Chapter 16

Climatic Change during the Pleistocene/ Holocene Transition in Upland Western Maharashtra, Western India

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16.1. Introduction

Upland Western Maharashtra is drained by the Krishna and Godavari rivers and their tributaries. These rivers have their source in the Western Ghats and flow into the Bay of Bengal. The region is semi-arid (800–400 mm rainfall) due to its location on the leeward side of the Western Ghats. The major rivers therefore derive much of their discharge from the high rainfall source region (up to 6,000 mm), and bring water to the semi-arid zone downstream. The landscape is dominated by flat denudational surfaces at 1,200, 1,000, 800 and 700 meters above sea level (Kale and Rajaguru, 1988) of pre-Quaternary age developed on 60 myr old Deccan Trap basalt. The rivers lack well-developed floodplains and alluvium is confined to a narrow belt less than 2 km wide. The non-alluvial part of the landscape is basalt bedrock, covered with varying thicknesses of weathered bedrock, locally called 'murrum' on which a soil has developed. This weathered mantle developed during the Tertiary, when the climate was comparatively humid. The thickness of the alluvium is generally less than 20 m. This alluvium includes several fills ranging in age from the Early Middle Pleistocene to the Late Holocene. The Holocene deposits are non-calcareous silts and sand and generally form an alluvial terrace 5–6 m high inset into an older Pleistocene alluvial fill terrace 10 to 15 m high. The Pleistocene alluvium is calcareous and dominated by sandy silt with lenses of gravels and fissured clays. Colluvium covers some footslopes.

The rivers of Upland Western Maharashtra are almost unaffected by either tectonic or sea level changes during the Quaternary. The rivers preserve evidence for

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several phases of aggradation and incision, which were responses to Quaternary climatic change. Rajaguru and Kale (1985), and Kale and Rajaguru (1987) have shown that most of the streams were aggrading during the last glacial period (21–12 kyr BP) and cutting/eroding through the alluvial fills during the post glacial period (10–4 kyr BP). Some evidence for aggradation is seen around 12 kyr BP. They showed that summer monsoons were weak during the Terminal Pleistocene and were strong during the Early-Mid Holocene (particularly between 7–4 kyr BP). The Late Pleistocene aridity seen in Western Maharashtra was severe. The most dramatic evidence of the severity is the filling of gorges seen on the Mandwe River near Chilewadi, and on the Mula River near Bote. The Mandwe evidence is particularly significant as it is within the high rainfall catchment zone.

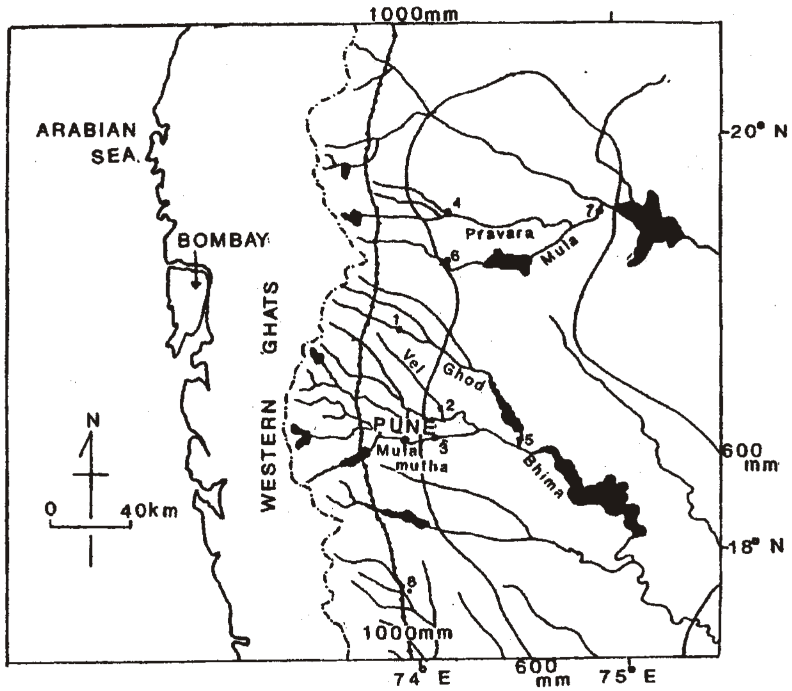
Mishra and Rajaguru (1993) have shown that the Quaternary record consists of short episodes of aggradation or erosion punctuating long periods of inactivity. Sadakata *et al.* (1993) showed that available radiocarbon dates from the region clustered into pre and post Last Glacial Maximum phases of gravel aggradation. This led us to infer that the rivers of the region have responded sensitively to global climatic changes. In this paper we focus on the sites where we have obtained absolute dates (radiocarbon, uncalibrated) between 14 and 7 kyr BP. Eleven sites have been dated within this timespan and the dates are given below in the order of oldest to youngest. The dates are uncalibrated using the radiocarbon half life of 5,730 years.

