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Lithic technology and social transformations in the South Indian Neolithic: The evidence from Sanganakallu–Kupgal

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ABSTRACT

Here we examine patterns in stone tool technology among Mesolithic, Neolithic and Iron Age localities in the Sanganakallu–Kupgal site complex, Bellary District, Karnataka, South India. Statistical tests are used to compare proportions of raw materials and artefact types, and to compare central tendencies in metric variables taken on flakes and tools. Lithic-related findings support the inference of at least two distinct technological and economic groups at Sanganakallu–Kupgal, a microlith-focused foraging society on the one hand, and on the other, an agricultural society whose lithic technologies centred upon the production of pressure bladelets and dolerite edge-ground axes. Evidence for continuity in lithic technological processes through time may reflect indigenous processes of development, and a degree of continuity from the Mesolithic through to the Neolithic period. Lithic production appears to have become a specialised and spatially segregated activity by the terminal Neolithic and early Iron Age, supporting suggestions for the emergence of an increasingly complex economy and political hierarchy.

Introduction

The Neolithic period inaugurates a number of profound changes in technology and human materiality (e.g. Childe, 1936; Wengrow, 1998; Boivin, 2008), with the introduction of new approaches to the landscape for food production, new uses of clay, for example in creating pottery and houses, and new techniques of lithic production, notably groundstone. In recent years the regional manifestations of Neolithic traditions in India have been defined largely on the basis of differing agricultural repertoires, as well as variations in ceramic assemblages and settlement patterns (Fuller, 2006, 2008a). It has been argued that in a few different regions of South Asia, plants were separately domesticated, with the implication that there may have parallel but independent developments of Neolithic cultural traditions. These Neolithic transitions remain, however, to be better documented in terms of their material culture components. One of the regions now suggested to have been an independent centre of Neolithic developments in South Asia is the Southern Deccan (Korisettar et al., 2001a,b; Boivin et al., 2008; Fuller, 2009), and here we explore in more detail some of the region's associated material remains.

Continuities or discontinuities in the material repertoire of Neolithic groups contribute to wider debates about the proximate causes of the spread of agriculture, whether by internal social evolution and adoption, or by the immigration of farmers. Recent debates in European Neolithic studies, for example, highlight these alternatives (e.g. Thorpe, 1996; Thomas, 1996; Ammerman and Cavalli-Sforza, 1984; Bogucki, 1988; Price, 2000; Whittle, 1996). Such debates are replicated for multiple regions, and at the global level, authors such as Bellwood (2005) have postulated a greater predominance of processes of migration, and therefore emphasised breaks in cultural traditions after the Mesolithic (see also), while others such as Barker (2006) have placed a greater emphasis on continuities, parallel origins and adoptions. What is needed to assess these models of displacement versus acculturation are more detailed studies of material culture typology and production practices in Neolithic cultures across a range of regions. The present paper makes such a contribution through a detailed quantitative assessment of the lithic assemblages from a set of key sites in south India that span the Mesolithic, Neolithic and post-Neolithic periods.

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Elsewhere in South Asia, the material remains of Neolithic traditions can be seen to contrast with preceding or contemporary cultures thought to represent hunter-gatherers. For example, in the Middle Ganges region, the first ceramics at the site of Lahuradewa as early as ca. 7000 BC accompany very limited lithic toolkits, notably lacking in groundstone technology (Tewari et al., 2005; Tewari et al., 2008), and are associated with the earliest precursors of rice cultivation in South Asia (see Fuller, 2009; Fuller et al., 2010). Contemporary with this and elsewhere in the Ganges plains were apparently aceramic hunter-gatherers who produced complex geometric microliths. In subsequent millennia, up to the third millennium BC, trade between "Mesolithic" hunter-gatherers and "Neolithic" farmers has been postulated, in part based on lithic raw material distributions (Lukacs, 2002). In the northwestern subcontinent, the initially aceramic Neolithic of Mehrgarh differs from the poorly dated Mesolithic sites in the region, not just in subsistence evidence but in terms of the introduction of extensive rectilinear mudbrick architecture, anthropomorphic clay figurines and the use of groundstone artefacts (see Possehl, 1999; Jarrige et al., 2006; Jarrige, 2008). In both cases, the findings suggest culturally distinctive Neolithic traditions that over time displaced or absorbed hunter-gatherers neighbours.

An open question is the extent to which such a clear distinction between the technology of the Neolithic and its Mesolithic precursors is evident in South India, and whether Mesolithic populations or technologies were entirely displaced. Some earlier commentators have suggested that there might have been generally continuity in the microlithic traditions between the Mesolithic and the Neolithic in South India, with the addition of ceramics and domesticates providing the major cultural distinctions (e.g. Devaraj et al. 1995; Korisettar et al. 2001a, p. 177) At the same time, similarities in the blade forms from the Southern Neolithic as well as the northern Indian Peninsula at this period have been taken as evidence of a shared lithic tradition distinct from those elsewhere such as the Indus Valley (Subbarao, 1955). Postulated population movements of pastoralist, ceramic-making groups speaking early Dravidian languages (Southworth, 2006; Fuller, 2007, 2009) could also relate to the introduction of new stone tool making techniques. Thus the role of local evolution versus introduction of lithic production techniques remains uncertain for South India, and in need of investigation through more detailed and systematic lithic studies across a range of sites.

The Sanganakallu–Kupgal site complex

Sanganakallu–Kupgal is a complex of Mesolithic, Neolithic and Megalithic period localities located 6 km north-east of the town of Bellary, in the state of Karnataka, South India. Some of the localities have been known since the nineteenth century (Foote, 1887) and are among the most important of the Indian Southern Neolithic tradition (Subbarao, 1948; Boivin et al., 2008). Lithic artefacts have been retrieved and studied in previous excavations at the site complex (Subbarao, 1948; Sankalia, 1969).

The South Indian Neolithic is characterised by hand-made pottery, groundstone axes and monumental features of burnt cowdung known as ashmounds (Wheeler, 1948; Korisettar et al., 2001a,b; Johansen, 2004). The South Indian Neolithic sites are found in the upper reaches of the Krishna River and its tributaries the Bhima, the Tungabhadra and the Hagari rivers, where an Archaean granite basement rock has weathered produces red sandy soil good for pastoralism and seasonal agriculture (Allchin, 1963). The sites themselves, including the Sanganakallu–Kupgal complex, are often located around and on top of hills formed of residual granite boulders. The granite hills around Bellary and the sites within them are currently being destroyed by quarrying activities. The material on which this article is based was recovered during rescue excavations conducted by the joint India–UK initiative known as the Sanganakallu–Kupgal Project (Boivin et al., 2005; Boivin et al., 2007; Fuller et al., 2007). Previous lithic-oriented publications of the Sanganakallu–Kupgal Project have focussed on the dolerite axe manufacturing industry (Brumm et al., 2007; Risch et al., 2009, 2011). The goal of the present work was to build on the findings of these lithic studies and to present new data through statistical analyses of the microlith and dolerite axe production assemblages from Sanganakallu–Kupgal. We thereby hope to move beyond focussed studies of particular artefact types and to examine lithics within the framework of broader questions about the nature of Southern Neolithic societies and the transition to a settled and agricultural lifeway in the region.

There are four main zones within the Sanganakallu–Kupgal complex, each containing one or more archaeological locales (Fig. 1): Hiregudda, the largest hill in the complex, which includes several Neolithic locales at the top of the hill, on its slopes and at its base; Choudammagudda, a hill 0.5 km to the south of Hiregudda containing a small ashmound locale at the summit; Sannarachamma, a hill 1 km to the south-west of Hiregudda containing a larger ash-mound locale on the plateau at the top; and Birappa, a rockshelter with rock art and microliths located 1 km to the north of Hiregudda (Boivin et al., 2002, 2005, 2007). More than 800,000 lithic artefacts were recovered by the Sanganakallu–Kupgal Project making this one of the largest excavated lithic assemblages in South Asia. Samples from selected contexts were classified according to typology and raw material, and chi-square tests were used to compare the proportions of these variables between periods and assemblages. A small sub-sample of artefacts was selected for detailed metric analysis, and because the data are not normally distributed, we use the non-parametric Mann–Whitney *U* test to compare central tendencies in this dataset. The chipped stone artefacts at Sanganakallu–Kupgal may be divided into two principle types: microliths made from a variety of raw materials including quartz, chert and chalcedony, and manufacturing debris relating to the production and use of dolerite groundstone axes. In this article we will discuss the lithic composition of the four localities outlined above and then make comparisons between the assemblages. We attempt to elucidate patterns in subsistence and exchange by examining the rock types exploited and the types of artefacts produced at different localities and in different periods across the Sanganakallu–Kupgal complex. We also aim to use patterns in lithic technology to explore the social transformations that occurred with the emergence of agro-pastoralism and social complexity in South India.

Sannarachamma

The Sannarachamma site is an ashmound and habitation locality located on the level summit of a granite inselberg, rising 50 m above the surrounding plain (Fig. 1). The attraction of inselbergs for occupation during the Neolithic may in part be explained by the presence of perennial springs: during the mid to late Holocene when the water table was higher, the dolerite dykes criss-crossing the granite inselbergs would have formed a barrier to ground water giving rise to springs where the dykes protruded on the surface (Boivin et al., 2005). On the north slope of Sannarachamma hill is a natural reservoir formed where an eroded vein of dolerite is enclosed within granite blocks. Inselbergs such as Sannarachamma also offer the natural fortifications of their granite boulder formations, as well as commanding views of people and animals on the surrounding plain (Foote, 1887; Fuller, 1999; Boivin, 2004).

Sannarachamma was originally excavated in the middle of the 20th century, when a hilltop village and ashy layer were reported

