POLLEN ANALYSIS OF FOSSIL SOILS ALONG THE BANK OF GHOD RIVER, INAMGAON, MAHARASHTRA*

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ABSTRACT

Pollen analysis of fossil soils along the bank of Ghod River, Inamgaon, Maharashtra, suggests the former occurrence of a dry deciduous forest dominated by *Holoptelea integrifolia*. The annual precipitation then was not higher than now and an environment of unstability of soil concentration along the banks had prevailed. The subfossil soils were formed by ponding of flood waters when the water level in the river had risen much higher than at the present caused probably by tectonic movement in the catchment area.

The percentage distribution of pore apertures on subfossil pollen grains of *Holoptelea integrifolia* has been found to differ considerably from the modern plants of this species suggesting a physiological change in the modern plants.

INTRODUCTION

THE occurrence of fossil soils along the right bank of Ghod river, a tributary of the Bhima River was first discovered by Lala Aditya Narayan, an archaeologist attached to the team of Prof. H. D. Sankalia excavating a Central Indian Chalcolithic site, Inamgaon, about 1·60 km distant and upstream from the right bank of the tributary. The attention of the senior author to these fossil soils was drawn kindly by Prof. H. D. Sankalia during his visit to Inamgaon in Feb. 1969. The site is about 90 km distant from Pune, district Pune, Maharashtra.

Inamgaon lies in the dry arid region bearing patches of the Southern Tropical Thorn Forest comprising open low communities in which *Acacia*, *Prosopis* spp. and the other thorny hard wood species predominate. Trees of *Zizyphus* and *Anogeissus latifolia*, *Soymida febrifuga* and shrubs of *Capparis* spp. occur scattered in various proportions. Fleshy Euphorbias are not very infrequent. The trees are stunted with short boles and low crowns. Species of *Aristida* and *Heteropogon contortus* are the prominent grasses. Clumps of *Typha* occur in and around seasonal nullahs. It is largely black cotton soil though sandy deposits are not infrequent.

This part of district Pune is highly arid. No climatic data are available for Inamgaon or for any station in the immediate vicinity. Pune has mean annual rainfall around 600 mm with only 47 rainy days in a year and 58 per cent humidity. The mean annual temperature ranges from 18°C to 32°C with the highest recorded around 43°C. Being drier than Pune, the mean anual precipitation at Inamgaon and vicinity is less than 500 mm (pers. information Mr. Kajale of Deccan College, Poona) and temperatures slightly higher than obtained at Pune.

