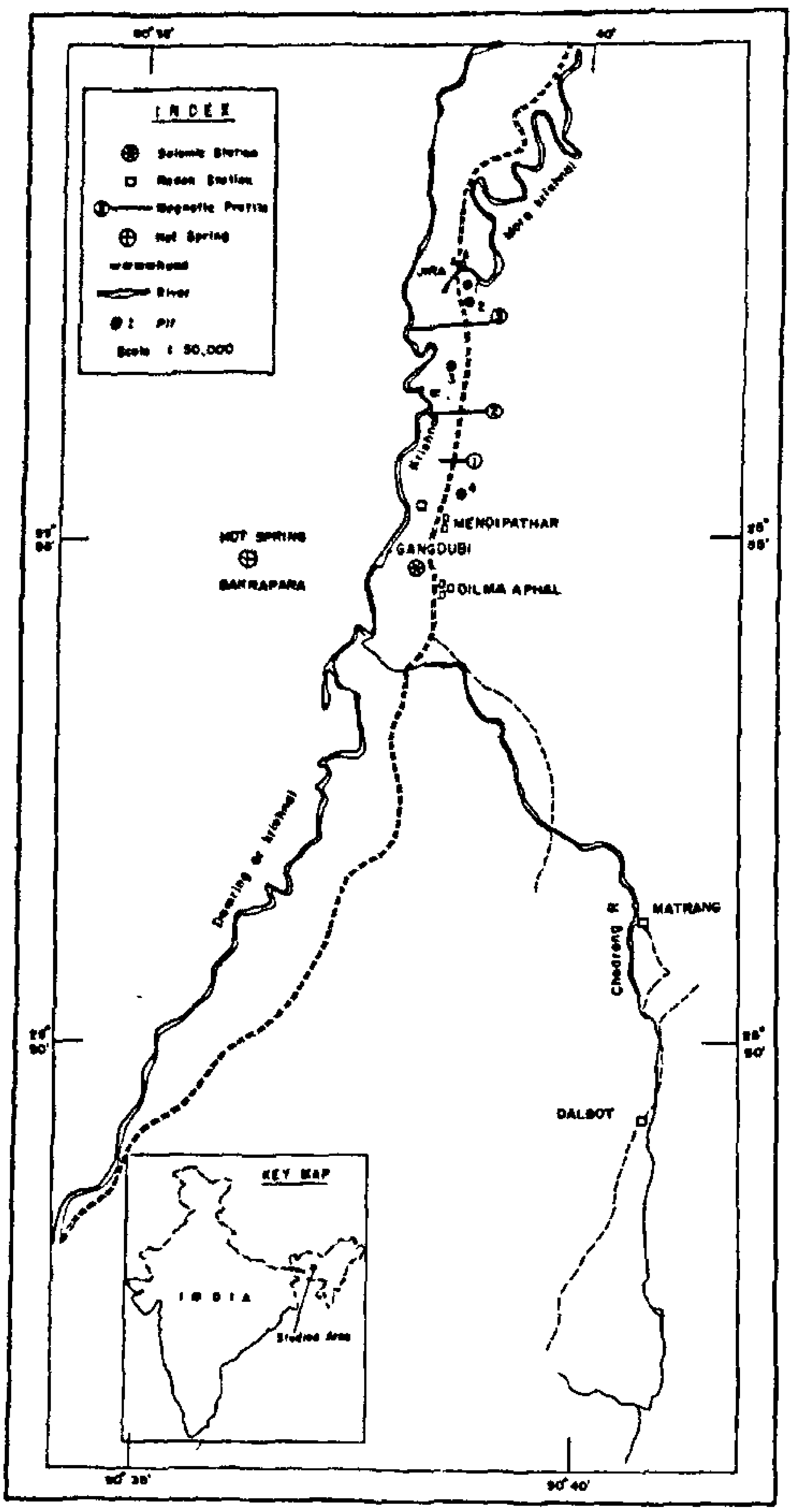

Figure 1. Location of four trenches (shown by solid circles) examined for paleoseismicity and three magnetic profiles.