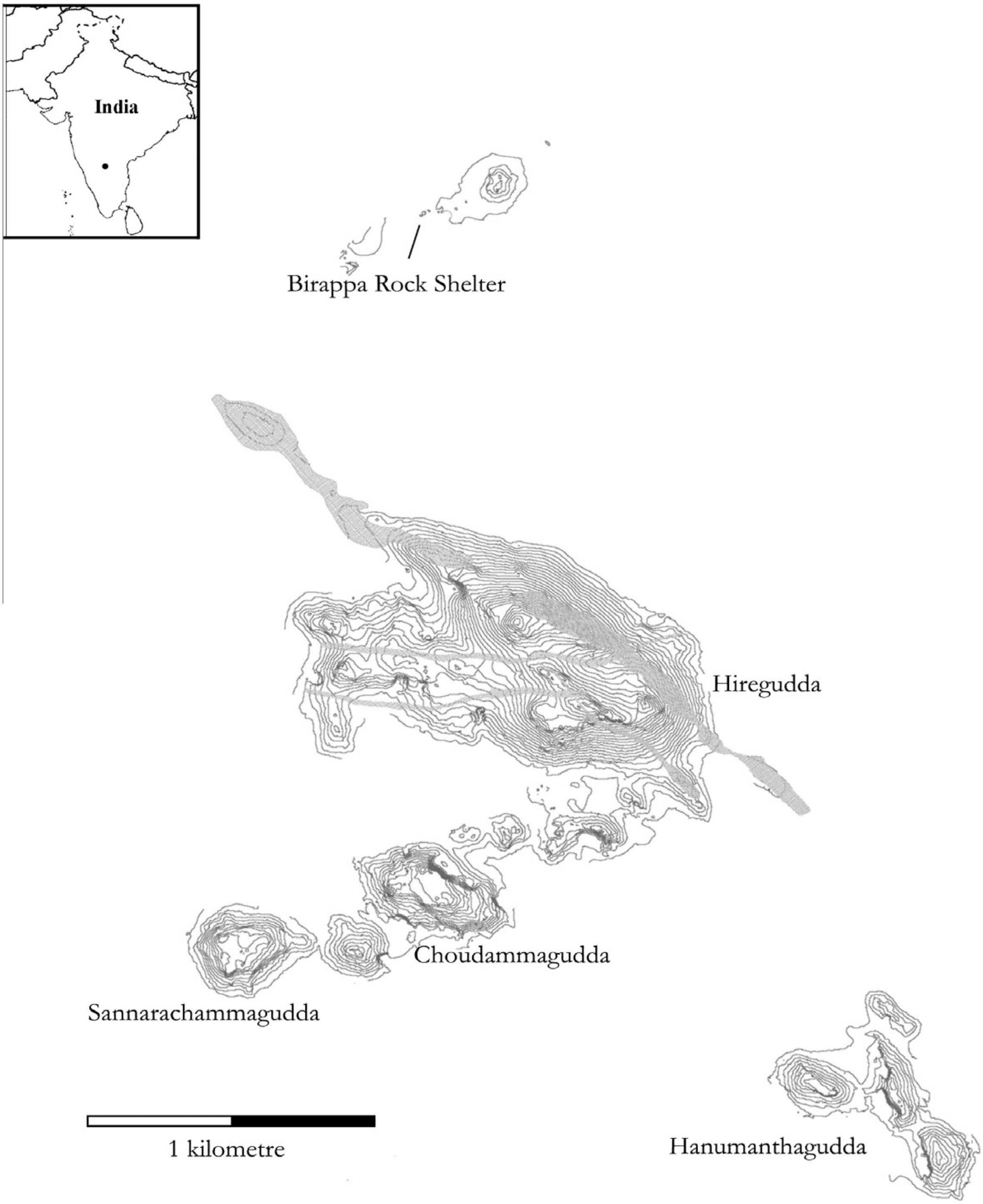

Fig. 1. Contour map of the Sanganakallu–Kupgal complex and its location in India.

on top of the hill (Subbarao, 1948; Ansari and Nagaraja Rao, 1969). Re-investigation by the Sanganakallu–Kupgal Project has led to the identification of an extensive ashmound covering much of the hilltop, which is sealed beneath later archaeological occupation deposits (Boivin et al., 2005). This site has produced one of the richest archaeobotanical assemblages in Neolithic South India, contributing to a regional picture of agricultural development and landuse (Fuller et al., 2004; Asouti and Fuller, 2008). It has a chronology well-constrained by stratified AMS-radiocarbon dates (Fuller et al., 2007), which has contributed to the identification of five main phases of occupation at Sannarachamma (Table 1): (1) A pre-ashmound Mesolithic occupation. (2) An initial ashmound formation phase dated to 1950 BC. (3) An ashmound expansion phase dated from 1850 to 1700 BC, during which the site became permanently occupied. (4) A post-ashmound habitation phase (1700–1400 BC). (5) A final Megalithic phase from 1400 BC, with the site eventually abandoned perhaps as late as 1000 BC. This chronology of initial ashmound formation pre-dating the establishment of permanent settlement is replicated across the Deccan plateau at sites where ashmounds and villages co-occur, (Fuller et al., 2007). Ashmounds are now understood to have been formed through the burning of large quantities of cow-dung, often in extremely hot fires. At the base of some excavated ashmounds, for example at Utnur, Hulikallu, and Budihal-S, there are constructed

Table 1
Chronology of the sites used in this study.

		Sannarachamma	Hiregudda	Other sites
Mesolithic	9000–3400 BC	Lowest aceramic level. Intermittent occupation		Birappa: some rock art and microliths
	3400–1950 BC	Hiatus?		
Neolithic	1950–1850 BC	Initial Ashmound		
	1850–1700 BC	Main Ashmound Possible Village	Area A Ashmound	Early Choudammagudda
	1700–1400 BC	Post-Ashmound Village occupation	Post-Ashmound Area A village	Upper Choudamagudda
	1500–1400 BC		Area A hiatus?	
	1400–1300 BC	Digging of storage(?) pits into ashmound	Area A axe factory	
Late Neolithic	1300–1200 BC?	Late village occupation	Hirregudda Area D, stone terraces and urn burials	Re-use of Birappa
	>1200/1100 BC?	Terminal hilltop village and abandonment		Earliest megalithic burials?
Iron Age	1100–0 BC			Megalithic burials at Shiddalamattigudda. Continued visits to Birappa

barriers, indicating the initial purpose of these structures may have been cattle pens (Allchin, 1963; Krishna Sastry, 1979; Paddayya, 1998). It has furthermore been hypothesised that the ashmounds represent a ritual activity of nomadic pastoralists or seasonally mobile elements within agropastoral societies (Allchin, 1963; Fuller et al., 2001; Korisettar et al., 2001a; Johansen, 2004; Boivin, 2004) and that these meaningful sites were subsequently occupied during the transition to sedentary agriculture (Fuller et al., 2007). Sannarachamma's hilltop location is interesting in this respect, as it has been argued that inter-visibility was a key aspect of ashmound location, the large fires possibly serving as markers for inter-community congregation sites (Fuller, 1999; Gupta, 2002; Boivin, 2004).

Three trenches were excavated at Sannarachamma (labelled 10, 11 and 12), yielding a total of 25,969 lithics. Trench 10 provided the most important stratigraphic information so a complete count and classification of the raw materials for the 10,252 lithics from this trench was carried out (Fig. 2). Fig. 2 illustrates that quartz dominates the Sannarachamma pre-ashmound lithics. This accords with Subbarao's (1948) previous finding that the earliest occupation of Sannarachamma was dominated by quartz microliths and may reflect a wider pattern across the South Indian Neolithic, as at the site of Watgal, just over 100 km to the north, the pre-Neolithic industry was also dominated by quartz artefacts (Devaraj et al., 1995; DuFresne et al., 1998). The cortices show that two types of quartz were in use at Sannarachamma: pebble quartz procured from the surrounding plain and larger clasts of blocky quartz that runs in veins across the hilltop at Sannarachamma. The recovery of 95 cores and over 6000 fragments of debitage in the pre-ashmound phase indicates that a substantial amount of reduction was taking place on site.

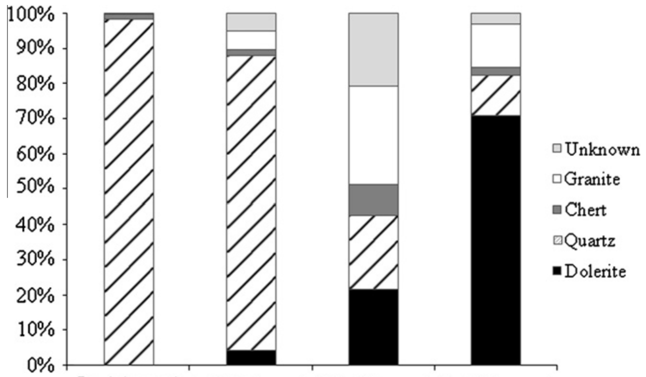

Fig. 2. The breakdown of raw material frequencies by period for all 10,252 lithic artefacts from Sanarachamma trench 10 (the quartz category includes nine crystal quartz artefacts and the chert category includes nine chalcedony artefacts).

The ashmound phases at Sannarachamma are characterised by a high diversity of raw material. Dolerite is introduced during the ashmound phase and becomes increasingly dominant through into the post-ashmound levels. Although dolerite dykes occur at Sannarachamma, it appears that the flaked dolerite at the site comes from one of the dykes running across the nearby hill known as Hiregudda, which provides a significantly finer grained material (Risch et al., 2009). To test the changing patterns in raw material exploitation across the history of the site, three chi-square tests were conducted comparing raw material distribution between the pre-ashmound and initial ashmound phases, the initial ashmound and main ashmound phases, and the main ashmound and post-ashmound phases. All three tests produced P values of less than 0.001, showing that there are highly significant differences in raw material distribution between each successive period.

The differences in raw material distribution between phases at Sannarachamma are symptomatic of shifts in technology, as each phase of occupation also has its own characteristic distribution of artefact types (Table 2). The pre-ashmound lithics are divided into two sub-phases on technological grounds. Both sub-phases are dominated by quartz microliths, but the older one is characterised by single platform cores, complete flakes and miscellaneous retouched artefacts, while the later sub-phase is characterised by multiplatform cores, bladelets and backed artefacts. The technological distinction between these two pre-ashmound sub-phases suggests intermittent occupation of the site, possibly over an extended time period.

In the initial ashmound phase, the proportion of bladelets and bladelet cores at Sannarachamma declines and overall lithic numbers decrease, potentially reflecting changes in the use of space. The excavated deposits of the ashmound consist largely of dung-derived sediments (including burnt dung ash), which are likely to derive from accumulation in cattle pens. Cattle bones dominate the faunal remains in the ashmound deposits, but elsewhere in the hilltop sites ovi-caprids are more common, suggesting cattle consumption was reserved for special occasions (Fuller, 2005a,b). While artefact inclusions, both ceramics and lithics, were present in the ashmound, these were less frequent than in the domestic occupation/midden deposits. Bladelets and bladelet cores are common again in the main ashmound phase before disappearing altogether in the post-ashmound phase (Table 2). While the pre-ashmound bladelets are of quartz and chert, the bladelets from the main ashmound are exclusively chert. The chert was probably procured from the Sandur greenstone formations located 10–15 km away (Boivin et al., 2005). The chert blades at

Table 2
Breakdown of diagnostic artefact types by period for selected contexts at Sannarachamma.

	1st Pre-Ashmound	2nd Pre-Ashmound	Initial Ashmound	Main Ashmound	Post-Ashmound
Single platform cores	13 (4%)	2 (1%)	5 (6%)	6 (3%)	3 (1%)
Multi-platform cores	0	39 (10%)	7 (8%)	16 (7%)	1 (1%)
Bi-polar cores	3 (1%)	3 (1%)	8 (9%)	5 (2%)	1 (1%)
Radial cores	3 (1%)	1 (<1%)	4 (4%)	0	0
Bladelet cores	1 (<1%)	7 (2%)	0	3 (1%)	0
Complete flakes	312 (90%)	260 (67%)	53 (60%)	70 (30%)	140 (67%)
Bladelets	1 (<1%)	55 (14%)	3 (3%)	34 (14%)	0
Retouched	13 (4%)	1 (<1%)	3 (3%)	7 (3%)	3 (1%)
Backed artefacts	0	16 (4%)	0	3 (1%)	0
Bifaces/axes	0	1 (<1%)	0	1 (1%)	3 (1%)
Bifacial flakes	1 (<1%)	0	0	0	31 (15%)
Hammerstones	0	1 (<1%)	3 (3%)	27 (11%)	20 (10%)
Grindstones	0	0	3 (3%)	65 (27%)	7 (3%)
Total	347	386	89	237	209

