ARCHAEOLOGY

Earliest evidence for intentional cremation of human remains in Africa

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Human cremation on an open pyre demands intensive labor, communal resources, and sensory exposures. We report the earliest evidence for intentional cremation in Africa, the oldest in situ adult pyre in the world, and one of only a few associated with hunter-gatherers. A large cremation feature at Hora 1 in Malawi dates to ~9500 years ago and contains the remains of a small, gracile adult with evidence for perimortem defleshing and postcremation manipulation. Subsequent revisiting of the site to build fires in the same place provided additional pyrotechnological spectacles. High-resolution, multiproxy reconstruction of the ritual associated with cremation and its subsequent deposition demonstrates complex mortuary practices among ancient African foraging groups with substantial social investment and use of natural landscape features as persistent mortuary monuments.

INTRODUCTION

Globally, there is scant evidence of intentional cremation before the mid-Holocene (*1*), and the practice is especially rare amongst hunter-gatherers. Cremation is the deliberate and accelerated transformation of a body through fire and smoke, reducing a human body from a recognizable individual into fragmented and calcined bone and ash (*2*, *3*). It can also serve practical functions related to hygiene, expediency, and ease of transportation (*4*–*6*), although successful open pyre cremations demand intensive labor to construct and maintain (*7*–*9*). While the earliest concentration of burned human remains dates to ~40,000 years ago at Lake Mungo, Australia (*10*), the burning is incomplete with no associated pyre (an intentionally built structure of combustible fuel). These factors make it difficult to reconstruct details of the mortuary practice, including the level of communal investment. The oldest evidence for an in situ pyre dates to ~11,500 years ago from the Xaasaa Na′ (Upward Sun River) site in Alaska and contains the remains of a ~3-year-old child (*11*). In Africa, some burned human remains in Egypt date to ~7500 years ago (*12*), but the first confirmed cremations do not appear until ~3300 years ago associated with the Pastoral Neolithic and early food producers (*2*, *13*, *14*).

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We report the archaeological context of an intact hunter-gatherer cremation pyre containing a single adult individual from the Hora 1 (HOR-1) site, Malawi (Fig. 1). Dated to 8530 ± 30 (UGAMS-30618) radiocarbon years, or 9540 to 9454 calibrated years before present [henceforth, cal BP using OxCal 4.4.2 and the SH20 curve (*15*)], the HOR-1 cremation is the oldest known cremation in Africa, one of the oldest in the world, and the oldest in situ pyre feature containing the remains of an adult person (texts S2 and S9). We reconstruct the specifics of this unique event using: (i) detailed spatial analysis of the site, (ii) microscopic and macroscopic examination of the pyre matrix and its contents, and (iii) osteobiographical and taphonomic analysis of associated human remains. Discovery of the remains within the pyre enables rich reconstruction of the sequence of events surrounding the individual's cremation, which involved multiple phases and considerable communal labor. This case study offers unprecedented insights into previously underappreciated social and pyrotechnological complexity among ancient African foragers.

RESULTS

Site background and mortuary record

HOR-1 in the Mzimba District of northern Malawi is a rock shelter at the base of Mount Hora, a granite-gneiss inselberg rising ~110 m above the modern Kasitu River Valley as a distinctive regional landmark (Fig. 1) (*16*). The site attests to more than ~21,000 years of human occupation (*17*) and was used for mortuary practice between at least ~16,000 and ~8000 years ago (*16*, *18*). The overhang opens to the east and forms an 80 m^2 flat, dry shelter that is easily accessed from most directions and has no enclosed spaces that could act as a natural furnace (fig. S1). The authors' pedestrian and drone survey, aided by local knowledge holders, has not revealed any other shelters at Mount Hora with the same combination of size and accessibility (text S3).

Clark and Rangeley's excavations at HOR-1 in 1950 (*19*) removed approximately 7 to 8 m^3 from the site, based on archival photographs georectified to modern maps (fig. S1). The only locatable excavated materials are two adults' nearly complete and uncremated remains (*20*). The male (HOR-1, UCT-242) and female (Hora 2,