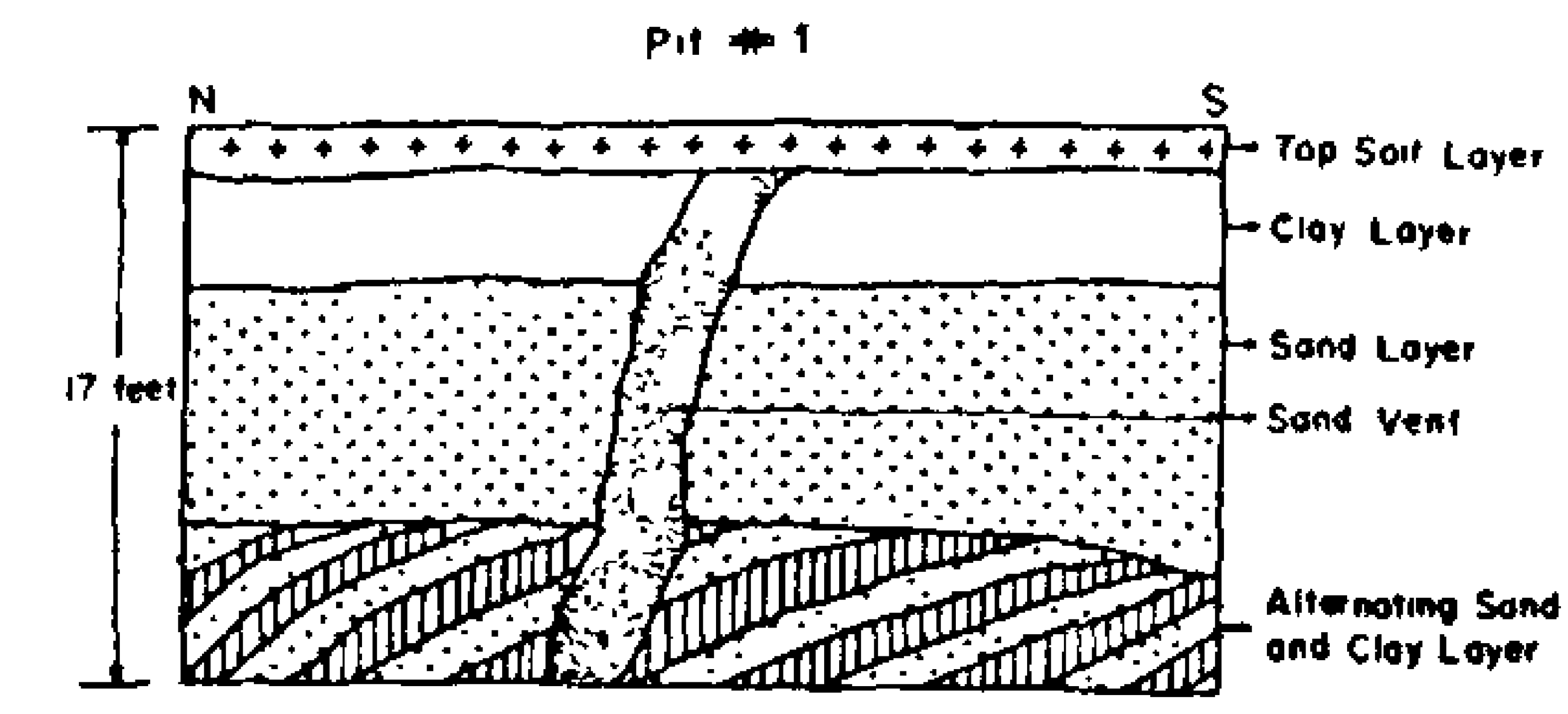

Figure 2. Vertical section of Trench no. 1, 0.5 km south of Jira.

