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Case report

Prasat and *Pteah*: Habitation within Angkor Wat's temple enclosure

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ABSTRACT

The Angkor empire (9-15th centuries CE) was one of mainland Southeast Asia's major civilizations, with a 3000 km^2 agro-urban capital located in northwest Cambodia. Since 2010, the Greater Angkor Project has been investigating occupation areas within Angkor's urban core. This work has identified temple enclosures as important residential areas that made up part of Angkor's civic-ceremonial center. In this paper, we review excavations from residential areas within Angkor Wat's temple enclosure. We concentrate on evidence for residential patterning by focusing on our 2015 excavations, one of the largest horizontal excavations of a single occupation mound within Angkor's civic-ceremonial center. These data offer further evidence for archaeological patterns of residential occupation within the Angkor Wat temple enclosure and a comparative dataset for future research of habitation areas within Angkor as well as domestic spaces in other urban settings.

1. Introduction

The Angkorian or Khmer civilization (9-15th centuries CE) dominated mainland Southeast Asia during the early to mid-second millennium CE. Its sprawling capital city of Angkor, located on the eastern edge of Cambodia's Tonle Sap floodplain (Fig. 1), was the world's largest pre-industrial settlement (Evans et al., 2007). Recent work suggests that over the course of five centuries, the 30 km^2 civic-ceremonial center, home to a majority of Angkor's famous stone temples (called *prasat* in Khmer), grew from a population of 77,000 to 160,000 citizens. At its 12th–13th century CE height, the entire 3000 km^2 Greater Angkor region (Fig. 2) may have housed between 700,000–900,000 inhabitants (Klassen et al., 2021).

Despite its size and large population, few projects have investigated residential aspects of Angkorian urbanism until recently (Bâty et al., 2014; Carter et al., 2018; Stark et al., 2015). Work by the Greater Angkor Project (henceforth GAP) since 2010 investigated habitation areas within Angkor's civic-ceremonial center, focusing especially but not exclusively, on temple enclosure spaces to elucidate the nature and timing of Angkorian-period habitation (Carter et al., 2018; Carter et al., 2019; Castillo et al., 2020; Heng et al., 2022; Stark et al., 2015). This paper concentrates on archaeological evidence for habitation within Angkor Wat's temple enclosure and focuses on our 2015 excavation when we undertook the broadest horizontal excavations of a single mound in the temple complex (Figs. 2 and 3). The 2015 investigations, couched within our longer-term research in the complex, offers insights on domestic activities and nature of occupation on mounds within the Angkor Wat temple enclosure.

2. Background and methods

2.1. Prasat and Pteah

The temple of Angkor Wat is perhaps the most iconic Angkorian temple, and an important symbol of Khmer identity. Appearing on the flag of Cambodia, Angkor Wat (or *Viṣṇuloka*) was constructed in the early-mid 12th century CE and attributed to King Suryavarman II (Coedès, 1920). Although built to honor the god Vishnu, Khmers transformed it into a Buddhist temple in the late 16th century, and it has remained an important focus of Buddhist worship and pilgrimage since

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Fig. 1. Map of Cambodia showing the location of Angkor. Inset map: regional map of Asia showing the location of Cambodia. Figure by Alison Carter. Inset map adapted from Wikipedia public domain map by ASDFGHJ.

then (Thompson, 2004). A large walled enclosure surrounds the temple and measures c. 1000x815 m; a 200 m wide moat surrounds the complex (Evans and Fletcher, 2015; Fletcher et al., 2015). Archaeologists began mapping mounds and depressions (which we interpret as ponds, Fig. 3) in the temple complex during 2010, but the 2012 lidar survey dramatically clarified the orthogonal organization within the walled temple complex (Evans and Fletcher, 2015; Evans et al., 2013). Notably, this grid system extended outside the moat to an external eastern enclosure that followed the same orientation and grid system of mounds and depressions (Evans and Fletcher, 2015; Stark et al., 2015).

Angkorian houses (called *pteah* in Khmer), like many houses in Cambodia and Southeast Asia today, were constructed largely from organic materials with the main living space elevated above the ground on piles or posts (Fig. 4) (Népote, 2002; Tainturier et al., 2006; Waterson, 1997; Zhou, 2007). This makes part of the living space archaeologically invisible and challenges archaeologists who study residential spaces working in Southeast Asia (see review in Carter, 2022) and elsewhere across the tropical world. The poor preservation conditions of organic remains are also a factor when studying residential spaces and associated activity areas in the tropics, as are issues with human, plant, animal, and insect bioturbation (Bâty et al., 2014; Castillo et al., 2020; Graham, 1996). Precisely defining an Angkorian household and its inhabitants (Wilk and Rathje, 1982), is thus beyond the scope of our study, although we suggest some possibilities in the conclusion. Nevertheless archaeological, ethnographic, historic, and art historic documents provide several criteria for recognizing domestic contexts in the archaeological record, which are discussed in Supplementary Material 1.