16.2. Variability of Fluvial Response to Climatic Change

While all the fluvial systems of Upland Western Maharashtra appear, for the reasons outlined above, sensitive to climatic change, it is quite likely that different parts of the fluvial system respond differently to changes in climate. Our ongoing research is focused on understanding this variability. The climatic gradient in the region is one of high rainfall in the windward Western Ghat zone with decreasing rainfall as one travels to the east, into the rainshadow zone. Out of the rainshadow zone, the rainfall tends to increase again. As the western Ghats are oriented almost North/South, the longitudinal position is a good approximate indicator of climatic differences and similarities. The rivers that originate in the high rainfall Western Ghats respond to climate differently to those that originate in the rainshadow zone to the east. Besides this, the size of the drainage basin, relief and surface cover are other factors creating variability in the fluvial response to Quaternary climatic change. In our current research we are contrasting the climatic record in the Western region, with that in the Eastern region. We find that while aggradation was ubiquitous during the Late Pleistocene, in the region West of approx. 75°E. long.; the region to the East of 75°E. shows evidence of Holocene aggradation. Data are currently more abundant for the Western zone and only the sites of Shaksal Pimpri, Ranjegaon and Akoni belong to the Eastern zone. All of them date from the Early

Table 16.1. Radiocarbon dates from the Pleistocene/Holocene transition in Upland Western Maharashtra

Site name	River	Material	Lab no.	Date	Context
Sangamner	Pravara	Shell	PRL 470	14840±350	gravel
Chandoli	Ghod	Shell	BS 1227	13510± 200	gravel
Nevasa	Pravara	Shell	BS 576	13220± 190	gravel
Sashtewadi	Mulamutha	Shell	BS 1226	13020± 190	gravel
Inamgaon	Ghod	Shell	BS 146	12040 ±150	gravel
Gargaon	Mula	Wood	TF 1111	10310 ±155	silt
Asla	Krishna	Shell	TF 1173	10035 ±150	silt
Talegaon	Vel	Shell	BS 1228	9420± 90	gravel
Ranjegaon	Sindphana	Shell	BS 1256	7800 ±130	silt
Shaksal-pimpri	Sindphana	Shell	BS 1259	7800 ±100	silt
Akoni	Nandi	Shell	BS 417	7150 ±80	gravel



1 Chandoli
2 Talegaon
3 Sashtewadi
4 Sangamner
5 Inamgaon
6 Gargoan
7 Nevasa
8 Asia
Lake

Figure 16.1. Upland Western Maharashtra.

Holocene. As Pleistocene archaeological sites are preserved mainly when there is an opportunity for burial, the two zones preferentially preserve archaeological sites of different periods.

16.3. Archaeological Evidence for the Period between 14–7 kyr

Most of the archaeological evidence for this period comes from the dated gravels themselves. Microliths are associated with all the dated samples except Asla and Gargaon, where the sample for dating comes from a silt deposit. The sites are therefore important for their geochronological and palaeoenvironmental information, but do not tell us much about human behavior during this period.

