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ORIGINAL PAPER

The Southeast Asian water frontier: coastal trade and mid-fifteenth c. CE "hill tribe" burials, southeastern Cambodia

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Abstract

In mainland Southeast Asia, the so-called water frontier unified an otherwise geographically broad and culturally disparate economic network of long-, medium-, and short-distance trade of the 14th–17th century CE "Age of Commerce." Focus on the rise of the larger port towns supporting this burgeoning maritime trade (e.g., Ayutthaya, Melaka, Hoi An) has overshadowed smaller maritime operations that must have serviced less regulated coastlines. In this paper, we evaluate the evidence of likely supply lines for relatively remote sites in the Southern Cardamom Ranges of southwestern Cambodia. We present the results of a geochemical analysis of ceramics from two contemporary and short-lived assemblages: comprehensively dated mid-15th c. to mid-17th c. CE burial complexes in the Cardamom Mountains, and a dated shipwreck (*Koh S'dech*) recovered from waters off the adjacent coastline. We compare the shipwreck assemblage with other wreck assemblages to contextualize it within larger maritime exchange patterns. The *Koh S'dech* wreck assemblage appears typical of a Southeast Asian short-haul coastal trader of this period, with a cargo consisting of a range of utilitarian household ceramics: large, medium, and small glazed stoneware storage jars, earthenware cooking pots, stoves and mortars, and "tableware" bowls. Comparison of burial, shipwreck, and reference ceramic compositional data confirms the jars and fine wares predominantly came from multiple production centers in Central and Northern Thailand. The few Angkorian jars identified in the burials were evidently heirlooms from what was, by the mid-15th c. CE, a likely defunct Khmer production complex east of Angkor. The results of this provenience analysis highlight (a) the Cardamom burials as an example of previously undocumented unregulated coastal interaction and (b) the relatively sophisticated and coordinated market-oriented strategies of inland ceramic producers at this time. For mainland Southeast Asia, the water frontier integrated not only ethnically diverse maritime port communities, but also those in more remote inland regions.

Keywords Age of Commerce · Neutron activation analysis · Shipwreck

Introduction

Recent historical narratives of mainland Southeast Asia during the 14th–17th c. CE have emphasized the bourgeoning scale and intensity of regional maritime trade at this time (e.g., the "Age of Commerce" (Reid 1988), or the "Water Frontier" (Li 2005; Lockard 2010)). The onset of the early modern period (EMP) by the mid-15th c. marks a new phase of European engagement with groups on the region's coastal littoral. However, we suggest that current understanding of the transformations of the EMP substantially underestimates the role of contemporary local inland and inland-maritime exchange networks across the region. While highly influential, conventional emphasis on the major, and historically well-documented, coastal entrepôts of the period (e.g., Hoi An, Ayutthaya, Melaka) overshadows the likely significant role of less regulated, and entirely undocumented, coastal traders in these broader networks.

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Here, we use a materials analysis framework to evaluate mid-15th–17th c. CE "hill tribe" ceramic burial assemblages (specifically large glazed stoneware jars used as funerary containers) from the southern Cardamom Ranges of southeast Cambodia, and ceramics from a contemporary coastal trader shipwreck on the adjacent coast. Using geochemical characterization (neutron activation analysis—NAA), we identify compositional groups common to both. In addition, we use reference NAA datasets from major inland stoneware production centers in Central Northern Thailand and Cambodia, and other shipwreck assemblages in the Gulf of Thailand, to contextualize the broader significance of the stoneware assemblages at these two sites.

Maritime exchange and the early modern period

Exchange systems and emergent economies in Southeast Asia Maritime interaction and trade have long been argued to play a critical role in the development of coastal polities throughout Southeast Asia (Manguin 2000). Archeologists and historians traditionally focus on the organization and operation of trade and exchange systems in this region. In the 1970s, the relationship between island and mainland economies was articulated in a dendritic model for island Southeast Asia that attempted to explain a pattern of distribution of coastal trade items (primarily ceramics) across inland sites (Bronson 1977). A weakness in this approach was its relatively static character. As a result, renewed focus has been on the dynamics of maritime patterns over time (Cartier 1988; Evers 1988; Manguin 1993). However, whether static or dynamic, these earlier models, with a few exceptions, relied heavily on historical data bolstered by ethnographic comparison, rather than drawing on the archeological data even then available (e.g., Junker 1993, 1998). Following Bronson (1977), we argue that understanding exchange patterns in SE Asia requires knowledge of both coastal and inland networks, as well as how they articulated.

Two main categories of evidence have been used to reconstruct pre-modern trade and exchange in the region: shipwrecks and trade goods. Shipwreck data make it possible to track the expansion of maritime trade (and technology). Beginning with the 9th c. CE *Belitung* shipwreck in Indonesia, carrying a combined cargo from China and the Middle East, shipwreck evidence increases through the early second millennium CE. The Gulf of Thailand, in particular, has a shipwreck record of extensive local trade from the 13th–15th c. CE (Brown 2004; Green and Harper 1987). Wrecks like the 15th c. *Pandanan*, in the South China Sea, reveal the extensive exchange between mainland SE Asia (Vietnam), and islands to the east (Diem 1998). Contemporary shipwrecks including the *Royal Nanhai* (~ 1460 CE, wrecked off the east coast of the Malaysian peninsula) as well as the later Manila Galleon *San Diego* (1600 CE, near Fortune Island, Nasugbu, Philippines) provide insights into the diversity of exchange network trajectories. This is most evident in their ceramic cargoes: these wrecks commonly comprise utilitarian household goods including a range of small, medium, and large glazed stoneware jars and fine tablewares (typically glazed bowls and plates) supplied by production centers across Southeast Asia and China (Grave and Maccheroni 2009).

The exchange landscape of the 15th c CE SE Asia grew out of large-scale changes in economic and political relationships that emerged in the 10th–11th c. CE. These included the development of the Khmer Empire and the expanded interaction with China (Wade 2009). Chinese interaction and exchange is apparent through both technological emulation and trade goods. Manguin (2000) argues that the 10th–13th c. CE period of intensified maritime exchange promoted the growth of coastal polities (Baker 2003). However, while the Khmer traded with the Chinese during this period, and expanded northward in mainland SE Asia, typologically distinctively Khmer stonewares appear to have been produced only for internal dissemination and exchange.

