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Local diversity in settlement, demography and subsistence across the southern Indian Neolithic-Iron Age transition: site growth and abandonment at Sanganakallu-Kupgal

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Abstract The Southern Indian Neolithic-Iron Age transition demonstrates considerable regional variability in settlement location, density, and size. While researchers have shown that the region around the Tungabhadra and Krishna River basins displays significant subsistence and demographic continuity, and intensification, from the Neolithic into the Iron Age *ca.* 1200 cal. BC, archaeological and chronometric records in the Sanganakallu region point to hilltop village expansion during the Late Neolithic and 'Megalithic' transition period (*ca.* 1400– 1200 cal. BC) prior to apparent abandonment *ca.* 1200 cal. BC, with little evidence for the introduction of iron technology into the region. We suggest that the difference in these settlement histories is a result of differential access to stable water resources during a period of weakening and fluctuating monsoon across a generally arid landscape. Here, we describe well-dated, integrated chronological, archaeobotanical, archaeozoological and archaeological survey datasets from the SanganakalluKupgal site complex that together demonstrate an intensification of settlement, subsistence and craft production on local hilltops prior to almost complete abandonment *ca.* 1200 cal. BC. Although the southern Deccan region as a whole may have witnessed demographic increase, as well as subsistence and cultural continuity, at this time, this broader pattern of continuity and resilience is punctuated by local examples of abandonment and mobility driven by an increasing practical and political concern with water.

Introduction

> From the great number of implements I procured during my first visit to this part of the hill, I came to the conclusion that this old celt factory had never before been visited by any one taking interest in the Neolithic artifacts and that the place remained in much the same condition as it had been left in by the old work people who abandoned the manufacture of stone implements. (R. B. Foote 1916. *The Foote Collection of*

Indian Prehistoric and Protohistoric Antiquities: Notes on Their Ages and Distribution. Madras: Government Museum).

Robert Bruce Foote provided the first detailed descriptions of a range of archaeological sites across the southern Indian peninsula during the nineteenth century, including the early village sites of the Deccan plateau. Of particular interest to him was the Kupgal Hill site complex, described in the opening passage, which provided evidence for a significant stone tool production industry, referred to by Foote as a 'celt factory'. Of notable attention in Foote's account of this site is its remarkable degree of preservation. While recognising the long time period that separated the Kupgal Hill celt factory remains from his own era, Foote was struck by the fact that it appeared to be 'in much the same condition as it had been left'. Subsequent years and particularly the last few decades have seen growing destruction of the Kupgal Hill sites as a result of increasingly industrial-scale granite quarrying (Boivin et al. 2004); however, there remain relatively undisturbed parts of the locality where contemporary researchers can still observe a remarkable degree of preservation. Pockets of surface features, including stone axe production 'camps', stone terraces, quarries and ringing rock sites appear to have been abandoned a few decades, rather than millennia, ago. Although researchers since Foote have often described this preservation, they have not evaluated its implications. In this paper, we provide the first systematic analysis of these features and consider the insight they provide into the transition from the Southern Indian Neolithic to the Iron Age in this locality.

Shifts in settlement patterns between the Southern Indian Neolithic (3000–1200 cal. BC) and Iron Age (1200–300 cal. BC) show considerable local variation in southern India. Fuller et al. (2007) presented then-existing radiocarbon dates for Southern Neolithic ashmound and village sites. Although some sites, such as Kodekal and Utnur, were abandoned in the Neolithic, many sites in the Sanganakallu-Kupgal region of the Deccan plateau demonstrate continued occupation into what has been termed the 'Megalithic' period, dated to 1400–1200 cal. BC. However, by 1200 cal. BC, an increasing intensity of Neolithic archaeological presence on the granitic hilltops in this area succumbed to almost total long-term abandonment, with 'Iron Age' archaeological evidence being found only in the form of mortuary monuments and sporadic settlement focused on the intersecting plains. In contrast, further to the north and west in the northern watershed of the Tungabhadra Rivers, sites such as Kadebakele, Maski, Piklihal and perhaps Watgal demonstrate continued occupation into the Iron Age (*ca.* 1200 cal. BC) (Allchin 1960; Thapar 1957; Devaraj et al. 1995; Bauer et al. 2007; Bauer 2010; Johansen and Bauer 2013). Continuity is also observed at Hallur on the upper Tungabhadra (Nagaraja Rao 1971; Fuller et al. 2007) and to the east at sites in the Kurnool and Cuddapah districts near the Krishna and Pennar river, such as Veerapuram, Ramapuram and Peddamudiyam (Sastri et al. 1984; Venkatasubbaiah 1992; Fuller et al. 2007). Recent survey around the Tunagabhadra River, the Benakal Forest area and in the region around the site of Maski (MARP) has confirmed that in many localities across the Koppal and Raichur districts of southern India, site numbers, sizes and apparently population densities actually increased at the onset of the Iron Age proper (*ca.* 1200 cal. BC), often in areas that had previously been occupied during the Neolithic period (Bauer et al. 2007; Bauer 2010, 2013; Johansen and Bauer 2013).

This local variation in settlement trends across the Neolithic-Megalithic-Iron Age transition in southern India has thus far received little attention. Indeed, only relatively recently has discussion of the changes that accompanied the end of the Southern Indian Neolithic and beginning of the Southern Indian Iron Age moved beyond cultural-historical frameworks of migration and diffusion (Subbarao 1955; Devaraj et al. 1995; Southworth 2006), to focus on the interconnection of palaeoenvironmental context (Bauer 2013), settlement patterns (Bauer et al. 2007; Morrison 2009; Johansen 2010) and subsistence strategies (Fuller 2006, 2009; Morrison et al. 2012) within a dynamic historically and socially recreated landscape (Bauer et al. 2007; Bauer 2010; Johansen 2014a). Furthermore, it is only over the last decade that detailed survey and excavation work have sought to document changes in site density, size and location across this period (Sinopoli and Morrison 2007; Bauer 2010; Morrison et al. 2012). We continue this trend by developing an integrated multi-disciplinary, locale-specific dataset of subsistence, settlement and site use in the Sanganakallu area of the southern Deccan. We use these data to argue that settlement dynamics and subsistence strategies, and their resilience to environmental change, across the Southern Indian Neolithic-Iron Age transition need to be considered locally.

Southern Indian Neolithic, Megalithic and Iron Ages: regional context and issues of terminology

The Southern Indian Neolithic (*ca*. 3000–1200 cal. BC) of Karnataka is associated with the so-called ashmounds – large, burnt mounds of cattle dung, characteristic of the Neolithic Period in the South Deccan (Allchin 1963; Allchin and Allchin 1968; Boivin 2004). These mounds reflect the cyclical and episodic burning of cattle dung, including both smallerscale, low-temperature and larger-scale, high-temperature burnings (Boivin 2004; Johansen 2004). The ashmounds have been linked to social or ceremonial gatherings of people during the Neolithic, as well as the investment of particular places with cultural importance (Allchin 1963; Boivin 2004; Johansen 2004). Ashmounds tended to either be abandoned or eventually become associated with subsequent hilltop village occupation, craft production and subsistence intensification. Given the apparent ritual importance of cattle in the Neolithic, both in ashmound production and Neolithic rock art in the region (Allchin 1963; Boivin 2004), it is unsurprising that cattle pastoralism formed the predominant subsistence focus at many sites (Paddayya 2001; Korisettar et al. 2002; Johansen 2004; Bauer et al. 2007). South Indian Neolithic subsistence also included the keeping of domesticated caprines, millet and pulse cultivation, some hunting and gathering and, later, the introduction of non-local crop domesticates, including wheat and barley, as well as crops of African origin, and later, cotton and flax (Fuller 2006, 2008). Evidence from burials, the apparent importance of communal feasting and gathering, and a lack of material or spatial differentiation have been used to suggest that Neolithic communities exhibit little evidence for rank or social stratification (Bauer et al. 2007).

The Southern Indian Neolithic is followed by a period that has variously been termed the Megalithic or Iron Age, which witnessed the introduction of iron technology, new weapons, burial styles and monuments, and the horse, as well as novel methods of controlling space throughout the broader South Deccan region. In and around the Tungabhadra River, the Krishna River and western Raichur Doab (e.g. the site complex of Maski), it has been shown that these material trappings of the Iron Age arrived together at *ca*. 1200 cal. BC (Bauer et al. 2007; Bauer 2010; Johansen 2014b). Here, Neolithic hill-top settlements were thoroughly re-used and rereferenced by Iron Age communities, with settlement size, density and number increasing between 1200 and 300 cal. BC (Bauer et al. 2007; Bauer 2010; Morrison et al. 2012; Johansen 2014a, b). A continuation of subsistence strategies (Bauer 2007; Bauer et al. 2007; Morrison et al. 2012), as well as the symbolic appropriation of Neolithic ashmound sites in Iron Age monuments (Johansen 2014a), has furthermore been used to suggest continuity of settlement and population between the Neolithic and Iron Age periods. However, there are also considerable social, subsistence and demographic changes during this transition (Bauer et al. 2007). Of considerable interest is the intensification of 'wet' farming, with increasingly elaborate irrigation technologies being developed to enable the cultivation of a growing variety of crops (Bauer et al. 2007; Morrison 2009; Bauer 2010; Morrison et al. 2012). This is accompanied by evidence for landscape modification and monument locations that demonstrate clear concern with the control of water (Bauer et al. 2007; Morrison 2009).

Whereas the coincident arrival of megalithic monuments and iron technologies in many areas of the Koppal, Raichur and Bellary districts of the southern Deccan has led to a redundancy of the term Megalithic, the situation towards the Sanganakallu region of the southern Deccan, and away from the Tungabhadra and Krishna drainage basins, appears to be more complex. Although there are considerable issues with the dating of megalithic monuments, a Megalithic transition period seems to begin here between *ca*. 1400 and 1200 cal. BC, marked by the appearance of slipped 'wheelmade' ceramics (traditionally called wheelmade but these are actually finely finished, slipped and turned, probably representing new forms of specialised craft production) that fit into Iron Age Black-andRed-Ware and red-slipped typologies in the upper levels of well-stratified sites like Sannarachamma hill, as well as parts of the Hiregudda site, but in the absence of evidence for iron (cf. Subbarao 1948; Ansari and Nagaraja Rao 1969; Cole and Prasanna 2004; Boivin et al. 2005; Fuller et al. 2007). In this region, Neolithic hilltop occupation continues, and sometimes intensifies, through this Megalithic transition period.

This 'Megalithic transitional' period sees evidence for craft specialisation based on Neolithic technology, such as largescale groundstone axe manufacture at Hiregudda (Brumm et al. 2007; Risch et al. 2009). There is also suggestive evidence of agricultural diversification, including the first evidence for fruit tree crops (mango, citrus), sandalwood exploitation, more evidence for crops of African origin and the likely establishment of cotton and flax cultivation (Asouti and Fuller 2008; Boivin et al. 2008; Fuller 2008; Korisettar 2014). Megalithic monuments, which are widely regarded as being indicative of the emergence of social stratification and new elite symbolism (e.g. Moorti 1994; Brubaker 2001), appear at around 1200 BC alongside terminal Neolithic ceramic types like white-painted conical lids, as at Komaranahalli (Chitradurga District) (IAR 1980-81; Singhvi et al. 1991). Across the majority of the Deccan plateau, iron implements become common inclusions of megalithic contexts from *ca*. 1200 BC. However, although iron working emerges at *ca*. 1200 BC at Bukkasagara (Johansen 2014b) and *ca*. 1000 BC at Hallur on the upper Tungabhadra river (Fuller et al. 2007), in association with increasing site densities and numbers, in the Sanganakallu region, hilltop occupation seems to disappear almost completely at this time and there is little evidence for occupation anywhere in the immediate vicinity nor any local development of iron working. We therefore argue that, for the Sanganakallu region at least, it is useful to maintain the concept of a Megalithic transition period, starting *ca*. 1400 BC, which is marked by new ceramic types and shifts towards a political economy with craft specialisation, prior to the onset of the Iron Age seen across the Central and Southern Deccan more broadly *ca*. 1200 BC (as per the chronometric chronology of Fuller et al. 2007).

Cultural and political ecologies of the Southern Deccan

Explanations of demographic and cultural patterns spanning the Neolithic and Megalithic/Iron Age period in southern India have seen a number of theoretical shifts over the past half-century. Culture-historical frameworks (Banerjee 1965; Gururaja Rao 1972; Leshnik 1974; Allchin and Allchin 1982; Rami Reddy 1992) suggested that the arrival of new groups of people brought the megaliths, iron technologies, pottery styles and horses that characterise the southern Indian Iron Age. These migrationist frameworks were contested by 'cultural ecology' approaches that argued that the regional manifestations of the Iron Age were driven by regionally-variable hydrological, environmental and geological settings (Subbarao 1948; Dhavalikar 1992), especially given the harsh, arid conditions that characterise much of the southern Deccan region. More recently, both Indian and international academics have sought more nuanced explanations of change, fore-fronting indigenous social and economic continuity and agency (Moorti 1994; Brubaker 2001; Johansen 2008, 2014a; Bauer 2010). This concern has been formalised into 'political ecology' concepts where 'the social and the natural are historically co-constituted' in the social production and social experience of landscapes (Bauer et al. 2007; pp. 7). Political ecology as applied to understandings of southern Indian prehistory acknowledges that ecological and environmental change can play an important role in the cultural and social experience of a landscape. At the same time, it clearly accepts that society does not passively respond to environmental forces, but rather incorporates them into its own 'social relations of power' (Rocheleau 1999: 22) as it constructs ecologies and landscapes (Bauer et al. 2007: 4).

Researchers working around the Tungabhadra and Krishna river complexes have used political ecology frameworks to explore the considerable continuity between the Neolithic and Iron Age periods in these regions. Here, a background of broad continuity in subsistence practices and settlement locations was overlain by an intensification of water-reliant crop use, novel technologies, emergent forms of symbolic expression and growing levels of population and settlement that encouraged a negotiation of spatial and material control (Bauer et al. 2007; Bauer 2010; Johansen 2014b). Although these changes led to considerable shifts in social stratification and spatial expression, they were built on indigenous continuities demonstrated, for example, by the considerable reference to previous sites of Neolithic importance, including the incorporation of ashmound monuments into megalithic burials and structures (Johansen 2014a). It has been argued that the Neolithic landscape was re-structured by Iron Age groups so that communal sites of gathering and interaction became sites of elite social expression, that key areas of pastoral movement for water became controlled and that 'dry' farming was supplemented and differentiated by new and elaborated wet farming (Morrison 2013). While within this scenario, increasing populations and new technologies are the main driving force, environmental and ecological change was likely also a major concern in the re-organisation of landscape use by postNeolithic communities on the Deccan plateau.

Deccan plateau environments and human habitation

The Deccan plateau offers a particular set of environmental and ecological parameters that have long shaped human occupation of the region. At the upper reaches of the Krishna and Tungabhadra Rivers and their tributaries, weathered Archaean granite rock has produced sandy soils that are reasonably good for monsoon seasonal agriculture and rich for pastoralism (Allchin 1963; Fuller et al. 2001). However, large stretches of flat, arid plains dominate the remainder of one of the more arid regions in India. Some water sources are generated by dolerite dykes crossing the granitic hill forms, forming a barrier to ground water, leading to the upwelling of springs where the dykes protrude to the surface (Boivin et al. 2005). These vital water supplies, as well as the natural defences and commanding views of hilltop locations (Foote 1887a, b; Boivin et al. 2004), would have provided important foci for prehistoric groups across many hills of the Deccan plateau. However, in the past, the climate would, at times, and in the driest zones, have posed a significant challenge to human populations without access to stable water resources. It is unlikely that the plains of the Deccan plateau ever supported extensive tree cover during the Holocene (Allchin 1963; Mujumdar and Rajaguru 1966; Korisettar et al. 2001b), with preliminary archaeobotanical evidence suggesting a scrub-savannah environment (Asouti and Fuller 2008). Furthermore, modern climatic maps demonstrate that while seasonal watercourses are filled by monsoonal rains, the region is one in which evapotranspiration greatly outweighs precipitation (Spate and Learmonth 1967) and thus over the course of the winter and dry season it is likely that all but the largest rivers and mountain springs would have dried out. This differential access to water across the Deccan plateau during the Neolithic-Megalithic-Iron Age transition was likely a major factor in the local cultural, demographic, subsistence and settlement variance witnessed in the archaeological record. However, until recently, the paucity of fieldwork and survey in the Sanganakallu region has led to considerable difficulty in investigating this diversity.

Case study area: the Sanganakallu-Kupgal complex

The Sanganakallu-Kupgal locale is defined by two modernday villages that border an area of concentrated archaeological remains near the town of Bellary, Karnataka, in southern India. There are four main foci of archaeological remains within the Sanganakallu-Kupgal complex, as summarised by Boivin et al. (2002, 2005, 2007) (Fig. 1). These are the following: Hiregudda, the largest hill in the complex with a range of Neolithic locales found on its slopes and base (A, B, D and J); Choudammagudda, 0.5 km south of Hiregudda, with a small ashmound locale and occupation remains at its summit; Sannarachamma, 1 km south-west of Hiregudda with a larger ashmound and evidence for denser habitation found on its plateau; and Birappa, a rockshelter with rock art and microliths located 1 km north of Hiregudda. A further ashmound site is located on the small hill of Shillimattilaguda to the east of Choudammagudda.