From an archaeological point of view, the most interesting site is Shaksalpimpri. Here, microliths, animal bones and some potsherds along with the datable shells come from the cultivated surface of a field. The shells were dated to 7.8 kyr BP. The association of the bones, microliths and shells therefore may be acceptable, although the material was found in a disturbed context. However, the earliest dates for pottery in this region go back only to 3.5 kyr BP. Therefore the association of the pottery with the shells, bones and microliths requires further documentation. The pottery is however entirely handmade, with mainly open basin forms. It is also similar to pottery reported by Sali (1996) from Patne, which he places stratigraphically between the Mesolithic and Chalcolithic. The association is therefore *prima facie* reasonable, although, considering its significance further work is required to confirm it. The association of the bones with the date of 7.8 kyr BP is supported by the fluorine/phosphate (100F/P205) ratio of the bones. The element fluorine occurs in most groundwater and replaces hydroxyl (OH) ions from hydroxyapatite in the buried bones. Fluorine gets accumulated in bones as the time passes. Fluorine/phosphate ratio is a better indicator of the relative age than fluorine content alone, since the ratio is independent of the density of bone which may change differently in varying soil environments. The theoretical maximum ratio is 8.92. The ratio increases with time. The method was first used by Oakely (1955) and helped in proving that the Piltdown man was a fraud. In India Joshi and Kshirsagar (1986) showed that this method was useful in relative dating. The saturation value of around 8 has been observed in fossils from the Late Middle Pleistocene period. The bones from Shakshal Pimpri gave a value of 3.94, which matches quite closely with 3.06t from Ranjegaon, which has the same C14 date.

The importance of this site is that both the bone and shells show evidence of human modification. Shakshal Pimpri therefore was the site of a human settlement during the early Holocene. The occupation was on the surface of the Pleistocene terrace and the occupational debris was preserved by a cover of flood silt soon after the abandonment of the site. The matching date from Ranjegaon, on the same river, in a similar geomorphological context, implies that they were affected by floods in the same period. There is less cultural material at Ranjegaon, and although shells and microliths were found, only a single bone fragment was, and no pottery.

16.4. Description of Dated Sites

16.4.1. SANGAMNER (*Indian Archaeology:* A review 78/79:105)

At Sangamner, a gravel 20 cm thick interbedded with clays was dated. This gravel is fine, sandy and shows cross beds. It is sandwiched within clays at 7 m above the modern Pravara level. The gravel, being a component of a floodplain facies is indicative that at 14.8 kyr BP the Pravara River was still in an aggradational mode.

16.4.2. CHANDOLI (this paper)

The dated gravel at Chandoli is a one meter thick sandy, pebbly gravel that has cut into older alluvium (see Fig 16.2) It occurs at 10 m above the present bed level of the Ghod River and is exposed over an area of 100 m x 20 m. It is not covered by any later sediment. The bivalve shells (which were used for dating) are whole single valves, abraded by transport in the gravel. The gastropod shells, however, are unabraded. Compact basalt and abraded calcrete nodules derived from the older alluvium are predominant in the gravel lithology. This gravel also contains a microlithic industry. The tools are also slightly abraded. The abrasion of the tools and shells is important in linking them with the phase of gravel deposition.

Two features are important in interpreting this gravel deposition in terms of fluvial processes. The first is the presence of a well-developed soil on the older alluvium that has been cut into by the gravel. This implies that before the deposition of the gravel, the river was not in an aggradational mode; it must have been at least slightly incised into the older alluvial deposits. The second feature is the complete isolation of the gravel. It is not part of a floodplain with both overbank and channel facies. It appears to have been deposited by a flood that was strong enough to deposit the gravel in an overbank situation, while eroding part of the older alluvium. The channel of the Ghod River just upstream of the gravel flows through a stretch of bedrock with a constricted channel. The flood waters flowing through the constricted bedrock stretch would have had an increased stream power allowing the lifting of gravel into suspension. This gravel therefore records a period of increased floods around 13.5 kyr.