The 15th c. CE was a critical nexus in both the political and the economic reorganization in SE Asia. Documentary sources suggest that, following a two-century decline that culminated in the mid-fifteenth century sacking by the Thais (cf. Penny et al. 2019), post-Angkorian power migrated south, first to a series of 15th–18th c. capitals that flanked the Tonle Sap Lake (Srei Santhor, Bakan (Pursat)), then to the Oudong and Longvek area c. 35 km NW of Phnom Penh (Hall 2018:11). At the same time, new polities emerged throughout mainland Southeast Asia (Grave 1995), participating in expanded maritime trade, and supported by a network of coastal entrepôts (e.g., Melaka, in the Malacca Straits (Stark 2014)). Despite Ming Dynasty trade restrictions, 15th c. private Chinese traders continued and expanded active networks throughout Southeast Asia (Hall 2016:406–409; Wade 2004:19–27). Chinese records suggest that post-Angkorian 15th c. Cambodia also maintained close relations with China (Vickery et al. 2004:43), and early 16th century Tomé Pires' Portuguese accounts describe Cambodia as a source of myriad resources, from elephants and food (dried fish, rice) to spice, cloth, and red pearls (Groslier 2006:1099–1100).

At least one previously established Ming trade route through Southeast Asia included Siam (Ptak 1998:27), and maritime research on 15th c. shipwreck sites offers ample evidence of durable Southeast Asian goods, including high-fired (stoneware) ceramics from kiln complexes in Central Northern Thailand (Flecker 2001:225–226). However, in contrast to the historical and shipwreck data that document a vibrant and diverse maritime exchange network, evidence for its articulation with inland centers has remained fragmentary.

For the second millennium CE, historical biases related to time frame (EMP) and geographic focus (ports and entrepôts of the Southeast Asian coastline) have focused attention on coastal regions, representing an important but very selective perspective on the overall economic and political development in Southeast Asia (Li 2005; Wallerstein 1974). This focus has also unavoidably emphasized the importance of European traders, promoting an externalist bias in how mainland political and economic transformations are viewed in terms of agency, exchange, and interaction (Bronson 1977; Reid 1988). Historical research suggests that, at least by the 18th century, a vibrant local and regional trade system operated along the stretch of coastline and associated islands from Saigon to the Gulf of Thailand accommodated by multiple unofficial ports (Li 2004:75–76; Pham 2016).

More recent archeology across both island and mainland Southeast Asia has expanded our understanding of the development of polities and their interaction beginning in the first millennium CE (Carter 2013; Hendrickson 2010, 2011; Manguin 2004, 2014; Murphy and Stark 2016; Orillaneda 2016; Stark 2006, 2010). With the improvement and expansion of both regional archeological databases and archaeometric analyses, we can begin to evaluate the regional trajectories of trade across coastal and inland SE Asia. In addition to site excavations and surveys, specific trade goods, such as carnelian beads from burials, provide some evidence of the direction, scale, and intensity of interaction across the region (Carter et al. 2016; Carter 2015; Theunissen et al. 2000). Patterns of exchange and emulation of South Asian religious items and iconography have also contributed insights into inland and maritime exchange networks (Brown 1996; Shaffer 2015). Together, this work suggests the operation of well-developed, large-scale, internally complex, and integrated exchange systems prior to European engagement (e.g., Manguin 2004, 2014; Orillaneda 2016; Stark 2014). The close articulation of different sources of material and historical evidence is required to create a more robust and comprehensive characterization of the potential role of pre-existing structures as facilitators or constraints on the Southeast Asian economy of the early modern period (Stark 2010). Yet the archeological data and interpretative schemes remain at the margins of scenarios of social and economic development in the centuries prior to the inception of the early modern transition in mainland Southeast Asia.

This paper focuses on a unique window of mid-15th c. CE coastal-inland interaction and exchange networks provided by two contemporary locales: relatively remote, systematically ^{14}C-dated burial sites in the Cardamom Mountains (Beavan et al. 2012a; Carter and Beavan 2014; Halcrow et al. 2014); and a recently documented shipwreck on the adjacent coastline demonstrated to be contemporary by ^{14}C dating (Beavan et al. 2012a) (Fig. 1).

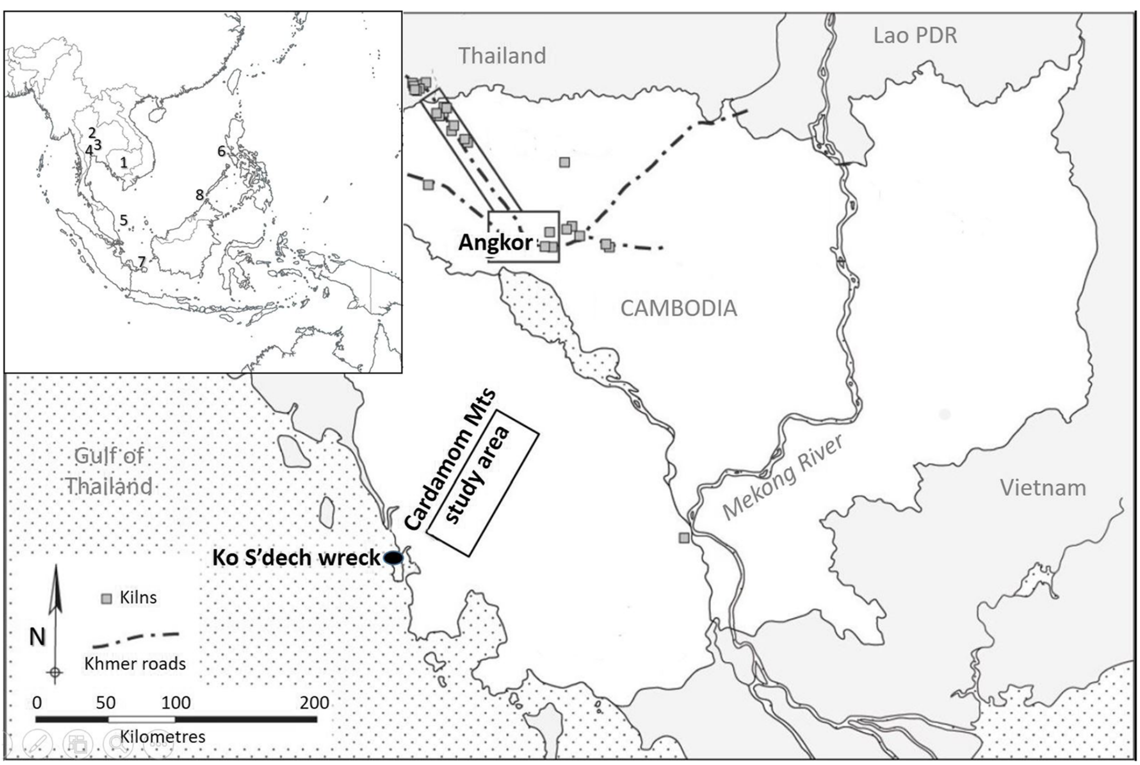

Fig. 1 Study area and general location within mainland Southeast Asia (inset) showing locations of burial sites and *Koh S'dech* shipwreck discussed in the text along with Khmer kiln locations. Other locales discussed in text numbered in inset (stoneware production centers in Thailand: Si Satchanalai—2, Singburi/Maenam Noi—3, Suphanburi—4; shipwreck locales: *Royal Nanhai*—5, *San Diego*—6, *Belitung*—7, *Pandanan*—8)

Using neutron activation analysis (NAA), we characterize ceramics from both the burials and shipwreck and compare these results with legacy stoneware NAA datasets from two other well-dated shipwrecks, as well as production centers in Thailand and Cambodia. Through this analysis, we lay the groundwork for evaluating the exchange networks that connected these upland communities with maritime traders beyond the major entrepôts on which EMP changes played out.

