POLLEN ANALYTICAL STUDY OF QUATERNARY DEPOSITS IN THE BENGAL BASIN

VISHNU-MITTRE & H. P. GUPTA
Birbal Sahni Institute of Palaeobotany, Lucknow

ABSTRACT

The pollen analytical investigations carried out at Sankrail and Jangalpur, Howrah, in the Bengal basin has shown that the fresh water *Heritiera* forest with a slight brackish water conditions existed during Late Quaternary time and the sites have remained far remote from the Sunderbans as evidenced by the occurrence of *Potamogeton*. From pollen sequence there is hardly any indication of change in climate from the present during the last 6000 years in the Bengal basin. The profiles from Sankrail have been radiocarbon dated to T.F. 856—5810±110 B.P. — top of the bottom clay, T.F. 855—4720±135 B.P. — top of the peat layer in Sankrail Pit 2 and the peat layer in Sankrail Pit 1 is dated to TF 851—4075±100 and TF 850—2615±100 B.P. for lower and upper layers respectively.

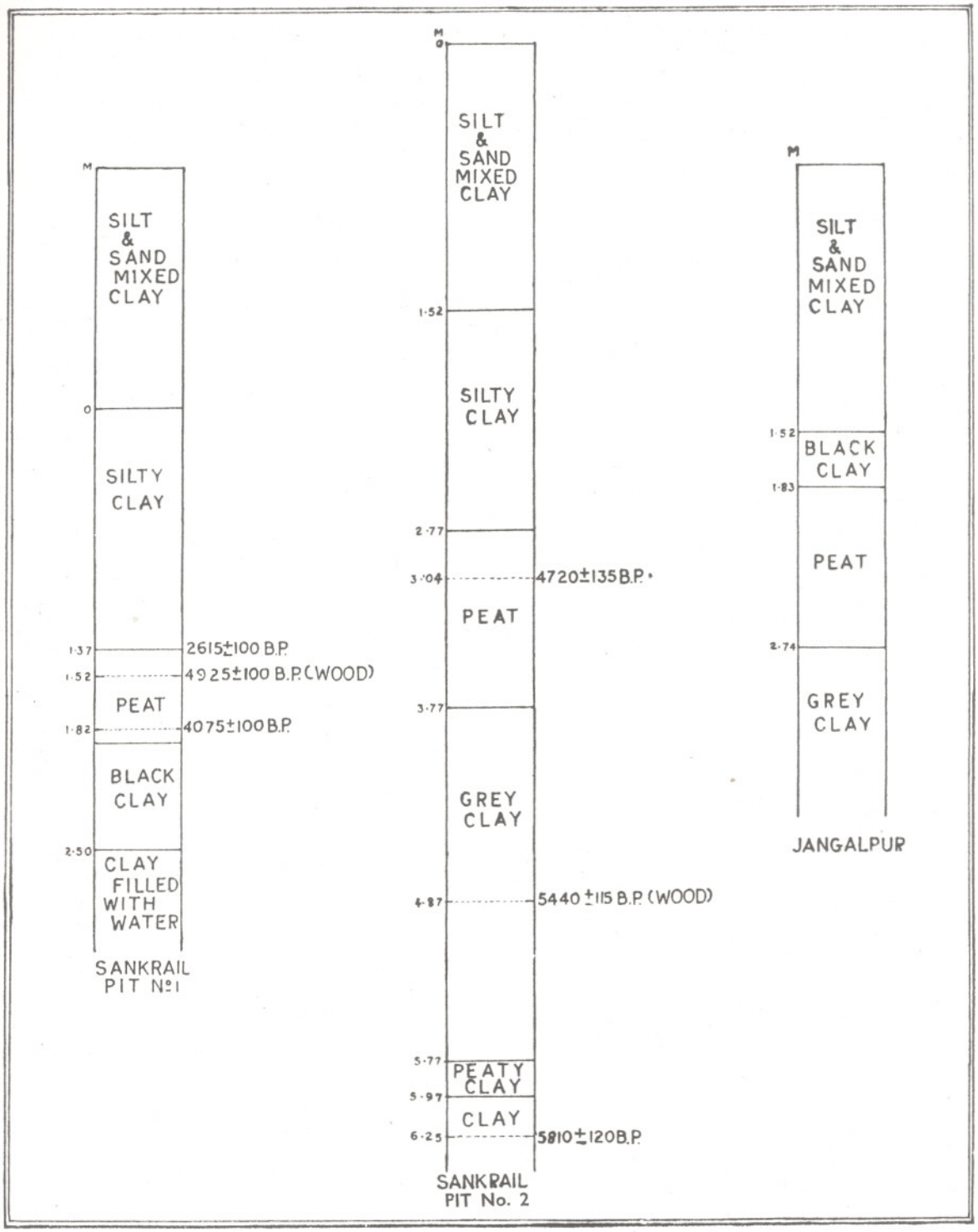
INTRODUCTION

THE Bengal basin delineated on the northwest and west by the Rajmahal hills and a southward hill extension and across the northeast by the Shillong Plateau — constituting the Rajmahal — Garo Hills Gap — is floored with Quaternary sediments deposited by the Ganges and Brahmaputra and their numerous tributaries. Four major areas of Pleistocene sediments and several smaller outliers have been described by Morgan and McIntire (1956), but the active floor plains are known since over hundred years (East, 1818, Baird Smith, 1841) to have been made up of sediments comprising clays and peats. Events of subsidence have been recognised in the occurrence of organic matter at varying depths of this basin (Coulson, 1940; Morgan & McIntire *l.c.*).

The pollen-analytical investigations in this basin have been undertaken with a view to trace the history of the Rajmahal-Garo Hills Gap, to date the events of subsidence and to determine the impact of these and the climatic alterations and the biotic influences upon the plant life in this region. Presently a beginning has been made in the western part of this basin towards the south of the Indian Botanic Gardens and on western side (left bank) of