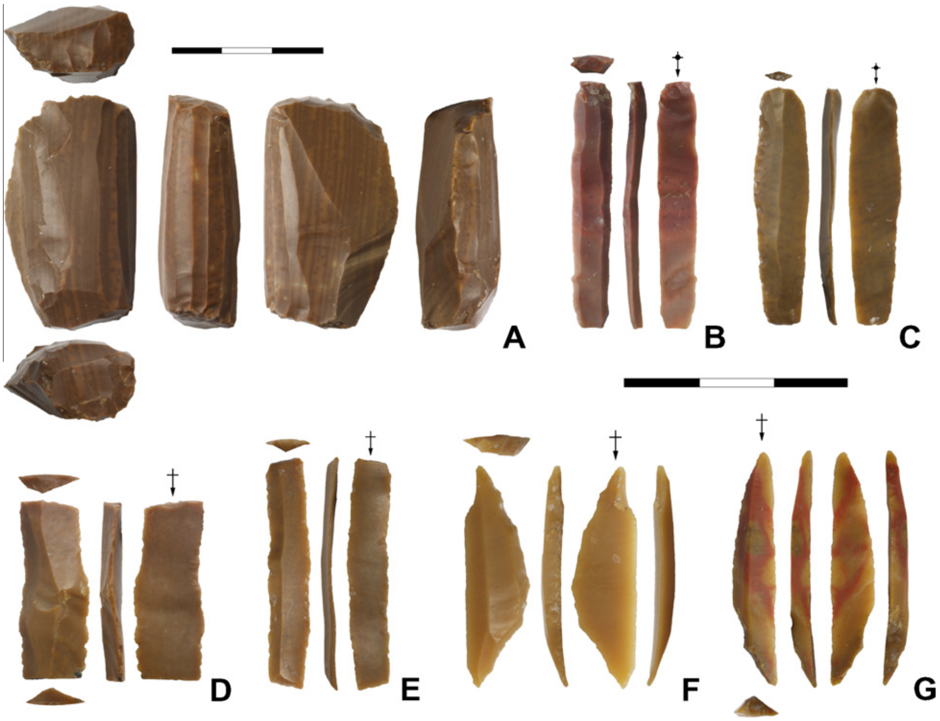

Fig. 3. A selection of microliths from Sannarachamma. (A) A chert pressure flaked bladelet core (shown on a different scale to the other artefacs); (B) a chert bladelet; (C) a retouched bladelet; (D) and (E) retouched segments; (F) and (G) backed bladelets (lunates).

Sannarachamma have punctiform platforms and parallel longitudinal ridges indicating they have been made using systematic pressure flaking, which produces thinner, narrower bladelets (Inizan et al., 1992; Inizan and Lechevallier, 1997; Andrefsky, 1998) (Fig. 3). Mann–Whitney U tests were conducted, comparing thickness and width for a sample of 10 bladelets from below the ashmound (median thickness 2.35 mm, median width 8.39 mm) and 32 bladelets from the main ashmound (median thickness 1.65 mm, median width 6.8 mm). The main ashmound bladelets were found to be significantly thinner ($P = 0.002$) and narrower ($P = 0.017$). Chert pressure flaking thus appears to be more prevalent in the main ashmound phase than at any other time. Pressure bladelets are found in Neolithic contexts elsewhere in South India, such as at the site of Jwalapuram 9 some 150 km east of Sanganakallu–Kupgal (Clarkson et al., 2009). Many of the pressure blades at Sannarachamma have been snapped into rectangular segments, which in other Neolithic contexts are used as sickle blades (Edens, 1999). Archaeobotanical evidence indicates that plant foods were dominated by domesticated crops, including native millets and introduced wheat and barley, which are best harvested with sickles (Fuller et al., 2001, 2004).

Grinding stones are absent in the pre-ashmound phase; they are then introduced in the initial ashmound phase, are very prevalent in the main ashmound phase and drop off in frequency during the post-ashmound phase (Table 2). This suggests the introduction of cereal processing during the initial ashmound phase, confirmed by the archaeobotanical evidence for millets, wheat and barley, as well as the native pulses mungbean and horsegram (Fuller et al., 2004). The increase in grinding stones confirms that substantial quantities of cereals were consumed in the main ashmound phase, with the subsequent drop-off reflecting either a decline in cereal consumption, a shift to crops that did not require grinding, or a change in the spatial patterning of grinding activities. A parallel may be drawn with the contemporary site of Watgal, where grinding stones reach a peak during the main Neolithic and then decline during the transition to the Iron Age (Devaraj et al., 1995).

Only one hammerstone was recovered from the pre-ashmound phases in Trench 10 despite the abundant evidence for on-site knapping, which suggests there was a greater emphasis on the use of soft-hammers during this period. In the initial ashmound phase hard hammers are more common (Table 2), which may be related to the greater frequency of bipolar flaking. In the main and post-ashmound phases, the abundance of hammerstones (Table 2) probably reflects both the increased use of dolerite, as this material requires substantial percussive force to detach flakes, and the production of grinding features by pecking.

Dolerite axes first appear in the main ashmound phase in Trench 10 at Sannarachamma. From the main ashmound, a broken edge-ground axe made on an unidentified hardstone was also recovered, which is morphologically distinct from the dolerite axes manufactured at Hiregudda. Another broken edge-ground axe recovered from this level was probably made from the Hiregudda dolerite, and it has been marked with parallel gouges, sometime prior to grinding. Engraved dolerite artefacts are known from Hiregudda and are hypothesised to relate to the perception of a life force within the dolerite (Brumm, 2006). Most of the dolerite in the main ashmound phase at Sannarachamma (Fig. 2) is coarse grained (gabbro) and is primarily not related to axes and their manufacture. Instead the gabbro and dolerite were used for polishing/abrasive tools related to food processing tasks and/or hammerstones for the production of flaked tools and the preparation and sharpening of grinding artefacts. Contrastingly in the post-ashmound phase, the majority of stone artefacts are connected to edge-ground axe reduction. Dolerite dominates the lithic raw materials represented (Fig. 1), and includes 28 bifacial thinning flakes (flakes with bending initiations, acute platform angles and complex dorsal scar patterns), three axe re-working flakes (flakes with evidence of pecking or polishing on their dorsal surfaces), two axe blanks (knapped but unpolished axes), and one broken axe (Table 2). Mann–Whitney U tests were conducted comparing the cortex percentage, dorsal scar count and platform complexity of the dolerite flakes from the main ashmound and post-ashmound phases at Sannarachamma (Table 3). The results demonstrate that the post-ashmound dolerite flakes have significantly lower cortex percentages, higher dorsal scar counts and more complex platforms, indicating that they represent later stages of reduction. This reflects the fact that in the post-ashmound stage, dolerite working at Sannarachamma was focussed on the later stages of axe blank reduction and axe resharpening. This increased spatial division of labour may reflect an increased social division of labour, as activities at neighbouring Hiregudda increasingly focussed on larger scale, more specialised axe manufacture.

The lithic technology at Sannarachamma passed through several distinct phases. Prior to the ashmound phase there were intermittent microlithic technologies based on the soft-hammer reduction of quartz clasts. In the early phase of ashmound formation, grindstones and a wider variety of raw materials were introduced and hard hammer bipolar flaking became prevalent. The main ashmound phase was characterised by a high diversity of raw materials, which included pressure flaked chert bladelets, a variety of hard hammer flaked dolerite artefacts and an abundance of grindstones. The lithics from the post-ashmound phase of occupation are dominated by the later stages of manufacture and the repair of edge-ground dolerite axes.

Choudammagudda

Choudammagudda is a hill located between Sannarachamma and Hiregudda (Fig. 1) that today is being quarried on an industrial scale. Prior to its destruction, the hill had a small ashmound on the south-western part of its summit, associated with sporadic occupation deposits, artificially aligned boulders, and petroglyphic rock art (Boivin et al., 2005). The predominance of cattle imagery in the petroglyphs of the hilltop sites and the cattle remains in the ashmounds, coupled with the pecking process used to create both the axes and the petroglyphs, means the art can be attributed to the Neolithic hilltop occupation with reasonable confidence. Another ashmound locality, Shiddalamattigudda, is located to the northeast of Choudammagudda on another very low hill, and a small cemetery of large Megalithic stone circles occurs on the plain between Choudammagudda/Shiddalamattigudda and Hiregudda. Numerous axe grinding grooves occur across Choudammagudda, more than at any other hilltop site.

One small trench was excavated in the hilltop habitation deposit at Choudammagudda, from which 635 lithics were recovered. The breakdown of raw material frequencies over time (Fig. 4) illustrates a pattern similar to that observed at Sannarachamma: quartz dominates the early to middle periods, with more chert being introduced in the middle period, and then dolerite dominates the latest phase of occupation. The quartz artefacts are microlithic in form and include cores, debitage and cortical flakes (Table 4), indicating reduction was taking place on site. Bladelets dominate the chert and chalcedony artefacts, representing over one third of the classified lithics (Table 4). Nearly one fifth of the classified chert lithics are retouched (Table 4), indicating that this siliceous cryptocrystalline material was highly curated. The dolerite artefacts include a bifacial thinning flake and two axe resharpening flakes, suggesting some axe manufacture and repair took place at Choudammagudda during the final phase of occupation.

Hiregudda

Hiregudda is the largest hill in the Sanganakallu–Kupgal area (Fig. 1) and contains multiple localities across its summit, along its slopes and at its base. Excavations were conducted in four areas of Hiregudda; Areas A, B, D and J (Boivin et al., 2005). Foote once described the dolerite axe factory at Hiregudda as ‘‘the largest Neolithic manufacturing activity as yet met with in any part of India’’ (1916: 82), and there have been no discoveries in the intervening years that would overturn this statement. While there are many dolerite dykes across the Deccan plateau, Foote noted that the principal dyke exploited at Hiregudda is particularly unusual both for its tendency to weather in small lenticular masses, allowing extraction and knapping into axe blanks with relatively little effort (Foote, 1916). A thin section characterisation of the dolerite from the dyke that was exploited during the Neolithic has shown that it is microcrystalline with the conchoidal fracture properties necessary for knapping (Risch et al., 2009). At Hiregudda, axe blanks

Table 3

Mann–Whitney *U* tests comparing the cortex percentage, dorsal scar counts and platform complexity of a sub-sample of dolerite flakes from Ashmound and post-Ashmound layers at Sannarachamma. Platform complexity was coded ordinally with cortical platforms being the least complex, followed by plain, dihedral and multiple platforms, through to pecked and polished platforms being the most complex.

Variable	Ashmound median	Post-ashmound median	Ashmound mean rank (N)	Post-ashmound mean rank (N)	Sig.
Cortex percentage	10	0	67.8 (41)	48.2 (69)	0.001
Dorsal scar count	2	3	38.3 (38)	55.9 (59)	0.002
Platform complexity	2	2	38.6 (39)	60.9 (65)	<0.001

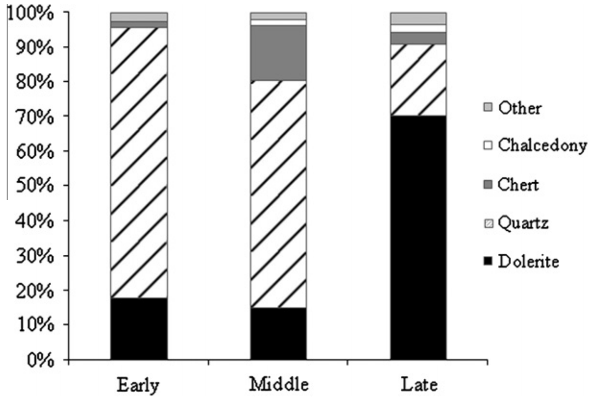

Fig. 4. The breakdown of raw material frequencies by period for all 635 lithic artefacts from Choudammagudda trench 1 (the quartz category includes nine crystal quartz artefacts and the other category includes 11 granite, three gabbro and one unknown artefact).

were knapped and then their edges were ground to create a finished tool. Brumm et al. (2007) identified three different reduction sequences for the manufacture of axe blanks at Hiregudda. The first method required the façonnage reduction of lenticular slabs to leave the axe blank. Axes made using this method are identifiable by the presence of cortex on both surfaces, with 21% of axes and axe blanks produced on slabs. The second method entailed the retouch of large flakes into axe blanks. This method was identified by the remnants of ventral surfaces on axes (Subbarao, 1948) (Fig. 5), with 72% of axes made on flakes. The third method involved the most complex reduction sequence and produced the largest axes. With this method, large blocks of dolerite were reduced in hierarchical stages to create long, thick axe blanks, which were then finished by pecking away surface irregularities. Axes made using this method were identified by their large size, thick cross-sections and high flake scar densities (Fig. 5). This method required large, internally homogenous blocks of stone which are rare along the dyke and so entailed mining pits into the subterranean rock mass. Only 7% of axes were made using the block method and these are found exclusively in the final occupation stage at Hiregudda. Axes which exhibited pecking and grinding all over their surfaces and made of the same raw material as the Sanganakallu–Kupgal axes, were also found at the site of Piklihal, over 100 km to the north-west, where there was no evidence for the flaking stages of manufacture (Allchin, 1960). It is likely that the pecked block-made axe type was the focus of axe trading and circulation activities in the southern Deccan.