The sample and context

Southern Cardamom Mountain burial sites

The sample assemblage studied here comes from three burial sites distributed in a cluster within the southern Cardamom Mountain range, 150–700 m asl, ca. 40 km inland from the east coast of the Gulf of Thailand (Figs. 1 and 2). The burial sites include log coffin and jar inhumations which elsewhere in mainland Southeast Asia appear sequential, separated by a significant chronological gap (log coffins ~ 1500 BCE–200 CE; jar burials ~ 1300–1600 CE (Grave 1995; Hotchkis et al. 1994)). For the Cardamom group, an extensive program of radiocarbon dating chronologically bracketed both log coffins and jar burials within a short mid-15th–17th c. CE range. The most extensively dated and largest site used in the present study (radiocarbon determinations $n = 52$) appears to have been used for a relatively short ~ 50 year period in the mid-15th c. CE (Fig. 3) (Beavan et al. 2012a; Beavan et al. 2015). Ceramics include predominantly stoneware jars, but also distinctive local globular earthenware jars with basket weave impressions on the exterior.

The relatively large corpus of stoneware jars (the largest site—Phnom Khnang Peung—KPP—has a total of 40 jars containing single and multiple skeletons) was used for secondary, and often multiple, interments (Fig. 2). Limited personal effects included for example, animal "offerings," plain copper finger rings, and typical SEA maritime trade glass beads (Carter et al. 2016), Thai (Si Satchanalai) undercarved green-glazed "celadon" bowls, and underpainted covered bowls (Beavan et al. 2015). The jars are relatively large (~ 50–60 cm high). The most common form has a flaring body, four vertical lugged handles on the shoulder, and a flaring rim removed to facilitate deposition of larger skeletal elements such as skulls. Less common is a black-glazed, relatively narrow, and cylindrical and handleless form.

Typologically, the lug handle jar form has conventionally been attributed to the central Northern Thai stoneware complex of Maenam Noi, Singburi (Cort 2017). The origins of the second jar type are less certain. Identified as "Angkorian," this type was compared with similar jars from Khmer stoneware complexes in Buriram, Eastern Thailand, and with jars produced at the Torp Chey kilns, part of a stoneware production complex east of Angkor (Beavan et al. 2012a) (Fig. 4). As will be seen, these conventional typological attributions gloss their more complex elemental provenience.

Fig. 2 Cardamom burials, Phnom Khnang Peung (KPP) site (with coauthor Tep Sohka), showing general appearance of ledge burials and jar types with neck and rim removed to facilitate deposition of corpse; inset: *Koh S'dech* wreck ceramic assemblage composed of stoneware jars and green-glazed (celadon) bowls and bottles, and earthenware cooking pots with at least three types of stoneware jar: large 4 lugged with poorly preserved surface glaze, medium lugged jar with well-preserved "dipped" dark brown glaze, small lugged stoneware jars with well-preserved "dipped" dark brown glaze; and Thai (Si Satchanalai) green-glazed bowls and "fruit-stands" with geometric inscribed underglazed decoration (foreground) (source: N. Beavan)

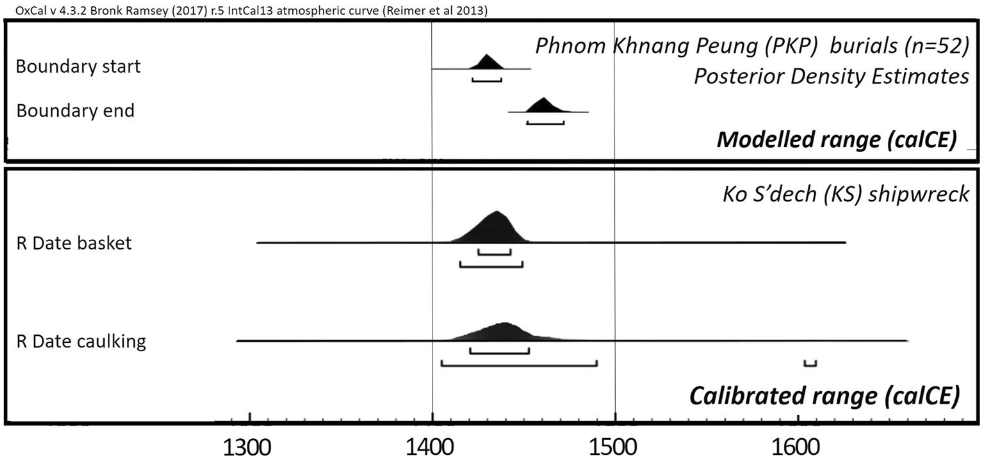

Fig. 3 Upper panel: Cardamom Mountain burial site Phnom Khnang Peung posterior density estimates for the start and end of use based on modeling 59 radiocarbon estimates for this site (adapted from Beavan et al. 2015; Fig. 3). Lower panel: *Koh S'dech* shipwreck radiocarbon dating of short-lived samples: a bamboo-cored lacquerware box (*KS* basket); and tree-resin caulking from recovered ship's planking (*KS* resin caulking). Results were calibrated using Oxcal v4.3.2, r:5 (Bronk Ramsey 2017) and the Southern Hemisphere calibration curve SHCal13 (Hogg et al. 2013). An offset of − 21 ± 6 years was applied following the work of (Hua et al. 2004) on a Thai dendrochronological database that reflected a contemporary mixing of Northern Hemisphere and Southern Hemisphere air masses

