PLANT REMAINS AND CLIMATE FROM THE LATE HARAPPAN AND OTHER CHALCOLITHIC CULTURES OF INDIA—A STUDY IN INTER-RELATIONSHIPS.*

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ABSTRACT

The paper reviews the climatic inferences so far drawn from the various kinds of plant remains known from the Harappan and Chalcolithic sites. It is interesting to note that the same food plants are cultivated today in the vicinity of the archaeological sites from where their remains have been discovered, and likewise several plant species identified from protohistoric charcoals still occur in the vicinity of the archaeological sites, thus suggesting that the climate has remained unchanged during the last 5000 years ago. No possibility suggests that *Cedrus deodara, Ulmus* sp., *Pinus roxburghii* and *Dalbergia latifolia* of which charcoals have been discovered ever grew in the vicinity of these sites. These were imported from the areas of their natural distribution.

The pollen sequences have been indirectly correlated with these cultures. The Kashmir Valley pollen diagrams suggest that the vegetational succession was governed by the biotic factor (man and his grazing animals) and the climate which was cool and dry to begin with subsequently became warm. No change in climate is indicated by pollen sequences from the Bengal Basin. A critical appraisal of plant indicators of climate chosen by SINGH (1970, 1971) to indicate wet climate in Rajasthan has revealed that they in fact are suggestive of prevalence of dry climate and the vegetational changes observed were caused by the biotic factor. Thus, there was no wet or high rainfall period in Rajasthan during the last 10,000 years and more particularly during the Harappan and Chalcolithic times.

INTRODUCTION

The plant remains from the archaeological sites usually comprise of timber and food grains. Pollen grains and spores from the archaeological soil samples have been rarely found (VISHNU-MITTRE, 1957; GUINET, 1966; SINGH, 1971). Some pollen diagrams constructed from lakes and swamps in some parts of India have been related to the archaeological periods through radiocarbon dates or by other conservative methods. The botanical environment provided by the plant remains from archaeological sites has recently been reviewed (VISHNU-MITTRE, 1972c). An attempt has been made to present a critical appraisal of the inference of climate from these plant remains from the Harappan and other Chalcolithic cultures on which divergence of opinion has appeared in literature.

I have found it convenient to discuss information of plant remains and of climate right from the beginning of the Harappan Period rather than from the late Harappan for certain obvious reasons. Within the time interval between the two, the emergence, the climax and the decline of the Harappan culture is indicated, and about two hundred years prior to the Harappan decline several ethnographic cultures, the Malwa, the Jorwe, the Banasian and the Ganga Yamuna Doab Cultures comprising the other Chalcolithic Cultures had already emerged or were co-existing with the Harappan Culture in Sind, Rajasthan, Punjab, U. P., M. P. and Maharashtra and in other states. It seems, therefore, profitable to discuss the climatic pattern in the country more particularly from

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3000 B. C. to 1000 B.C. so that its impact upon cultural evolution, if any, can be assessed properly.

I have further chosen to avoid botanical technicalities as far as possible, and have preferred to discuss the climatic inferences from the plant remains rather than the plant remains themselves on which information has already been published (VISHNU-MITTRE, 1972c). An archaeologist perhaps requires the former most than the latter.

FOOD REMAINS AND CLIMATE

A sizeable information of the cultivated plants during the Harappan and other Chalcolithic Cultures has been obtained by now. A remarkable feature observed is that the same cultivated plants are cultivated even today in the vicinity of the archaeological sites from where their remains have been discovered. Wheat and barley for instance, are still cultivated in the viciniteis of the Harappan sites; Rice, *Sorghum* (Jowar) and *Pennisetum* (Bajra) are still cultivated in the vicinity of Ahar, Lothal and Rangpur, in the Banas and Chambal Valleys; Wheat, barley and rice are still cultivated at Atranji Khera in U. P. and Chirand in Bihar where they were cultivated 1800—2000 years B.C. Rice is predominantly cultivated today in eastern India and this is the only cereal to have been cultivated here prior to 1000 B.C. No millets which otherwise require dry climate have ever been discovered from eastern India.

