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Reinvestigation of Kuumbi Cave, Zanzibar, reveals Later Stone Age coastal habitation, early Holocene abandonment and Iron Age reoccupation

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ABSTRACT

The late Pleistocene and Holocene history of eastern Africa is complex and major gaps remain in our understanding of human occupation during this period. Questions concerning the identities, geographical distributions and chronologies of foraging, herding and agricultural populations — often problematically equated with the chronological labels 'Later Stone Age (LSA)', 'Neolithic' and 'Iron Age' — are still unresolved. Previous studies at the site of Kuumbi Cave in the Zanzibar Archipelago of Tanzania reported late Pleistocene Middle Stone Age (MSA) and LSA, mid-Holocene Neolithic and late Holocene Iron Age occupations (Sinclair *et al.* 2006; Chami 2009). Kuumbi Cave considerably extends the chronology of human occupation on the eastern African coast and findings from the site have been the basis for the somewhat contentious identification of both a coastal Neolithic culture and early chicken, a domesticate that was introduced to Africa from Asia. The site therefore warrants further investigation. Here we report on a new excavation of the Kuumbi Cave sequence that has produced a suite of 20 radiocarbon and optically stimulated luminescence (OSL) dates. Our results suggest that the cave's stratigraphy is complex, reflecting taphonomic processes that present interpretive and

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dating challenges. Our assessment of the stratigraphic sequence demonstrates three phases of habitation, two of which reflect terminal Pleistocene occupation and are characterised by quartz microliths, bone points and the exploitation of terrestrial and marine species, and one of which reflects later reoccupation by AD 600. In this latter phase, Kuumbi Cave was inhabited by a population with a locally distinct material culture that included idiosyncratic Tana or Triangular Incised Ware ceramics and medium-sized limestone stone tools, but with a subsistence economy similar to that of the late Pleistocene, albeit with more emphasis on marine foods and smaller terrestrial mammals. Our results suggest that Kuumbi Cave may have been unoccupied for much of the Holocene, after Zanzibar became an island. Our findings also place into question earlier identifications of domesticates, Asian fauna and a mid-Holocene Neolithic culture at the site.

ABSTRAIT

La séquence du Pléistocène tardif et de l'Holocène en Afrique orientale est complexe et des lacunes importantes subsistent dans notre compréhension de l'occupation humaine durant cette période. Les questions concernant les identités, les distributions géographiques et les chronologies des populations de chasseurs-cueilleurs, d'éleveurs et d'agriculteurs — souvent problématiquement confondues avec les étiquettes chronologiques 'Later Stone Age (LSA)', 'Néolithique' et 'Âge du Fer' — sont encore en suspens. Des études antérieures sur le site de la grotte de Kuumbi Cave, dans l'archipel de Zanzibar en Tanzanie, avaient signalé pour le Pléistocène tardif la présence d'occupations humaines appartenant au Middle Stone Age (MSA) et au Later Stone Age, ainsi que des occupations Néolithiques du mi-Holocène et de l'Âge du Fer pour l'Holocène tardif (Sinclair *et al.* 2006; Chami 2009). Les données provenant de Kuumbi Cave étendent considérablement la chronologie de l'occupation humaine sur la côte orientale de l'Afrique, et elles ont aussi été à l'origine de l'identification quelque peu controversée et d'une culture néolithique côtière et de la présence du poulet, animal domestique introduit en Afrique à partir de l'Asie. Le site méritait donc une enquête plus approfondie. Nous rapportons ici de nouvelles fouilles de la séquence de Kuumbi Cave, qui ont produit une série de 20 datations par radiocarbone et par la luminescence stimulée optiquement (OSL). Nos résultats montrent que la stratigraphie est complexe, reflétant des processus taphonomiques qui présentent des défis d'interprétation et de datation. Notre évaluation de la séquence stratigraphique indique trois phases d'habitation. Deux d'entre elles reflètent l'occupation du Pléistocène terminal, et se caractérisent par les microlithes en quartz, les pointes en os et l'exploitation d'espèces terrestres et marines; la dernière représente une réoccupation plus tardive, datant d'environ 600 ap. J.-C. Dans cette dernière phase, Kuumbi Cave fut habitée par une population possédant une culture matérielle locale et distincte, qui comprenait des céramiques idiosyncratiques de la tradition Tana ou de la tradition du Triangular Incised Ware, ainsi que des outils de calcaire de dimensions moyennes. L'économie de subsistance de cette phase était similaire à celle de la fin du Pléistocène, mais portait davantage d'emphase sur les aliments marins et les petits mammifères terrestres. Nos résultats suggèrent que le site de Kuumbi Cave a peut-être été inoccupé pendant une grande partie de l'Holocène, après que Zanzibar soit devenu une île. Nos résultats

remettent également en question les identifications antérieures d'espèces domestiquées, d'une faune asiatique, et d'une culture néolithique datant du mi-Holocène sur le site.

Introduction

Kuumbi is a large limestone cave located near the southeastern coast of Unguja Island in the Zanzibar Archipelago of Tanzania (Figure 1). Previous excavations led by Felix Chami and Paul Sinclair established that Kuumbi Cave is an important site for addressing a range of key issues on the eastern African coast, including the coastal adaptations of Pleistocene hunter-gatherers, the spread of domesticated animals and Indian Ocean trade connections (Sinclair *et al.* 2006; Chami 2007, 2009). Stone artefacts over 25,000 years old have been reported from the cave (Sinclair *et al.* 2006), providing some of the earliest dates for coastal occupation in equatorial eastern Africa. These dates render Kuumbi Cave potentially crucial for testing currently popular models of the coastal adaptation and dispersal of *Homo sapiens* in the late Pleistocene (Stringer 2000; Mellars *et al.* 2013). The site is also argued to have been occupied around the sixth millennium BP by Neolithic populations with pottery (suggested at other coastal sites as having affiliations with Rift Valley Pastoral Neolithic pottery; Chami and Chami 2001; Chami and Kwekason 2003; Kwekason 2011), stone tools and domesticates including taurine and zebu cattle (*Bos taurus* and *Bos indicus*), sheep (*Ovis aries*) and/or goat (*Capra hircus*), dog (*Canis familiaris*) and chicken (*Gallus gallus*), as well as large quantities of cat, which may be either domestic (*Felis catus*) or wild (*Felis silvestris libyca*) (Chami 2009). Zebu cattle and chicken are both Asian domesticates and their presence implies precociously early Indian Ocean trade, for which previous excavations found support in the form of an Indian drawn glass bead from a purportedly Neolithic layer (Chami 2009). The Kuumbi Cave findings built upon work at Machaga Cave (Chami 2001), where claims were also made for beads indicative of Indian Ocean contact, as well as finds of chicken, cat and Rift Valley-affiliated Neolithic pottery (Chami and Kwekason 2003). These findings, particularly the identification of a coastal Neolithic and the early spread of chicken, have, however, been questioned (Sinclair 2007; Dueppen 2011; see also Sutton 2002), necessitating new data from Kuumbi Cave. A re-examination of Kuumbi Cave was accordingly undertaken by
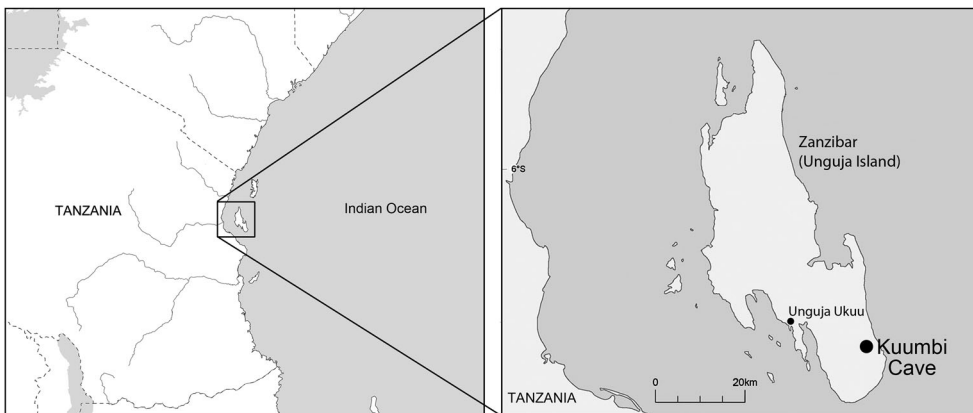

Figure 1. Location of Kuumbi Cave and other locations on Zanzibar mentioned in the text.

the Sealinks Project in 2012, as part of wider investigations of eastern Africa's coastal pre-history and early trade connections (Helm *et al.* 2012; Boivin *et al.* 2013, 2014; Shipton *et al.* 2013; Crowther *et al.* 2014, 2015, in press).

Geological and environmental context

Unguja is the largest island in the Zanzibar Archipelago, spanning some 85 km long and 30 km wide at maximum extent (1660 m^2). Aside from a central north-south ridge that reaches a highpoint of 117 m a.s.l. just north of Stone Town (Figure 1), the island is generally flat and low-lying. Unguja lies on the continental shelf and is separated from the eastern African mainland by a narrow, fault-bounded channel, 35 m deep at its shallowest point and 37 km wide at its narrowest (General Bathymetric Chart of the Oceans 2015). The island has been connected to the mainland at various times since the Miocene, most recently in the late Pleistocene, until about 10,000 BP, when sea level rise separated it from the mainland (Prendergast *et al.* 2016). Kuumbi Cave is now situated about 2–3 km from the present-day coast (Figure 1) and, although this distance would have fluctuated a small amount over time, the steep continental shelf off the eastern coast of the island means that the cave was always within 10 km of the coast throughout the last 20,000 years.

The eastern side of Unguja Island is largely comprised of coral rag (exposed coralline limestone bedrock) that is only shallowly covered by loose, relatively infertile '*kinongo*' soils (Kombo 1994; Juma 2004). This part of the island is generally less humid than the western part (where deeper, more fertile '*kichango*' soils are found) and is dominated by semi-deciduous coral rag forest, composed mainly of low scrubby bush (e.g. *Psiada dodaneifolia*, *Xyorphytes* sp*., Euphorbia* sp*., Pheonix reclinata* [wild date], *Causarina equisetifolia*, and *Pandanus livingstonianus*) as well as ferns, grasses and other trees (Juma 2004). Today, however, the area immediately surrounding the cave is tropical evergreen coastal forest, part of the Zanzibar-Inhambane floral mosaic (White 1983), which is likely to have once covered much of the island. This flora has been preserved in the vicinity of the cave largely owing to local cultural taboos against cutting the forest near the cave (Chami 2009).

Unguja island has a rich marine and littoral fauna and also supports a variety of terrestrial species suitable for hunting or trapping, including blue and Ader's duikers (*Cephalophus monticola* and *C. adersi*), suni (*Neotragus moschatus*), bushpig (*Potamochoerus larvatus*), colobus (*Colobus kirki*) and vervet monkeys (*Chlorocebus aethiops*), giant rat (*Cricetomys gambianus*), tree hyrax (*Dendrohyrax validus*) and Nile monitor lizards (*Varanus niloticus*), as well as ducks, geese and guinea fowl (*Numida meleagris*) (Walsh 2007). The Zanzibar leopard (*Panthera pardus adersi*) is the island's only extant large carnivore, although it may have been exterminated in recent decades (Goldman and Walsh 2002; Walsh and Goldman 2003); civets, genet, and mongoose remain. As Unguja was previously connected to the mainland, it once supported a wider range of terrestrial fauna, including zebra *(Equus* cf. *quagga)* and giraffe (*Giraffa camelopardalis*) (Sinclair 2007; Chami 2009). Today, mixed farming communities keep some livestock, mainly cattle (taurine-indicine crossbreeds) and goats, with chicken being the most ubiquitous domesticate (Revolutionary Government of Zanzibar 2012). Giant African land snails (*Achatina fulica*) are also a common sight on the island today, but are not known to be eaten locally.