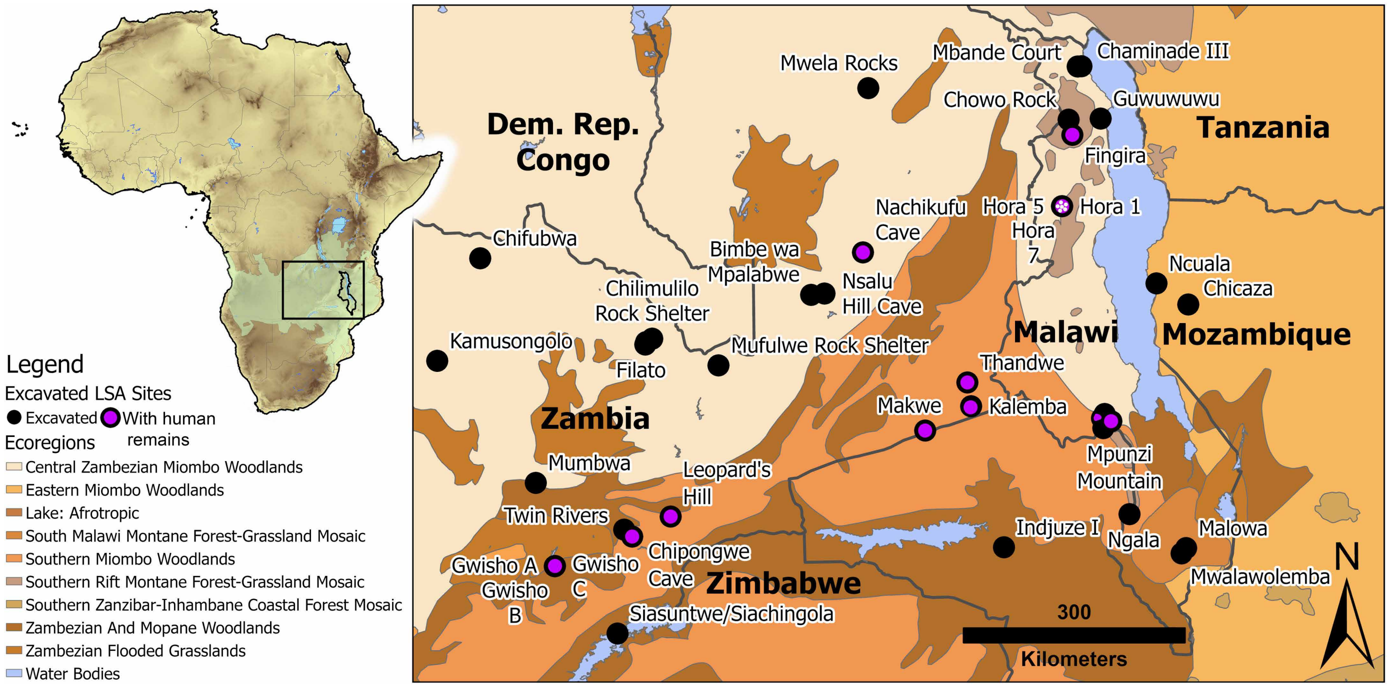

Fig. 1. HOR-1 site in context. HOR-1 site (11°39′S, 33°39′E; 1470 m above mean sea level, white stipples) relative to published excavated LSA sites. Light green in inset outlines the Zambezian Biome (ZB). Topography basemap in inset is SRTM (darker is higher elevation). Ecoregions and ZB outline from The Nature Conservancy. Country outlines from Natural Earth. Water bodies from RCMRD. Map assembled in ArcGIS Pro 3.4 and Microsoft Powerpoint. Cluster of sites near Mpunzi (or Mphunzi) Mountain includes six additional sites, three with human remains (Mtuzi, Changoni Bible School, and Chencherere II).

UCT-243) yielded ancient DNA (aDNA) and are directly dated to 9081 to 8725 cal BP and 8172 to 7875 cal BP, respectively (*18*, *21*).

Between 2016 and 2019, the Malawi Ancient Lifeways and Peoples Project (MALAPP) excavated an additional 7.8 m^3 of sediment from two blocks of squares (Area I and Area II), water-sieved it through 1-/3-mm mesh, and plotted ~46,500 objects using a total station (*16*, *22*). Two nearly complete male infant skeletons (designated Kahora 1 and Kahora 2) also yielded aDNA and were dated by association to ~14,000 and ~16,000 years cal BP after direct dating attempts failed in collagen recovery (*18*). Careful sorting of all osteological materials, including faunal remains, revealed at least four additional adults (Hora 4–Hora 7) and five additional non-adults (Kahora 3–Kahora 7) represented by isolated remains only, suggesting complex mortuary behaviors involving secondary burial and potentially token-taking (*16*).

Here, we report a large, complex ash feature with one additional set of remains that can be attributed to a single cremated adult individual, designated Hora 3, who was interred at a time between Hora 2 and Kahora 1 (text S4). Other individuals from HOR-1 show genetic population continuity across the terminal Pleistocene and early Holocene (*18*), but efforts to extract aDNA from Hora 3 (fragment ID 8269) were unsuccessful.

Stratigraphy and chronology of the pyre feature

Area I excavations (table S1 and Fig. 2) contained a large, cemented ash feature dated to ~9500 cal BP (Unit B-I-b) that divides Late Pleistocene deposits dating between ~12,000 to 17,000 cal BP (Units C-I and D-I) from overlying Early Holocene deposits (*22*). The core of the feature contains human remains designated as "Cluster 1" that sit at the interface between a thick (~10 to 15 cm) ash layer measuring at least ~2.5 by 1.5 m ("Upper Ash"), and a deeper set of lenses of consolidated ashes, charcoal, and rubified sediment ("Lower Ash"). Together, these comprise the overall "ash feature" that accumulated through multiple burning events (texts S5 and S6).

The Cluster 1 remains were positioned directly on a layer of incompletely combusted charcoal, under stratified lenses of ash and rubified sediment (figs. S4 to S6, S26, and S27). Additional human remains to the northwest of, and 5 to 10 cm deeper than, Cluster 1 and at the margin of the ash deposit are designated as "Cluster 2" (Fig. 2, A and B). Refitting fragments between Clusters 1 and 2 show that they belong to the same individual (figs. S9 and S10). The deposits containing Cluster 1 are the intact part of the pyre that cremated the Hora 3 individual and Cluster 2 is a secondary deposit of fragments from this individual that were displaced during the same event (text S8). We consider both as the "core" part of the feature.

Twenty radiocarbon dates, 11 reported here, provide age control for the core pyre and larger ash feature (Fig. 2 and Table 1). Dates stratigraphically below the core show evidence for multiple earlier combustion events between ~12,699 to 9918 cal BP covered by thin, discontinuous lenses and pockets of brown sediment (Fig. 2C). Above this, charcoal from amongst the human remains in the core feature dates to 9540 to 9454 cal BP, identical to the thick ash in the eastern excavation wall [Fig. 2C; 9538 to 9455 cal BP (*18*)]. A land snail bead preform from a brown lens immediately above the core feature shows that noncombustion deposition covered the ashes quickly after remains were deposited (9537 to 9441 cal BP). Another large combustion event, without human remains, occurred on top of this within the following 400 years (9452 to 9142 cal BP). Site occupation then covered the ash with noncombustion sediment dating to <9403 to 9031 cal BP. Therefore, the core feature and at least one