Hoogly River. The occurrence of peat in this region was observed by the senior author through the window of the train passing through Andul to Howrah during April 1968. Peat bands were observed in the dug-out pits called in the local language " Pokhars " with the object of storing rainwater. Visit to these pits at Sankrail about 10 km. south of Sibpur and another about 10 km. west of Sankrail at Rajganj revealed that these storage tanks were squarrish about 125-900 square meters and ranged in depth from 3 to 6 meters. Two pits at Sankrail were about 1·5 km. distant from each other. The nature and distribution of various strata in these storage tanks is shown in the profiles (Text-fig. 1). No evidence of any fault was noted. The individual strata in each pit were more or less of uniform thickness.

The paper describes the results of pollen analysis carried out at Sankrail and Jangalpur. Earlier, pollen analyses of sediments from this basin and towards the east and south east of Hoogly River within the vicinity of Calcutta have been published by Chanda & Mukherjee (1969) and Mallik (1969). Subfossil fungal spores have recently been reported by one of us (GUPTA, 1970) from the peat layer at Sankrail of which the depth of peat sample is 2·80 m. and not 80 cms as stated in the paper. South of these sites lies the deltaic region called the Sunderbans where the Mangrove Vegetation predominates. From the pollen of mangrove plants Chanda & Mukherjee (1969) inferred the former occurrence of Mangroves at Calcutta and concluded that the mangrove forest had migrated to the south of Calcutta by about 3000 B.C.

Frequent finds of woody fragments and even logs of wood at varying depth both in clayey and peaty beds is a common experience and has been reported ever since drillings or diggings were conducted in the basin. Most woody fragments so far discovered have been found to belong to *Heritiera, Carapa, Sonneratia* but so far



TEXT-FIG. 1 — Data of the bore-holes from Sankrail and Jangalpur, Howrah, Calcutta.

no woody remains of *Rhizophora* and *Bruguiera* have been found. However, pollen of the later has been recognized by Chanda & Mukherjee (l.c.).