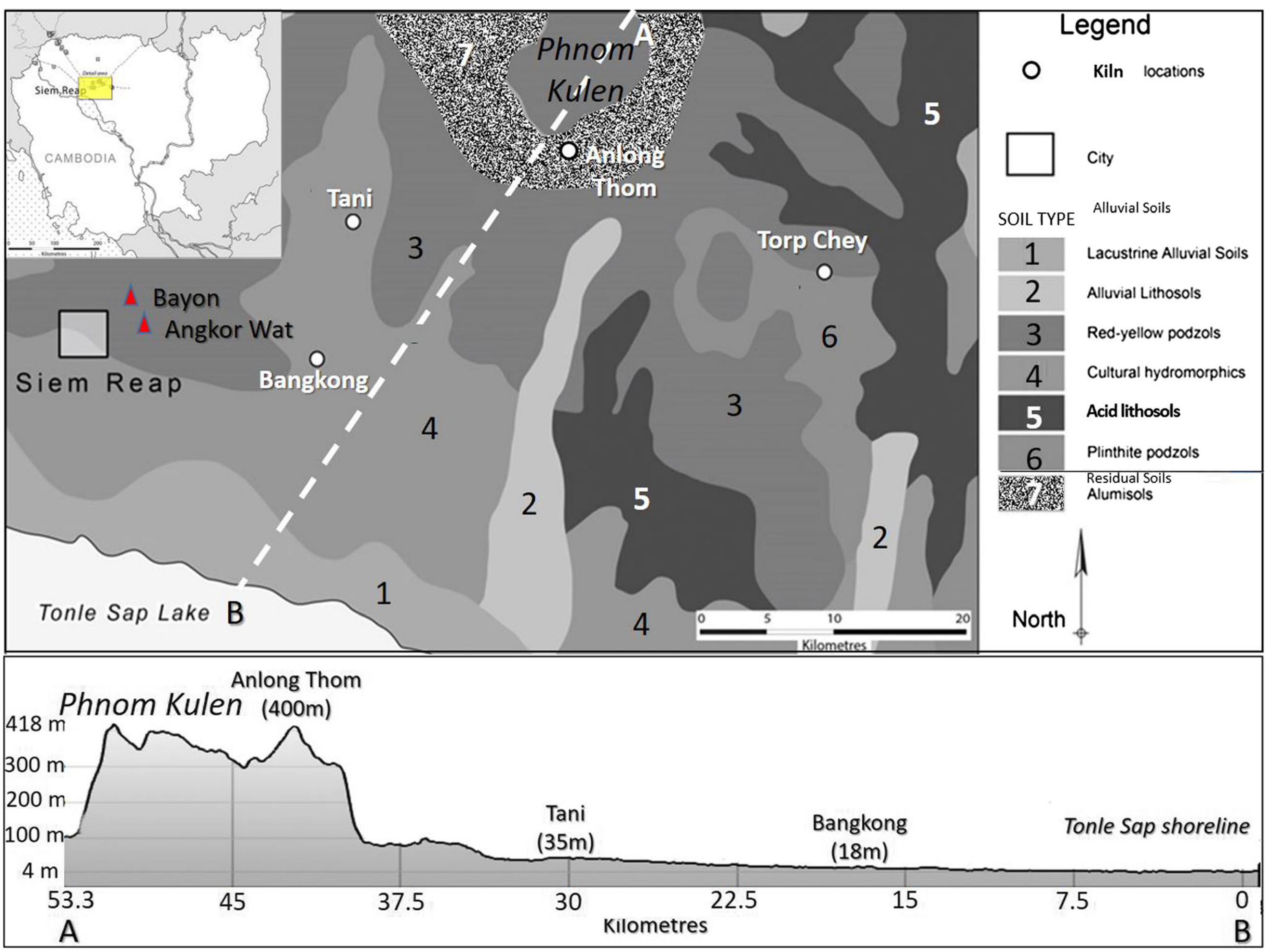

Fig. 4 Four major Angkorian Khmer stoneware kiln complexes showing topographical and geological relationships (through transect A-B) (adapted from Grave et al. 2015)

Koh S'dech shipwreck site

The shipwreck site is located in the Gulf of Thailand, near the island of *Koh S'dech*, some 20 km off shore of the Thai/Cambodian coast (Fig. 1). The shipwreck assemblage included small, medium, and large brown-black-glazed stoneware jars, typologically also identified as originating in Singburi (Maenam Noi) (Cort 2017) (Fig. 2 inset). It also included ceramic basins, bowls, mortars, and *kendis* of uncertain origin, and "tableware" unambiguously of central Northern Thai (Si Satchanalai) production (green-glazed/celadon pedestalled bowls—in foreground Fig. 2 inset). Earthenwares included cooking pots, lids, and stoves. The few Chinese ceramic bowls recovered were interpreted as the private items of the ship crew rather than items of trade per se (Sokha 2013). Other cargo included lacquerware, "picul" (lead tokens), a betel box, metal ingots, a cannon, two ivory tubes, and some sandstone.

Methods

The sample from burials and wreck assemblages is composed of 71 ceramic fragments of both stonewares and earthenwares. Burials are represented predominantly by samples from the KPP site ($n = 25$), with the remainder from Phnom Pel and Rong Damrei ($n = 9$). The stoneware sample contains body, rim, and base fragments with brown, black, green glazes, and fabrics that ranged in color from light gray/white to red/dark brown. The earthenware sample includes both the *KS* shipwreck (fine wheelmade earthenwares ($n = 7$)) and burials (handmade, basket-impressed vessels ($n = 13$)). In several cases, multiple sherds from single vessels were sampled. For these replicates, results were averaged, reducing the total sample number of individual vessels represented to 49 (three burial sites in the Cardamom Range ($n = 35$); the *KS* shipwreck assemblage ($n = 14$)) (Table 1).

To identify potential production origins of the study sample, we compared legacy NAA datasets for stonewares from contemporary shipwrecks recovered in the Gulf of Thailand and several key kiln sites in Cambodia and Thailand. This analysis involved multiple stages of data comparison: within the burial clusters (combining both earthenware and stoneware samples) to evaluate the overall diversity of the burial assemblage; comparison of burial and *KS* ceramics to evaluate potential exchange relationships; and comparison with Thai and Angkorian Khmer production complexes to identify possible sources.

The Cambodia reference data come from our previous published work on kilns from four Khmer kiln "complexes" that correspond to clear geospatial chemical provenances (cf. Fig. 4, 5) (Grave et al. 2015). These complexes have been shown to represent two chronological phases (Marriner et al. 2018) (Fig. 6): the first (~ 1000–1200 CE) includes two western kiln complexes (Bangkong, Tani) and one central complex (the Kulen Mountain Plateau kilns of Thnal Mrech). A second phase in the 14th c. CE is represented by an eastern complex of kilns centered on Torp Chey.

Pre-16th c. production complexes in Thailand included known producers of maritime trade wares (Brown and Sjostrand 2002): Suphanburi and Singburi (upper Chao Praya River valley), and further north, Si Satchanalai (Yom River Valley). A program of absolute dating at Si Satchanalai (Barbetti and Hein 1989), and the disappearance of previously ubiquitous Si Satchanalai ceramics in Southeast Asian wreck assemblages, suggests this very long-lived complex (commencing ~ 1000 CE) ceased operation by no later than ca. the third quarter of the 16th c. CE (Brown 1988). Based on jar typology and shipwreck chronologies, Singburi production (~ 1430–1625 CE) has been suggested to have replaced that of nearby Suphanburi (~ 1300—~ 1430 CE) (Brown 1988).