Area A at Hiregudda is a plateau on the southern summit of the hill and a rich archaeological locality, containing evidence for domestic occupation (Korisettar et al., 2001b) followed by industrial scale axe manufacturing (Boivin et al., 2005). The oldest feature at Area A is a small ashmound dated to over 1700 BC, which was subsequently buried by occupation deposits (Fuller et al., 2007) (Table 1). This ashmound has since been almost entirely removed to be used as fertiliser and building material. Alignments of stone created pathways across Area A, while circles of granite boulders delineated spaces. Area A was originally nicknamed 'the Lithics Plateau' due to the vast quantities of lithics visible on the surface, and a total of 724,899 lithics were recovered during rescue excavations that primarily targeted the edges of the large modern ash quarrying pit. A total of nine trenches were excavated in Area A and the two with the highest artefact counts were selected for lithic analysis: Feature 1 and Trench 1.

Feature 1 is a structure formed by a circular arrangement of granite boulders (Fig. 6). The circle's internal diameter is 7 m and at the south-east corner is an entranceway some 0.7 m wide. A staggering total of 604,187 lithics were excavated in Feature 1, 99% of which were related to dolerite axe manufacture, so Feature 1 may be described as a dolerite axe workshop. There is evidence for spatial organisation within Feature 1, as the knapping debris is concentrated in the north-west at the back of the structure, while there are numerous grinding grooves on the stones around the entrance in the south-east (Brumm et al., 2007). Clusters of axe grinding grooves were also found on four boulders within 10 m of Feature 1. Two small pits were dug inside Feature 1, which were filled with knapping debris and seemed to have served to clear the space. Stratigraphically the upper layer of Feature 1 contains the most intensive axe manufacturing debris, while bone and pot sherds in the lower layers point to domestic habitation alongside axe production on a less intensive scale. Small post-holes around the inner edge of the structure indicate the construction of a roof during the earlier habitation phase. Radiocarbon dating shows the habitation layers span the time period from 1700 to 1500 BC (Fuller et al., 2007) (Table 1). Following the habitation period, there appears to have been an occupational hiatus lasting for approximately 100 years, during which time a patina developed on the dolerite artefacts left exposed. The site was then reoccupied around 1400 BC and Feature 1 became a dolerite axe factory for the next 150 years until the site was abandoned. In both the habitation and factory stages a number of engraved dolerite artefacts were recovered. Cupules were pecked into the granite boulders of Feature 1 during its use-life, and pieces of lustrous red ochre, fragments of ceramic figurines and occasional copper beads recovered from Feature 1, suggests that it was an area of symbolic importance (Brumm, 2006). A parallel may be drawn with the late Neolithic site of Liangchengzhen in China, where the secondary stages in axe production were likewise carried out (Bennett, 2007). This site was the largest Neolithic settlement in the Shandong peninsula of north-east China, and axe production was demarcated in a high status area of the site, next to the burial ground and with a view of the Wulian mountains that provided the raw material for the axes. The axe production area contained

Table 4
Breakdown of all lithic artefacts by typology and raw material from Choudammagudda trench 1. Early reduction flakes are defined by the presence of cortex or a limited number of flake scars on the dorsal surface.

	Dolerite	Quartz	Chert	Chalcedony	Other	Total
Cores	0	14 (4%)	0	0	0	14
Bladelet cores	0	0	2 (3%)	1 (11%)	0	3
Debitage	115 (78%)	318 (85%)	23 (32%)	1 (11%)	18 (82%)	475
Early reduction	29 (20%)	19 (5%)	8 (12%)	1 (22%)	1 (4%)	60
Bifacial flakes	3 (2%)	0	0	0	0	3
Bladelets	0	20 (5%)	25 (34%)	5 (56%)	0	50
Retouched	0	4 (1%)	14 (19%)	0	0	18
Hammerstones	1 (<1%)	1 (<1%)	0	0	3 (14%)	5
Total	148 (100%)	376 (100%)	73 (100%)	9 (100%)	22 (100%)	628

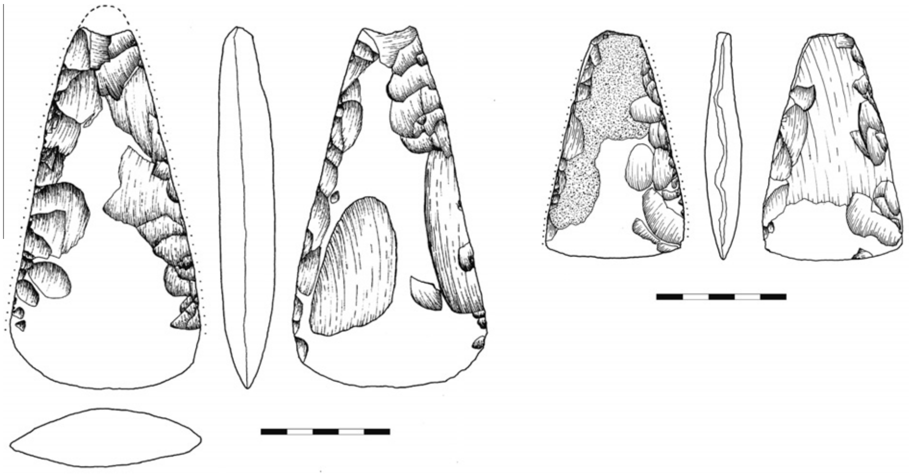

Fig. 5. Dolerite axes from Sanganakallu–Kupgal. The axe on the left is made using the block-based technique while the axe on the right is made on a flake.

Fig. 6. Feature 1 at Hiregudda during excavation.

Table 5
The breakdown of diagnostic dolerite artefacts by type, from selected contexts of the habitation and factory phases of feature 1 and trench 1 in Hiregudda area A.

	Habitation	Factory	Total
Early reduction flakes	17,773 (90%)	16,596 (73%)	34,369
Bifacial thinning flakes	1677 (9%)	5872 (26%)	7549
Axe reworking flakes	114 (0.6%)	73 (0.3%)	187
Axe blanks	69 (0.3%)	61 (0.3%)	130
Axes	20 (0.1%)	7 (<0.1%)	27
Total	19,653 (100%)	22,609 (100%)	42,262

elite-style floors of rammed earth and crushed stone, with artefacts including axes and butchered human remains ritually interred in the same area (Bennett, 2007). At both Liangchengzhen and Hiregudda Feature 1 axe production was a symbolically charged activity of great importance to local communities, a pattern that has been observed more widely in Neolithic groups and other societies using groundstone axes (McBryde, 1984; Bradley and Edmonds, 1993; Brumm, 2010).

Trench 1 at Hiregudda Area A was located to the south-east of Feature 1 in a lithic midden deposit which mirrors the domestic and knapping activities taking place in Feature 1. In the upper levels of Trench 1, the artefacts are almost exclusively dolerite lithics, while in the lower layers the dolerite is mixed with domestic refuse and small quantities of other lithics. A trample layer between the habitation and factory phases also indicates an occupational hiatus. Trench 1 measured 2 m^2 by 1.6 m deep and yielded 39,640 lithics.

A sample of 148,008 lithics from Feature 1 and Trench 1 were counted and classified. Dolerite axe manufacturing debris dominates both sequences. In both Feature 1 and Trench 1, non-dolerite artefacts are present in low numbers during the habitation stage (2% of 63,339 sampled lithics), then they drop away to negligible proportions during the factory stage (0.3% of 79,284 sampled lithics). Trench 1 also includes a third, basal context where quartz was the dominant raw material type (58% of 103 sampled lithics). Chi-square tests showed the differing patterns of raw material distribution between the occupational phases in Feature 1 and Trench 1 were significant at $P < 0.001$ level. This demonstrates that lithic production at Hiregudda became increasingly geared towards dolerite axe production over time. The non-dolerite artefacts in Feature 1 and Trench 1 include quartz, chert and chalcedony bladelets, and are akin to the microliths made on these materials from the other Sanganakallu–Kupgal localities.

From the selected contexts in Feature 1 and Trench 1, 86 hammerstones were recovered, mostly of dolerite, indicating the importance of hard hammer percussion in the production of dolerite axe blanks. Over half of the dolerite artefacts from Feature 1 and Trench 1 consisted of flake shatter, angular shatter, broken flakes and non-flake debitage, with the remaining diagnostic artefacts clearly related to axe manufacture and repair (Table 5). Table 5 indicates that in the habitation phase there were more early reduction flakes, while in the factory phase there were more biface thinning flakes. A chi square test showed the diagnostic artefact type distributions between the two phases to be significantly different at the $P < 0.001$ level. Though all stages of reduction including resharpening were being carried out in both the habitation and factory stages of Feature 1, there was a shift in emphasis towards later reduction in the factory stage. Uniquely, Feature 1 produced cylindrical chisel blanks, which ethnographic analogy suggests may be related to the creation of axe handles for hafting (Hampton, 1999).

Area B is located just above Area A on the east of the Hiregudda hilltop, and includes evidence for stone walls, petroglyphic rock art and dolerite quarrying. The dolerite dyke that runs through Area B provided the highest quality raw material for groundstone axe manufacture. Four trenches were excavated in Area B at Hiregudda, from which 2420 lithics were obtained. Trench 1 was placed on the dolerite dyke alongside a mining spoil pile and was selected for further analysis to understand dolerite quarrying behaviour and the spatial organisation of reduction. As would be expected, 99%

of the 1262 sampled lithics from Trench 1 were dolerite, 78% of which were debitage. Of the diagnostic dolerite lithics, most were early stage reduction flakes (87% of 281 lithics), which, together with an assayed core, confirms that the beginning of the reduction sequence was commonly carried out at the raw material source. The presence of 13 bifacial thinning flakes and 3 axe blanks indicates that sometimes the reduction sequence was taken further in Area B, but the absence of finished axes and axe reworking flakes suggests that grinding and resharpening were not carried out here. Several roughly flaked granite slabs in the form of early stage querns were found in Trench 1. Granite working in Area B was confirmed by the presence of flake shatter, an early reduction flake and a granite tool fragment.