The above information reflects that the present climatic pattern has been stable during the last 5000 years. The thesis of GHOSH (1961) that Western India was wet during the Harappan times for the rice* to have grown at Lothal is not borne out by the facts discussed above. We indeed lack information on two important points and therefore two questions, one, Did the Harappans or later Chalcolithic people cultivate these cereals or import them from distant regions?, two, Have the areas of cultivation been extended to the vicinities of the archaeological sites in recent times? Regarding the first we have now convincing evidence from Kalibangan that cultivation was done in the vicinity of the site. Slight shifts in the areas of cultivation of certain cereals both in the past and at the present, dependent so far as they may be on strictly local factors, can have hardly any bearing on the general pattern of climate. And this pattern appears to have been stable during the last five millenia.

TIMBER REMAINS AND CLIMATE

It would perhaps suffice here to draw attention to the conclusions arrived at by the investigations of timber remains from Harappa (CHOWDHARY & GHOSH, 1951), Rangpur (GHOSH & LAL, 1962-63), Lothal (RAO & LAL, in press), PRAKASH (RAO & SHAHI, MS 1967), Navdatoli-Maheshwar (PRAKASH & AWASTHI, 1971), Atranji Khera (CHOWDHURY *et al.*) and from Maski (GHOSH & CHOWDHURY, 1957) that there has been no change in climate during the time of the Harappan and Chalcolithic Cultures. A very critical review by SETH (1962) and subsequently by VISHNU-MITTRE (1967-68, 1972b) uphold the above conclusions.

Although several plant species identified from charcoals still occur in the vicinity of these archaeological sites, useful timber of certain plant species such as Deodar (*Cedrus*

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*It is yet to be proven if the Lothal rice belonged to the cultivated or wild species. Wild rice is known to grow in marshes along the north-western coast even today.

deodara) and Elm (*Elmus* sp.) was imported by the Harappans from the Himalayas; and Chir-pine (*Pinus roxburghii*) was obtained by the Atranji Kherians from the Himalayan foothills. Wood of *Dalbergia latifolia* was collected by the Harappans from the south eastern periphery of their nucleus. It needs no mention that the Harappans and the other Chalcolithic peoples wandered far and wide in search of raw materials and had even cultural contacts with contemporary peoples outside India.

POLLEN AND CLIMATE

Pollen assemblages from stray samples from archaeological sites as reported by Vishnu-Mittre (1957), Guinet (1966) and Singh (1970, 1971) are unreliable for any climatic or other inference (Cf. Vishnu-Mittre, 1972c) owing to the differential preservation of pollen grains in the terrestrial sediments.

Information of past botanical environment and of climate has however been obtained from pollen diagrams constructed from western Himalaya, Rajasthan and Bengal. Of these the botanical phases in Rajasthan and Bengal pollen diagrams can only be reliably related to the cultural periods, since they are radiocarbon dated. The western Himalayan pollen diagrams from the Kashmir Valley are correlated with the cultural periods through conservative estimates; the earliest evidence of farming dated to 2500 B.C. in analogy to the Neolithic date of Burzahom; maximum prosperity on botanical and historical evidence dated to 7th and 9th cent. A.D.; correspondence of the dates of the flood levels in stratigraphy calculated from rate of sedimentation with those recorded in history (Vishnu-Mittre & Sharma, 1966). On the conservative estimate the decline of oak woods in the Kashmir Valley was dated to 700 A.D. and that this conservative method of dating may not be off the mark, has been proved in the adjoining state Himachal Pradesh (Sharma, 1970) where radiocarbon assay has given more or less the same date for the decline of oak woods.

