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Form, structure and long-term Angkorian urbanism: A view from the Kok Phnov site (9th–10th century CE)

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ABSTRACT

The capital of Angkor remained the powerbase of the Khmer polity for more than 600 years, indicating its resilience. Recent work at Angkor investigates the evolution of this massive agro-urban center, but most of that research has focused on large-scale landscape developments rather than occupational sequences at urban localities. Our paper blends remotely-sensed ground survey, excavation, art historic, and epigraphic data in the Pre Rup area (and specifically around the Kok Phnov settlement) to provide a fine-grained perspective on the development of Angkor's urban configuration through time. We write against the assumption that successive state temples defined neighborhoods and temple communities across Angkor urban space and illustrate their interconnectivity as "districts" that sustained the urban core. Districts, as administrative units, included civic-ceremonial, craft production, and residential neighborhoods. Drawing on field-based investigations of mound clusters at Kok Phnov we offer evidence for continuous habitation and craft production from the 9th–16th centuries. We use this patterning in the larger Eastern District to argue that Angkorian urbanism developed unevenly through time and space, and that bottom-up social forces – as well as state design and topography – crafted its form. Such neighborhoods and districts were foundational elements to Angkorian urbanism, and studying their occupational sequences sheds light on Angkor's dynamic and resilient 600-year urban history.

1. Introduction

During its 12th to 13th century peak, Angkor was perhaps the pre-industrial world's largest urban center. The 3000 km^2 metropolitan area that we call Greater Angkor has inspired archaeological research since the end of the 19th century CE. Successive Angkorian rulers reorganized and expanded this urban core by adding extensive water management and ritual networks. Incremental archaeological research begun in the 1960s has now produced a time series of maps that outlines Angkor's urban development (e.g., Evans et al., 2013; Evans and Fletcher, 2015; Fletcher et al., 2008; Groslier, 1979; Pottier, 1999). This work has demonstrated that Greater Angkor was a sprawling agro-urban settlement complex (Fig. 1), built on lower-density rural habitation areas and higher-density temple-based urban settlements linked by a series of interlocking infrastructures like roads and canals (Fletcher, 2011). That the city of Angkor was long-lived and remained the Khmer polity's epicenter for more than 600 years indicates its resilience: perhaps in part because of its agro-urban structure (e.g., Barthel and Isendahl, 2013; Isendahl and Smith, 2013). At Angkor, this is reflected in several different forms of residential patterning: a tightly clustered civic-ceremonial core whose urban anatomy and population density varied through time (see Carter et al., 2021; Klassen et al., 2021), and largely dispersed habitation beyond this core, containing house gardens and infield agricultural systems (Fletcher, 2009, 2011; see also Evans et al., 2007; Hawken, 2013; Pottier, 2000b). Recent research suggests, however, that even higher-density state temple enclosures in the city's core contained occupation areas with likely household gardens (Castillo et al., 2020).

Our paper builds on recent high-resolution excavation data on domestic activities (Bâty et al., 2014; Carter et al., 2018; Stark et al., 2015) to identify another important urban residential zone common across the ancient world: the district. Our earlier work that described temple enclosure spaces (Carter et al., 2018, 2019; Stark et al., 2015) offers insights on one possible form of Angkorian neighborhood, or smaller zones of "intensive face-to-face" social interaction (Smith, 2010, 137). The districts that we explore in this paper are also residential areas, but

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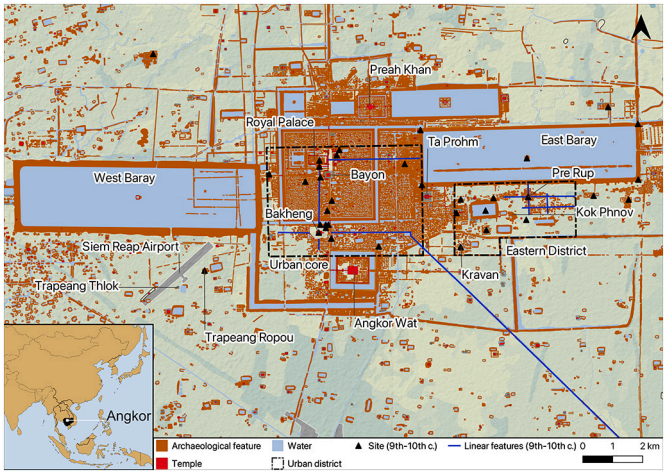

Fig. 1. Angkor urban center (9th–15th centuries) and possible extent of its two 9th–10th century districts (the urban core and Eastern District) based on dated inscriptions, temples, and spatial concentration of large reservoirs. Dataset: a) archaeological feature data courtesy of Christophe Pottier and Damian Evans; b) Japanese International Cooperation Agency's (JICA) land use map; and c) Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) version 2 is a product of Ministry of Economy, Trade, and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA).

are larger and consist of "some kind of administrative or social identity within a city" (Smith, 2010, 140). We focus specifically on an urban sector we call the Eastern District, a roughly 10 km^2 area located within Angkor's civic-ceremonial core (Fig. 1).

The Kok Phnov area was an important production area within Angkor and offers some of the first excavated evidence for ceramic production within the Angkorian capital. Our 2012 field investigations produced an occupational history that began in the 9th–10th centuries CE and continues through the 16th century. Initially constructed as an extension of the civic-ceremonial area to its west, Kok Phnov was only marginally included in the 12th century orthogonal grid that covered most of Angkor's effective urban core. Yet residential and industrial activities at Kok Phnov intensified during the 11th–12th centuries, and habitation continued after the decline of the Angkorian state in the 15th century. Incorporating LIDAR, epigraphic, and art historical data, we demonstrate the dynamic and resilient history of this residential zone.

Research at Kok Phnov illustrates the kind of neighborhood that comprised Angkor's fundamental social unit, and our local focus expands discussions of Southeast Asian urbanism that have, until recently, focused primarily on macroscale settlement patterning, water management and cosmology (see review in Stark, 2015). Our research acknowledges recent scholarship on neighborhoods as key organizational units in the social construction of ancient cities (Pacifico and Truex, 2019; Smith and Novic, 2012; Smith et al., 2014). We offer insights on long-term social processes that produced neighborhoods in ancient cities and provide an effective locus to explore "practices, sentiments, and places" (Pacifico and Truex, 2019, 6) that shaped Angkorian urbanism.

2. Angkorian contexts: Urban plan through time

2.1. Angkorian urban form

Greater Angkor covers at least 3000 km^2 with an urban core that contains 30 km^2 of civic-ceremonial construction, and that is surrounded by interlocking rural settlements, roads, mounds, canals, ponds, and temples (Evans et al., 2007; Fletcher et al., 2003). Previous research has teased out Angkorian urban forms, agricultural and ritual functions, and symbolism (Gaucher, 2002, 2004, 2017; Goloubew, 1935, 1941; Groslier, 1979; Pottier, 2000b; for South Asian parallels, see Coningham et al., 2007; Smith, 2006). Recent LiDAR surveys have enabled a fine-grained analysis of Angkorian urbanism based on the coordinated arrangement of its urban structures like city blocks, roads, temples, walled enclosures, mounds, and ponds (Evans et al., 2013; Evans, 2016). This work facilitated the creation of a diachronic demographic model of Angkor's growth and development over time (Carter et al., 2021; Klassen et al., 2021). Here, however, we take a closer look at Angkorian urbanism in the 30-km^2 civic-ceremonial center, dividing developments in this area into two broad phases: 1) axial settlements and ritual complexes (c. 9th–11th centuries) that we call the Formative Phase; and 2) the Expansion Phase (c. 12th–15th centuries), which introduced an orthogonal grid and large enclosed/walled settlements. The Eastern District was established during the Formative Phase, but as will be discussed further below, was not transformed during the Expansion Phase.

In Phase I (Formative Phase), Angkor's urban form, like its 9th-century predecessors of *Mahendraparvata* (Phnom Kulen) and *Hariharālaya,* was axial and loosely structured: settlements were organized along the cardinal causeways of central state temples and their reservoirs (e.g., Chevance et al., 2019, 1315; Evans et al., 2013, 3; Groslier, 1979, 174–75; Heng and Lavy, 2018; Pottier and Bolle, 2009). Moats demarcated some temple spaces, but few temple and residential spaces were enclosed by walls, and habitation mounds and ponds that surrounded temples lacked a clear grid system of city blocks. During Phase II (Expansion Phase in the 12th century), urban development reflected greater top-down central planning. In contrast to the loosely structured axial pattern, residential spaces were formalized in an orthogonal grid system, with large temple enclosures transforming and expanding Greater Angkor. Axial urbanism that consisted of habitation, temple mounds and their ponds characterized Khmer urbanism since the 6th–8th centuries CE pre-Angkorian period (Heng and Lavy, 2018); however, a formalized system that packs this mound-pond settlement template inside an orthogonal urban grid only occurred after the 12th century (Carter et al., 2018; Evans and Fletcher, 2015; Stark, 2006, 106, Fig. 7; Stark et al., 2015, 1443, Fig. 3).

2.2. Urban district: Settlement in Angkor's eastern district

Early scholars considered Angkor's urban space to be made up of a series of successive capitals, each of which hosted a state temple built in almost every new reign (Jacques and Lafond, 2007; Stern, 1951). Recent research has instead revealed Angkor's urban structure as a series of interconnected "temple cities" or perhaps more accurately neighborhoods or urban sectors that expanded the urban core (Fletcher et al., 2015). Here, we argue that some of these urban sectors were "districts," each of which contained smaller residential, temple, and craft neighborhoods. The clearest example of this residential zone is a cluster of sites established during Phase I around the Pre Rup temple, which we call Angkor's Eastern District.