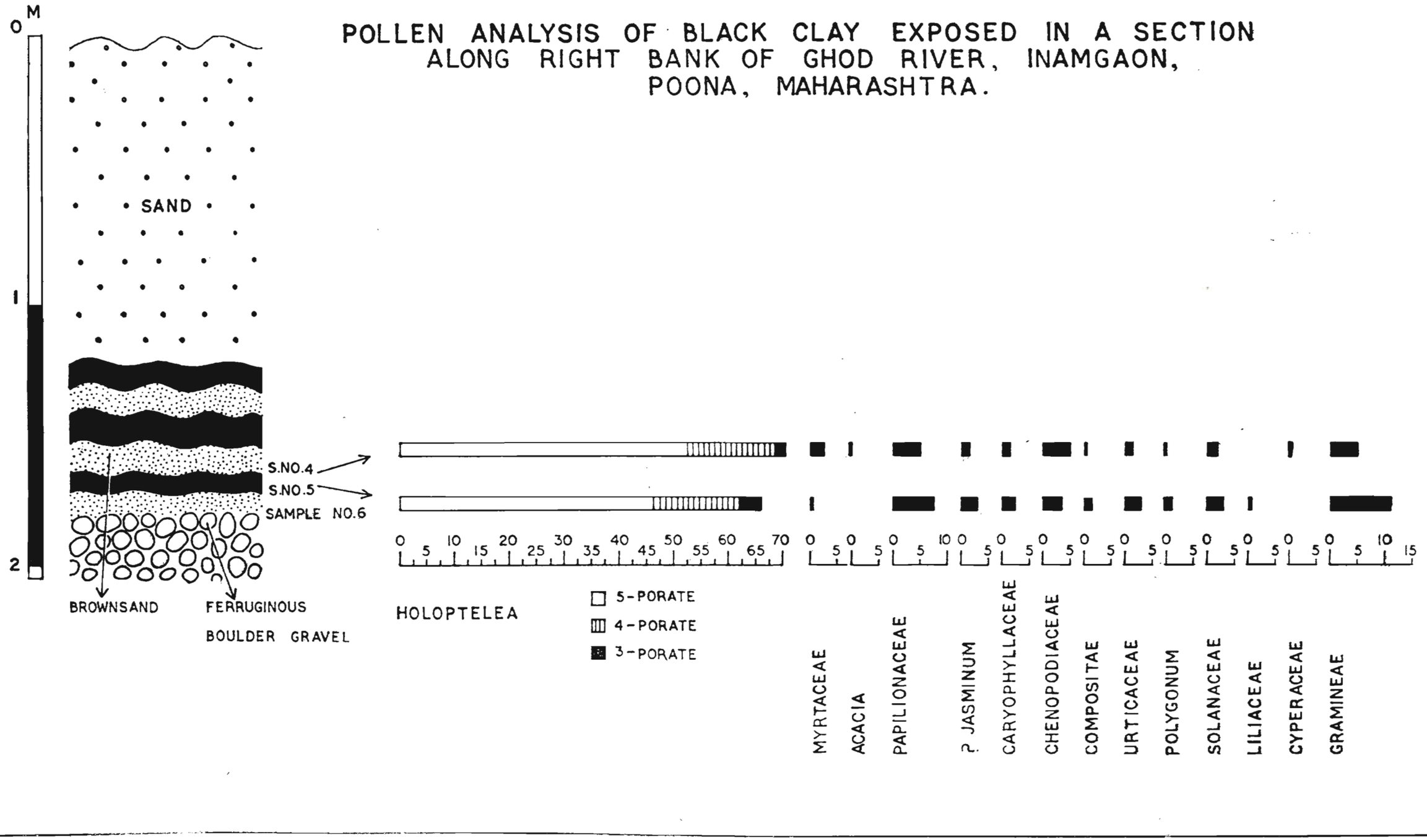
STRATIGRAPHY OF FOSSIL SOILS

The fossil soils occur along the right bank of Ghod river in the form of bands of dark black clay extending over a short distance of about 1½ m. There are three prominent bands measuring about 7-21 cm in thickness alternating with thin bands of sand or silt in between. The section comprising the bands of clays intercalated with sand layers lies over a thin layer of brown sand resting on highly ferruginous boulder gravel about 21 cm of which is exposed, and is overlain by about 1·20-1·50 m sand making the top of the bank. The boulder gravel is about 1·50-2·50 m high from the river bed.

The top layer of black clay, about 15-20 cm in thickness, was highly weathered and penetrated by rootlets of vegetation growing over the bank. The middle layer below about 20-25 cm of sand layer, consisted of thin bands of black clay alternating with fine bands of silt or sand. The bottommost layer of black clay resting on a thin layer of brown sand of about 3-6 cm in thickness was about 7-10 cm thick. The brown sand overlay the boulder gravel.

*Pollen analyses by H. P. Gupta; text and interpretation by Vishnu-Mittre.

POLLEN ANALYSIS OF BLACK CLAY EXPOSED IN A SECTION ALONG RIGHT BANK OF GHOD RIVER, INAMGAON, POONA, MAHARASHTRA.



TEXT-FIG. 1

A thorough search was made both up and downstream along both the banks of the river to discover similar exposures of fossil soils, but the search proved fruitless.

The black clay bands in the section appear to have been formed by ponding of water after an intermittent flooding episode causing the deposition of silt and clay repeatedly over one another when the water level in the river must have risen about 3·50 m above the present river level. The overlying thick deposit of sand must have deposited by another flooding episode of more severe nature than the one preceding it. *A C^{14} date (TF-1003, 21725 $\pm \frac{630}{585}$ i.e. 19775 B.C.) of shells from a pebble conglomerate occurring about 2 m above the modern bed of the Ghod river reveals that the formation of these black clay layers is subsequent to 20,000 years B.C.

The ferruginous boulder gravel appears to be the top of the pebble conglomerate and both the gravel and the conglomerate are highly suggestive of the first major flooding phase here. The last flooding phase which tended to deposit the top sand deposit may be of early historical times as evidenced by the embankment remains of boulders set in hard mortar towards the west of the Chalcolithic site, Inamgaon. These flooding episodes resulted in alteration of the river course as is evidenced by the occurrence of a river channel running close to the embankment which diverted the floodwaters in a N/S direction. From the above it would appear that the formation of the black layers took place during the receding phase of the last Pluvial or subsequent to it.

Early Stone Age man was witness to the major flooding episode as stone tools of this age have been recovered from the gravel deposits opposite Inamgaon together with remains of *Bos namadicus*. The region has been inhabited by man since then as evidenced by the large factory site probably of Late Stone Age near Inamgaon and by the Malwa and the Jorwe cultures dated from 1600 to 1000 B.C. Deer was the most hunted animal here during the central Indian Chalcolithic Culture as its bones have been discovered in every house excavated (Indian Archaeology-A Review, 1969-70).