2.2. 2010–2015 Greater Angkor Project fieldwork at Angkor Wat

Initial fieldwork within the Angkor Wat enclosure began in 2010, with subsequent field seasons in 2013 and 2015 (Stark et al., 2015). Our 2010 and 2013 field seasons focused on the enclosure's less-impacted eastern portion, using systematic transect coring and seventeen 1x2 m test excavation trenches on thirteen different mounds. This strategy aimed to determine whether all mounds were used as occupation areas, if assemblage variation existed across different the mounds, and followed APSARA Authority excavation restrictions that precluded large areal exposures at this UNESCO World Heritage site. Matrix homogeneity dictated the use of arbitrary 5 and 10 cm levels or "spits" rather

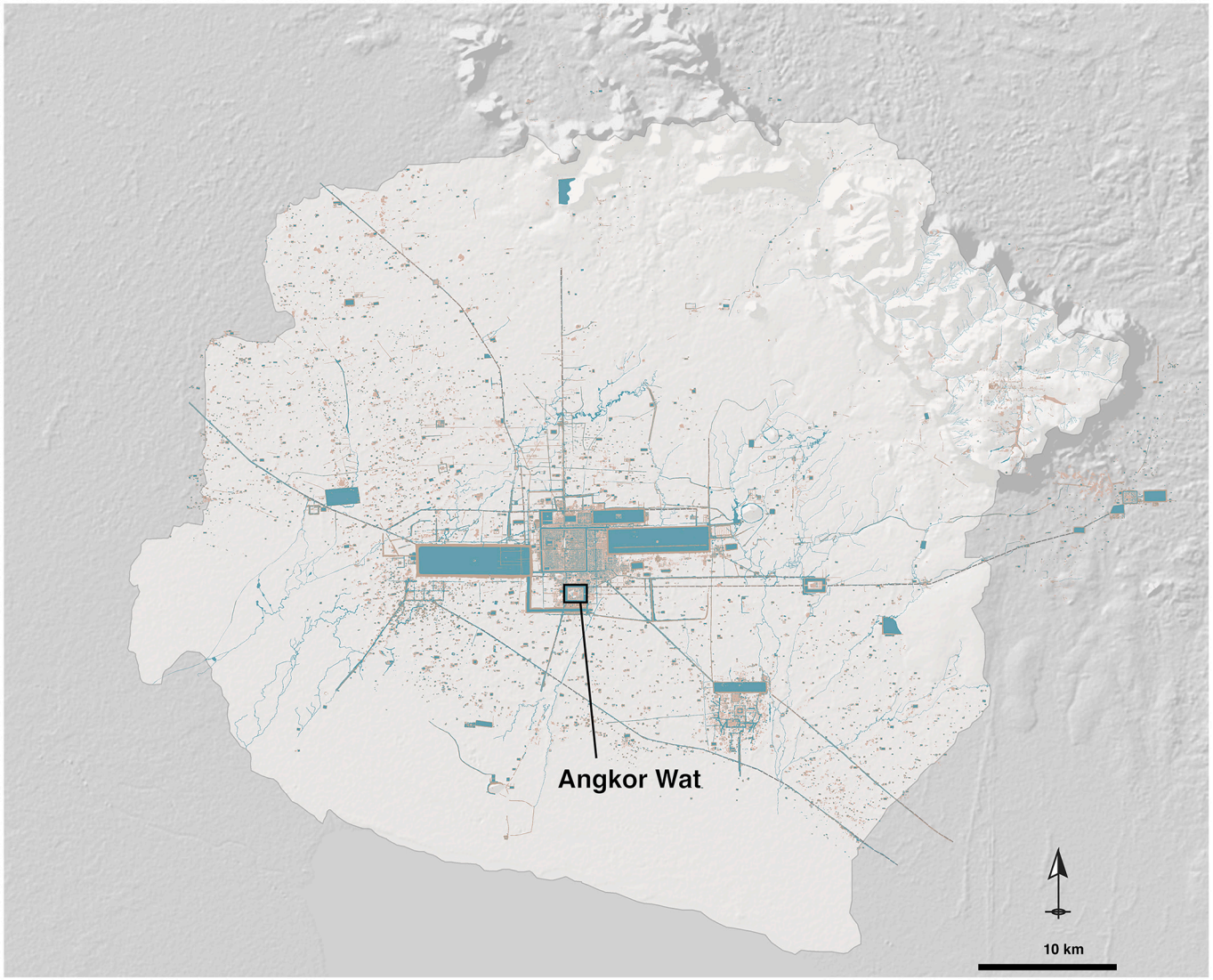

Fig. 2. Archaeological map of 3000 km^2 Greater Angkor Region noting the location of Angkor Wat. Map by C. Pottier, D. Evans, J-B. Chevance, S. Klassen, and P. Wijker.

than excavation by natural layer; all materials were screened through 1 cm mesh. Flotation and macrobotanical samples were collected from each trench, and specific contexts were targeted for phytolith analysis (Castillo et al., 2020). Artifact density was generally low, but some trenches yielded features that were possibly associated with residential occupation like possible postholes, ceramic clusters, visible macrobotanical remains, and flat-lying stones, which we interpreted as possible occupation surfaces.

The 2015 fieldwork involved horizontal excavation to understand residential patterning on a single mound whose previous testing produced ample possible habitation evidence and an 11th to 13th century radiometric date (see the SI Appendix in Carter et al., 2019): Mound 1 in Grid S1E2 (Fig. 3). This earlier excavation identified a ceramics concentration with multiple