The pollen diagram from the Haigam Lake in Kashmir Valley shows a succession between the dry Ash-Oak-Alder woods, the Blue Pine woods and the Oak-*Artemisia* community suggesting prevalence of dry and cold climate during 2500 B.C.—1000 B.C. (Vishnu-Mittre, 1966; Vishnu-Mittre & Sharma, 1966). The vegetational succession here is largely governed by the influence of biotic factor (man and animals). Humidity in the valley is even today high and it was high in the past too. The succession of Pine forest—broad-leaved forest—Pine or Deodar forest characterises the pollen diagram from Kumaon (Vishnu-Mittre *et al.*, 1967) and the latter two phases of forest development are seen in Himachal Pradesh diagrams (Sharma, 1970). No severe or drastic change in climate is inferred and the pollen sequences in analogy to the Kashmir diagram are dated from the Neolithic period in Kumaon and subsequent to the Neolithic in Himachal Pradesh (Cf. Vishnu-Mittre, 1972c).

The warm and moist climate indicated in the chart published earlier by Vishnu-Mittre (1967-68) may be read as cool and dry for the Blue Pine forest phase; and warm and dry and not cool and moist as reported (Vishnu-Mittre, 1972c) for the broad-leaved oak-*Artemisia* community, since Blue Pine forest in the Kashmir Valley occurs today in dry climate.

The Tosh Maidan pollen diagram constructed by Singh (1963) reflects more or less similar succession of plant communities as the Haigam pollen diagram. It must obviously be dated from slightly before the Neolithic period. The absence of typical sub-arctic phase in Kashmir pollen diagrams unlike that in the European pollen diagrams with which the western Himalayan pollen sequences compare most in the nature of plant communities and vegetational development does not uphold the thesis of SINGH (1963, 1967) that it begins from the Late Glacial. This high level pollen diagram is influenced both by the pollen grains carried up by the upthermic winds from the Kashmir Valley on the north and the Jammu-Poonch area on the south of Pir Panjal mountain on the northern face of which lies Toshmaidan.

Whereas the climate has been more or less stable, the floristic alterations have been governed by the edaphic changes and biotic interference (deforestation and grazing), the influence of the latter has been on the increase since 2500 B.C.

The radiocarbon dated pollen diagrams from Rajasthan can be more securely related to the cultural periods in Rajasthan. For reasons best known to Dr. Gurdip Singh these pollen diagrams have not been published so far though the results have been published briefly (SINGH, 1967, 1970, 1971). His conclusions in regard to former climatic fluctuations in the Rajasthan desert are as follows—

1.	Before 8000 B.C. ..	Severe aridity
2.	8000 B.C.—7500 B.C.	Excess of 25 cm. (10″) rainfall over the present in the arid belt
3.	7500 B.C.—3000 B.C.	Slight lowering of rainfall
4.	3000 B.C.—1800 B.C.	Maximum wetness
5.	1800 B.C.—1500 .BC.	A small dry oscillation
6.	1500 B.C.—1000 L.C.	Weakly wetter
7.	After 1000 B.C.	Considerably arid.

In the absence of pollen diagrams it is not possible to assess the validity of these conclusions. One who has access to his diagrams can perhaps comment upon them better.

SINGH (1970, 1971) has constructed four pollen diagrams one each from the following lakes, the present climatic belts and the rainfall regimes of which are shown against them.

Site	*Climatic belt*	*Rainfall*
1. Lunkaransar	Arid ..	.. less than 25 cm.
2. Sambhar	Semi-arid	.. 25-50 cm.
3. Didwana	,,	.. 25-50 cm.
4. Pushkar	Semi-humid	.. 50-60 cm.

Of these four, the fresh water Pushkar lake is situated in the moistest zone in the south-east, and the salt lake Lunkaransar in the driest zone in the north-west of western Rajasthan with the other two salt lakes more or less in the middle though closer to the Pushkar lake than to the Lunkaransar. There is a successive climatic gradient as shown by the Isohyet lines.

SINGH (1970, 1971) has based climatic inferences on certain pollen grains believed by him to indicate wet or high rainfall. These are

1. high values of sedges (Cyperaceae) and grasses
2. high values of *Artemisia*
3. presence of *Mimosa rubicaulis* and *Oldenlandia*
4. presence of *Typha angustata*.

But for the above indicators, the rest of the pollen evidence indicates the occurrence of vast grasslands with arid desertic vegetation, throughout the sequences.