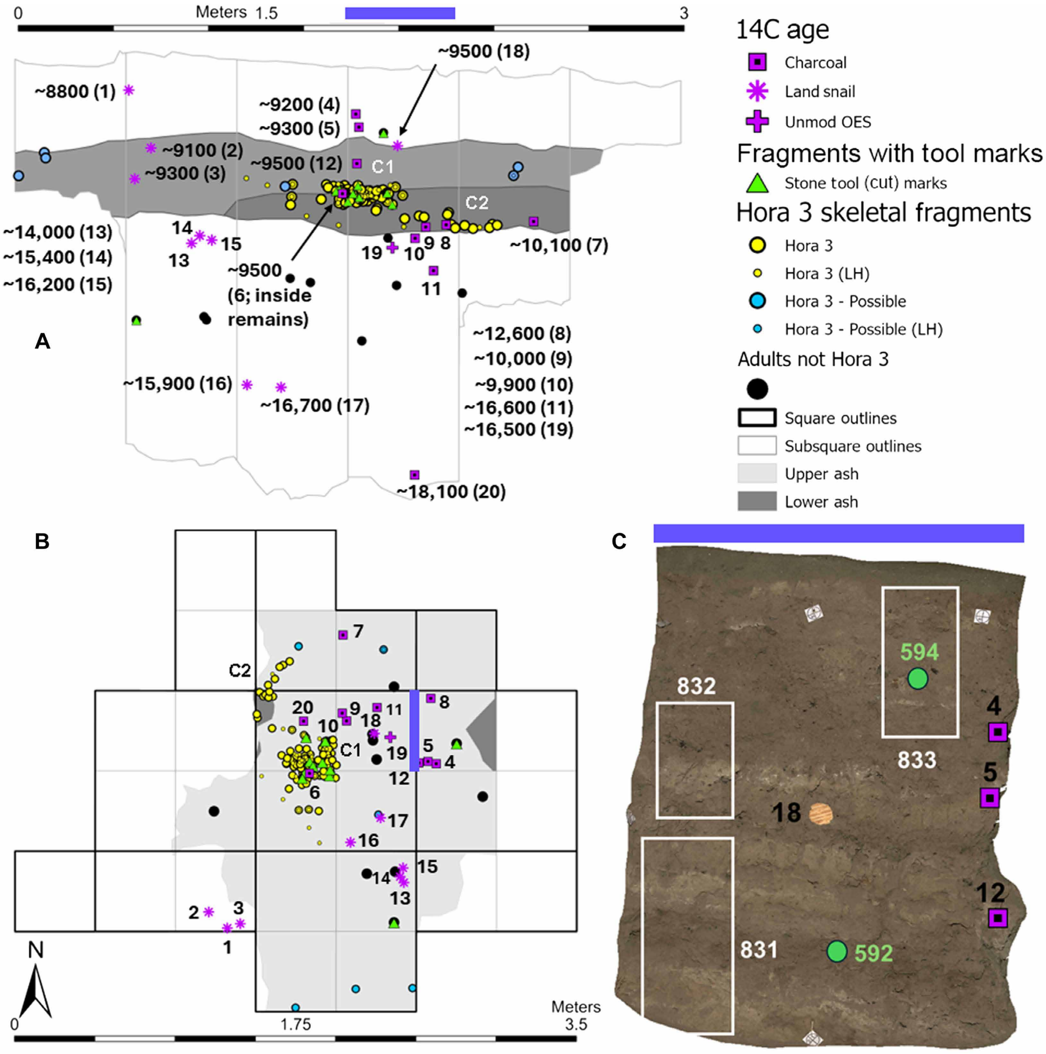

Fig. 2. Spatial relationships of dated materials, samples, and human remains. HOR-1 excavations in profile (**A**) and plan (**B**) views showing positions of dated materials and adult cremated remains with different degrees of certainty (LH = "likely human" based on size, texture, and preservation, but not morphologically diagnostic). Full details of ^{14}C ages are in Table 1. (**C**) shows phytolith (green) and micromorphology (white boxes) sample positions. Thick blue line shows how the profiles correspond in each view. "C1" = "Cluster 1" and "C2" = "Cluster 2". Photo credit: (C) J.C.T.

subsequent large combustion event were deposited within a maximum period of ~500 years, plausibly within the timeframe of community memory.

The feature core's chronostratigraphic coherence demonstrates its in situ character, as does spatial patterning of human remains (fig. S10), macroscopic observations of Cluster 1 human remains relative to the layers of ash, charcoal, and rubified sediment (figs. S26 and S27), and microscopic observations of thick, microlaminated ash at the top of the feature that stretches across more than 1 m of horizontal extent (figs. S5, S6, S17, and S19). Insect and/or root tunnels penetrate the upper ~5 cm of the mounded ash feature, especially apparent where it tapers to the south (Fig. 2A). This likely occurred after the ash was cemented and did not compromise the microlaminated ash lenses (fig. S5). Sediment micromorphology and phytolith analysis of the pyre matrix shows it consists mainly of wood ash and occasional non–woody plant fibers (text S6). Carbonized fungus of the genus *Ganoderma* and rubified clay aggregates within the pyre that originated with termite constructions on trees indicate the collection of deadwood (fig. S23). The thickness, microlamination, compaction, and sintering of the ashes show that people used large quantities of firewood over the course of repeated relighting (*23*), with rapid burial. The layer of charcoal under the remains indicates incomplete combustion at this location, suggesting moisture retention via flesh and/or a wrapping.

Artifact and ecofact densities also show rapid accumulation of large quantities of ash during burning events. Numbers of plotted finds (any object >1 cm) in all ash contexts are approximately half of those from non-ash sediments (text S5). However, the core part of the feature containing the human remains has a spike in the concentration of lithics, including smaller objects from the sieve (fig. S11). A concentration of convergent flakes and points within the core pyre also suggests that specific knapping products were introduced

Table 1. HOR-1 radiocarbon dates. Radiocarbon dates from above the thinning southwest margin of the feature (quadrant D12-b), amongst the human remains (quadrant E11-a), and above and below the main components of the feature (quadrant E11-b).

Fig. 2 no.	Square	Lot	MAL-APP ID	Fraction	Type	SHCa120	^{14}C Age	±	Lab Sample no.	Context description	Easting	Northing	Elevation	Reported in
1	D12-b	148	6089	Plotted	Giant land snail	8980–8592	7930	30	UGAMS-31758	Near top of southern wall above pyre complex	1649.177	2885.478	549.249	This paper
2	D12-b	203	6911	Plotted	Giant land snail	9264–8995	8170	30	UGAMS-31759	Middle of southern wall section above pyre complex	1649.293	2885.378	549.51	This paper
3	D12-b	233	7668	Plotted	Giant land snail	9479–9156	8390	30	UGAMS-31760	Bottom of southern wall section immediately above pyre complex	1649.096	2885.451	549.649	This paper
4	E11-b	31	384	Plotted	Charcoal	9403–9031	8280	25	UGAMS-30615	Above uppermost ash above pyre complex	1647.875	2884.455	549.357	This paper
5	E11-b	634	385	Plotted	Charcoal	9452–9142	8350	25	UGAMS-30616	In uppermost ash above pyre complex	1647.927	2884.441	549.416	This paper
6	E11-a	258	273	Plotted	Charcoal	9540–9454	85.30	30	UGAMS-30618	Amongst human remains within pyre complex	1648.665	2884.515	549.716	This paper
7	E10-d	889	1007	Plotted	Charcoal	10240–9918	8990	42	YAS-IC-65562.1.1	Lowermost ash within pyre complex	1648.456	2883.654	549.841	This paper
8	E11-a	1070	1055	Plotted	Charcoal	12699–12470	10540	48	YAS-IC-65563.1.1	Lowermost thick ash below main pyre complex	1647.909	2884.048	549.856	This paper
9	E11-b	484	379	Plotted	Charcoal	10179–9772	8871	42	YAS-IC-65559.1.1	Lowermost thick ash below main pyre complex	1648.461	2884.14	549.866	This paper
10	E11-b	486	381	Plotted	Charcoal	10155–9718	8844	41	YAS-IC-65560.1.1	Lowermost thick ash below main pyre complex	1648.434	2884.188	549.917	This paper
11	E11-b	491	389	Plotted	Charcoal	16796–16313	13676	63	YAS-IC-65561.1.1	Immediately below lowest ash in pyre complex	1648.244	2884.105	550.063	This paper
12	E11-b	238	386	Plotted	Charcoal	9538–9455	8520	25	UGAMS-30617	Within ash of pyre complex, 50-cm cast of remains	1647.984	2884.45	549.58	Lipson *et al.* (*18*)
13	E12-b	1231	49513	Plotted	Giant land snail	14118–13867	12180	25	UCI-AMS-235026	Within Kahora 1 burial	1648.077	2885.195	549.939	Lipson *et al.* (*18*)
14	E12-b	1144	48301	Plotted	Giant land snail	15563–15250	12915	30	UCI-AMS-235025	Within Kahora 1 burial	1648.1	2885.158	549.905	Lipson *et al.* (*18*)
15	E12-b	1231	4960.3	Plotted	Giant land snail	16374–16079	13510	30	UCI-AMS-235027	Within Kahora 1 burial	1648.082	2885.104	549.925	Lipson *et al.* (*18*)
16	E11-d	1771	75525	Plotted	Giant land snail	16059–15778	13295	25	UCI-AMS-235023	Within Kahora 2 burial	1648.409	2884.945	550.577	Lipson *et al.* (*18*)
17	E11-d	1771	75517	Plotted	Giant land snail	16851–16457	13775	30	UCI-AMS-235024	Within Kahora 2 burial	1648.2222	2884.792	550.588	Lipson *et al.* (*18*)
18	E11-b	216	35699	Sieved	Giant land snail	9537–9441	8510	30	UGAMS-36258	Immediately above pyre complex; giant land snail bead preform	1648.261	2884.267	549.5	Miller *et al.* (*66*)
19	E11-b	488	35456	Sieved	Unmodified OES	16604–16310	13660	30	UGAMS-35794	20 cm below lowest ash in pyre complex	1648.161	2884.29	549.959	Keller *et al.* (*17*)
20	E11-a	1838	1582	Plotted	Charcoal	18280–17915	14880	80	PSUAMS-7052	Lowest anthropogenic layer at HOR-1; charcoal pit	1648.702	2884.19	550.983	Keller *et al.* (*17*)