Kuumbi is one of several caves within a flight of multiple terraces of Pleistocene marine limestone (Kourampas *et al.* 2015). The limestone bedrock of the cave walls consists of bivalve-gastropod packstone with extensive mouldic porosity. As with other eastern African Quaternary marine limestones, this was formed at least as early as — or, more likely before — the Last Interglacial (Arthurton 2003), the minimum age for the subsequent formation of the cave. Kuumbi Cave likely formed initially as a phreatic cavity and was then exposed to the exterior by collapse of the ceiling. In addition to the two sloping entrances, there are also four vertical openings to the cave. These openings mean that the two main chambers of the cave are well lit (Figure 2) with little difference in temperature and humidity from the outside. Following ceiling collapse, Kuumbi Cave received large quantities of detrital sediment from the surrounding landscape. In profile, the floor of the first chamber is shaped like a very open U (Figure 3), the product of the combined effects of karstic dissolution and the deposition of steep rock fall and talus cones under the two cave entrances. The floor thus slopes from both entrances down to the cave well, an approximately 2 m deep depression where water pools in the rainy season.

Previous excavations of Kuumbi Cave

Earlier archaeological excavations at Kuumbi Cave were undertaken over three field seasons: the first in 2005 under the direction of Felix Chami and colleagues, with a second season in the same year in collaboration with Paul Sinclair and a third in 2007

Figure 2. Kuumbi Cave: interior of the site looking northeast towards the entrance from the well. The second chamber is off to the right and Trenches 6 and 10 are located on the right between the sinkhole and the main entrance behind the spoil heap. Note that the ground surface slopes up towards the cave entrance.
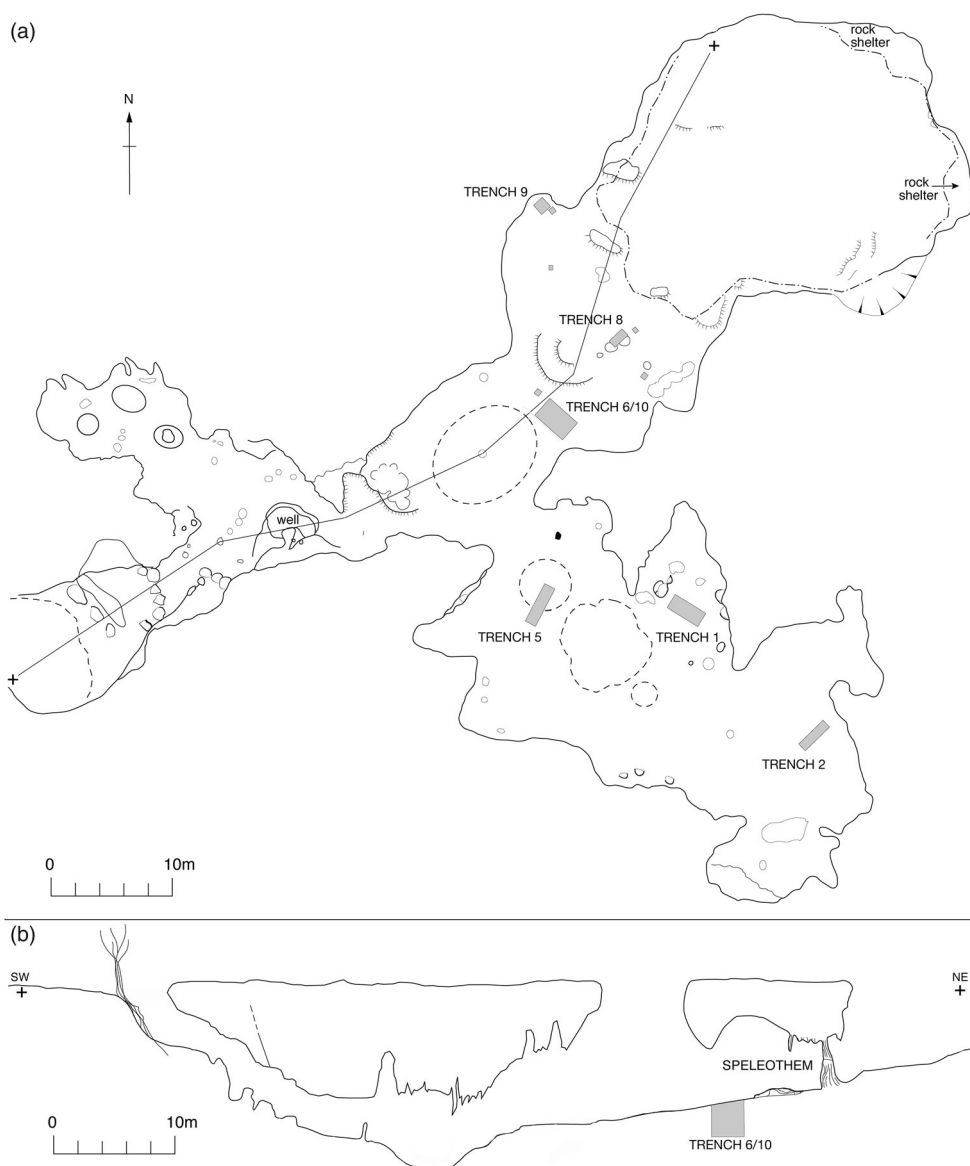
Figure 3. Kuumbi Cave: a: plan showing the location of various trenches from the previous excavations; b: the profile of the first chamber of showing Trench 6/10.

led by Chami and colleagues (Chami 2006, 2007, 2009; Sinclair et al. 2006). In total, these researchers excavated nine trenches (Figure 3). Excavations proceeded by a combination of 5–10 cm arbitrary spits and distinguishable stratigraphic contexts (Sinclair et al. 2006). The radiocarbon dates from these earlier excavations are summarised in Table 1 and come exclusively from Trenches 6, 8 and 9, which also provided the most detailed cultural sequences.

The main sequence was derived from Trench 6, a 3×2 m unit in the first chamber initially excavated by Chami and later extended by Sinclair and Chami to form a 4×2 m

Table 1. Kuumbi Cave: previous radiocarbon determinations published by Sinclair *et al.* (2006) and Chami (2009), recalibrated according to the methods described in text.

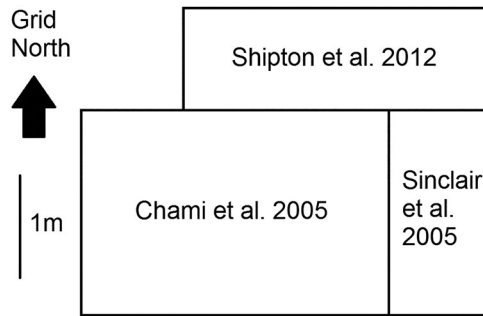| Trench	Level (cm)	Material	Laboratory number	Uncalibrated ^{14}C date BP	Calibrated date range BP (BC/AD also indicated where relevant)	Notes
Trench 1	65–70	Charcoal	Ua-24751	1980 ± 45	2005–1750 (60 cal. BC–cal. AD 200)	Chicken bones 20 cm below this level (Chami 2009: 90).
Trench 6 extension	80–95	Charcoal	Ua-24919	4005 ± 40	4750–4290	Chicken bone (Chami 2009: 90).
Trench 6 extension	130–135	Charcoal	Ua-24920	1815 ± 40	1825–1605 (cal. AD 125–345)	Ashy layer (Chami 2009: 90).
Trench 6 extension	175–180	Charcoal	Ua-24921	5330 ± 45	6210–5940	Cattle bone (Chami 2009: 90).
Trench 6 extension	210–215	Terrestrial snail shell	Ua-24922	21695 ± 300	26,605–25,350	Occupational hiatus (Sinclair *et al.* 2006: 101).
Trench 8	55–60	Charcoal	GrA-37807	1535 ± 30	1520–1310 (cal. AD 440–640)	Iron Age (TIW or EIA) (Chami 2009: 92).
Trench 8	55–60	Charcoal	Ua-35922	1525 ± 40	1511–1306 (cal. AD 440–645)	Chami (2009: 93).
Trench 8	65–70	Charcoal	GrA-37809	1590 ± 30	1530–1375 (cal. AD 420–575)	Iron Age (TIW or EIA) (Chami 2009: 92).
Trench 8	115–120	Charcoal	GrA-37811	5110 ± 35	5915–5740	Cattle, goat, chicken (Chami 2009: 92).
Trench 8	160–165	Terrestrial snail shell	GrA-37813	16,080 ± 60	19,555–19,190	Few material remains in this layer (Chami 2009: 92).
Trench 8	185–190	Terrestrial snail shell	GrA-37815	15,980 ± 60	19,455–19,035	Beginning of occupation (Chami 2009: 92).
Trench 8	185–190	Terrestrial snail shell	Ua-35924	16,360 ± 115	20,025–19,445	Beginning of occupation (Chami 2009: 92).
Trench 9	20–25	Charcoal	GrA-37816	3850 ± (data missing)	??	Imported pottery(?) (Chami 2009: 92).
Trench 9	25–30	Charcoal	GrA-37817	2110 ± 30	2150–1900 (200 cal. BC – cal. AD 45)	Pottery with incised panel (Chami 2009: 92).
Trench 9	25–30	Charcoal	Ua-35925	1245 ± 55	1271–986 (cal. AD 440–645)	Pottery (Chami 2009: 93).
Trench 9	80–86	Charcoal	GrA-37818	10,645 ± 45	12,695–12,435	Human skeletons below pile of stones (Chami 2009: 92).
Trench 9	80–85	Terrestrial snail shell	Ua-35926	10,885 ± 85	12,965–12,655	Human bones.
Trench 9	95–100	Terrestrial snail shell	GrA-37806	23,590 ± 90	27,845–27,540	Beginning of occupation.
Trench 9	95–100	Terrestrial snail shell	Ua-35927	31,195 ± 665	36,570–33,935	Beginning of occupation.

Figure 4. The relationship of the three excavations of Trench 6/10 to one another.

unit (see Figure 4 below). This trench revealed evidence of human occupation extending back to the late Pleistocene. The lowest layer of Trench 6 was reported to contain heavy-duty stone tools of limestone or coral, including handaxes, picks and chopping tools (Sinclair *et al.* 2006), indicating a possible MSA affiliation (Chami 2009). A radiocarbon date on a terrestrial shell from a sterile layer overlying this lowest layer suggested that this early occupation was at least 25,000 years old (Table 1).

After a period of abandonment of several millennia, the cave was argued to have been reoccupied in the mid-Holocene. Three radiocarbon dates on charcoal gave ages of 6210–5940 cal. BP (175–180 cm depth), cal. AD 125–345 (1825–1605 cal. BP) (130 cm depth) and 4570–4290 cal. BP (80–95 cm depth) (Sinclair *et al.* 2006; Chami 2009) (Table 1), suggesting an approximate time frame for this phase of occupation. Owing to the stratigraphic inversion of the dates, however, the excavators advised caution in their chronological interpretation (Sinclair *et al.* 2006: 104). The lowermost layers of this occupation phase (from approximately 200 cm deep) included a quartz microlith industry, marine shell, decorated bone and pointed bone fragments that were suggested to have been used as projectile points (Sinclair *et al.* 2006; Chami 2009). From a depth of approximately 160 cm, pottery as well as possible domesticated cattle and chicken bones appeared in the sequence, while a different stone tool assemblage, characterised by crystalline limestone flakes, occurred from *c.* 120–45 cm deep, replacing the quartz microlith industry. The main concentration of pottery from this phase comprised 30 red burnished sherds found at a depth of 120–125 cm (Sinclair *et al.* 2006). Together, this cultural sequence of apparently mid-Holocene ceramics, stone tools and domesticates was suggested by Chami (2007, 2009) potentially to record an early Neolithic presence on the island. An Indian red drawn glass bead was also recovered at a depth of 140–145 cm, which was situated between dates on charcoal samples of 6210–5940 cal. BP and cal. AD 125–345 (1825–1605 cal. BP), suggesting very early Indian Ocean trade connections (Chami 2009).