The typical mangrove vegetation is today restricted to the Sunderbans, extreme south of the basin abutting on the Bay of Bengal. *Heritiera* is absent today in the western part of this basin. Champion (1936, 100-108) recognizes four major types in the tidal forests of Bengal, namely the Low Mangrove Forest, the Tree Mangrove Forest, the Salt Water *Heritiera* Forest and the Fresh Water *Heritiera* Forest in more or less broad successional order from the sea to the inland. The soft tidal mud in both the Low and Tree Mangrove Forests is submerged by salt water at every tide. Water is definitely brackish in the Salt Water *Heritiera* Forest and there is less of silt deposition than in the fresh water type. The soil has less humus and loam and it is stiffer clay cracking extensively when exposed. The Fresh Water type is best developed on the ground lying between the drier banks of the larger streams and the central depressions — the "bils" of Sunderbans. The tidal influence is felt here too but the water is moderately brackish. The soil is formed by bare mud. The higher levels are affected by spring tides and the varied undergrowth comprises *Pandanus*, canes and ferns. It is in distinctly brackish water situations that *Phoenix paludosa* usually occurs.

Heritiera is intolerant of extreme salt-water conditions and is replaced by *Rhizophora*. It cannot survive continued flooding particularly during the monsoon (Stamp, 1925) and a too high rise in level owing to annual silting. The latter inhibits its regeneration and eventually it is replaced by Delta Fresh Water Swamp Forest (Champion, l.c.).

The succession in the new mud banks at low levels is initiated by wild rice (*O. coarctata*) and *Sonneratia acida*. Along certain banks and in some depressions *Sonneratia apetala*, *S. acida* and *Avicennia officinalis* constitute a recognizable subtype. With the rise in land, this subtype is replaced by *Ceriops* and latter by *Excoecaria agalocha* and other trees and subsequently by *Heritiera* when the land is occasionally flooded.

The region under investigation is largely cultivated. The arboreal vegetation comprises largely planted trees mostly seen along the road. Swamps are seen overgrown with *Phragmites karka* and *Typha* with wild rice and *Nymphaea*. *Eichornia* is the ubiquitous and obnoxious weed prominently prevalent in all watery situations.

STRATIGRAPHY

The usual feature of stratigraphy is peat, noted in either a single or two bands intercalating with the clayey or silty beds. The clay is grey to dark in colour indicating deposition under swampy conditions. San krail Pit-2 is the deepest of the three storage tanks, hereafter called, pit.

In these three sections (Text-fig. 1) peat bed varies in thickness from 50 to 100 cm. Woody fragments of *Heritiera* and *Sonneratia* have been found in clayey and peaty beds. Fresh water shells occur in clayey and silty layers.

Silt, mud and sand appear to be fluviatile deposits resulting from throwing back of the flow of water in Hoogly River by the rising and advancing tidal currents, thus flooding banks and the surrounding regions. Peat beds probably suggest a cessation in the flooding episode. The region being sufficiently distant from the Bay of Bengal, hardly any direct tidal influence has been experienced at the sites investigated. Sediments have been found devoid of Foramenifera and remains of *Ruppia* and Naiadaceae. Diatoms so far examined have been found to be of fresh water, those of Centrales are extremely rare. *Chara* nucules found in the sediments are again indicative of fresh water sediments. Estuarine conditions have so far been recorded at a depth of 317 m in the Akra Road Tube well sunk in 1938 (COULSON, 1940, 22).

The top of the bottom clay in Sankrail Pit 2 is dated to 3860 B.C. (TF 851-5810 $\pm$ 100 B.P.) and the top of the peat layer in this section is dated to 2770 B.C. (TF 855—4720 $\pm$ 135 B.P.). The peat layer in Sankrail Pit 1 is dated to 2125 B.C. to 665 B.C. (TF 851—4075 $\pm$ 100 and TF 850—2615 $\pm$ 100 B.P.) respectively. No dates are available for the Jangalpur profile.

POLLEN ANALYSIS

Peat is of amorphous nature, and occasionally contains small woody fragments. No seeds and fruits could be observed on

macroscopic examination. The examination of the debris after boiling with 10% KOH revealed the occurrence of *Chara*, a few fragments of a moss other than *Sphagnum*, and several sporangia of a polypodiaceous fern. The occurrence of pollen of fresh water plants, such as *Potamogeton*, *Lemna*, *Typha* and *Myriophyllum* indicates its formation under fresh water conditions and suggests its deposition in a fresh water swamp.