into the pyre as part of the ritual and/or embedded in the body (fig. S12).

Osteobiographical profile and taphonomic analysis

Excavations at this part of the site (Fig. 2) yielded 170 individual adult human bone fragments; 160 are from the ash feature complex, and 152 of these are from the "core pyre." Of the total sample, 112 are identifiable as "definitely human" (morphologically diagnostic), and the others are "likely human" based on size, texture, and preservation (table S1). Of the definite human fragments, 97 could be identified to element, and 93% of these ($N = 90$) are arm or leg long bone fragments. Other fragments from the core pyre include partial left and right calcanei, an unsided patella, the lower right articular facet of a lumbar vertebra, and four phalanges. All are consistent with a single individual (Fig. 3 and table S1).

Osteological analysis suggests that Hora 3 was a female between 18 and 60 years old (text S7). Age at death is estimated on the basis of skeletal maturation and complete fusion of the distal femur and

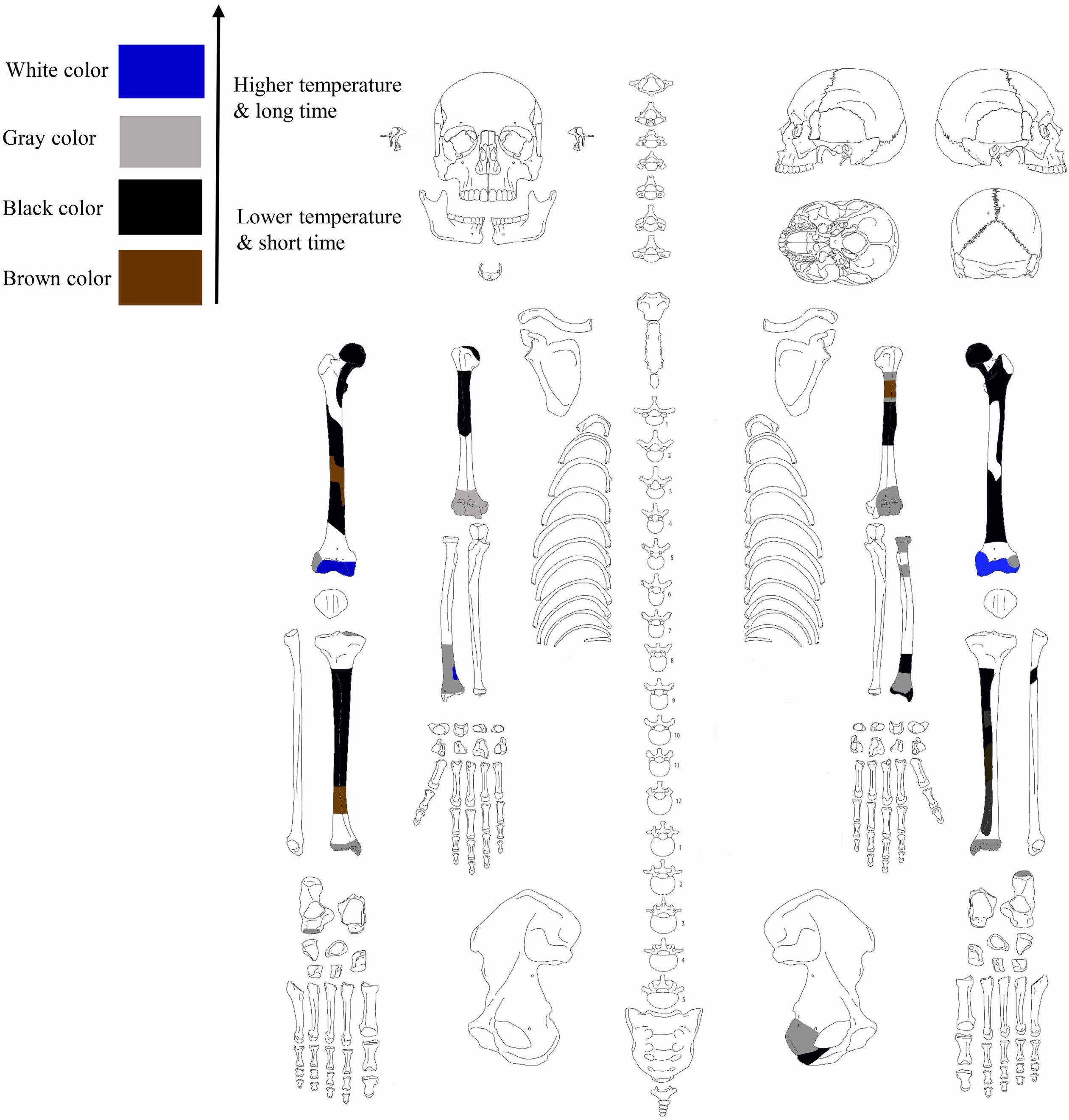

Fig. 3. Skeletal inventory and thermal alteration color changes. Preserved skeletal elements and changes in bone coloration in relation to temperature and fire exposure. Additional fragments not shown in the figure: an unsided patella, the lower right articular facet of a lumbar vertebra, and unidentified long bone fragments. Modified with permission by J.I.C.-R. from (*65*).

