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Investigating regional land use patterns: pollen, charcoal and archaeological analyses in precolonial South India

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Introduction

The analysis of spatially extensive remains of past settlement, productive activities and land use has proved to be consistently challenging to archaeologists. In part, this challenge relates to the large spatial scale of research required to address such issues. However, issues of scale are not the only challenges; a host of archaeologically interesting activities such as agricultural production, short-term residence and pastoralism leave only an ephemeral or at best subtle material record. In this short paper I will give a brief overview of some work in progress around the city of Vijayanagara, which investigates the structure of late precolonial land use, settlement and agricultural production. This research program has been designed to address some of the challenges identified above, and employs three distinct lines of evidence, taken from the archaeological, historical and palaeoecological records. Each of these forms of evidence provides a different, and ultimately complementary perspective on the use of this complex landscape. Here I will consider only the issue of agricultural land use in the region between about AD 1300 and the present, focussing on pollen, charcoal and some of the archaeological evidence for agricultural change.

Vijayanagara: background

The city of Vijayanagara, located in the dry interior of southern India, was the capital of a vast empire that claimed hegemony over much of peninsular India between the 14th and 16th centuries AD. One of the largest cities of South Asia at its peak, Vijayanagara was established in a region which had never been politically central or densely populated. Pre-Vijayanagara settlements are known in the region around the city from at least the Neolithic (Foote 1916; Allchin 1963), and several small settlements dating to around the 10th century AD can be identified in the area (Michell 1991; Morrison 1992). However, the scale of settlement and landscape modification prior to the 14th century appear to have been modest (Kotraiah 1983). A major expansion of population and construction came in the early 14th century, with the formal establishment of the city and the construction of the urban core walls (Fritz, Michell & Nagaraja Rao 1985). In the early 16th century, Vijayanagara again underwent a period of expansion in population, military conquest, and construction of monumental architecture. This expansion is evident from inscriptional material (Morrison 1992; Stein 1980), dates of monu-

mental structures in the city center (Fritz, Michell & Nagaraja Rao 1985; Michell 1990), and archaeological evidence of settlement expansion beyond the inner walls of the city (Morrison & Sinopoli, in press). At its peak in the mid-16th century, the city had an estimated population of between 100,000 and 500,000 people. The impact of this dense population aggregation on the surrounding landscape was considerable. After a military defeat in AD 1565 and the abandonment of the city shortly afterwards, regional population densities again dropped until the construction of a large dam in the 1940s and 1950s.

The settlement and agricultural history of this area, then, has been marked by rapid and fairly dramatic changes in regional land use. These changes include two periods of intensification of agricultural production, the early 14th and the early 16th centuries, followed by a period of 'disintensification' (cf. Brookfield 1972); all of these related to urban growth and decline. There was also a later, mid-20th century, period of re-intensification, not, however, associated with the expansion of a large city. These changes in the organization of agricultural production have also been associated with significant restructurings of the political and social landscape and thus provide an excellent opportunity to investigate the process of productive intensification and its impact on the archaeological and palaeoecological records. The first step in this investigation, which I have considered at greater length elsewhere (Morrison 1992; 1994), is simply to outline the nature of production and its impact on the environment at different times, a problem I will address here.

Environment and vegetation

The Bellary District of northern Karnataka receives a low and highly variable annual rainfall of less than 500 mm (Johnson 1969; Spate 1954: 58), falling within what has been called (Kanitkar 1960: 1) the 'scarcity tract' for agricultural production. The landscape is now dominated by cultivated fields and by a degraded thorn scrub of the *Albizzia amara-Acacia* series (Gaussen *et al.* 1966). Although dry deciduous forests probably covered much of this area prior to large-scale human impact, it will become clear below that by the early 14th century much deforestation had already taken place, and agricultural modification of the landscape was already extensive.