The city of Angkor was first established by the ruler *Yaśovarman I* (r. 889–910 CE) who demarcated the urban space of *Yaśodharapura* (Angkor) across a c. 20 square km area encompassing the ceremonial center of the Bakheng temple, the Royal Palace, and the East Baray (*Yaśodharatatāka*) (Jacques, 1978; Stern, 1951). After a 16-year break, during which the political center moved c. 90 km east to Koh Ker, *Rājendravarman* (r. 944–968 CE) returned to *Yaśodharapura* and continued to shape Angkor's urban configuration, expanding eastward. (Fig. 2:1). As a result, Phase I's urban core comprised of two urban clusters or "zones of condensation" (Pottier 1999, 196–199, 2000a, 103–104; see also Marchal, 1934) of temples, large and small ponds (c. 0.5–4 ha and 10–32 ha), and causeways. Both clusters are separated by an approximately 1 km gap that lacks large ponds, which implies an uninhabited space (Fig. 2:2). Figs. 1 and 2 depict the two urban clusters that included temples, mounds, and large ponds, with inscriptions that anchor the date of the Angkor urban space to the late 9th-mid-10th

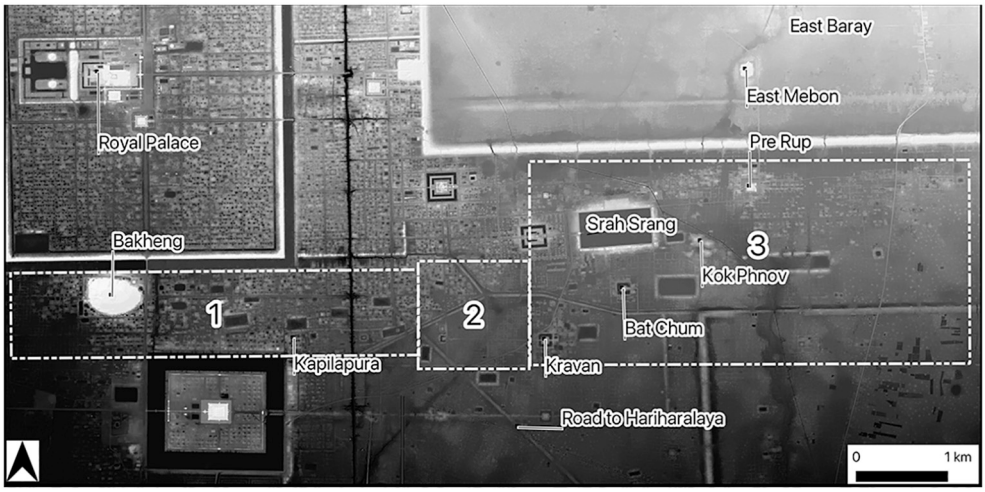

Fig. 2. Approximate remaining locality of the 9th–10th century urban occupation and large reservoirs oriented east-west: 1) Western cluster of the Bakheng-temple-centered civic-ceremonial core, 2) A c. 1 km gap of large reservoirs, and 3) the Eastern cluster of Pre Rup's civic-ceremonial area that we call the Eastern District. (LiDAR data courtesy of the Khmer Archaeology LiDAR Consortium, KALC).

century (Coedès 1951a, 3:199–204, 1952, 4:88–101; Finot, 1925, 1932; Jacques, 2006). The first cluster corresponds to *Yaśovarman I*'s urban core centered on the Bakheng temple and the Royal Palace. The second cluster is associated with *Rājendravarman* and located south of the East Baray surrounding the 10th-century state temple of Pre Rup. Previous scholars designated this area, which included *Rājendravarman's* (r. 944–968 CE) temples (Pre Rup and Mebon) and the temples of high-ranking officials (Kravan, Bat Chum, and Leak Neang) surrounded by habitation mounds and rice fields, as the "*ville de l'est*" (Jacques, 1978, 294–495; Stern, 1951, 653) or an "urban center" (Pottier, 1999, 196–99).

An inscription from the Bat Chum temple implied that there was the construction of a palace in this new urban area and contributed to the view that Angkor's urban space was a series of relocated capitals, in this case from Phnom Bakheng to Pre Rup (e.g., Coedès, 1908b, 217; Jacques, 1978, 297–300; Pottier, 1999, 193–96). Yet, whether this palace was the "restored" ancient palace or built in a new location was never specified. This inscription stated that *Rājendravarman* "restored" the royal city of *Yaśodharapura*, which was left emptied for a long time, by building houses (*gṛha*) decorated with gold (*survarṇagṛha*) and "palaces" (*vimāna*) enriched with precious stones (*ratnavimāna*) (Coedès, 1908b, 239, stanza A13) and that the prime minister, *Kavīndrārimathana*, was the architect of a "palace" (*mandira*) in *Yaśodharapura* (Coedès, 1908b, 251, stanza C34). Since dated inscriptions and temples suggest that both the Bakheng and the Pre Rup urban areas were simultaneously occupied and were parts of the single urban space of *Yaśodharapura*, we propose that during Phase I Angkor's civic-ceremonial core was not two successive capitals, but two districts that we label the "Eastern District" and "Western District".

The Western District was always central to Angkor's capital city, especially the Bakheng-Royal Palace civic-ceremonial center. Most of the original habitation was covered over by later Expansion Phase (Phase II) developments. The Eastern District housed a series of neighborhoods clustered around the state temple of Pre Rup. Fig. 3 shows mounds concentrated around Pre Rup's cardinal causeways, and mound settlements attached to both state and private temple neighborhoods (like Bat Chum, Kravan, and Ong Mong), which hosted religious personnel, elite households, teachers, students, pilgrims and travelers, rice farmers, dancers, musicians, cooks, weavers, warders, etc. (for details on the populations often associated with Khmer temple, see Jacques, 1986; Jacob, 1993; Lustig and Lustig, 2019; Sahai, 1970, 2012; Sedov, 1978; Vickery, 1998). Also part of this district was a "kiln zone" located on a mound complex called Kok Phnov, which produced ceramics and perhaps also architectural ceramics and bricks for nearby

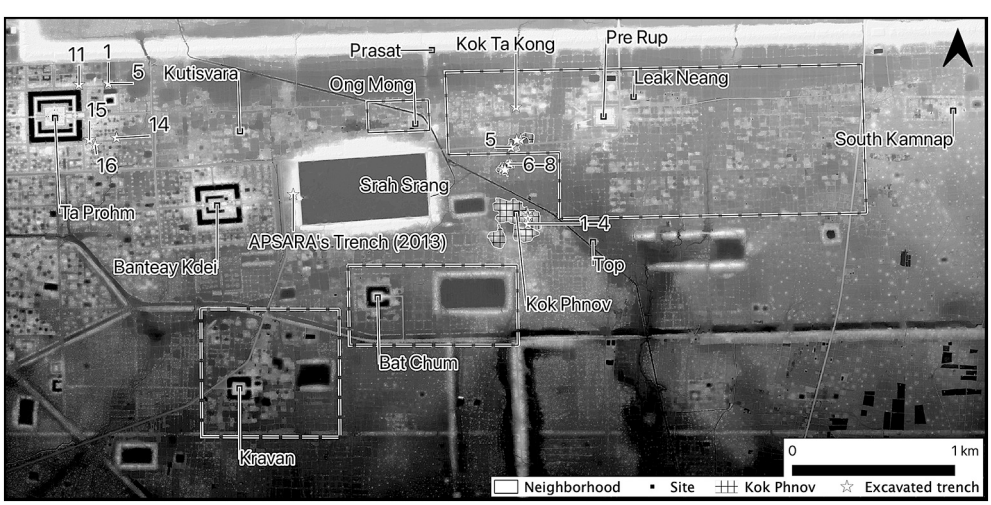

Fig. 3. Eastern District's urban residence of the Pre Rup neighborhood surrounded by smaller temple neighborhoods (Kravan, Bat Chum, Kuṭiśvara, and Ong Mong) and Kok Phnov's craft neighborhood with locations (numbered stars) of excavated trenches used in this paper. (LiDAR data courtesy of KALC).

temples (Desbat, 2009; Pottier, 1999, 192–93). Craft production zones are routinely associated with premodern cities elsewhere (Cowgill, 2004, 538–39), and previous research has documented ateliers for stone lintel carving, sculptural production and bronze casting within the Royal Palace (Polkinghorne, 2007; Polkinghorne et al., 2014; Polkinghorne et al., 2015; Vincent, 2014). Little previous work at Angkor has documented urban ceramic production (but see recent work at Thvea Dei Chhnang located on the embankment of Angkor Thom's northern moat in APSARA, n.d.).

Greater Angkor's 12th–15th century urban reorganization during Phase II replaced and expanded much of the original habitation in the Western District with a formalized orthogonal grid. For example, the construction of the modular temple neighborhoods of Ta Prohm, Banteay Kdei, and Srah Srang overlaid the previously occupied spaces (Fig. 3). However, this reorganization expanded into only part of the Eastern District. Much of its Phase I (9th–11th centuries) axial settlements persisted, including two mound clusters that are conventionally called Kok Phnov (also spelled as Kok Phnauv/Phnœu, "Mound of *Aegle marmelos*") and known previously as Kôk Phnéao/Phneao (Mound of *Baccaurea ramiflora*) or Kok Khneau or Kôk Trapeang Thmâ Andèt (Desbat et al., 2008, 2; Desbat, 2009; Pottier, 1999, 192, note 610; Pottier et al., 2001; Trouvé, 1933).

Kok Phnov lies c. 400 m to the east of the Srah Srang reservoir, and c. 500 m south of Pre Rup; the site covers a c. 20 ha area (max. 700 m north-south and c. 350 m east-west). The northernmost of these two mound clusters includes three separate and irregularly shaped mounds called Kôk Trapéang Snôr and Trapéang Snô (Kok Phnov Mound VI) (Pottier, 1999, 84, 192). The southern cluster, Kok Phnov, separated from the north by rice fields and a canal constructed in 1978, is a fusion of four mounds larger than those of the northern cluster (Fig. 4). The following section describes our project's field investigations at this site. Understanding the life history of this craft neighborhood located between the residential areas surrounding the state temple of Pre Rup and the elite temple of Bat Chum allows us to reconstruct the nature and development of Angkor's Eastern District.

2.3. Archaeological field investigations at Kok Phnov

No formal excavations occurred at Kok Phnov prior to our 2012 field seasons, although earlier testing at the northern section of Kok Phnov's Mound VI (then grouped with another mound to its north called Kok Ta Kong) suggested that Kok Phnov was part of a residential area associated with Pre Rup neighborhood settlements (Johnson et al., 2012). Previous surface collections and ceramic geochemistry at Kok Phnov (Desbat et al., 2008; Desbat, 2009, 2011; Pottier, 1999, 192–93) established the site as a discrete locality within *Rājendravaman*'s Eastern District. The Greater Angkor Project (GAP) and Cambodia's APSARA Authority conducted joint field investigations at Kok Phnov during two 2012 field seasons: February–March and June–July. Fieldwork involved site mapping, systematic surface collections, subsurface excavations, and coring to study the nature and function of this mound complex.