The dyke that runs through Area B extends down to the base of Hiregudda Hill, where it was extensively quarried. In the lower quarry, named Area J, Trench 1 was a 1 × 1 m excavation into a quarry pit, while Trench 2 consisted of systematic artefact collection from a section exposed by recent granite quarrying. Trench 1 produced 7096 lithics and Trench 2 produced 538. Similarly to the upper quarry at Area B, 97% of the lithics were dolerite, 71% of which were debitage. The great majority of diagnostic artefacts were early stage reduction flakes (94% of 794 sampled lithics), which together with 10 assayed cobbles and cores corroborates Area J's designation as a quarry and primary reduction locale. A limited number of bifacial thinning flakes and axe blanks (4% of 794 sampled lithics) indicates that later reduction occasionally took place here. A hammer made of the hard stone gabbro, procured from another dyke on Hiregudda, was introduced into Area J. A chi-squared test showed that there is a significant difference in the cortex types at the $P < 0.001$ level between the two trenches in Area J, with Trench 1 containing mostly angular cortex (82% of 28 sampled artefacts) and Trench 2 containing mostly sub-rounded cortex (84% of 50 sampled artefacts). This reflects the fact that at Trench 2 the naturally weathered lenticular dolerite clasts were exploited, whereas Trench 1 was dug into a subterranean mining pit from which larger, less weathered dolerite clasts were extracted.

Area D is a terraced area, located on a valley slope between the two Hiregudda peaks. Several infant urn burials were exposed in one of the terraces, which date to the final occupation of Hiregudda (Table 1). Two natural reservoirs exist on a gabbro dyke adjacent to Area D, while there are particularly dense concentrations of petroglyphic rock art on Hiregudda's dolerite dyke which runs above Area D. Over a thousand panels of petroglyphic art have been identified on Hiregudda (Robinson et al., 2008), which for the most part are dominated by images of bulls (Boivin, 2004). Six small trenches were sunk into Area D at Hiregudda, producing a total of 37,191 lithics. The ceramics from Area D suggest that the archaeological deposits date to the late Neolithic or early Megalithic. The infant burial jars were recovered from Trench 5 and the lithics from two contexts in this trench were selected for raw material and technological classification (Table 6). Table 6 shows that most knapping activity in Area D was related to the various stages of dolerite axe production, with a core, early reduction flakes, bifacial thinning flakes and axe reworking flakes all represented. There is also a high frequency of granite lithics at the locality, which appears to relate to the production of grindstones (Table 6).

Table 6
Breakdown of lithics by raw material and technology for selected contexts in Hiregudda Area D Trench 5.

	Dolerite	Quartz	Chert	Granite	Total
Debitage	902	8	0	290	1200
Early reduction flakes	185	2	1	0	188
Bifacial thinning flakes	20	0	0	0	20
Axe reworking flakes	1	0	0	0	1
Redirecting flakes	3	0	0	0	3
Core	1	0	0	0	1
Hammerstones	3	0	0	0	3
Grindstones	1	0	0	4	1
Total	1116	10	1	294	1417

Hiregudda appears to have been a major Neolithic axe-manufacturing complex, with large quantities of dolerite lithics recovered from every excavated locality on the hill. In the early stages of occupation, an ashmound was in use in Area A and lithic production focussed on quartz microliths. More intensive occupation after 1700 BC saw a shift to dolerite axe production and the construction of Feature 1, which functioned as an axe making workshop and domestic dwelling. There then appears to have been an occupational hiatus between 1500 and 1400 BC, at least in the main occupation zone of Area A, before Hiregudda was reoccupied and became an edge-ground axe-making 'factory' until abandonment around 1300–1250 BC. Axe manufacture during both the habitation and factory periods involved the extraction of dolerite clasts from the dyke that runs through Areas B and J. Some of the early stage reduction into rough-outs would have taken place at these quarries before the rough-outs were transported to Area A. Feature 1 at Area A seems to have functioned as the central axe making workshop and it is here that most of the rough-outs would have been knapped into axe blanks. Some of these blanks would then have been ground into finished axes using the many grinding grooves in and around Feature 1. The waste which accumulated in Feature 1 was dumped nearby, including where Trench 1 in Area A was excavated. There are two principal differences in axe manufacturing between the early habitation and later factory stages of occupation: firstly the introduction of the more complex block-based manufacturing method in the factory period, which would have involved the excavation of mining pits to obtain larger dolerite clasts in Area J; and secondly in the factory stage there appears to have been greater spatial segregation of the reduction sequence, with Feature 1 dedicated more exclusively to the later stages of reduction than in the habitation stage. In addition to all the dolerite axe manufacturing, granite grindstones were produced in various locations at Hiregudda, including Areas B and D. These grindstones were produced and employed within a technological framework that involved the grinding of stone against stone across a wide range of activities, including food preparation, axe production and the creation of art (Boivin et al., 2007).

Birappa rockshelter

Birappa is a granite boulder rockshelter situated on the plain just over 1 km to the north of Hiregudda, (Boivin et al., 2002) (Fig. 1). The shelter is named after the god of the pastoralist Karuva tribe, who use the rockshelter today. The Karuvas dedicate their modern paintings inside the rockshelter to this deity, who is said to ride a goat and be an assistant of Shiva (Robinson et al., 2008). The god Birappa is also associated with forests and huntresses, and at the beginning of the annual Birappa festival at Balapalapalle (in the neighbouring Kurnool District) a mock hunt is enacted (Murty, 1985). The Birappa rockshelter is also adorned with ancient red paintings of wild animals, anthropomorphs and geometric designs. This is in marked contrast to the art at Hiregudda which consists of petroglyphs rather than paintings, and where cattle dominate the imagery (Robinson et al., 2008). Superimposition of images at Birappa shows that a change in style occurred in the rock art, with outline figures being superseded by filled in images. Radiocarbon dates, all on minute pieces of charcoal, from the Birappa excavations range from 9000 to 10 BC (Boivin et al., 2005). These dates are not in coherent stratigraphic order and given the small size of the pieces they may have moved up and down

Table 7
Breakdown of raw material types for selected contexts in trenches 2 and 5 at Birappa. The contexts are grouped into earlier pre-ceramic levels and later ceramic bearing levels. For the chi-squared tests the materials were pooled into three groups: dolerite, granite, quartzite and unknown; chert and chalcedony; and quartz.

	Early	Late	Total
Dolerite	2 (0.08%)	23 (0.2%)	25
Quartz	2460 (97.9%)	9121 (96.6%)	11,581
Chert	32 (1.3%)	230 (2.4%)	262
Chalcedony	3 (0.1%)	29 (0.3%)	32
Granite	0	2 (0.02%)	2
Quartzite	1 (0.03%)	3 (0.03%)	4
Unknown	16 (0.6%)	33 (0.4%)	49
Total	2514 (100%)	9441 (100%)	11,955

Table 8
Breakdown of diagnostic artefact types for selected contexts in trenches 2 and 5 at Birappa. Bladelets includes both complete and broken pieces. The contexts are grouped into earlier pre-ceramic levels and later ceramic bearing levels. Bi-polar cores, hammerstones and grindstones were not included in the chi-square tests.

	Early	Late	Total
Multi-platform cores	25 (13%)	73 (12%)	98
Blade cores	21 (11%)	37 (6%)	58
Bi-polar cores	0	3 (<1%)	3
Retouched artefacts	44 (23%)	98 (17%)	142
Bladelets	58 (31%)	228 (38%)	286
Complete flakes	41 (22%)	147 (25%)	188
Hammerstones	1 (<1%)	4 (<1%)	5
Grindstones	0	3 (<1%)	3
Total	190 (100%)	593 (100%)	783

through the sequence without the overall stratigraphy being disturbed. The radiocarbon dates suggest the site was sporadically used during the Mesolithic (9000–3400 BC), and then re-visited from the Neolithic–Megalithic transition (c. 1300 BC) onwards (Table 1). Microliths and wild fauna are found throughout the Birappa sequence, red pigment occurs sporadically, while pottery and domestic ovi-caprids are restricted to the upper part of the sequence (Robinson et al., 2008). Charcoal from a context containing both some of the earliest pottery at the site and a large chunk of red ochre was dated to 1300–1250 BC (Boivin et al., 2005). Birappa lacks the coarse hand-made pottery characteristic of the Neolithic occupation on the hilltop sites and instead the earliest pottery from this site is the wheel-made Megalithic type. The ceramic and radiometric evidence thus suggest an occupational hiatus at Birappa during the Neolithic occupation at the hilltop sites, with Birappa coming into use again as dolerite axe production waned.

Six small trenches (1 m^2 or less) were excavated at Birappa, yielding a total of 32,818 lithic artefacts. Trenches 2 and 5 were deemed to be the least affected by stratigraphic disturbance as they produced finely stratified sequences of 7 and 10 layers, excavated to bedrock at depths of just 1.4 and 1.14 m respectively. The artefacts from these trenches were chosen for more detailed analysis due to their stratigraphic integrity. Trench 2 produced a sequence of 7 layers excavated to bedrock at a depth of 1.4 m. Raw material and technological classification was undertaken for selected contexts in Trenches 2 and 5 (Tables 7 and 8). Tables 7 and 8 show that in the pre and post-ceramic contexts at Birappa, there are similar patterns of raw material use and technology. The early and late contexts are both dominated by quartz artefacts, with other materials used occasionally, and both assemblages may be classed as microlithic, with an emphasis on the production of bladelets (Fig. 7). Quartz pebbles are readily available near the site, occurring in gravel surfaces on the pediment plain around Birappa. The most common retouched tools in both the pre and post-ceramic levels are geometric backed artefacts such as lunates. Geometric backed artefacts are associated with mobile hunter-gatherers populations wherever they are found across the world, including other sites in South India (Hiscock et al., 2011; Clarkson et al., 2009). Experimental, use-wear and residue analysis on geometric backed artefacts from Africa and Australia suggests that they were used interchangeably for a variety of purposes, with barbs or tips on arrows and harpoons a principal function (Phillipson and Phillipson, 1970; Robertson, 2005; Lombard, 2008; Lombard and Pargeter, 2008). Outline drawings of wild land animals and fish also indicate the predation of these animals (Robinson et al., 2008). Chi-squared tests on the data in Tables 7 and 8 showed some significant differences in technology and raw material exploitation between the pre-ceramic and ceramic periods at the $P = 0.05$ level. In the ceramic period, there are slightly greater proportions of dolerite, granite, chert and chalcedony (Table 7). Despite the occasional dolerite artefact, there is no evidence for dolerite axe

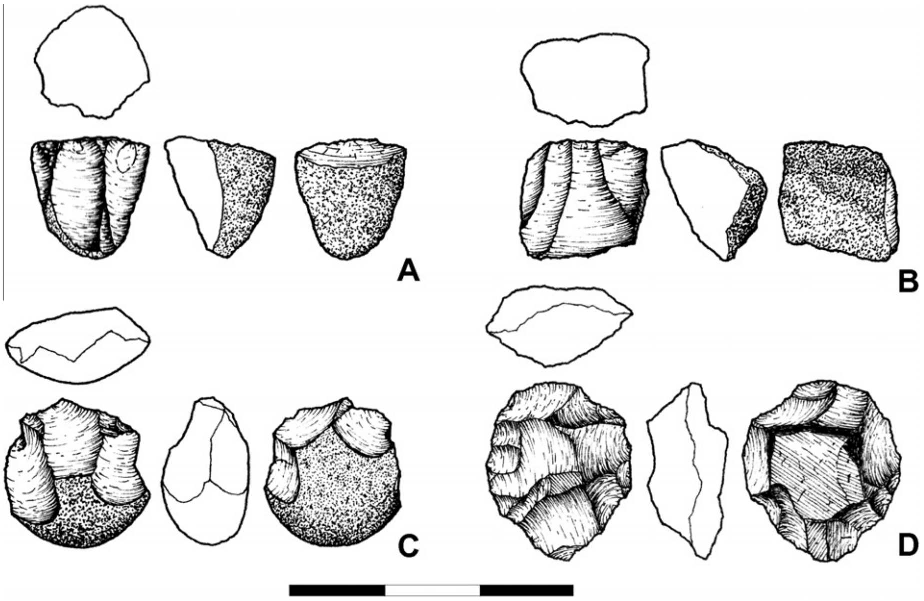

Fig. 7. Quartz pebble cores from Birappa.

manufacture or resharpening, which is surprising given the vast dolerite axe industry at nearby Hiregudda. The introduction of granite grindstones in the ceramic period (Table 7) is important, as it indicates cereal processing and possible interaction with, or use of the site by, agriculturalists. There are a greater proportion of blade cores in the earlier period, but curiously less bladelets, which is probably because more bladelets were being retouched into other artefacts in the earlier period (Table 8). The greater retouch in the earlier period suggests populations were more mobile and were using tools for longer before they were discarded.