Archaeological survey: methods and background

Although the city of Vijayanagara itself has been studied by archaeologists, historians, and others, prior to the initiation of the Vijayanagara Metropolitan Survey, comparable research on the city's hinterland, and indeed on any non-urban, non-elite remains of the Vijayanagara Period had not been carried out. Beyond the walled center of the city lies a fortified area more than 350 km^2 in extent which we have termed the greater metropolitan region of Vijayanagara (fig. 46.1). This area constituted part of the immediate productive and demographic hinterland of

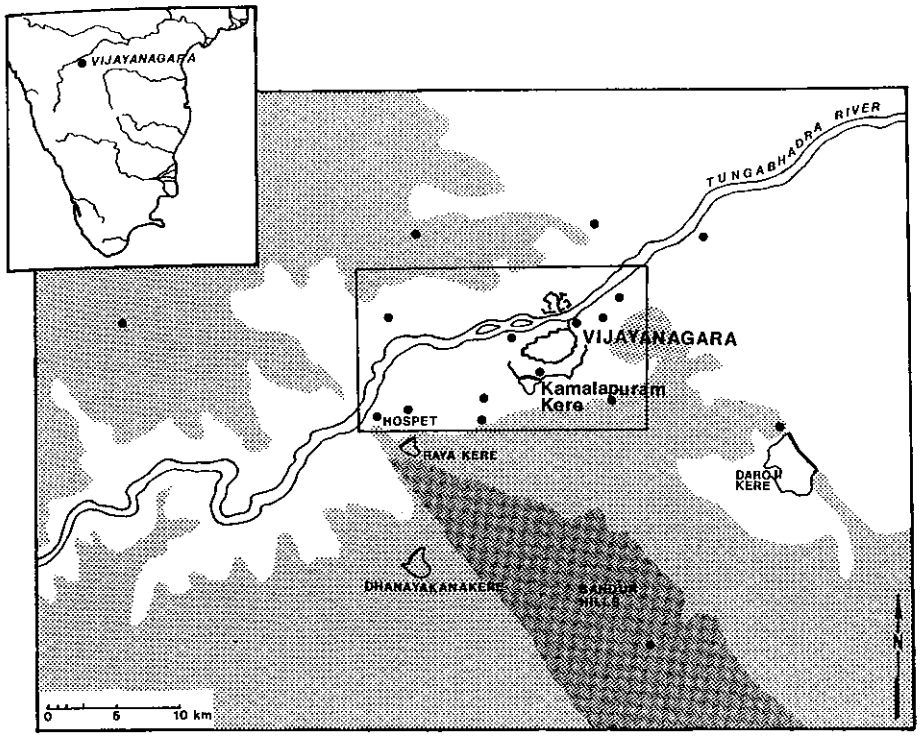

Fig. 46.1. Vijayanagara Period walled settlements and forts (small circles) surrounding the walled urban core of the city of Vijayanagara. Heavy black lines indicate masonry walls. Lighter shading is land over 500 m, darker shading land over 750 m. Only selected reservoirs are shown. The large rectangular area is the Vijayanagara Metropolitan Survey sample universe.

the city itself. In 1987, I carried out a pilot season (Morrison 1991) of the Vijayanagara Metropolitan Survey, a project designed to investigate the nature of settlement and production in the area around the city, and three full-scale seasons of field research co-directed by myself and Carla Sinopoli were carried out in 1988, 1990 and 1992 (Lycett 1991; Means 1991; Morrison 1992; Morrison & Sinopoli, in press; Sinopoli & Morrison 1991; 1992; in press; Sinopoli 1991; in press). The survey consists of two phases, including both detailed study of a smaller area, and more extensive analysis of the greater metropolitan region.

The study area has been divided by previous researchers into large 'blocks' (Fritz & Michell 1985). We have chosen the eight blocks surrounding the city – each slightly more than 20 km^2 – for intensive study. In this intensive phase of the survey, survey teams walk systematically along north-south transects (see Lycett 1994), recording all archaeological occurrences.

