Bioarchaeology of the Near East, 1:35–57 (2007)

The practice of cremation in the Roman-era cemetery at Kenchreai, Greece
The perspective from archeology and forensic science

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Abstract: *Since 2002 the Kenchreai Cemetery Project has explored subterranean chamber tombs of Roman date in the main cemetery of the ancient port of Kenchreai, on the eastern coast of the Isthmus of Corinth, Greece. Analysis of the human remains recovered from three tombs has furnished evidence for cremation as well as inhumation. The cremated remains represent both adults and immature individuals. Forensic analysis indicates that the original event of cremation reached high temperatures over a long duration, and that only a fraction of the cremated remains were transferred to the tombs.*

Ancient mortuary sites represent valuable repositories of information regarding not just the burial customs of past societies, but also biocultural information about the people represented and their attitudes toward life and death. Such information is augmented through a thoughtful bioarcheological approach in which knowledge gleaned from skeletal analysis is integrated with archeological interpretation following meticulous excavation. This report exemplifies this sort of analysis, focusing on the interpretation of cremated remains from chamber tombs of Roman date in the main cemetery at Kenchreai in southern Greece.

Key words: Greece; cremation; bone; Roman; Kenchreai

1. Kenchreai and the cemetery on the Koutsongila Ridge

Kenchreai was located on the eastern coast of the Isthmus of Corinth, which connected central Greece with the Peloponnesos, or the southern Greek peninsula (**Figure 1**). The cemetery under discussion, the most important burial ground serving the port–town, was located on Koutsongila, a low coastal ridge immediately north of the ancient harbor (**Figure 2**). Kenchreai was the eastern port of Corinth throughout classical antiquity, but the harbor was especially active and the associated settlement was particularly prosperous during the Roman Empire, between roughly the first and seventh centuries AD.

Since 2002, Joseph L. Rife has directed the Kenchreai Cemetery Project (KCP), an interdisciplinary program of excavation, conservation and research sponsored by Macalester College (St. Paul, Minnesota) and worked under the auspices of the American School of Classical Studies in Athens and with the permission of the Hellenic Ministry of Culture (Rife et al. 2007). KCP has explored all the known cemeteries at Kenchreai but concentrated on the major site on the

Received 23 April 2007; accepted 22 August 2007; published online 15 March 2008 on www.anthropology.uw.edu.pl; corrected online 20 October 2008

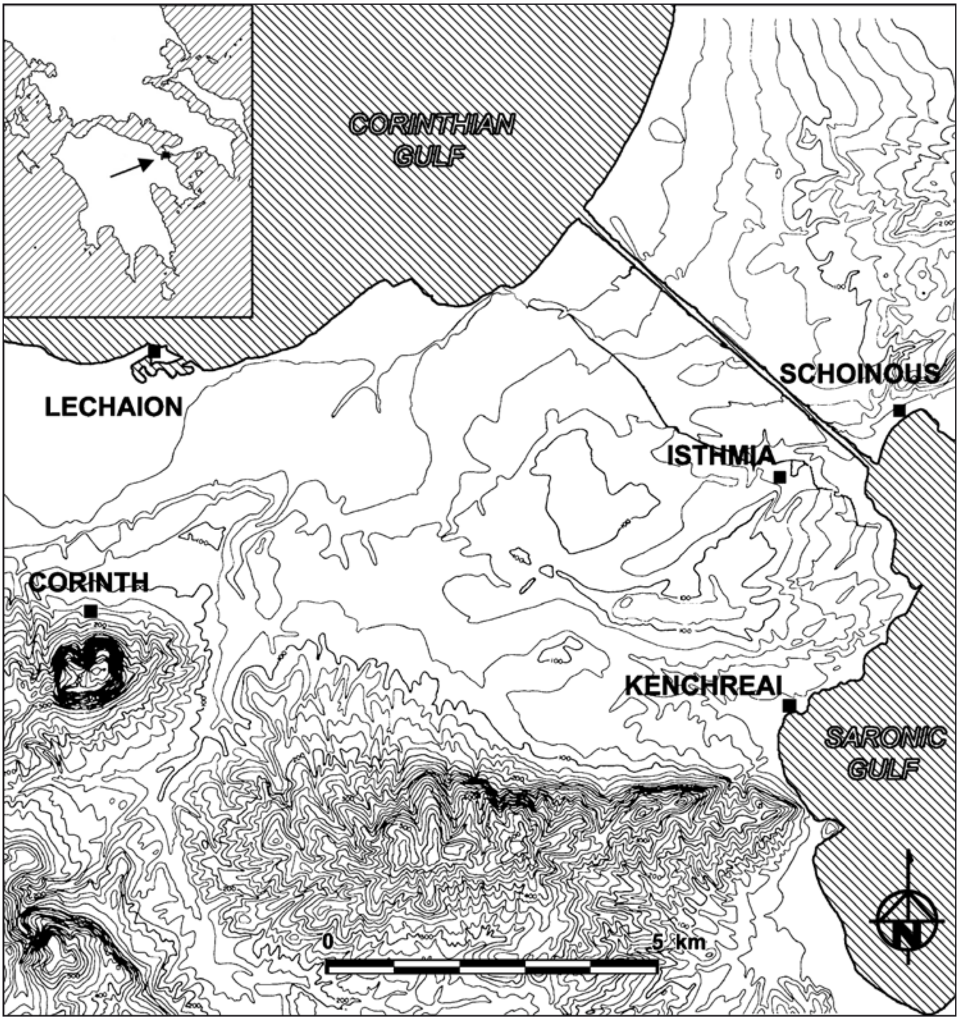

Figure 1. Greece (insert) and the Isthmus of Corinth (J.L. Rife).

Koutsongila Ridge. The site has been selectively studied by Greek and American archeologists since 1906, but KCP has conducted the first comprehensive investigation of the area, responding in part to rampant looting that has continued for decades. Intensive survey and excavation by KCP over five summers has documented 30 subterranean chamber tombs and 28 individual cist graves that had been cut into the bedrock along the seaward slope of the ridge and extending northward into adjacent areas.