*The other date for shells from Middle Stone Age tools bearing sandy pebbles 2m above the river bed is TF-1177, 19290 ± 360 i.e. 17340 B.C. (Agrawal & Kusumagar, 1975, p. 150)

POLLEN ANALYSIS

Text-fig. 1

No samples for analysis were collected from the top layer of the fossil soils, for it was found much weathered and penetrated by rootlets. The middle layer was comparatively less weathered and the bottom layer the least. Two to three samples each in vertical series were collected from the middle and the bottom layers.

The samples were subjected to usual chemical treatment involving the use of HF and subsequently acetolysis after Erdtman (1943). All the samples from the middle layer and the one from the bottom layer did not yield sufficient pollen for the construction of pollen spectra. The details (based upon percentages of each individual calculated on the number of pollen grains of all land plants) of the two pollen spectra from sample nos. 4 and 5 belonging to the bottom layer are set against stratigraphical profile in text-fig. 1.

Pollen Spectra — The two spectra are dominated by pollen of *Holoptelea integrifolia*, of which the pollen grains are 3-5 porate as contrasted from 4-6 porate in modern plants of this sepcies reported by Khandelwal and Vishnu-Mittre (1974). The percentage distribution of pores on pollen of modern and subfossil *Holoptelea integrifolia* also differs considerably as shown in table-1 below.

TABLE 1 — PERCENTAGE DISTRIBUTION OF PORES ON POLLEN GRAINS OF MODERN AND SUBFOSSIL *HOLOPTELEA INTEGRIFOLIA*

Number of pores	Modern pollen	Subfossil pollen	
		Sample No. 4	Sample No. 5
3-porate	—	2·8%	6·0%
4-porate	40·8%	22·6%	24·2%
5-porate	42·6%	74·6%	69·8%
6-porate	16·6%	—	—

Pollen grains of *Syzygium* vary from 0·48- to 2·25 per cent indicating long distance transport. A single polyad of *Acacia* has

been met with only in sample no. 4 indicating its local origin. Pollen grains referred to Leguminosae-Papilionaceae are also recognised. They are all finely reticulate, colporate or colporoidate, 20-28×15-23 μ in size, and could as well belong to genera outside this natural order. Pollen grains referred to *Jasminum* (0·75% to 3·3%) may as well belong to other members of Oleaceae.

Pollen of aquatics is singularly absent. The ground vegetation is poorly represented by small percentage of pollen grains of Caryophyllaceae, Cheno-amaranths (referred to as Chenopodiaceae in text-fig. 1), Compositae, Solanaceae, Liliaceae, Gramineae and Urticaceae. A single grass pollen of 75 μ has been observed in sample no. 5. A wild grass producing large-sized pollen can only be inferred. Two pollen grains of Cyperaceae have been observed in only sample no. 4 wherein a single pollen of *Polygonum* has also been encountered.

Interpretation — In the absence of data concerning pollen preservation phenomena and the comparable modern pollen spectra, a tentative interpretation of the pollen spectra can only be attempted here. The predominance of arboreal pollen particularly of *Holoptelea integrifolia* over that of NAP is highly suggestive of a forest of *Holoptelea* with *Acacia* in the vicinity. *Syzygium* of which small percentage of pollen grains has been recovered, is a high pollen producer. Its pollen obviously has been transported from long distance.

From an account of the ecology and distribution of *Holoptelea integrifolia* given by Champion and Seth (1968) one finds it a deciduous tree, widely distributed in India and ascending to 700 m in the hills. It is a light demander and not frost resistant. It occurs as a primary sere in new reverine soils throughout drier deciduous forest to semievergreen post climax. Secondary seres are more xerophytic tending to resemble dry deciduous forest. On deep and porous soils it is capable of thriving without much moisture in soil. It occurs on lateritic and black cotton soils and *Dalbergia latifolia* is one of its close associates.

Under the moist climate it is known to occur in Kerala in the Tropical West Coast Evergreen Forest under a rainfall regime of 2000-2500 mm. Here it usually forms a narrow strip between the wet evergreen and moist deciduous forests. It also occurs in the very moist Teak forest (rainfall over 2500 mm).

Elsewhere it occurs in the dry deciduous forests, viz., Dry Teak forest in Madras and as *Holoptelea* forest in Western Ganges Khola in Uttar Pradesh under a rainfall regime of 900-1500 mm. *Dalbergia sissoo* and *Salmalia malabarica* are conspicuous associates in the *Holoptelea* forest in U.P.

Forming narrow strips along streams it occurs along Mahi river in Banswara Division in Rajasthan; on sandy alluvium in the Kher-Sissoo (*Acacia catechu* and *Dalbergia sissoo*) forest all along rivers in Haldwani division, U.P. It also occurs in the Northern Tropical Thorn forest under a rainfall regime of 250-670 mm on flat alluvial soils in the Desert Thorn forest with mean annual temperature being 25°C-31°C; in the Desert Thorn forest in Bassi, Jaipur division and in the Ravine Thorn forest in Etawah together with *Acacia*.