2.3.1. Survey and ceramic surface collection

A total station survey generated a topographic map and a coordinate N0E0 grid system with 20-m square units serving as the basis for systematic surface collection (Fig. 4). A representative 1 m-radius collection area was carried out in each 20 m^2 unit with a target minimum of one sherd per square meter. If less than 20 sherds were found, a general ceramic collection was made in the whole grid; this method was used in the northern mound cluster where there were fewer surface ceramics. With the exception of tradeware, only sherds larger than 2 cm^2 were collected and processed (i.e., washed, sorted, counted, weighed, and photographed). Two decades of intensive plowing, by draft animals and recently by small machinery at least twice annually, ensures uniformity in horizontal–not lateral–surface artifact distribution within the 30 cm plough zone (for discussions on artifact distribution in the plough zone,

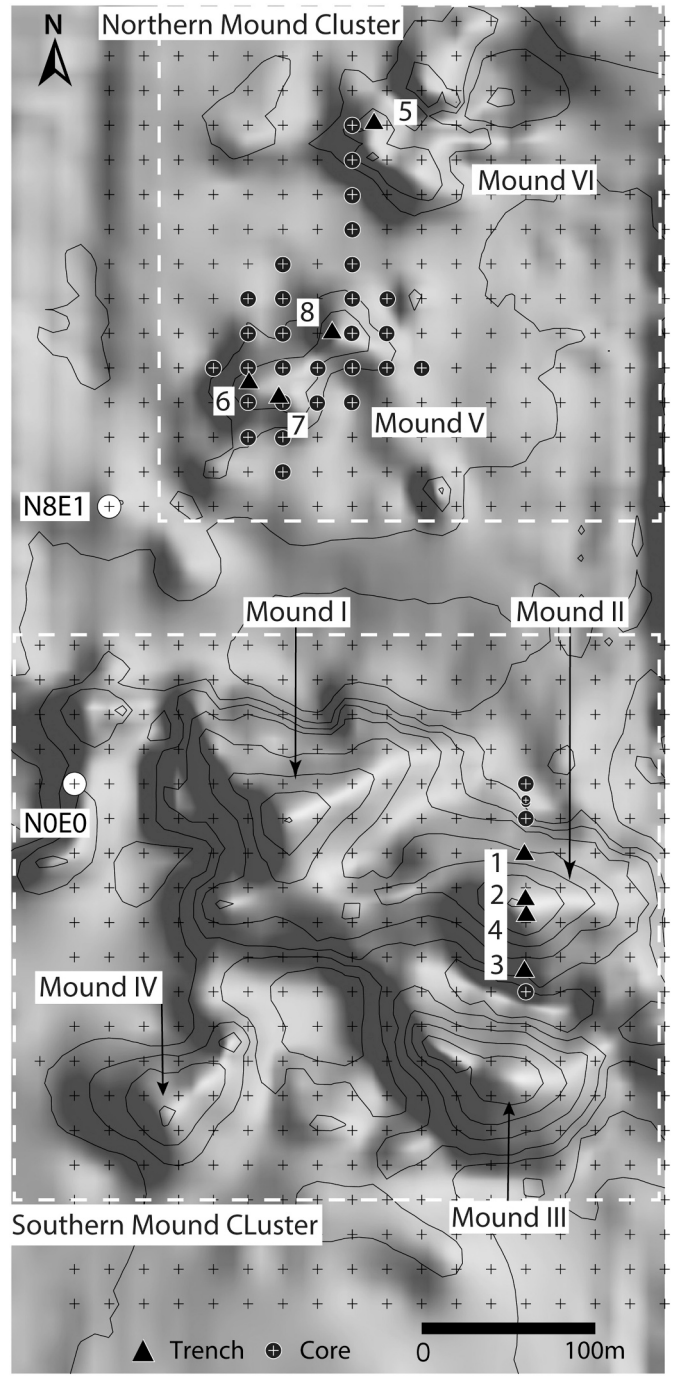

Fig. 4. Total station-based topographic map (50 cm contour intervals) of the Kok Phnov mound complex overlaid with a 20m^2-N0E0 grid system for surface collection, trench locations (numbered), and core locations. N0E0 was placed on an embankment of a water reservoir located directly west of the southern mound cluster (see Fig. 3).

see: Barnes, 1986; Mudar, 1993; Welch and McNeill, 1991; Stark, 2006). A preliminary chronology of the surface ceramics is thus applicable to at least the site's upper 30 cm strata.

Utilitarian earthenware ceramics and Khmer stonewares recovered from our surface collections and excavations conformed to earlier surface collections (Desbat, 2009) and collectively date between the 10th and the 13th centuries (Chhay et al., 2012; Chhay et al., 2013; Desbat, 2011; Marriner et al., 2018). Tradeware from China, Thailand, and Vietnam date slightly later between the 12th and 16th century CE (e.g, Brown, 2008; Brown, 2004; Cheng et al., 2005; Desbat, 2009; Dupoizat,

1999, 2018; Shimizu, 2000). These ceramics, most of which are concentrated in the site's southern mound clusters (Table 1), suggest that the plough zone of Kok Phnov dated between the 10th and 16th centuries CE, spanning from the Angkorian to post-Angkorian periods.

Spatial ceramic concentrations suggest that residential and industrial activities occurred primarily on the mound surfaces, not in the surrounding modern rice fields, as does the absence of subsurface ceramics from 15 core samples placed across these low-lying areas (Fig. 4). Different surface ceramic densities between the mound clusters (Fig. 5) suggest spatial and/or temporal variability in site functions beyond habitation, which characterized most of the site. Ceramic production activity, reflected in concentrations of fired clay/brick (kiln) fragments and Khmer Glazed-Earthenware, clustered on Mounds I and II. The sparse occurrence of these fragments in the northern mound cluster (Mound V and VI) suggests that ceramic production may have been less intense in these areas and may indicate habitation zones.

2.3.2. Subsurface artifacts

Five 1 × 2 m, one 2 × 2 m, and two 1 × 1 m test excavations accompanied by 33 cores were conducted to collect subsurface artifacts, stratigraphic and chronometric data, and to study the site's post-depositional formation processes. These trenches were placed at three different mounds (Mounds II, V, and VI) with intact preservation that could yield a deep chronology and maximize our spatial coverage. Evidence of ceramic production was encountered in Trenches 2, 4 and 5, including fired clay fragments and a series of baked floors associated with kiln structures or ceramic firing areas (Fig. 6 B & C). However, due to limited time and resources, investigating the kiln structure was not the objective of our excavations and the excavation of Trench 2 was terminated at 70 cm below surface (cmbs, hereafter). Similar constraints also limited our coring program to focus mainly on understanding the stratigraphies of Mound II and Mound V and their surroundings (Fig. 4). The combined excavation and coring results allowed us to reconstruct different phases of mound formation (see Section 2.3.3 below).

The excavations yielded 490 kg of artifacts (excluding the brick rubble) and 26,484 earthenware, stoneware, and tradeware sherds (Table 2; Fig. 7). Similar to the surface collection results, the excavated contexts yielded Angkorian stonewares and tradewares from the habitation contexts, primarily in the southern mound cluster. Unglazed stoneware outnumbered other categories because they were primarily storage vessels used in the kitchen (Groslier, 1981, 11–14). The fired clay fragments found in Trench 1 likely belonged to a discard zone where fragments of kiln features and wasters were concentrated (Fig. 8; Fig. 7A). The high density of earthenware, some of which bore burned-marks from cooking (Fig. 7H), and Khmer Glazed-Earthenware produced at Kok Phnov (Fig. 7: A, F, G) suggest both residential and industrial activities.

Table 1
Surface ceramics distributions from Kok Phnov in Northern and Southern Mound Clusters.

Mound cluster	North	South	Total			
Category	%	%	Count	%	North %	South %
Khmer Unglazed-stoneware	22	3	249	6	4	2
Khmer Brown-Glazed	5	3	139	3	1	3
Khmer Green-Glazed	1	1	41	1	0	1
Thai Ceramics	3	0	27	1	1	0
Chinese Ceramics	0	1	40	1	0	1
Vietnamese Ceramics	0	0	2	0	0	0
Khmer Glazed Earthenware	49	62	2398	60	8	52
Earthenware	17	22	848	21	3	18
High-fired ware	1	2	67	2	0	2
Brick or baked clay	1	5	183	5	0	4
Total	100	100	3994	100	17	83

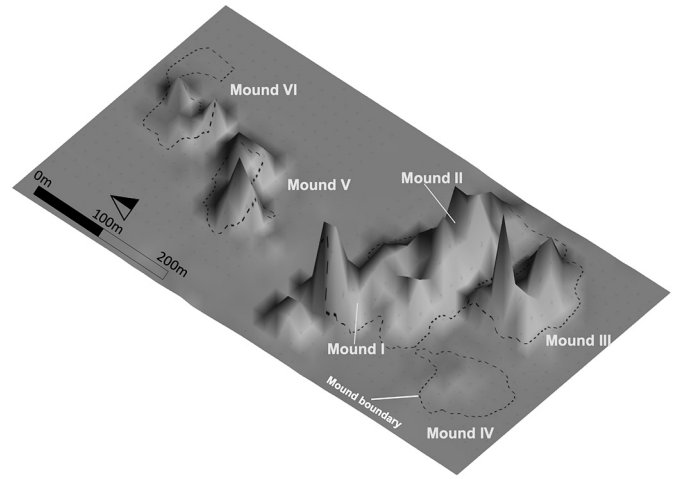

Fig. 5. Surface ceramic density, per square meter, is predominantly confined to mound boundaries.

2.3.3. Kok Phnov site formation and chronology

Our field investigations suggest Kok Phnov was a multi-component and multi-functional residential and industrial complex. Stratigraphic analyses indicate that this mound complex was built successively atop a natural sandy clay stratum (between 150 and 230 cmbs). The earliest occupation began with a series of sandy clay layers (in the northern mound cluster) or fine sandy loam layers (in the southern mound cluster) where artifacts first appeared. The soil matrix becomes increasingly sandy – as the artifact density also increased – toward the site's uppermost layer, which is a sandy/sandy loam plough zone matrix. These stratigraphies, aided by a series of coring surveys, allow us to broadly categorize three phases of occupation at Kok Phnov: Phase I (9th–10th centuries CE), Phase II (11th–14th centuries CE), and Phase III (15th–16th centuries CE) (Fig. 9).

Multiple lines of evidence suggest that Kok Phnov had both residential and industrial functions throughout its Phase I–Phase II occupations (Table 3). The percentage of artifacts from residential and industrial activities increased through each phase. Phase I Kok Phnov hosted both habitation and ceramic production: we recovered cooking vessel fragments, glazed earthenware wasters and vitrified clay rubble in two trenches that suggest Phase I ceramic production. Phase II Kok Phnov remained a multifunctional site, with increased frequencies of ceramics and fired clay (kiln) fragments concentrating mainly in the southern mound complex (see also Desbat, 2009, 44). Phase III occupation, associated with stratigraphies of the plough zone, included tradeware that suggests continued habitation into the 16th century, a century after Angkor's political collapse in the 15th century.