The most impressive context for burial in the cemetery on Koutsongila was the chamber tombs (Rife et al. 2007). These were large structures cut into the bedrock that were used over a long period (see below) and contained numerous individuals (Rife et al. 2007). Each tomb (**Figure 3**) has a stairway leading from ground level down into a rectangular chamber area, which measures on average approximately 3.7 m long by 3.3 m wide by 2.5 m high. Certain tomb entrances were enclosed at the surface by a rectangular structure with a monumental

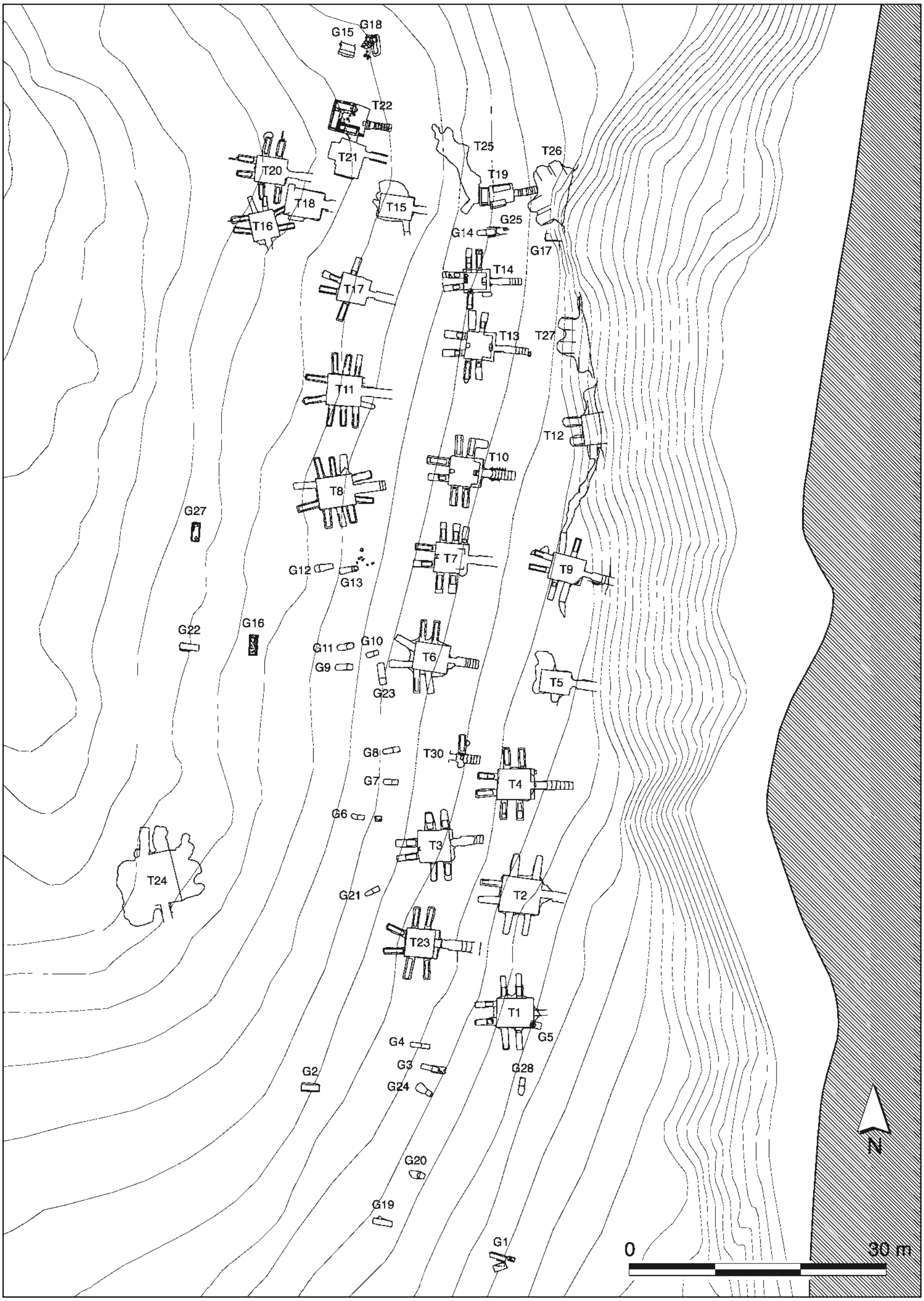

Figure 2. Cemetery on the Koutsongila Ridge, 1 m contour interval (C. Mundigler, J.L. Rife, D. Edwards, M.C. Nelson).