nearly complete vessels, including an earthenware water jar and carbonized materials whose haphazard position suggests a dump (US19007, Fig. 5). Working within APSARA Authority excavation restrictions, we began by placing a series of 1x2 m trenches across the mound and expanded with additional trenches to follow features. A total of 22 trenches were opened, with a location in the eastern portion of the mound containing numerous features (Figs. 3 and 6).

2.3. Timing of habitation in the Angkor Wat enclosure

Our 2010 and 2013 field seasons identified four layers associated with different phases of activity within the enclosure, which we summarize here (for detailed discussions, see Carter et al., 2019; Stark et al., 2015). Layer 4 is our bottom sterile layer, encountered in the 2010 and 2013 excavations (Stark et al., 2015). We associate Layer 3 with the reorganization of the landscape around the site of the future Angkor Wat temple into an orthogonal grid of mounds, depressions (that were likely ponds or seasonal water storage), and linear features (that were likely roads or paths). The depressions/ponds were formed by digging into the alluvial sediments of the wider landscape and soil was likely piled to raise the mound surface. Geoarchaeological analysis identified an abundance of micro-charcoal, suggesting that there was also widespread land clearance (Carter et al., 2019, SI Appendix). There was not widespread evidence for intensive previous habitation in this landscape, although a GPR survey in front of the Angkor Wat temple has identified evidence for earlier architecture in this location (Sonnemann et al., 2015).

Following the implementation of a grid system, we observe evidence for habitation on top of the mounds, which we associate with Layer 2 and date primarily to the 12th century CE (Carter et al., 2019).