Kok Phnov was a multifunctional settlement where people lived and at least some people manufactured ceramics from the 9th through 13th centuries (Phases I-II). The presence of earthenware and glazed-earthenware as well as kiln structures, vitrified clay features, and fired clay rubble (Trench 4's Layer IV and Trench 5's Layer IV and V), indicates that the ceramic production began in Phase I. Most activities, however, were concentrated in the Southern Mound cluster. Little evidence for industrial activities from Mounds V and VI implies that the Northern Mound Cluster was primarily residential. Residential activities persisted in Phase III, well after Angkor's political collapse; however, whether on-site earthenware production persisted is unknown.

3. Dynamism of Angkorian urbanism and a life history of Angkor's eastern district

To understand the dynamic structure of Angkorian urbanism (Fig. 3), we blend results from our Kok Phnov work with earlier research at the temple enclosure sites of Ta Prohm (2012, 2014), and Angkor Wat

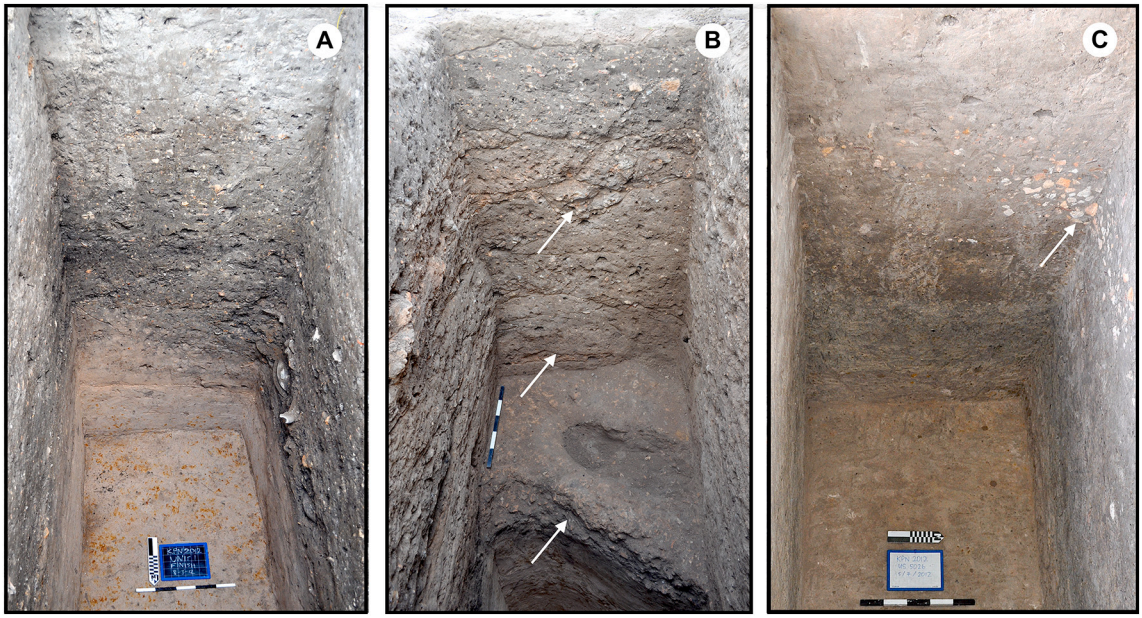

Fig. 6. Wall profiles. A) Trench 1's south profile, B) Trench 4's north profile with multiple kiln floors (arrows), C) Trench 5's west profile with rubble of kiln structure (arrow).

Table 2
Percentage of excavated ceramics from each trench (T) and total count separated into north and south mound clusters.

Mound cluster	North				Total		South				Total	
Trench/Category	T5%	T6%	T7%	T8%	Count	%	T1%	T2%	T3%	T4%	Count	%
Khmer Unglazed-Stoneware	4	4	6	5	177	4	1	1	3	0	269	1
Khmer Brown-Glazed	1	2	0	2	52	1	1	1	1	1	170	1
Khmer Green-Glazed	2	3	7	4	111	3	1	0	1	1	137	1
Thai ceramics	0	0	0	0	0	0	0	0	0	0	0	0
Chinese ceramics	0	1	2	1	21	0	0	0	0	0	50	0
Vietnamese ceramics	0	0	0	0	0	0	0	0	0	0	1	0
Khmer Glazed Earthenware	35	51	9	39	1624	37	32	75	38	53	11,268	51
Earthenware	55	32	68	47	2183	50	64	22	56	43	9992	45
High Fired Ware	3	7	9	3	170	4	1	0	1	3	259	1
Total	100	100	100	100	4338	100	100	100	100	100	22,146	100

(2013), as well as data from other temples and features in the Eastern District (i.e., Ong Mong temple, Srah Srang reservoir, and Banteay Kdei temple) to reconstruct their origin, structure, and relationships through time. Our research identified two sectors of Angkorian urbanism: the broader administrative district and multiple neighborhoods that comprised it. Following Smith (2010), neighborhoods differ from districts spatially (neighborhoods are geographically smaller than districts), socially (neighborhoods are primarily residential and involve regular interpersonal interaction amongst residents), and politically (some districts have an administrative or religious function within a city). Given its size (approx. 10 km2) and the multiple zones within this area, we argue that the Eastern District is better defined as a district than a neighborhood. Bringing together these data, we are able to discuss changes in the Eastern District's settlement patterns over the Formative and Expansion Phases (or Phase I and Phase II). Our analysis suggests that Angkorian urbanism developed unevenly through time and space, and was shaped by bottom-up social forces as much as topography and top-down urban planning (see a landscape-level analysis in Klassen and Evans, 2020).

3.1. *Phase I: Formative phase of an affluent eastern district (c. 9th–11th centuries CE)*

The Eastern District was a core element of Greater Angkor's Formative phase. LiDAR-based spatial analysis assisted by excavations and ground surveys at Kok Phnov and selected neighboring sites indicate that the 9th–11th century Eastern District comprised at least three types of neighborhoods: temple, civic-ceremonial, and craft specialist, which we detail below. The epigraphic data portray the Eastern District as an affluent urban space hosting communities of the Pre Rup's civic-ceremonial center, which could include administrative and religious function for the royal court, and private temple neighborhoods founded by high-ranking elites. Table 4 lists known inscriptions from the Eastern District dated between the 9th and 13th centuries; ten of these were commissioned by high-ranking officials in the 10th century. The settlements of this area began as a series of discrete temple neighborhoods of the royal shrines attached to the East Baray, all of which were constructed in 889 CE. Upon returning the capital to Angkor, the 10th century ruler *Rājendravarman* and his officials populated the Eastern District with multiple construction projects including the state temples of East Mebon and Pre Rup, commemorated in 953 CE and 962/3 CE respectively. The neighborhoods of these state and elite-sponsored temples formed the structural components of the Eastern District that evolved in form and function throughout its life history.

3.1.1. *Temple neighborhoods*

The 9th–10th century temple communities were planned "modular" neighborhoods (sensu Chicoine and Whitten, 2019) that varied in size,

Fig. 7. Residential and industrial ceramics from Trench 1's Phase II. A) Wasters of High-fired ware products; B) & C) Decorated earthenware sherds and rim sherds; D) Unidentified Small earthenware object (plumbob?); E) Unidentified object; F) A cooking stove foot fragment; G) A complete small Glazed-Earthenware pot, possibly manufactured at Kok Phnov kiln; H) A large rim-mouth sherd from a cooking pot with burned-mark from Trench 1.

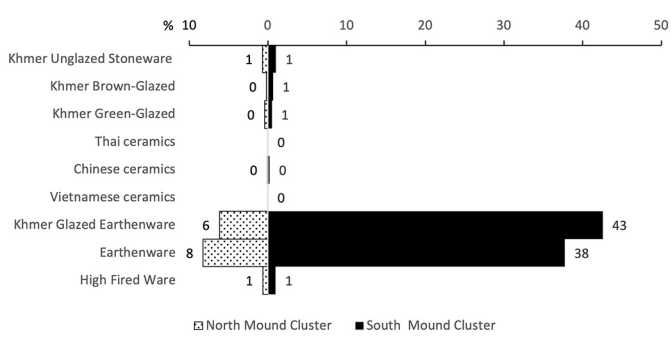

Fig. 8. Percentage of excavated ceramic category from each mound cluster.

date, and occupational intensity. The temple neighborhoods of the Eastern District belonged to the communities supporting small state and elite temples that began in the 9th century. These planned neighborhoods were subdivided into ritual and residential spaces separated by a wall or moat but lacking the orthogonal grids of Phase II. Their residents consisted largely of ritual specialists, farmers, and other specialized conscripts provisioning the temple rituals. These included the 9th-century royal *āśrama* communities, a series of 6 ha temple compounds that housed over 50 personnel including religious teachers, students, laborers, and travelers/pilgrims (Coedès, 1932). Archaeological research at two of these *āśramas*, Ong Mong and South Kamnap temples, dated the earliest foundation between 710 and 995 CE, and suggested that residential and ritual activities of these neighborhoods were confined to their walled precincts (Chea, 2018, 274–78) (Fig. 10). The conformity in the layout of the state-sponsored *āśramas* around the East Baray corresponds to *Yaśovarman*'s claims that he established these features at the same time to serve the same ritual functions.

Other elite temple neighborhoods were added to expand the Eastern District during the 10th century. These include a discrete 36 ha temple neighborhood around Kravan temple that defined the southern boundary of the Eastern District (2 km south of the East Baray). A 6 ha neighborhood of the Bat Chum temple (approx. 953 CE), hosted an unspecified number of Buddhist monks and workforces as alluded to in its inscriptions (Coedès, 1908b). Both neighborhoods have clear habitation mounds formally organized around their temples and moats in rectangular parcels. Neither neighborhood is surrounded by an enclosing wall, but both have clear boundaries marked by earthen bunds that delineate a perimeter for the habitation mounds that suggest formal spatial separation (Fig. 11A). A similar arrangement can be observed at the temple neighborhood of *Kutiśvara*, which has visible habitation mounds but without identifiable boundaries due to modern

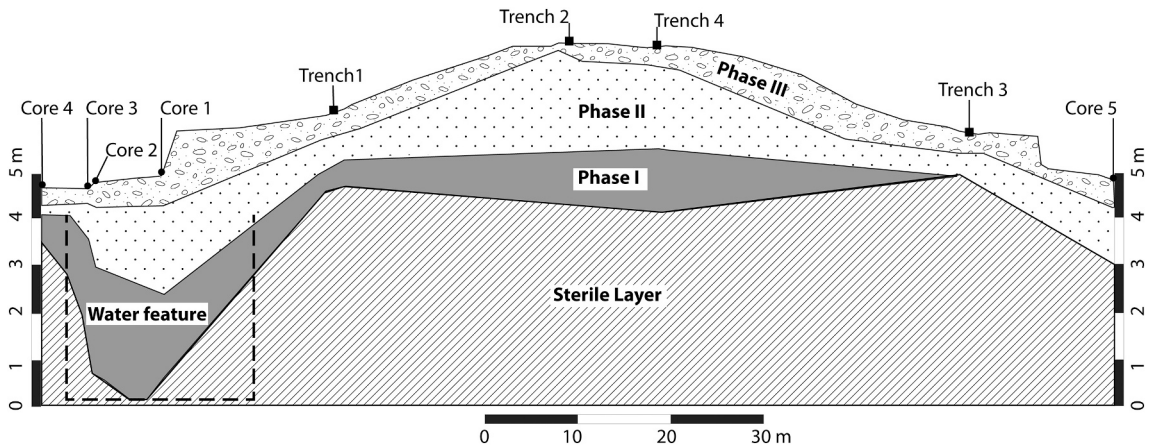

Fig. 9. Cross-section of Mound II (Southern Cluster) presents three phases of occupation based on the excavated and coring results. Kiln features were found in Trench 2 and Trench 4 at the top of the mound.

disturbances. Poor preservation and continuing land use also obscure spatial patternings of other temple neighborhoods like Leak Neang and Top.