Sanganakallu-Kupgal as a complex of Mesolithic, Neolithic, Megalithic and Iron Age activity, some of which was described as early as the nineteenth century (Foote 1887a, b), is among the most frequently discussed sites in the context of southern Indian prehistory (Foote 1887a, b, 1895; Subbarao 1947, 1948; Allchin 1963; Mujumdar and Rajaguru 1966; Ansari and Nagaraja Rao 1969; Boivin et al. 2005, 2008). Publications regarding the complex have thus far addressed sizeable and well-studied lithic assemblages (Brumm et al. 2007; Risch et al. 2009; Shipton et al. 2012), the organisation of craft activities (Brumm et al. 2007), rock art (Boivin 2004; Boivin et al. 2008) and radiocarbon chronologies (Fuller et al. 2007). This, alongside abundant and systematically analysed archaeobotanical and archaeozoological evidence (preliminary datasets in Korisettar et al. 2001b; Boivin et al. 2005; Fuller et al. 2004), means that SanganakalluKupgal is an excellent candidate for a detailed local analysis of subsistence strategies, settlement patterns and site usage across the later Neolithic-Megalithic-Iron Age transition.

Materials and methods

Archaeological evidence from the complex comes from several seasons of fieldwork in the Sanganakallu-Kupgal area between 1998 and 2006 (previously summarised in Boivin et al. 2005; Boivin et al. 2007; Fuller et al. 2007). We present the results of previously unpublished systematic mapping of visible surface features across the Sanganakallu-Kupgal complex. We also discuss, in detail, the settlement and site-use patterns exhibited at areas within the complex that include the following: the hilltop site of Sannarachamma, the hilltop site of Choudammagudda and a number of localities on Hiregudda (Areas A, B, D and J).

Chronometric studies, using direct AMS radiocarbon dating of identified seed samples, have been applied across the Sanganakallu-Kupgal complex (Fuller et al. 2007). This work approximately doubled the number of radiocarbon dates for the southern Neolithic of India and led to the first robust radiocarbon chronologies, using a Bayesian statistical approach to build high probability models of site sequences that provided refined sub-phases for the Southern Neolithic of India (Fuller et al. 2007). Here, we build on this framework by producing Bayesian models of transitions between occupation phases at the Sannarachamma and Hiregudda localities that have yielded the majority of dates for prehistoric occupation at Sanganakallu-Kupgal. By linking this chronometric sequence to characteristic stratigraphies and artefact assemblages, we extrapolate this phased model across the

SanganakalluKupgal complex. OxCal 3.10 and the IntCal13 (Reimer et al. 2013) curve were used for all models.

During test excavation, occupation layers and distinct contexts at various sites across the complex were sampled for archaeobotanical remains. Approximately 20 litres of sediment per context were subjected to washover bucket flotation, with remains collected on 500-micron mesh (Fuller et al. 2004). For most layers, a small sediment archive sample was also collected for potential phytolith extraction. A pilot study of phytolith analysis at Sanganakallu demonstrated the usefulness of such an approach, clearly differentiating ashmound and non-ashmound deposits (Weisskopf 2005). Flotation samples were sorted to separate seed and fruit remains and to quantify identifiable crop and wild seed fragments. The initial analyses that focused on establishing the economic staples (Fuller et al. 2004) has now been augmented (Weisskopf 2005; Barnard 2010).

Pilot investigations at Sanganakallu-Kupgal and the other central Deccan Neolithic sites produced only small quantities of faunal remains as a by-product of flotation. Although these allow some evidence regarding the range of major taxa present at the sites (Korisettar et al. 2001b), the sample size was insufficient for any comprehensive temporal comparison. We present, for the first time, detailed archaeozoological data from the sites of Sannarachamma and Hiregudda with a view to gaining some insight into temporal changes in faunal reliance at Sanganakallu-Kupgal. These remains came from complete sieving of all sediments from all stratified archaeological contexts. The heavy fraction from flotation was wet-sieved through 2mm mesh, while the remainder of all excavated sediment was dry-screened through 4-mm mesh. This material was recovered during the 2003–2006 excavation seasons and analysed metrically in Pune with reference to the Deccan College archaeozoological reference collection. Measurements were made following standards developed for European sheep, goat and cattle by von den Driesch (1976).

Finally, in order to place our site and others that have been documented or excavated in the region into a local environmental setting, we carried out GIS-based analysis of site locale in relation to rainfall and riverine water sources. To reconstruct drainage patterns and potential water available from water courses, we built a model that combines topographic watersheds with the input of annual precipitation into a model of annual flow accumulation. The geophysical data for the flow accumulation model were obtained from GIS map layers in the public domain: the elevation data from the Shuttle Radar Topography Mission (Farr and Kobrick 2000), at 30 arcsec resolution, and the annual precipitation data, both for present day and mid Holocene (6000 BP), from WorldClim, as derived by Hijmans et al (2005), also at 30 arcsec resolution.

The flow accumulation model was developed using the GRASS GIS package, in particular the *r.watershed* module (GRASS Development Team 2014). The amount of overland flow per cell, an input for the module, was estimated with recourse to present-day annual precipitation data. However, in India, a maximum of 91 % rainfall will actually become runoff (8.56 % of annual rainfall will become natural groundwater recharge; Kumar et al. 2005). Applying this adjustment to model flow accumulation and converting the resulting figures to discharge units (cubic kilometres per year), the results were positively compared with the average annual discharge values for two local rivers, the Krishna and the Pennar (Kumar et al. 2005, 797). A cutoff was then imposed so that cells with flows lower than 0.05 cubic km/year (less than 1 % of the Pennar discharge) were not shown on the maps. The model is conservative on two counts: firstly, by not including the effects of evapotranspiration, the model overestimates the amount of rainfall that becomes runoff and, secondly, the semi-arbitrary cutoff employed is very low (lower than the discharge of the Pennar River in the dry season). These two effects combine to produce a flow accumulation model that overestimates the existence of streams and watercourses of low discharges.

Results

Archaeological survey and excavation

Sannarachamma

Sannarachamma is an ashmound and habitation locality found on the level summit of a granite inselberg, the geology of which has resulted in the formation of a natural reservoir on its northern slope. An extensive ashmound covering a significant area of the hilltop was revealed, sealed beneath later archaeological occupation and ashmound erosion deposits (Boivin et al. 2005). Occupation evidence included the remains of circular stone structures, many large pits and rich deposits of ceramics, lithics and other material remains, as well as abundant faunal and botanical remains (Ansari and Nagaraja Rao 1969; Boivin et al. 2005).

Dating evidence from Sannarachamma has enabled landscape use at this locale to be placed within a well-constrained, phased chronology (Fuller et al. 2007) consisting of: (1) a preashmound Mesolithic occupation; (2) an initial ashmound formation phase dated to 1950 cal. BC; (3) an ashmound expansion phase dated from 1850 to 1700 cal. BC, during which the site became permanently occupied; (4) a post-ashmound habitation phase from 1700 to 1400 cal. BC; and (5) a final Megalithic phase from 1400 cal. BC, with the site eventually abandoned *ca.* 1200 cal. BC.

Hiregudda

Hiregudda has multiple archaeological localities across its summit, slopes and base. Study focused in particular on areas designated as Areas A, B, D and J (Boivin et al. 2005). Area A bears the richest concentration of dolerite artefacts identified so far from across the Sanganakallu-Kupgal complex (Brumm et al. 2007). Archaeological features have been exhaustively surveyed and mapped from this area and can be seen in Fig. 2. Much of this work has focused around the margins of a large pit that had been created by the modern removal of an ashmound for fertiliser and construction activities. This ashmound is the oldest feature at Area A and dates to before 1700 cal. BC. Investigation revealed that earlier ashmound layers gave way to habitation debris (Fuller et al. 2007).

As shown in Fig. 2, structural remains in the form of granite walls and foundations are present across the mapped area. Feature 1 is a particularly interesting circular arrangement of granite boulders with an internal diameter of 7 m (Fig. 2). Stratigraphically, the lower layers of Feature 1 point to domestic habitation alongside low-intensity axe production. By contrast, the upper layer of Feature 1 contained the largest quantity of axe manufacturing debris found with the SanganakalluKupgal complex. Ceramic figurines, copper beads and red ochre were also all associated with Feature 1 during its later use life, suggesting that it increasingly became an area of symbolic importance (Brumm et al. 2006).

Chronometric information from this locale confirms the overall shift from early Neolithic ashmound layers, to more permanent occupation with ephemeral craft working, to specialised axe production in the latest Neolithic until late Megalithic abandonment. Dates from Feature 1 suggest that the habitation phase of Area A lasted between 1700 and 1500 cal. BC (Fuller et al. 2007). This was then followed by an occupational hiatus of nearly 100 years. The site was then reoccupied *ca.* 1400 cal. BC during which time Feature 1 became a dolerite axe factory for the next 150 years until site abandonment *ca*. 1250 cal. BC.

Area B can also be seen in Fig. 2. This area includes evidence for stone-walls, petroglyphs and the construction of small terraces. The dolerite dyke seen running through Area B provided the highest quality raw material for groundstone axe manufacture. Analysis by Shipton et al. (2012) demonstrated an absence of finished axes and axe-working flakes, suggesting that only preliminary knapping to create axe 'rough-outs' was undertaken in this area (Risch et al. 2009). Brumm et al. (2007) cited this specialisation and spatial division of activity as indicating increased complexity of organisation at this time. Evidence for quernstone production could also be identified in Area B.

Area J lies to the southeast of the locality shown in Fig. 2, where the dyke running through Area B extends down to the base of Hiregudda. As with Area B, the great majority of diagnostic artefacts were found to be early stage reduction flakes, leading to Area J being identified as a quarry and primary reduction locale (Shipton et al. 2012). Stone quarries in Areas B and J are likely to have serviced axe production in both the habitation and 'factory' periods of Area A.

Area D of the Hiregudda locale was also extensively surveyed and is shown in Fig. 3. It consists of a terraced area, located on a valley slope between the two main Hiregudda peaks (the North Peak and the South Peak). Area D sits towards the base of the extensively terraced North Peak and features various surface stone and boulder alignments and circles. Figure 3 demonstrates the significant effort that must have gone into the Neolithic alteration of the area during the habitation phase, with terraces extending for considerable distances up and around the North Peak. Several Neolithic infant urn burials were exposed in one of the terraces, dating to the final, late Neolithic, occupation of Hiregudda.

Choudammagudda

Surveying at Choudammagudda has demonstrated the existence of a Neolithic ashmound to the southwest of the hill's summit. Figure 4 demonstrates the association of structural remains and artificially aligned boulders with this feature. Deposits from the ashmound itself consist of layers of occupational debris. Numerous stone querns, as well as axegrinding grooves, also occur across Choudammagudda alongside scatters of Neolithic ceramics, grindstones and other lithics.

As at Hiregudda Area A, the onset of sedentary occupation and increasing intensity of activities associated with dolerite axe manufacture at Choudammagudda is accompanied by large-scale landscape alteration of the surrounding area (Fig. 4). A large Neolithic network of terraces and stonewalls cover the slopes surrounding the central occupation area on top of the hill. Also worthy of mention is the presence of another ashmound locality, Shiddalamattigudda, located to the northeast of Choudammagudda on another very low hill. A small cemetery of large Megalithic stone circles occurs on the plain between Choudammagudda, Shiddalamattigudda, and Hiregudda, falling between a series of clearly important Neolithic locales.

Birappa

Birappa is a granite rockshelter situated on the plain 1 km to the north of Hiregudda (Boivin et al. 2002). The rockshelter is decorated with ancient red paintings of wild animals, anthropomorphs and geometric designs. This contrasts with the art found at Hiregudda, which largely consists of petroglyphs rather than paintings, and where cattle dominate the imagery (Gordon and Allchin 1955; Robinson et al. 2008). Radiocarbon dates from charcoal fragments from the site range from 9000 to 10 cal. BC (Boivin et al. 2005). These dates are not always in coherent stratigraphic order, probably due to the movement of the small charcoal fragments within the sequence, creating challenges for site interpretation. The radiocarbon dates suggest that the site was sporadically used in the Mesolithic (9000–3400 cal. BC) and then revisited from the Neolithic-Megalithic-Iron Age transition (*ca.* 1300 cal. BC) onwards. Microliths and wild fauna are found throughout the Birappa sequence. Pottery and domestic ovi-caprids, meanwhile, are restricted to the upper layers (Robinson et al. 2008). Charcoal from a context containing some of the earliest pottery at the site was dated to 1300–1250 cal. BC (Boivin et al. 2005). The Birappa pottery assemblage is made up entirely of Megalithic type ceramics. The ceramic and radiometric evidence therefore implies an occupational hiatus at Birappa at the time that Neolithic groups inhabited the nearby hilltop sites, with Birappa coming into use again as hilltop occupation and activities declined. Interestingly, however, there is also evidence for continuity between the preceramic and ceramic lithic levels at Birappa, with only subtle changes in raw material variety and bladelet production (Shipton et al. 2012).

Chronological model

Figures 5 and 6 show the results of Bayesian chronological modelling of phase transitions using the available radiocarbon dates from Sannarachamma and Hiregudda, respectively. An Agreement Index is indicated for each Bayesian calibration within these phased models. These models, alongside existing dates from the sequence of Birappa and archaeological interpretations of site usage and material culture change from across the site complex, have been used to construct a phased chronology and description for the entirety of SanganakalluKupgal (Fig. 7).

Archaeobotanical study

Initial archaeobotanical results came from two initial test pits (Fuller et al. 2004). These can now be augmented by analysis of a selection of samples collected in later field seasons, studied by Weisskopf (2005) and Barnard (2010) as well as Fuller. These data provide a total assemblage of 2464 identified seeds and seed fragments spanning all of the main stratigraphic phases of Sannarachamma and Hiregudda Area A combined (Fig. 8). Total ubiquity and relative frequency indicates mixture of a Southern Neolithic crop package (millets, *Macrotyloma*, *Vigna*) with wheat and barley throughout the sequence, but with the major addition of hyacinth bean (*Lablab*) after 1600 cal. BC (Fig. 9; Tables S1-S4).

There is a clear increase in seed density at Sannarachamma and Hiregudda over time (from phase 2 to 5B) (Fig. 8). This likely reflects the increasing frequency of plant-based activities, such as crop-processing or cooking, which, in turn, is likely to signal increasing population density or site occupation throughout the year. In terms of relative proportions, pulses dominate over cereals throughout the assemblage. The presence of possible tuber and fruit foods is represented by identified parenchyma and fruit seeds, which decline markedly after 1750 cal. BC (Fuller et al. 2004) (Fig. 9; Tables S1– S4). The decline in fruits at this time implies a decrease in tree cover in the immediate region of the site, either as a result of increased forest removal by human or climatic influences, or a human shift towards a greater reliance on agriculture across the complex (Fig. 9). The archaeobotanical assemblage indicates a general reliance on millets and pulses common to the South Indian complex of crops as well as wheat and barley (Table S2). From phase 5A (1770–1500 cal. BC) at the site, wheat and barley increase in the assemblage, while there is a reduction in the proportion of millet by phase 5B (Tables S2– S4).

Archaeozoological study

The animal bones recovered across Sanganakallu-Kupgal during multiple field seasons were generally in poor condition. Weathering of bone and post-depositional processes resulted in a high degree of fragmentation and frequent, heavy encrustation in calcium carbonate. Consequently, although large numbers of bones were recorded in detail, only 165 of 25, 000 were measurable. The most robust elements, such as phalanges and astragali, yielded the most metrical data and provided the best point of comparison with the Deccan College material. Despite faunal remains being excavated from the Birappa and Choudammagudda locales, their small quantity inhibited meaningful analysis. As a result, we only report data from the Sannarachamma and Hiregudda material here.

As with the archaeobotanical remains, the number of faunal fragments (NISP, number of identified specimens) reaches a dramatic peak in phases 5A and 5B, indicative of increasing food preparation and population density at Sannarachamma and Hiregudda Area A at this time (Fig. 10). Figure 11 demonstrates the percentage of the faunal assemblage made up of deer/antelope, domesticated bovines and caprines in each site phase for Sannarachamma and Hiregudda combined. Although limited by sample size of bones identifiable to species, the majority of identifiable 'Bovine' specimens can be attributed to domesticated cattle, *Bos indicus* (Table S5). Two larger than normal *Bos* bones could be argued to provide evidence for the persistence of wild animals into the Neolithic period. Alternatively, they could be representative of castrated domesticates used as part of a traction regime, as suggested elsewhere in the southern Deccan (R. Bauer 2007). However, the sample size remains too small to make this argument confidently. Similarly although water buffalo (*Bubalus bubalis*), whether wild or domesticated, is present throughout the occupation of the Sanganakallu-Kupgal sites, where *Bos* remains are identifiable to species level, *B. indicus* is the major contributor throughout the sequence (Table S5). Despite the difficulty of distinguishing sheep, goat and blackbuck bones (Pawankar and Thomas 2001), it was possible to securely identify a significant number of individuals of all three species at SanganakalluKupgal. There was no evidence for wild sheep or wild goats at the site complex during the Neolithic, with all identifiable sheep or goat bones being attributable to *Capra hircus* and *Ovis aries* that are non-native to India. Although isolated finds of sheep or goat bones from Palaeolithic sites in the Deccan (Murty 1974; Badam 1984) have been used to suggest indigenous domestication, recent chronological work suggests these are actually Holocene in age (Miracle 2003).