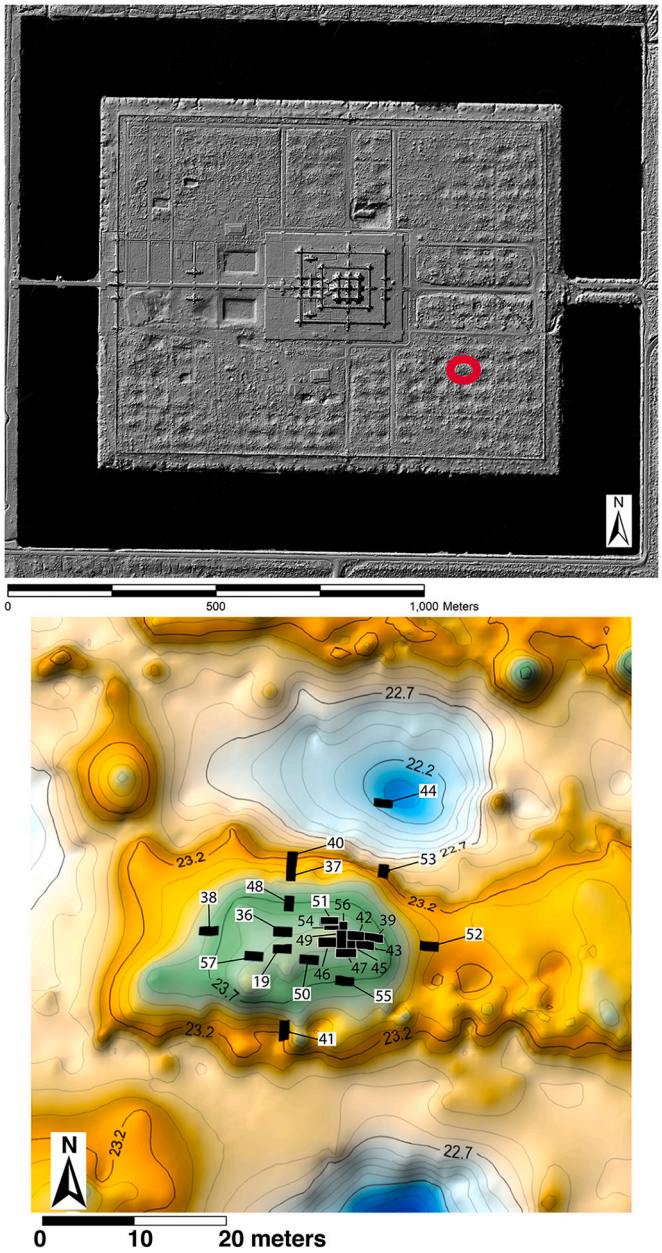

Fig. 3. Top: Lidar image of Angkor Wat showing the mound-depression grid system within the enclosure and the location of Mound 1 in Grid S2E2. Bottom: Topographic map of mound S1E2M1 within the Angkor Wat enclosure showing locations of trenches excavated during the 2015 GAP field season. Trench 19 was excavated in 2013. The depression (in blue) to the north of the mound is a pond. Digital terrain and elevation data provided courtesy of Digital terrain image courtesy of the Khmer Archaeology Lidar Consortium (KALC). Figure by Alison Carter and Piphal Heng. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Micromorphological and sedimentological study has found that Layer 2 contained abundant clay textural (e.g., dusty clay coatings) and redoximorphic (e.g., iron nodules) features in a poorly to moderately sorted groundmass with fine-to-coarse sand. These features indicate disturbed surfaces due to regular maintenance and continuous habitation of the mound. The surface remained mostly dry, punctuated by periodic short wet events. In the late 12th to early 13th century CE there is a gap in our radiocarbon dates and seemingly a small abandonment or transformation in the use of the mounds at Angkor Wat until the late 14th or early 15th centuries CE, when the mounds appear to be reoccupied (Layer 1), albeit in a less intensive fashion (Carter et al., 2019). Layer 1 was largely a loamy topsoil with post-Angkorian cultural material. Our discussions below focus largely on Layers 2 and 3, although not all trenches were excavated to Layer 3.

3. Results from the 2015 excavations

3.1. Postholes and features representing possible occupation surfaces

The 2015 excavations were not large enough to uncover the entire outline of a dwelling, but several possible postholes were identified, with most in a cluster of trenches on the mound's eastern portion (Fig. 6; see Appendix 2). Cambodian house posts today frequently sit on a stone base (Fig. 4), however ethnographic reports suggest this practice was not widespread until the late 19th century CE, and earlier houses buried their piles in the ground for stability (Tainturier, 2006, pp. 16, 28). Postholes were approx. 15-25 cm in diameter; similar column diameters are reported ethnographically [15-20 cm (Delvert, 1961, p. 192); 20-30 cm (Hok, 2006, p. 44)] and from the excavation of an Angkorian rural

Fig. 4. Ethnographic photo of a Khmer house on piles/posts. Photo by Judy Ledgerwood reprinted with permission from the Southeast Asian Digital Library, Northern Illinois University.

habitation site, Trapeang Ropou [18-28 cm (Bâty et al., 2014, p. 351)]. Posthole features frequently consisted of a similar soil type to surrounding soils, generally a sandy clay loam, but were identified due to their differing coloration and/or were sometimes more compact (Fig. 7). It was often difficult to identify postholes, so in many cases we suspect the tops of these features were missed initially during excavation. Not all postholes were excavated completely, but those that were had varying depths, from 3 to 4 cm to perhaps up to 45 cm (Supplementary Material 2). Posthole bases were equally difficult to determine, and many seemed to disappear into the surrounding soil. For comparison, posthole features excavated at Trapeang Ropou were reported to be 10–20 cm deep, with one group approximately measuring 50 cm deep (Bâty et al., 2014, p. 351). As posthole features were often ephemeral, phytolith samples were taken from several of these features to determine if features were in fact postholes and if trees or palms were used; these samples await processing and analysis.