Only two 10th-century temple neighborhoods have been explored by archaeologists previously: Kok Trapeang Ropou and Trapeang Thlok (Fig. 11B). Located beyond the urban core of Greater Angkor, these sites were excavated extensively during the Siem Reap airport expansion (Bâty et al., 2005; Bâty and Bolle, 2005). Epigraphic and art historical data, and radiometric dates associated with residential activities (remains of post holes from wooden structures and ceramic concentrations) of these temples produce a similar chronological sequence to Kok Phnov and Ong Mong temple (Bâty, 2010, 88, 90; Bâty et al., 2014, 333, 377–78 footnotes 12–13). Despite sharing the same architectural inventory of mound, pond, and temple, their spatial organization is less formal compared to Bat Chum and Kravan and do not have a clear boundary.

Precisely how many residents comprised these temple communities is unclear, since these temples required support from both local residents and more distant supporting communities (but see Klassen et al., 2021 for population estimate based on spatial modeling). The Kravan temple inscriptions (Table 4) listed more than 330 people from different communities who serviced the temple between 921 CE and 971 CE; yet the number of people living inside the temple property was not specified. Leak Neang and Kravan temples both had lands and supporting communities at a locality named *Sindūra*, probably located around *Hariharālaya* near the Great Lake[1] or Tonle Sap Lake. Another distant supporting community (re)assigned to Kravan was in a provincial center of *Bhīmapura*, c. 80 km southwest of Angkor in Battambang province (Groslier, 1924; Hun, 2019). The examples above suggest that the structure (physical and social) of Angkorian temple neighborhoods varied across time, space, function, and possibly, the social status of their founding elites, which illustrates their dynamism. Next, we will examine the civic-ceremonial neighborhood of the Eastern District.

3.1.2. *The civic-ceremonial neighborhood*

A second urban category of the Eastern District consisted of the axial settlements of the state temple of Pre Rup (Fig. 3). The structure of this neighborhood was greater in extent and complexity of coordination compared to the surrounding temple neighborhoods and is therefore considered as a separate entity. Its greater extent and status as a civic-ceremonial neighborhood attached to the state temple suggest a primary settlement hierarchy compared to the surrounding neighborhoods and could hold an administrative function (see discussion in Smith and Novic, 2012). A series of mounds, ponds, and linear depressions (roads) was formally structured by the Pre Rup causeways extending in each cardinal direction. There is no evidence of a walled enclosure or boundary surrounding this neighborhood other than the wall and moat of the Pre Rup temple that demarcates the ritual from residential space (like the smaller temples discussed above). The southeast section of this neighborhood was arranged into a simple grid of four linear depressions or roads (Fig. 12). This c. 150 ha civic-ceremonial neighborhood is bordered by the embankment of the East Baray (north), the temple neighborhoods of South Kamnap (east), Top and its pond (south), and Ong Mong (west), and Kok Phnov (southwest). The nature, extent, and function of this neighborhood requires further investigation as only one formal excavation occurred at Kok Ta Kong of the Pre Rup's west causeway (Johnson et al., 2012). Most artifacts uncovered from this excavation were earthenware cooking pots from residential activities. The absence of kiln features and wasters suggests that Kok Ta Kong, like the northern section of Kok Phnov's Mound VI, were part of this civic-ceremonial neighborhood. The absence of tradeware in the basal layers suggested that the early occupations began between the 9th and 10th centuries contemporary with the foundation of Pre Rup.

This civic-ceremonial neighborhood hosted residents of the newly expanded Eastern District, which may include those who followed *Rājendravarman* from Koh Ker to settle in Angkor and were in need of new land. A similar pattern of subjects relocating to an area in association with a ruler can be observed in the 11th century Sdok Kak Thom inscription (Sak-Humphry and Jenner, 2005, 137–38, stanzas D36–38). Their tasks may have included the maintenance of the two state temples: Pre Rup and East Mebon (which was an island in the East Baray and therefore does not have surrounding habitation mounds). The foundation stela of Pre Rup only briefly mentions that the people placed at the head of this foundation received a bowl of six-flavored food offered to the gods (Coedès, 1937, 1:141, stanza 285), possibly as a sign of prestige. An unspecified number of people were also needed to observe the prescribed daily and monthly rituals mentioned in the East Mebon inscription (Finot, 1925, 351, stanza 110). This example again reveals the social dynamics of the civic-ceremonial neighborhood that materialized in the urban landscape.

3.1.3. *Craft neighborhood*

The Kok Phnov mound complex forms a neighborhood of craft specialists in the Eastern District bridging the neighborhoods of Bat Chum

[1] Inscription K.809/878 or 887 CE from Prasat Kondol Dom (in *Hariharālaya*) referred to a group of labor in *Sindūra* donated by the ruler *Indravarman I* (877/78 and 889/890 CE) (Coedès, 1937, 1:37–46). Inscription K.265/959 CE from Leak Neang specified that a land in *Sindūra* was purchased from the temple *Śrīndrīśvara* (Bakong temple in *Hariharālaya*, state temple of *Indravarman I*) and from the Bakheng temple (Coedès, 1952).

Table 3
Three radiometric dates complement the ceramic chronology and infer three phases of site formation processes recorded at Kok Phnov spanning from the 9th to 16th centuries.

Phase	Stratigraphy	Period	Cal. 2 sigma (CE)	Relative dating sources
I	Layers IV - VII of Mounds II, IV, and VI	9th–10th centuries	775–975 and 890–1015	Most artifacts are earthenware ceramics. Unglazed stoneware, including *lie-de-vin* wares, could date from the 10th century onward. Green-glazed stoneware began in the 9th century; while the absence of Khmer Brown-Glazed stoneware and tradeware predated the 11th century (Desbat, 2011, 26, Table 2). Phase I is associated with the late 9th century Ong Mong temple and the mid-10th century Pre Rup temple.
II	Layers II- III of Mounds II and VI, and Layers II-VII of Mound V	11th–14th centuries	1020–1155	Industrial and residential activities intensified during this phase. Chinese tradeware including *qingbai* (bluish white), white covered boxes, and Celadon dated between the 11th and 14th centuries (Song and Yuan dynasties). Khmer Brown-Glazed stoneware occurred in this phase.
III	Surface and Layer I	15th–16th centuries	N/A	This plough zone comprises tradeware including the Ming Dynasty's Blue and White, and Thai and Vietnamese ceramics and dated between the late 14th and 16th centuries. Khmer Brown-Glazed stonewares gained prominence compared to the decreasing number of Green-Glazed ceramics.

and Top (IK539) to those of Pre Rup. Our excavated data from Kok Phnov complement the epigraphic evidence and excavated data from Ong Mong temple that the initial settlements of the Eastern District began in the 9th and 10th centuries (Figs. 10 & 12). The stratigraphic analysis of Mound II suggests that its 10th century phase was associated with a low mound with relatively flat surface and a water feature to its north (Fig. 9). A similar pattern was also observed at the northern mound cluster, Mound V and Mound VI. The latter has a pond to its northeast and could belong to the surrounding mound clusters aligning with the Pre Rup causeways. The southern mound cluster (Mounds I–IV) formed a larger group with reservoirs attached to Srah Srang, Bat Chum, and Top temple.

Craft production is an attribute of premodern cities elsewhere (Cowgill, 2004, 538–39) and often constitutes a socio-spatial unit like quarter or neighborhood (see review in Smith, 2010) and their spatial relationship to other urban units defined their community status. For example, in the Maya center of Caracol (Chase and Chase, 2007, 67), the poor potter communities occupied the interstitial space between the civic-ceremonial center/downtown and the elite residential zones of the outer ring, comparable to the concentric model of 20th-century industrial cities (Burgess, 2020). In another example, in Teotihuacan, the poor potter communities of Tlajinga (Nichols, 2016, 11) and the ethnic communities of Tlailotlacan that produced Oaxaca-styled pottery (Gibbs, 2010), both resided outside the civic-ceremonial center. In Angkor, ateliers for stone lintel carving, sculptural production and bronze casting have been found within the temple and/or palace compounds, which suggests an élite association (see parallel example in Manzanilla, 2015); while stoneware production was located outside the Angkor's civic-ceremonial core (Chhay et al., 2020), possibly due to clay resource availability. The nature and function of Angkorian earthenware manufacturing communities remain unknown.

Kok Phnov is one of the only two (the other is the recently discovered and excavated site of Thvea Dei Chhnang) known urban earthenware production sites in Angkor. Recovery of earthenware with soot marks and Khmer stoneware suggests both residential and production activities in this space. The communities of Kok Phnov, who began their earthenware production during the 10th century, occupied the area between the Pre Rup civic-ceremonial center and the elite temples (belonging to a Prime Minister and a Royal guru) in the core of the Eastern District. Yet, there is no clear spatial correlation between Kok Phnov (particularly the Southern Mound Cluster) and the surrounding neighborhoods. This location, however, is similar to the Caracol example above and suggests that Kok Phnov was an urban production zone hosting a community of craft specialists and/or part-time farmers (see discussion on Angkorian earthenware production in Stark, 2003, 205).