The assemblages were also compared with two shipwreck assemblages. The first was the *Royal Nanhai* (~ 1460 CE) a close contemporary of the *KS* wreck. The *Royal Nanhai*,

Table 1 Summary of study sample: Cardamom Mountain burial sites, shipwrecks *Koh S'dech*, *Royal Nanhai* (includes jars typologically associated with the Thai complex at Singburi), and *San Diego*, and Thai kiln complexes: Suphanburi, Si Satchanalai

Site		∑	SW1	SW1.1	SW1.2	SW2	EW	Underpaint	Celad.	outliers
Cardamon burial sites	Phnom Khnang Peung	25	4	2	2	5	12			
	Phnom Pel (coffin ledge)	3				1	1		1	
	Phnom Pel (jar ledge 1 and 2)	6	1			2		1		2
	Rong Damrei	1	1							
	Burial ∑	35	6	2	2	8	13	1	1	2
Shipwrecks	*Koh S'dech* (~ 1450 CE)	14	6		1	7				
	Royal Nanhai (~ 1460 CE)	52				52				
	San Diego (1600 CE)	29	20	2		7				
Kilns	Si Satchanalai complex	17				14		2	1	
	Suphanburi (Ban Poon)	5	5							
	∑	152	37	4	3	88	13	3	2	2

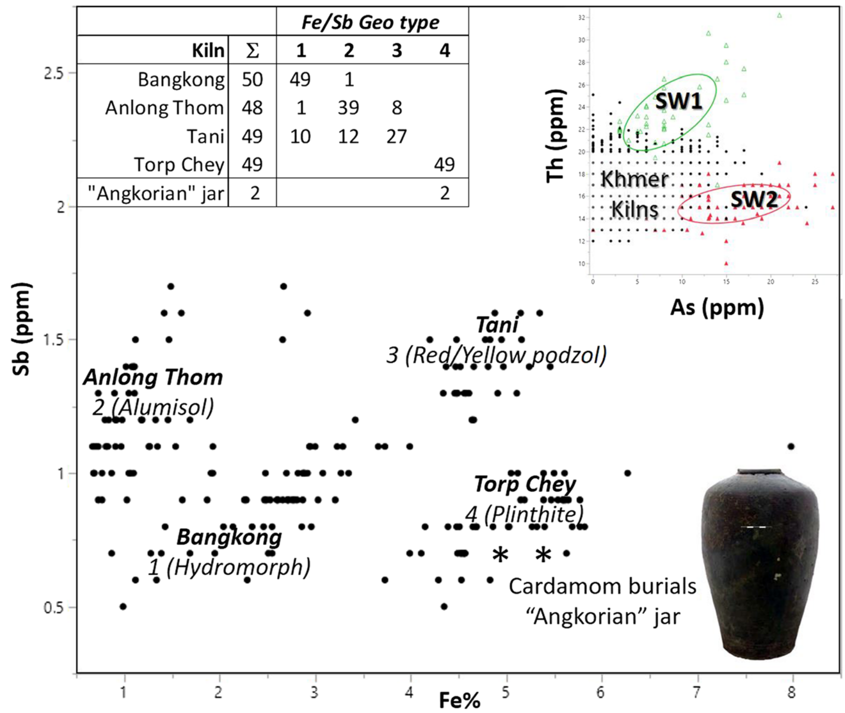

Fig. 5 INAA results: biplot of iron (Fe) and antimony (Sb) for four major Angkorian Khmer kiln complexes showing strong and distinctive relationship between geology (Fig. 4) and compositional profiles for each complex (adapted from Grave et al. 2015). Inset: Th/As biplot comparison of the Angkorian Khmer groups with the two major stoneware compositional groups identified in this study (SW1/SW2) highlighting overall differences between the two datasets. An exception is the black-glazed "Angkorian"-type jars from the Cardamom burials - asterisked (example of jar type lower right ht. 63 cm—adapted from Beaven et al. 2015) which match the Torp Chey compositional profile and confirm a likely origin at this complex

however, was very different in type as a Southeast Asian–built long haul trader with a large and relatively homogenous ceramic cargo composed of ~ 21,000 celadon bowls from Si Satchanalai, and large and small brown-glazed jars. The *Royal Nanhai* sank in the waters off of Malacca while apparently heading to destinations in island Southeast Asia. The second wreck assemblage is from the *San Diego* (1600 CE), a Manila galleon outbound to Acapulco when intercepted by a Dutch competitor. The recovered cargo included ~ 1000 Wan Li blue and white bowls, and a large number of stoneware jars ($n = 570$) from a diverse range of Chinese and Southeast Asian (Thai, Viet, and Burmese) sources. This eclectic range of large jars reflects a different economic logic: the needs of crew whose interest in jars was as waterproof storage of goods for personal trade rather than as trade items in their own right (Grave and Maccheroni 2009).

Ceramic samples were processed at UNE (i.e. photographed prior to removal of ~ 1-g section, surface abraded with tungsten carbide high-speed burr, crushed, and placed in numbered vial) and shipped to Maxxam Labs, Ontario, Canada, for NAA. Results were analyzed using a combination of non-parametric multivariate procedures (PCA), hierarchical cluster analysis (Ward's method), and iterative factor analysis to establish compositional groups and characteristic-defining elements.

To identify the source and type of the resin, material was submitted to the Conservation and Scientific Research Department of the Freer Gallery of Art and Arthur M. Sackler Gallery, Smithsonian Institution. The resin was analyzed using pyrolysis-gas chromatography–mass spectrometry (Pyr-GC/MS) and compared to contemporary materials, specifically a *Chor Cheung* resin sourced from the

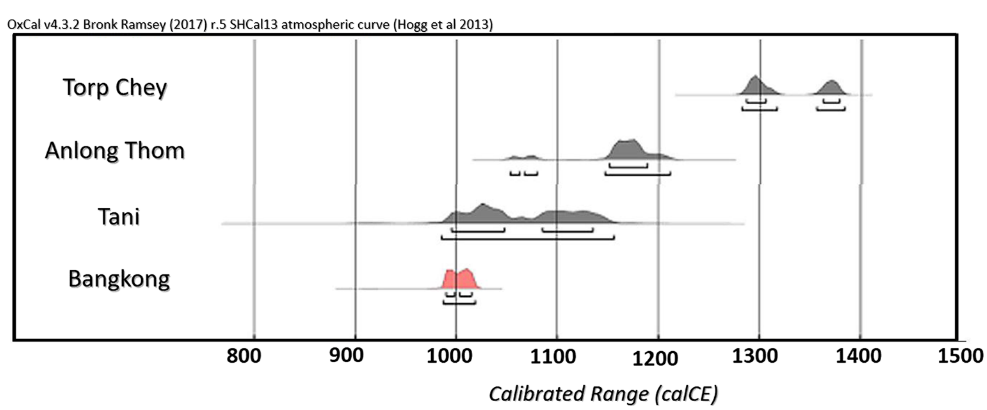

Fig. 6 Calibrated radiocarbon dates for the four Angkorian Khmer stoneware kiln complexes of Fig. 4 (adapted from Marriner et al. 2018)

Cardamom Highlands, and Cambodian commercial *dammar* for identification. The Getty Conservation Institute's RAdICAL lacquer program was also employed to identify chemical markers for different resin types. The *Koh S'dech* shipwreck sample was reported to be a possible mixture of natural resins, possibly elemi and dammar, or a single-sourced but processed resin, with a best match being elemi (α-amyrin, β-amyrin, β-amyrin methyl ether, and elemol).