16.4.3. NEVASA (Kale and Rajaguru, 1988)

The gravel at Nevasa is about one meter thick and cuts into Late Pleistocene silty deposits. It is similar to the gravel at Chandoli and Sashtewadi in its unconformable relationship to the older alluvium. At Nevasa however there is no soil preserved on Pleistocene alluvium at the site were the gravel is exposed, although further away from the river, it is present. This shows that erosion of the Pleistocene alluvium had begun before the deposition of the gravel. The gravel also shows relatively good sorting and rounding.

16.4.4. SASHTEWADI

The dated gravel at Sashtewadi is a one m thick sandy pebbly gravel containing abraded bivalve shells and a few microliths. This gravel cuts into the older alluvium at Sashtewadi (Fig 16.2). It is first seen cutting into a reddish silt at 4 m above the Mula bed and then rises to about 7 m above the river bed where it cuts into the soil developed on the older alluvium. The condition of the shells in this gravel are single, unbroken abraded bivalve shells like those seen in the Chandoli gravel. The gravel is also texturally and lithologically similar to the gravel at Chandoli. It is sandy—pebbly with compact basalt and calcrete nodule pebbles.

The two features of the isolated gravel cutting into older alluvium on which a soil had developed are present at Sashtewadi as at Chandoli. The local geomorphic setting is also similar to that at Chandoli in that the river runs through a stretch of minor rapids developed in the bedrock channel at this locality. This could therefore be a factor in this site recording floods. The dates from the two sites differ by about 500 years, although the standard deviations of the dates just overlap. The presence of abraded bivalve shells in both the gravels implies that the gravel deposition was not one event. The shells would have to both grow in the gravel and then be transported in it. The gastropod shells however show no abrasion. The gastropod shells are much more fragile than the bivalves. The gastropods present in the gravel were not transported and therefore belong to the final phase. The gravels at Chandoli, Nevasa and Sashtewadi therefore are important evidence for increased discharges in the rivers during 13 to 14 kyr BP.

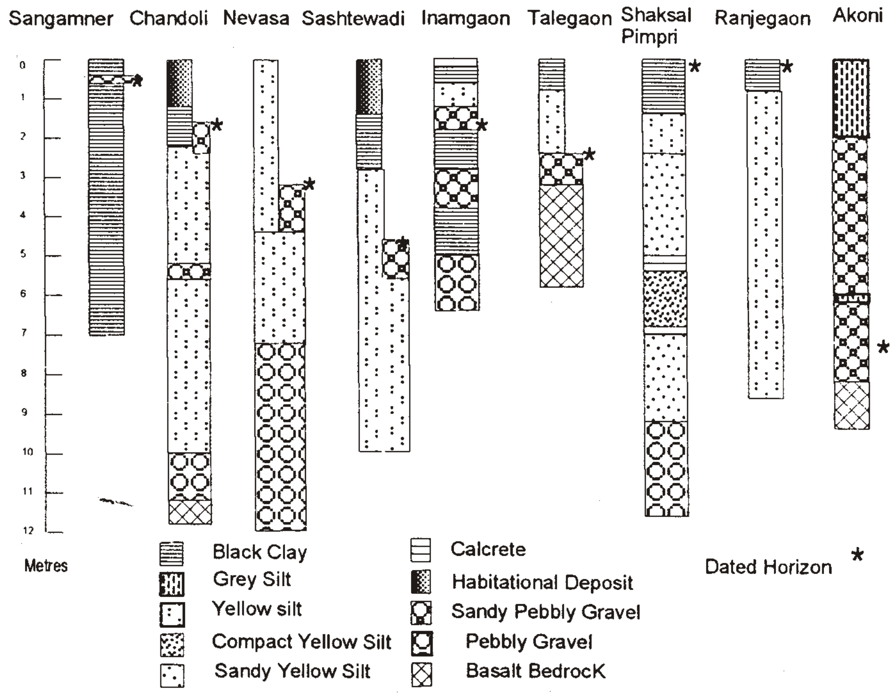


Figure 16.2.