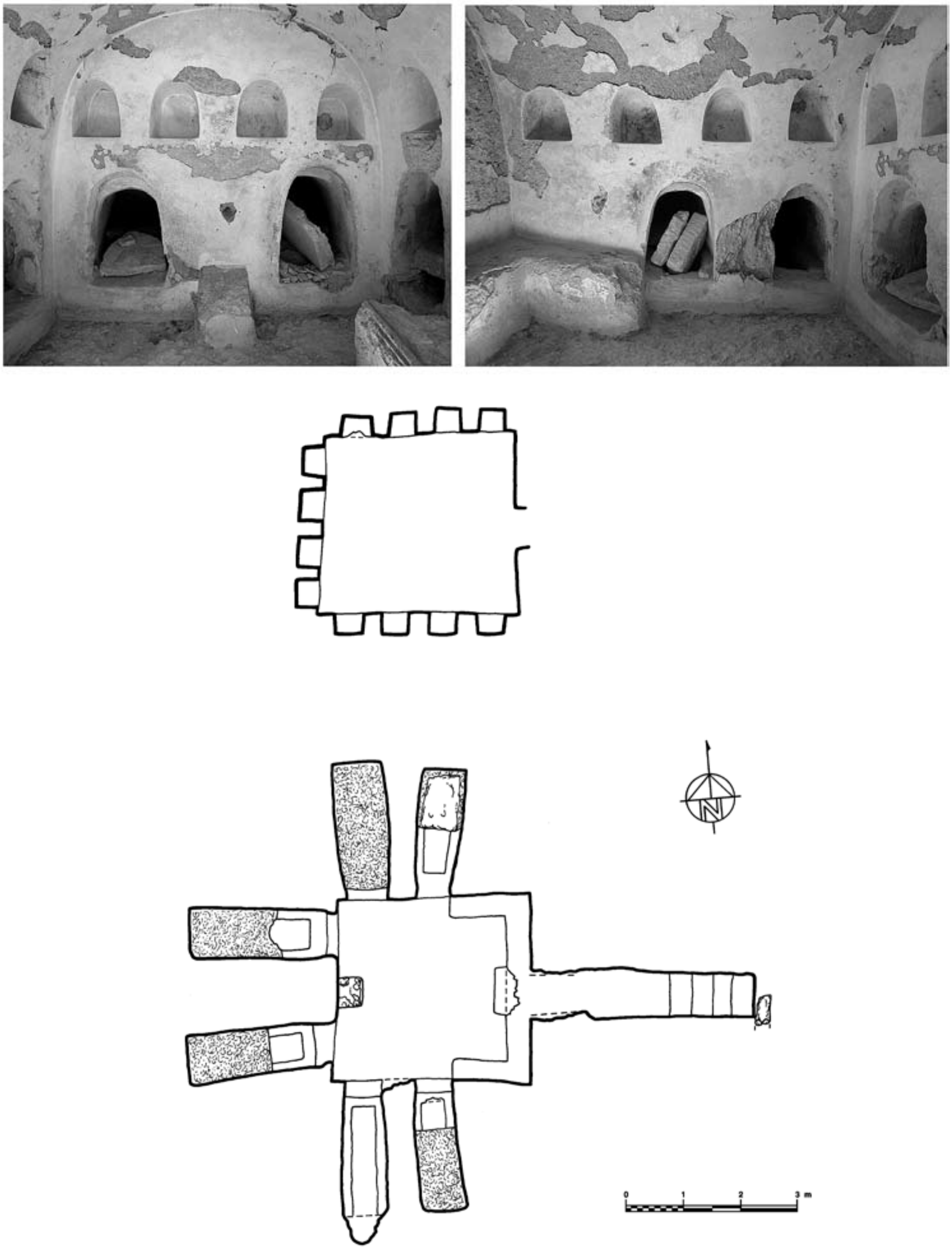

Figure 3. Tomb 13, views of south (top left) and west walls (top right) of Tomb 13 and plan at level of niches (above) and loculi (below) (J.L. Rife).

façade, which marked the site of the tomb, protected the entrance, and displayed an epitaph. Those epitaphs that survive reveal that the tombs were built and first used by parents and their children, followed by their descendents and freedpersons (Rife et al. 2007). The tomb interiors were finished in white or painted plaster and furnished with benches and altars. Each tomb accommodated two different mortuary procedures. The primary burial of bodies most frequently occurred in long, narrow compartments (loculi) cut into the lower part of the chamber walls, though in rare cases cists were cut directly into the chamber floor. In addition, urns with cremated remains were deposited in small niches cut into the upper part of the chamber walls (Rife et al. 2007).

The evidence of monumental architecture, wall-painting, and rich funerary artifacts shows that the tombs were owned and used by members of the local elite class. They buried their dead in the chambers over a span of four to eight generations between roughly the middle or late first and the middle or late third centuries AD. Apparently the loculi were subsequently used for further burial during the Late Roman period, or the fifth to sixth or seventh centuries, but these individuals are most likely unrelated to the original owners of the tombs (Rife et al. 2007).

Investigation of the burials within the tombs has revealed complex procedures for burial. During the Early Roman phase of use, multiple individuals were placed inside the chambers either as intact corpses or as cremated remains. Bodies were placed in the loculi and covered with a thin layer of soil, after which the compartments were sealed with large limestone slabs or terracotta tiles that could be removed for the addition of other individuals. Cremated bone and tooth fragments without artifacts were placed in heavy, cylindrical urns, which were then deposited in the open niches. Burial during the Late Roman phase of use involved the placement of bodies on top of the loculus covers and possibly the disturbance of the skeletal remains of those previously deposited (Rife et al. 2007). Thus so-called disturbed remains associated with loculi likely represent an aspect of normal mortuary practice for the period.

Since antiquity, diverse environmental and anthropogenic factors have altered the preservation of the human remains in the tombs on the Koutsongila Ridge (Ubelaker and Rife, in press). Small animals, especially mice, rats, and snails, have burrowed into the tombs and displaced bones on a small scale. Water transporting fine sediment seems to have continuously entered the tombs through the porous, calcareous bedrock into which the tombs had been cut and directly through the entrances. This moisture and soil stimulated the growth of plant roots, especially from pine trees at the surface. These taphonomic conditions left a clayey crust on some remains and contributed to their general degradation and displacement.

The main cause of the disturbance of the tombs and their contents has been illicit digging. Looting on Koutsongila probably began in ancient times, but it has intensified since the 1960s. Looters apparently searching for intact pottery and precious jewelry have tunneled into the tombs and disturbed the contents of loculi, cists, and niches. This clandestine activity, possibly coupled with seismic factors, has relocated human remains from their primary state of deposition in the niches and loculi to scattered, commingled deposits across the tomb floors, and it has mixed the human remains preserved within single loculi.

2. Cremation in antiquity

The presence of cremated human remains in association with unburned human remains within the tombs in the cemetery on Koutsongila at Kenchreai represents a mortuary custom known in many areas of the world. As shown by Prothero (2001), the practice of cremation was widespread in ancient times outside Europe and the Mediterranean Basin. For example, in North America, cremation is well known among Native Americans from the Southwestern United States, especially in Arizona (Merbs 1967) and in New Mexico (Toulouse 1944), where it increased over time in the prehistoric Mimbres area (Creel 1989). Burned bone and evidence for cremation have been reported at early sites in Australia (Bowler et al. 1970) and Africa (Cain 2005; Sillen & Hoering 1993). Researchers have also studied cremated remains from British sites (Williams 2004) dating to the Early Bronze Age (Brown et al. 1995; Bond 1996) and the Roman Empire (McKinley 2001; Williams 2004; Faber et al., in press). Cremation is also reported at archeological sites in France and Luxembourg (Van Doorselaer 1967; Pajot 1987; Toupet 1987; Polfer 1996, 2001), Norway (Oestigaard 1999), Sweden (Kaliff 1998), Denmark and Germany (Pearson 2000), Holland and Luxembourg (Musgrave 2005), the Czech Republic (Holnerova 1978), and among ancient hunters and fishers of northern Eurasia (Häusler 1968), the peoples of India (Van Gennep 1960), Nepal (Oestigaard 2000), Bali (Downes 1999), and other cultures of Asia (Irion 1968). Metcalf and Huntington (2006) describe practices in groups in Borneo and Bali in which remains are accumulated over long periods of time, cremated and then the ashes and fragments are collected and then stored in wooden containers (Borneo) or dispersed at sea (Bali).