Features and ceramics (discussed below) were generally concentrated on the eastern portion of the mound. Although one might expect a house to be placed in the center of the mound, a study of house construction practices amongst contemporary communities in the Angkor area observed that construction of a house in the center of a property was bad luck (Luco, 2006, p. 98). This view is reinforced by geoarchaeological analyses taken from Trench 36, closer to the center of the mound, which suggests it was not under a house or part of a house structure and therefore exposed to rainfall (Carter et al., 2019: 12230).

Flat-lying sandstone fragments found approx. 40-75 cm below the ground surface are the most notable artifacts recovered from multiple trenches in the eastern portion of the mound (Figs. 6 and 8). (A small number of postholes, sandstone pieces and ceramics were also found in Trenches 37 and 40 on the northern slope of the mound approx. 75 cm below surface, suggesting this area is worthy of future investigation). Large sandstone pieces were also found in other mounds during our 2013 excavations, including in the external eastern enclosure, outside the moat of Angkor Wat (Fig. 9). These pieces were likely castoffs from the adjacent temple construction (several had decorations). They frequently occurred on a single plane (rather than stacked or lying atop one another) at the same depth as flat-lying ceramics and two possible hearth or cooking areas (discussed below), suggesting occupational surfaces. A complete vessel, believed to be a possible ritual deposit (discussed below), was also found below the flat lying stone features in Trench 56 (Fig. 11). The recovery of flat stones at different depths may reflect either multiple occupation surfaces or mound-raising activities. For example, sandstone, brick, and fired clay pieces were found at approx. 40-58 cm below surface in Trenches 49 and 54, but in Trench 51, directly north of Trench 54, sandstone pieces were largely found at approx. 70–82 cm below surface. Some stone fragments may not have been in situ, such as an especially large stone in Trenches 39 and 43, which was nearly vertical as well as pieces in Trench 56. Numerous termite holes were encountered during the excavation of Trench 43, and it is possible this piece and others may have been affected by bioturbation.

Small quantities of small sandstone pieces or chips were occasionally found in other trenches during our 2015 excavations, but not in large quantities or thick layers. However, sandstone chip layers were observed in trenches closer to the temple in 2010 that varied in thickness from 0.8 to 1.3 m (Greater Angkor Project, 2010), and similar sandstone chip layers were found in GAP mound excavations at Ta Prohm in 2014 (Carter et al., 2018). These sandstone chips were likely produced

Fig. 5. Ceramics concentration found in Trench 19 (feature US 19007) on Mound 1 in Grid S1E2 during the 2013 field season. Photo by Alison Carter.

through temple wall carving and finishing and also likely related to mound construction activities.

Two possible hearth or cooking areas were identified. The first, in Trench 49, initially presented as a darker soil area above a feature (c. 55 cm below surface - US 49014/49015) with fired clay, brick, and sandstone. Part of the feature appears to have been destroyed or disturbed through the installment of a post. Macrobotanical samples that were collected from the layer above this feature (US 49012) as well as a charcoal-rich feature found at the southern end of the trench approximately 15 cm below this feature (US 49021 and 49023) produced rice, cotton seed fragments, fruit, and nut fragments (Castillo et al., 2020).

A second potential hearth was identified in Trench 43 (US 43014–43016) (Fig. 10). Soil discoloration at c. 63 cm below surface contained charcoal flecking and ceramic sherds. Continued excavation revealed a circular feature of sandstone and brick at approx. 73 cm below surface, similar to hearths described by Zhou Daguan in 13th century Angkor (2007, see discussion in Supplementary Material 1). Phytoliths from this feature includes cucurbits, banana, and palm (Castillo et al., 2020). Macrobotanical analysis from context US 43016 was not productive. Fragments of ceramic stoves had also been identified in other mound contexts during the 2013 excavations, indicating that both portable ceramic stoves and ground-based hearths were in use in the Angkor Wat enclosure.

Two large roughly circular features of indeterminate function were identified at different locations within our excavations. The first was approx. 70 cm in diameter in Trench 46 (US 46015–46016, 46018–46025), first identified approx. 90 cm below surface and approximately 50 cm in depth. The sediment was a sandy clay, flecked with manganese. Macrobotanical samples from in the upper layers of this feature included rice and weedy plant remains. A second feature (51023, 51028–51029) was found in Trench 51 amongst flat-lying sandstone pieces and approximately 40 cm deep. This feature was lighter than the surrounding sediments and more amorphous in shape, measuring approx. 60 cm NS and 45 cm EW (Fig. 10). This was the only context in which rice phytoliths were identified amongst those analyzed (Castillo et al., 2020).