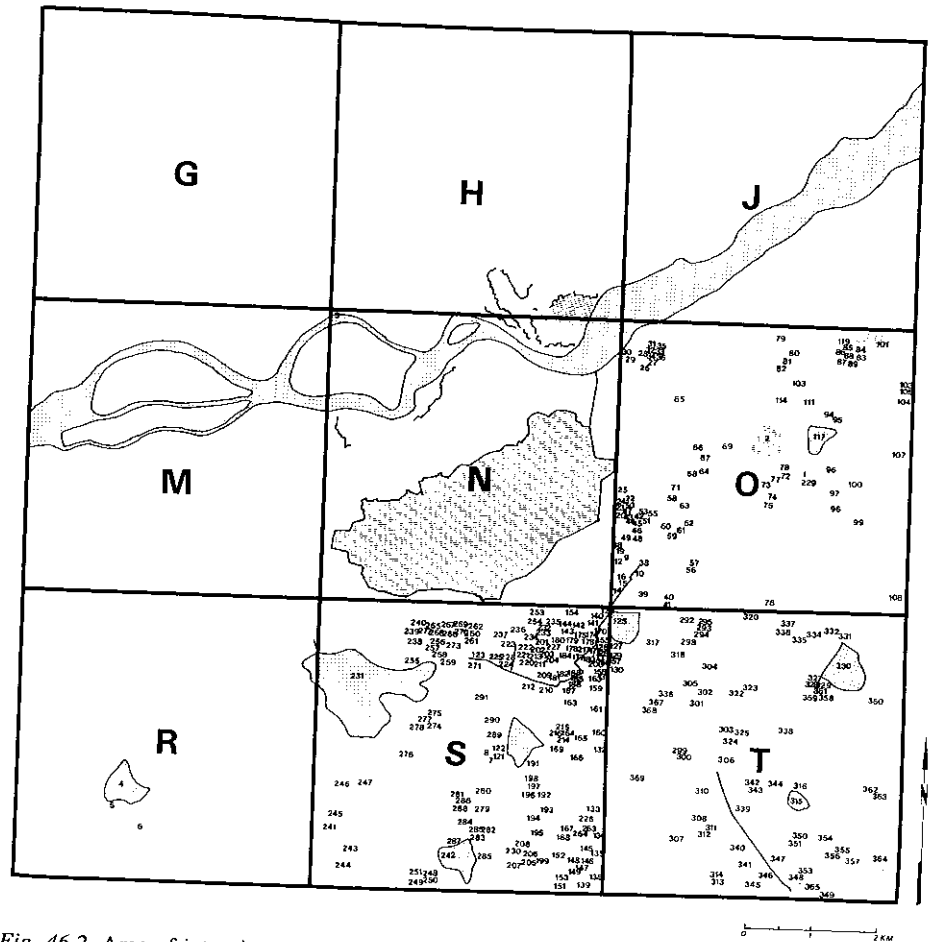

Fig. 46.2. Area of intensive survey, showing block boundaries and locations of recorded sites. Dark shading indicates nucleated settlements, lighter shading reservoirs and rivers. Major fortification walls are shown.

Archaeological survey: patterns of land use

At this point, we have surveyed three blocks, O, S and T, and have recorded nearly 400 sites. Although the project is ongoing, several strong patterns relating to land use, settlement, fortification and transportation have already emerged. The overwhelming majority of sites date to the Vijayanagara Period. Only one prehistoric site, a Neolithic ashmound (Sinopoli & Morrison 1991), was identified, although we have also recorded several small lithic scatters of unknown temporal affiliation.

During the Vijayanagara Period, by far the bulk of the population in the area of intensive survey appears to have lived within the city walls. However, we have found several towns and villages (fig. 46.2), most situated along major roadways

leading to the city. Many of these settlements are overlain by modern villages and are thus heavily disturbed. Evidence for Vijayanagara Period occupation includes architectural remains, sherds of Chinese and Southeast Asian porcelains and celadons, and inscriptions. Most of the Vijayanagara Period villages and towns were fortified, either by enclosing walls or nearby bastions. Indeed, the entire survey area is contained within an extensive zone of fortification in which stone walls block accessible passes in the rocky hills. Although internal chronological assignments are difficult to make given the lack of an artifact-based chronology for the 200 plus years of Vijayanagara occupation, stylistic and historical data make it clear that the expansion of settlement to the southeast of the urban core walls took place during the 16th century, and that this urban extension engulfed small pre-existing settlements such as Kamalapuram (fig. 46.2).