Cremation was a common mode of mortuary treatment in Greece from prehistory through the Roman era (Kurtz & Boardman 1971; Morris 1987). Irion (1968) observes that cremation was widespread in ancient Europe after about 1500 BC and entered Greece from the north around 1000 BC. After that point, cremation occurs simultaneously with inhumation, though with variable frequency, down through the Classical period, or until the late fourth century BC (Robinson 1942; Childe 1945; Kurtz & Boardman 1971; Popham et al. 1979; Garland 1985; Morris 1987; Musgrave 1990; Liston 1993; Liston & Papadopoulos 2004; Musgrave 2005). During the Hellenistic era, or the late fourth to first centuries BC, cremation was widely practiced in Greece, and it was the standard custom in chamber tombs belonging to the royalty and elites of Macedonia (Prag et al. 1984; Musgrave 1990; Miller 1993), though as noted by Kurtz and Boardman, the transition toward cremation was gradual. Burial by cremation increased in frequency during the Early Roman period, when it occurred with high frequency in many Greek communities but particularly those with ties to Roman Italy, such as the colonies at Patras and Corinth (Blegen et al. 1964; Walbank 2005). This is not surprising, because cremation was the predominant mortuary procedure in the western provinces during this time (Audin 1960; Toynbee 1971).

Garland (1985:78) notes that cremation of the very young (infants and young children) was rare in ancient Greece. Papathanasiou (2001) described the possible cremation of two children (1.5 and 3.5 years of age) in addition to primary inhumations from the Neolithic Alepotrypa Cave in southern Greece. The evidence suggests that neonates and infants were sometimes cremated in the Early Bronze Age and Early Iron Age (Branigan 1998). Note also that calcined animal bones (sheep, goat, fox, and cattle) were reported from the Sanctuary of Apollo Hylates at Kourion in Cyprus dating to 2500 years ago (Davis 1996; Buitron-Oliver 1996) and also from sites in Greece (Forstenpointner 2003).

Some evidence from prehistoric Greek sites also indicates that human remains can be burned through exposure to the ritual use of fire, and thus may not represent intentional body cremation practices. Gallou (2005) provides a useful summary of such examples, noting that even calcination can result from such accidental exposure.

3. Reconstructing Greek cremation practices

While it is often difficult to reconstruct the full procedure of cremation from the cremated remains alone, the archaeological study of cremated bone has clearly demonstrated that practices varied considerably over time and from place to place. Cremation in ancient Greece was hardly a consistent or standardized custom. Research on Greek cremation has focused on evidence from Iron Age, Classical and Hellenistic sites (see references above). No large-scale study has attempted to reconstruct the procedure of cremation in a cemetery of Roman date in Greece, even though it was a widespread practice in the Greek world at this time.

In his discussion of the human remains recovered during excavations at the Classical city of Olynthus in northern Greece (fifth to fourth century BC), Robinson (1942) provides some perspective on the likely procedures employed for cremation in the area. Robinson noted that although evidence for cremation occurred at a variety of archeological sites in Greece, methodology and frequency varied considerably. For example, Robinson indicates 'no cremations were reported from Corinth' (1942:145) in the early excavations, while about 94% of burials at the site of Vroulia on Rhodes (eighth to fourth century) involved cremations. We now know that cremation was widespread at Early Roman Corinth (Fox Leonard 1997; Walbank 2005), but it was not exclusively practiced. At Olynthus, about 25% of the cremations recovered in the early excavations were thought to have originated from children, but infants were not included. Robinson (1942) notes that in some areas of Greece, the expense of cremation, particularly the cost of wood for fuel, may have been a factor influencing decisions regarding cremation versus inhumation. However, Robinson argues this was probably not the case in Olynthus, where wood presumably was relatively plentiful. Other possible motivations for cremation include the transport home of individuals who had died abroad, general attitudes toward the significance of death, the conferring of public honors, and the expression of wealth and status (Irion 1968). The final decision likely was an individual or family one.

The procedure, as interpreted by Robinson (1942), initially involved washing and dressing the body, usually by family members. After lying in state, the body was carried to the crematory on a bier or coffin and placed on the pyre. The pyre was constructed within a trench, and, if the cremation represented the primary burial site, the residue following cremation was covered with soil. Robinson suggests that in constructing the pyre, straw or hay was first placed on the floor of the trench to serve as kindling. Wood was then stacked in layers upon the kindling. Robinson notes that the wood at Olynthus likely originated from deciduous trees, but that a variety of types of wood could have been utilized. The pyre also could be constructed on the ground surface, especially for those intended for secondary deposition elsewhere. Such pyres probably had better air flow during the burning. Trench cremations, especially deep ones, often had secondary vent–type structures, which enhanced the circulation of air (Kurtz & Boardman 1971). Kurtz and Boardman (1971) note that trench cremations frequently are thought to be primary, meaning that the remains of the individual were left in the trench and not transported elsewhere. Secondary cremains, in which remains are transported to another location, frequently require the use of ash urns.

A similar method has been reconstructed for the cremation of the Macedonian royalty in the Late Classical period, or the late fourth century BC (Prag et al. 1984). Musgrave (Prag et al. 1984) has proposed that the central individual who was cremated and deposited in Tomb II at Vergina, identified by some as King Philip II, was burned in an oven. The body was enclosed in a brick box, which was packed with fuel and heated up to 900°C for as long as 45 to 90 minutes. The bones show the degree of warping, fracturing, and shrinkage typical of exposure to such intense heat over this interval, but the skeleton is relatively intact, Musgrave argues, because it was burned in the container rather than on an open pyre. While the extended application of heat to the skeleton would have been typical of Greek cremations, the testimony of ancient art and literature indicate that the use of a pyre, not a brick box or oven, was the conventional practice. Bartsiokas (2000) has studied the same cremated remains, which he identifies as Phillip III, and concludes that the bones were collected and burned dry, not in the flesh.