A more or less equal amount of the sediment was first treated with 10% KOH and later with HF and then Acetolysed. Slides were prepared in glycerine. Unfortunately the longest profile including the peaty layer (Sankrail pit No. 2) did not yield any or sufficient pollen grains. The peaty and dark clay layers at Sankrail Pit 1 were found to be sufficiently polleniferous but the black clay at Jangalpur was free from pollen. Either it is the rate of deposition of sediments or their chemical nature that may be held responsible for differential preservation of pollen in these sediments. No evidence of microbial action has been noted on the pollen grains and fungal remains have been found rarely (GUPTA, 1970). Consequently pollen diagrams could only be constructed for a small part of the profile each for Sankrail Pit 1 and Jangalpur. Pollen sum was constituted of all the land plants and the percentages of all constituents have been calculated in terms of total land plants pollen.

Identification of pollen is based upon the reference collection available at the Institute and upon slides of some mangrove plants received by the kind courtesy of Dr Sunirmal Chanda of Palynological Section, Bose Institute, Calcutta.

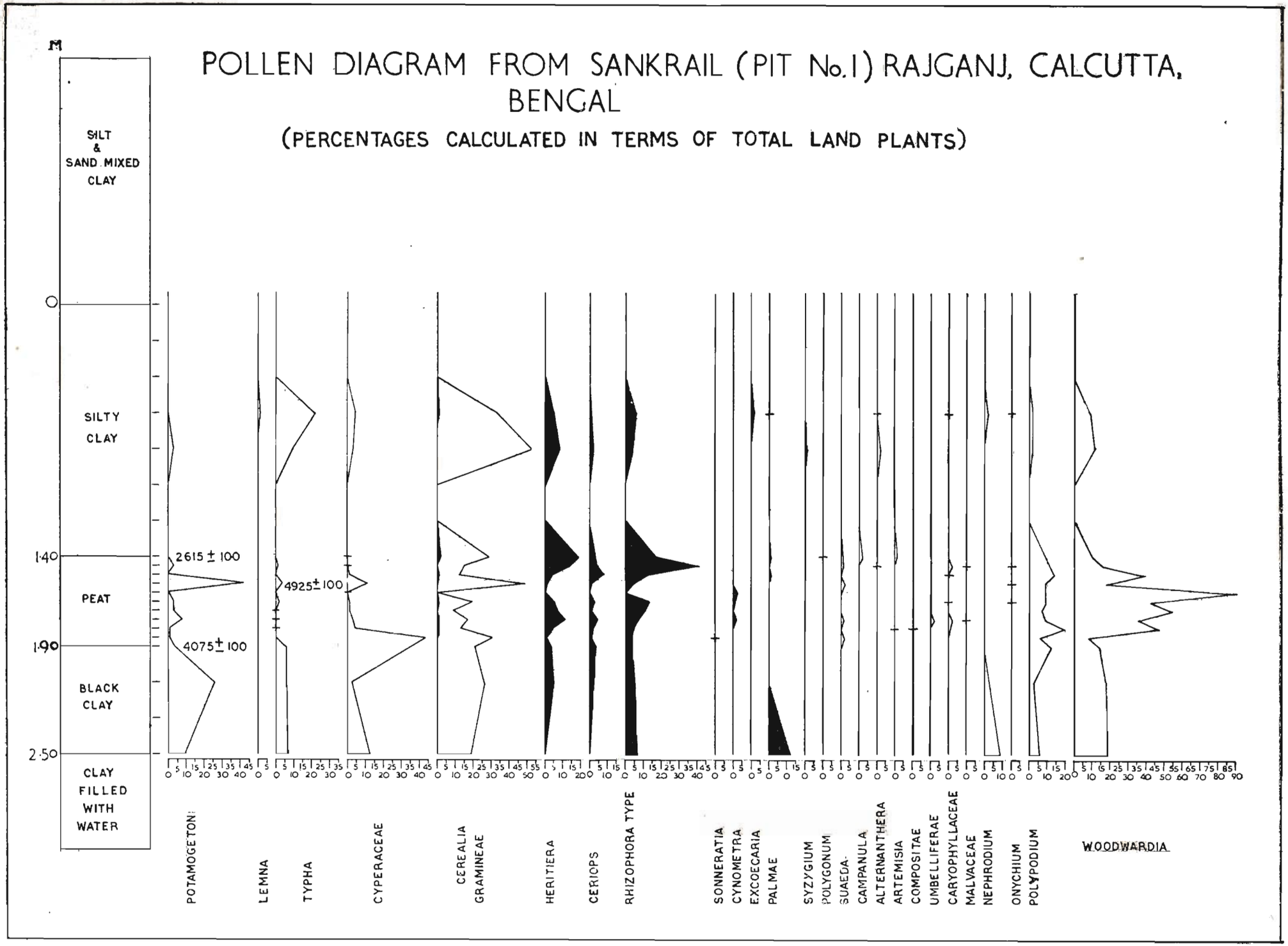
VEGETATIONAL HISTORY

In view of lack of pollen in large part of the profile, it is not possible to build up the history of vegetation for the last about 6000 years. Further the little sequences constructed can only be tentatively interpreted since the invaluable information of the reflection