We have had a great deal of success in tracing transportation routes, both through the study of structural alignments and through the more direct evidence of road walls and surfaces. Several main arteries led into the city, with a larger number of narrow paths and openings. Interestingly, what direct evidence we have of nonagricultural production, mostly stone working and iron production (Morrison & Sinopoli 1992), indicates small-scale, dispersed production, much of which appears to have been situationally and perhaps seasonally mobile. Stone working for architectural elements and sculptures often took place either at quarry locations (which are abundant among the massive granite boulders that dominate the landscape) or on building sites. One small temple in Block O, VMS-79, was abandoned before construction was completed, and piles of granite columns ranging from rough slabs to finished pieces are scattered about the site along with the chipping debris. Iron processing sites are uniformly small, and although many contain furnace elements, most are not associated with permanent structures and have been disturbed by recent plowing (Morrison & Sinopoli 1992). The association between iron processing sites and water is strong. Iron processing sites situated on the edge of seasonally dry reservoirs may also have been only seasonally used.

Within the Vijayanagara hinterland, roads passable to bullock carts did exist, and food production for urban markets constituted an important part of regional agricultural production. Vijayanagara agricultural facilities and strategies were diverse both in form and in scale, with areas of production ranging from vast canal networks to small rain-fed plots. Low rainfall ensured that agricultural potential was strictly limited by factors such as runoff, slope and soils. While millets, sorghum and other dry crops could have been grown in rain-fed plots, the production of other food crops such as paddy rice and various vegetables and fruits required the use of supplemental irrigation (Kanitkar 1960). The Tungabhadra River provided a source of water for an extensive canal network serving the city and its hinterland, a canal system which has continued in use up to the present.

Reservoirs, or 'tanks', were also important for agriculture and domestic water supply, and we have documented hundreds of reservoirs in the survey area. Most of these reservoirs now lie abandoned. A wide range of dryland facilities is also present in the survey area, including small walls designed to check erosion, ter-

races and gravel-mulched fields. Many agricultural features were integrated into systems of connected facilities. The most striking example of this are the 'system reservoirs', (Sharma & Sharma 1990), or series of interconnected reservoirs arranged along valleys or other drainage systems (Morrison 1993). Other examples include terrace and reservoir systems, in which terraces cover the slopes of a reservoir's watershed. The extensive and diverse repertoire of archaeological features related to Vijayanagara agriculture attest to the intensity of agricultural effort and the complexity of land use in the city's hinterland.

Several strong patterns emerge from the survey of the metropolitan region. In settlement, we see that most dated habitation locales were established in either the Early Vijayanagara Period (14th century) or the Late Period (16th century). With a few exceptions, early settlements were located close to the Tungabhadra River and are associated with forms of intensive, wet agriculture such as canals and canal-fed reservoirs. Most of these settlements appear to have been occupied throughout the Vijayanagara Period, although better chronological resolution awaits future excavation. The pattern of agricultural intensification in the 14th and 16th centuries involved very intensive wet agriculture from the very beginning, with more labor and land extensive strategies occurring throughout the sequence (Morrison 1992).

Reservoir construction was particularly important in the early 16th century, when agricultural strategies diversified. In the 16th century, as noted, we have also documented a major expansion of settlement. Finally, we have been able to track the abandonment of agricultural areas and settlements. The city itself was largely depopulated by the end of the 16th century, while most small rural settlements persisted. Many of these outlying settlements do appear to have been reduced in size and monumentality, and even with the advent of a large-scale irrigation scheme in the region, much agricultural land used during the Vijayanagara Period is now devoted primarily to grazing and firewood collection.