A more detailed comparison of metric and qualitative variables was carried out on a sub-sample of the Trench 2 and 5 lithics. Mann–Whitney U tests were used to compare early and late Birappa cores for the following variables: weight, length, width, thickness, the last platform angle, the number of platform quadrants, the number of elongated parallel scars, the number of aberrant terminations, the number of scars longer than 15 mm, the percentage of cortex remaining, the length of the longest core face, and the frequency of unidirectional, bidirectional and bipolar flaking (Table 9). The only significant differences at the $P = 0.05$ level were that the early cores were longer, with more unidirectional flaking and longer longest faces. In concurrence with the raw material and technological counts, this suggests a greater emphasis on the systematic production of quartz bladelets in the pre-ceramic levels, as longer cobbles were being selected and flaked unidirectionally down their longest axis. It should be noted however, that there was no difference in the number of bladelet scars between the two periods, with bladelets still forming an important component of the ceramic period lithic technology (Tables 8 and 9). A battery of Mann–Whitney *U* tests were used to compare early and late flakes (including bladelets and retouched flakes) for the following variables: weight, length, width, thickness, proximal width, medial width, distal width, maximum dimension, platform width, platform thickness, platform angle, dorsal scar count, flaking success and cortex coverage (Table 10). Not one of these 14 variables showed any significant differences between the two periods.

In general there is broad continuity throughout the sequence at Birappa, with only three out of 28 metric variables tested showing a significant difference. The minor differences between the preceramic and the ceramic levels suggest more systematic blade production in the earlier period and the use of a greater variety of raw materials in the later period, but these are differences of degree not kind.

Microlith inter-locality comparisons

Here we compare the microliths from Birappa rockshelter and Sannarachamma hilltop, as these sites provide the longest microlithic sequences and the largest sample sizes. The lower levels of Birappa and Sannarachamma are considered to be the oldest contexts in the Sanganakallu–Kupgal complex and they are both dominated by quartz microliths. The ratio of quartz to other raw materials (chert, dolerite and unknown) was virtually identical between the pre-ceramic levels at Birappa and the pre-ashmound levels at Sannarachamma (Table 11). The emphasis on bladelets in the pre-ceramic contexts at Birappa suggests more similarity with the second pre-ashmound phase at Sannarachamma. Using the sub-sample of metrically measured artefacts, a series of Mann–Whitney *U* tests was performed comparing the cores from the second pre-ashmound phase at Sannarachamma, with those from the pre-ceramic levels at Birappa. The cores were compared

Table 9
Results of Mann–Whitney *U* tests comparing a sample of cores from earlier pre-ceramic levels and later ceramic bearing levels at Birappa.

Variable	Early median	Late median	Early mean rank (N)	Late mean rank (N)	Sig.
Weight	8.8	4.65	42.7 (10)	30.6 (54)	0.059
Length	27.51	22.08	46.1 (10)	30 (54)	0.012
Width	20.1	17.57	36 (10)	31.9 (54)	0.518
Thickness	15.44	12.42	42.4 (10)	30 (54)	0.05
Platform angle	92	80	35.7 (10)	26.3 (45)	0.095
# Platform Quadrants	2	2	28.8 (7)	25 (43)	0.493
# Bladelet scars	2.5	2	31.2 (10)	30.4 (50)	0.895
# Aberrant terminations	0	0	37.2 (10)	31 (53)	0.227
# Scars > 15 mm	2	1.5	28.3 (8)	28.5 (48)	0.971
Cortex percentage	45	5	38.7 (10)	28.9 (50)	0.089
Longest face	26.94	22.11	46.4 (10)	28.6 (52)	0.004
Unidirectional	1	0	42.1 (10)	30.7 (54)	0.04
Bidirectional	0	0	27.7 (10)	33.4 (54)	0.237
Bipolar	0	0	32.1 (10)	32.6 (54)	0.927

Table 10
Results of Mann–Whitney *U* tests comparing sampled flakes (including bladelets and retouched flakes) from earlier pre-ceramic levels and later ceramic bearing levels at Birappa.

Variable	Early Median	Late Median	Early Mean Rank (N)	Late Mean Rank (N)	Sig.
Weight	1.2	1.4	72.7 (17)	77.5 (136)	0.669
Length	17.09	17.17	67.2 (24)	73.6 (120)	0.491
Width	8.5	10.83	77.5 (24)	92.5 (156)	0.189
Thickness	3.85	4.5	54.8 (18)	65.5 (109)	0.253
Proximal width	8.81	7.91	68.6 (17)	58.6 (102)	0.266
Mesial width	13.03	12.02	60.7 (17)	57.5 (98)	0.723
Distal width	8.16	7.68	37.5 (11)	42.1 (71)	0.549
Maximum Dimension	18.65	19.1	71.7 (17)	77.7 (136)	0.597
Platform width	8.91	8.6	56.6 (16)	48.1 (82)	0.273
Platform Thickness	3.32	3.54	47.9 (16)	52.2 (86)	0.597
Platform angle	71.5	76	54.6 (16)	58.6 (99)	0.659
Dorsal scar count	3	2	83.4 (17)	75.1 (134)	0.445
Flaking success	1	1	65 (17)	63.9 (110)	0.577
Cortex percentage	0	0	85.6 (17)	75.4 (135)	0.312

Table 11
Comparison of raw material distribution between selected context from Sannarachamma pre-ashmound and Birappa pre-ceramic phases. Quartz includes quartzite and crystal quartz artefacts, chert includes chalcedony artefacts.

	Sannarachamma pre-ashmound	Birappa pre-ceramic
Dolerite	2 (<1%)	2 (<1%)
Quartz	7368 (98%)	2461 (98%)
Chert	114 (2%)	33 (1%)
Granite	0	0
Unknown	20 (<1%)	16 (1%)
Total	7504 (100%)	2512 (100%)

Table 14
Comparison of raw material distribution between sampled Birappa ceramic and Sannarachamma ashmound levels.

	Birappa ceramic	Sannarachamma ashmound
Dolerite	23 (<1%)	250 (14%)
Quartz	9124 (97%)	931 (50%)
Chert	230 (2%)	98 (5%)
Chalcedony	29 (<1%)	1 (<1%)
Granite	2 (<1%)	322 (17%)
Unknown	33 (<1%)	246 (13%)
Total	9441 (100%)	1848 (100%)

across 14 variables, none of which showed a significant difference between the sites (Table 12).

The sample of metrically measured flakes from the post-ceramic levels at Birappa, was compared with those from the ashmound layers at Sannarachamma using Mann–Whitney *U* tests. The results show that the Sannarachamma flakes are longer, yet thinner and lighter than those at Birappa (Table 13). This agrees with the suggestion made above that many of the flakes from the ashmound phase at Sannarachamma were made by pressure flaking, as this technique produces thinner flakes than percussion. Pressure flaking is most effective on cryptocrystalline materials such as chert and chalcedony, and while both the Birappa ceramic and Sannarachamma ashmound periods showed increases in these materials, the change was significantly more pronounced at Sannarachamma ($P < 0.001$) (Table 14). The overall pattern in microlith raw material procurement and technology at Birappa and Sannarachamma is thus divergent trajectories from similar starting points.

The Birappa pre-ceramic and Sannarachamma pre-ashmound levels both suggest a low mobility hunting economy with artefacts largely consisting of microliths made on locally available quartz, with lunates dominating the retouched artefacts. In the Sannarachamma ash-mound levels there was a shift in emphasis to the use of cryptocrystalline materials obtained from several kilometres away, suggesting either a more mobile group, or that materials were being acquired through trade. The production of long pressure flaked bladelets that were often snapped into sections and the concomitant decline in lunates may reflect an economic shift away from hunting and toward crop cultivation with sickle harvesting. During the ashmound period at Sannarachamma there may have been an occupational hiatus at Birappa as there no radiometric or ceramic evidence for contemporary occupation. The lithics from the ceramic phase at Birappa show strong continuity with the pre-ceramic technology, characterised by the production of quartz microliths including lunates. Whether this represents immigration of a new group of people who had retained the ancestral Mesolithic techniques, or a reversion of the local Neolithic population during the terminal Neolithic decline is unclear. The marked artistic differences between Birappa and the hilltop sites suggests either two groups with contrasting ideologies, or a dramatic ideological shift within a group (Robinson et al., 2008).

Dolerite inter-locality comparisons

Metric analyses were used to compare dolerite artefacts between different areas and occupation periods in the Sanganakallu–Kupgal complex. The metric dataset used here comprises all of the axes (including roughouts) from the contexts selected for complete counts and classifications, as well as a sub-sample of dolerite flakes and hammers from each of the areas where substantial amounts of dolerite reduction took place.

Table 12
Mann–Whitney *U* comparison of cores from selected contexts in Birappa pre-ceramic and Sannarachamma 2nd pre-ashmound levels.

Variable	Birappa median	Sannarachamma median	Birappa mean rank (N)	Sannarachamma mean rank (N)	Sig.
Weight	8.8	4.5	15.9 (10)	14.5 (19)	0.701
Length	27.5	26.9	14.7 (10)	15.2 (19)	0.91
Width	20.1	18.6	14.6 (10)	15.2 (19)	0.875
Thickness	15.4	12.1	17.4 (10)	13.7 (19)	0.286
Platform angle	92	88.5	15.2 (10)	14.1 (18)	0.759
# Plat. quadrants	2	2	11.7 (7)	9.9 (13)	0.536
# Bladelet scars	2.5	3	11.4 (10)	14.8 (16)	0.262
# Aberrant terms.	0	1.5	6.7 (10)	9.5 (4)	0.304
# Scars > 15 mm	2	2	7.8 (8)	10.1 (9)	0.37
Cortex%	45	20	18.1 (10)	13.4 (19)	0.164
Longest face	26.9	27	14.6 (10)	15.2 (19)	0.875
Unidirectional	1	1	17.1 (10)	13.9 (19)	0.353
Bidirectional	0	0	14 (10)	15.6 (19)	0.636
Bipolar	0	0	13.9 (10)	15.6 (19)	0.604

Table 13
Mann–Whitney *U* comparison of a sample of flakes (including blades and tools) from Birappa ceramic and Sannarachamma ashmound levels.