Beyond 'deer/antelope', our dataset also includes the presence of more diverse wild fauna including small-medium carnivores, birds and fish (Table S6). However, based on preliminary study and identification, the proportion of identified wild animals, both large and small, in both the Sannarachamma and Hiregudda faunal assemblages remains low throughout Neolithic and Megalithic occupation (see comparison with Table S5). This paucity of wild fauna contrasts with that of the other systematically recovered Neolithic and Iron Age faunal dataset in the southern Deccan at Kadebakele (Bauer 2007). Here, large numbers of wild, aquatic bird resources were exploited, mainly during the Iron Age (from 1200 cal. BC), but also during the Neolithic, making up a considerable, and often dominant, percentage of the Iron Age faunal structure (Bauer 2007; Bauer et al. 2007). While researchers have suggested that this large wild proportion, in comparison to other sites, could be a result of inadequate recovery techniques at other excavations, the fine-scale sieving and flotation practiced in the archaeozoological analyses performed at Sanganakallu would suggest that this is not the case here. Indeed, given that the majority of the Kadebakele wild fauna is made up of riverine, aquatic birds, their absence at Sanganakallu, a site disconnected from major river basins, is perhaps unsurprising.

The dominance of domesticated livestock from the initial ashmound phase (phase 2 at *ca*. 1950–1900 cal. BC) until the cessation of occupation following phase 8 *ca.* 1000 BC (Fig. 11) is witnessed at the majority of sites across the central and southern Deccan from the arrival of domesticated cattle in the region during the Neolithic, perhaps from *ca*. 3000 cal. BC but certainly by 2500 cal. BC (Allchin 1963; Paddayya 1973; Korisettar et al. 2001a; based on chronology in Fuller et al. 2007). Available data indicate that a general emphasis on domesticated fauna was retained throughout the early ashmound and later settlement periods in the South Deccan, except at Kadebakele. However, within this reliance on domesticated fauna at Sanganakallu is a shift in domesticated taxa frequencies (Fig. 11; Tables S5, S7, S8). During the initial ashmound formation *ca.* 1950–1900 cal. BC at Sannarchamma, the percentage of cattle in the assemblage dwarfs that of the caprines. This dominance continues into phase 3. However, from phase 4 onwards, caprines become a more significant element of the faunal assemblage until phase 6 when they form by far the major faunal component. This shift coincides with the height of the ashmound phase and subsequent development of settlement structures and deposits at both Sannarachamma and Hiregudda.

GIS flow accumulation model

Our model of water availability, shown in Fig. 12 and Table 1, is calculated on the basis of average annual precipitation and accumulated downstream flow along watersheds. The flow model shows, qualitatively and quantitatively, that the sites with known settlement continuity are closer to water streams than the core of sites with discontinuity (average distances of 1.6 and 7.2 km, respectively) (see also 'Discussion'). The sites with continuity are not only closer to stable watercourses but also closer to streams with higher discharge (cyan, blue) than those with discontinuity.

Discussion

Settlement and subsistence at Sanganakallu across the Neolithic-Megalithic-Iron Age transition

Looking broadly across the Sanganakallu-Kupgal site complex as a whole, clear chronological patterns emerge. As shown in Fig. 7, the hill sites of Sannarachamma, Hiregudda A and Choudammagudda demonstrate similar trajectories of ashmound development. Initial ashmound development began at Sannarachamma between 1950 and 1900 cal. BC and pre1750 cal. BC at Hiregudda Area A. Sannarachamma witnessed an intensification to a 'Main Ashmound' phase between 1900 and 1750 cal. BC, prior to slight decline between 1750 and 1700 cal. BC. Initial ashmound accumulation appears to have begun slightly later at Hiregudda Area A, between 1900 and 1750 cal. BC, with a subsequent intensification to a Main Ashmound phase between 1750 and 1700 cal. BC. The two sites that witness an intensification of ashmound development, Sannarachamma and Hiregudda Area A, document the subsequent formation of a 'village phase' dated to 1700–1500 cal. BC. This period also appears to have witnessed the commencement of activity at Hiregudda Area B. This subsequent occupation is not seen at the smaller ashmound accumulation at Choudammagudda, where evidence of further occupation or activity is absent until the appearance of Megalithic structures.

Following more permanent settlement phases at Sannarachamma and Hiregudda A, there is more ephemeral use of the sites between 1400 and 1250 cal. BC, with postashmound pitting at Sannarachamma and the specialisation of Hiregudda A as an 'axe factory'. Beyond this period, which signifies the Neolithic to Megalithic transition, there is little evidence for occupation across the complex with the exception of the Birappa rockshelter, which sits on the surrounding plain where many megaliths of uncertain Megalithic or Iron Age date also occur. Between 1300 and 1250 cal. BC, with the seeming abandonment of the hilltop sites, Birappa shows evidence for occupation by Megalithic ceramic-making groups. Interestingly, accompanying microlithic toolkits of these Megalithic groups show some similarities to the early Mesolithic occupation of the site between 9000 and 2300 cal. BC, suggesting a substantial change in subsistence practice at this time (Shipton et al. 2012). Importantly, be tween 1200 and 1000 cal. BC, occupation, craft production and subsistence activities cease across the Sanganakallu hilltops entirely, with the only evidence for Iron Age activity being found in the form of megalithic structures (burial and other) in the intervening plains and continued evidence for ephemeral occupation at the Birappa rockshelter.

Archaeobotanical remains from the sites of Sannarachamma and Hiregudda Area A imply the dominance of the indigenous Indian Southern Neolithic crop package and wheat and barley throughout both the ashmound and settlement phases of the Sanganakallu complex. An increase in seed densities through time may imply an intensification of food production practices to support higher population densities associated with the permanent 'village' occupation of the complex *ca.* 1700 cal. BC. This period also witnessed an increasing importance of wheat and barley remains in the crop assemblage, with a marked de cline of tuber foods post-1750 cal. BC (Fuller 2006), perhaps implying a more dedicated crop-based subsistence. An increasing proportion of wheat and barley, crops considered to be in need of considerable water resources due to cultivation in the non-rainy winter season, suggests that some efforts were made to improve access to the spring water resources of the Sanganakallu hilltops during the Late Neolithic. Increased reliance on wheat and barley has already been documented at Iron Age Kadebakele (Morrison et al. 2012). Pigeonpea (*Cajanus cajan*) also appears only in the latest levels from Sanganakallu, and while this crop can be grown in dry climates, it is reported to require some irrigation (ICAR 1997, p. 857). Thus there are clear indications of increasing water demands for crops over the course of the Neolithic occupation at Sanganakallu.

Both Sannarachamma and Hiregudda Area A show archaeozoological evidence for a reliance on domesticated livestock from the earliest ashmound phase *ca.* 1950–1900 cal. BC, with very limited input from wild food resources, until the eventual cessation of occupa tion of these hilltop sites with the Neolithic-Megalithic transition. However, the changing emphasis from cattle to caprines with the shift from ashmound accumulation to the emergence of settled village communities implies a significant change in herding practices. Given that many argue that the ashmounds of the Deccan plateau provided seasonal meeting places for transhumant cattle herders, the emergence of more permanent village communities in their place may have encouraged changing practices of animal husbandry. Caprines are better suited to small-scale farming practices, requiring both less fodder/browse and producing smaller food packages when slaughtered. This implies a potential shift from more communal to more household-focused units of production and consumption. This faunal change is also potentially significant from a palaeoenvironmental perspective, given that caprine populations are better adapted to arid conditions. A similar shift has also been seen at Inamgaon *ca.* 1200 cal. BC (Dhavalikar 1988; Panja 1999). At around this time, there is also an increased presence of wild fauna from layers of renewed occupation at Birappa *ca.* 1300–1200 cal. BC. Although these are accompanied by domesticated ovi-caprids at the site (Robinson et al. 2008), a much more broad based and transient subsistence strategy appears to be indicated at this time. This increased faunal diversity from *ca.* 1200 cal. BC onwards is also documented at the systematically recovered Iron Age deposits at Kadebakele, albeit with a greater focus on the riverine resources of the Tungabhadra River (Bauer 2007; Bauer et al. 2007).

Settlement at Sanganakallu in broader central and southern Deccan perspective: regional variation in Neolithic-Iron Age transition

The patterns documented in the Sanganakallu dataset appear to stand in stark contrast to new survey findings reported elsewhere, notably along the Tungabhadra River to the west. As already noted, where detailed survey has been performed, in Raichur and Koppal, the Iron Age (from *ca.* 1200 cal. BC) has been shown to be a period of settlement intensification, increasing settlement size, and general demographic continuity and expansion from the Neolithic period. Along the Tungabhadra River and its tributaries and around the site of Maski, Neolithic occupation deposits are frequently overlain by Iron Age deposits, and Neolithic monuments are frequently referenced or even used in Iron Age megalithic structures and mortuary contexts (Bauer et al. 2007; Johansen 2008, 2014a; Bauer 2010). This settlement and spatial continuity is also backed by a consistent subsistence focus on domesticated cattle and caprines and the cultivation of indigenous millets, pulses, wheat and barley (Bauer et al. 2007; Morrison et al. 2012). Another site with probable continuity is Piklihal (Allchin 1960), where recent archaeobotanical sampling and radiocarbon dates indicate continuity through to the Early Historic period, although some hiatus during parts of the Iron Age is possible (see Fuller et al. 2007). Wheeler's excavations at Brahmagiri might also indicate continuity, although the stratigraphic resolution and chronometric control of his samples remain limited (Morrison 2006).

The Sanganakallu area sites, however, are not unique in being abandoned before the end of the second millennium BC. Excavations at Kurugodu, Tekkalakota and Velpumudugu all indicate abandonment sometime between 1500 and 1200 BC (see Korisettar et al. 2001b, and dates in Fuller et al. 2007). The Neolithic village locality at Tekkalakota (Nagaraja Rao and Malhotra 1965) was dated by a sequence of single seed AMS dates between 1900 and 1600 BC based on 1-sigma range and not later than 1500 BC based on the 2-sigma range.

Some ashmound sites, such as Palavoy and Budihal, also cease to be occupied before the end of the Neolithic (Paddayya 1993). Recent systematic survey undertaken around Tekkalakotta indicates some Iron Age/ Early Historic hill-base occupation, but apparently without evidence of a final Neolithic phase, although the dating of these sites remains problematic (Sugandhi 2008). Another site of likely discontinuity is Watgal. Although the preliminary report emphasised continuity in the site's material culture traditions from the Neolithic to the Iron Age and Early Historic period (Devaraj et al. 1995), the layers of rammed earth features and recurrent dumping from pyrotechnic activities that characterise Occupation III (early-mid second millennium BC) subsequently become much less artefact dense, and well stratified, and are punctuated by many burials. This suggests a major downsizing, if not abandonment, of village occupation at this site.

However, while the contrast between Iron Age abandonment at Sanganakallu and the sites discussed above, and Iron Age hilltop intensification and continuity from the Neolithic period elsewhere in the southern Deccan, appears to be a real pattern, it is worth noting some issues in the comparison of the different datasets. Firstly, while recent survey has produced a wealth of data regarding Neolithic and Iron Age settlement for the Bellary, Raichur and Koppal districts of the southern Deccan, it can currently only provide limited chronological resolution for these patterns. While some radiocarbon dates are now available from excavation at the sites of Kadebakele and Bukkasagara (Bauer et al. 2007; Bauer 2010), there are often significant temporal gaps between Iron Age and Neolithic occupation deposits that could be representative of an occupational hiatus at the very end of the Neolithic period, such as that seen at Sanganakallu, prior to the emergence of Iron Age settlement. Such short occupation periods and temporal discontinuities have already been documented at many other Neolithic and Megalithic sites in the southern Deccan (Fuller et al. 2007). Secondly, an increase in the number of sites in these regions does not necessarily mean increasing sedentism or intensification in *all* cases. Indeed, we argue that both local continuity and local abandonment of sedentism must be seen as potential strategies for coping with water-poor environments and linked environmental change. As illustrated for western Asia by Rosen (2007, 172–173) 'some human groups have become more capable of controlling the effects of climatic change in their particular locality, time frame, and cultural milieu', while others have not, and 'different segments of society have different motivations for action when faced with environmental change'.

In Fig. 13, we present a compilation figure that compares climatic and environmental records from the Arabian Sea and the Godavari delta core, summed probability distributions of all calibrated dates from selected South Indian sites (Table S9), and the total summed probability distribution of all South Deccan radiocarbon dates from Neolithic or Iron Age contexts from Karnataka, Andhra Pradesh and northern Tamil Nadu. The contribution of Iron Age radiocarbon dates has been indicated in grey. This approach has increasingly been employed elsewhere as a regional population proxy (e.g., Collard et al. 2010; Stevens and Fuller 2012; Shennan et al. 2013), and although there are issues in the correlation between radiocarbon dates and past demography, it remains one of the few means of gaining wider regional perspectives of prehistoric population change. Figure 13 demonstrates that climatic fluctuations between warmer/wetter and drier/colder periods became quite marked throughout the second half of the second millennium BC and early first millennium BC across the Indian subcontinent. Few dated Southern Neolithic sites show continuity through this period, and the most probable modelled abandonment date of the Sanganakallu hilltop sites centres on 1200 cal. BC. The site of Velpumudugu demonstrates similar but weaker trends. The overall summed radiocarbon dataset suggests an increase in Neolithic populations during the early second millennium prior to decline towards the end. Although some continuity is evident and there is potential for bias as fewer Iron Age sites have been excavated and dated, we believe this reflects a real decline in sedentary Neolithic occupation, but that this was regionally varied and location-specific.

Differential access to water across the Southern Neolithic-Megalithic/Iron Age on the Deccan plateau

The general location of the South Indian Neolithic is in the driest area of the Deccan (Fig. 14). It can be seen however that rainfall is progressively higher towards the west and north and thus the sites explored and surveyed in the western Raichur and along the Tunghbandra (Bauer et al. 2007; Bauer 2010; Johansen and Bauer 2013) are in a higher rainfall zone than the Sangankallu complex. Under mid-Holocene conditions, which were wetter prior to the Neolithic, rainfall would have made the Bellary region more comparable to surrounding regions (Fig. 15). Palaeoclimatic data indicate that rainfall decreased over the course of the fourth and third millennia BC (see

Fuller and Korisettar 2004; Ponton et al. 2012), and thus, the rise of more sedentary Neolithic sites around 4000 years ago correlated with the onset of drier conditions. Nevertheless, fluctuations during the second millennium BC and into the first millennium BC may have made conditions even drier during some periods, with considerable fluctuation between wetter and drier conditions (Fig. 13). This would have resulted in some crops and some areas becoming more viable for cultivation than others. In turn, such changes would have impacted short-term spring rejuvenation, making the availability of water from stable watercourses, and its control, of particular interest.

The water availability model developed above (Fig. 12 and Table 1) suggests that in low rainfall years, access to water might have been very limited for people occupying sites with demonstrable discontinuity in contrast to those populations with reliable access to stable water courses. In reality, this effect would have been more intensive than suggested by the model, due to its conservative nature (not factoring in evapo-transpiration, for example). These results suggest that despite cultural continuity from the Neolithic into the Iron Age and a longer-term, millennial pattern of population growth, some sites and regions in the Deccan, such as those in the Sanganakallu region, experienced a decline in archaeologically visible populations and sedentism. The extent to which this contributed to increased population densities in adjacent regions (like the Kopal district), through localised migration as a coping strategy, or whether micro-regional population collapsed, as a failure of strategy, requires further research. Nevertheless, we can conclude that not all microenvironments were equally sustainable, at least in terms of sedentary agricultural lifeways, across the Neolithic-Iron Age transition in the Southern Deccan.

Political and practical concerns with water in the Iron Age Deccan plateau

The extreme aridity of the central and southern Deccan region makes water a particularly valuable resource from a practical, cultural, and political perspective. In modern and historical India, the agricultural communities of the Deccan plateau have faced recurrent droughts as a result of an acute rainfall shortage in a region where rainfall rarely reaches higher than 500 mm annually. During the Indian Famine of 1896–1897, many domesticated cattle starved and crops failed as agricultural communities were forced to eat seeds and animal fodder (Tomlinson 1993). Despite the potential importance of Indian Summer Monsoon (ISM) dynamics to understandings of prehistoric settlement transformations in central India, until recently, long-term, well-dated palaeoenvironmental records have been unavailable for the region. Across the broader South Asian landmass and flanking regions, weakening of the ISM and monsoon rainfall contribution from around 6000 years ago has been noted in records from northwestern India (Prasad and Enzel 2006; Madella and Fuller 2006; Giosan et al. 2012), Oman (Fleitmann et al. 2003), northeastern India (Berkelhammer et al. 2012) and eastern Tibet (Hong et al. 2003), while increasing variability in the ISM throughout the Holocene has been indicated by marine records off the Bay of Bengal (Sinha et al. 2011) and speleothem records from northeastern India (Breitenbach 2010; Adkins et al. 2011). Recent work has suggested that fully modern aridity was potentially established in the Indus Valley and Thar Desert regions of northwestern India by 4100 years ago (Dixit et al. 2014).