The upper part of Trench 6 contained a large ceramic assemblage. The majority of it was concentrated in the topmost 10 cm of the deposit, but it was also scattered through underlying layers to a depth of about 90 cm (Sinclair *et al.* 2006). Local Tana Tradition/Triangular Incised Ware (TT/TIW) ceramics were recovered to a depth of about 40 cm (Chami 2009).

In 2007, an additional two trenches (8 and 9) were excavated near the entrance of the cave (Chami 2009) (Figure 3). A new series of radiocarbon dates suggested that cattle, goat, dog and chicken remains in Trench 8 were as old as 5915–5740 cal. BP (from a date on

charcoal), while the earliest human presence in the trench, signified by marine shells, was dated to *c.* 19,000 cal. BP (from two dates on terrestrial snail shell: Table 1). Trench 9 uncovered a human skeleton beneath a pile of stones interpreted as a cairn. A piece of charcoal associated with the skeleton dated it to 12,695–12,435 cal. BP. Stone artefacts and marine shell recovered from near the lowest levels in Trench 9 were dated to 27,845–27,540 cal. BP by radiocarbon on terrestrial snail shell.

Two of the main claims for Kuumbi Cave, that it has a pre-20,000-year-old MSA occupation and that it has a mid-Holocene Neolithic occupation, remain controversial. From the photographs in Sinclair *et al.* (2006) it is not possible to assess whether the heavy-duty coral limestone lithics from the lower deposits of Trench 6 are genuine artefacts; clearer photographs in Knutsson (2007) and Chami (2009) do not have any visible diagnostic traits of flaked lithics. The identification of the chicken bones, critical to the Neolithic hypothesis and the question of early maritime trade, has been questioned on the grounds that the specimens thus far illustrated are undiagnostic (Dueppen 2011). Likewise, the three 'Neolithic' ceramic sherds illustrated by Chami (2009: 73) are typologically ambiguous because some decorative features are shared between Neolithic and TT/TIW ceramic traditions. In light of these issues, the current study aimed to clarify the site's chronology and geoarchaeology (see also Kourampas *et al.* 2015) and to shed further light on its possible significance for understanding eastern Africa's early coastal occupation and trans-oceanic trade connections through bioarchaeological and material cultural studies.

Fieldwork and analytical methods

Excavation method

Four trenches were excavated in Kuumbi Cave during the Sealinks field season in 2012: Trench 10 was located in the upper main chamber and was an extension of Chami and Sinclair's Trench 6, while Trenches 11–13 (KC11–13) were located in the lower main chamber and were small (1.0×0.5 m) extensions of Chami's Trenches 1, 2 and 5, excavated for the primary purpose of recording the cave's lithostratigraphy and sampling for palaeoenvironmental and geoarchaeological analyses. Very little cultural material was recovered from KC11–13, with no pottery, beads or stone tools and only very rare finds of marine shell. Given the small areas excavated, this result likely reflects a very low density of human-deposited materials in this area of the cave, rather than an absence of occupation. We limit our report here to the discussion of the main sequence obtained from Trench 10.

Trench 10 was placed immediately adjacent to the northern wall of Chami and Sinclair's Trench 6 (Figure 4). Grid north in our excavations was oriented towards the entrance of the cave, though we note that this corresponds to Chami and Sinclair's grid east (the trench was aligned at approximately 45° to true north) (Figure 4). Trench 10 measured 3×1 m and ran parallel to the northern wall of Trench 6, starting in the northeastern corner (Figure 4). Thus, the total size of Trench 6/10 measured 3×4 m with a 1×1 m baulk left in its northwestern corner.

Trench 10 was excavated by single stratigraphic context in accordance with the Museum of London Archaeological Site Manual (1994), where each depositional unit is

treated as a single excavation unit. The single context method has proved effective for excavating and understanding complex stratigraphies, such as those in caves, as it gives absolute primacy to stratigraphic changes, in contrast to horizontal spits, which impose arbitrary structure on a sequence. This approach was facilitated by removing the backfill of the previous excavations to draw the stratigraphic profile (Figure 5), so that the major layers were identified prior to commencing excavation. The excavation was challenging owing to the upper part of the sequence (Contexts 1004–1017) comprising dusty grey sediments that were difficult to differentiate. These upper deposits were also riddled with animal burrows up to 20 cm in diameter (burrow-fills were excavated as separate contexts and the sediments from them discarded). The lower part of the sequence was far less disturbed and the sediments were more compact. All excavated deposits were dry-sieved on-site through a 3 mm mesh from which all artefacts, bone and marine shells were collected. A 60 litre bulk sediment sample (or 100% for smaller contexts) was also taken from every context for off-site flotation (using a 0.3 mm mesh) and wet-sieving (through a 1 mm mesh) in order to recover archaeobotanical remains, terrestrial snail shells and any smaller cultural materials.
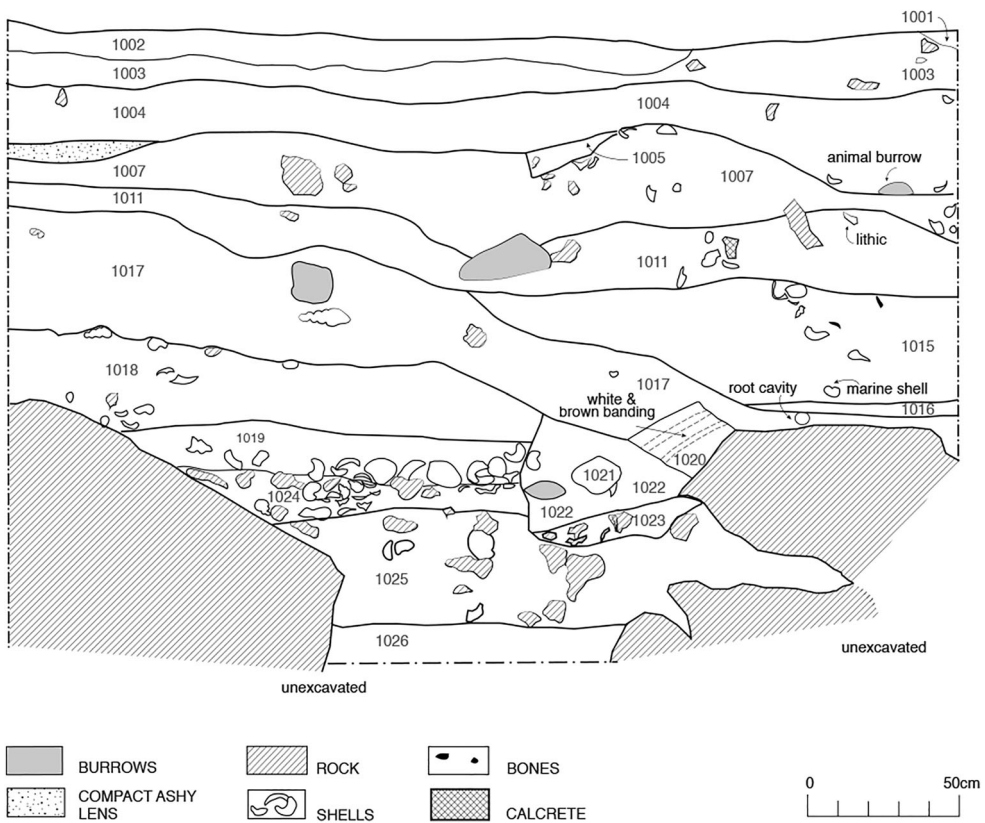
KC10 SOUTH SECTION

Figure 5. Kuumbi Cave: south section of Trench 10 prior to excavation (equivalent to the grid east section of Kuumbi Trench 6 excavated by 2006 et al. (2006: Fig. 9)).

Chronometric dating

The Trench 10 sequence was dated through the application of both radiocarbon (AMS) and Optically Stimulated Luminescence (OSL) methods. Ten AMS dates on charcoal, one AMS date on human bone, five AMS dates on terrestrial snail shell, and four OSL dates on ceramic sherds were obtained across the sequence (Tables 2 and 3). In addition, 39 bones belonging to various taxa from across the Trench 10 contexts were pre-screened for collagen preservation in order to assess their suitability for radiocarbon dating (after Brock et al. 2010, 2012). With few exceptions, however, most samples from KC10 yielded very poor results, well below the 0.75% nitrogen threshold considered reliable for radiocarbon dating. Even though a couple of samples were over this threshold, we were concerned they might therefore be intrusive (since some %N levels were much higher than the average), and decided against directly dating them. We therefore focused our dating efforts on charcoal and snail shell instead. One specimen of human bone was also dated.

Charcoal fragments for radiocarbon dating were identified to genus and family level where possible, according to standard charcoal analysis procedures and using wood anatomy atlases of flora from Africa and adjacent regions for comparison (Fasolo 1939; Fahn and Werker 1986; Neumann et al. 2000). Charcoal fragments were selected for dating on the basis of having a clear taxonomical attribution, if possible to the same genus across the dated contexts (e.g. Ziziphus sp. or Acacia sp.). Single fragments (not bulk samples) were dated in each case.

Charcoal, shell and bone samples were radiocarbon dated using routine methodologies at either the Oxford Radiocarbon Accelerator Unit (ORAU) or the University of Waikato Radiocarbon Facility. For charcoal, an Acid-Base-Acid preparation was performed, while for the human bone, dated at the ORAU, the ultra-filtration protocol was used. For the conversion of the radiocarbon determinations to calendar years we used mixed Southern and Northern Hemisphere calibration curves (70% SHCal13, 30% IntCal13) to account for the fact that Zanzibar is affected by the Intertropical Convergence Zone, as well as an annually updated interim curve and the OxCal platform (Bronk Ramsey 2009).

OSL dating was carried out on four samples of pottery obtained from three archaeological contexts (1003, 1007 and 1011). The measurements were made on sand-sized quartz (90–12 μm) extracted from the sherds using standard preparation techniques. These included removal of the outer layers, careful crushing of the core material, dry sieving, HCl (10%) treatment to remove carbonates, HF treatment (48%) to dissolve feldspathic minerals, heavy mineral separation with sodium polytungstate and final re-sieving of the treated mineral fraction. Measurements were performed using a Lexsyg-Research luminescence reader manufactured by Freiberg Instruments (Richter et al. 2013). The reader was fitted with a new type of ring source (Richter et al. 2012) that was calibrated against a gamma-irradiated quartz standard supplied by the Nordic Centre for Luminescence Research in Denmark (Hansen et al. 2015). OSL measurements were made using a SAR post-IR blue measurement protocol (Murray and Wintle 2000; Banerjee et al. 2001; Wintle and Murray 2006). The concentrations of radioisotopes (potassium, thorium and uranium) within the pottery and the surrounding sediment were derived from elemental analysis by ICP-MS/AES using a fusion sample preparation technique. The final OSL age estimates are presented in Table 2 and include an additional 4% systematic error to

Table 2. Kuumbi Cave: summary of luminescence dating results from the present study.