radius (*24*, *25*). The presence of marginal lipping at the articular margin of the distal femoral epiphysis, suggestive of mild degenerative disease, was considered in estimating the upper age range (*26*–*28*) (text S7). No other key indicators for age-at-death estimation were preserved. In the absence of pelvic remains or aDNA, biological sex was estimated using overall small size and gracility and the vertical diameter of both preserved femoral heads (left, 36.29 mm, and right, 36.31 mm; table S5), which fall within the range of African females (*29*–*31*). Discriminant function analyses on the linear metric data from the humerus, femur, and radius also suggest that Hora 3 was female based on posterior probabilities (tables S6 to S9). Stature estimates based on vertical femoral diameter suggest this individual was small, around 145 to 155 cm or just under 5 feet tall (*32*). Habitual activity was assessed using the maximum and minimum midshaft diameters of the right humerus and femur (DProd), which serve as a reliable proxy for polar second moments of area (*33*), a measure of diaphyseal torsional rigidity (fig. S24). The results indicate that this individual exhibited relatively low terrestrial mobility compared to other southern African hunter-gatherers, along with a somewhat elevated level of manual labor, as suggested by the proportionally greater humeral robusticity.

In total, the remains attributed to Hora 3 weighed 585 grams, substantially less than expected for a typical cremated adult's bones (>1500 g) (*34*, *35*). No elements from the head were recovered except for a sphenoid fragment recovered in the larger ash feature but outside the core pyre. Cranium and teeth fragments are usually preserved and easily identified when highly burned (*36*), and if it was burned within the core pyre, then at least small dental fragments would have been recovered through the complete 1-mm wet sieving protocols.

Transverse, curved-transverse, and longitudinal cracks caused by fire are present in all body areas, with no evidence of checking pattern fractures usually associated with remains burned dry. The type and distribution of the cracks in the remains suggest that the body was fleshed and still had moisture or at least some collagen (*37*). Most fragments were gray to black, with some brown, bluish-white, and white hues (Fig. 3 and fig. S28). Elements closer to the torso are black or charred. In contrast, appendicular elements with lower tissue quantity are gray to white, suggesting greater flame exposure (*38*–*41*). Many fragments with white on the external surface are gray on the inside, showing that burning occurred when elements were intact. Color changes also indicate that the fire was ≤500°C closer to the torso and ≥500°C in the appendicular area. Four white/gray fragments were subjected to Fourier-transformed infrared spectroscopy (FTIR) (fig. S29), and showed peaks at ~630 and one at 1088 that corroborate temperatures of ≥500°C (*42*). Faunal remains in the same feature are distinct in fragmentation and burning stage data, suggesting that they entered through different taphonomic pathways that involved nutrient-based processing and less burning of more complete elements (figs. S30 to S32).

Despite evidence for postcremation body manipulation, many fragments were recovered together, encased in ash, and in some cases, physically cemented (fig. S25). One instance of articulation was found in Cluster 1 between the right distal humerus and right proximal radius (fig. S27), cemented with long bone fragments and a potential metacarpal fragment. This shows that some intact joints mixed together with other fragments were present at the time of final disposal. Calcium carbonate obscured many bone surfaces, and 49% of all fragments identified as human from the feature had surface visibility <50%, which limited bone surface analyses. Even so, eight specimens exhibited marks from stone tools (Fig. 4), consistent with both disarticulation (e.g., anterior aspect of the greater trochanter of the left femur; Fig. 4E) and defleshing (e.g., parallel clusters of marks on the right radius midshaft; Fig. 4C). In contrast, we observed no carnivore tooth marks, gastric etching, or subaerial weathering on those same surfaces (table S1) (*43*).

DISCUSSION

Reconstructing the HOR-1 cremation

Results permit reconstruction of the sequence of events leading up to, during, and after the pyre construction and cremation (table S10, Fig. 5, and text S9). Beginning ~21,000 years ago, people began using HOR-1 for habitation (*17*) and eventually burial (*16*, *18*–*21*). The earliest intact burials date to ~14,000 and ~16,000 cal BP, represented by two unburned infants (*16*, *18*). Small ash features attest to modest campfires at the site during the terminal Pleistocene. By 10,240 cal BP, large campfires began to be built in Area I. Occupants then used the same location to construct a cremation pyre several hundred years later (Fig. 5).

Between 9540 and 9454 cal BP, construction began with collecting and assembling at least 30 kg of deadwood and grass, with some hairy herbaceous leaves included (text S6), requiring considerable communal effort to collect and transport. Osteological analysis, skeletal representation, fragment weights, and combustion characteristics indicate that a small adult, likely female, was burned as a complete body, likely within a few days of death (before skeletonization). Although fragmentation makes it difficult to reconstruct body position, the distribution of elements, which are almost entirely long bones, suggests that the arms and legs were flexed or in a pugilistic position, burned in situ at Cluster 1 (fig. S10). Cut marks show some disarticulation and/or defleshing of limbs near the time of burning, although some joints were still intact, and either flesh or wrapping was present during combustion. The skull may have been removed before the event (*36*). We consider the alternative explanations, including scavenging or meticulous anthropogenic collection of burned cranial remains, highly unlikely given total absence of cranial vault and dental remains, which would have likely been numerous and fragmentary if subjected to the pyre. A single sphenoid fragment, found outside the core pyre, is not conclusively from this individual. Removal of the skull is related to mortuary practices associated with remembrance, social memory, and ancestral veneration, which involved the posthumous manipulation and curation of body parts and have been observed at a regional level in the area (*16*). Skull removal, bone relics, and other forms of secondary treatment have been documented over time among various groups in Africa, although never before with this antiquity (*44*–*51*).