Recently, two important palaeoclimatic and palaeoenvironmental records of more local relevance to the central Indian region have become available. Ponton et al. (2012) describe carbon isotope measurements from leaf waxes from a sediment core located offshore from the Godavari River in the Bay of Bengal. This record indicates an increase in aridadapted vegetation from *c*. 4000 to 1700 years ago (2000 BC to 300 AD), followed by the persistence of arid-adapted plants from this point onwards (Ponton et al. 2012). Prasad et al. (2014) report multi-method analysis of a 10-m-long sediment core from Lonar Lake, central India that indicates a prolonged drought period between 4600 and 3900 years ago (2600–1900 BC) that the authors argue is related to the dynamics of the Indo-Pacific warm pool. After 3900 years ago (1900 BC), environmental conditions at Lonar Lake improved and appeared stable for about a millennium. The weakening of the Indian monsoon documented by these records has also been indirectly documented in the Deccan region (Caratini et al. 1994; Asouti et al. 2005), alongside increasing anthropogenic shaping of the landscape (Bauer et al. 2007; Bauer 2013).

The pace of climatic and environmental change in this region, over centuries and even millennia, means that it is unlikely that increasing aridity had a catastrophic and deterministic influence on agricultural Deccan communities across the Neolithic to Iron Age transition. However, it may provide insight into the strategic and locally variable approaches that Iron Age communities were to take to occupation of an increasingly unpredictable landscape. It has been argued that increasingly dry conditions from *ca*. 2600 cal. BC would have encouraged agricultural subsistence strategies based on transhumant cattle herding among populations that gathered for occasional seasonal meetings at important places within the landscape. Cultivation can be hypothesised to have increased as a response to dwindling or shifting wild plant availability (Fuller and Korisettar 2004). Wild millets grow in damp micro-environment patches while wetter woodland taxa like wild mungbean would have been extirpated in an increasing number of areas as savannah zones expanded (Asouti and Fuller 2008). The wild ecology of horse gram is less well known, but as a likely savannah species, it might have been impacted by the expansion of pastoralism. Thus, cultivation may have been undertaken as a resource conservation strategy. It has been argued that this early phase of cultivation involved shifting systems of both fields and occupation sites within the broader territories defined by seasonal transhumance of herding (Kingwell-Banham and Fuller 2012).

Increased agricultural production and sedentism subsequently became widespread. Slight increases in humidity identified from 1900 cal. BC onwards in the Lonar Lake core may have facilitated an intensification of agricultural production (Prasad et al. 2014). In addition to the dominant monsoon season crops (millets and native pulses), higher rainfall would have facilitated water storage for the small-scale addition of winter crops like wheat and barley (Fuller et al. 2004). Such agricultural intensification encouraged an increasing permanence of settlement at the Sanganakallu-Kupgal complex and also supported population growth. Across both the South and North Deccan, there are increasing numbers of village sites from this period, with a peak around 1700–1500 cal. BC (Asouti and Fuller 2008; Ponton et al. 2012). The main period of ashmound formation at Sanganakallu-Kupgal (1900– 1750 cal. BC) also saw a substantial decrease in the importance of cattle for population subsistence, with caprines gradually increasing in importance in parallel with a trend towards increasing settlement density across the Sanganakallu site complex.

Importantly, increasing aridity throughout the Iron Age, from 1200 cal. BC to 300 cal. AD, would have provided local communities with an important resource in the renegotiation and redevelopment of their relationships with the Deccan landscape. The ongoing importance of water meant that sites of expanding size and density displayed clear preference for reliable watercourses, including the Tungabhadra and Krishna rivers. Increasingly large and stratified social forms were drawn together at these locations, with numbers perhaps swelling as a result of site abandonments elsewhere in the region. Meanwhile, at Sanganakallu, a locale positioned at considerable distance from riverine resources (Korisettar 2014), settled village life and agriculture seemingly became unsustainable or undesirable. The hilltop springs upon which growing Neolithic communities had relied would likely have continued to diminish, with local permanent sources of water for irrigation also significantly lacking. The absence of unambiguous permanent settlement at Sannarachamma and Hiregudda Area A beyond 1400 cal. BC, and the almost complete lack of archaeological activity at these sites after 1250 cal. BC, attests to a clear change in settlement and subsistence in the area. Furthermore, the renewed occupation of Birappa by populations herding ovi-caprids and using microlithic technologies to hunt wild animals further indicates that the Neolithic-Megalithic transition included some reassertion of latent hunter-herder traditions.

Human practical and political concerns with water are therefore evident across the Deccan region during the Iron Age, ranging from a complete shift in subsistence and settlement choice in and around the Sanganakallu region to river and rock pool focus and elaboration elsewhere in the southern Deccan. Researchers surveying Iron Age sites in and around the Tungabhadra and Krishna river complexes, including the sites of Kadebakele, Maski, Veerapuram and Rampuram, note increasing human intervention in the control of water resources, whether through the modification of existing rock pools or the construction of reservoirs (Bauer et al. 2007; Morrison 2009). Indeed, this concern with water is also documented in the changing subsistence elements of the Iron Age. Although, as noted above, a general continuity in subsistence is documented into the Iron Age, important differences are centred on the practice of wet farming. Starch grain and phytolith analysis from the Middle Iron Age levels of Kadebakele suggests that water-dependent crops, including banana, rice, yams, wheat and barley, are increasingly cultivated throughout the Iron Age alongside more traditional dry-farmed pulses and millets (Morrison et al. 2012). In parallel, the faunal records from Iron Age Kadebakele discussed above indicate an increased concern with wild, riverine avifauna at this time period (Bauer 2007).

We suggest that interwoven practical and political concerns with water during the Iron Age, at a period of ongoing aridification, shaped local variation in settlement, site-usage and subsistence patterns in the central and southern Deccan. We do not imply that climate and environmental change drove the social, spatial, economic and cultural manifestations of the late prehistoric period in the Deccan in a simple or deterministic manner. Rather, at a time of changing social, spatial and political structures, an ever-decreasing water supply presented itself as a highly significant resource. In localities supported by reliable river or stream resources, farming and settlement intensified. However, an increasing concern and control over water is evident in the emergence of an elaboration of water resources, intensification of wet farming and the increasing input of labour into the modification and creation of stable water sources. For the dense Iron Age populations of the Tungabhadra and Krishna rivers, declining water supply provided a tangible and practical material resource, alongside iron technology and structural space, with which to negotiate new political forms, social structures and landscapes. In other regions, increasingly removed from reliable water sources, the decline in water availability was a practical consideration that led communities to reshape long-term subsistence and settlement. At Sanganakallu, although Neolithic and Megalithic hilltop settlements were almost completely abandoned during the Iron Age, continued construction of megalith monuments and the subsistence activities of mobile communities of pastoral-hunter-gatherers in the intervening plains demonstrate the ongoing significance of this landscape to its occupants, as well as their considerable resilience. The local variability in the social and economic interaction of South Indian Neolithic-Megalithic-Iron Age communities with their landscape demonstrates that broad trajectories of settlement and subsistence change can often miss local, punctuated instances of change and resilience that characterise subsistence and demographic shifts associated with early agricultural populations.

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Figures and Tables for Roberts et al (2015) Local diversity in settlement, demography and subsistence across the southern Indian Neolithic-Iron Age transition: site growth and abandonment at Sanganakallu-Kupgal. Published version: DOI 10.1007/s12520-015-0240-9

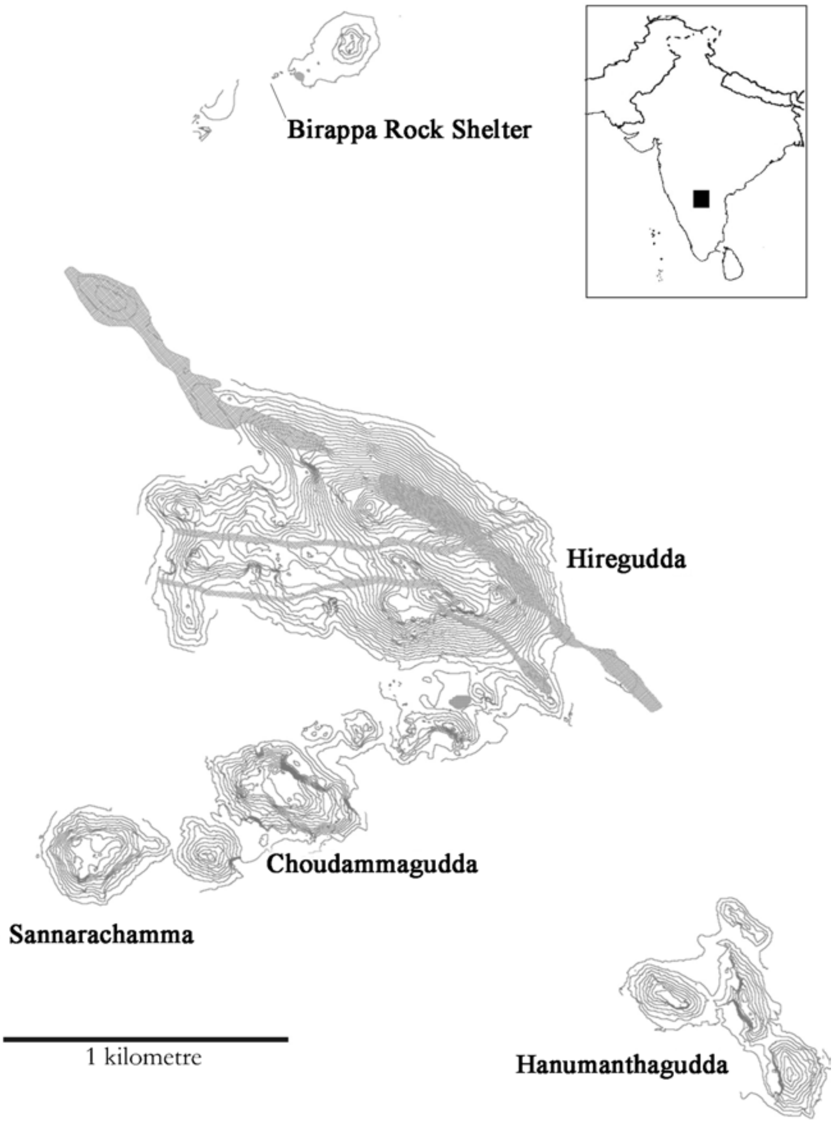

Fig. 1 Map of Sanganakallu- Kupgal complex localities within the Indian Subcontinent