Laboratory Code	Context	Depth[a] (cm)	Water[b] (%)	Radioisotopes[c]			External (Gy/ka)	Cosmic (Gy/ka)	Total dose rate (G7/ka)	D$_e$ (Gy)	OSL age[d] (years)
				K (%)	Th (ppm)	U (ppm)					
X6696P	1003	245	1.71	1.05	5.6	1.8	0.34 ± 0.02	0.14 ± 0.06	1.61 ± 0.10	0.95 ± 0.06	590 ± 50
X6697P	1007	275	2.83	0.68	9.2	1.9	0.30 ± 0.02	0.13 ± 0.05	1.38 ± 0.08	1.88 ± 0.13	1360 ± 125[e]
X6698P	1007	275	1.75	0.73	9.6	2.0	0.30 ± 0.02	0.13 ± 0.05	1.44 ± 0.08	0.99 ± 0.11	685 ± 85
X6699P	1011	300	2.03	1.15	11.6	2.2	0.40 ± 0.02	0.13 ± 0.04	1.92 ± 0.10	1.84 ± 0.11	960 ± 80

[a]Includes the thickness of the cave roof.
[b]Measured water contents are expressed as a percentage of the dry mass of the sample. A long-term mean water content of 1–6% was assumed for the dose rate determinations of the sediment as well as the pottery samples.
[c]Measurements were made on dried, homogenised and powdered material by ICP-MS/AES (out-sourced to Actlabs in Canada) with an assigned systematic uncertainty of ± 5%. Dry beta dose rates calculated from these activities were adjusted for the field water content.
[d]The age datum refers to years before AD 2015 when the samples were measured and the luminescence dates are based on central age model estimates of the weighted mean De values.
[e]If this sample has been reworked from a deeper depositional context (i.e. 1011) then the calculated date is likely to have been overestimated by c. 100 to 150 years due to higher levels of radioactivity in the underlying sedimentary unit.

Table 3. Kuumbi Cave: summary of new radiocarbon and OSL dates for Trench 10.

Context	Material	Method	Laboratory number	Uncalibrated ^{14}C date/ OSL date	Calibrated date range BP at 2 σ (or date BP/AD for OSL samples)	Charcoal source	Phasing / interpretation
1003	Charcoal, *Acacia* sp.	AMS	Wk-40631	5332 ± 20	6185–5995	Sediment	Phase 1 (reworked colluvium)
1003	Pottery	OSL	X6696P	590 ± 50	640–540 BP (AD 1375–1475)		Phase 1
1004	Charcoal, *Ziziphus* sp.	AMS	Wk-40635	4467 ± 21	5280–5880	Sediment	Phase 1 (reworked colluvium)
1004C	Charcoal, unidentified	AMS	Wk-40964	1622 ± 21	1535–1415 (cal. AD 410–540)	Hearth	Phase 1 (old wood?)
1007	Charcoal, *Ziziphus* sp.	AMS	Wk-40636	4459 ± 20	5275–4875	Sediment	Phase 1 (reworked colluvium)
1007	Pottery	OSL	X6697P	1360 ± 125	1485–1235 BP (AD 530–780)		Phase 1
1007	Pottery	OSL	X6698P	685 ± 85	770–600 BP (AD 1245–1415)		Phase 1
1008	Charcoal, unidentified	AMS	Wk-40963	3100 ± 22	3360–3210	Hearth	Phase 1 (older material reworked into later deposits?)
1011	Charcoal, *Ziziphus* sp.	AMS	Wk-40634	4887 ± 20	5645–5490	Sediment	Phase 1 (reworked colluvium)
1011	Pottery	OSL	X6699P	960 ± 80	1040–880 BP (AD 980–1135)		Phase 1
1011	Bone, *Homo sapiens*	AMS	OxA-31427	1479 ± 23	1370–1300 (cal. AD 580–660)		Phase 1
1015	Charcoal, unidentified	AMS	Wk-40962	5082 ± 23	5900–5730	Sediment	Phase 2 (reworked colluvium)
1015	Shell, *Achatina* sp.	AMS	Wk-42253	10549 ± 35	12620–12410		Phase 2
1016	Charcoal, unidentified	AMS	Wk-40961	1899 ± 20	1875–1740 (cal. AD 80–230)	Sediment	Phase 2 (bioturbation?)
1016	Shell, *Achatina* sp.	AMS	Wk-42254	10069 ± 32	11,750–11,340		Phase 2
1017	Shell, *Achatina* sp.	AMS	Wk-42255	11082 ± 37	13,040–12,790		Phase 2
1017	Shell, *Achatina* sp.	AMS	Wk-42256	10582 ± 35	12,640–12,420		Phase 2
1019	Shell, *Achatina* sp.	AMS	OxA-30467	15460 ± 65	18,830–18,555		Phase 3
1019	Charcoal, *Ziziphus* sp.	AMS	Wk-40632	14221 ± 62	17,485–17,080	Sediment	Phase 3
1025	Charcoal, Leguminosae (Caesalpimioideae type)	AMS	Wk-40633	16656 ± 56	20,240–19,880	Sediment	Phase 3

account for uncertainties in source calibration and measurement reproducibility. Dose rate calculations are based on Aitken (1985) and incorporate beta attenuation factors (Mejdahl 1979) and dose rate conversion factors (Guerin *et al.* 2011), as well as an absorption coefficient for the water content (Zimmerman 1971). The contribution of cosmic radiation to the total dose rate was calculated as a function of latitude, altitude, burial depth (including the thickness of the cave roof) and average over-burden density based on data by Prescott and Hutton (1994).

Archaeological assemblages

The small sample of 44 excavated stone artefacts was analysed through attribute recording and metric measurements on each individual artefact. Ceramic artefacts were classified into different types based on visual inspection of fabric (local/non-local, colour, paste), form (body, rim, etc.) and decoration (incised, appliqué, punctates etc.) and according to published typologies (e.g. Horton 1996; Fleisher and Wynne Jones 2011). The sherds in each type were then counted and weighed. The fabrics of a selection of local sherds of broadly similar appearance that were distributed between different upper ceramic-bearing contexts (1001–1007) were examined using low powered (x30) microscopy. This analysis was undertaken to assess whether these sherds were possibly derived from the same vessel and were spread through multiple contexts as a result of post-depositional disturbances rather than as a reflection of archaeological distribution. Meanwhile, bone artefacts were examined using technological and trace analysis methods and these findings are presented in Langley *et al.* (2016).

A total of 17.6 kg of bone was recovered from Trench 10. This assemblage was analysed using the reference collections at the National Museums of Kenya in Nairobi, leading to the identification of 117 fish specimens (Number of Identified Specimens (NISP)) and 6667 tetrapod specimens to, at minimum, skeletal element and taxon or taxonomic group. For a sub-sample of 5051 tetrapod specimens, numerous taphonomic variables were also recorded, including breakage patterns, cortical preservation, burning and surface modifications, such as cut or tooth marks. The tetrapod assemblage is summarised here, but has been published in detail separately (Prendergast *et al.* 2016).

The marine and terrestrial macro-molluscan assemblage, represented by a total of 3,556 individuals (Minimum Number of Individuals (MNI)), was identified to taxon or taxonomic group using published reference material (e.g. Abbott and Dance 1998; Rowson 2007; Richmond 2011; Appeltans *et al.* 2012). Additionally, preliminary metrical analyses were undertaken on *Achatina* spp. using a series of preserved landmarks to predict original size via regression analysis based on comparative data derived from published sources (Bequaert 1951) and provided by the Department of Natural Sciences, National Museum of Wales (Ben Rowson, pers. comm., 29 November 2014).

Results

Trench 10 was excavated to a depth of 2.5 m below surface, at which point large boulders prevented further excavation (see Figures 5 and 6). A total of 24 contexts were identified in this sequence. These were grouped into phases, based on material culture, lithostratigraphic and chronometric patterns. Absolute dates obtained from Trench 10 in the
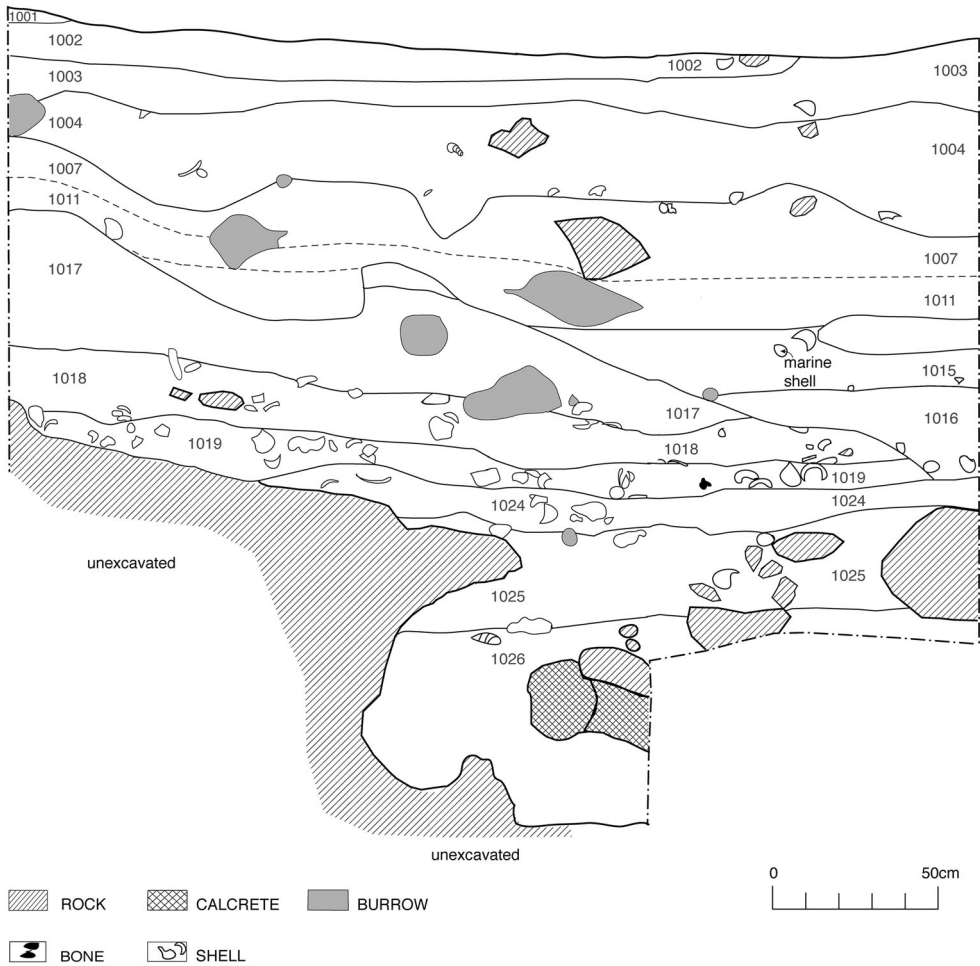
KC10 NORTH SECTION

Figure 6. Kuumbi Cave: north section of Trench 10 after excavation.