16.4.5. INAMGAON (Rajaguru *et al.*, 1979)

The Inamgaon gravel matches the Sangamner gravel in its character. The Inamgaon gravel is also a thin bed of cross bedded sandy gravel interlayering within the clays (Rajaguru *et al.*, 1979). A recent visit to the site showed that this gravel is part of a 5 m thick fill inset into the older alluvial fill 10–15 m thick.

16.4.6. GARGAON (*Indian Archaeology:* A review 1972/73:)

The wood from Gargaon is from a brown silt that abuts the Pleistocene alluvium. It is reported (Rajaguru and Kale, 1988) to be 12 m above the river level.

16.4.7. ASLA (Rajaguru and Kale, 1985)

The shells at Asla do not come from a gravel, but were found within silty alluvium only a few meters above the modern Krishna river. This data is important in showing that by 10 kyr BP, and after the minor aggradation of 12 kyr BP the rivers have reached almost the modern level.

16.4.8. TALEGAON (this paper)

The shells at Talegaon were collected from a gravel that is exposed in a field. The positioning of this gravel in relationship to the alluvium is being further studied.

16.4.9. SHAKSAL PIMPRI (this paper)

Shells were collected from the surface of a cultivated field on a 10 m Pleistocene terrace at Shaksal Pimpri. These shells show old breaks, due to human activity. Animal bones, microliths and some potsherds were found in the same context. The shells were dated to 7.8 kyr BP. While the artifacts could have survived on the terrace surface for the 7.8 kyr, it is unlikely that bones and shells would have (especially in the unabraded and unweathered condition they were found in), unless they were covered by some sediment. Therefore we think that the evidence for human activity was preserved by a thin cover of flood silt, shortly after the abandonment of the site. This therefore dates not only the human activity but also the flood which preserved it.

16.4.10 RANJEGAON (this paper)

The shells at Ranjegaon occurred in an identical situation to those at Shaksal Pimpri, except that the material was less abundant and no potsherds were found.

16.4.11 AKONI (Kale and Rajaguru, 1984)

Microliths and shells were found in a gravel exposed in a well on the Nandi river, a small tributary of the Bhima. Thus this shows the aggradation of one of the low order streams during the Early Holocene in the more easterly zone.

16.5. Pleistocene/Holocene Transition in Western Upland Maharashtra

The limited data available suggest that the fluvial deposits of Western Upland preserve a sensitive and complex record of Quaternary climate change. The rivers not only adjusted to changing climate, but different components of the fluvial systems varied in their response. While this does complicate interpretation, it also means that different components of the system were sensitive to different climatic variables. Depositional records absent in one region are present in others. With a more complete record, a richer archaeological and palaeoenvironmental interpretation becomes possible. Based on present data, we can divide the Pleistocene/Holocene transitional period into the following stages:

16.5.1. LATE PLEISTOCENE AGGRADATION

The period between 26–14 kyr was one of aggradation. Most of the dates from this period come from gravels interlayering with floodplain deposits. These gravel are poorly sorted, with a large component of reworked calcrete nodules. Although it is the gravels that have been dated, they represent only a minor component of the terrace fill, which is predominantly silty. This is the major phase of Late Pleistocene aridity.

16.5.2. INITIATION OF THE INCISIONAL PHASE BETWEEN 13–14 KYR BP

Three sites have been dated to this phase—Nevasa, Chandoli and Sashtewadi. The dated units are all gravels which have an unconformable relation to the Late Pleistocene alluvium. The lithology and rounding of the gravels also shows better rounding and more mature lithology compared to the gravels of 26–14 kyr. We have interpreted these gravels as having been deposited during the initiation of the incision into the Late Pleistocene alluvium. These gravels may be restricted to favorable stretches of the rivers.