Ethnographic analogy helps to draw a plausible picture of Greek methods at the usual site of the pyre. Oestigaard (2000) notes that in Nepal, as the pyre cremation advances, those in charge used long sticks to reorganize the burning wood and to break apart the burning human remains. Such intervention during the cremation was likely needed to ensure that ample fuel was present, that proper airflow was maintained, and that the heat was directed toward the human remains.

4. The evidence for cremation at Kenchreai

As noted above, the excavation of tombs on the Koutsongila Ridge at Kenchreai has revealed that cremation was practiced in addition to inhumation. Although cremated remains were found primarily in niches, small quantities were also found dispersed throughout deposits on the chamber floors and rarely in loculi. The past activities of people inside the tombs, including occasional squatters and frequent looters, have apparently displaced cremated bones from the niches, where they were originally deposited, to the floors. This movement is understandable if we imagine, for instance, that residents removed the sturdy cinerary urns from the niches for practical re-use outside the tombs but first dumped out the contents on the floor, or that looters sifted through the cremated fragments in the niches in search of artifacts. During such activity, it seems that a small quantity of cremated fragments was sometimes inadvertently moved from the niches or swept from the floors into the fronts of the loculi.

Table 1 summarizes the amount of human remains in three tombs, nos. 13, 14, and 22. These tombs were selected for this discussion because their excavation and analysis are complete, and they provide good evidence for interpreting cremation and inhumation in the cemetery. Of the 12 tombs so far explored on Koutsongila by KCP and earlier archaeologists, these three provide the most comprehensive view of cremation at Kenchreai. Two other tombs at the site (nos. 4 and 9), excavated in 1990 and 1969, respectively, have produced very small quantities of cremated bone (35 g and 152 g, respectively). These have not been included here because they

Table 1. Comparison of the weights of burned remains versus the total weights of samples of human remains recovered from three tombs in the cemetery on Koutsongila.

Tomb	Total Weight (g)	Total Weight Burned (g)	% Burned
13	12,245	2,949	24
14	34,235	2,471	7
22	12,486	221	2

were only partially excavated and all the remains were not recovered. A third tomb (no. 10), has produced large quantities of cremated bone, but it is still under study. As KCP expands into a large–scale excavation in 2007–2009, it is hoped that further investigation will uncover more evidence for mortuary practices, in particular cremation, at Roman Kenchreai.

As shown in **Table 1**, the total weight of human remains recovered from the three tombs varies dramatically, despite careful and exhaustive excavation and complete recovery of all materials within the tombs. At the extremes, Tomb 13 yielded 12,245 g and Tomb 22 yielded 12,486 g, while Tomb 14 produced over two and half times as much bone, or 34,235 g. This disparity of representation reflects not only the different numbers of individuals deposited within each tomb during the Roman era, but also the differential destruction of human remains by natural and cultural processes. Over the centuries, the slow influx of sandy to gravelly sediments along with numerous cobbles, scattered structural debris, and occasional boulders through the opened tomb entrances, together with the periodic collapse of calcareous bedrock from the ceilings and walls of the chambers, have crushed and pulverized many smaller bone fragments. The violent displacement of bones by looters, who have churned through deposits in niches and loculi to find valuables, has also led to the destruction of already fragmentary remains. It is, however, highly improbable that interlopers in the tombs after antiquity have collected and removed large quantities of bone or introduced bone that was originally deposited in other chamber tombs. Apart from the possible extraction of select bones during the Late Roman to Byzantine era (Ubelaker & Rife in press), it seems that no bones have left or entered the tombs since ancient times.

The representation of individuals also varied considerably between tombs. While the relatively large deposits within Tomb 14 represented at least 52 individuals, the smaller deposits within Tombs 13 and 22 represented at least 19 and 13 individuals, respectively. Thus, at least 84 individuals are represented in the three tombs, with a mean of at least 28 individuals per tomb. The minimum number of individuals within each tomb correlates generally with the amount of human material recovered, but it should be noted that the calculation of the minimum number of individuals (MNI) has involved certain assumptions. In the cases of Tombs 13 and 14, the calculation assumes that there was no mixing of bones from separate individuals between loculi or between niches, that the movement of cremated bone fragments from the niches to the loculi was minimal and easily recognized, and that material recovered from the tomb floor originated from both the niches and loculi. The calculation of MNI in Tomb 22 required the combined study of bone from all contexts, because both burned and unburned bone was found only in commingled deposits on the chamber floor, below the niches, and above the looted cists that were built into the floor.

Separate tombs also displayed different frequencies of burned material within the bone assemblage. Of the 58,966 g of all human remains recovered from the three tombs, only 5,641 g, or 9.6%, revealed clear evidence of burning. Of the 5,641 g of burned bone, most originated from Tomb 13, even though Tomb 14 yielded more human remains overall. The cremated fragments ranged in color from gray to white, reflecting the results of extreme heat over a long duration (**Figure 4**). Many of the calcined (white) fragments reveal transverse fracture patterns, warping and twisting suggestive of burning in the flesh (**Figure 5**). Some of these fragments (**Figure 6**) display extreme alterations in bone morphology suggesting prolonged exposure to high temperatures.

Fragmentation, especially of the cremated material, limited the inventory of skeletal elements and the interpretation of sex and age at death. Within the total sample of burned bone from the three tombs, all different regions of the skeleton were represented. The estimated ages at death among the cremated individuals ranged from young child to adult. At least four subadults were

Figure 4. Calcined bone fragments from the chamber of Tomb 13 showing warping and transverse fracture patterns indicative of in-flesh cremation (J.L. Rife).

Figure 5. Calcined cortical bone fragment from Loculus V in Tomb 13 (locus T13–040) showing warping and transverse fracture patterns indicative of in-flesh cremation (A.J. Suehle).

Figure 6. A calcined left radius from Loculus IV in Tomb 13 (locus T13–037) displaying severe alterations in morphology indicative of prolonged exposure to high temperatures (A.J. Suehle).

present, two in Tomb 14, a two to three year old child in Tomb 22 and another child of undetermined age from Tomb 22. No cremated infant remains were detected. Standard methods were employed for the estimation of age at death (Ubelaker 1999), as appropriate.