The ship resin used as plank caulking in the *KS* shipwreck was also ^{14}C dated by accelerator mass spectrometry (AMS) with the results reported here for the first time. A portion of the original sample of the shipwreck caulking resin was submitted to the radiocarbon dating facility at the Scottish Universities Environmental Research Centre (SUERC). The resin was given the identifier GU34839. The pre-treatment stage involved acid washing of a 0.4594-g fragment of the resin in 0.5 M HCl, rinsed in demineralized water, and dried to result in a post-treatment sample weight of 0.3831 g. A small aliquot (0.0137 g) of the treated resin was graphitized for AMS dating, with a resultant percentage carbon of 78.2%. Graphitization and AMS dating proceeded according to SUERC analysis protocols (Dunbar et al. 2016).

Results

Dating

The two radiocarbon dates from the shipwreck are of short-lived organic materials with no in-built radiocarbon offsets (Fig. 3). The first determination, from the bamboo core of a lacquerware box discovered among the shipwreck's ceramic assemblage, places the piece in the early to mid-15th c. CE (D-Ams-1219-006, 475 ± 22 years BP; cal AD 1415 to cal AD 1449 at 2 sigma). The initial results first reported in Beavan et al. (2012b) have been refined using the most recent SHCal13 curve in OxCal v 4.2 (Bronk Ramsey 2009). The use of the SHCal13 curve follows research by Hua et al. (2004) indicating a northward shift of the ITCZ in the period. The calibration curve use an offset of − 21 ± 6 years applied to account for mixing with the Northern Hemisphere (Q Hua, personal communication, 15 November 2011).

The second ^{14}C determination, on the ship-planking resin (SUERC-54944), was 460 ± 37 years BP, calibrated using the SHCal13 curve and offset as above to cal AD 1405 to cal AD 1490 at 94.6% probability. These dates confirm the near contemporary age between the *Ko S'dech* ship and its contents (with calibrated determinations ranging between 1405 to 1490 cal AD at 2 sigma), and how they sit within the overall calibrated mid-15th–17th c. CE age range of the Cardamom burials.

Ceramics

The stoneware sample separates into two broad compositional types (SW1, SW2) that can be summarized by differences in arsenic/ thorium concentrations (Fig. 5 inset). Both compositional types include shipwreck and burial samples, of varying size and compositional range (Table 1). The largest (n = 11) contains samples of glazed stoneware jars from the Cardamom burials. Conversely, the second compositional type (n = 13), with low arsenic/high thorium, is restricted to stonewares from *KS* and the burials. To understand the significance of these groups, we first compared the two sites with the Khmer kiln dataset, and then with the Thai kiln and legacy shipwreck datasets.

The geochemical distinctiveness of the four complexes represented in the Khmer kiln dataset can be summarized in an iron/antimony biplot (Fig. 5). Comparison with the Cardamom/*KS* dataset shows that only samples of jars identified as "Angkorian" (CAR64-66, e.g., Fig. 6 jar lower right) match the group 4 compositional profile of the 14th c. CE Angkorian eastern kiln complex (Torp Chey), confirming this production complex as the most likely source.

We now turn to comparisons with an NAA legacy dataset for reference stoneware samples from the two Thai stoneware kiln complexes (Si Satchanalai (n = 17) and Suphanburi (n = 5)) and the two wreck assemblages (*Royal Nanhai* (sample n = 52), *San Diego* (sample n = 29)) for a total of 152 samples (Tables 1, 2). Multivariate analysis identified two major compositional groups (Fig. 7). Compositional group SW1 (n = 36), characterized by low Fe/high Th, represents brown-glazed jar fragments with gray-to-white fabrics. This includes the Suphanburi reference samples, and a relatively large number of jars from the *San Diego* conventionally attributed to be Maenam Noi (Singburi) type. The second and larger of the two groups (SW2, n = 87 and two smaller subsets: SW2.1 n = 4; SW2.2 n = 3), characterized by high Fe/low Th, includes the fine-stamped earthenware cooking pots from the *Koh S'dech* assemblage. The stoneware component, while more typologically diverse, shares a glossy, black glaze finish on a reddish fabric and includes all of the Si Satchanalai black-glazed reference samples of jars, all of the *Royal Nanhai* large and small jar sample that have been typologically attributed to Singburi, and a small number of jar samples from the *San Diego* n = 7). Two finely painted and celadon samples from the burials with white fabrics and their typologically matched reference samples from the Thai production center of Si Satchanalai also share comparable compositional profiles (Fig. 7, #8, 9; Table 3). Both *KS* and Cardamom burial samples are relatively evenly split between the two groups (*KS*: SW1 = 5; SW2 = 7; burials SW1 = 6; SW2 = 7; Table 2).

From this comparison, we suggest the Cardamom/*KS* wreck sample originated in two regionally distinctive

Table 2 Summary statistics for NAA groups (average - Avg. and coefficient of variation - CV) organized by Cardamom Mountains/*Koh S'dech*, Thai production centers and *Nanhai* and *San Diego* wrecks