Palaeoecological research

In the region around the city of Vijayanagara, reservoirs (cf. Leach 1971; Morrison 1993; Stargardt 1983) were particularly important facilities, collecting water from rainfall and runoff and allowing for more secure and intensive agricultural production. Reservoirs, like natural lakes and bogs studied by Quaternary pollen analysts (e.g. Aaby 1988; Berglund 1986; Davis & Ford 1982), act as 'traps' for pollen produced by the surrounding vegetation. Pollen settles into the reservoir on a regular basis, forming a stratigraphic record of past vegetation. The analysis of pollen profiles from these reservoirs affords a uniquely detailed view of land use patterns and environmental impact, a view which extends from the Vijayanagara Period until the present. Charcoal from local and regional fires – caused by, among other things, agricultural clearing, sugarcane burning, craft production and domestic burning – also settles into reservoir settlements, leaving a proxy record of the intensity of past burning (Clark 1988; MacDonald *et al.* 1991; Morrison, in press (a); Patterson, Edwards & Maguire 1987).

By examining the pollen and charcoal records from several reservoirs, the differential impact of agriculture, settlement and other forms of land use across a large area can be explored, and patterns of change may be discerned. These patterns of change include: agricultural intensification and expansion associated with the growth of urban and rural settlements in the Vijayanagara Period; the collapse of the agrarian system following abandonment of the city; the reorganization of agriculture under British colonial domination; and the impact of the Tungabhadra dam project on regional vegetation.

The consequences of agricultural intensification and increased settlement density in the pollen and charcoal record take the form of increases in the pollen of crops and field weeds, increases in the quantity of charcoal particles, and decreases in the pollen of trees and shrubs as agricultural land encroaches on forests and as the pressures of firewood collection and grazing increase. Certainly the relationships between land use and vegetation, and between pollen and vegetation are neither simple nor direct. However, the massive restructurings of land use during the Vijayanagara Period ought to have had significant effects on vegetation, effects which we can monitor in the pollen record.

In order to study the vegetation history of the Vijayanagara Region, I collected sediment cores from the Kamalapuram *kere*, or reservoir, located just to the south of the city (Morrison, in press (b)). A more extensive analysis of a series of cores from reservoirs in the area is underway. The Kamalapuram reservoir is dated by an unpublished inscription to the mid-14th century. The Kamalapuram reservoir is still in use; thus the pollen record from this reservoir should extend from the mid-14th up to the 20th century. Unfortunately, radiocarbon dates from the core are problematic, so the chronology is based partly on stratigraphy and partly on temporal indicators in the vegetation itself.

Fig. 46.3 shows the pollen percentages of several general groupings of plants. On the far right are pollen from species introduced into India from the New World after AD 1500. Several strong patterns in the pollen record can be discerned. These patterns include very high values for grass pollen at the very beginning of the record and a concurrent sharp decrease in the pollen of trees and shrubs. The quantities of tree and shrub pollen were reduced significantly in what is suggested to be the Middle or Late Vijayanagara Period, only to undergo a rebound, probably at the end of the Vijayanagara Period. This portion of the core reflects a very open landscape, and one which archaeological and historical data also suggest was dominated by cultivated fields (Morrison 1992). In the post-Vijayanagara Period, the reservoir became choked with aquatic vegetation (fig. 46.4). About the time the reservoir was cleared of swampy vegetation, the first introduced New World species appear in the record, and the concentrations of pollen also decreased, possibly as a result of increased erosion. At one point (*c.* 24 cm), the reservoir may have dried out completely for a time.

Toward the top of the record, probably the later colonial or the post-independence periods, agricultural production seems to be of renewed importance, but this agricultural landscape appears different from the Vijayanagara Period landscape in several important respects. First of all, the grass-dominated Vijayanagara record is not duplicated in the record of modern, commercial agriculture. Instead,