3.1.4. *Structure of the eastern district during the formative phase (phase I)*

The Eastern District's spatial patterning of a state civic-ceremonial neighborhood surrounded by smaller temple and craft neighborhoods fits with the definition of administrative districts as "*large residential zones that serve as administrative or religious units within cities*" and sometimes "*contain civic buildings used in administration*" (M. E. Smith, 2010, 140). This configuration shares many similarities with districts of the Mesoamerican examples of the Maya and Aztec settlements reviewed in Smith and Novic (2012). We estimate that in Phase I, by the mid-10th century, the Eastern District was approximately 1000 ha (Arahi, 2003; Chea, 2018; Coedès, 1942, 2:159; Finot, 1925; Marchal, 1937; Pottier, 1999, 191–192). This is complicated somewhat by new constructions in Phase II, which buried some of the earlier Phase I habitation. For example, our excavations within the temple enclosure of Ta Prohm recovered evidence for earlier habitation that was buried by later temple construction and the creation of an urban grid between 1180 and 1186 CE (Carter et al., 2018, 496, 500). Subsurface artifacts found in trenches (Layer 4 of Trench 1, 11, 14, and 15) from the northeast and southeast part of the enclosure included earthenware, unglazed and Green-glazed stonewares and four AMS dates taken from these contexts ranged between 676 CE and 968 CE (Fig. 10).

Our dataset suggests that civic-ceremonial and urban elite temple neighborhoods were more standardized than non-urban elite temples like Trapeang Ropou (Bâty and Bolle, 2005; Bâty et al., 2014), and implies some degree of a centralized urban planning. The coherent spatial coordination of different neighborhoods discussed earlier, water reservoirs, linear features, and mounds in the Eastern District followed an axial urban configuration that began with the East Baray. Empty spaces between each neighborhood are interpreted as agricultural fields integrated into the urban design common to pre-industrial agro-urbanism (Carter et al., 2021; Hawken, 2013; Pottier, 2000b; for parallel case studies, see Barthel and Isendahl, 2013; Isendahl, 2012; Lucero et al., 2015). The 10th century temple neighborhoods like Kravan, Bat Chum,

Table 4
Royal and Elite inscriptions (9th–13th centuries) of the Eastern District (excluding graffiti).

#K	Temple	Date CE	Ruler	Founder/title	Reference
283	Thnal Baray	9th c.	*Yaśovarman I*	*Yaśovarman I*	(Bergaigne, 1893, 504–25)
290(1)	Tep Pranam	9th c.	*Yaśovarman I*	*Yaśovarman I*. This inscription possibly came from Ong Mong, an *āśrama* of the East Baray.	(Coedès, 1908a)
269 & 271	Kravan	921	*Harṣavarman I*	*Vīrendrādhipativarman* with the title of *mratāñ khloñ* (Lord warder of the royal bedchamber) and *Mahidharavarman (see below)*	(Coedès, 1952, 4:74–75)
270	Kravan	921 & 971	*Harṣavarman I* & *Īśānavarman II*	*Mahidharavarman* bore the title of *kaṃsteṅ añ (Lord)* (also in K.1229 and K.257 both dated to 979 CE); in another inscription of K.198/966 CE, he was a *mratāñ khloñ* (Lord of an unspecified office). Another donor was *kaṃsteṅ añ (Lord) Jayavīravarman.*	(Coedès, 1952, 4:68–76)
267–8	Bat Chum	953	*Rājendravarman*	*Kavīndrārimathana* bore the title of *mratāñ* and was the Prime minister and architect of a new palace.	(Coedès, 1908b)
266	Bat Chum	953 & 960	*Rājendravarman*	*Ditto*	(Coedès, 1908b)
528	East Mebon	953	*Rājendravarman*	*Rājendravarman*	(Finot, 1925, 309–52)
265	Leak Neang	959 & 960	*Rājendravarman*	*Raṇavikhyāta* bore the title of *mratāñ* of unknown office.	(Coedès, 1952, 4:102–5)
806	Pre Rup	961/2	*Rājendravarman*	*Rājendravarman*	(Coedès, 1937, 1:73–142)
532	Banteay Kdei	10th c.	*Īśānavarman II*	*Śivācārya* bearing the title *steṅ añ* was a royal spiritual preceptor of *Īśānavarman II* or *Rājendravarman,* or both.	(Finot, 1925, 354–363)
530	Banteay Kdei	10th c.	*Rājendravarman (?)*	*Virendravarman* was a *mratāñ khloñ /khloñ glāṅ eka (first class chief treasury)* in K·265S/959CE; then a *kaṃsteṅ añ rājaguru*/royal spiritual preceptor in K.265 N/960 CE and K257/979 CE.	(Coedès, 1942, 2:159)
290(2)	Tep Pranam	1015	*Suryavarman I*	*Suryavarman I*. This inscription possibly came from Ong Mong.	(Coedès, 1951a, 3:231–33)
527	Pre Rup	1080	*Jayavarman VI*	*Jayavarman VI*	(Coedès, 1943, 15)
273	Ta Prohm	1186	*Jayavarman VII*	Written by Prince *Sūryakumāra*, son of *Jayavarman VII*	(Coedès, 1906; Maxwell, 2007, 31)
274 & 909	Ta Prohm	12th-13th c.	*Jayavarman VII*	Posthumous names of deified individuals	(Coedès, 1951b, 103–5)
272 & 531	Banteay Kdei	12th-13th c.	*Jayavarman VII*	Posthumous names of deified individuals	(Coedès, 1951b, 103)

and *Kutiśvara* generally contained a standard inventory of temple architecture, moats, ponds, and habitation mounds, although each had variations in their size and spatial configuration.

Despite little fine-grained chronometric evidence from the 11th century, other evidence suggests continued habitation. An inscribed stelae at the Pre Rup temple dates to 1080 CE, and 11th-century Baphuon style statuary found in Kravan, Bat Chum, and Pre Rup (CISARK, 2020) indicate ritual continuities in these temples. The absence of new temple construction and the appearance of Brown-glazed stoneware, which began in the 11th century (also known as, "Buriram Type," see Desbat, 2011), allow us to infer that the habitations of the Eastern District continued in the same locales. Excavated data from Kok Phnov, Kok Ta Kong, Ong Mong temple, and Srah Srang suggest an increase in residential activities starting in the 11th century and extending beyond the 9th/10th-century temple compounds. Srah Srang's west embankment may have been used as a cremation burial ground as early as the 10th century; nonetheless, most diagnostic remains appeared after the 11th century (APSARA, 2013, 174–75; Courbin, 1988, 22–24).

3.2. Phase II: Expansion and incorporation (c. 12th–15th centuries CE)

Phase II is characterized by the formalization and expansion of the Western District, which partially encroached into the Eastern District. Royal urbanization projects of gridded enclosures and an orthogonal grid system of repetitive "city blocks" of mounds and ponds began in the 12th century under *Sūryavarman II* (r. c. 1113–1150 CE) (Evans and Fletcher, 2015; Carter et al., 2018). Angkor Wat reorganized and extended Angkor's civic-ceremonial core southward, possibly affecting parts of the Phase I's settlements in this location. The new urban blocks northeast of its moat incorporated the 10th-century *Kapilapura* temple settlement (Fig. 2). Five radiocarbon samples from the Angkor Wat excavations, found within fill or disturbed contexts, yielded a date range between the 8th and 11th centuries CE consistent with the radiocarbon dates of Phase I's settlements in the Eastern District (Carter et al., 2019, supplementary information; Sonnemann et al., 2015, 1431). The degree to which this urbanization program affected the rest of the urban core remains to be investigated.

The late 12th/early 13th century ruler, *Jayavarman VII* (r. ca. 1182/83–1219/20 CE), undertook Greater Angkor's most ambitious reorganization program. Major construction projects such as the walls of Angkor Thom, the North Baray (*Jayatatāka*), as well as the enclosures of Preah Khan, and Banteay Kdei defined the extent of a new urban core. This centralized urban reorganization incorporated parts of the Eastern District, with massive modular temple neighborhoods surrounded by gridded urban blocks extending east to Ta Prohm, Banteay Kdei, and Srah Srang. Ta Prohm's 68 ha formal gridded neighborhood was arranged into four mound-pond configuration patterns, each corresponding to different occupation intensities (Carter et al., 2018, 503–504, Fig. 4). A less complex but similar configuration can be observed at the 34 ha-gridded settlements of Banteay Kdei (Fig. 3).

The 10th-century Srah Srang was modified during this phase and yielded a radiometric date range between 1049 and 1256 CE (Fig. 10). Whether this urban expansion dismantled other 9th-century *āśrama* around the East Baray is unknown (Jacques, 2008, 7). Our excavations at Ta Prohm found Phase I residential debris (i.e., earthenware sherds, unglazed and Green-glazed stonewares) buried beneath these new urban blocks. The Ta Prohm inscription dated to 1186 CE states that the temple was built on land *Jayavarman VII* "seized by [the strength] of his own arms" (Coedès, 1906, 74, stanza 35; Maxwell, 2007, 31), presumably from its previous owners. Lands and temples belonging to the descendants of the 10th-century elites including a royal spiritual guru or a first class chief treasury were probably seized to build the Banteay Kdei neighborhood because their stone inscriptions were repurposed for the Banteay Kdei construction (K.530 and K.532; Table 4). This period relates to four AMS dates from Ta Prohm (Trenches 5, 14, 15, and 16) with a date range between 1024 and 1210 CE (Fig. 10).