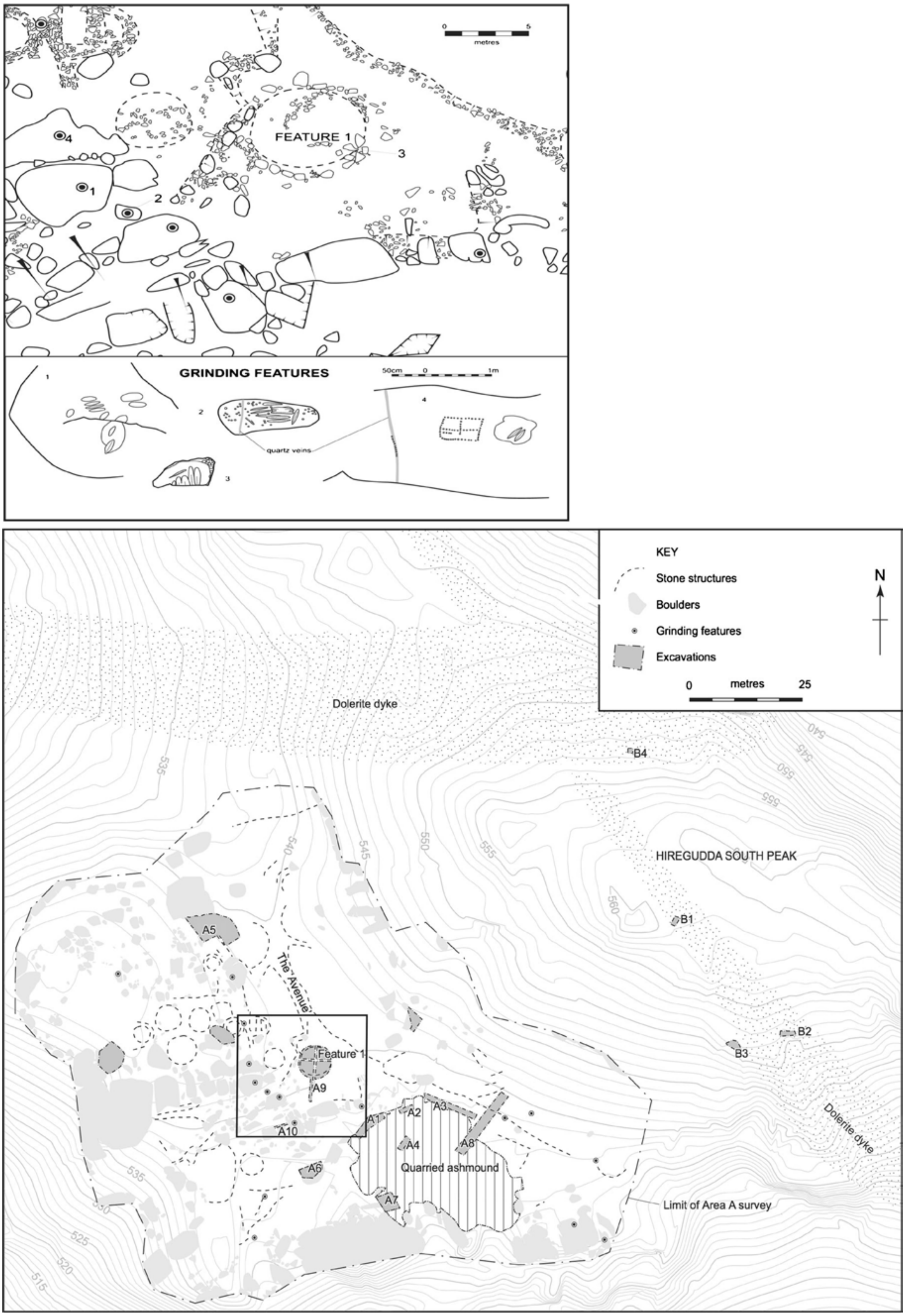

Fig. 2 Plan of Hiregudda A locality and Feature 1

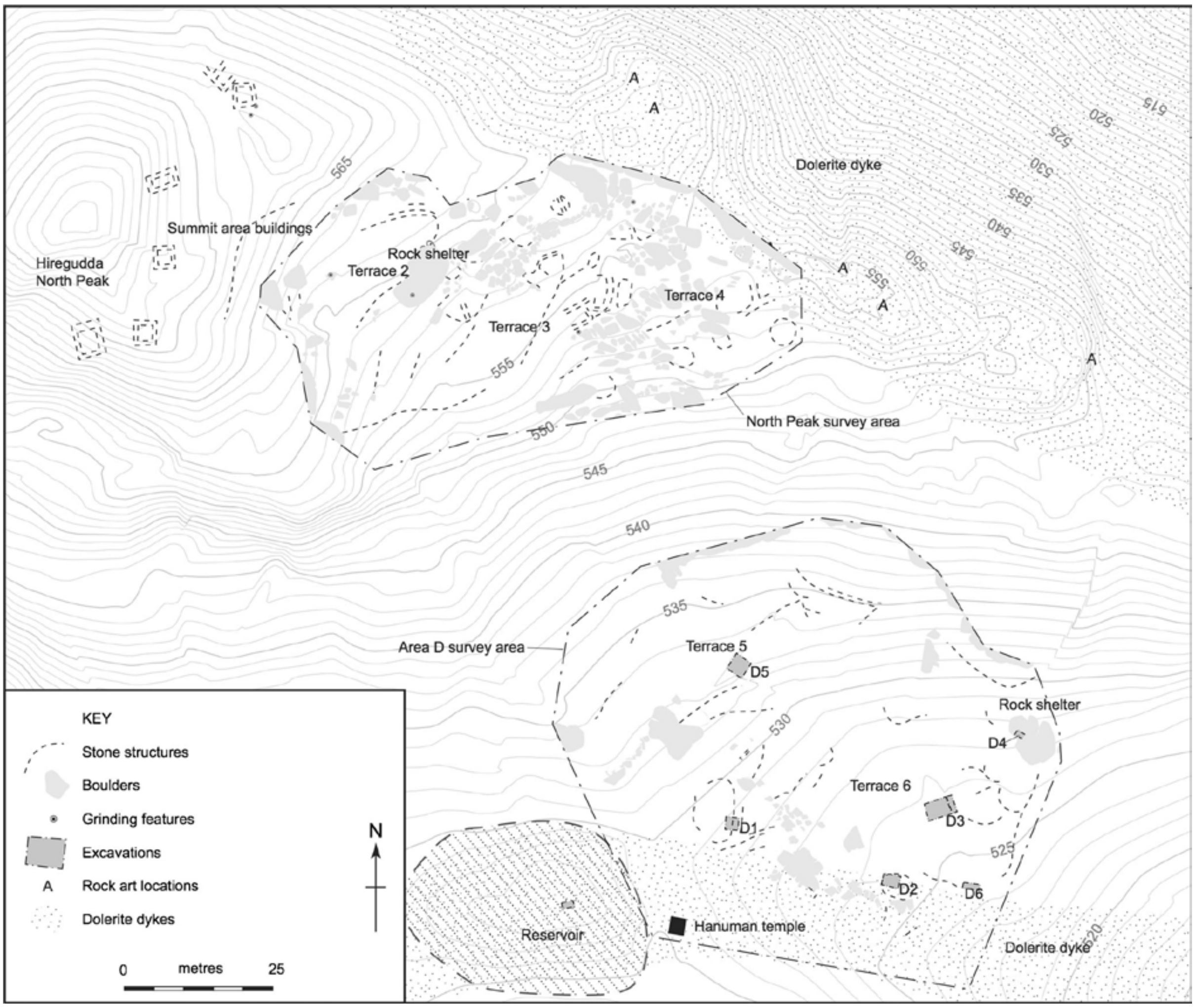

Fig. 3 Plan of Hiregudda D locality

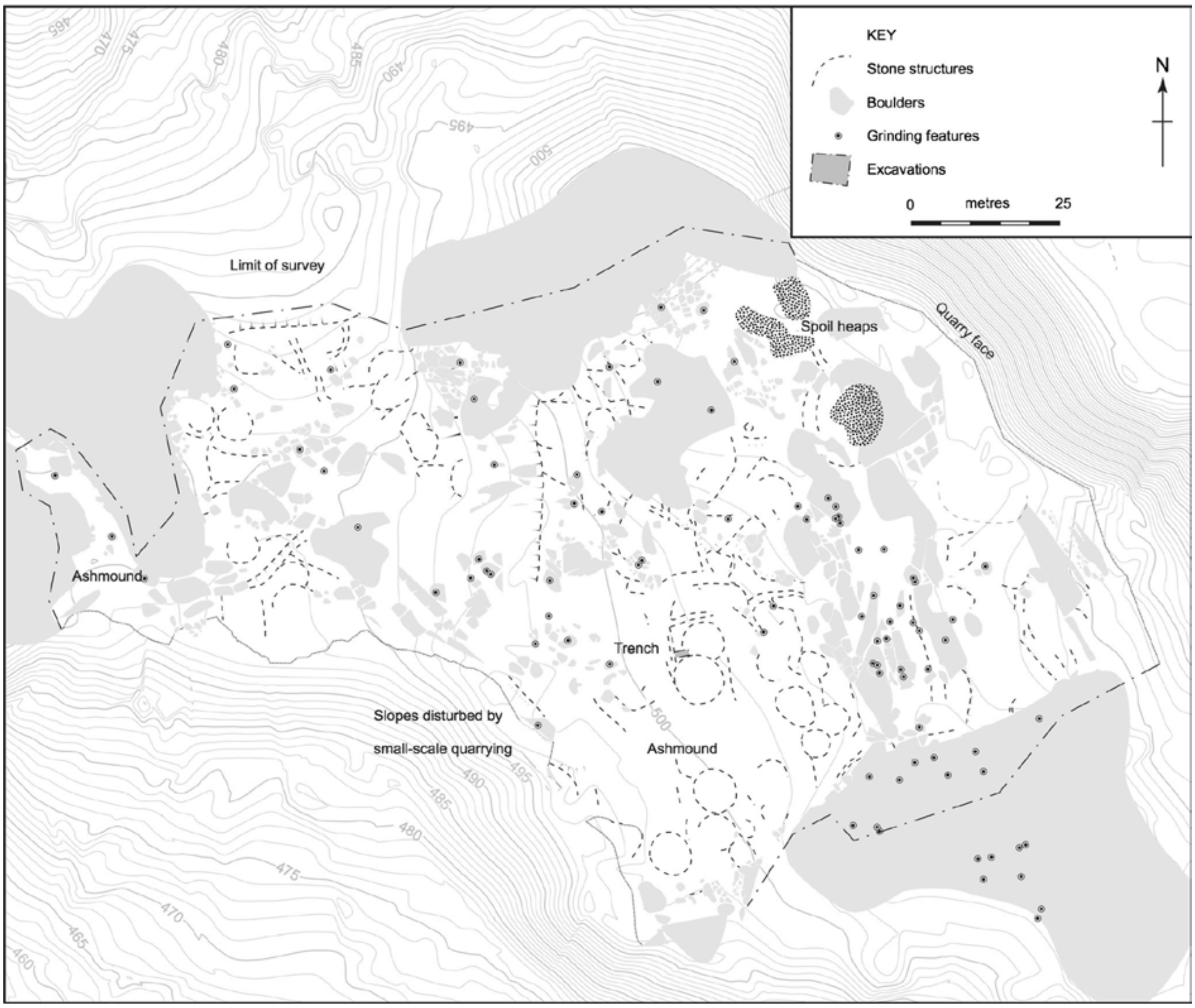

Fig. 4 Plan of Choudammagudda locality

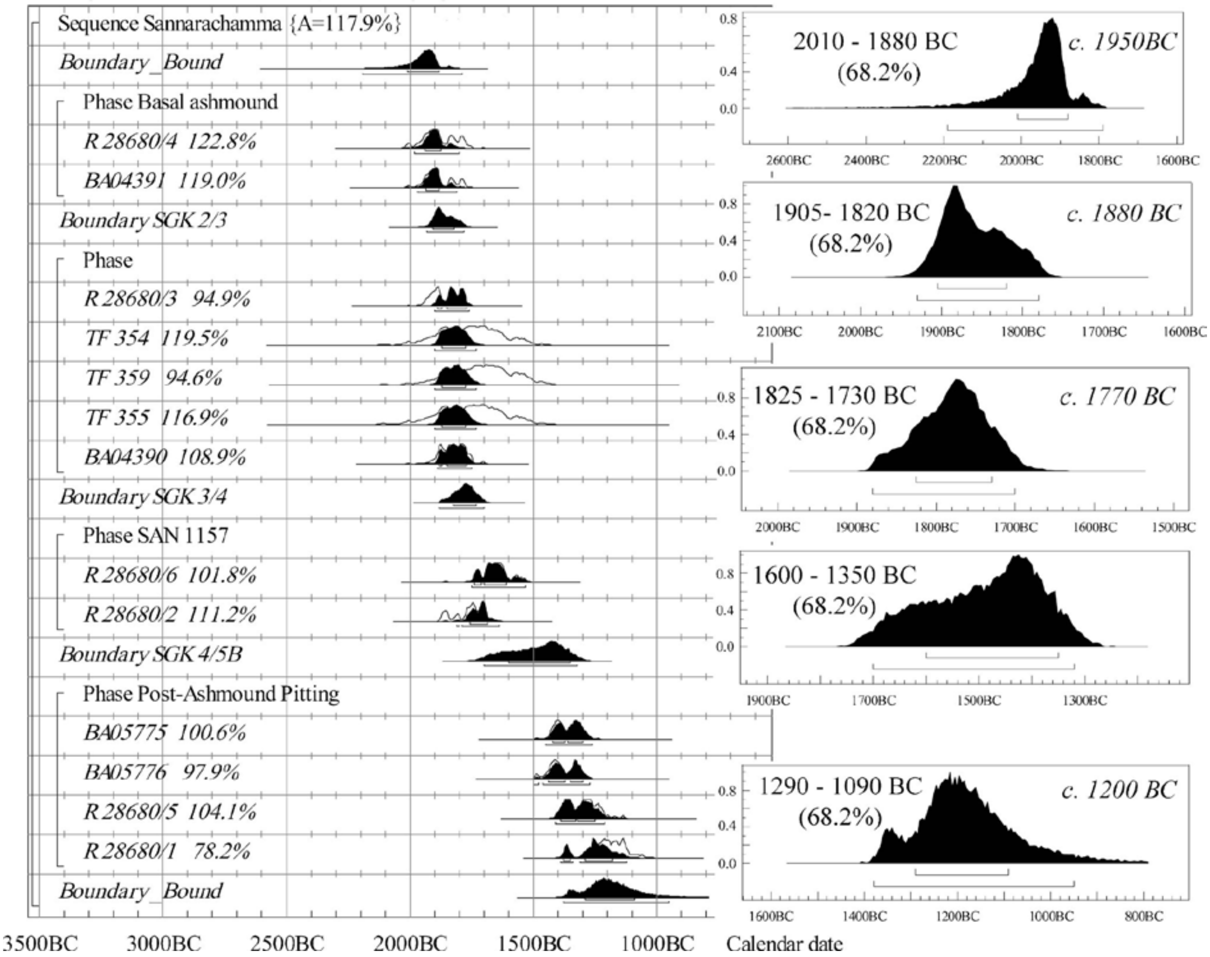

Fig. 5 Bayesian chronological model of transitions between occupation phases at the Sannarachamma locality based on existing radiocarbon dates (Fuller et al. 2007). Insets show the modelled transitions with the 1-sigma date range highlighted and a single modal date indicated. The Agreement Index is indicated for each Bayesian calibration as a percentage. Created in Oxcal 3.10 (Bronk Ramsey 2009) using IntCal13 (Reimer et al. 2013)

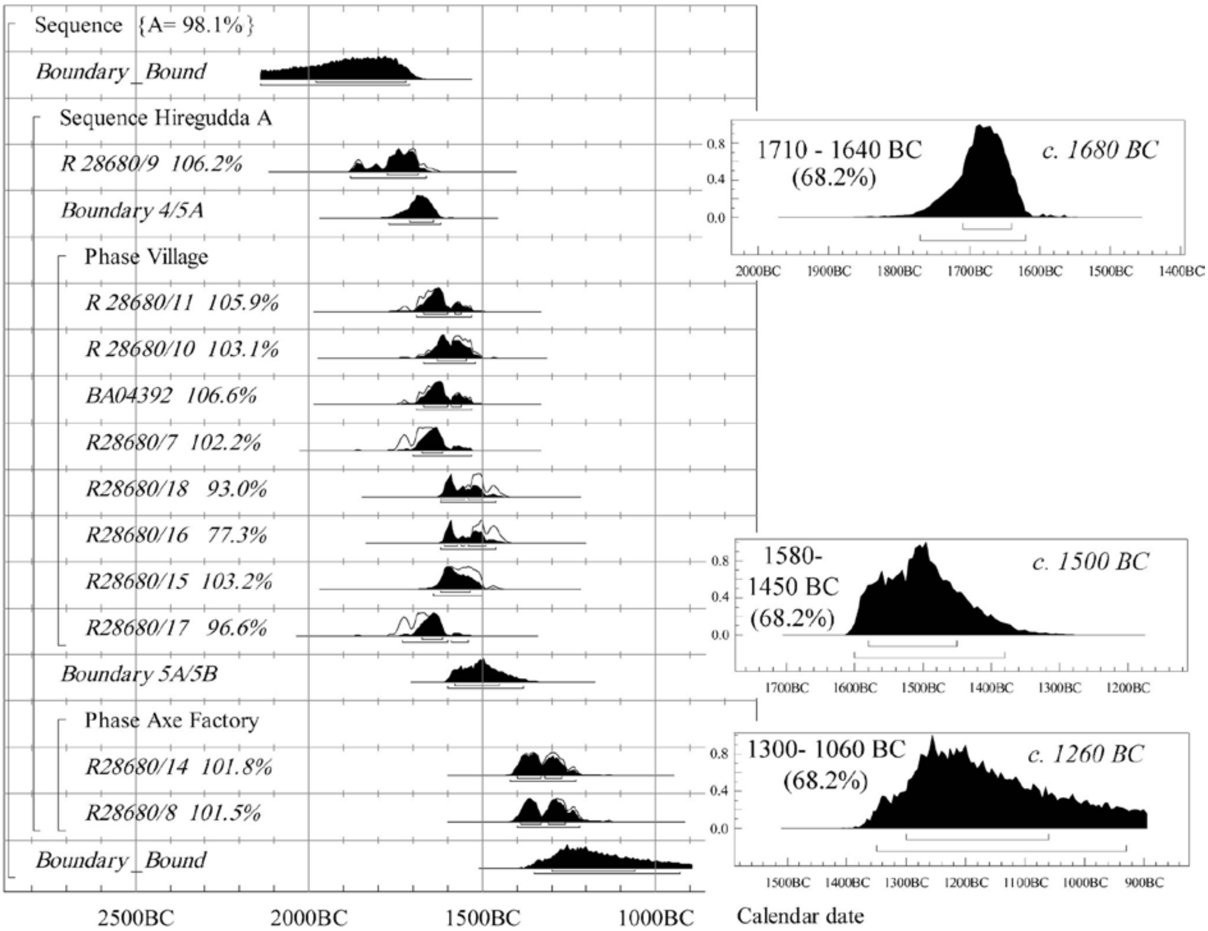

Fig. 6 Bayesian chronological model of transitions between occupation phases at the Hiregudda A locality based on existing radiocarbon dates (Fuller et al. 2007). Insets show the modelled transitions with the 1-sigma date range highlighted and a single modal date indicated. The Agreement Index is indicated for each Bayesian calibration as a percentage. Made in Oxcal 3.10 (Bronk Ramsey 2009) using IntCal13 (Reimer et al. 2013)

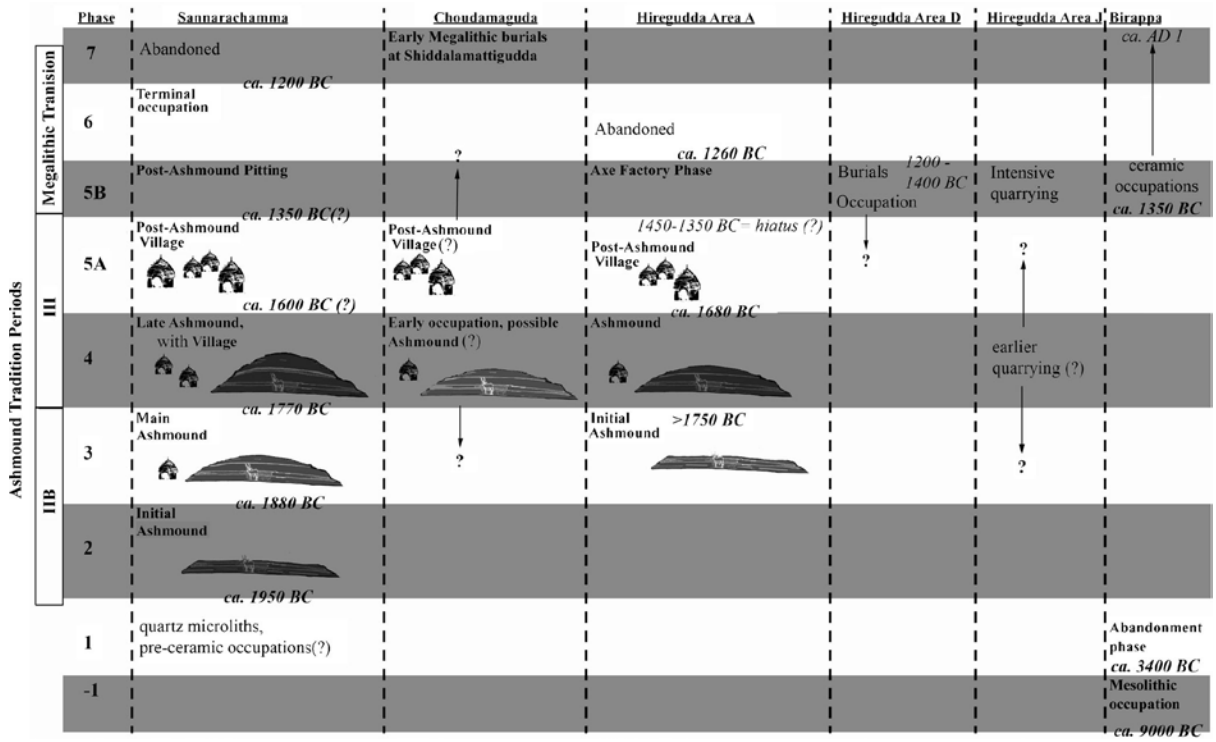

Fig. 7 Phasing of Sanganakallu-Kupgal complex based on transition models from Figs. 5 and 6 and existing radiocarbon dates reported in Fuller et al. (2007). *Arabic numerals* refer to phases within the Sanganakallu-Kupgal site complex. *Roman numerals* refer to regional periods (after Fuller et al. 2007). Correlation between stratigraphic se- quences across the complex is based on a combination of shared artefacts, especially preliminary ceramic analyses, and Bayesian modelling of ra- diocarbon dates (see Figs. 5 and 6)