of modern plant communities in modern pollen spectra is too scantily available and further our knowledge of the production and dissemination of pollen of plant species distributed in the Bengal basin and particularly in the Sunderbans is practically nil. Through the investigations of diatoms in recent sediments of Bengal, Das (1961) did not find pollen of mangrove plants in the recent mud samples from the environs of Calcutta and Garia whereas they occur in the recent muds of Sunderbans. Muller's observations in this regard that both *Rhizophora* and *Bruguiera* produce high pollen, *Sonneratia* fairly abundantly and *Avicennia* scantily can, however, be taken as guide lines to interpret the data (Muller, 1964, 35-40).

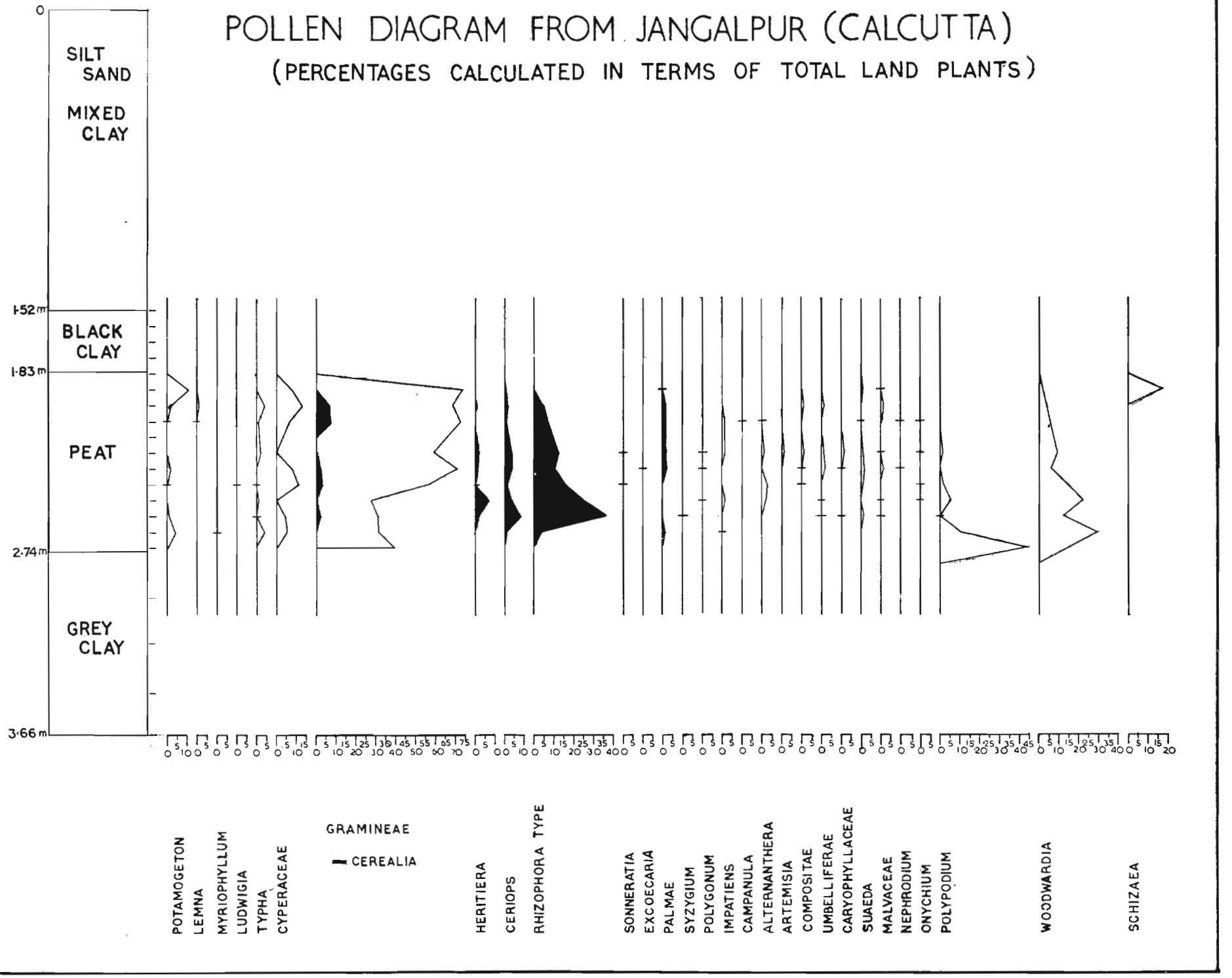
As already discussed above, no evidence of brackish water conditions has been found. *Potamogeton*, *Lemna*, and *Myriophyllum* suggest that fresh water conditions had prevailed at the sites. The megafossils of *Heritiera* found comparatively more frequently and of *Sonneratia* sparingly further suggest a Fresh Water *Heritiera* Community to have grown in the vicinity, where fresh to slightly brackish water conditions might have prevailed, or else the wood of these genera was transported by water into these fresh water swamps. The inference of fresh water conditions completely rules out the local occurrence of *Rhizophora*, as it is known to occur on the ground flooded every day by salt water. Its pollen is obviously transported from long distance by wind or water currents.