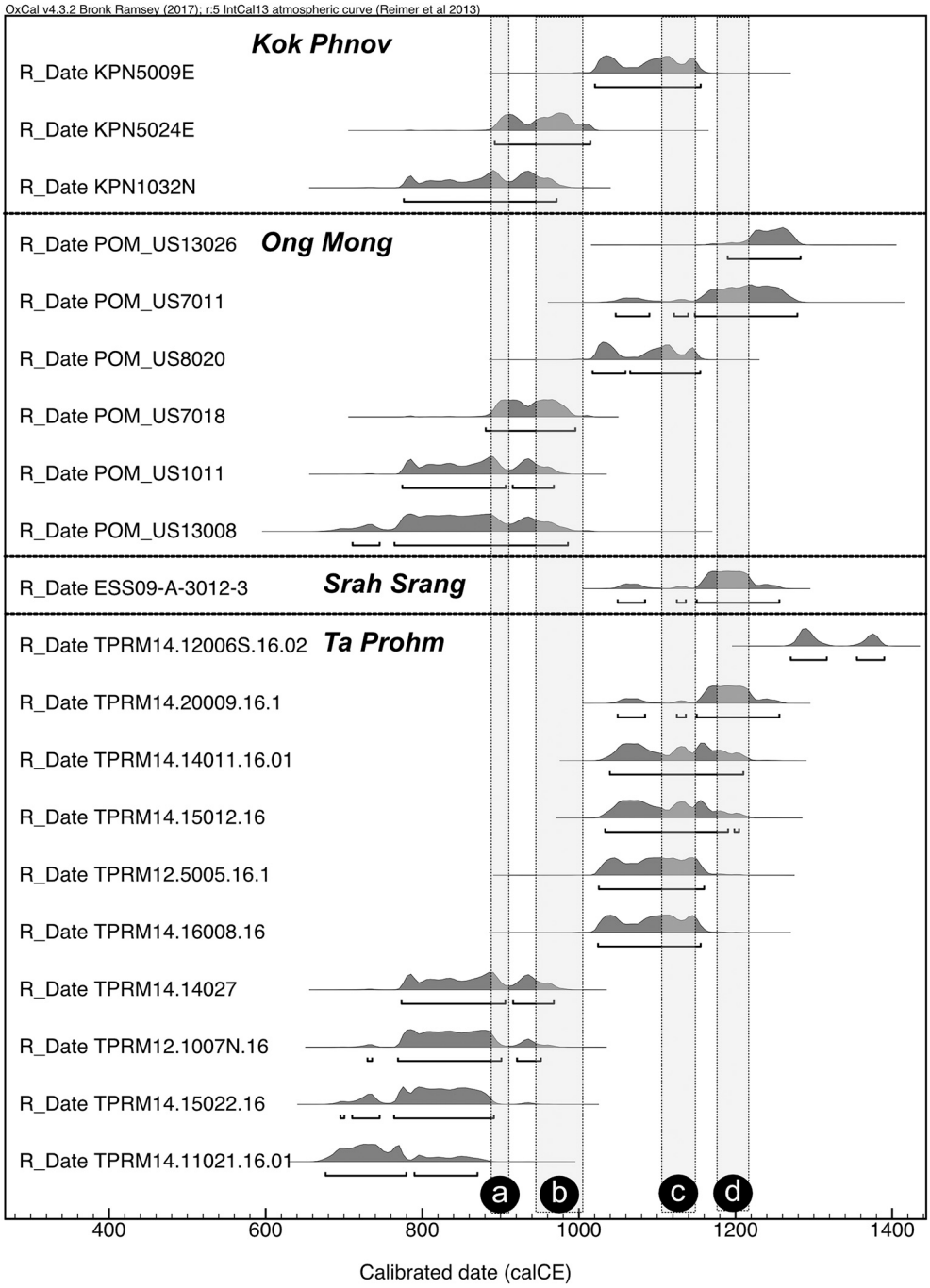

Fig. 10. Calibrated AMS dates from Kok Phnov and surrounding sites (In this Fig. 10, the charcoal sample from Ta Prohm's Trench 1's Layer III (50–60 cmbs), TPRM12.1007N.16, was either from a disturbed context of sandstone chips concentration and two Brown-glazed ware sherds (post-11th century) that predated the construction of Ta Prohm temple or the results of old wood effect. Nonetheless, 10th-century strata were identified in the surrounding trenches in the levels beneath this sandstone chips feature.) Reigns of rulers associated with Angkor's two-phased urbanism are shaded: a) Yaśovarman (889–910 CE), b) Rājendravarman (944–968 CE) and his son Jayavarman V (968–1002 CE), c) Suryavarman II (1113–1150 CE), and d) Jayavarman VII (1181–1218 CE).

Angkorian people continued to live in the Eastern District's low-density axial settlements despite the scale and intensity of 12th century urban reorganization further west. Bayon-style statuary, dated to the reign of *Jayavarman VII* and found in the 10th-century temples (Kravan, Bat Chum, and Pre Rup), suggest ritual continuities in the Eastern District (Chea, 2018, XXIX, LI, XCI; CISARK, 2020; Marchal, 1937, Planches LVIIIa, LIX-LX). The Kok Phnov mound complex achieved its current amorphous shape during this phase; as earthenware production increased, the Southern Mound Cluster was filled with Khmer Glazed Earthenware wasters and kiln fragments (Fig. 9 and Fig. 12). There all ceramic categories in Kok Phnov's Phase II and III increased over fivefold from Phase I (Table 1). Finding Kok Phnov's Glazed Earthenware in excavated contexts is extremely rare due to the fragility of its diagnostic characteristic: the shell-derived transparent glaze (Desbat, 2009, 44). Some Glazed Earthenware, similar to those produced at Kok Phnov, were found in our excavated contexts of Angkor Wat (eight sherds from Trench 13 Layer II-13003 and Trench 23 Layer I-23003E, Layer II-23005W-23006W) and Ta Prohm (three sherds from Trench 15 Layer II-15011, and Trench 16 Layer II-16012S). A three-footed earthenware stove similar to those produced at Kok Phnov (Fig. 7F) is depicted in bas relief on the Bayon's wall. These ceramics came from the 11th to 13th centuries and imply that the communities of Kok Phnov production zone supplied utilitarian earthenware to the urban core through the 13th century.

A surge in the frequency of domestic ceramics suggests an increase in residential population that took place when industrial activities expanded at Kok Phnov. Intensified residential activities were similarly recorded in the excavations at Ong Mong (Chea, 2018:274–286), Srah

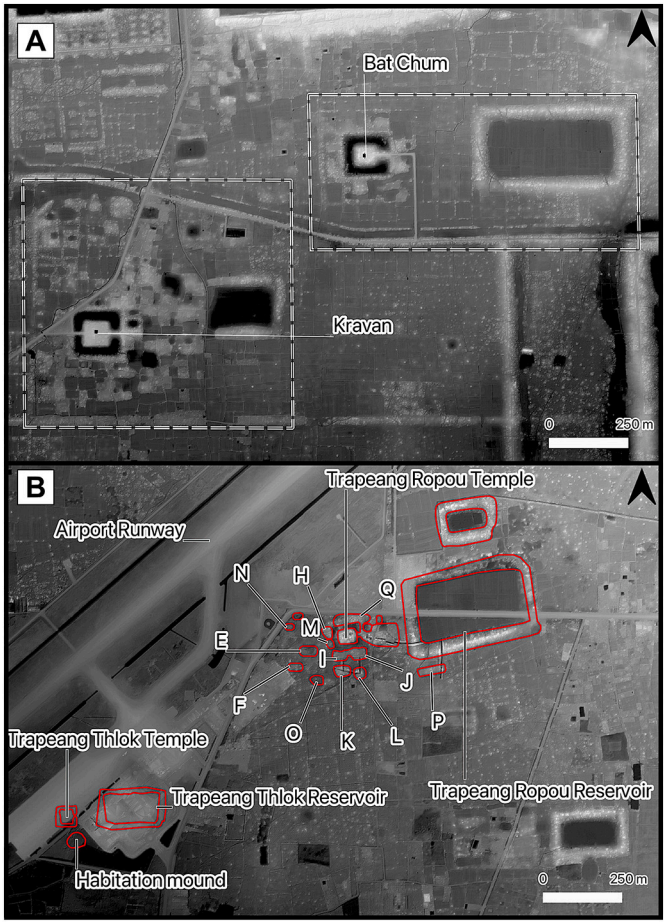

Fig. 11. Tenth-century Angkorian temple neighborhoods. A) Kravan and Bat Chum of the Eastern District; B). Non-urban Trapeang Ropou and Trapeang Thlok temples (Trapeang Roupou and Trapeang Thlok data digitized from Bâty et al., 2005. LiDAR data courtesy of KALC).

Srang (Courbin, 1988, 22–24; APSARA, 2013, 174–75), and Banteay Kdei (Nhim, 2019, 93). Such patterns reflect Phase II's Urban Expansion after the 11th century (Fig. 13). Evidence for habitation along embankments after the 12th century also suggests the extension of residential patterning in the Angkorian capital. These settlements were informal and have been documented around the Srah Srang reservoir and on sections of the East Baray's west embankment, northeast of Ta Prohm through the excavations above and our informal surface inspections. Associations between these new residential areas and more established 9th–13th century neighborhoods that surround them are unknown; yet they do not appear to be structured along temple axes. Scholars have suggested that people living on Angkorian embankments were more recent migrants to the city and Greater Angkor region (see Carter et al., 2021: 8).

Who lived on mounds of Phase II's Eastern District? Zhou Daguan (2007, 50) observed in 1296 CE that only elite dwellings and temples had roof tiles (also see, Bâty et al., 2014; Carter et al., 2018, 496, 502). No roof tiles were found at Kok Phnov or Kok Takong, suggesting these were commoner settlements, some of whom were potters. Whether changes in Kok Phnov's settlement configuration from a locus surrounded by affluent 10th-century neighborhoods to an amorphous settlement outside the main urban core in the later phase infer changes in the socioeconomic status of these communities or a conscious urban planning project requires further investigation. Kok Phnov's amorphous shape is closer to the contemporaneous rural earthenware ceramic production community of Kok Bei, a located 18 km to the south, and other non-urban settlements of Greater Angkor like those illustrated in Fig. 11B (Brotherson, 2019, 92–103; Brotherson and Chhay, 2013; Evans et al., 2007). This spatial configuration is comparable with contemporary earthenware production in Mainland Southeast Asia, where most rural potters embed their part-time manufacturing activities into a farming schedule: even in cases of village-based ceramic production (Lefferts and Cort, 2003).

Our analysis suggests that Angkorian Khmers lived in the capital's Eastern District for more than five centuries, and perhaps continuously. Such residential patterning in the face of the royal urbanization programs in the 13th century suggests either the community's resilience to the central planning program or the spatial limits of the latter. Whether the Eastern District's local elites were powerful enough to resist state power (like land-seizure) remains unclear. Litigations revolving around Angkorian land ownership portrayed a complex relationship between the rulers, the elites, and occasionally the local communities (Lustig and Lustig, 2019; Ricklefs, 1967). These inscriptions suggest that the rulers frequently upheld a system of private land ownership, but the Ta Prohm inscription provides a rare instance where the ruler seized land for an urban expansion project in an Angkorian example of eminent domain.

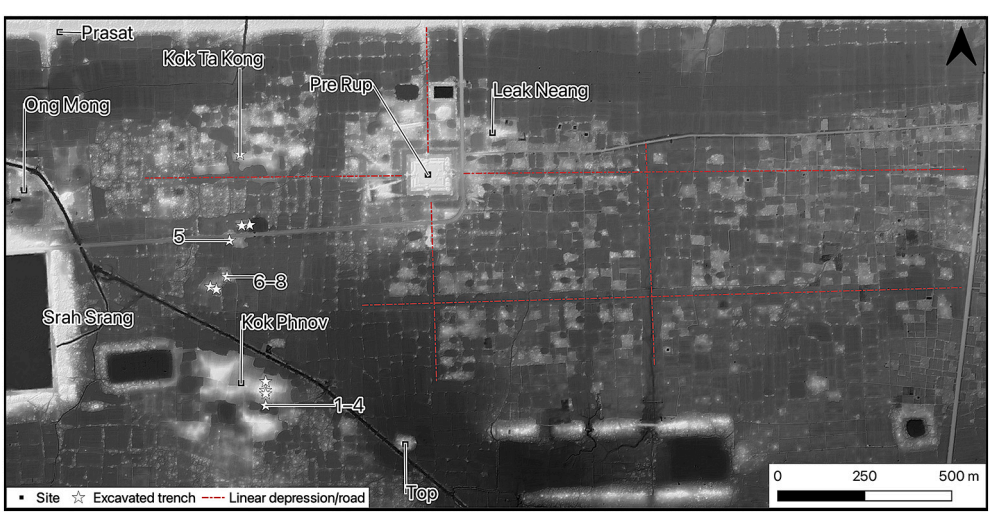

Fig. 12. Pre Rup civic-ceremonial neighborhood with linear features subdividing habitation mounds. Numbers are locations of excavated trenches at Kok Phnov. The three stars north of Trench 5 (one of which is Kok Ta Kong) were excavated by another GAP team (Johnson et al., 2012). LiDAR data courtesy of KALC.