The Pushkar Lake pollen diagram is rightly believed to be post-Harappan (SINGH,

1971) and it is the only diagram which bears no radiocarbon date. Being from the moistest zone of all the lakes, its pollen digaram can be used to assess the validity of wet and high rainfall indications of the plant species selected by Singh. Even the top of the Lunkaransar pollen diagram can be used for the same purpose since it is dated to the recent and correlated with the top of Pushkar pollen diagram. Further these top sequences, one from the driest (Lunkaransar) and the other from the moistest (Pushkar) belt, can be used as guides for the representativity of modern vegetation in pollen spectra and for the over-all effect of differential pollen production and pollen preservation phenomena which usually influence the pollen percentages of individual constituents of vegetation.

The assessment of the validity of supposed climatic indicators for wet and high rainfall is as follows—

1. 20—40% pollen frequency of Cyperaceae in top of Lunkaransar pollen diagram and under 20% pollen in top of Pushkar lake pollen diagram indicates that high values of Cyperaceae are suggestive of aridity rather than wetness. Higher the frequency of Cyperaceae more arid the climate, should be the reasonable inference.
2. Both Cyperaceae and *Artemisia* the so-called high rainfall indicators, in Pushkar lake diagram as a whole show under 20% and under 5% pollen grains respectively. In the pollen diagrams from the arid and semi-arid regions there are 60—80% pollen grains of Cyperaceae and 30 to 40% of *Artemisia*. Both these high rainfall indicators selected by Singh should have been represented by higher frequencies in Pushkar lake diagram which is from the moistest zone but this is not the case. They are rather higher in pollen diagrams from the arid and semi-arid belts. Obviously then these are not the indicators of high rainfall but of aridity.
3. Pollen grains of grasses are equally high in all the pollen diagrams, and no particular climate can be attached to their consistently high values. A patch of desert even today, when protected from grazing can develop into lush grassland without any seeds or manures supplied to it (vide information from The Central Arid Res. Institute, Jodhpur).
4. Pollen frequencies of *Mimosa rubicaulis* are equally sporadic and low in all the pollen diagrams. Towards the top of Pushkar lake pollen diagram reflecting modern vegetation and climate, its frequencies should have been higher, if it was indeed a mesophytic species indicating higher rainfall. It may be pointed out here that *Mimosa hamata* even today occurs in the arid belt in western Rajasthan. Blatter & Hallberg (1918, p. 245) believe that *M. rubieaulis* in Rajasthan has been identified by mistake for *M. hamata*.
5. Pollen grains of *Oldenlandia* are extremely rare in the Pushkar Lake pollen diagram as compared with the other pollen diagrams from the progressively drier areas.
6. Pollen of *Typha* is extremely low and sporadic in the fresh water Pushkar Lake pollen diagram. Locally wherever it grows it produces enormous quantities of pollen grains. In the top sediments of Haigam Lake in the dry Kashmir Valley, for instance, 50—100% pollen of *Typha* has been recovered (Vishnu-Mittre & Sharma, 1966).

From the above assessment it becomes sufficiently clear that the so-called wet and high rainfall indicators selected by Singh (1967, 1971) on the other hand are indicators of dry arid climate. Consequently the moist or wet phases inferred by him from Rajasthan pollen diagrams have been incorrectly based. There was no wet or high rainfall period during the last 10,000 years in western Rajasthan. These pollen diagrams on the other hand show ample evidence of the prevalence of aridity during this long period of time.

The Harappan and the latter Chalcolithic Cultures lived in western Rajasthan under a dry and arid climate. The botanical environment consisted of desert vegetation and in the past, due to reduced biotic pressure, the grass cover was very abundant. The climatic pattern has been stable though the vegetation has undergone change owing to biotic interferences.

Pollen sequences constructed from the Bengal Basin from the suburbs of Calcutta and dated from 3000 B.C.—660 B.C. (CHANDA & MUKHERJI, 1969; MALIK, 1969; VISHNU-MITTRE & GUPTA, 1972) do not reveal any change in climate during this period. Swampy conditions with marsh vegetation existed which were influenced by flooding of the tributaries caused by tidal fluctuations.