Thus, the arboreal pollen assemblage in the two diagrams (Text-figs. 2 & 3) points towards a Fresh Water *Heritiera* Forest comprising *Heritiera*, *Bruguiera gymnorhiza*, *Sonneratia*, *Avicenia*, *Ceriops* and *Excoecaria* which grew in the vicinity. Characterized by slightly brackish water conditions, pollen and wood of these genera recovered at these sites were transported by wind and water currents. The absence of *Potamogeton* in the Sunderbans and its occurrence at the sites investigated further reveals that the salt water communities had never extended to these sites.

The local origin of ferns is attested by large number of fern sporangia present in peat. The brush wood nature of peat, reduction of aquatics in the peat and comparatively high values of fresh water *Heritiera* community, however, suggest the community to have grown at the site. But we have no positive information if soil rich in humus is favourable to the growth of the community. The occurrence of this community in the vicinity on the ground lying between the drier bank of Hoogly River and its tributaries and the swampy



TEXT-FIG. 2 — Pollen diagram from Sankrail (pit No. 1), Howrah, Calcutta.



TEXT-FIG. 3 — Pollen diagram from Jangalpur, Howrah, Calcutta.

depressions is the only plausible explanation at the moment.

Around 3000 B.C. there existed swamps at Sankrail which were colonized by *Potamogeton, Myriophyllum* and *Lemna*, along the shores of which *Typha* and sedges grew. High frequencies of grass pollen may be attributed to wild rice, *Phragmites karka, Chamaeraphis spinescens*, a floating aquatic grass, and *Hygrorhiza aristata*, which usually occur in these swamps.

Judging purely from the face value of the pollen diagrams it appears that the mangrove vegetation did not grow very far from the vicinity. By about 660 B.C. the pollen diagrams record an increase in mangrove vegetation suggesting either its movement closer in vicinity or increase in wind and transported pollen. The mangrove vegetation declines thereafter perhaps due to rapid rate of deposition of sediments.

The cerealia type pollen grains making a small and low curve in both the diagrams is largely restricted to peat layers only. Pollen grains ranging in size between 50 and 70 μ and mostly granulate in pattern could belong to cereals particularly wheat and maize. We have no knowledge of the pollen grains of all grasses in Sunderbans and Bengal. *Coix lacryma jobi*, for instance, is known to produce pollen as large as of maize, and at the same time tetraploid forms of *Oryza sativa* can have pollen as large as 72 μ. The indications of cerealia pollen curve cannot be stressed any further.