present study are summarised in Tables 2 and 3, and Figure 7. As Figure 7 shows, the dating of the Trench 10 sequence was complicated, reflecting the burrowing and associated bioturbation observed during excavation, as well as the complex depositional regime of this part of the cave, which was affected by colluvial input from further upslope at the cave entrance and also from a roof opening located only a few metres away (see Figure 3). Nevertheless, four clear sets of dates can be discerned: a set of late Pleistocene dates from the lower part of the sequence spanning c. 17,000 to 20,000 cal. BP; a set of terminal Pleistocene dates spanning the period 11,000–13,000 cal. BP; a set of mid-Holocene dates mostly focused in or near the sixth millennium cal. BP (with the exception of one 4th millennium cal. BP date); and a set of late Holocene dates from the upper part of the sequence spanning 1850–500 cal. BP (c. cal. AD 100–1450) (Figure 7).
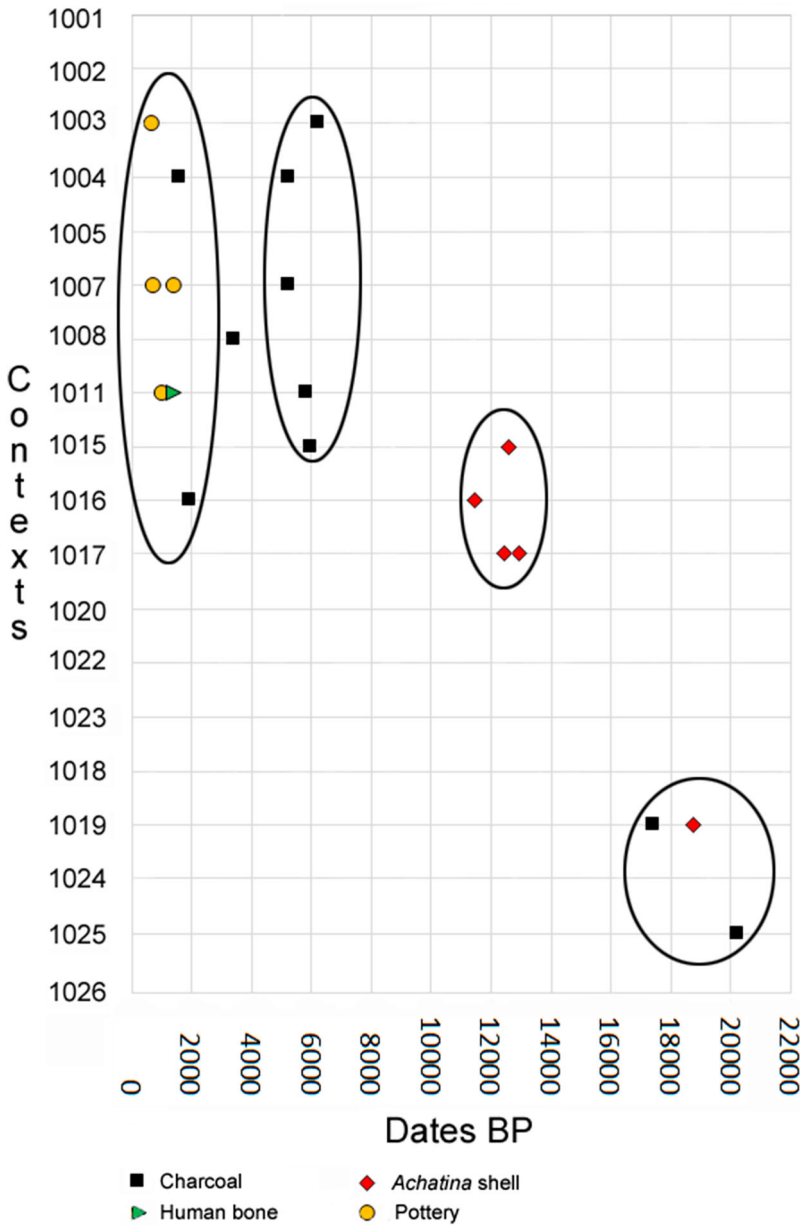
Figure 7. Kuumbi Cave: dates from Trench 10 in stratigraphic order. Note that error bars at 2 sigma are not visible at this scale, that the stratigraphic order of the dates does not necessarily correspond to numeric order and that contexts relating to anthropogenic features (hearth pits) are not shown. Four clusters are evident: a late Pleistocene cluster at the beginning of the sequence, a terminal Pleistocene transition cluster in the middle of the sequence, and a mid-Holocene and a late Holocene cluster that overlap stratigraphically at the top of the sequence.

The Pleistocene and late Holocene dates cluster separately, but the mid-Holocene dates overlap stratigraphically with many of the terminal Pleistocene and late Holocene dates. Unlike the other sets of dates, the mid-Holocene dates are all derived from dispersed

charcoal samples and are not direct dates on material culture, human remains or large shell fragments. These mid-Holocene dates appear to reflect input of older charcoal-bearing sediments, most likely from the cave entrance and, perhaps, the roof opening. It remains unclear whether these charcoal fragments are of anthropogenic or natural origin. This pattern in the dates agrees with the four dates from Trench 6 reported in Sinclair *et al.* (2006) and Chami (2009), with a *c.* 26,000 year date from the lower part of the sequence and inverted mid- and late Holocene dates from the upper part. We present our results by phase below. Specialist reports on the long-term cave and landscape evolution (Kourampas *et al.* 2015), bone tools (Langley *et al.* 2016) and fauna (Prendergast *et al.* 2016) can be found elsewhere.

Phase 4: occupied or archaeologically sterile?

The base of Trench 10 contained large limestone boulders with vestiges of speleothem encrustation (Figures 5 and 6) that likely represent roof fall from a major collapse event. If roof fall, they may reflect the point in time when the entrance first opened up. Over time, these boulders became buried by orange-red colluvial sediment that originated upslope of the cave entrance, and/or washed in from the roof opening nearby (Contexts 1026, 1025). The slope above the cave entrance and the over-cave surface appear to have been the major sources of sediment input to the Trench 10 location throughout the deposition of the Trench 10 sequence.

The lowest levels of Trench 10 (Phase 4), Contexts 1026 and 1025 (Figures 5 and 6), did not yield definitive evidence for human occupation. Context 1025 contained ambiguous evidence for human activity in the form of charcoal flecks, five pieces of burnt bone (<4% NISP), three individual marine molluscs (MNI) and a total of six marine shell fragments (and a further two fragments of marine mollusc shell in Context 1026). While this could represent ephemeral human use of the cave, it may also be that this material arrived in this layer through colluvial or aeolian (in the case of charcoal flecks) deposition (regardless of whether its source was anthropogenic) or bioturbation. In the faunal assemblage, 152 tetrapod NISP were identified from these lower contexts, consisting of diverse terrestrial mammals, including smaller and larger bovids, zebra, hyrax, monkey, leopard, rodents and bats, in addition to an assemblage of snails. None of these bones bore cut marks. A fragment of charcoal from Context 1025 gave a date of 20,240–19,880 cal. BP (Table 3).

Previous investigation had suggested a heavy-duty local coral limestone industry in this basal part of the Kuumbi sequence (Sinclair *et al.* 2006; Chami 2009). All pieces of limestone removed during the present excavation were inspected by the lithic analyst (CS) on site. No platforms, bulbs of percussion, negative scars or any other features used as criteria to identify human-modified flaked stone were visible on any of the pieces. This analysis included all pieces recovered during excavation, as well as specimens from 60 litre samples that were wet-sieved after flotation. We also note that the local coral limestone was thoroughly peppered with pores and inclusions so that it was not isotropic and did not fracture conchoidally, making it unsuitable for stone tool manufacture.

Phase 3: late Pleistocene LSA occupation

Contexts and chronology

The first clear evidence of occupation in Trench 10 (phase 3) derives from Contexts 1024, 1019 and 1018, in the form of quartz microliths, very abundant faunal remains (2699 tetrapod NISP) with numerous cut-marked bones, a few marine fish and 169 MNI of marine shells. The earliest of these contexts, 1024, contains 122 burnt bones (12% of total NISP excluding teeth). These layers also contained dense concentrations of terrestrial snail shells of at least two local species, *Achatina fulica* and *A. reticulata,* which, as discussed further below, may represent middens. The sediments comprising these layers were heterogeneous, with frequent inclusions, many of which were clearly anthropogenic (lithics and marine shell), in contrast to the homogenous reddish-coloured sediments of the contexts below. The deposits also contained frequent flecks of charcoal and became progressively ashier from Context 1024 to Context 1018. Their horizontal bedding, and dense, 'snail-supported' fabric, suggests that these contexts represent a series of occupation floors. Two dates were obtained for Context 1019 (the main shell layer): one on snail shell of 18,830–18,555 cal. BP and one on charcoal of 17,485–17,080 cal. BP, indicating a late Pleistocene onset of occupation at the site. The difference between the two dates could be owing to the effect of terrestrial snails incorporating old carbon into their shells (e.g. Goodfriend and Stipp 1983), although further investigation is required for this particular species.

The next three contexts in the Trench 10 sequence, 1023, 1022, and 1020, appeared to be the fill of a channel that was eroded into Context 1018 by water flowing around a large rock on the eastern side of the trench (Figures 5 and 8). The rock has a vertical face on its

Figure 8. Kuumbi Cave: the main *escargotière* layer (Context 1019) prior to excavation. The shovels are approximately 1 m high. Note the high density of snails on a horizontal surface, the (emptied) channel going around the rock on the right and the burrow holes in the wall behind.

north side (i.e. facing the main cave entrance), so any water flowing down into the cave would be deflected around it. The channel cut by this rivulet was filled by three successive layers (Figure 5). The lowest fill (1023) was fine gravel with frequent fragments of snail shell and limestone, perhaps deposited as lag on the rivulet bed. Context 1022 was silt with frequent large bone fragments, marine shells and large intraclasts of red (fire-reddened?) sediment, with abundant charcoal fragments (Context 1021). This sediment may have been deposited by debris flow. Context 1020 consisted of steeply dipping brown/black charcoal laminae and white, ashy, finely interstratified bands, perhaps deposited as successive tip lines: this is what Sinclair *et al.* (2006) refer to as 'white ash' in their north section drawing. This context likely represents an ash dump from raked out hearths. Two cut-marked bone fragments and several quartz artefacts were recovered from these channel fill contexts. As we do not currently have any absolute dates for the channel fill contexts, we cannot be certain of their chronological extent, but they clearly occur after the main snail-rich layers and before the subsequent Phase 2.

Material culture

The main types of cultural materials recovered from the late Pleistocene occupation layers (Contexts 1018–1024) were stone and bone artefacts. The 27 stone artefacts (one core and 26 flakes) were exclusively made on milky and crystal quartz, with 62% of them displaying crushed platforms or distal ends, or often both, consistent with their manufacture using the bipolar technique. This method of on-anvil production is common throughout the eastern African Later Stone Age (Kwekason 2011; Eren *et al.* 2013) and is a way of obtaining flakes from small pebbles, the common form of quartz. The mean maximum dimension of flakes is just 13.36 ± 4.48 mm; over half have cortex on them, while scar counts average 1.3 per artefact, testifying to the small clast size and short reduction sequences. Knutsson (2007) also describes a bipolar LSA industry on small quartz nodules in the equivalent depths of both Chami and Sinclair *et al.*'s Trench 6 excavations. Artefact sample sizes are small throughout the Trench 10 late Pleistocene sequence, but it is notable that more artefacts were recovered from the channel fills (N = 16) than the snail midden layers (N = 11), even though the latter are far larger contexts (91 versus 520 litres). This could be because stone artefacts, as larger objects, were more likely to be deposited in the channel lag and/or because the snail layers were deposited relatively rapidly.

A number of bone artefacts were recovered from the late Pleistocene occupation layers (see Langley *et al.* 2016 for details). Context 1019 contained a single piece of worked bone, the overall morphology of which and the wear patterns on its distal tip are consistent with it having been used as an awl. Two distal-mesial bone point fragments were recovered from Context 1018 with a further fragment from Context 1022. The morphology and use wear of all three worked bone pieces suggest that they were used as projectile points, although their use as awls cannot be absolutely ruled out as both these functions result in the same use wear (i.e. crushing, rounding, chipping etc.; Arndt and Newcomer 1986; Pétillon 2006). One of these points has five short, horizontal lines incised into the left side.

Subsistence

The faunal remains (2867 tetrapod NISP) from Contexts 1018–1024 indicate a broad subsistence base, dominated by small bovids (duikers and suni), which might have been

hunted with bow and arrow or trapped with snares, traps or pitfalls, as they have been recently (Ingrams 1931; Williams *et al.* 1996; Marlowe 2010). Trapping technologies were also likely used to obtain giant rat, hyrax and monkeys, with cut marks on the latter indicating that, while monkeys may have inhabited the cave, at least some entered the assemblage as (human) food remains. Hunting of larger animals such as bushpig, reedbuck, bushbuck, waterbuck, buffalo and zebra also occurred, though most of these animals are present in low numbers and without the same degree of skeletal completeness as small bovids. Small murid rodents are more commonly found in these contexts than anywhere else in the Trench 10 sequence. While carnivores (leopard, mongoose and civet) are present in this phase, there is little to suggest they were responsible for the faunal accumulations. Although definitive cut marks are rare (<3% NISP), carnivore tooth marks are rarer still (<1%) and a substantial portion of the fauna (11%) is burnt.