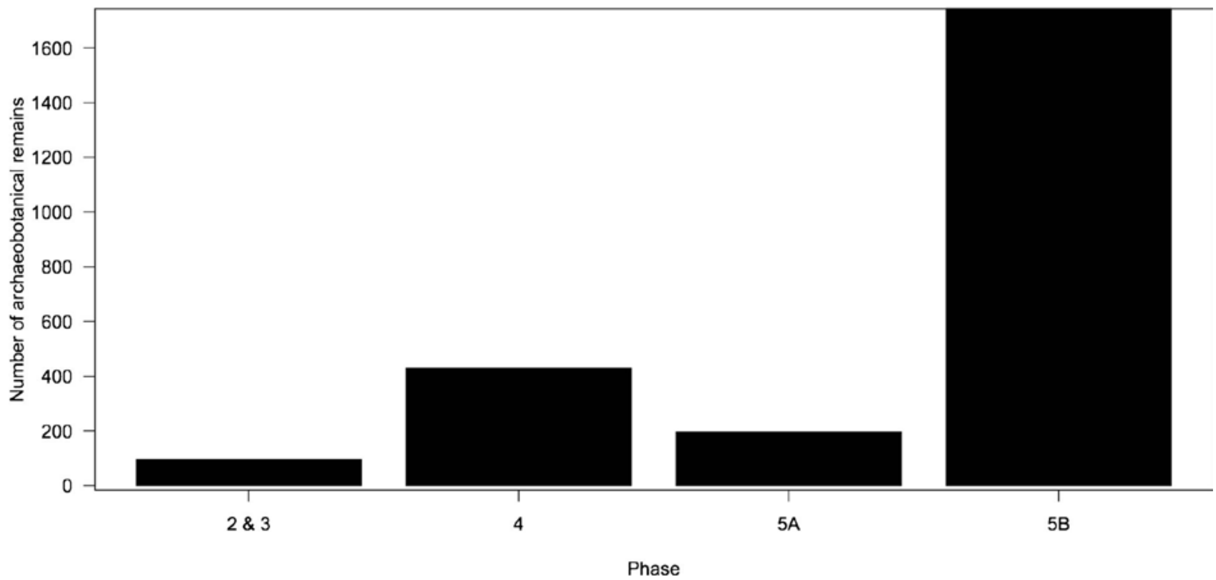

Fig. 8 Number of archaeobotanical remains from the Sannarachamma and Hiregudda Area A localities shown by phase (2–5B)

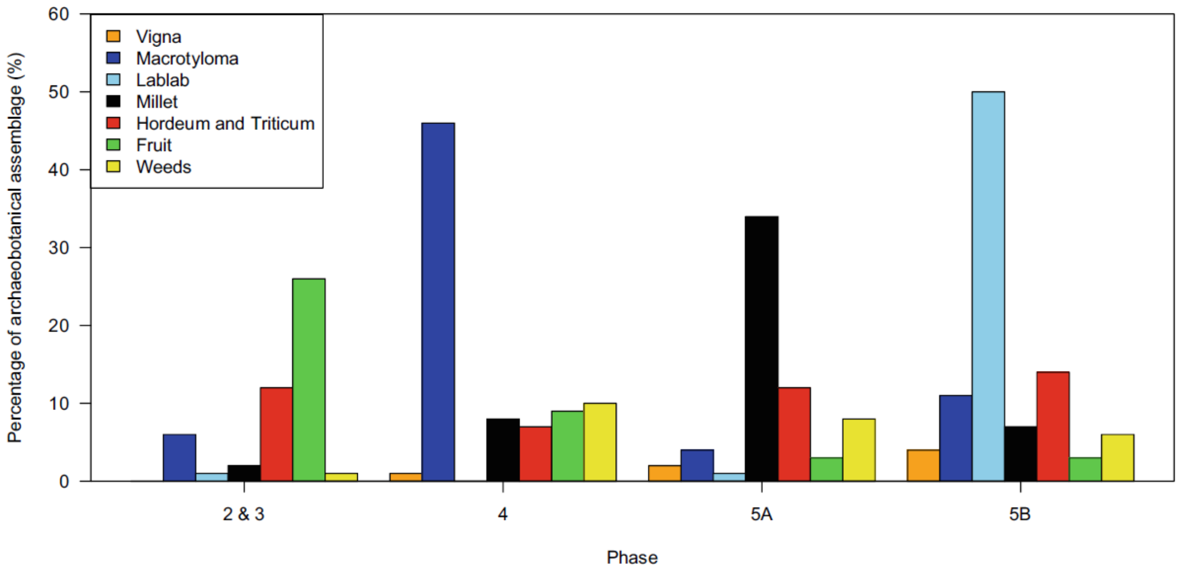

Fig. 9 Percentages of main identified archaeobotanical groups from the Sannarachamma and Hiregudda Area A localities shown by phase (2–5B)

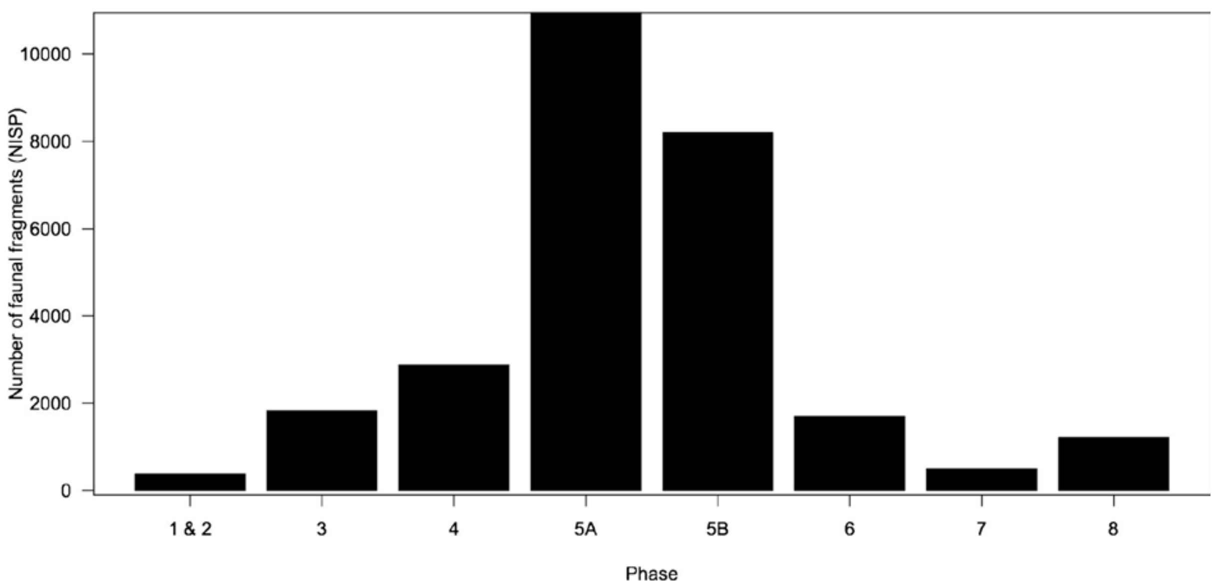

Fig. 10 Number of faunal fragments (NISP, number of identified specimens) from the Sannarachamma and Hiregudda localities shown by phase (1–8)

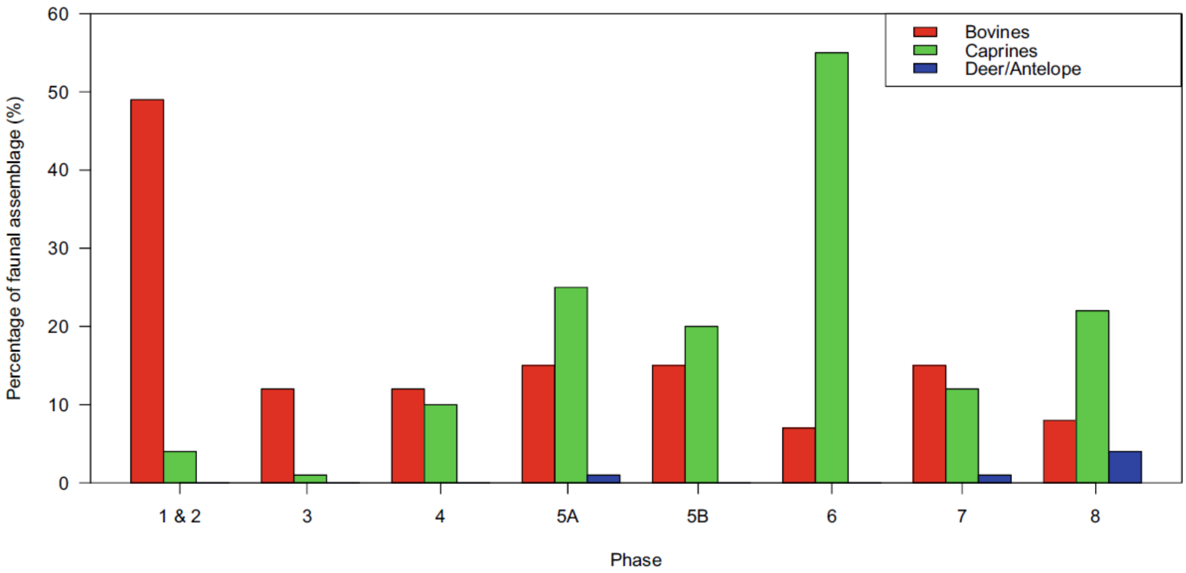

Fig. 11 Percentage of main identified archaeozoological groups (bovines, caprines, deer/antelope) from the Sannarachamma and Hiregudda localities shown by phase (1–8)

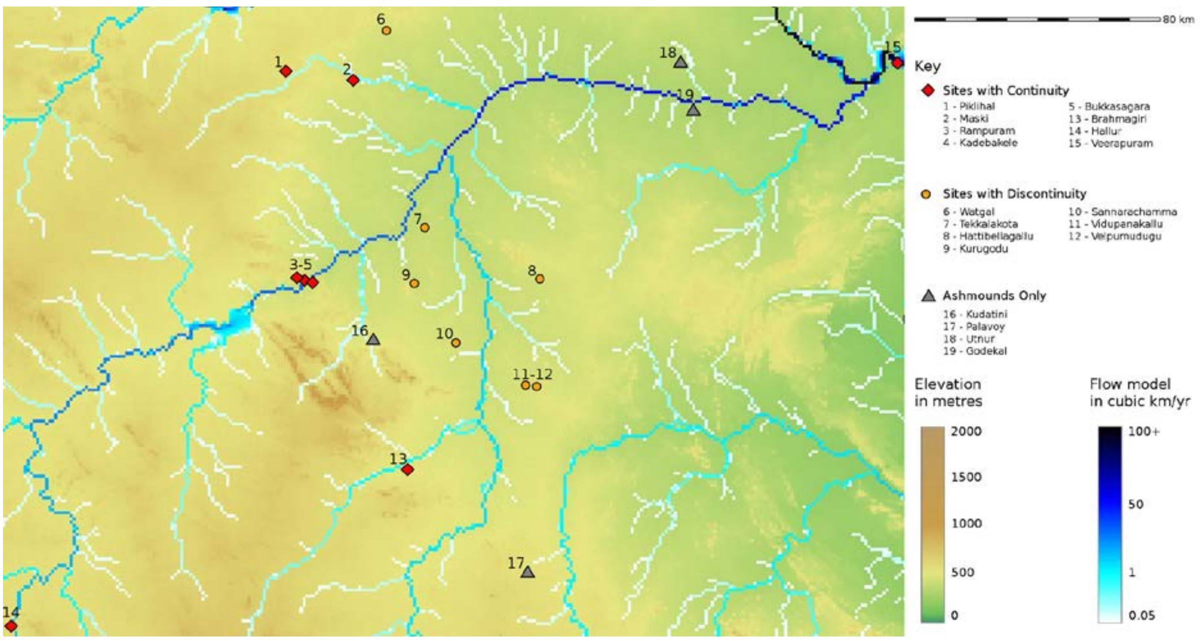

Fig. 12 Flow accumulation model for the Southern Deccan region. Flow accumulation model (*shaded white*, *cyan*, *blue* and *black cells*) indicating modelled discharge rate of runoff water is laid over an elevation map. *Darker blue tone* denotes higher discharge

Table 1. Distances (in m) of sites to streams modelled using flow accumulation models.

		Distance (m)
Continuity		
1	Piklihal	2654
2	Maski	1858
3	Rampuram	2238
4	Kadebakele	147
5	Bukkasagara	1092
13	Brahmagiri	2828
14	Hallur	1957
15	Veerapuram	194
Average		1621 ± 1039
Discontinuity		
6	Watgal	8997
7	Tekkalakota	6529
8	Hattibellagallu	5552
9	Kurugodu	7385
10	Sannarachamma	3711
11	Vidupanakallu	8824
12	Velpumudugu	9331
Average		7190 ± 2073

The averages (with standard deviations) for the two groups of sites—with Neolithic-Iron Age continuity and discontinuity, respectively—show a clear contrast

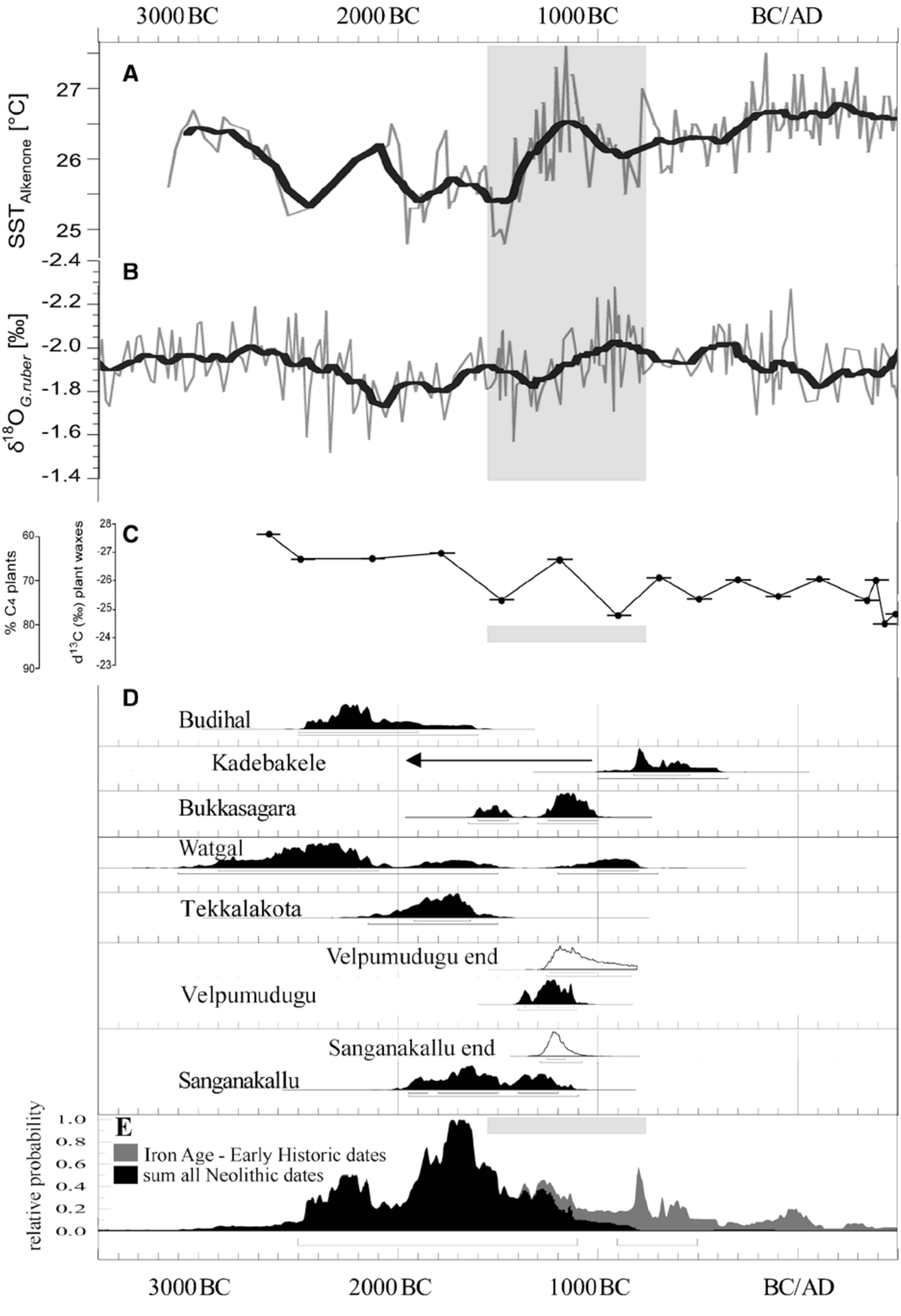

Fig. 13 a Arabian Sea surface temperature estimated from core 56 KA□ (Doose-Rolinski et al. 2001). b $\delta^{18}O$ from northern Arabian Sea core 63KA (Staubwasser et al. 2003); a and b are chronologically correlated after Staubwasser (2012). Area in these cores that shows large shorter term fluctuation between warmer and colder conditions has been highlighted. c δ[13]C from leaf waxes from the Godavari delta core NGHP-01-16A and the estimated % of C_4 vegetation in the Godavari catchment (Ponton et al. 2012). d Summed probability distribution of all calibrated dates from selected South Indian sites, including Bayesian statistical models (*outlined*) for the abandonment dates of Velpumudugu and the Sanganakallu site groups. e Total summed probability distribution of all South Deccan radiocarbon dates from Neolithic and Iron Age contexts in the states of Karnataka, Andhra Pradesh and northern Tamil Nadu (Dharmapuri and North Arcot districts) (see Table S9). *Grey highlight* shows the contribution of Iron Age dates (data in Fuller et al. 2007 and sources therein, augmented with Bauer et al. 2007; Morrison 2009; Johansen 2014b