5. Approaches to the analysis and interpretation of cremation

In the past cremated bone from archeological sites was discarded because of its presumed lack of analytical potential. But in recent decades, the experience brought by physical anthropologists (Cook 1999), modern forensic work, commercial cremations, experimentation and broader concepts of research design have led to a growing literature on what information can be extracted from such samples (e.g., Musgrave 1990, 2005; Liston 1993, 2007). A variety of authors have addressed methodological approaches to the analysis and interpretation of cremation in different contexts (Gejvall 1969; Lisowski 1968; Kurzawski et al. 1987; Masset 1987; Mayne Correia & Beattie 2002; McKinley & Roberts 1993; McKinley 2000, 2001; Thompson 2004). Together these sources reveal the broad range of information that can be gleaned from the study of cremation when the proper methods are applied.

5.A. Perspective from forensic science

The practice of modern forensic science furnishes considerable insight into the analysis of cremation. Even commercial cremations present situations requiring forensic investigation, which in turn yield valuable information on the cremation process. For example, in Tucson and Pima County, Arizona in 2002–2003, 0.8% of requests for cremations became medical examiner cases after appropriate review (Nelson & Winston 2006). Burning cases also result from criminal attempts to destroy forensic evidence (Fanton et al. 2006), from suicide (Shkrum & Johnston 1992), and from a variety of disasters such as aircraft accidents, bombing and explosive use, and earthquakes (Sledzik & Rodriguez 2002). Many of these forensic scenarios present challenges for evidence recovery (Dirkmaat 2002) and analysis. Heat related changes to the human remains frequently limit analysis and shift the focus toward those aspects that survive (Owsley et al. 1995; Ubelaker & Scammell 1992; Ubelaker et al. 1995; Houck et al. 1996; Ubelaker 1999). In a typical house fire, ceiling temperatures increase to 500°C in about 10 minutes, climb to between 700 and 800°C in about 55 minutes, and subsequently diminish (Richards 1977), providing an opportunity for the extensive heat alteration to human victims.

Forensic experience has yielded considerable information on both the effects of heat on the human body and the limitations to analysis. For fleshed remains, extreme heat produces the classic pugilistic pose in which post-mortem muscle contracture causes joint flexure. According to Saukko and Knight (2004), the muscle in such conditions is shortened by “dehydration and protein denaturation,” causing the bulkier flexors to contract more that the extensors. As soft tissue is reduced by heat exposure, bone is increasingly exposed, creating a contrast between heat-related changes in the exposed bone and in the bone still protected by soft tissue.

The analysis of burned bone recovered in a forensic context involves such diverse approaches as simple reconstruction of fragments to form larger segments or complete bones (Grèvin et al. 1998), scanning electron microscopy (Carr et al. 1986; Bush et al. 2006), and elemental analysis (Brooks et al. 2006), including trace element analysis (Herrmann & Grupe 1988). Trace element data may, however, reveal environmental factors, and it may be limited due to "volatilization and crystal modification" (Grupe & Hummel 1991). In spite of the fragmentation that is frequently associated with skeletal exposure to extreme temperatures, evidence of pre-existing trauma can survive (Pope & Smith 2004), especially sharp force trauma (Herrmann & Bennett 1999), including chop marks (De Gruchy & Rogers 2002). Although DNA recovery can be challenging in cases involving burned bone, techniques are available to increase both the purity and yield of DNA in such cases (Ye et al. 2004).

5.B. Perspective from modern cremation practice

The growing popularity of modern cremation as a method of disposal of the dead gives an additional perspective on the effect of high temperature on human remains. As noted by Wells (1960), crematoria use gas jets to reach temperatures of 820 to 980º C, or 1500 to 1600º F (Eckert et al. 1988). These regulated temperatures and burning times can be correlated with changes in bones and teeth. The alterations to bones reveal both the sequence of soft tissue reduction and the body position in relation to the heat source (Wells 1960). Reporting on the practice of cremation in the United Kingdom, McKinley (1989) has observed that modern retorts (firing chambers) reach temperatures as low as 500ºC and as high as 1000º C. McKinley (1994) also reports the weights of remains resulting from the cremations of 15 individuals in the United Kingdom. Male weights ranged from 1735 g to 3001 g with a mean of 2284 g. The female range was 1227 g to 2216 g, with a mean of 1616 g.

Warren and Maples (1997) have presented a study of 100 individuals who had been commercially cremated. In particular, they compare the pre–cremation body weight with the weight of the recovered cremated material. For adults, the weights of the latter ranged from 876 g to 3,784 g, with a mean of 2,430 g. They found that all individual weights above 2750 g originated from males and those below 1887 g originated from females. The resulting cremated matter represented 3.5% of the body weight in adults, 2.5% in children, and about 1% in fetuses.

Murad (1998) summarized unpublished research by Alexander Sonek in 1992 on the weights of the cremated remains of 150 individuals. Although these materials were not separated by sex, the weight of remains from individuals ranged from 892 g to 4,056 g, with a mean of 2,348 g. Murad (1998) also noted that, though the heat source in retorts is shut down at about 1600º F (889º C), temperatures within the retort can climb as high as 2300ºF (1278ºC).

Those analyzing materials from commercial cremations face the challenge of extreme skeletal fragmentation but recognize that non-skeletal inclusions, such as dental restorations and surgical materials, can facilitate identification. One such analysis even reported evidence of arteriosclerosis that had survived in cremated material (Warren et al. 1999). The nature of the equipment used in commercial cremations also contributes to the qualities of the resulting human materials (Warren & Schultz 2002).

DeHaan and Nurbakhsh (2001) make the important point that the body itself can represent a fuel source in the process of incineration. In fact, the body can become a primary heat source if an initial outside heat source is present along with a "wick" and adequate oxygen.

Bass and Jantz (2004) have also addressed the topic of cremation weights. In a regional study of commercial cremations in East Tennessee with retort temperatures documented between 1600ºF and 1800ºF, cremation time varied between two and three hours, and several hours were required for the retort to cool down before removal of the cremations. Male cremations weighed between 1,865 g and 5,379 g, with a mean of 3,380 g. Weights of females ranged from 1,050 g to 4,000 g, with a mean of 2,350 g.