3.2. Ceramics

Ceramics were recovered from every context, but the highest quantities occurred in the primary Angkorian occupation layer (Layer 2) in trenches in the eastern portion of the mound.

Table 1 summarizes the counts and weights of major ceramic types from Layers 2 and 3. Several unique pieces point toward specific household activities beyond food preparation (see Supplementary Material 3 for ceramic counts/weights by trench and layer and total ceramic density by unit). The tail of a brown glazed zoomorphic elephant vessel, believed to have held lime paste for betel chewing, was identified in Trench 39 (Fig. 11) (Rooney, 2000). A broken Chinese tradeware ceramic in the form of a rooster or chicken (Fig. 11) was found in Trench 51 (US 51005–6). The small hole on the side of the rooster's mouth suggests this may have been a water dropper commonly used as part of a Chinese scholar's writing kit (Stroeber, 2016). It is unclear if this object served a similar function within this household; no other components of a writing kit such as a grinding stone or ink have been found.

A nearly complete vessel was found during excavation of Trench 56 from 74 to 87 cm below surface (US 56023). The vessel was placed below a layer of flat-lying sandstone pieces and had evidence for a potter's mark on its exterior (Fig. 11). While the ceramics concentration

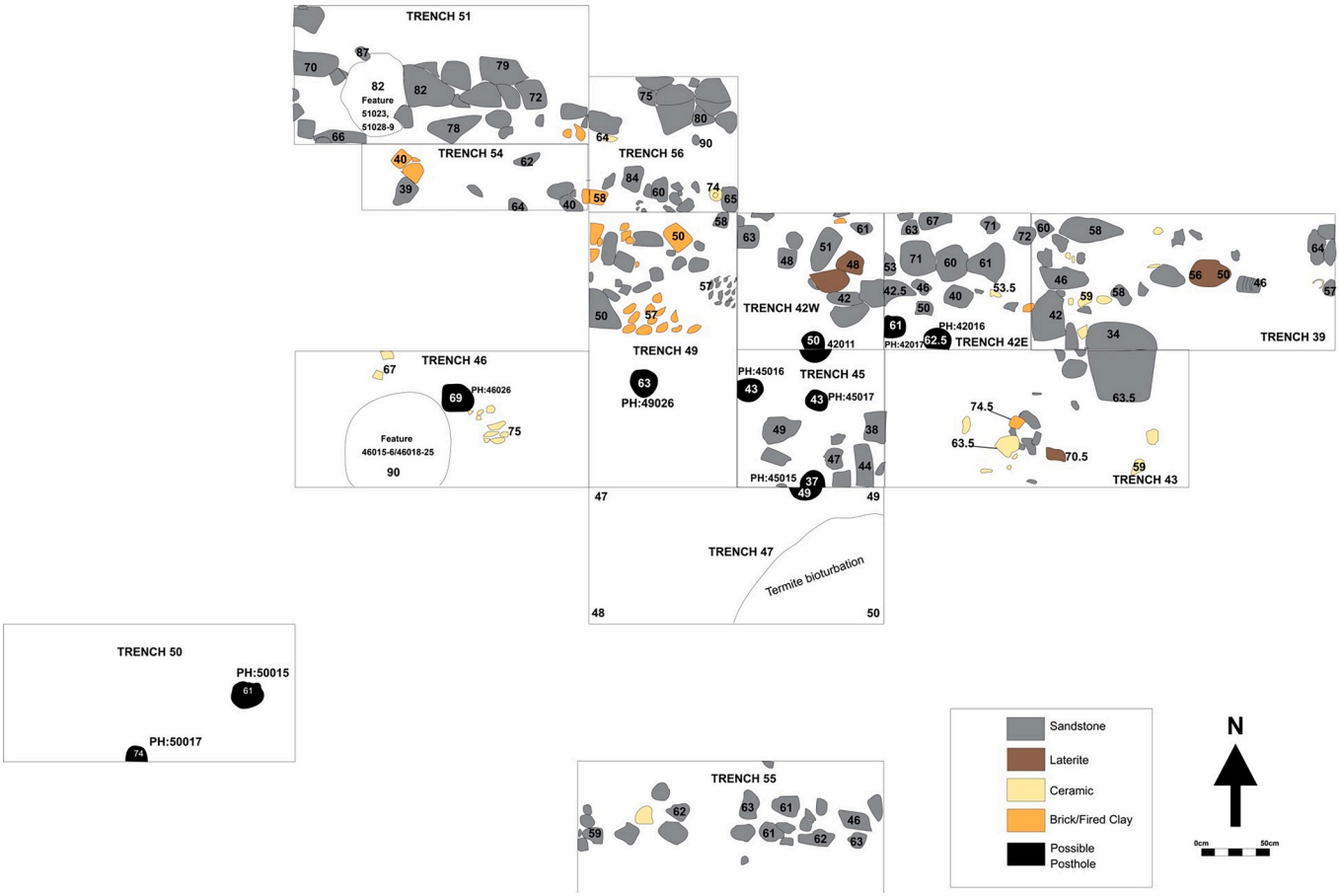

Fig. 6. Plan drawing of trenches in the eastern portion of the mound showing flat lying stones and selected possible postholes and features (listed by feature number). Numbers on sandstone, brick, and ceramic pieces represent cm below the surface. Figure by Alison Carter.

Fig. 7. Example of a cross-section of a posthole feature with surrounding soil removed from Trench 45.

identified in 2013 in Trench 19 appears to have been a dump, this vessel was placed upright and without associated carbonized material. Ritual deposits are a common component of Angkorian temple construction and activities in sacred spaces (Dumarçay and Royere, 2001, pp. 34–35; Groslier, 1981, p.14). Possible ceramic foundation deposits have also been found from habitation areas at prehistoric sites in northeast Thailand (see Carter, 2022: 21–22). Could the placement of this vessel beneath the possible sandstone living floor be associated with a kind of ritual or foundation deposit? Further excavations are required to determine if this was a more widespread practice in domestic contexts at

Fig. 8. Overhead view of trenches on eastern portion of mound with numerous features. Photo by Phirom Vitou.

Fig. 9. Flat lying stones identified in 2013 excavations. Top: Stones in Trench 13 on Mound S2E2M4 within the Angkor Wat enclosure. Bottom: Stones from Trench 31 in the external eastern enclosure (outside the Angkor Wat moat).

Angkor.

A small number of ceramic roof tile pieces (5 pieces of unglazed stoneware roof tile fragments and 18 fragments of earthenware roof tiles) were identified during the 2015 season. This is perhaps too few to be expected if there was a large roof made of ceramic tiles in this location. However, a structure with ceramic roof tiles may have been located nearby, leading to the deposit of these broken pieces into our assemblage.