A small number of fish bones (11 NISP), three of which were burnt, suggest that marine fish were also consumed by the early cave occupants. These fish remains represent the earliest evidence to date of marine fish consumption in coastal eastern Africa, where the archaeological record of fish consumption previously dated back to the first millennium AD (Chami 2004; Crowther *et al.* 2014, in press). The identified taxa occur in nearshore habitats and are today captured with various fishing gears, such as spears, traps and nets, which suggests that they were obtained with the aid of tools. However, the small number of fish at Kuumbi Cave indicates that fishing was not a major subsistence activity.

An interesting feature in the late Pleistocene deposits was the presence of a dense and thick concentration of snail shells in Contexts 1018, 1019, and 1024. All three of these layers, but especially Context 1019, were extremely rich in the shells of at least two local species of giant African land snail — *Achatina fulica* and *A. reticulata*. These taxa are part of the natural environment of the cave and its vicinity today, and indeed are present throughout the entire Trench 10 sequence. While they are not widely consumed on the island at the present time, it is notable that, owing to its large size, *Achatina* is eaten by many people across the tropics, including Hadza women and children in adjacent mainland Tanzania (Marlowe 2010). This observation raises the question of whether the dense snail shell assemblages at Kuumbi Cave might have accumulated as the result of human predation rather than natural aestivation. While we cannot yet provide a definitive answer, preliminary metric analyses of snail shell lengths, estimated using linear regression for those individuals recovered from the bulk sediment samples and retaining measurable features, indicate patterns congruent with human foraging. Although sample sizes are relatively small (as they were only collected from the wet-sieved flotation samples), for both the *Achatina fulica* (N = 47, 42% MNI) and *Achatina reticulata* (N = 67, 27% MNI) specimens, size frequency distributions highlight the very restricted size ranges for both taxa. In addition to these size analyses, there is a very low occurrence of juveniles in total (<1% MNI), which would not necessarily be expected in a natural assemblage. Although juveniles are likely to be subjected to higher fragmentation rates given their comparatively thin shells, such fragmentation is not expected to impact the preservation of diagnostic features used for identification to Family level. In addition to this, the distribution of other thin-shelled terrestrial mollusc taxa remains relatively stable throughout the sequence, indicating a certain degree of preservation of smaller bodied individuals. These patterns are therefore tentatively interpreted as indicating human selection rather than a natural population (which would be expected to contain
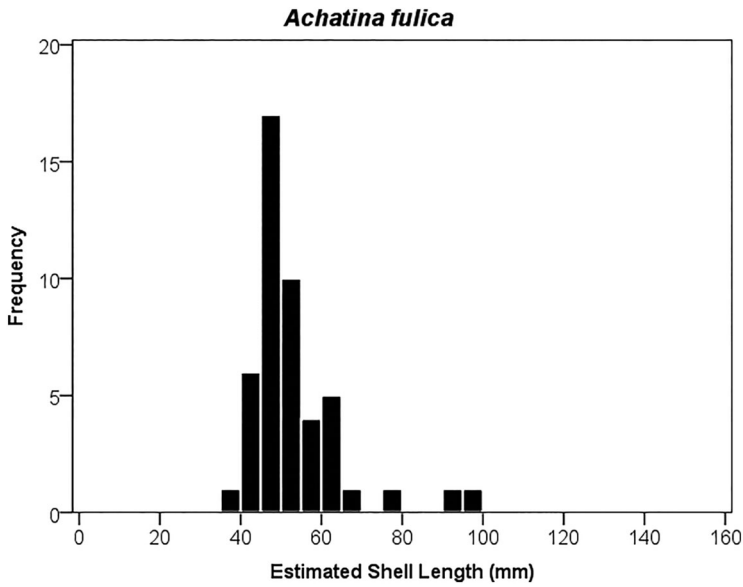
Figure 9. Kuumbi Cave, Trench 10: predicted shell length histogram for *A. fulica* shells.

the full age-range of individuals from juveniles to adults) (Figures 9 and 10). We also note that, while some are complete, many of the mature *Achatina* spp. specimens are highly fragmented in spite of their thickness, which, along with their close packing and imbrication, may suggest some degree of trampling, presumably by humans. Although detailed taphonomic analyses are still to be undertaken on the molluscan remains, some shells also show signs of breakage around the aperture and just above the body whorl that

Figure 10. Kuumbi Cave, Trench 10: predicted shell length histogram for *A. reticulata* shells.

might be related to meat extraction (see also Sinclair *et al.* 2006: 103; Chami 2009). Also significant is the fact that the snail 'midden' phenomenon is not unique to Kuumbi Cave: comparable '*escargotière*' layers have also been documented in mainland Tanzania (Harrison *et al.* 1997; Bushozi 2003, 2011) and they are also widely reported at sites in the circum-Mediterranean region spanning the Pleistocene-Holocene transition, where they are invariably attributed to consumption by humans (Lubell 2004). This combination of factors, in addition to the associated presence of other evidence of human occupation as mentioned above, leads us to surmise that these snail layers represent midden deposits associated with a stratified series of occupation floors.

Phase 2: terminal Pleistocene LSA occupation

In the middle of the Trench 10 sequence, Contexts 1017, 1016, and 1015, the depositional regime becomes more complex and there are fewer artefacts, although faunal density is still high (1179 tetrapod NISP). Context 1017 is light grey and comprised largely of ash and burned residue. This context is very rich in marine shells and animal bone, with much of the latter (27% NISP) being burnt and 11 specimens (1%) having cut marks. The context thus clearly represents human occupation and from the purity of the ash would appear to be close to its primary depositional location. However, stone artefacts are completely absent, a pattern also found in the middle part of the sequence in the Trench 6 excavations (Knutsson 2007). The only cultural materials recovered from this deposit were two pieces of worked bone. One is a point, the form of which is akin to those from the Phase 3 layers, while the other is a notched piece of bovid upper limb bone (Langley *et al.* 2016). Both these items show signs of having been worked by stone tools (Langley *et al.* 2016), so their absence from the assemblage would seem to reflect changing site use in the vicinity of our excavation area, rather than technological change. Two terrestrial snail shells from this layer were dated to 13,040–12,790 cal. BP and 12,640–12,420 cal. BP, indicating this layer likely corresponds to the same phase of occupation as the burial in Trench 9 (Chami 2009) that is associated with a date of 12,695–12,435 cal. BP.

Contexts 1016 and 1015 have conflicting dates with both terminal Pleistocene and mid- to late Holocene ages (Table 3). The lower context, 1016, of heterogeneous orangey brown appearance and containing frequent baked earth, pieces of charcoal and small lumps of white ash, appears to have accumulated broadly *in situ*. A date on snail shell gave an age of 11,750–11,340 cal. BP, while a date on charcoal produced a date of just 1875–1740 cal. BP (cal. AD 75–210). We think that the younger piece of charcoal may have been introduced through bioturbation, as it is from Phase 2 upwards that burrowing becomes common. No artefacts were found in Context 1016.

Context 1015 is a mid-brownish grey ashy fill of a likely erosive hollow on the surface of the talus slope (1017/1015 boundary; see Figure 5). Marine shells and abundant fauna (21% burnt) also occur in this context. Two artefacts were recovered from 1015, both of which link it to the LSA. The first was a bipolar quartz core with some cortex on it, the second another bone point. The latter artefact has fractured post-depositionally across its shaft.

Two radiocarbon dates were obtained from Context 1015, a terminal Pleistocene date on snail shell in line with that from Context 1017 (12,620–12,410 cal. BP) and a mid-

Holocene date on charcoal (5900–5730 cal. BP). To explain the inconsistencies between the charcoal and shell/bone/ceramic ages in this and later layers, we suggest that the small fragments of sedimentary charcoal that have been dated relate not to the human activities the chronologies of which we seek to understand, but to sedimentary input from elsewhere in the cave. We propose that the mid-grey sediments that constitute the bulk of the sequence from Context 1015 upwards were reworked as colluvium from deposits originally located further upslope, perhaps around the entrance of the cave. The entire Trench 10 sequence is likely to form part of a talus cone emanating largely from the cave entrance (Kourampas *et al.* 2015), so it is possible that some parts of this talus contain higher amounts of reworked sediment than others, perhaps corresponding to periods of lower vegetation and greater surface run-off. The mid-Holocene dates for this sediment could come from charcoal produced through natural burning, a phenomenon that appears to have occurred more commonly in the mid-Holocene drought phase of tropical Africa (Kiage and Liu 2006). An increase in large charcoal particles has also been documented at Unguja Ukuu and Makoba Bay on the west coast of the island around this time (Punwong *et al.* 2013a, 2013b). The talus deposition also explains why many of the deposits slope down to the east, as Trench 10 captures the eastern side of the cone. Consistent with our observations, Sinclair *et al.* (2006) also had an inversion in their dates in this part of the sequence, with charcoal dates of 1825–1605 cal. BP in the grey ash layer at a depth of 130–135 cm and a date of 4750–4290 cal. BP at one of 80–95 cm.

In agreement with our findings, both Sinclair *et al.* (2006) and Chami (2009) also identified a gap in dates from the early Holocene to around 6000 BP. The distribution of the dates (Figure 7, Tables 1 and 3) is most likely explained by an occupational hiatus, with abandonment of the cave between the terminal Pleistocene and the Iron Age, the only periods for which we have several secure occupation dates (see below).

Phase 1: Iron Age occupation

Contexts and chronology

Sediments from Context 1011 upwards comprise a series of mid-brownish grey silty loams. Several hearths occur in this upper part of the sequence, suggesting *in situ* occupation. From this point, ceramics appear in the Trench 10 sequence. Included in the assemblage are several diagnostic TT/TIW sherds, an eastern African ceramic known from approximately the seventh to the fifteenth centuries AD (Fleisher and Wynne Jones 2011) and seen to mark the local periods often referred to as the Middle and Late Iron Ages. OSL dates on quartz grains from within the matrix of four sherds — three plain and one from Context 1007 with diagnostic TT/TIW incised/punctate decoration (see Figure 11) — yielded dates of 1040–880 BP (AD 980–1135) (Context 1011), 1485–1235 BP (AD 530–780) (TT/TIW sherd from Context 1007), 770–600 BP (AD 1245–1415) (Context 1007) and 640–540 BP (AD 1375–1475) (Context 1003), confirming the Middle–Late Iron Age attribution of the ceramic assemblage. A date of 1370–1300 cal. BP (cal. AD 580–650) on human bone from Context 1011 also suggests that this part of the sequence starts with the Middle Iron Age. However, radiocarbon dates on charcoal from these contexts produced age estimates of 5645–5490 cal. BP (Context 1011), 5275–4875 cal. BP (Context 1007) and 6185–5995 cal. BP (Context 1003). Likewise, a date on charcoal from one of the *in situ* hearths (Context 1004C) is in disagreement with the
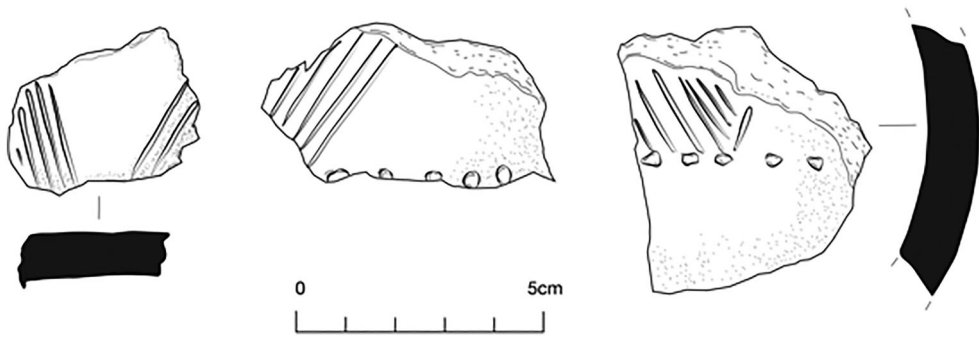
Figure 11. Kuumbi Cave: examples of ceramic sherds with typical TT/TIW incised and punctate decoration recovered from Trench 10. The sherd on the left is from Context 1001 and the two on the right are from Context 1007.

date obtained from charcoal from the overlying sediment (Context 1004), with the hearth charcoal dating to 1535–1415 cal. BP (cal. AD 415–535) and that from the sediment to 5275–4875 cal. BP. These findings are consistent with the model of a reworking of older deposits from further upslope (perhaps around the cave entrance), which likely explains the discrepancies between the dates of artefacts, hearths and human bone versus the background charcoal in the sediments in which these occur.