6. Experimentation

Considerable research and experimentation has generated useful data on heat-induced alterations in bone (Thompson 2005). Experiments by Baby (1954), which were later supported by Binford (1963) and Thurman and Willmore (1981), have suggested that remains cremated as dry bones could be distinguished from those cremated with fresh and/or flesh covered bones. According to Baby (1954), the former exhibited superficial surface checking, longitudinal splitting, and lack of warping, while the latter were characterized by warping with transverse fractures.

Van Vark (1970) conducted controlled experiments with an electric oven in which bones were measured and examined after successive increases of 100°C. Van Vark noted that the bones became increasingly brittle but no shrinkage was recorded until about 700°. Between 700 and 800°, the bones became white with extensive shrinkage and loss of histological features. Between 800° and 1500° no additional changes were noted. Van Vark also introduced statistical procedures to evaluate sex and age at death from calcined remains (Van Vark 1970, 1974, 1975). It is important to note that many publications discuss the typical color change with burning from black to gray to white, but substances in the environment can cause variations of this pattern (Dunlop 1978).

Shipman et al. (1984) conducted additional experiments using sheep and goat mandibles in a test kiln to document heat related changes in bone, dentin and enamel. Their study recorded changes in coloration, microscopic morphology, size, and crystal structure. They made the key point that the duration of the heat exposure is important, because the temperature of the heat source is usually distinct from the bone temperature.

Although it has been common knowledge that cremation leads to bone fragmentation, Chandler (1987) noted that tooth size and the ability to recognize individual tooth types are affected by cremation. Christensen (2002) added that osteoporotic bone is more likely to fragment than normal bone.

Experiments with electron miscroscopy reported by Wilson and Massey (1987) have shown that structural changes in tooth dentin begin at about 600°C and at 800°C enamel rod structure becomes altered. Additional experimentation by Spennemann and Colley (1989) noted that the surface texture of bone changes with exposure to temperatures of 500°C and above. They also made the important observations that staining results from materials in the environment, fragmentation is augmented during recovery, and increased heat produces increasing whiteness in bone but coloration exhibits great variation. Holland (1989) added that exposure to low temperature (less than 800°C) produces minimal shrinkage of bone.

David (1990) conducted a series of experiments testing hypotheses on the factors in patterns of burning in bone. A controlled bushfire produced no calcinations but brown to black color changes and some fractures. A campfire using eucalyptus wood reached a temperature of 840°C in one hour and five minutes and produced bone fractures, some gray–black coloration, but mostly bone fragments with a white, calcined appearance. Some bones removed from the campfire after 25 minutes displayed fractures and a color range of brown, black, gray and white/blue. The study documented that the duration of the fire, not just the temperature, was a key factor in bone alteration. Similar experiments by Stiner et al. (1995) emphasized that calcination was linked to exposure to live coals.

Post-mortem taphonomic issues complicate interpretations of fragment size. Certainly conditions of cremation contribute to fragmentation, but taphonomic factors such as mortuary treatment and even techniques of excavation and processing also lead to increased fragmentation (McKinley 1994).

Key experiments by Holden et al. (1995) documented that in cremations, the combustion of the organic component of bone occurred up to 400°C. Beginning at 600°C, bone mineral displayed recrystallisation. Beginning at 1600°C, the bone mineral melted. This research shows how temperature is related to basic morphological transformations of cremated bone.

In a review of the literature, Mayne Correia (1997) relates several important points concerning cremation. Calcination with a white color represents a complete loss of organic material and fusion of bone salts. The extent of shrinkage depends on the type of bone, the temperature and the amount of bone mineral present. Weight (stress) on the bones during cremation can produce plastic deformation at high temperatures. Denser bones and those protected by soft tissue will demonstrate better preservation and less fragmentation. The literature presents conflicting evidence on the ability to distinguish bones burned with or without flesh attached. Mayne Correia noted the similarity of bone to ceramics in the nature of heat reaction: dehydration is followed by pyrolysis of organic material, followed by loss of carbonates and crystal conversion, followed by fusion.

Quatrehomme et al. (1998) failed to find a correlation between temperature and patterns revealed through examination with the scanning electron microscope. Using transmission electron microscopy, Koon et al. (2003) detected changes in collagen fibrils following the roasting of sheep humeri.

Hurlbut (2000) noted that bone exposed to minimal heat is difficult to distinguish from unburned bone. Whyte (2001) emphasized the nature of cracks and fissures, as well as the warping noted by many others, in distinguishing bones burned in the flesh versus those burned as dry bones. Walker and Miller (2005) noted that oxygen availability, duration and temperature of the heat all affect resulting bone color.

Experimentation has also focused on the correlations between heat and the preservation of DNA, dental pulp and albumin. Tsuchimochi et al. (2002) found that DNA amplification and typing of dental pulp was successful up to a temperature of 300°C but not at higher temperatures. Duffy et al. (1991) described a procedure to facilitate sex chromatin counts from tooth pulp cells but noted that the extent and duration of heat as well as the extent of flesh present affect it. Duffy et al. (1991) also noted the difference between fire temperature and temperature of the specimen. Cattaneo et al. (1994) added that human albumin survives cremation up to temperatures of 300°C but no higher. Bone integrity and exposure to water affect protein survival in such cases (Cattaneo et al. 1995). Although Sanjantila et al. (1991) reported successful DNA typing on all 26 samples from 10 fire victims exhibiting extensive charring, Cattaneo et al. (1999) reported that no mitochondrial DNA samples could be amplified in bone experiments with temperatures reaching 800 to 1200°C. In attempting to determine human versus non-human status in fragments of burned bone using standard microscopy, quantitative microscopy, albumin analysis, and DNA analysis, quantitative microscopy emerged as the method of choice.

In a discussion of human cremation in an outside wood fire, McKinley (1989) noted that up to seven or eight hours would be required for calcination, and fuel would need to be added during the process. The center of the fire would be much hotter than the periphery. McKinley (1989) also argued that, in ancient times, bodies were most likely placed on top of the pyre to promote oxygen access, and stirring would be necessary during the process.

7. Interpretation of the cremated remains from Kenchreai

This forensic and experimental research on cremation can shed light on the interpretation of the cremated remains from the Roman-era cemetery on Koutsongila at Kenchreai, especially in regard to the number of individuals represented, the duration and temperature of the original cremation event, and the specific character of the mortuary procedure.