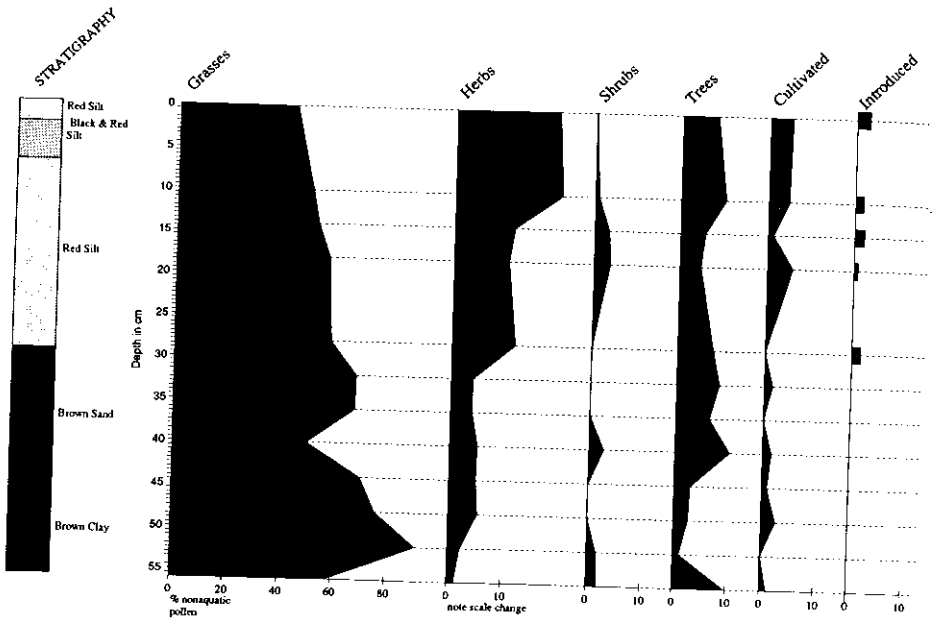

Fig. 46.3. Percentage diagram of general vegetation groups, Kamalapuram core 1. Note changes of scale.

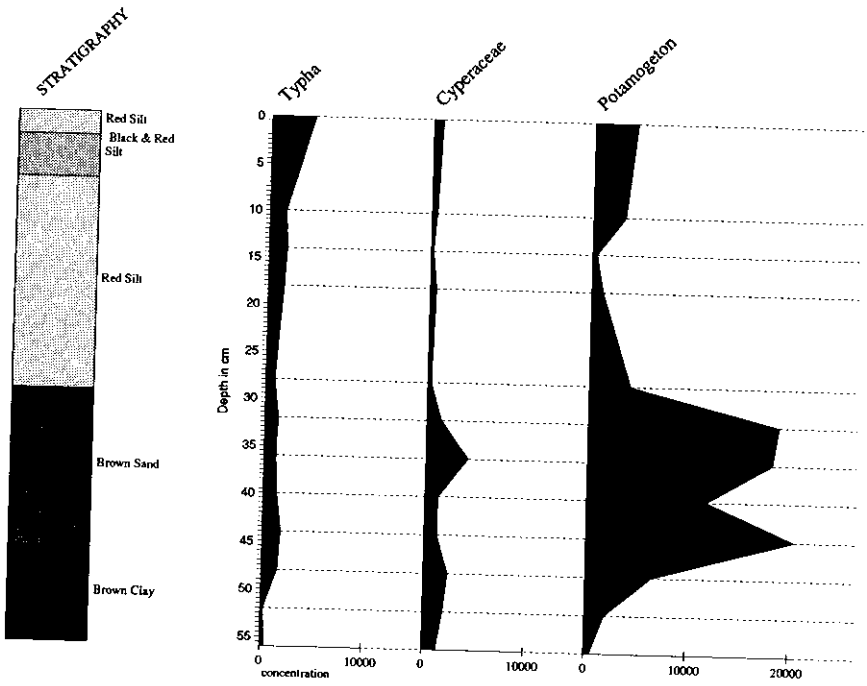

Fig. 46.4. Concentration of aquatic plants in Kamalapuram core 1.