Cardamom burials/*Koh S'dech* wreck											Outliers	
Group	SW1 (*n* = 11)		SW1.1 (*n* = 2)		SW1.2 (*n* = 3)		SW2 (*n* = 15)		EW (*n* = 14)		CP out	CP out2
	Avg.	CV	Avg.	CV	Avg.	CV	Avg.	CV	Avg.	CV		
As	5.39	32.33	11.00	38.57	16.33	25.49	13.72	27.61	3.87	85.76	16.00	9.60
Ba	444.48	13.15	555.00	21.66	516.67	2.96	315.89	19.46	609.88	14.08	74.00	202.40
Ce	79.48	11.72	109.50	14.85	101.67	4.65	80.69	33.61	52.89	46.11	37.00	42.80
Cr	86.81	7.21	93.25	3.26	93.00	1.13	87.82	9.59	62.39	20.33	66.80	58.86
Cs	13.35	6.85	14.00	10.10	17.33	3.33	9.00	16.49	3.83	78.54	1.00	3.18
Eu	1.09	11.93	1.45	4.88	1.27	4.56	1.33	27.40	1.03	30.91	0.81	0.90
Fe%	2.85	7.50	4.01	17.28	4.56	6.85	4.47	23.74	3.89	16.44	2.79	3.56
Hf	7.14	6.82	7.20	1.96	9.63	6.59	6.07	24.63	4.78	17.32	6.80	5.36
K%	1.20	15.81	1.50	9.43	1.87	3.09	1.41	15.68	1.88	19.44	0.00	0.77
La	37.21	7.47	45.95	3.85	49.00	0.94	38.96	25.53	27.35	34.31	20.60	20.92
Lu	0.51	5.75	0.57	1.25	0.61	1.64	0.49	10.92	0.34	20.57	0.28	0.39
Na%	0.18	9.74	0.25	8.66	0.33	15.75	0.30	43.38	1.49	32.43	1.10	0.70
Rb	133.39	5.05	145.00	4.88	166.67	3.46	95.11	17.08	83.76	32.30	15.00	58.80
Sb	1.79	8.27	2.20	6.43	2.20	9.09	1.15	27.15	0.65	69.31	0.50	0.62
Sc	15.13	7.57	16.45	7.31	16.53	1.26	16.57	7.03	14.19	16.29	7.66	14.26
Sm	6.20	10.00	8.19	2.42	8.51	0.65	6.67	26.24	4.72	34.67	3.35	3.92
Ta	1.98	8.47	2.30	6.15	2.70	9.80	1.37	20.23	0.74	55.95	0.80	0.98
Tb	0.86	13.44	1.10	0.00	1.20	8.33	0.85	23.21	0.46	93.13	0.00	0.52
Th	21.67	5.53	24.60	10.92	30.77	4.41	15.31	8.00	12.50	25.44	11.00	15.20
U	5.91	5.42	7.05	21.06	9.07	9.95	5.30	39.59	2.34	37.32	2.10	2.94
Yb	2.89	7.35	3.35	2.11	3.47	1.67	2.85	11.29	1.97	23.35	1.80	2.26
Zn	73.18	10.89	85.50	7.44	97.33	11.27	78.56	21.70	106.76	53.68	52.00	75.60
	Suphanburi		San Diego		San Diego		Sisatch		San Diego		Royal Nanhai	
	SW1 (*n* = 5)		SW1 (*n* = 20)		SW1.1 (*n* = 2)		SW2 (*n* = 14)		SW2 (*n* = 7)		SW2 (*n* = 52)	
	Avg.	CV	Avg.	CV	Avg.	CV	Avg.	CV	Avg.	CV	Avg.	CV
As	4.80	45.17	9.55	39.69	10.50	60.61	15.48	34.18	15.43	26.69	17.77	23.63
Ba	500.00	16.61	420.50	12.88	580.00	21.94	317.57	17.54	320.00	21.95	396.92	19.88
Ce	91.80	2.48	88.10	10.69	104.00	4.08	79.09	15.85	80.43	26.22	79.65	20.69
Cr	88.80	4.09	95.95	8.84	108.55	25.34	85.59	12.31	94.56	9.41	92.92	11.73
Cs	13.60	6.58	12.00	10.81	13.50	5.24	8.59	11.72	8.11	17.38	8.85	14.86
Eu	1.34	8.51	1.13	19.74	1.00	0.00	1.45	17.13	1.34	27.76	1.47	23.24
Fe%	3.46	8.21	3.73	27.11	3.81	14.11	5.35	12.53	5.05	24.56	6.40	16.49
Hf	7.04	10.17	7.04	10.91	9.20	3.07	5.69	10.83	6.10	36.23	4.79	29.15

Table 2 (continued)

	Cardamom burials/*Koh S'dech* wreck										Outliers	
K%	2.10	4.76	1.20	21.97	2.10	26.94	1.60	19.78	1.31	26.51	1.67	39.00
La	46.32	4.50	42.11	11.57	50.80	5.01	42.59	16.78	38.30	29.46	40.78	12.60
Lu	0.49	4.88	0.47	10.02	0.53	9.43	0.43	10.25	0.42	13.33	0.47	10.06
Na%	0.34	12.77	0.22	34.90	0.27	77.38	0.26	44.81	0.24	30.58	0.27	21.68
Rb	178.00	4.70	134.50	12.41	175.00	20.20	106.96	12.87	95.43	19.93	123.90	16.86
Sb	1.86	11.15	1.75	24.98	1.50	66.00	0.99	27.20	1.36	49.77	1.11	25.27
Sc	16.94	5.29	16.70	8.72	18.00	15.71	17.98	7.52	18.44	9.94	19.51	7.05
Sm	7.52	5.10	6.90	10.79	7.45	13.67	6.84	16.66	6.63	28.15	7.24	11.71
Ta	2.18	17.88	2.08	32.48	1.60	17.68	1.23	59.13	2.41	44.32	3.17	73.86
Tb	1.02	8.20	0.90	49.38	1.10	12.86	0.89	25.18	0.91	69.22	072	92.75
Th	22.36	5.12	23.74	7.57	25.25	15.40	14.26	6.82	14.86	11.28	15.69	9.06
U	6.54	6.54	5.50	15.42	5.95	29.71	2.99	12.40	2.91	12.75	3.33	19.68
Yb	3.40	4.65	3.26	8.41	3.35	6.33	2.95	9.40	2.93	14.45	3.27	7.81
Zn	74.00	10.20	78.60	43.68	113.50	20.56	33.70	77.84	*85.71*	44.67	73.10	54.63

geochemical precincts in Thailand (SW1: Suphanburi to the northwest of Ayutthaya; SW2: combining jar types attributed to Singburi in the upper Chao Phraya valley system and Si Satchanalai in the more northern Yom River valley). This contrasts with the more restricted patterning evident for the mid-15th c. CE Southeast Asian trading vessel *Royal Nanhai* (composed of glazed tablewares from Si Satchanalai, and the same jar types attributed to Singburi), and the 1600 c. CE Spanish Manila galleon *San Diego.* The *San Diego* assemblage contains a diverse range of jar types from Chinese and Southeast Asian sources, including a relatively small subset that can be typologically identified as Thai (our sample is largely Suphanburi SW1, with the remainder matching the Singburi/Si Satchanalai SW2 compositional profile). This difference in patterning between the wreck assemblages appears to reflect not only differences in context but also between two different phases of Southeast Asian regional production separated by ~ 150 years.

Handmade earthenware samples from the Cardamom burial sites were distinguished from all other samples by low chromium and cesium concentrations. In combination with their distinctive form, this reinforces a local origin for this ware although the small size of the earthenware sample prohibited evaluation of further potential geochemical subgroups.