Variable	Birappa median	Sannarachamma median	Birappa mean rank (N)	Sannarachamma mean rank (N)	Sig.
Weight	1.3	0.6	123.3 (146)	104.9 (86)	0.044
Length	17.3	24.7	109.3 (189)	162.1 (51)	<0.001
Width	10.9	9.3	156.9 (230)	162.7 (86)	0.614
Thickness	4.3	3	137.6 (182)	117.5 (80)	0.048

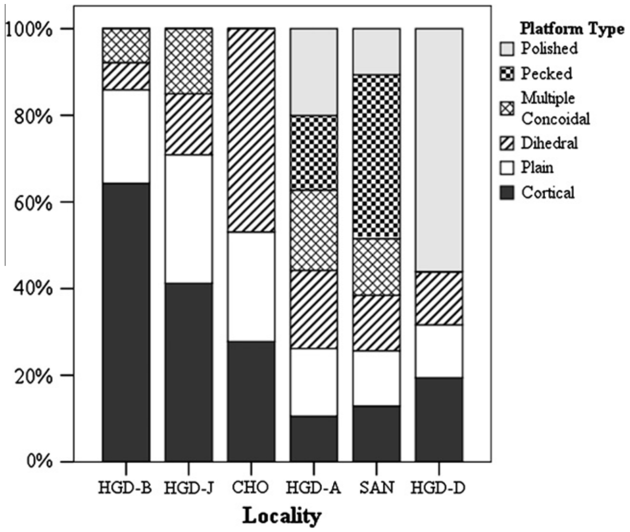

Fig. 8. The proportion of platform surface types (excluding crushed platforms) on samples of dolerite flakes for each locality in Sanganakallu–Kupgal with substantial amounts of dolerite processing.

Platform surfaces were categorised to compare flake complexity between the localities at Sanganakallu–Kupgal (Fig. 8). Fig. 8 shows that Hiregudda Areas J and B are dominated by flakes with cortical or plain platforms, while Hiregudda Areas A and D, and Sannarachamma, are dominated by flakes with polished, pecked and multiple conchoidal platforms. This confirms the observation that Hiregudda Areas J and B are early reduction quarry localities while Hiregudda Areas A and D and Sannarachamma are later stage reduction and axe resharpening locales. Choudammagudda, which had a small sample size of flakes, is ambiguous, falling somewhere in between the two locality types.

A set of Mann–Whitney *U* tests was carried out comparing lithics from the quarries and later stage reduction areas in the following variables: the major dimensions of axes; the weight of hammerstones; and on flakes, their dorsal scar counts, cortex coverage, platform size, the frequency of platform preparation, and the frequency of bending initiations (Table 15). As would be expected, the results show that axes from the quarries are larger in every dimension than those from the later reduction areas. The samples suggest that there are nearly ten times as many axes in the late reduction areas than the quarries, showing that most axe roughouts were transported to the late reduction areas, but a proportion were discarded at the quarries. Hammers were significantly heavier in the quarries indicating a greater amount of force was used in the early stages of reduction. Cortex coverage is greater and dorsal scar counts are less in the quarries, since this is where initial decortication and roughing out was undertaken. In the late reduction areas, the higher frequency of platform preparation and bending initiations, the smaller platforms, and the lighter hammerstones, all indicate more careful and controlled flaking, as the knappers were attempting to finely shape the bifaces.

The rare block-made axes are significantly larger in every dimension than the other types of axe and they are also relatively thicker (Table 16). As the initial form of the large blocks is further removed from the finished axe shape than either a flake or slab blank, manufacturing these block-made axes would have required considerable skill. The ability to strike invasive flakes which extend across the face of the piece, rather than just chipping away at the edge, is essential to forming a large biface (Callahan, 1979). Table 16 shows that the block-made axes were significantly more invasively flaked than the others, and this ability to strike long invasive flakes would have been crucial in reducing a large block into an axe blank.

The block-made axes are only found in the factory stage of occupation at Hiregudda. To test aspects of knapping skill which may have underpinned the production of the block axes, we compared flakes from the factory and habitation stages of occupation at Hiregudda Area A. Mann–Whitney *U* tests were used to compare the length, width, thickness, platform size, and dorsal scar counts of dolerite flakes (Table 17). The results show that knappers in the factory stage were able to strike marginally larger flakes from the same size platforms than knappers in the habitation stage. Although the size difference is small, it is nonetheless significant. The ability to strike large flakes from small platforms is critical in

Table 15
Mann–Whitney *U* tests comparing dolerite flake variables, axe dimensions and hammerstone weights between quarry and late stage reduction localities. Artefacts analysed are samples from selected contexts in Sannarachamma and Hiregudda Areas A and D (late stage reduction localities) and Hiregudda Areas B and J (quarry localities). Platform preparation and bending initiations are analysed as frequency variables, so their percentage relative to all flakes is shown rather than the median value.

Variable	Quarry median	Late reduction median	Quarry mean rank (N)	Late reduction mean rank (N)	Sig.
Dorsal scars	2	3	503.4 (255)	722.5 (1107)	<0.001
Cortex%	10	0	1014 (376)	770.6 (1275)	<0.001
Platform area	105.21	80.72	720.8 (237)	640.5 (1072)	0.003
Platform preparation	21%	43%	719.2 (423)	911 (1304)	<0.001
Bending initiations	22%	31%	664 (287)	728.4 (1143)	0.003
Hammer weight	450	190	19.8 (8)	11.6 (19)	0.011
Axe length	102.69	70.86	237.1 (29)	134.1 (259)	<0.001
Axe width	59.39	42.43	230.9 (28)	136.4 (262)	<0.001
Axe thickness	35.02	20.95	235.9 (27)	135.6 (262)	<0.001

Table 16
Mann–Whitney *U* tests comparing the length, width, thickness, width to thickness ratio and invasiveness of a sample of block-made and non-block-made axes. Invasiveness is measured according to Clarkson (2002).

Variable	Block median	Other median	Block mean rank (N)	Other mean rank (N)	Sig.
Length	122.17	79.33	73.6 (5)	38.3 (75)	<0.001
Width	74.53	46.3	66 (5)	38.8 (75)	0.008
Thickness	41.52	19.54	75.8 (5)	38.2 (75)	<0.001
Width/thickness	1.55	2.38	6.6 (5)	42.8 (75)	<0.001
Invasiveness	0.7	0.4	63 (5)	39.6 (75)	0.028

Table 17
Mann–Whitney *U* tests comparing length, width, thickness, platform size and dorsal scar count of samples of dolerite flakes from the factory and habitation phases of occupation at Hiregudda Area A.

Variable	Habitation median	Factory median	Habitation mean rank (N)	Factory mean rank (N)	Sig.
Length	32.65	34.61	381.1 (354)	428.6 (461)	0.004
Width	29.62	32.32	400.9 (370)	457.9 (496)	0.001
Thickness	6.32	6.81	395.7 (357)	428.7 (471)	0.049
Platform size (mm^2)	86.64	88.35	394 (337)	400.1 (457)	0.708
Dorsal scar count	2	3	350.5 (347)	430.8 (443)	<0.001

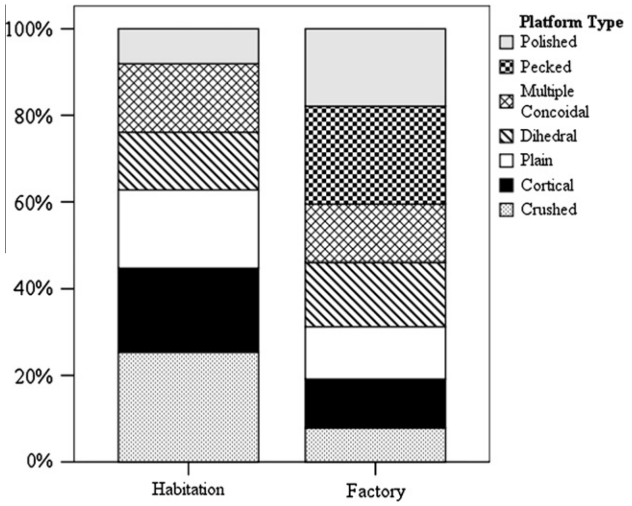

Fig. 9. The proportion of platform surface types on dolerite flakes for the habitation and factory phases of occupation in Hiregudda Area A.

biface knapping, as it allows each face to be worked while maintaining the edge for future removals. The higher dorsal scar counts in the factory stage indicate an increased focus on the later stages of reduction in Area A. Fig. 9 compares platform surfaces of flakes between the habitation and factory stages in Area A. A chi-square test showed the differing distributions of platform types to be significant at the $P < 0.001$ level (pecked and polished platforms were pooled together for this test). There are less cortical and plain platforms in the factory stage, further indicating that Area A was more specialised towards late stage reduction in this period. Pecked platforms only occur in the factory stage, which accords with the observation that the laborious process of pecking was principally reserved for the large block-made axes of the factory period. Finally, there is a lower frequency of crushed platforms in the factory stage than the habitation stage, which implies greater knapping skill in the factory stage.

These metrical analyses of dolerite artefacts have demonstrated the spatial segregation of different knapping stages into two classes: quarries and later reduction areas, a difference which becomes more marked in the factory phase of occupation. Furthermore, these metric analyses have suggested that during the factory phase of occupation, knappers were significantly more skilled than in the preceding habitation phase.

Conclusion

In general we may describe two broad cultural trajectories during the period of pre-Iron Age occupation at Sanganakallu–Kupgal. The earliest occupation in the area is an undifferentiated Mesolithic phase, in which lithic material culture was dominated by quartz microliths, including bladelets and lunates. This cultural phase is represented by the pre-ceramic levels at Birappa and the pre-ashmound levels at Sannarachamma. The manufacturers of this industry were probably hunters who exploited the local quartz. The differentiation of two distinct assemblages in the earliest phase at Sannarachamma suggests intermittent occupation over a long time period. As yet, these earliest occupation phases are undated but they are certainly older than the ashmound.

Early in the second millennium BC, the local ashmound tradition began at Sannarachamma, with ashmounds also appearing on Choudammagudda and Hiregudda. The ashmound Neolithic may represent either a locally intrusive cultural tradition or a development out of the earlier Mesolithic. There is continuity between the second pre-ashmound and the initial ashmound phases at Sannarachamma in the predominance of quartz, the use of single platform, multiplatform, radial and bipolar cores, and in the manufacture of chert bladelets through pressure flaking. This accords with the evidence from other South Indian sites, such as Watgal and Jwalapuram 9 where there is continuity between the Mesolithic and Neolithic lithic technology (DuFresne et al., 1998; Clarkson et al., 2009). Overall the lithic evidence appears to broadly agree with the hypothesis of indigenous plant domestication processes in South India (Fuller et al., 2004; Fuller, 2006), although immigrant Early Dravidian-speaking pastoralists coming from the more northerly Peninsula (cf. Fuller, 2007, 2009; Southworth, 2006) can be postulated to have integrated with indigenous hunter-gatherer-cultivators. The initial ashmound phase at Sannarachamma sees the introduction of grindstones and the use of dolerite and granite. Human genetic evidence, in particular Indian specific mitochondrial DNA lineages with coalescence dates that are pre-Holocene, suggest that the Indian Neolithic did not entail a large-scale population replacement (Kivisild et al. 2003; Metspalu et al., 2004). A parallel situation occurs in western Eurasia and China, where closer to the original agricultural zones there is evidence for population replacement, while in the more peripheral areas such as north-western Europe or northern China there is evidence for continuity (Thomas, 1996; Lu, 1998). As discussed elsewhere (Fuller, 2009), one of the archaeological challenges in South India is that the earliest cultivators appear to have been non-sedentary, and as a result their archaeological record is sparse and poorly known. Nevertheless, the limited elements of lithic continuity between the developed sedentary Neolithic (from ca. 2000 BC at Sanganakallu–Kupgal) and the Early Holocene Mesolithic hint at the existence of cultural continuities, albeit with major innovations or introductions in the Neolithic.