4. Discussion and conclusions

Data from our 2010–2015 fieldwork on occupation mounds within the Angkor Wat enclosure provide a preliminary model for Angkorian temple enclosure habitation, but also highlight limitations including difficulties in demarcating an entire dwelling structure. Confirming some postholes was challenging within the soil contexts of the enclosure, and even extensive open-area excavations at Trapeang Ropou could not identify posthole features that demarcated complete dwelling structures and buildings (Bâty et al., 2014). Nevertheless, we argue that the presence of postholes in association with flat-lying features such as ceramics, hearths, and large sandstone pieces are indicative of habitation on the mound surface.

Given the concentration of features and ceramics in the eastern part of the mound and comparative lack of features and reduced density of ceramics in other locations on the mound, we offer a preliminary interpretation that the approx. 600m^2 mound contained one household, which ethnographic data suggests included approximately 5 residents (see rationale in Carter et al., 2021, p. 7; Klassen et al., 2021, p. 6). Multiple structures may have been built on each mound, following ethnographic precedent, and could include a dwelling, separate kitchen structure, and additional storage buildings like a rice granary (e.g., Delvert, 1961; Ebihara, 2018). Some mounds may also have had more than one dwelling structure. If so, ethnographic evidence suggests it would most likely be married offspring living near their parents, which could still be considered part of a household unit (Delvert, 1961, p. 204; Ebihara, 2018, pp. 50–68). Such assumptions require further testing and fieldwork but form our working assumptions for modeling demographic trends within Greater Angkor (Carter et al., 2021; Klassen et al., 2021).

Clear midden features were notably missing from our excavations within Angkor Wat, as well as occupation areas in Ta Prohm (Carter et al., 2018) and Trapeang Ropou (Bâty et al., 2014). Why middens have been so elusive in temple enclosures remains unclear, but perhaps reflects their ritual contexts. No trenches were cut outside the walls (ostensibly beyond the sacred space) where household trash might have been disposed. Such locations would be ideal for future field investigations. These missing middens make determining who lived on Angkor Wat's mounds equally enigmatic. Inscriptional data suggests the range of inhabitants would have included attached specialists including religious practitioners, temple dancers, musicians, and other laborers who could have lived on the mounds nearby (e.g., Lustig and Lustig, 2013; Sedov, 1978). Given current evidence, we believe the residents of this mound were not members of the elite class, based on the lack of rooftiles associated with houses of the elites, as well as the small proportion of Chinese tradeware ceramics (2% of the total assemblage by weight and 6% by count in Layers 2 and 3 (Table 1), versus nearly 11% of the assemblage within excavations at the Royal Palace (Cremin, 2006).