Above Context 1003 sits a cemented loam (Context 1002) that caps much of the detrital sediments on the cave floor. Swahili type ceramics (*c.* AD 1200–1400) were found in this deposit and in the overlying Context 1001. This cemented deposit may represent a change in the depositional regime at Kuumbi Cave, perhaps cementation due to increased precipitation, or vegetation change on the over-cave surface.

Material culture

A moderate-sized assemblage of pottery, comprising 72 sherds in total, was recovered from Trench 10 at Kuumbi Cave. Many of these were very small fragments and the majority (N = 41) derived from the uppermost context (1001). Contexts 1011 and 1007 contained a total of nine potsherds, six of which are diagnostic of the Early Tana Tradition/Triangular Incised Ware (ETT/TIW), decorated with triangles and punctates (Figure 11). Context 1003 contained seven further diagnostic ETT/TIW sherds. ETT/TIW ceramics from the eastern African coast are known to date from around AD 600–1000 (Helm 2000; Fleisher and Wynne-Jones 2011). This period was characterised by small-scale village settlements, pottery and iron manufacture, mixed food production involving a range of African and Asian plant and animal domesticates and the florescence of Indian Ocean trade (Helm *et al.* 2012; Fleisher and LaViolette 2013).

The 13 Early Tana Tradition sherds from Contexts 1011, 1007 and 1003 differ in their fabric from the numerous examples excavated at Unguja Ukuu and Fukuchani, also on Unguja Island, in that they contain much less sand temper and have been more heavily fired, with an angular fracture pattern. The body sherds are up to 10 mm thick, somewhat thicker than the examples found on the coastal sites (though still within the Tana range: Wynne-Jones and Fleisher 2013). Decoration comprises stick-punctates along the shoulder of what were probably necked jars and inverted triangles with single line

hatching (Figure 11). Punctates and hatched triangles are typical of the Early Tana Tradition, but inverted triangles are rare, with standing triangles being much more common. The Kuumbi Cave Early Tana sherds may thus be described as idiosyncratic, a local variant of the Tana tradition.

The fabrics of six sherds from the upper part of the sequence (Contexts 1001–1007) were examined using a low power stereoscopic microscope. Several of these sherds were of the thick type described above. This analysis was conducted to determine whether the few sherds recovered from these contexts resulted from the breakage and reworking of just one or several vessels. The analysis demonstrated distinctive fabrics across the different sherds, with varying types and sources of clay, as well as varying sand grains, inclusions and degrees of oxidation. They clearly derived from numerous different pots, supporting the notion of a local Tana variant rather than just the presence of a single unusual vessel and also confirming that the OSL dates were not on a single reworked vessel.

The lithic assemblage in these later levels at Kuumbi Cave stands in contrast to the LSA bipolar quartz industry found in the lower part of the sequence. This assemblage, found from Contexts 1011 to 1002, consists of medium-sized siliceous limestone lithics made through freehand percussion (Figure 12). The artefacts from Phase 1 are in general far larger than those from Phase 3 (median maximum dimension 35.61 mm vs. 11.76 mm, Mann-Whitney U=7, N=43, p<0.001). The Phase 1 assemblage is equivalent to the crystalline limestone lithics found by Sinclair *et al.* (2006) in their 'grey brown' layer and described by Knutsson (2007). It should be noted that this limestone is not local to the cave and is distinct from the coral limestone of the purported MSA artefacts. Two small quartz artefacts were also found in this later phase, one in Context 1011 and one in Context 1007. These may have been reworked from older sediment, may reflect
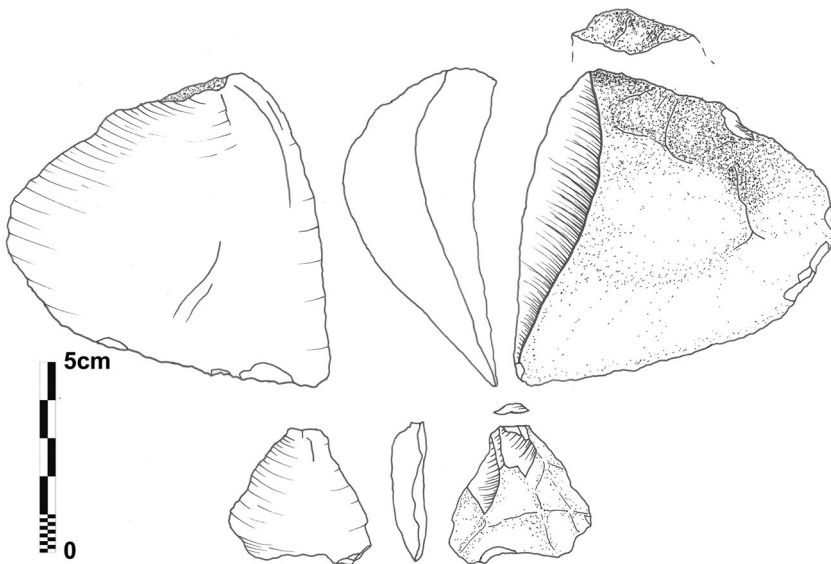

Figure 12. Kuumbi Cave: limestone flakes. The upper flake is the same artefact shown in the south section (Figure 5).

contact between the two traditions or may indicate that the expedient flaking of quartz was also occasionally practised by the makers of the limestone artefacts. While stone artefacts are commonly found at TT/TIW sites in Tanzania (e.g. Walz 2010; Kwekason 2011; Crowther *et al.* 2014), they are usually small quartz bipolar flakes. The larger freehand limestone artefacts documented at Kuumbi Cave may therefore constitute a distinctive tradition. At most TT/TIW sites with lithics, the latter are vastly outnumbered by ceramics (e.g. Walz 2010); however, at Kuumbi Cave, stone artefacts and ceramics occur in roughly equal proportion (although sample sizes for both are small). The Kuumbi Cave artefact assemblage thus more closely resembles those at LSA cave and rockshelter sites on the Nyali Coast of southern Kenya, where TT/TIW ceramics occur in similar quantities to the stone tools in the later occupation phases (Helm *et al.* 2012; Shipton *et al.* 2013). However, at these Nyali Coast sites there was no abrupt change in lithic technology in the later parts of the sequence and the Tana Tradition ceramics are 'classic' as opposed to crude. Kuumbi Cave is thus unique in having both idiosyncratic lithic and ceramic assemblages in the last 2000 years.

We also recovered a small assemblage of beads from the upper part of the Kuumbi Cave sequence, two from Context 1002 and three from Context 1007 (Figure 13). These beads

Figure 13. Kuumbi Cave: shell beads of the family Olividae from Trench 10. The upper two are from context 1002 and the lower three are from context 1007.

were made exclusively on marine shells of the family Olividae, a common tropical/subtropical taxon that occurs naturally on the Zanzibar coast. The beads are fairly uniform in size, ranging in length between 8.78 and 10.01 mm and in width between 4.42 and 4.91 mm. The dorsal surfaces of the shells have been cut to form oval apertures with the short axis aligned to the width of the bead. The aperture of one bead has been broken post-depositionally, while another shows abrasion, likely from the process used to make the hole, but no signs of use. The aperture edges on the remaining three beads (two from Context 1007 and one from Context 1002) have been smoothed into a rounded 'bull-nose' shape, likely from wear during use. This use-wear may have resulted from the beads having been sewn on to fabric, though further microscopic and experimental analyses are required to test this hypothesis. From the photographs in Chami (2009: 67), it seems that he also recovered a similar bead.

Subsistence

The faunal spectrum in Contexts 1011 and above (tetrapod NISP = 2469) is similar to that of the late Pleistocene occupation, with a dominance of small bovids and a similar range of smaller fauna such as hyrax, giant rat and monkey. The occupants of Kuumbi Cave had similar foraging-based diets throughout the history of the site. However, it is clear that by the TT/TIW period there had been a shift in prey taxa. Zebra and larger bovids are very few, disappearing at the top of the sequence, and the assemblage shows an even greater emphasis on small bovids. While some of these small bovids (i.e. bush duiker) are not extant on Zanzibar today, they seem to have lingered on the island longer than any of the other extirpated fauna. The possible explanations for these extirpations are explored elsewhere (Prendergast *et al.*, 2016). A further difference in fauna between the late Pleistocene and the Iron Age occupations is an increased consumption of fish in the latter, with 90 NISP found in Contexts 1011 and up, largely consisting of reef fish such as parrotfish (Scarinae).

It is worth pointing out an important difference between the faunal spectra in the (earlier) Trench 6, 8, and 9 excavations and that of Trench 10. In the former, the faunal analysts identified high numbers of domesticates, equivalent to nearly a quarter of non-human, non-marine NISP for all contexts (Chami 2009). By contrast, we have identified only a handful of specimens from the TT/TIW contexts 1011 and above that could be attributed to domesticated cattle or caprines, none of which are definitive attributions at this time. These 11 specimens (<1% of NISP) are lower limb bones or heavily fragmented teeth and, given the presence of similarly-sized wild bovids throughout the occupation of Kuumbi Cave, we treat these identifications with caution. In the cemented loam of Context 1002, a single coracoid of a gallinaceous bird was identified as a possible, but by no means definitive, chicken, based on the presence of sulcus on the proximal end, a trait described by MacDonald (1992: 311) as 'unreliable in marginal cases'. Without distinctive epiphyseal portions, it is impossible to use any of the Galliformes remains in Trench 10 (NISP = 7) to distinguish chicken from indigenous fowl. The dearth of domesticated fauna suggests that the TT/TIW people occupying Kuumbi Cave were primarily hunter-foragers.