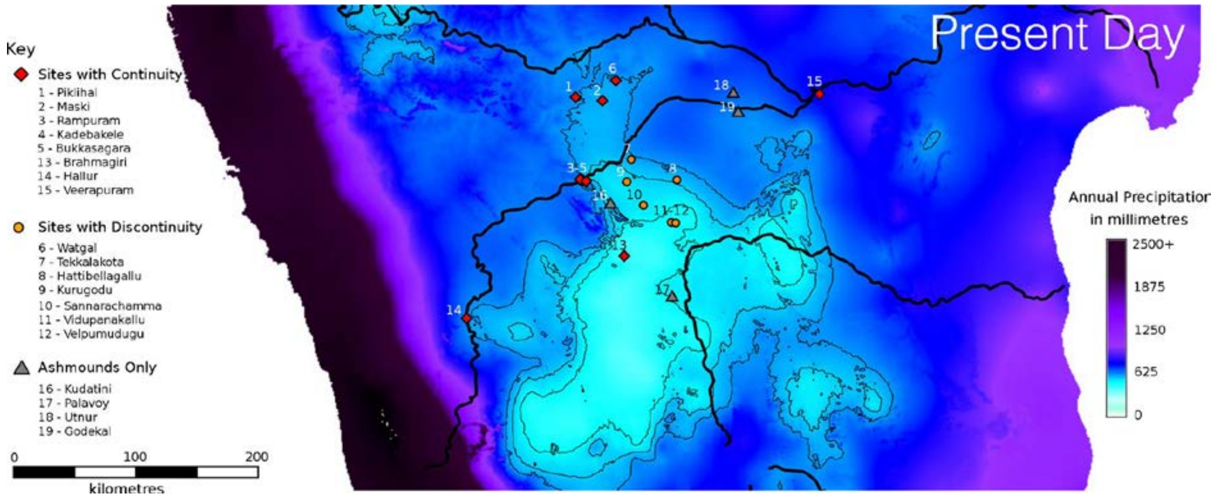

Fig. 14 Present-day annual rainfall (mm) for the Southern Deccan region. Major rivers marked by *thick black lines*. Isohyets (*thin black lines*) are marked for 500, 550 and 600 mm annual rainfall

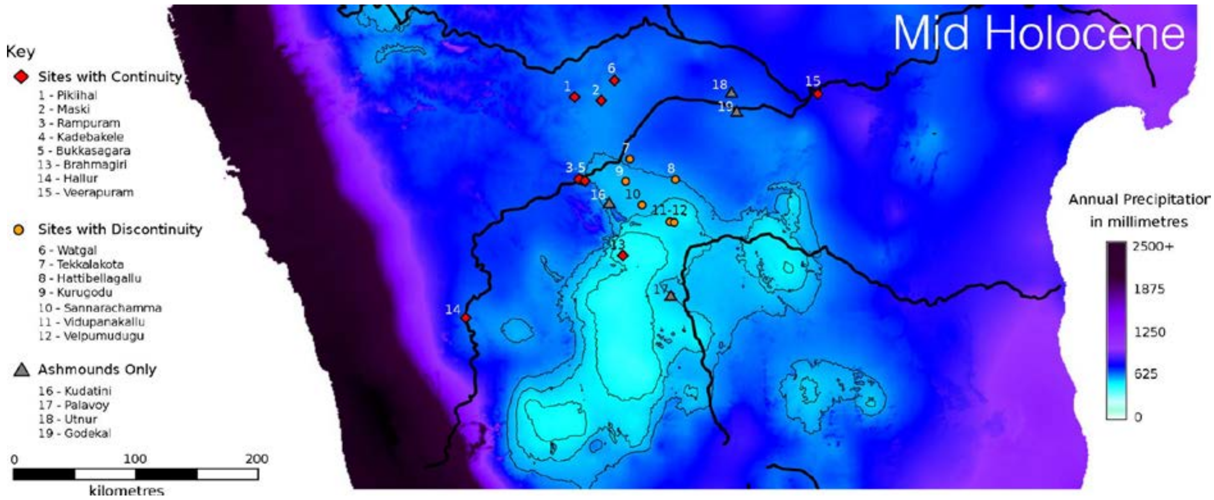

Fig. 15 Mid-Holocene (i.e. 6000 BP) annual rainfall (mm) for the Southern Deccan region. Major rivers marked by *thick black lines*. Isohyets (*thin black lines*) marked for 500, 550 and 600 mm annual rainfall

Electronic Supplementary Material for:

Settlement shifts and climatic change in the southern Indian Neolithic: growth and abandonment at Sanganakallu-Kupgal11T **from a regional environmental perspective.**

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Table S1. Archaeobotanical remains identified by phase for Sannarachamma, Sanganakallu-Kupgal complex.

	2 & 3	**4**	**5A**	**5B**
Parenchyma	45	75	12	56
Vigna	0	4	1	71
Macrotyloma	6	199	6	181
Lablab	1	0	2	869
Cajanus	0	0	0	19
Lathyrus/Vicia	0	0	0	8
Millet	2	27	0	114
Hordeum/Triticum	11	31	19	251
Fruits	25	18	6	37
Weeds	5	38	0	98
Total	95	392	46	1704

Table S2. Archaeobotanical remains identified by phase for Hiregudda, Sanganakallu-Kupgal complex.

	4	**5A**	**5B**
Parenchyma	1	38	8
Vigna	0	3	1
Macrotyloma	0	2	3
Lablab	0	0	0
Indet. legume	4	21	7
Millet	8	67	5
Hordeum/Triticum	0	4	1
Fruits	20	0	12
Weeds	5	15	2
Total	38	150	39

Table S3. Main categories of archaeobotanical remains identified by phase for Sannarachamma and Hiregudda, Sanganakallu-Kupgal complex.

	2 & 3	**4**	**5A**	**5B**
Vigna	0	4	4	72
Macrotyloma	6	199	8	184
Lablab	1	0	2	869
Millet	2	35	67	119
Hordeum/Triticum	11	31	23	252
Fruits	25	38	6	49
Weeds	5	43	15	100

Table S4. Percentage of main categories of archaeobotanical remains of total assemblage identified by phase for Sannarachamma and Hiregudda, Sanganakallu-Kupgal complex.

	2 & 3	**4**	**5A**	**5B**
Vigna	0	1	2	4
Macrotyloma	6	46	4	11
Lablab	1	0	1	50
Millet	2	8	34	7
Hordeum/Triticum	12	7	12	14
Fruits	26	9	3	3
Weeds	1	10	8	6

Table S5. Faunal remains (NISP) identified to species level by phase for Sannarachamma and Hiregudda, Sanganakallu-Kupgal complex.

Phase	**1&2**	**3**	**4**	**5A**	**5B**	**6**	**7**	**8**
Antilope cervicapra	0	1	0	33	1	0	1	17
Axis axis	0	1	0	0	0	0	0	0
Bos indicus	0	6	4	21	4	0	10	0
Boselaphus tragocamelus	0	0	2	2	0	0	1	0
Bubalus bubalis	0	0	1	4	1	1	1	0
Canis familiaris	0	0	0	0	0	0	0	1
Capra hircus	0	2	0	0	2	712	0	0
Equus asinus	0	0	0	0	0	0	0	2
Felis chaus	0	0	1	0	0	0	0	0
Lepus nigricolis	0	0	1	0	0	0	0	1
Ovis aries	0	0	2	1	1	0	0	0
Muntiacus muntjak	0	0	1	0	0	0	0	1
Sus scrofa	0	0	0	1	0	0	0	0
Tetracerus quadricornis	0	0	0	0	0	0	0	1
Vulpes bengalensis	0	0	0	0	0	0	0	1

Table S6. 'Wild' fauna identified (NISP) by phase for Sannarachamma and Hiregudda, Sanganakallu-Kupgal complex. The 'small carnivore' category is assumed to be representative of wild fauna.

Phase	**1 & 2**	**3**	**4**	**5A**	**5B**	**6**	**7**	**8**
Antilope cervicapra	0	1	0	33	1	0	1	18
Axis axis	0	1	0	0	0	0	0	0
Bird	0	0	2	11	1	0	0	0
Felis chaus	0	0	1	0	0	0	0	0
Fish	0	0	2	1	3	1	0	2
Lepus sp.	0	0	1	0	1	1	0	0
Muntiacus muntjak	0	0	1	0	0	0	0	1
Ostrich	0	0	0	0	0	0	0	15
Small carnivore	0	0	2	1	0	0	0	6
Sus scrofa	0	0	0	1	0	0	0	0
Tetracerus quadricornus	0	0	0	0	0	0	0	1
Varanus bengalensis	0	0	0	0	0	0	0	2
Vulpes bengalensis	0	0	0	0	0	0	0	1

Table S7. Faunal remains (NISP) identified as Cervids, Deer/Antilope, Bovines, Caprines or Other by phase for Sannarachamma and Hiregudda, Sanganakallu-Kupgal complex.

Phase	**1&2**	**3**	**4**	**5A**	**5B**	**6**	**7**	**8**
Cervids	0	2	3	11	14	3	0	2
Deer/Antelope	0	7	13	85	19	6	3	43
Bovines	180	211	343	1678	1268	127	72	94
Caprines	13	27	278	2748	1624	940	60	267
Other	175	1572	2233	6424	5278	619	357	798

Table S8. Faunal remains (MNI) identified as Cervids, Deer/Antilope, Bovines, Caprines or Other by phase for Sannarachamma and Hiregudda, Sanganakallu-Kupgal complex.

Phase	**1&2**	**3**	**4**	**5A**	**5B**	**6**	**7**	**8**
Cervids	0	0	0	0	0	0	0	0
Deer/Antelope	0	0	0	1	0	0	1	4
Bovines	49	12	12	15	15	7	15	8
Caprines	4	1	10	25	20	55	12	22
Other	48	86	78	59	64	37	73	66

Table S9. Table of dates used in the summed probability model of Figure 13.

Site	State	Cultural region	Cultural period	Site Phase	Material	Labcode	C14 Age	Error	Source
Radiocarbon									
VMS-110	Karnataka	Daroji Valley	Early Historic	Lv 4	Charcoal	Beta-115794	2180	40	Morrison, 2009
VMS-110	Karnataka	Daroji Valley	Early Historic	Lv 3	Charcoal	Beta-115793	2040	50	Morrison, 2009
VMS-110	Karnataka	Daroji Valley	Early Historic	Lv 5	Charcoal	Beta-131371	1980	50	Morrison, 2009
Piklihal	Karnataka	Raichur	Early Historic	03B-20	Seed. Cicer	R 28680/28	1747	30	Fuller *et al.* 2007
Sanyasula Gavi	Andhra Pradesh	Kunderu	Late/Historic	A-2	Charcoal	R 28680/32	1159	30	Fuller *et al.* 2007
Birappa	Karnataka	Bellary-Antapur	Megalithic/ Iron Age	Tr. 5 sp. 3	Charcoal	R 28680/19	3031	30	Boivin *et al.* 2005
Birappa	Karnataka	Bellary-Antapur	Megalithic/ Iron Age	Tr. 5 sp. 8	Charcoal	R 28680/21	2032	30	Boivin *et al.* 2005
Halingali	Andhra Pradesh	Kurnool	Megalithic/ Iron Age	Megalithic	Charcoal	TF-685	1970	95	Moorti, 1994
Satanikota	Andhra Pradesh	Kurnool	Megalithic/ Iron Age	Megalithic	Charcoal	BS 201	1620	100	Moorti, 1994
Satanikota	Andhra Pradesh	Kurnool	Megalithic/ Iron Age	Megalithic	Charcoal	BS 202	1440	100	Moorti, 1994
Satanikota	Andhra Pradesh	Kurnool	Megalithic? (intrusive)	Megalithic?	Charcoal	BS 203	7520	140	Moorti, 1994
Satanikota	Andhra Pradesh	Kurnool	Megalithic? (intrusive)	Megalithic?	Charcoal	BS 204	8960	120	Moorti, 1994
Veerapuram	Andhra Pradesh	Kurnool	Megalithic/ Iron Age	Tr. B. L. 9, 1.7m	Charcoal	PRL 725	2007	144	Sastri *et al.* 1984; Agrawal 2002
Veerapuram	Andhra Pradesh	Kurnool	Megalithic/ Iron Age	Tr. C13, L. 12, 3.0	Charcoal	PRL 728	2871	144	Sastri *et al.* 1984; Agrawal 2002
Veerapuram	Andhra Pradesh	Kurnool	Megalithic/ Iron Age	Tr. B14, L. 14, 3.1	Charcoal	PRL 729	2833	150	Sastri *et al.* 1984; Agrawal 2002
Veerapuram	Andhra Pradesh	Kurnool	Megalithic/ Iron Age	L. 10, 2.3m	Charcoal	PRL 727	2094	144	Sastri *et al.* 1984; Agrawal 2002
Hatti gold mine	Karnataka	Raichus	Megalithic/ Iron Age		Charcoal	PRL-253	2630	150	Moorti, 1994
Hallur	Karnataka	Upper Tungabhadra	Iron Age	98B	Seed Macrotyloma	BA04393	2835	30	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Iron Age	9&B	Seed. Gossypium	R 28680/31	2709	30	Fuller *et al.* 2007

Bukkasagara	Karnataka	Vijayanagara	Iron Age	Ashy dung	Charcoal	Beta-200520	2930	40	Johansen, 2014b
Bukkasagara	Karnataka	Vijayanagara	Iron Age	Iron working	Charcoal	Beta-2775742	2960	40	Johansen, 2014b
Bukkasagara	Karnataka	Vijayanagara	Iron Age	Iron working	Charcoal	Beta-277575	2930	40	Johansen, 2014b
Kadebakele	Karnataka	Vijayanagara	Iron Age	B Feature 12	Charcoal	[2005-7]P[1]	2430	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	B Feature 13	Charcoal	[2005-5]P[1]	2550	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	B Feature 7	Charcoal	[2003-9]P[1]	2620	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	B Level 15	Charcoal	[2003-7]P[1]	2770	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	B Level 5	Charcoal	[2005-6]P[1]	2400	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	B Level 9	Charcoal	[2003-6]P[1]	2360	60	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	B top Feature 7	Charcoal	[2003-8]P[1]	2530	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	NM Level 10	Charcoal	[2003-2]P[1]	2600	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	NM Level 20	Charcoal	[2003-4]P[1]	2540	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	NM Level 27	Charcoal	[2003-3]P[1]	2590	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	NM Level 6	Charcoal	[2003-1]P[1]	2520	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	SS Feature 3	Charcoal	[2005-2]P[1]	2530	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	SS Level 10	Charcoal	[2005-1]P[1]	2520	40	R. Bauer, 2006
Kadebakele	Karnataka	Vijayanagara	Iron Age	SS Level 23	Charcoal	[2005-3]P[1]	2490	40	R. Bauer, 2006
Polakonda	Andhra Pradesh	Warangal District	Megalithic	Megalithic	Charcoal	BS-97	2045	90	Moorti 1994
T. Narsipur	Karnataka	Southern Karnataka	Megalithic?	Intrusive	Charcoal	TF-414	220	90	Moorti 1994
Birappa	Karnataka	Bellary-Anatapur	Mesolithic	Tr. 5 sp. 7	Charcoal	R 28680/20	4639	35	Boivin *et al.* 2005
Birappa	Karnataka	Bellary-Anatapur	Mesolithic	Tr. 5 sp. 4	Charcoal	R 28680/22	5469	35	Boivin *et al.* 2005
Birappa	Karnataka	Bellary-Anatapur	Mesolithic	Tr. 2	Charcoal	R 28680/23	9626	40	Boivin *et al.* 2005
Huli Kallu	Andhra Pradhes	Anantapur	Neolithic	Tr. 4, L. 5, 0.97m	Charcoal	PRL-633	2886	150	Agrawal *et al.* 1985
Hattibelagallu	Andhra Pradesh	Bellary-Anatapur	Neolithic	98C-3	Seed. Macrotyloma	BA05778	3475	40	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	4	Seed. Lablab	R 28680/16	3235	30	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	4	Seed. Hordeum	R 28680/17	3382	35	Fuller *et al.* 2007

Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	4	Seed. Macrotyloma	R 28680/18	3250	30	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	4	Charcoal	R 28680/7	3371	35	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	4	Charcoal	R 28680/9	3433	35	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	5A	Charcoal	BA04392	3340	30	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	5A	Charcoal	R 28680/10	3314	30	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	5A	Charcoal	R 28680/11	3346	30	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	5A	Seed. Triticum	R 28680/15	3282	35	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	5B	Charcoal	R 28680/12	3027	30	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-AnatapuSeed. r	Neolithic	5B	Charcoal	R 28680/13	3019	40	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	5B	Seed. Lablab	R 28680/14	3058	30	Fuller *et al.* 2007
Hiregudda	Karnataka	Bellary-Anatapur	Neolithic	5B	Charcoal	R 28680/8	3042	30	Fuller *et al.* 2007
Kurugudu	Karnataka	Bellary-Anatapur	Neolithic	98A-6	Seed. Hordeum	BA05780	3390	40	Fuller *et al.* 2007
Palavoy	Andhra Pradesh	Bellary-Anatapur	Neolithic		Charcoal	TF 700	3390	95	Rami Reddy 1976
Palavoy	Andhra Pradesh	Bellary-Anatapur	Neolithic		Charcoal	TF 701	3805	100	Rami Reddy 1976
Sannarachamma	Karnataka	Bellary-Anatapur	Neolithic	2	Seed. Ziziphus	BA04391	3550	30	Fuller *et al.* 2007
Sannarachamma	Karnataka	Bellary-Anatapur	Neolithic	2	Seed. Triticum	R 28680/4	3550	40	Fuller *et al.* 2007
Sannarachamma	Karnataka	Bellary-Anatapur	Neolithic	3	Seed. Hordeum	R 28680/3	3536	30	Fuller *et al.* 2007
Sannarachamma	Karnataka	Bellary-Anatapur	Neolithic	3	Charcoal	TF 354	3440	100	Fuller *et al.* 2007
Sannarachamma	Karnataka	Bellary-Anatapur	Neolithic	3	Charcoal	TF 355	3435	100	Fuller *et al.* 2007
Sannarachamma	Karnataka	Bellary-Anatapur	Neolithic	3	Charcoal	TF 359	3400	100	Fuller *et al.* 2007
Sannarachamma	Karnataka	Bellary-Anatapur	Neolithic	4	Charcoal	R 28680/2	3441	30	Fuller *et al.* 2007
Sannarachamma	Karnataka	Bellary-Anatapur	Neolithic	4	Seed. Hordeum	R 28680/6	3361	40	Fuller *et al.* 2007
Sannarachamma	Karnataka	Bellary-Anatapur	Neolithic	5B	Seed. Lablab	BA05775	3105	40	Fuller *et al.* 2007

Sannaracham ma	Karnataka	Bellary-Anatapur	Neolithic	5B	Seed. Hordeu m	BA05776	3125	40	Fuller *et al.* 2007
Sannaracham ma	Karnataka	Bellary-Anatapur	Neolithic	5B	Seed. Lablab	R 28680/1	2973	35	Fuller *et al.* 2007
Sannaracham ma	Karnataka	Bellary-Anatapur	Neolithic	5B	Seed. Lablab	R 28680/5	3042	40	Fuller *et al.* 2007
Tekkalakota	Karnataka	Bellary-Anatapur	Neolithic	98A-3	Seed. Vigna radiate	BA05779	3430	45	Fuller *et al.* 2007
Tekkalakota	Karnataka	Bellary-Anatapur	Neolithic	98B-2W	Seed. Macroty loma	BA05784	3545	80	Fuller *et al.* 2007
Tekkalakota	Karnataka	Bellary-Anatapur	Neolithic	98D-2	Seed. Macroty loma	BA05781	3415	40	Fuller *et al.* 2007
Tekkalakota	Karnataka	Bellary-Anatapur	Neolithic	98D-5	Seed. Ziziphus	BA05782	3510	60	Fuller *et al.* 2007
Tekkalakota	Karnataka	Bellary-Anatapur	Neolithic		Charcoa l	TF 237	3465	105	Nagaraja Rao and Malhotra 1965; Possehl and Rissman 1992
Tekkalakota	Karnataka	Bellary-Anatapur	Neolithic		Charcoa l	TF 239	3395	105	Nagaraja Rao and Malhotra 1965; Possehl and Rissman 1992
Tekkalakota	Karnataka	Bellary-Anatapur	Neolithic		Charcoa l	TF 262	3460	135	Nagaraja Rao and Malhotra 1965; Possehl and Rissman 1992
Tekkalakota	Karnataka	Bellary-Anatapur	Neolithic		Charcoa l	TF 266	3625	100	Nagaraja Rao and Malhotra 1965; Possehl and Rissman 1992
Velpumudug u	Andhra Pradesh	Bellary-Anatapur	Neolithic	03A-2	Seed. Ziziphus	R 28680/25	2974	30	Fuller *et al.* 2007
Velpumudug u	Andhra Pradesh	Bellary-Anatapur	Neolithic	03A-3	Seed. Macroty loma	R 28680/24	3029	35	Fuller *et al.* 2007
Terdal	Karnataka	Bijapur	Neolithic		Charcoa l	TF 683	3615	120	Possehl and Rissman 1992

Terdal	Karnataka	Bijapur	Neolithic		Charcoal	TF 684	3775	95	Possehl and Rissman 1992
VMS-110	Karnataka	Daroji Valley	Neolithic	Lv. 13	Charcoal	Beta-124328	3880	40	Morrison, 2009
VMS-110	Karnataka	Daroji Valley	Neolithic	Lv. 7	Charcoal	Beta-131370	3780	50	Morrison, 2009
VMS-110	Karnataka	Daroji Valley	Neolithic	Lv. 8	Charcoal	Beta-124327	3850	40	Morrison, 2009
Hanumanta-raopeta	Andhra Pradesh	Kunderu	Neolithic	97. 1-3	Seed. Hordeum	BA04394	3295	30	Fuller *et al.* 2007
Hanumanta-raopeta	Andhra Pradesh	Kunderu	Neolithic	97. 1-3	Seed. Macrotyloma	R 28680/34	3259	40	Fuller *et al.* 2007
Hanumanta-raopeta	Andhra Pradesh	Kunderu	Neolithic	97. 1-5	Seed. Vigna radiate	R 28680/35	3374	35	Fuller *et al.* 2007
Hanumanta-raopeta	Andhra Pradesh	Kunderu	Neolithic	97. 1-6	Seed. Vigna radiata	R 28680/36	3365	30	Fuller *et al.* 2007
Peddamudiyam	Andhra Pradesh	Kunderu	Neolithic		Charcoal	BS 758	3059	120	Venkatasuah *et al.* 1992
Peddamudiyam	Andhra Pradesh	Kunderu	Neolithic		Charcoal	BS 811	3391	90	Venkatasuah *et al.* 1992
Ramapuram	Andhra Pradesh	Kunderu	Neolithic	Tr. XA 0.5m	Charcoal	PRL-761	690	110	Agrawal 2002
Ramapuram	Andhra Pradesh	Kunderu	Neolithic	Tr. XB, L. 5, 0.9m	Charcoal	PRL-762	3800	110	Agrawal *et al.* 1985
Ramapuran	Andhra Pradesh	Kunderu	Neolithic	Tr. XB	Charcoal	PRL-768	855	130	Agrawal *et al.* 1985
Ramapuram	Andhra Pradesh	Kunderu	Neolithic		Charcoal	BS 383	3187	110	Agrawal 2002
Ramapuram	Andhra Pradesh	Kunderu	Neolithic		Charcoal	BS 386	3231	105	Agrawal 2002
Sanyasula Gavi	Andhra Pradesh	Kunderu	Neolithic	B-5	Seed. Ziziphus	BA04397	3505	40	Fuller *et al.* 2007; Petraglia *et al.* 2009
Sanyasula Gavi	Andhra Pradesh	Kunderu	Neolithic	B-5	Seed. Vigna radiata	R 28680/33	3616	35	Fuller *et al.* 2007; Petraglia *et al.* 2009
Veerapuram	Andhra Pradesh	Kunderu	Neolithic	Tr. B15, L. 15, 3.4	Charcoal	PRL 730	3153	144	Sastri *et al.* 1984; Agrawal 2002
Veerapuram	Andhra Pradesh	Kunderu	Neolithic		Charcoal	PRL 728	2871	144	Sastri *et al.* 1984; Agrawal 2002

Veerapuram	Andhra Pradesh	Kunderu	Neolithic		Charcoal	PRL 729	2833	144	Sastri *et al.* 1984; Agrawal 2002
Piklihal	Karnataka	Raichur	Neolithic	03B-100	Seed. Macrotyloma	BA05771	3405	45	Fuller *et al.* 2007
Piklihal	Karnataka	Raichur	Neolithic	03B-100	Seed. Lens	BA05772	3445	40	Fuller *et al.* 2007
Piklihal	Karnataka	Raichur	Neolithic	03B-130	Seed. Ziziphus	BA05773	3460	40	Fuller *et al.* 2007
Piklihal	Karnataka	Raichur	Neolithic	03B-130	Seed. Triticum	R 28680/27	3441	30	Fuller *et al.* 2007
Piklihal	Karnataka	Raichur	Neolithic	03B-50	Seed. Macrotyloma	BA05774	3435	40	Fuller *et al.* 2007
Piklihal	Karnataka	Raichur	Neolithic	03B-70	Seed. Macrotyloma	BAO5770	3430	40	Fuller *et al.* 2007
Piklihal	Karnataka	Raichur	Neolithic	03D-4	Seed. Macrotyloma	R 28680/26	3366	30	Fuller *et al.* 2007
Utnur	Andhra Pradesh	Raichur	Neolithic	I	Charcoal	BM-54	4120	150	Allchin 1963
Utnur	Andhra Pradesh	Raichur	Neolithic	II	Charcoal	TF 167	3890	110	Allchin 1963
Utnur	Andhra Pradesh	Raichur	Neolithic	III	Charcoal	TF 168	3875	110	Allchin 1963
Watgal	Karnataka	Raichur	Neolithic	IIA	Charcoal	PRL-1575	4227	100	Deveraj *et al.* 1995
Watgal	Karnataka	Raichur	Neolithic	IIA	Charcoal	PRL-1576	3926	90	Deveraj *et al.* 1995
Watgal	Karnataka	Raichur	Neolithic	IIA	Charcoal	PRL-1581	3877	40	Deveraj *et al.* 1995
Watgal	Karnataka	Raichur	Neolithic	IIB	Charcoal	PRL-1580	3411	100	Deveraj *et al.* 1995
Watgal	Karnataka	Raichur	Neolithic	IIB	Charcoal	PRL-1584	3800	60	Deveraj *et al.* 1995
Watgal	Karnataka	Raichur	Neolithic	IIB	Charcoal	PRL-1586	2769	100	Deveraj *et al.* 1995
Watgal	Karnataka	Raichur	Neolithic	IIB	Charcoal	PRL-1589	4033	50	Deveraj *et al.* 1995
Budihal	Karnataka	Shorapur	Neolithic	Ashmound	Charcoal	BM-2886	3810	50	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Ashmound	Charcoal	BM-2887	3880	60	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Ashmound	Charcoal	GrN-19661	3795	30	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Ashmound	Charcoal	GrN-19662	3805	50	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Ashmound	Charcoal	GrN-19663	3795	40	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Ashmound	Charcoal	PRL-1531	4610	140	Kusumgar and Yadava

									1997; Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Butchery floor	Charcoal	GrA-2483	3770	60	Paddayya *et al.* 1995
Budihal	Karnataka	Shorapur	Neolithic	Butchery floor	Charcoal	GrA-2489	3810	50	Paddayya *et al.* 1995
Budihal	Karnataka	Shorapur	Neolithic	Butchery floor	Charcoal	GrN 19981	3820	45	Paddayya *et al.* 1995
Budihal	Karnataka	Shorapur	Neolithic	Habitation	Charcoal	PRL-1530	2250	140	Kusumgar and Yadava 1997
Budihal	Karnataka	Shorapur	Neolithic	Village L.2	Charcoal	GrA 2484	3600	60	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Village L.2	Charcoal	GrA 2488	3600	60	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Village L.2	Charcoal	GrA 2504	3730	50	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Village L.2	Charcoal	GrA 250640	3610	50	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Village L.2	Charcoal	GrN 19978	3370	40	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Village L.2	Charcoal	GrN 19979	3470	40	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Village L.2	Charcoal	GrN 19980	3750	35	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Village L.3	Charcoal	GrA 2486	3830	60	Paddayya 2001; 2002
Budihal	Karnataka	Shorapur	Neolithic	Village L.3	Charcoal	GrA 2487	3850	60	Paddayya 2001; 2002
Kodekal Ashmound	Karnataka	Shorapur	Neolithic		Charcoal	TF 748	4285	105	Paddayya, 1973
Hallur	Karnataka	Upper Tungabhadra	Neolithic	00+30cm	Seed. Macrotyloma	R 28680/29	3221	30	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Neolithic	00+50cm	Seed. Lablab	R 28680/30	3154	30	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Neolithic	98A-7	Seed. Lablab	BA04499	3300	40	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Neolithic	98A-8	Seed. Macrotyloma	BA05777	3435	40	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Neolithic		Charcoal	TF 570	2970	105	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Neolithic		Charcoal	TF 573	2820	100	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Neolithic		Charcoal	TF 575	2895	100	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Neolithic		Charcoal	TF 576	3280	105	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Neolithic		Charcoal	TF 580	3560	105	Fuller *et al.* 2007
Hallur	Karnataka	Upper Tungabhadra	Neolithic		Charcoal	TF 586	3055	95	Fuller *et al.* 2007

Bukkasagara	Karnataka	Vijayanagara	Neolithic	Pre-Iron	Charcoa l	Beta-277573	3250	40	Johansen, 2014b
Polakonda	Andhra Pradesh	Warangal District	Neolithic	Neolithic	Charcoa l	BS-98	3255	120	Krishna-murthy 1990
Banahalli	Karnataka	Southern Karnataka	Neolithic		Charcoa l	PRL 1674	3440	60	Krishna-murthy 1990
Banahalli	Karnataka	Southern Karnataka	Neolithic		Charcoa l	PRL 1675	4780	70	Krishna-murthy 1990
T. Narsipur	Karnataka	Southern Karnataka	Neolithic		Charcoa l	TF 412	3645	105	Sesahdri 1971; Possehl and Rissman 1992
T. Narsipur	Karnataka	Southern Karnataka	Neolithic		Charcoa l	TF 413	3345	105	Sesahdri 1971; Possehl and Rissman 1992
Togarapalli	Tamil Nadu	Dharmapuri	Iron Age			PRL-134	2180	100	Moorti, 1994
Togarapalli	Tamil Nadu	Dharmapuri	Iron Age			PRL-135	2150	100	Moorti, 1994
Palyampalli	Tamil Nadu	N. Arcot	Neolithic		Charcoa l	TF 349	3340	100	Moorti, 1994; Agrawal, 1982
Palyampalli	Tamil Nadu	N. Arcot	Neolithic		Charcoa l	TF 827	3570	105	Moorti, 1994; Agrawal, 1982
Palyampalli	Tamil Nadu	N. Arcot	Neolithic		Charcoa l	TF 833	3215	210	Agrawal, 1982
Palyampalli	Tamil Nadu	N. Arcot	Megalithic?			TF 824	785	90	Moorti, 1994
Palyampalli	Tamil Nadu	N. Arcot	Megalithic?			TF 825	695	95	Moorti, 1994
Palyampalli	Tamil Nadu	N. Arcot	Megalithic			TF 823	2515	100	Moorti, 1994
Palyampalli	Tamil Nadu	N. Arcot	Megalithic			TF 828	2100	95	Moorti, 1994
Korkai	Tamil Nadu	Toothukudi District	Megalithic			TF-987	2605	90	Moorti, 1994
Nagarjuna-konda	Andhra Pradesh	Guntur District	Not Neolithic?	Gr. 8, Skelton 10	Human bones	TF-74	1900	985	Subramany am*et al.* 1975 pp. 213
Nagarjuna-konda	Andhra Pradesh	Guntur District	Not Neolithic?	Gr. 5 Sk. 7	Human bones	TF-63B	1750	100	Subramany am*et al.* 1975 pp. 213

Nagarjuna-konda	Andhra Pradesh	Guntur District	Not Neolithic?	Site 46 V/36	Animal bones	TF-30	1535	95	Subramanyam *et al.* 1975 pp. 213
Nagarjuna-konda	Andhra Pradesh	Guntur District	Not Neolithic?	Gr. 6, Sk. 8	Human bones	TF-72	1525	95	Subramanyam *et al.* 1975 pp. 213
Nagarjuna-konda	Andhra Pradesh	Guntur District	Not Neolithic?	Gr. 4, Sk. 6	Human bones	TF-73	1495	105	Subramanyam *et al.* 1975 pp. 213
Thermoluminescence									
Kumarahalli	Karnataka		Megalithic		Pottery	PRL-TL-46	3300	100	Singhvi *et al.* 1991
Kumarahalli	Karnataka		Megalithic		Pottery	PRL-TL-47	3360	300	Singhvi *et al.* 1991
Kumarahalli	Karnataka		Megalithic		Pottery	PRL-TL-47	3180	280	Singhvi *et al.* 1991
Kumarahalli	Karnataka		Megalithic		Pottery	PRL-TL-49	3110	500	Singhvi *et al.* 1991
Kumarahalli	Karnataka		Megalithic		Pottery	PRL-TL-49	2910	470	Singhvi *et al.* 1991
Kumarahalli	Karnataka		Megalithic		Pottery	PRL-TL-50	3420	290	Singhvi *et al.* 1991
Kumarahalli	Karnataka		Megalithic		Pottery	PRL-TL-50	3080	260	Singhvi *et al.* 1991

1. These dates are listed in Bauer 2006 without labcodes. They are listed as reported by sample submission codes.

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