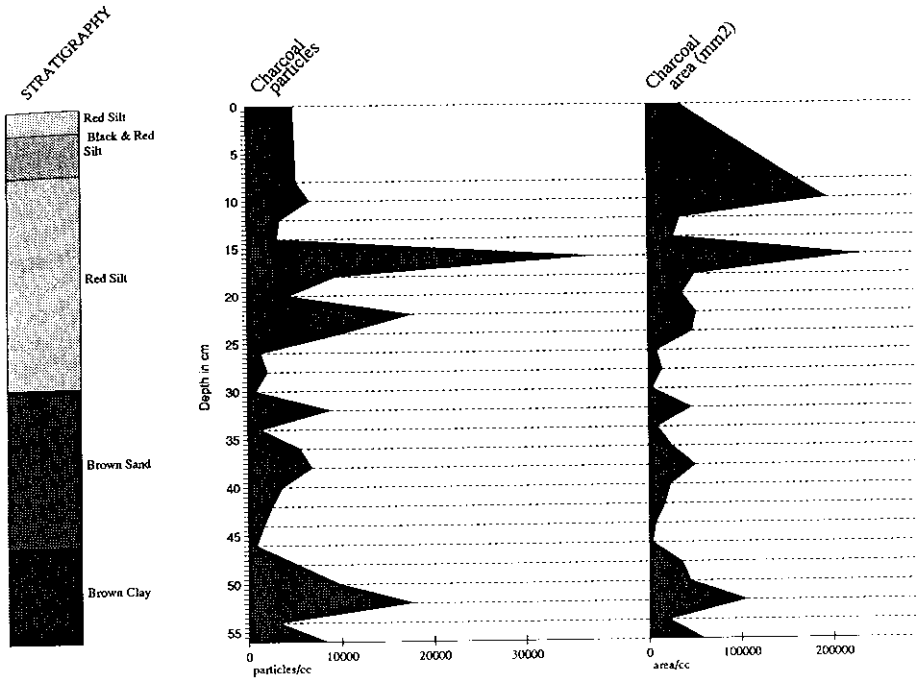

Fig. 46.5. Charcoal particle concentrations, measured in terms of the number of particles (left) and the total area of particles by level (right), Kamalapuram core 1.

herbaceous plants appear much more important, and what may be an introduced weed constitutes a significant proportion of the pollen flora. Coconut pollen, reflected in the 'cultivated' category, also appears in greater quantities. While coconuts did appear in the Vijayanagara Period record, their numerical importance in more recent sediments is striking, and is consistent with their current value as commercial crops. Thus, the pollen record of Vijayanagara agriculture shows a pattern of intensive land use and a landscape significantly altered by forest clearance already established by the mid-14th century.

Charcoal data tend to reinforce the pollen evidence. Fig. 46.5 shows the concentration of microscopic charcoal particles in the core, as measured by both the number of particles (on the left) and the total area of the particles (on the right). Beginning at the base of the core, a small charcoal peak can be seen in the lowest level, followed by a decline and then a major peak at about 52 cm. At this same level was also recorded a decline in trees and shrubs and an increase in grasses. Thus, although some of this charcoal may be attributable to domestic burning in the Vijayanagara Period, it is likely that it also relates to land use practices which led to the creation of a more open, less wooded landscape. Following the marked charcoal peak at 52 cm, the amount of charcoal in the sample drops off, and then rises again into two minor peaks. Above this point, the difference between the count data and the area data become much more pronounced with a peak in char-

coal area (on the right) at 10 cm. I have suggested elsewhere (Morrison, in press (a)) that this pattern relates to a change in the location and intensity of fires and may reflect the inception of cane burning on the edge of the reservoir.

The charcoal patterns correspond, at least in a general way, with the patterns of open, transformed vegetation. Both burning and open vegetation are indicated in the Vijayanagara Period and again in the colonial to recent periods, when agricultural production was the most intensive. In the period during which the reservoir sediments contained a large amount of aquatic pollen, the charcoal record reaches its minimum, with both measures perhaps indicating a cessation of maintenance activities in and around the facility.

Conclusion

In this short discussion I have tried to indicate how two of the three lines of evidence employed in my analysis of Vijayanagara settlement and land use patterns, archaeological survey and palaeoecological analyses, can be combined to produce a fuller view of agricultural organization and change in the past. Although the research is still in progress and significant chronological issues remain to be resolved through future research, we can already begin to see the broad outlines of change caused by productive intensification in the Early and Late Vijayanagara periods, and the partial reforestation associated with settlement contraction in the post-Vijayanagara periods. It is not until we are able to outline clearly these empirical patterns of agricultural production that we will be able to make any progress in proposing and evaluating more general models for the causes and courses of change.

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