CONCLUSIONS

A critical appraisal of the work done on the plant remains particularly in relation to the former climate during the Harappan and late Chalcolithic periods has revealed important information of former botanical environments and the kind of food grains these peoples had grown and consumed. It has also brought to light stability of climate during the last 5000 years. The divergence of opinion on climates during this period of time has largely resulted from our inadequate knowledge of the ecology and distribution of plant life in India, and lack of care in proper assessment of the results particularly from pollen analyses (VISHNU-MITTRE, 1972a).

The vegetational patterns in the areas where the Harappans and later Chalcolithic Cultures came to settle down were indeed different though in equilibrium with the then prevailing climate which was much as it is today. The virgin lands with mature soils or the periodically deposited silts by the rivers and tributaries and lush vegetation provided an hospitable environment for them to build their permanent settlements. The vegetation now came under the impact of a new and powerful factor, man and his grazing animals. The large-scale repeated deforestations, selective use of wood, bringing under cultivation large areas, the voracious nibbling of ground vegetation by sheep and goats began to change the pattern of vegetation and let loose the erosional phenomenon. The impact was certainly not very great on the quick growing plant species but several others in course of time succumbed to this biotic factor. The preference of the grazing animals for certain palatable plant species eventually reduced or exterminated them and those the spiny ones or with objectionable or poisonous alkaloids were later preferred for want of the palatable ones. The vegetational patterns went on changing giving way to the edaphic, bio-edaphic and secondary plant communities of today.

Thus, amelioration and worsening of climate were indeed not responsible for the rise and fall of these cultures. Rather, partly the environment created by prehistoric people themselves, depletion in fertility of soils or social, economic or health problems arising out of urbanization or crowded living or more positively the geomorphological changes such as repeated flooding of the sites, changes in river courses, rise or fall in water table, the former causing alkalinity in soils adversely affecting their agriculture and the latter cutting off their all-the-year-round water supply were responsible for the end of these cultures, and forcing these early peoples to migrate to other areas. The contemporaneity of the Harappan and Chalcolithic Cultures further bears out that these local factors have been responsible for the decline of one culture and at the same time the emergence of another at a distance under the same climatic regime.

The above critical appraisal of the climatic inference from the plant remains is not the final verdict on past climates between 2500—1000 B.C. More botanical evidence ought to be collected and properly assayed taking into consideration the role of biotic factor upon vegetational change (Vishnu-Mittre, 1972a, 1972b) for or against the stability of climate as inferred here during the last five millenia. The present climatic inference of the past is deduced singularly from the botanical remains, and it may be compared with climatic inference from other evidences for what it is worth.

REFERENCES

Chanda, S. & Mukherjee, B. (1969). Radiocarbon dating of two microfossiliferous Quaternary deposits, in and around Calcutta. *Sci. Cult.* **35**(6): 275-276.

Chowdhury, K. A. & Ghosh, S. S. (1951). Plant remains from Harappa. *Ancient India* **7**.

Chowdhury, K. A. & Saraswati, K. S. & Brith, G. M. Pre-vedic and later economs in agriculture and Forestry in the Ganga at Atranjekhera (in press)

Ghosh, S. S. (1961). Further records of rice (*Oryza* sp.) from ancient India. *Indian Forester.* **87** (5): 295-301.

Ghosh, S. S. & Chowdhury, K. A. (1957). Plant remains. In "Maski, 1954: A Chalcolithic site of the south-east Deccan" by B. K. Thapar. *Ancient India.* **13**: 134-142.

Gunet, Ph. (1966). What may afford Palynology to Archaeology and ancient history of India. *J. M. S. Univ. Baroda.* **15** (1): 15-19.

Ghosh, S. S. & Lal, K. (1962-1963). Plant remains from Rangpur. *Ancient India.* **18-19**: 161-175.

Malik, N. (1969). Microfloristic studies of Calcutta peat. *J. Sen Mem. Vol. bot. Soc. Bengal*: 153-160.