Fires hot enough to achieve >500°C heated parts of the still-fleshed body unevenly, and the repeated deposition of sintered, compressed, and microlaminated ashes indicates that attendees continued to add fuel (Fig. 5). Refits and differential burning between human remains in Clusters 1 and 2 and the greater degree of burning at Cluster 1 demonstrate manipulation of the body to displace fragments to Cluster 2 as combustion was ongoing at Cluster 1. This further shows active attendance at the pyre. Knapping activity also likely occurred during pyre formation, including a concentration of points that was either added to or embedded within the burning remains. This suggests they were intentionally placed, perhaps

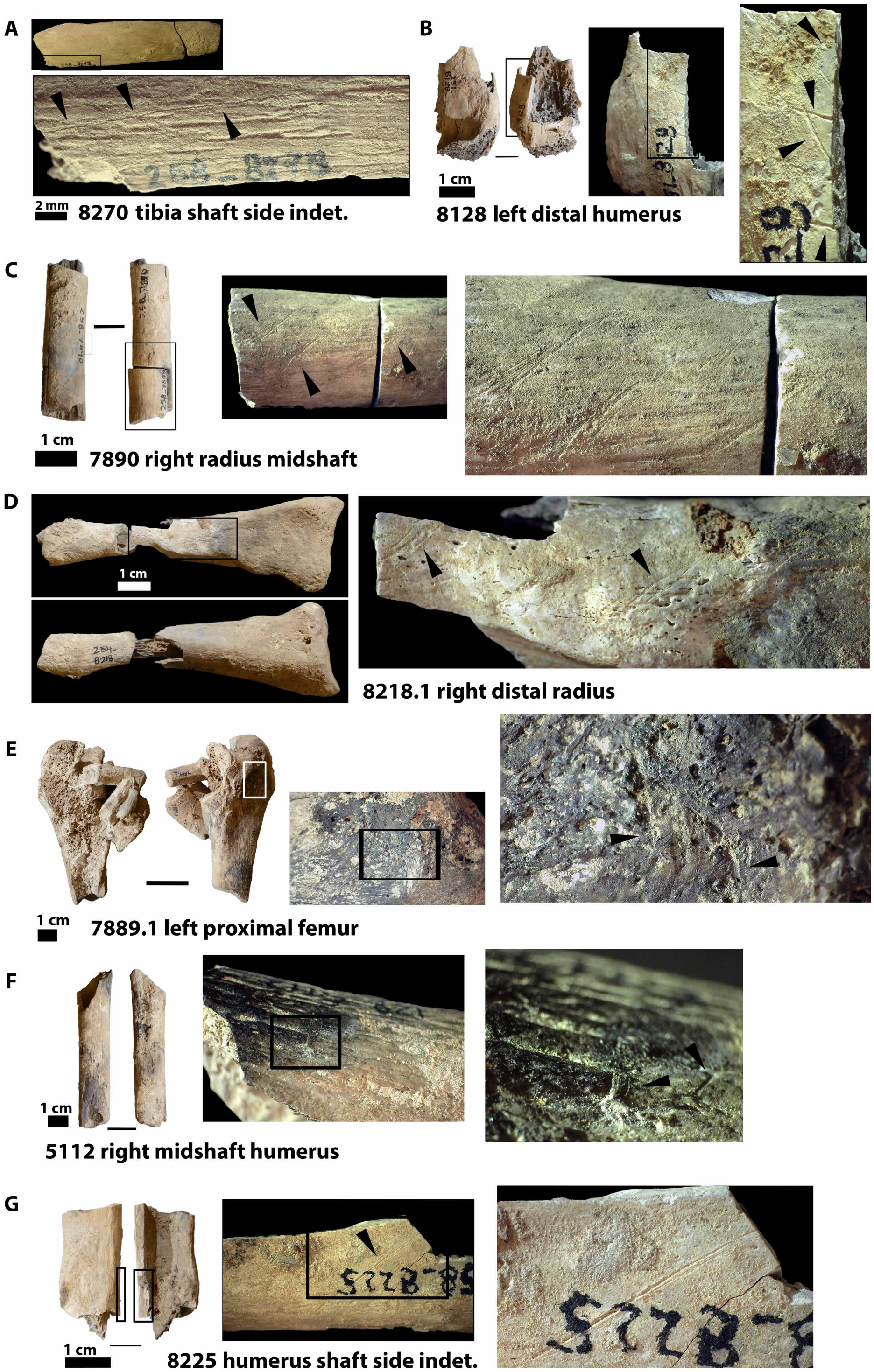

Fig. 4. Bone modifications made with stone tools. Bone surface modifications made with stone tools. (**A**), (**B**), (**C**), (**D**), and (**G**) are cut marks. (**E**) is a percussion mark. (**F**) is an indeterminate mark made with a sharp object. (B) to (G) show the variable bone colors and superficial calcination with carbonization at the interior. (C) shows the minor "skin" of calcium carbonate overlying the marks. (G) shows remaining adhering ash. (B) to (G) show two aspects of the fragment, with close-ups of the modifications in the boxed area. Photo credit: J.C.T.