This evidence goes well with the finding that the Himalayas were free of ice below 3,100 m by 15 kyr (Singh and Agrawal, 1976). The first major phase of deglaciation was very rapid throughout the world, with near interglacial conditions being established before the climatic reversal during Younger Dryas times.

16.5.3. RAPID/COMPLEX CHANGE IN CLIMATE BETWEEN 12–10 KYR BP

For the time period between 10 and 12 kyr BP the climatic evidence is varied, suggesting either rapid climatic change or different responses between the dated sites or both. Therefore we find that on the Inamgaon floodplain aggradation was going on at 12.0 kyr and at Gargaon silty aggradation at 10.3 kyr while at Asla, the river was close to the modern bed level at 10.0 kyr. The records of climate for this time period from other parts of the world do indeed show this to be a period of rapid change in climate. More data is needed to understand it better.

16.5.4. EARLY HOLOCENE FLOODS

The covering of the microlithic sites at Shakshal Pimpri and Ranjegaon have been interpreted as evidence for large floods during the early Holocene.

16.5.5. EARLY HOLOCENE AGGRADATION

The gravel at Akoni shows the aggradation of one of the minor tributaries with a drainage basin entirely within the semi-arid zone. Though such a tributary might become defunct during the periods of arid climate, the aggradation indicates a response to a discharge capable of transporting the accumulated sediment supply. The Nandi River was therefore aggrading, during the time when the larger rivers, with discharge from the Western Ghats, were eroding the Pleistocene floodplains.

16.6. Human Response to Environmental Change during the Pleistocene/Holocene Transition

The data on the human response to changing environments during the Pleistocene Holocene transition is scanty in comparison to the evidence for environmental change. The most important point is that man was present in the region during all the phases of climatic change. Artifacts are present in all the dated gravels. Moreover, their density in the gravels is quite high. The artifacts are usually unabraded or slightly abraded. This would imply they were discarded in the gravel, rather than washed in from a different location.

The stone industry during the Pleistocene/ Holocene transition was microlithic. Small chalcedony blades were backed and inserted into handles to make tools. The main types of backed blades are lunates and points.

Therefore Upland Western Maharashtra continued to be a congenial home to the Terminal Pleistocene hunter gatherers, as the allochthonous rivers were perennial water sources even in the rain shadow zone. Badam (1979) has shown that the region supported a rich herbivorous fauna even during the Late Pleistocene. The rapid fluctuations in climate must have provided a challenge to the Late Pleistocene hunter-gatherers, but much more archaeological data are required before the human response can be properly known.

16.7. Conclusion

Late Pleistocene hunter-gatherers have coped with the very drastic climatic fluctuations during the Pleistocene Holocene transition although we can imagine that the adjustment might have been difficult. In contrast, modern human populations have increased their vulnerability to environmental changes in spite of a more sophisticated technology due to the increased demand on resources. Understanding past climatic changes and planning for future ones therefore is of prime importance.

The major purpose of this particular paper has been to present the new data from Western Maharashtra that shows not only that the Upland rivers responded to Late Pleistocene aridity by aggradation, but that minor episodes of aggradation and erosion are also present recording the response of the fluvial systems to short episodes of climatic change during the Pleistocene Holocene transition. The gravels from Nevasa, Chandoli, Sashtewadi and Talegaon, representing overbank gravel deposition in channel constriction localities during floods, have been recognized for the first time. The dating of an incisional phase before 13.5 kyr has also been suggested for the first time based on the dates from Chandoli and Sashtewadi and Nevasa. A minor aggradation is seen from the evidence from Inamgaon and Gargaon. The rivers have reached to the present entrenched levels by around 10 kyr.

The rivers of Upland Western Maharashtra are thus beginning to yield a more detailed ~~palaeoclimatic~~ record. At present the inferences have been made on relatively little data. We expect further work will give a more complete picture of the impact of past climatic changes on the fluvial systems and past humans living in Upland Western Maharashtra.

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