Current evidence, including radiocarbon dates and micromorphology, suggest mounds were inhabited continuously during the 12th century CE. As noted earlier, there does appear to be a shift in the use of the mounds beginning in the late 12th or early 13th centuries (Carter

Fig. 10. Possible hearth or cooking features from Trench 43 (left). Pit feature from Trench 51 (right).

Table 1
Counts and weights of the major ceramic types from Layers 2 and 3 in the 2015 excavations at Angkor Wat.

	Unglazed	Brown Glaze	Green Glaze	Earthenware	Earthenware (less than 2 cm^2)	Chinese Tradeware	Total
Angkor Wat Layers 2 and 3 weight (g)	3475 (21.7%)	915 (5.7%)	1019 (6.4%)	8135 (50.8%)	2099 (13.1%)	385 (2.4%)	16,024
Angkor Wat Layers 2 and 3 count	278 (8.5%)	102 (3.1%)	213 (6.5%)	1036 (31.7%)	1453 (44.5%)	185 (5.7%)	3267

et al., 2019). These changes may have been part of the broader socio-political transformations taking place at Angkor as it was beginning its slow depopulation starting in the late 13th to 14th centuries CE (e.g., Buckley et al., 2010; Hall et al., 2021; Penny et al., 2019).

Our excavations, specifically botanical evidence reviewed in an earlier publication (Castillo et al., 2020) also provide some detail about the types of domestic activities taking place on this mound. The presence of rice spikelet bases and husk fragments denote that rice was being processed on site. Weeds associated with rice agriculture were examined, but were inconclusive, as they can represent both wet and dryland cultivation. The diversity of these weedy plants could indicate that rice was being brought in from different environments in the surrounding region (Castillo et al., 2020; Hawken and Castillo, 2022). Although rice was likely sourced from nearby areas, palaeobotanical evidence suggests many other economic plants were grown in a domestic horticultural setting, including bananas, palm trees, black and long pepper and crepe ginger (Castillo et al., 2020). A significant number of charred cotton seed fragments were identified (Castillo et al., 2020: 8, 12) and likely related to textile production. Zhou (2007), p. 76) observed cotton weaving as a craft activity at Angkor in the late 13th century. Cotton could have been grown in gardens for trade, or some basic processing of cotton may have taken place on the mounds as part of the domestic economy (see further discussions in Castillo et al., 2020 and Castillo, 2022).

Our preliminary efforts to identify habitation evidence in Greater Angkor underscores the need for future archaeological field investigations to complement the extant focus on both temple architecture and remotely-sensed datasets. Additional work is necessary to make meaningful interpretations about urban settlement in this premodern capital (Drennan et al., 2010). Do dwelling spaces on additional mounds within the Angkor Wat enclosure show similar patterns? What about those in the external eastern enclosure, mounds surrounding other temples, or habitations in non-temple enclosure spaces in Angkor's civic-ceremonial center? Preliminary work at a more rural Angkorian settlement indicates that these spaces were larger to accommodate the agrarian focus of the domestic economy (Bâty et al., 2014). What variation is seen in house lot size and activities within different locations? While these questions remain to be answered, we believe the data presented here provide a foundation on which to build the burgeoning field of Angkorian household archaeology as well as a comparative example for others undertaking the archaeology of domestic spaces in other urban settings.

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Fig. 11. Top left: Chinese water dropper in the shape of a chicken. Top right: Angkorian brown glaze zoomorphic vessel. Bottom Left: Complete vessel showing potter's mark on surface. Photo by Vitou Phirom and Moul Komnet. Bottom Right: Vessel in situ in upper right corner of Trench 56. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Author's contribution

AKC and MTS conceptualized and planned the research. AKC, MTS, CCC, PH, YZ, and RC carried out data collection and research. AKC prepared the initial draft. MTS CCC, PH, YZ, and RC reviewed and edited the draft.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Disclosure statement

The authors declare no financial or non-financial competing or conflicting interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ara.2022.100405.

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Further-reading

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