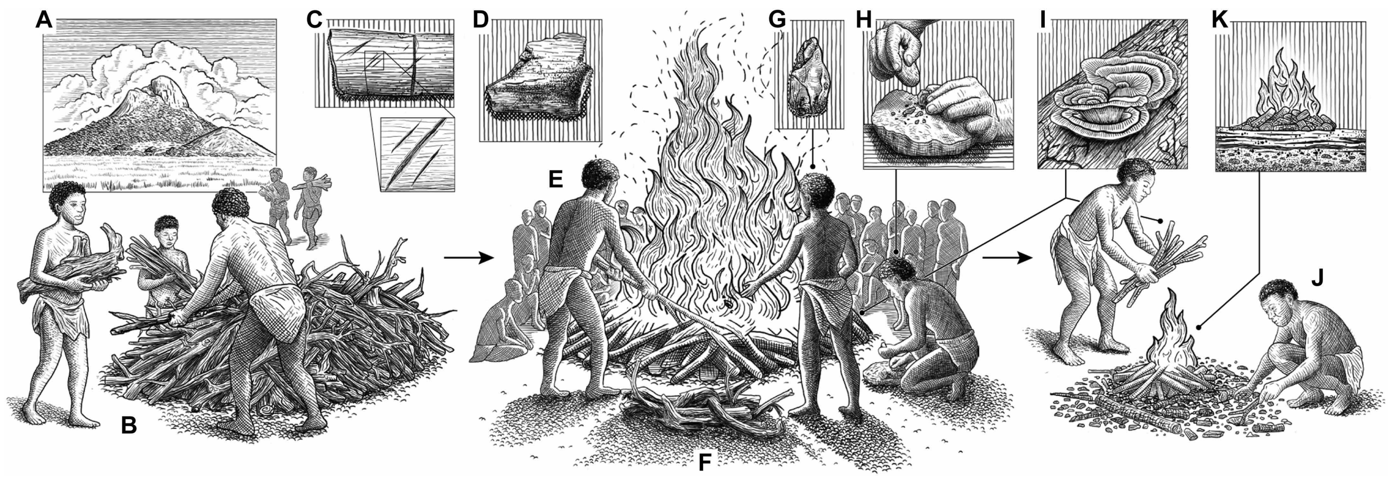

Fig. 5. Reconstruction of the cremation ritual. Sequence of events leading to the formation of the cremation feature at HOR-1. (**A**) Site location at an inselberg, a natural monument. (**B**) A large quantity of wood was collected to construct the pyre, suggesting communal labor. (**C**) Cutmarks on bone show parts of the body were defleshed. (**D**) Human remains display black coloration and curved transverse fractures, indicating some moisture in the remains. (**E**) The pyre and body at Cluster 1 were actively disturbed during burning, creating Cluster 2. (**F**) High temperatures were maintained by attendees adding additional fuel. (**G**) Convergent points are uniquely associated with the cremation. (**H**) Bipolar reduction dominates a lithic assemblage that occurs in higher concentrations with the remains than in the rest of the ash feature. (**I**) The presence of carbonized *Ganoderma* and the remnants of termite tunnels indicates the use of deadwood as the primary fuel. (**J**) The absence of cranial and dental remains suggests these may have been collected and removed. (**K**) Multiple fires were relit atop the original pyre location within communal memory. Artist credit: B.P.F., Institute of Human Origins, Arizona State University.

as associated funerary objects. The body continued to burn in situ at Cluster 1, and wood ash continued to be deposited across an area of at least 1 m^2. Within the subsequent few hundred years, multiple large fires were re-lit in the same area, although no further evidence exists for cremation at the site.

Growing evidence for complexity among African hunter-gatherers

Archaeological evidence for cremation amongst African hunter-gatherers is extremely rare, with no reported cases south of the Sahara. The earliest reported burned remains are of one individual dating to ~7800 to 7300 at Nabta Playa site E-91-1 in Egypt, where 75 to 80% of a complete skeleton, including the skull, shows evidence of blackening from a low temperature fire (*12*). While charcoal within the burial pit suggests burning in situ, archaeologists interpreted this feature as a partially burned inhumation rather than an intentional cremation. The sole other early Holocene case reported from Africa concerns five individuals in a midden recovered near Lake Besaka, Ethiopia (*52*). The excavators described an unspecified proportion of the bodies as burned, and the midden phase remains undated but it is estimated to be as old as ~7000 years BP based on geological correlations (*52*). Neither of these putatively early Holocene hunter-gatherer examples can be regarded as an in situ pyre comparable to HOR-1, which is a rare phenomenon even when cremations become more common and are typically found in secondary context (*2*). The first undisputed cremations other than HOR-1, and the earliest cremation-based mortuary traditions, do not appear until the Pastoral Neolithic in Kenya ~3300 BP associated with Elmenteitan pastoralists (*2*, *13*).

Cremation is a complex and socially mediated process, and open-pyre cremations such as that at HOR-1 demand substantial social and labor-intensive investment on behalf of the deceased. Thus, cremation is rarely practiced amongst small-scale hunter-gatherer societies (*53*, *54*). Although ~2 hours of combustion in a chamber or furnace can cremate a fully fleshed adult human (*55*), open pyre cremations require continual maintenance of fires to at least 800°C degrees, a process that can take several hours (*7*–*9*). People attending the cremation and participating in the ritual will have sensory experiences as they engage with the pyre maintenance, disarticulation and/or defleshing, and removal of body parts potentially for secondary mortuary rituals as documented elsewhere in the region (*16*).

While this cremation is highly unusual in the African archaeological record, it contributes to growing evidence of complex social worldviews among tropical African hunter-gatherers. Contrary to antiquated perceptions that tropical hunter-gatherers had social practices that were largely homogenous over time and space, more detailed examination of the record shows both significant regional variation and evidence of sustained use of memorialized landscapes (*16*). These hunter-gatherers did not engage in megalithic or other architectural behavior, yet sites were positioned at notable landscape features and used repeatedly in diverse mortuary rituals that spanned multiple generations for at least ~16,000 years (texts S4, S6, and S9). The extended mortuary use of HOR-1, as well as evidence we provide here of activities within the bounds of living community memory, attests to its role as an important place associated with a natural monument (*16*).

The evolution of social cooperation and complexity in hunter-gatherer societies has been documented across various regions and time periods worldwide, yet evidence from Africa remains comparatively limited (*56*). This case study from northern Malawi shows that a new perspective is necessary for understanding and detecting both complexity and diversity in ancient African hunter-gatherer communities. Although residentially mobile, the people who used sites in the area had limited foraging ranges (*22*, *57*), low terrestrial mobility (fig. S24), and very similar genetic ancestry, likely related to local marriage patterns (*18*). The communal labor required to establish, maintain, and potentially reenact the pyre ritual required coordinated community investment. Not only was a substantial investment made in the cremation ritual but people also continued to build and use fires, including at least one large, nonmortuary fire at the same exact spot for the next several hundred years. These complex communal behaviors, as expressed in the mortuary practices, were most plausibly associated with social demarcation and the creation of a persistent sense of space tied to territory, ancestral connections, and a monumental landscape.

In conclusion, here we report the earliest evidence of an intentional pyre cremation in Africa, and the world's oldest known adult pyre cremation. At the HOR-1 site, ~9500 years ago, a community invested substantial time and energy into the construction and performance of a funeral and the postburning treatment of a body. The history of large fire construction at that location in the site, the maintenance associated with the cremation event, and the subsequent large burning events reflect a deep-rooted tradition of repeatedly using and revisiting the site, intricately linked to memory-making and the establishment of a "persistent place." This connects with other documented practices at the same site and other sites in the region of token burial and fragmentation (*16*), which is usually found in groups that practice rituals associated with memory-making, ideas of commemoration, personhood, and ancestor veneration (*58*). These practices emphasize complex mortuary and ritual activities with origins predating the advent of food production, and challenge traditional assumptions about community-scale cooperation and place-making in tropical hunter-gatherer societies.