PALYNOLOGICAL CORRELATION OF PEAT BEDS

The Jangalpur peat bed has not been radiocarbon dated as yet. The comparison of pollen sequences from the peat beds at Sankrail and Rajganj strongly suggests the correlation of base of peat at Rajganj with the top of peat at Sankrail Pit 1, since the sequences at these levels show the highest values attained by the pollen curves of the mangrove plants and low aquatic pollen curves. The decline in the curves of mangrove pollen at the extreme top of the peat bed at Sankrail is faithfully followed by the entire peat bed at Jangalpur. It would seem that the Jangalpur bed is younger in age and is subsequent to 660 B.C. the age of the top of peat bed at Sankrail. It therefore, seems contemporary with the silty clay, overlying the peat at Sankrail. Even the pollen sequence from the silty clay is not much different from the sequence from the top of the peat bed at Jangalpur.

CONCLUSION

Attempt at building up a complete vegetational history of the Bengal basin has been defeated owing to the unfossiliferous nature of large part of the profiles. Peat layer in one of the profiles (Sankrail Pit 2) has been found to be devoid of pollen grains. There is thus strong evidence of differential or overall destruction of pollen in the sediments in the basin and the small pollen sequences cannot be adequately interpreted in view of lack of our knowledge of pollen production, dissemination and preservation phenomena of particularly the arboreal vegetation in this region. The tentative interpretation brings out the existence of swamps in which peat was largely formed by the decaying parts of the aquatic vegetation, and the sites have remained far remote from the Sunderbans as is evidenced by the discovery of *Potamogeton* which does not occur in the Sunderbans and further by the lack of estuarine conditions. The forests in the vicinity comprised Fresh Water *Heritiera* community, of which pollen and wood was transported into the swamps either by wind or water.

When the peat was forming during 2000 B.C.-660 B.C. the land surface was about 3·20-3·65 m higher in level at Sankrail and about 2·74 m at Jangalpur above the present surface, which is presently 4-10 m above sea level. The tidal forests must have occurred farther away and if at all, it was the indirect tidal influence by pushing back the current of the Hoogly River that was felt here. The examination of overlying clays for marine influence can only reveal if the deltaic region had moved further north than the present. It is certain that with the subsequent deposition of thick loads of silt and silty clay, the present level has been achieved and this rise in level might have been responsible for the destruction and eventual extermination of *Heritiera* from the western part of this basin. Constituting the outermost fringe of the mangrove forests and immediately within easy reach by Man, human influence

in search of firewood and timber might have further helped towards its extermination. That the very hard, tough and elastic wood of *Heritiera fomes* is much in demand for boat-building, buggy shafts building and other purposes (Troup, 1921, 153) strongly suggests the human factor as the major cause for the extermination of *Heritiera* from West Bengal.

Chanda & Mukherji's (1969, p. 2) conclusion that the mangrove forest existed in and around Calcutta about 5000 years ago needs convincing support from the examination of modern pollen spectra from Calcutta across the entire Sundarbans. The pollen assemblage reported by them includes *Bauhinia*, *Terminalia* and *Dipterocarpus* and several herbacious members which do not grow in mangroves, thus suggesting a mixed pollen flora derived both from the fresh water riverine forest and the tidal forests. Which of these is of local or distant origin remains to be established.

There is hardly any indication from the patchy pollen sequences that the climate was in any way different from the present during the last 6000 years in the Bengal basin.

Practically no evidence of agriculture has been detected from the pollen sequences and the difficulties regarding that have been mentioned above. On the other hand Chanda & Mukherji (1969, p. 1, 2) report large quantity of cultivated variety of grass pollen together with pollen of *Plantago*, etc. and conclude "presence of human settlement and resulting sporadic agricultural practices in the man-made clearings of swampy lands of this region." Cereals are autogamous. Consequently the large quantity of grass pollen cannot belong to a cultivated grass. Further *Plantago* spp. are weeds of wheat and barley cultivation and in this predominently rice cultivation area wheat is known to have been introduced during 1000 B.C. (VISHNU-MITTRE, 1968). Thus, the event of agriculture inferred by them remains to be established.

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