Aside from the perspective they offer on debates about the indigenous versus introduced nature of the Southern Neolithic, the lithics assemblages at Sanganakallu–Kupgal also provide insight into local social and economic patterns. Both at Sannarachamma and Choudammagudda, the ashmounds are associated with high lithic diversity. The transport of lithic materials from different sources to Sanganakallu–Kupgal reinforces the interpretation that ashmounds functioned as inter-community congregation sites for pastoralist communities (Fuller, 1999; Fuller et al., 2001; Boivin, 2004). The nearest potential sources for the chert and chalcedony artefacts are in the Sandur greenstone formations, some 10–15 km away. Technologically these raw materials are associated with an increased emphasis on pressure bladelets. The high proportion of granite grindstones and backed microliths in the main ashmound phase at Sannarachamma, in conjunction with numerous cooked bones (Boivin et al., 2005) and rich archaeobotanical evidence for pulses and grains, adds weight to the hypothesis that food processing and feasting were associated with ashmound creation (Boivin et al., 2007). The grindstones also suggest the introduction of crop cultivation in the region, which is confirmed by the presence of pulses, millets, wheat and barley dating from 1950 BC at Sannarachamma (Fuller et al., 2007). A parallel may drawn with the early Neolithic megaliths of western Europe where the communal labour required for farming is archaeologically expressed not in domestic dwellings but in monuments (Sherrat, 1990). Towards the end of the ashmound phase, dolerite becomes an increasingly important component of the lithic assemblages, linked to more permanent occupation of the hilltops.

Ashmound creation ceased around 1700 BC at both Sannarachamma and Hiregudda, after which hilltop villages emerged at the sites. It was during this time that Feature 1 was constructed at Hiregudda and dolerite axe manufacture begins in earnest. The symbolic importance of groundstone axes is a globally universal feature of cultures where these implements occur (e.g. Sharp, 1952; Edmonds, 1993; Hampton, 1999; Skeates, 2002; D'Amico, 2005; Bennett, 2007), probably as a result of their aesthetic qualities, the effort required to produce them (which experimental evidence suggests would take several days (Madsen, 1984)), and their functional importance. The primary function of groundstone axes was presumably in chopping down trees to prepare land for agriculture, which explains why they are a type fossil for the Neolithic. Their appearance thus not only represents an important technological transformation, but also an ecological transformation in which humans began to consciously alter the landscape to cultivate their own food. The manufacture of groundstone axes at Sanganakallu–Kupgal represents a key transformation in the relationship between human societies and their environment in South India. The clearing of land for cultivation would have increased agricultural productivity and enabled the hilltops to support permanent villages.

The spatial division of axe manufacturing into quarry and early reduction locales on the one hand, and late reduction, grinding and resharpening locales on the other, indicates that axe production at Sanganakallu–Kupgal was organised at the group level. At Mount Isa in Australia where axes were also being produced for trade on an industrial scale there is a similar spatial division into early reduction, late reduction and grinding areas (Hiscock, 2005). In an ethnographic account of Neolithic axe production among the Dani of West Papua, all men were able to shape and sharpen axes by grinding, but only a few were skilled knappers capable of producing axe blanks (Hampton, 1999). Grinding grooves appear to be more widely distributed around Bellary than evidence for the earlier stages of axe manufacture, indicating the latter was a more specialised task (Subbarao, 1948; Risch et al., 2009).

The profusion of axe-making debris, in conjunction with the relatively limited number of axes recovered, suggests that axes were transported away from the site, probably as part of trade networks. Elsewhere in the South Indian Neolithic, at sites such as Piklihal and Budihal, we encounter the reverse situation, where dolerite axes occur in the absence of substantial manufacturing debris, suggesting the axes at these sites were acquired through exchange (Allchin, 1960; Risch et al., 2009). Groundstone axe distribution networks are a pervasive feature of the Neolithic the world over (Edmonds, 1990; Patton, 1991; Mandal, 1997; Hampton, 1999; Harrison and Kohler, 2001; Pétrequin et al., 2002; D'Amico, 2005). The scale of axe production at Hiregudda seems to far exceed the functional needs of the local population (Risch et al., 2009) and, given the rarity of this fine-grained, small-clast dolerite across the Deccan plateau, trading of the Sanganakallu–Kupgal axes seems probable.

Following a possible century-long occupational hiatus, Hiregudda Area A emerged as an important dolerite axe production site around 1400 BC. Iron Age wheel-finished pottery first appears at both Hiregudda and Sannarachamma at this time, and was used in several child urn burials from Hiregudda Area D (Fuller et al., 2007). During this period, the spatial division of axe knapping became more pronounced, probably indicating increased specialisation in axe manufacture. Several flake variables illustrate that knappers attained a higher degree of skill in the factory stage than in the habitation stage, which accords with the appearance of the more technologically challenging large block-made axes. These block axes required a far greater effort on the part of the axe manufacturers than either the slab or flake made axes, as the initial clast had to be mined out of the ground, the reduction sequence was much longer than for the other axes, and they were finished by the laborious process of pecking. Allchin (1957) argued that the large pecked axes of Sanganakallu–Kupgal were of symbolic importance. Indeed the process of pecking mirrors the act of creating petroglyphic rock art which comprises the bulk of evidence for symbolic behaviour at Hiregudda. Brumm et al. (2007) suggest that the block-axes were highly valued prestige items which may have been used in long distance exchange networks. Among modern stone axe makers in New Guinea, the size of the stone blade reflects its trade value and its symbolic importance (Battaglia 1983; Sillitoe, 1988; Pétrequin and Pétrequin, 1993; Hampton, 1999), while in archaeological settings the longest axes are generally transported furthest, and they most often occur in ritual contexts (Cross, 1993; D'Amico, 2005). The appearance of the large block-made axes in the factory stage suggests an emerging status rivalry and social hierarchy during this period. A parallel may be drawn with the terminal Neolithic of Thy in Denmark, where the appearance of flint daggers of varying craftsmanship are indicative of a society where there is increasing competition between households (Earle, 2004).

The greatest intensity and specialisation in the production of axes at Sanganakallu–Kupgal occurs at the end of the Neolithic when there is an expanding range of evidence for long-distance contacts and trade on the south Deccan. The diffusion of ceramics between South India and the North may start as early as 2000–1900 BC (Fuller, 2005a,b), while crops of African origin appear in South India at 1600–1500 BC (Fuller et al., 2007). From ca. 1500 BC the first metals occur in South India, both copper and gold (Fuller et al., 2007), and spindle whorls suggest the growth of local textile production, based on cotton and perhaps flax (Fuller, 2008b). By the terminal Neolithic (1400–1100 BC), sandalwood appears to have been introduced to South India from Indonesia (Asouti and Fuller, 2008, p. 117; Boivin et al., 2008). The population at Sanganakallu–Kupgal seems to have been large enough and generating enough wealth through exchange and agriculture to support specialist craftsmen, such as knappers and potters, in this period. The early megalithic monuments which occur on the plain between Hiregudda and Sannarachamma may also date from this time (Fuller et al., 2007). Excavations of South Indian megaliths have revealed mortuary status inequalities and the emergence of megaliths reflects a stratified society with high status individuals who were able to organise labour and control substantial resources (Bauer et al., 2007). Within an increasingly hierarchical society the laborious manufacture of prestige items, such as groundstone axes, may have contributed to a system of value, whereby individual wealth could be accumulated and displayed (Earle, 2004). Land cleared land using these axes may also have been seen as a possession of the individual, family or group that cleared it, thereby further contributing to a system value and the opportunity for differential wealth. In Sanganakallu–Kupgal these processes resulted in a shift from an egalitarian society that created group monuments: the ashmounds, to a hierarchical society that created individual monuments: the megaliths.

The hilltop sites of Sanganakallu were abandoned after 1200 BC around the time of the Neolithic to Iron Age transition. A similar situation occurs at the nearby Neolithic site of Tekkalakota (Rao and Malhotra, 1965), but elsewhere in South India there is continuity with Iron Age sites (Johansen, 2004). Occupation at Sanganakallu–Kupgal may have moved out onto the plain as part of a more dispersed agricultural settlement pattern, although hard evidence from this period remains elusive. While cultivation in the Iron Age is increasingly argued (e.g. Fuller et al., 2007), there is also the possibility that the terminal Neolithic abandonment of sites represents a local decline in population. At the site of Watgal, where there is continuity between the Neolithic and the megalithic Iron Age, grinding stones decline in the latter period, suggesting a shift in emphasis away from crop production. At Iron Age sites in South India such as Kadebakele it appears that more wild resources were being consumed than in the Neolithic (Bauer et al., 2007). It has been suggested that this reflects a social change, since cattle butchery is typically associated with large-scale communal feasting while smaller game animals are more characteristic of small groups or individual household consumption (Bauer et al., 2007).

At Birappa, farming-era occupation occurs after 1300 BC, and includes ovi-caprid pastoralism and the use of pottery, but there is no evidence for cultivation. Despite the absence of agriculture, granite grindstones were recovered from Birappa, suggesting that cereals were obtained from other sources. Across South Asia there are numerous examples of microlith-using foragers trading with agricultural groups to acquire cereals (Morrison, 2007). Technologically, there is much resemblance to the earlier Mesolithic period at Birappa, with similar quartz microliths manufactured using similar techniques. It is unclear whether they represent a newly established mobile group descended from the earlier Holocene hunter-gatherers, or instead saw terminal Neolithic reinvention. Wild animals dominate rock art depictions at Birappa, suggesting that hunting as well as ovi-caprid pastoralism were important modes of subsistence. The god Birappa is associated both with hunting and ovi-caprids, reinforcing the link between the two. The lack of evidence for occupation at Birappa during the main occupation phases of the hilltop sites suggests that use of the shelter is favoured by hunters and pastoralists, and not agriculturalists. In addition, it is likely that the quartz resources that brought stone knappers to the Birappa rockshelter were less attractive during the main Neolithic occupation at Sanganakallu–Kupgal, when superior sources for making microliths were being acquired from further afield.

The divergence between Birappa and the hilltop village sites is emphasised by attitudes towards cattle amongst their occupants. Cattle are conspicuous only by their absence in the rock art and faunal remains from Birappa. In marked contrast, the creation of ashmounds using cow-dung, the numerous cattle bones, and the profusion of cattle in the petroglyphic rock art imagery, illustrates the ideological and economic importance of cattle to the people who occupied the granite hills at Sanganakallu–Kupgal. Whether these ideological differences represent different groups with different traditions, or the same group during different adaptive phases is a matter for speculation. What is clear is that the technological and social changes which accompanied these ideological differences were profound. At Birappa, hunting and direct percussion microlithic technology recur across several millennia. By contrast on the hilltops within a single millennium the occupants adopted pressure flaking, groundstone technology, cattle pastoralism and communal monument construction. They then underwent a further transformation becoming a more stratified society, constructing individualised monuments and becoming part of an inter-continental trade network, before finally abandoning groundstone technology and their hilltop villages. Contrasting cultural trajectories such as these were probably played out elsewhere in the Indian sub-continent, leading to the panoply of social groups across India today.

Overall, the lithic assemblage recovered from Sanganakallu–Kupgal represents a major resource that is now one of the most systematically and comprehensively studied for the subcontinent. While lithic studies are in themselves unable to provide conclusive answers, they do nonetheless offer an important strand of evidence. Here lithics are suggestive of at least a degree of long-term continuity in technological traditions in the southern Deccan. They also provide insights into the mechanisms by which more complex spatial organisation and craft production emerged at Southern Neolithic sites in conjunction with the beginnings of evidence for hierarchical societies. Further study of the rich material remains of the Neolithic and Iron Age societies that produced the remarkable ashmounds and megaliths of South India will undoubtedly help to provide a richer understanding of some of India's most fascinating and fastest disappearing archaeological sites.

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