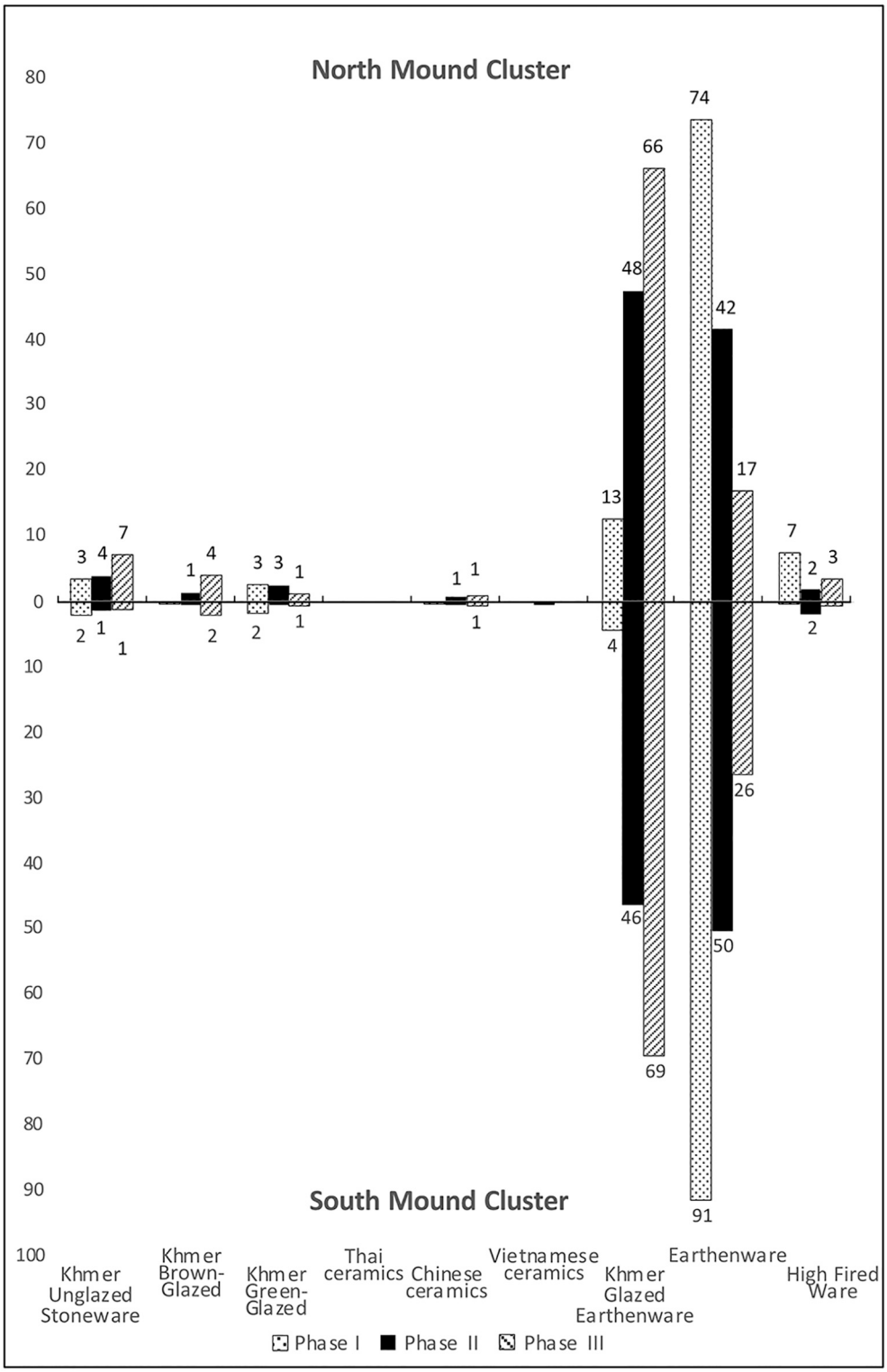

Fig. 13. Percentage of each excavated ceramic category at Kok Phnov representing both residential and industrial activities in each Phase. A spike in the combination of earthenware and Khmer Glazed-Earthenware in Kok Phnov's Phases II and III suggests an intensified ceramic production after the 11th century.

4. Discussion and conclusions

4.1. Structure and dynamism in Angkor's urban residential zones

Angkorian people lived in both urban and rural settings across the polity, but districts and neighborhoods created its residential urban sectors. Districts involved temple neighborhoods, civic-ceremonial areas, and craft production zones in an urban lattice of state temples and shrines whose maintenance required substantial populations. The Eastern District is an example of an administrative district created through a top-down process where the state temple of Pre Rup and its civic-ceremonial neighborhood integrated smaller neighborhoods into a district (see parallel examples in Smith, 2010, 148–49). Angkor's Eastern District provides evidence for long-term use of both public and

private spaces, and temporal changes in this district offer one proxy for understanding long-term Angkor urbanism and resilience. During the Eastern District's Formative (Phase I), urban planning in the 9th–11th centuries was based on an axial plan, with settlements concentrated within the Pre Rup civic-ceremonial neighborhood and the surrounding temple neighborhoods. Others (craft specialists, and certainly potters) lived in the Kok Phnov mound complex. During the Expansion Phase from the late 12th to the early 13th centuries urban reorganization erased most earlier settlements in the Western District and expanded to incorporate part of the Eastern District into its grid. Nonetheless, habitation continued in areas beyond the grid, and population may have increased, identified in part by an overall increase in both residential and industrial ceramics. The Eastern District's occupation continued long after the "collapse" of Angkor as indicated by the 15th–16th century tradeware, inscription, Buddhist structures in Banteay Kdei, and the 14th–19th century AMS dates associated with re-excavation/maintenance of Srah Srang (Nhim, 2019; Penny et al., 2007, 391–93).

The Eastern District was an important part of the capital throughout its 500-year three-phase occupation whose craft production and temple neighborhoods integrated different scales of Angkorian societies through producer-consumer networks that brought people from more remote communities in Angkor's urban landscape (following Smith, 2014) to the capital to service the city. They included religious teachers, students, cooks, dancers, farmers, construction workers, travelers/pilgrims, and elites. These urban neighborhoods, thus, provided a coherent vertical and horizontal integration of Angkorian societies. While its diverse and integrated components seem to have contributed to the Eastern District's longevity, our research cannot determine whether Angkor's Eastern District residents lived beyond the direct reach of the state. Long-term occupation of the Eastern District suggests that this urban area was never abandoned, perhaps because well-established neighborhoods (based on internal cohesion) were sufficiently resilient to withstand urban reorganizations and macroscale political shifts.

Using a neighborhood lens to study the city of Angkor offers comparative insights on urbanism elsewhere in the ancient world (Barthel and Isendahl, 2013; Gómez-Chávez, 2012; Keith, 2003; Manzanilla, 1996; Pacifico and Truex, 2019; Smith, 2010). Blending remotely-sensed with excavated data identifies and dates urban social units like neighborhoods and districts (Smith, 2010; Stone, 2019, 190): a task that requires ground-truthing to develop chronological control across social units and define neighborhood and district boundaries. Combining excavated data with the LiDAR-derived spatial data has identified the anatomy and scale of a 10th-century urban "hotspot" in the Eastern District of Greater Angkor and underscored its resilience through multiple reorganizations that reshaped the urban core. Understanding the life histories of particular neighborhoods offers nuanced perspectives on the growth of this preindustrial city, and urban resilience in this Angkorian neighborhood demonstrates the value of long-term interdisciplinary research on premodern urbanism.

4.2. Future directions in the social construction of Angkorian urbanism

Our primary goal in this paper was to identify Angkorian urban sectors like districts and neighborhoods and demonstrate the feasibility of tracing urban life histories using Angkor's Eastern District. The Angkorian state and its elite personnel helped shape the Angkorian city (see discussion in Smith, 2003) by establishing and organizing neighborhoods and districts across Angkor's urban core. Historical examples include sequential Angkorian rulers like *Yaśovarman*, *Rājendravarman*, and *Jayavarman VII*, whose temple projects resculpted most of Angkor's urban core. Religious aspects, particularly religious segregation, also influenced urban configurations in preindustrial cities elsewhere (Smith, 2010, 150). In Angkor's Eastern District, however, religious pluralism (rather than segregation) defined its urban space. Multiple communities of different religious affinities co-existed in a shared urban space: Shaivism (Pre Rup), Vaishnavism (South Kamnap and Kravan), and Buddhism (Ong Mong and Bat Chum). The Bat Chum inscription claims that its Buddhist founder served as prime minister and architect for the Shaivite ruler, *Rājendravarman* (see Table 4).

Inscriptions also suggest that core-area temples owned resources, like rice fields and land revenues, in locations outside Angkor's civic-ceremonial center; and the people who serviced these distant resources were also linked to urban temple neighborhoods. Angkorian urbanism contrasted with other well-documented archaeological urban case studies in some respects but resembled them in others. Multiple types of urban neighborhood (including planned modular temple neighborhoods) fused to create Angkor's capital city, in contrast to Teotihuacan (Manzanilla, 2015) and Early Horizon Peru (Chicoine and Whitten, 2019). As described elsewhere (Pacifico and Truex, 2019; Smith, 2010, 151), however, friction between top-down and bottom-up forces also shaped Angkorian urbanism: from temple laborers, students, and religious personnel, to founding elites and rulers. Future work on other neighborhoods and districts inside Greater Angkor will continue to shed light on the dynamic social aspects that influence the urban spatial configurations through time and vise-versa.

CRediT authorship contribution statement

Piphal Heng: Writing – original draft, Writing – review & editing, Methodology, Data curation, Visualization. **Miriam T. Stark:** Writing – review & editing, Methodology, Data curation, Funding acquisition. **Alison K. Carter:** Writing – review & editing, Methodology, Data curation. **Rachna Chhay:** Writing – review & editing, Methodology, Data curation.

Declaration of Competing Interest

None.

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