Although this deciduous plant species is distributed in a variety of climatic regimes, yet it is of more common occurrence in the dry deciduous forest on flat alluvial soils along the streams. It is a member of the primary series with the second arrivals to the original colonists, *Acacia catechu* and *Dalbergia* of the riverain type. Along with its associates such as *Adina cordifolia, Lagerstroemia, Albizzia, Salmalia, Terminalia*, etc. it occurs on immature riverain sandy or gravelly soils liable to frequent flooding. It also occurs on consolidated sand dunes as at Bassi in the Jaipur Forest Division in Rajasthan. Passing through a dry deciduous phase, this primary succession leads to the climatic climax vegetation of the area. The influence of the soil exceeds that of climate as is apparent from the similarity of the riverain seres from U.P. to Kerala and from Punjab to Assam. Its occurrence therefore reflects unstability of soil concentration in various stages of consolidation and its distribution is governed and controlled by edaphic factor rather than by climate. With the progressive development of mature soils the divergence in succession takes place leading to climax vegetation in equilibrium with the climate of the region. The succession is quicker under better distributed rainfall and milder winter than in regions where such favourable conditions do not exist (Champion & Seth 1968a, 1968b).

Abundant occurrence of *Holoptelea* pollen in the fossil soils discovered along the bank of Ghod River strongly suggests the former local occurrence of *Holoptelea* forest fringing the banks of the river. That the forest was of a deciduous type is also suggested by the identification of polyads of *Acacia*. An environment of unstability of soil concentration in various stages of consolidation flooded periodically had prevailed when the soils now burried had been laid. A dry climate with precipitation from 250 to 760 mm can only be surmised. The formation of the subfossil soils is the result of ponding of flood waters when the water level of the river had risen much higher than at the present. Pollen data do not suggest that the floods were caused by high precipitation. Tectonic factor in the catchment area can not be overlooked.

Holoptelea integrifolia is a very high pollen producer. A twig of 150 flowers produces as much as 6, 62, 350 to 16, 264, 500 pollen grains (Khandelwal & Vishnu-Mittre, 1974). The amount of pollen preserved in local sediments at Lucknow ranges from 1·5% to 43·7% whereas the atmosphere during its flowering period has up to 42·5% pollen (Khandelwal, 1974). At Lucknow itself its plants occur from scattered trees to groves including the planted ones. The recovery of 65-70% pollen therefore in the fossil soils is not surprising and it indeed suggests the occurrence of a dense *Holoptelea* forest provided such high percentage of its pollen is not due to differential preservation.

The subfossil pollen being 3-5 porate in contrast to 4-6 porate in modern plants suggests a distinct change in the physiology of *Holoptelea integrifolia* since the late Pluvial times.

CONCLUSION

The fossil soils along the right bank of Ghod River were formed through ponding of flood waters during a flooding episode subsequent to 20,000 years ago. The absence of pollen in all the fossil soils has limited our inference of past vegetation and climate to only two pollen spectra from the bottom layer. The abundance of *Holoptelea* pollen in the pollen spectra suggests the occurrence of a dense *Holoptelea* forest along the banks of the river during the later part of the last pluvial. No trees of *Holoptelea* were observed at Inamgaon and in the vicinity during the senior author's visit to the area. Very likely the trees were missed since they were leaflets at the time of visit in Mid-February and flowering had not commenced yet.

The climate when the black clay layers were deposited was probably arid as at present with an environment of unstability of soil concentration along the banks of the river.

It is hoped that the investigation of more such fossil soils in this area would certainly throw decisive information on past vegetation and climate than inferred here from two pollen spectra only.

The senior author records his thanks to Professor H. D. Sankalia for drawing bis attention to the site and for the facilities to visit it and to collect samples for analysis.

REFERENCES

Agrawal D. P. & Kusumagar, Sheela (1975). Radiocarbon dates of some Late Quaternary samples. *Curr. Sci.* **44** (5): 149-151.

Champion, Sir Harry, G. & Seth, S. K. (1968a). A revised survey of the Forest Types of India. *Delhi*.

Idem (1968b) General silviculture for India. *Delhi*.

Erdtman, G. (1943). An Introduction to Pollen Analysis. *Waltham, Mass. U.S.A.*

Indian Archaeology — A Review, 1969-70.

Khandelwal, Asha (1974). Studies in atmospheric pollen grains and fungal spores at Lucknow. *Ph.D. Thesis. Lucknow University.*

Khandelwal, Asha & Vishnu-Mittre (1975). Palynology of *Holoptelea integrifolia* Planch. *Palaeobotanist.* **22** (2): 127-132.