MATERIALS AND METHODS

Excavation and site recording

All remains, artifacts, and manuports (e.g., chipped and ground stone, pigments, beads, modified bones, pottery, etc.) and ecofacts (e.g., unmodified bones, land snail shells, charcoal, etc.) >1 cm both within and outside of the pyre, were piece-plotted using a total station, and assigned a unique specimen identifier tagged in the field with a barcode, as described in the supplement of Cerezo-Román *et al.* (*16*). Orientations were taken on objects with a long axis (*59*). A maximum volume of 50 cm by 50 cm by 5 cm was excavated for each context, or a smaller volume was excavated if there was a change in sediment characteristics (e.g., inside and outside the feature were excavated separately); these volumes of sediment are designated as "lots." All sediments were floated and water-sieved through 1- and 3-mm sieves. Artifacts recovered in the screen and designated for further individual analysis were given barcode numbers in the lab using the same sequential numbering as piece-plotted finds. Because these do not have individual 3D coordinates, they are visualized in geographic information system (GIS) maps at the midpoint of each excavated lot of sediment.

Sediment micromorphology and FTIR

Oriented blocks of intact sediment were collected from exposed profiles with plaster of Paris. Each block produced one to three thin sections, which were scanned at high resolution (2400 dpi). The thin sections were further studied using a stereomicroscope and petrographic microscope with plane polarized light and crossed polarized light at magnifications from 20× to 500×. Micromorphological descriptions followed guidelines for thin section analysis by Stoops (*60*) and Stoops *et al.* (*61*).

FTIR spectra were collected at Pennsylvania State University on a vertex 70 spectrometer (Bruker optics, Billerica, MA) equipped with a deuterated tryglycerine sulfate detector. IR spectra were acquired in attenuated total reflection (ATR) mode using a DiaMax diamond ATR accessory (Harrick Scientific, Pleasantville, NY).

Radiocarbon sample preparation

Charcoal samples YASIC-65559.1.1, YASIC-65560.1.1, YASIC-65561.1.1, YASIC-65562.1.1, and YASIC-65563.1.1 were prepared by S.G.H.F. at the Yale Department of Anthropology and Yale Analytical and Stable Isotope Center (YASIC). Preparation was modified from the ABA treatment of the Bristol Radiocarbon AMS (BRAMS) facility (*62*) as follows: acid wash of 1 M HCl at 60°C for 20 min, a base wash of 0.2 M NaOH at 60°C for 20 min, and a final 1 M HCl at 60°C for 60 min. After each wash, the samples were rinsed three times with distilled water. The samples were then dried in the oven at 40°C for 24 hours. Compared to the BRAMS protocol, the modification is a slightly lowered temperature of the acid and base washes, from 75°C, according to the BRAMS protocol, to 60°C, for a gentler treatment. Samples were weighed and prepared according to the YASIC protocol for graphitization using an Elemental Analyzer. Samples and standards were weighed in tin boats (blank = 1.6 to 1.8 mg; C7 & Ox2 = 5.2 to 5.5 mg). Samples were converted into graphite by adding 2.5 ± 0.15 mg of Fe to the bottom of 50 mm height by 6 mm outer diameter glass tubes and run through the automatic graphitization equipment (AGE3). Samples were then pressed into targets using a pneumatic sample press and wiped down with ethanol before beginning and between each press. Samples were run on an Ionplus MICADAS.

Charcoal samples UGAMS-30615, UGAMS-30616, and UGAMS-30618, and land snail samples UGAMS-31758, UGAMS-31759, and UGAMS-31760 were prepared at the Center for Applied Isotope Studies at the University of Georgia. The charcoal sample was pretreated following the acid–alkali–acid protocol to remove secondary carbonates, acid-soluble compounds, and humic acids. The sample was placed 1 N HCl and heated to 80°C for 1 hour, centrifuged, and decanted, and rinsed in deionized water. The sample was then washed with 0.1 M NaOH and rinsed in deionized water, followed by a second treatment with dilute HCl to remove atmospheric CO_2, rinsed, and dried at 60°C. The shell carbonates were acid-etched with dilute HCl to remove the outer shell layer, which is most likely to be affected by secondary or diagenetic carbonates. The pretreated charcoal sample was placed in quartz ampoule with CuO and combusted at 900°C to produce CO_2. The pretreated shell carbonate samples were reacted with 100% phosphoric acid in evacuated reaction vessels to produce CO_2. CO_2 samples were cryogenically purified from the other reaction products and catalytically converted to graphite using the method of Vogel *et al.* (*63*). Graphite $^{14}C/^{13}C$ ratios were measured using the 0.5-MeV accelerator mass spectrometer. The sample ratios were compared to the ratio measured from the oxalic acid I standard (NBS SRM 4990). For shell carbonates, Carrara marble (IAEA C1) was used as the background, and travertine (IAEA C2) was used as a secondary standard. The quoted uncalibrated date is given in radiocarbon years before 1950 (years BP), using the ^{14}C half-life of 5568.

Software

Taphonomic and identification data were collected using Microsoft Access and manipulated in Excel. Figures were assembled in Microsoft PowerPoint and Adobe Photoshop. Statistical tests were performed in PAST version 4.12b. YASIC sample graphitization was done using IonPlus AGE3 and Unicube software.

Biological data

The biological data include estimations of sex, age at death, pathological conditions, and trauma. The protocols for osteological data collection were based on Buikstra and Ubelaker (*24*) and additional work (*25*–*32*). First, a detailed skeletal inventory of the individual was generated, including recording elements present and their preservation conditions. These analyses allow for interpretations of body completeness upon burial and the number of individuals represented in each deposit. Second, age at death was estimated using morphological and metric analysis, which can give physiological age range at death following accepted standards (*24*–*28*). Third, sex was estimated following standard accepted protocols (*29*–*31*). Fourth, evidence of pathological conditions and trauma were recorded when present using accepted protocols (*24*).

Posthumous treatment of the body

The variables documented for the posthumous treatment of the body, taphonomic, and archaeological context include (i) skeletal part abundances, bone surface modifications, fragmentation, and thermal alterations, (ii) spatial analysis, deposit type, and context, and (iii) associated objects. Thermal alteration and body manipulation were analyzed to produce a detailed reconstruction of posthumous practices in relation to the burned bones, following standard protocols (text S8). Identification of bone surface modifications such as cut and percussion marks was conducted using a 10 to 40× binocular light microscope following Blumenschine *et al.* (*64*). Microscopic images were taken using a Dino-Lite Edge Digital Microscope Model A,4815ZT. Attributes associated with thermal alteration of osseous tissue were documented by anatomical region and in each skeletal fragment, including colors (e.g., brown, black, and white), degree of shrinkage, degree and patterns of fractures, bone weights, and maximum lengths of bone fragments (text S8).

Supplementary Materials

The PDF file includes:
Supplementary Text
Figs. S1 to S32
Tables S2 to S11
Legend for table S1
References

Other Supplementary Material for this manuscript includes the following:
Table S1

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