The distribution of both marine and terrestrial molluscs in Trench 10 by phase (Figure 14) indicates an increase in the overall discard of shell from the basal part of the sequence (Phase 4: Contexts 1025 and 1026). This shift from a low density of terrestrial
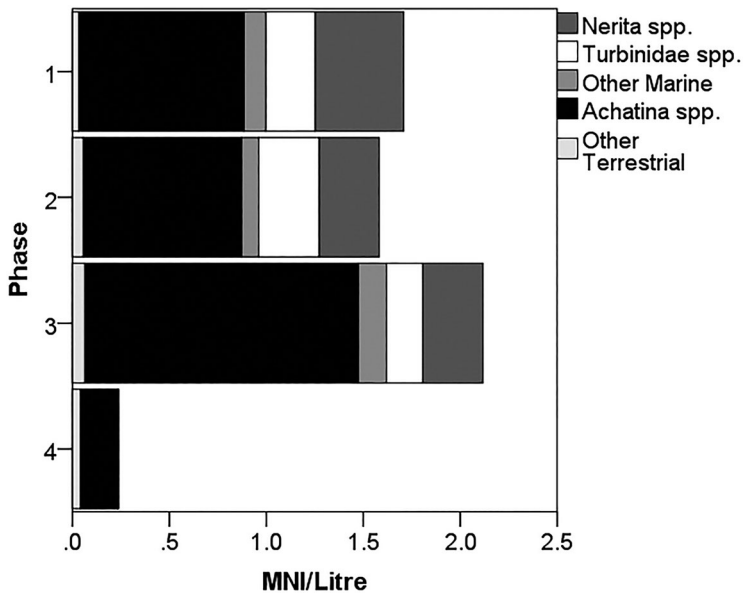
Figure 14. Kuumbi Cave: mollusc density (MNI/litre) by phase and dominant taxa. *Achatina* spp. are terrestrial, *Nerita* spp. and Turbinidae marine. Phase 4 comprises the basal layers, Phase 3 the late Pleistocene *escargotière* layers, Phase 2 the terminal Pleistocene and Phase 1 the Iron Age layers.

molluscs (predominantly *Achatina* spp. with a MNI of 23) into the Phase 3 *escargotière*, where there is a markedly increased deposition of both terrestrial gastropods and a range of marine mollusc taxa, represents more definitive evidence for human occupation. Given that distance to the shoreline varied between 10 and 2 km throughout the period of occupation (Prendergast *et al.* 2016), the occurrence of marine invertebrate taxa (total MNI of 393) in Phase 3 is unlikely to relate to processes other than human consumption and provides further support for the cultural origin of the denser land snail deposits (MNI 382 in Phase 3). This is followed by a decrease in the overall density of molluscan remains in Phases 2 and 1. Within this general trend, there is an increase in the proportion of marine taxa in Phase 2 and a slight further increase in Phase 1. The dominant taxa represented within the overall assemblage remain similar across the three occupation phases: *Achatina* spp., *Nerita* spp. and Turbinidae spp. Although the degree of assemblage richness and diversity increased through time, there was continuity in those taxa focused on for exploitation. This continuity across phases also emphasises a focus for marine foraging on near-shore environments dominated by hard shore or rocky habitats, with fringing mangrove stands and reefs. Aside from the *escargotière* phenomenon, within the macro-mollusc assemblage there is little evidence for changes either in foraging patterns or coastal environments.

Discussion

Kuumbi Cave is a complex archaeological site that has seen several phases of investigation since 2005 (Figure 15). The numerous radiocarbon and OSL dates that have now been obtained for the sequence are not straightforward to interpret. This could in part be

Spit/Depth	Sinclair *et al.* 2006	Chami 2009	This paper	Context
0-10	?	Layer 1: Sixteenth to nineteenth centuries AD		
10-20				
20-30		Layer 2: Swahili-TIW	Phase 1A: Swahili pottery	1001-1002
30-40			Phase 1B:	1003
40-50	limestone flake industry	Layer 3:	large limestone flakes	1004
50-60	uppermost spits contain	early first millenium AD	crude ETT/TIW pottery	1004
60-70	pottery and beads		Olividae shell beads	1007
70-80			Late first to early second	1007
80-90		Layers 4-6:	millennia AD	1011
90-100		early and late Neolithic	Phase 2: LSA, bone tools	1017/1015
100-110		early domesticates	rare quartz microliths	1017/1015
110-120		stone tools	*c*. 13,040 - 11,340 BP	1017/1016
120-130	quartz microliths		Phase 3: LSA	1018
130-140	domestic animals		quartz microliths	1018
140-150	decorated bone		bone tools	1018
150-160	*c*. 5000 BP		*c*. 18,830 - 17080 BP	1019
160-170				1019
170-180				1024
180-190		Layer 7: *c*. 6000 BP	Phase 4: sterile	1025
190-200	Hiatus		> 20,000 BP	1025
200-210				1025
210-220	late Pleistocene foragers	Layer 8: *c*. 26,000 BP		1025
220-230	*c*. 26,000 BP	Middle Stone Age /		1026
230-240		transitional LSA		1026
240-250		Not excavated	Not excavated	

Figure 15. Kuumbi Cave: comparison of the phasing between the three excavations of Trench 6/10. The offset of Sinclair *et al.* (2006) and Chami's (2009) depths in comparison to our contexts is likely due to differential heights in the datum, as well as horizontal variation in the thickness of deposit.

due to the extensive bioturbation (mainly by burrowing animals) observed during excavation, as well as to the use of horizontal spits across sloping and undulating stratigraphy that may have confounded previous excavations. Ultimately though, a complex process of sediment reworking and redeposition appears to have operated in the first chamber of the cave where Trench 6/10 is located.

In general, there is considerable agreement between our stratigraphy (Figures 5 and 6) and that delineated by Chami (2009). This agreement is found to a lesser extent with Sinclair *et al.* (2006), who present a more simplified stratigraphy reflecting the visual homogeneity of the dusty upper layers. In regard to interpretations of the phasing of the site, there is some common ground, but also important differences between our excavation findings and both previous interpretations (Figure 15).

Our earliest phase of the Trench 10 sequence did not produce definitive evidence for occupation greater than 20,000 years ago. No artefacts were found in the initial part of the sequence dating to this time, contrary to the observations made by Sinclair *et al.* (2006) for the presence of heavy-duty limestone artefacts in these layers. The sediments lacked unambiguous evidence for human occupation, without either the baked earth of the *escargotière* or the ash of Phases 1 and 2. Very occasional marine shell, burnt bone and flecks of charcoal might reflect sporadic human occupation, or they may have resulted from bioturbation and natural fires. Sinclair *et al.* (2006) obtained a date of *c*. 27,000 cal. BP on terrestrial snail shell from the lower levels of Trench 6, which are probably

equivalent to Context 1026 in our stratigraphy (note, however, that we do not have independent dates from 1026). Our date on charcoal from Context 1025 (c. 20,000 cal. BP) agrees with a general late Pleistocene attribution for this phase of cave sedimentation. The difference between the Sinclair et al. (2006) date and our own might be due to the effect of terrestrial snails sometimes incorporating old carbon, as mentioned above (note that this effect can vary even within a single shell), or, alternatively, may simply reflect relatively slow sediment deposition during this period.

Regardless of whether the snail accumulation in the escargotière layers was caused or mediated by humans, a number of lines of evidence suggest that this layer marks the onset of relatively regular and intensive human occupation at Kuumbi Cave around 17–19,000 cal. BP. These include the presence of the lowermost lithic and worked bone artefacts, along with cut-marked bones and the significantly increased frequency of charcoal, baked sediment, burnt bone and marine shell. The snail 'middens' may have been produced as humans first moved into this environment in the terminal Pleistocene and found a bountiful new resource that could be intensively exploited. It is possible that Achatina populations around Kuumbi Cave expanded in the warmer and more humid conditions of early post-Last Glacial Maximum climatic amelioration (cf. Tierney et al. 2010), a factor also thought to have influenced the formation of escargotières in the circum-Mediterranean (Lubell 2004). The lithic artefacts from the escargotière layers are simple and appear in low densities, while worked bone is relatively common compared to most LSA sites. The foragers who lived in or carried out activities at Kuumbi Cave during the LSA appear to have placed emphasis on the consumption of both marine and terrestrial molluscs, supplemented by terrestrial hunting or trapping, which included the use of bone points. Stone artefacts were perhaps used expediently for butchery and the manufacture of bone points, though use-wear and residue studies are needed to confirm this inference.

In the middle part of the Kuumbi Cave sequence (Contexts 1017, 1016 and 1015) bone artefacts, rare bipolar stone tools and dates in the range 13,040–11,340 cal. BP suggest intermittent occupation but broad cultural continuity into the terminal Pleistocene LSA. It is possible that the erosion and fill of the channel (Contexts 1020, 1022, 1023) accounts for much of the intervening period between the escargotière layers and Phase 2, in which case there could be general occupational continuity in the Late Pleistocene. The absence of dates for the period from c. 11,000 to 6000 years ago in both our and Chami's (2009) excavations may suggest site abandonment for thousands of years in the early Holocene, perhaps as the island of Unguja was cut-off from the mainland (Chami 2009). The presence of charcoal dating from the sixth to the third millennia BP is probably not associated with the cultural remains in Trench 10, but may instead derive from natural fires, in which case the period of abandonment at Kuumbi Cave would span most of the Holocene.

After AD 500 there is evidence for in situ occupation of Trench 10 in the form of hearths, but the mixed set of dates suggests that much of the sediment from these layers may have derived from erosion and reworking of older deposits. In this later phase of occupation, there are pronounced changes in material culture: worked bone disappears from the record and simple ETT/TIW ceramics appear, while small quartz bipolar stone artefacts are replaced by medium-sized limestone freehand percussion flakes. Faunal remains are still focused on the same spectrum of wild species as in the LSA, but with increased emphasis on small bovids, reef fish and marine molluscs. Given the evidence for the arrival of Iron Age people at the nearby town site of Unguja Ukuu by the sixth

century AD (Juma 1996, 2004), it seems possible that the reoccupation of Kuumbi Cave reflects a broader recolonisation of Unguja Island in the mid-first millennium AD.

Conclusion

Our renewed investigation of Kuumbi Cave, using the single context excavation method and informed by multidisciplinary study of the site's geoarchaeological, chronological, artefactual and faunal remains, highlights the complexity of the site's stratigraphy and the natural and anthropogenic processes that created its deposits. This complexity has played a role in the debates and differing interpretations of the site, confounding attempts to date cultural remains clearly and to understand the depositional processes and sequence of human occupation within it.

Given that our trench was larger than that of Sinclair *et al.* (2009) and immediately adjacent to it, we think that the lack of heavy-duty coral limestone artefacts in our excavation is evidence of absence rather than of sampling bias. We also note the unsuitability of the local coral limestone for lithic manufacture. Our data therefore do not support the previous report of a MSA occupation at the site. Given the absence of stone tools and worked bone in Phase 4, as well as the lack of ash or baked sediment, we are currently sceptical of a pre-20,000 BP occupation at Kuumbi Cave. Similarly, we find no supporting evidence for pre-Medieval Indian Ocean trade connections at Kuumbi Cave, either in the form of imported glass beads or of the remains of domestic chicken or other non-native fauna likely to have been introduced through trade. No unambiguous identifications of domesticated species could be made from the Trench 10 faunal assemblage and all potential domesticate candidates were from the Iron Age levels. While the ceramics from the earlier part of the Iron Age occupation were somewhat crude and idiosyncratic, we nevertheless find them to be diagnostically TT/TIW in decoration; direct OSL dates support this affiliation. Our excavations are accordingly not able to support the hypothesis of a coastal Neolithic at Kuumbi Cave (*pace* Chami 2009).

Cumulative work at Kuumbi Cave has nonetheless clearly revealed evidence for late Pleistocene occupation of the eastern African coastal region. Evidence for coastal sites and adaptations, so critical to currently popular models of out-of-Africa dispersals (Stringer 2000; Mellars *et al.* 2013), is actually thin on the ground and largely absent between southern Africa (Marean *et al.* 2007; Marean 2011) and Eritrea (Walter *et al.* 2000). The Kuumbi Cave sequence does not, however, provide strong support for coastal occupation until *c.* 18,000 years ago, well after the dispersal of our species out-of-Africa. Coastal adaptation by hunter-gatherers instead appears to be part of a broader pattern of resource intensification that also involved consumption of land snails, in addition to the shellfish and marine fish. The clustering of dates in Sinclair *et al.* (2006), Chami (2009) and our own excavations suggests that Kuumbi Cave was abandoned in the early Holocene when Unguja Island was cut off from the mainland. While the upper part of the sequence is complicated by the redeposition of older charcoal, the sixth-century date on human bone from Trench 10 provides unequivocal support for human presence at this time, coinciding with the earliest human activity recorded at open-air sites on the island like Unguja Ukuu and Fukuchani. This later Holocene activity on the island, including oceanic trade, is not Neolithic, but more likely a Middle to Late Iron Age phenomenon.

Note

1. All radiocarbon dates reported in this paper, including previously published dates, have been calibrated using a mix of the latest Southern and Northern Hemisphere calibration curves (70% SHCal13, 30% IntCal13, 2σ), an annually updated interim curve, and the OxCal platform (Bronk Ramsey 2009).

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