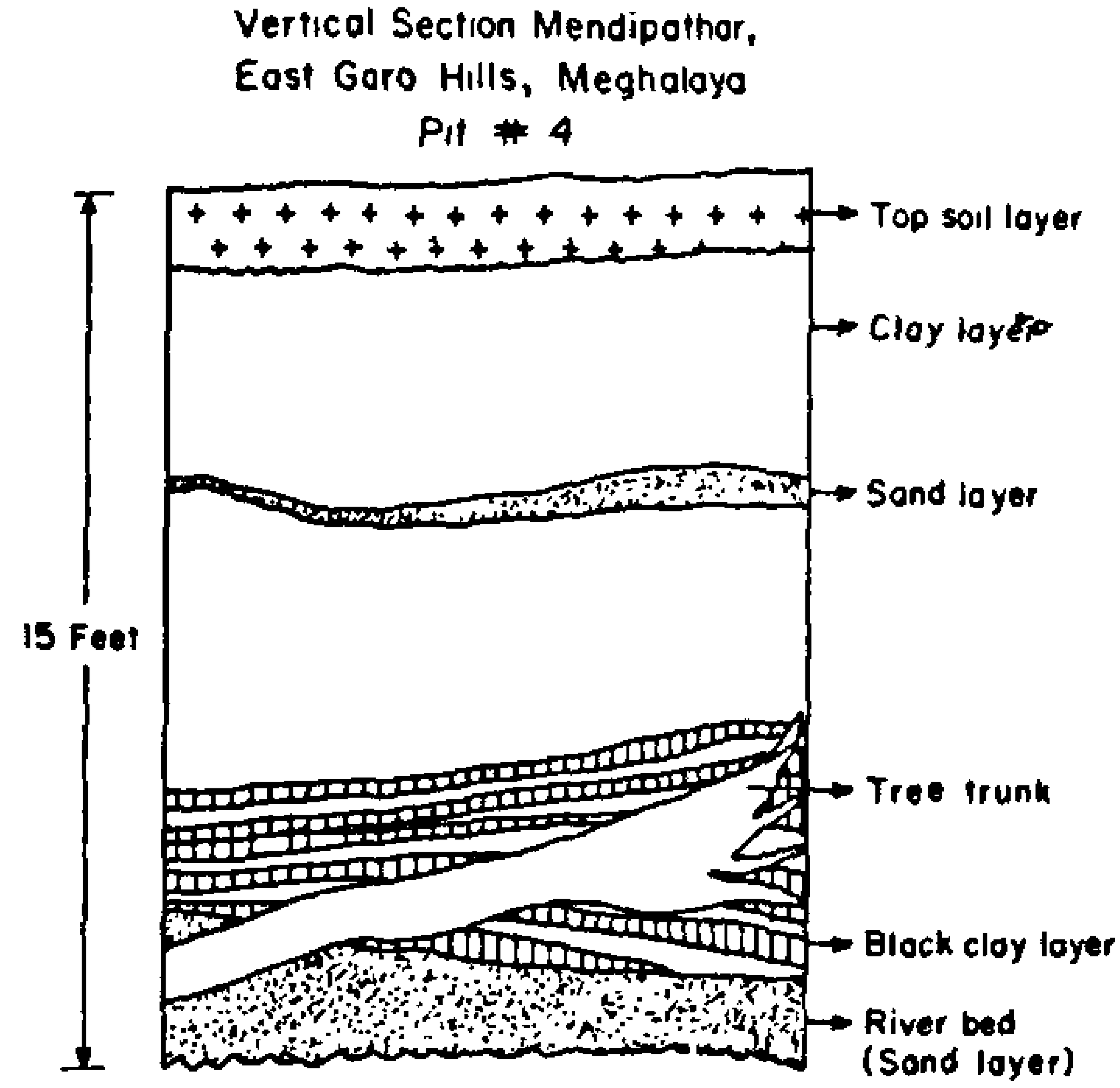

Figure 3. Vertical section of Trench no. 4, near Mendipathar.

buried river channel was extruded into the upper alternating silty sand and clay, as discernible in Trench no. 2, near Jira. Trench no. 3 exposes an inclined sand dyke cutting across alternating layers of clay and sand, and exhibiting slumping of clay layers.

Trench no. 4 near Mendipathar (Figure 3) revealed a buried tree trunk at a depth of 4 m. At the base is buried river channel filled with alternating clay and silty sand, cut by sand veins.

Radiocarbon dating

Decomposed tree-trunk in Trench no. 4 and carbonaceous material collected from different layers of clays and sands were dated in the laboratory of Birbal Sahni Institute of Palaeobotany.

The ^{14}C-age for the sample of buried tree trunk is found to be 1220 ± 100 years. A part of this sample was also dated by Dr Jim White at Lamont-Doherty Geological Observatory New York, (USA) who corroborated the result by Drs D. P. Agrawal and Sheela Kusumgar at Physical Research Laboratory, Ahmedabad who obtained the age of 1110 ± 100 years.

Discussion

The study of the trenches revealing sand dykes and 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

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The palaeomonsoonal history can be reconstructed utilizing climatically sensitive properties of marine micro-organisms: 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