Prakash, U. & Awasthi, N. (1971). Some plant remains from Navdatoli, India. In "*Chalcolithic Navdatoli*" by H. D. Sankalia, S. B. Deo and Z. D. Ansari, Poona.

Rao, K. R. & Lal, K. (MS). Plant remains from Lothal. *Ancient India.* (in press).

Rao, K. R. & Shahi, R. (1967). Plant remains from Prakash. *Ancient India.* **20-21**: 139-153.

Seth, S. K. (1962). A review of evidence concerning changes in climate in India during the protohistorical and historical periods. *Indian Forester.* **88**(1): 2-16.

Sharma, C. (1970). Studies in the late Quaternary vegetational history in Himachal Pradesh. Ph. D. Thesis Lucknow Univ. (MS).

Singh, G. (1963). A preliminary survey of the postglacial vegetational history of Kashmir Valley. *Palaeobotanist.* **12**(1): 73-108.

Singh, G. (1967). A preliminary approach towards the resolution of some important problems in Rajasthan. *Indian Hydrol.* **3**(1): 111-128.

Singh, G. (1970). History of Postglacial vegetation and climate in the Rajasthan desert. *Rep. Univ. Wisconsin, Madison, U.S.A.* (in press)

Singh, G. (1971). Indus Valley Culture seen in the context of postglacial and climatic and ecological studies in north west India *Archaeol. Physical Anthropology in Oceania.* **6**(2): 177-189.

Vishnu-Mittre. (1957). Pollen analysis. In "Maski, a Chalcolithic site of the Southern Deccan" by B. K. Thapar. *Ancient India.* **13**:192-134

Vishnu-Mittre. (1966). Some aspects of pollen analytical investigations in the Kashmir Valley *Palaeobotanist.* **15** (1 & 2):157-175

Vishnu-Mittre. (1967-68). Inter-relations between Archaeology and plant Sciences. *Puratattva.* **1-2**: 4-14.

Vishnu-Mittre. (1972a). Problems concerning Quaternary Palynology in India. *Proc. Palaeo-Palynological Seminar, Calcutta.* 1971: 48-56.

Vishnu-Mittre. (1972b). Climate vs. Biotic Factor: Pollen evidence in the Postglacial vegetational history. *Prof. J. Sen. Comm. Vol. bot. Soc. Bengal. Calcutta.* (in press)

Vishnu-Mittre. (1972c). Palaeobotany and the environment of early man in India. *Archaeological Congress and Seminar Papers* Ed. S. B. Deo, Nagpur **19**(3): 206-212.

Vishnu-Mittre & Gupta, H. P. (1972). Late Quaternary vegetational history from the Bengal Basin. *Archaeological Congress and Seminar Papers.* Ed. S. B. Deo, Nagpur. **19**(3): 297-306.

VISHNU-MITTRE & SHARMA, B. D. (1966). Studies of Postglacial vegetational history from the Kashmir Valley, I. Haigam lake. *Palaeobotanist.* **15**(1): 185-212.

VISHNU-MITTRE, GUPTA, H. P. & ROBERT, R. D. (1967). Studies of the late Quaternary vegetational history of Kumaon Himalaya. *Curr. Sci.* **36**(20): 539-540.

POST-SCRIPT

Recently SINGH *et al*(*Quaternary Research* vol. **2:** pp. 496-505, 1972,) have concluded from botanical evidence that the salinsty in the Rajasthan Salt Lakes has increased owing to drying up of these lakes during the Harappan times. This obviously suggests that the climate during the Harappan times in Rajasthan was dry arid rather than wet as held earlier by SINGH (1970, 1971). That the climate during the Harappan times was dry arid is further supported by increase in the pollen frequencies of desert species in the pollen diagrams from the Salt Lakes in Rajasthan (SINGH, 1970, 1971). Both the increase in salinity in the Rajasthan lakes and increase in desert plant species during the Harappan times could not have been possible under a wet climate. Thus, the climate then prevalent was sufficiently dry arid to cause the drying up of the lakes and to induce strong aeolian activity which became responsible for vast sand expanses and intensified the dune formation activity as indicated by increase in desert plant species.