7.A. Weights

A relatively large quantity of cremated remains (2,949 g) was recovered from several depositional contexts representing the contents of separate niches in Tomb 13. The remains were highly fragmentary, and therefore morphological analysis could detect the presence of only one adult older than 13 years of age. According to the estimate by Warren and Maples (1997) that the cremated remains of one adult weigh on average 2,430 g, the total weight of cremated bone from Tomb 13 could represent just over one individual. However, it is known on archaeological grounds that these combined bone fragments originated in several niches containing the burials of multiple individuals. Therefore, it is reasonable to conclude that only a fraction of all cremated remains was recovered from the burial site for deposition in the tomb.

Tomb 14 presents a similar scenario for interpretation. The total sample of cremated remains from this tomb weighs 2,471 g, which falls within the estimated range of weights for the cremated remains from one adult (Warren & Maples 1997; Bass & Jantz 2004). But analysis of this sample detected the presence of at least two subadults and one adult-size individual. Moreover, as in Tomb 13, the cremated remains recovered from Tomb 14 represent multiple individuals buried in separate niches. To be sure, the weights of subadult cremated remains are less than those of adults. Nonetheless, the analysis of combined data and consideration of the archaeological context together demonstrate that the cremated remains from Tomb 14 comprise but a fraction of the total amount that originally existed at the primary cremation site(s).

In contrast to Tombs 13 and 14, Tomb 22 contained very few bone fragments with signs of burning (121 g). According to the standard estimate of the weight of cremated remains from one adult, this quantity would constitute less than 5% of one skeleton. However, examination of the sample of burned bone from Tomb 22 has shown that elements from at least two subadults and at least one adult were buried here. The gradual filling of the chamber with sediment has undoubtedly crushed numerous small fragments. But this process cannot account for such a significant disparity between the preserved weight of the cremated bone sample in Tomb 22 and the expected total weight of cremated bone from at least, and probably many more than, three subadult and adult bodies. The explanation must be mortuary procedure. As in the case of Tombs 13 and 14, it appears that mourners at Roman Kenchreai collected only a small percentage of all cremated remains from the pyre at the primary event of cremation. Note that Liston (2007) reached similar conclusions of minimal representation in her study of secondary cremation burials dating to the Early Iron Age at Kavousi Vronda, Crete. In other cases, however, such as the "rich Athenian lady" buried during the Early Iron Age in the area of the Athenian Agora, mourners recovered a large percentage of the skeleton from the pyre (Liston & Papadopoulos 2004).

7.B. Condition of individuals at the time of cremation

A majority of the cremated fragments recovered from the tombs on Koutsongila exhibit the patterns of calcination, fragmentation, fractures, fissures, transverse fracturing and warping (**Figures 4–6**) consistent with having been burned as fresh bone with the flesh still attached, as opposed to having been burned dry, without flesh. Of course, not all burned fragments show such diagnostic qualities; some displayed an intact form but distinct discoloration. The experimental studies cited above indicate clearly that such variation is normal, even in cremations that reached relatively high temperatures. Research reported by Baby (1954), Binford (1963), Thurman and Willmore (1981), and Ubelaker (1999), among others, together indicate that the overall pattern displayed by most burned fragments in the three tombs at Kenchreai is consistent with the burning of fleshed remains.

7.C. Burning temperatures and duration

The overwhelming evidence of calcined bones within the tombs shows that, during the initial event of cremation, pyre temperatures reached at least 700°C at the level of the body. The research discussed above collectively suggests that mourners employed a pyre constructed of available wood, perhaps with kindling. The body was likely placed on top of the pyre, but certainly it would have shifted toward the base of the pyre as the fire progressed. Alternative approaches may have involved placement of the individual on a burial bed surrounded by wood fuel or use of a properly oxygenated trench structure. To achieve the extent of calcination observed in the fragments from the tombs, the individuals associated with the event of cremation probably added fuel during the burning process and may have promoted body reduction by manual prodding with long sticks or similar instruments. The greatest heat changes likely occurred when the burning had advanced so far that the human remains were in contact with the hot coals at the base of the exhausted pyre.

Some bone fragments recovered from the tombs, such as a radius recovered from Tomb 13 (**Figure 6**), display not only calcination and other evidence of exposure to high temperatures for a long period but also extreme morphological disfigurement. This condition appears consistent with the "melting" effect described in the literature (e.g. Holden et al. 1995), in which temperatures reaching 1600°C transform bone salts. Such conditions attest to the care and attention given to the cremation event, the extent and quality of the fuel, as well as the long duration, which must have lasted several hours or even days.

8. Summary

Careful excavation and analysis of three tombs in the cemetery on the Koutsongila Ridge at Kenchreai in Greece have provided important evidence for the role of cremation in the mortuary practices in the community during the early to middle Roman periods, or the middle to late first to middle or late third century AD. Local residents chose to dispose of their dead using both inhumation and cremation. Methods and conclusions gleaned from the rapidly growing body of published studies in forensics and experimental research, coupled with archeological interpretation, have contributed to the understanding of cremation at Roman Kenchreai.

This study suggests that cremation pyres were constructed from a substantial amount of wood and were closely attended during the procedure of cremation. This likely involved the addition of fuel to prolong the fire and the rearrangement of the human remains during the process which resulted in extreme reduction. The extreme heat-related alterations evident in certain bone fragments point to long contact with very hot coals. In addition, it appears that only a relatively small percentage of the cremated remains were recovered and transferred to the niches in the tombs. It is uncertain why mourners did not recover more remains from the site of cremation. Perhaps they thought that only a selection of bone fragments was sufficient to represent the deceased at the burial site. Moreover, the recovery of minute pieces from a large heap of carbonized wood must have been a difficult task.

Despite a complex history of use in ancient times and extensive disturbance since antiquity, the cemetery on Koutsongila is furnishing much information about the people buried there and the community they represent. The evidence for cremation at Kenchreai attests to a common mortuary procedure during the Early Roman period in Greece, one in which great care was devoted to the dead. As the exploration of this rich site expands in coming years, it is hoped that new evidence will illuminate this important chapter in the history of Greek burial and society.

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