Discussion

This window on predominantly mid-15th century coastal-inland exchange dynamics underlines the complexity of inland/coastal production and exchange networks. About half of our jar sample from both the burials and *KS* wreck is compositionally consistent with a Suphanburi origin (Fig. 1 #4; Fig. 7 SW1), but includes jar types conventionally attributed to the Singburi complex (Cort 2017). This contradicts previously proposed production chronologies where Suphanburi production ceases before the mid-15th c. CE and is subsequently replaced by Singburi (inferred from the disappearance of a distinctive large jar type with shoulder-impressed decoration associated with Suphanburi kilns (see Fig. 7 #1). The other half of the jar sample originates in more northern Thai production complexes. The complex at Si Satchanalai is unambiguously the source of the glazed celadon and underpainted bowl fragments. The economic reach of Si Satchanalai is further supported by the additional evidence from the *Royal Nanhai* shipwreck, with its large component of celadon bowls. The provenience of the large and small brown-glazed jars of the *Royal Nanhai* cargo, typologically attributed to the Singburi complex, shares a geochemical profile that includes both Si Satchanalai and Singburi (SW2 and subsets). As a result, both complexes appear firmly enmeshed in the wider SEA economy at this time. The small subset of "Angkorian" jars are an exception. While the geochemical match supports an origin in the eastern Khmer

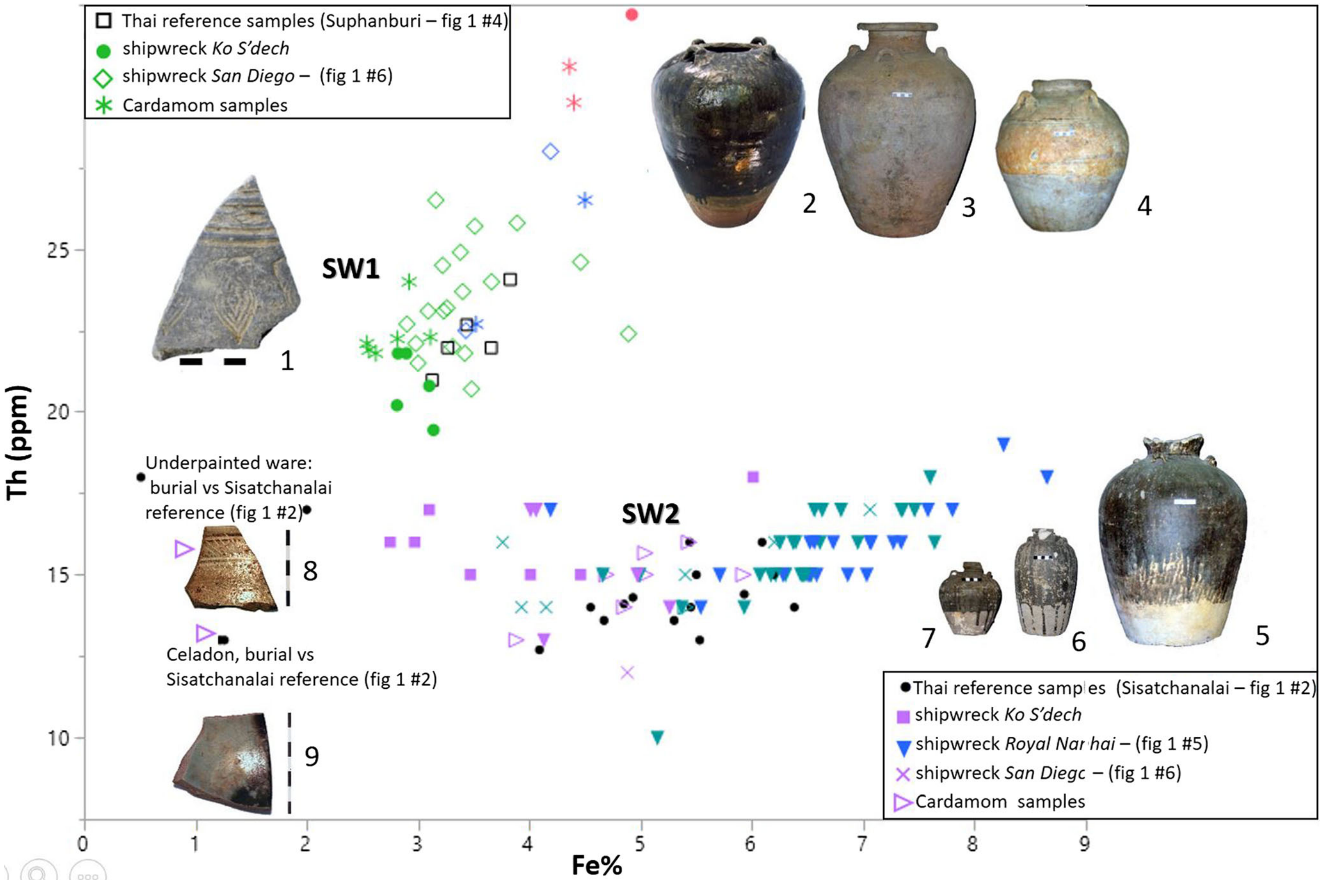

Fig. 7 INAA results (note: sample numbers with KPX or UNE prefixes refer to either the project supporting the current study (Khmer production and Exchange) or earlier work on stoneware from shipwreck assemblages (Grave and Macchernoni 2012)): biplot of Th and Fe showing major groups (SW1 and SW2) for stoneware samples from Cardamom burials, *Koh S'dech* shipwreck, reference samples from Thai production complexes of Si Satchanalai and Suphanburi (Pan Boon kiln site), and legacy data for shipwreck stonewares from the *Royal Nanhai* (~ 1460 c. CE) and the Manila Galleon San Diego (1600 CE). Jars types represented: #1—impressed shoulder fragment, Pan Boon kilns, Suphanburi; 2—Cardamom burials lugged jar with rim and neck removed to facilitate insertion of human remains—ht. 57 cm (adapted from Beaven et al. 2015; Fig. 5); 3, 4, 5—*San Diego* (UNE137, UNE107, UNE101); 6, 7—*Royal Nanhai* (UNE879, UNE927); 8, 9 Cardamom Mountains, Phnom Pel site: Si Satchanalai tablewares: underpainted bowl (above) (KPX 8314), and celadon (below) (KPX 8311) - (Table 3) not to scale

production complex at Torp Chey, the radiocarbon range for this complex places it several decades before the mid-15th c. CE burials, suggesting the Angkorian jars maybe heirlooms rather than proxies of an active exchange network.

Differences between the shipwreck assemblage and the Cardamom burials also highlight the limitations inherent in comparisons of fundamentally different cultural contexts. The diversity of the *KS* ceramic assemblage, in contrast with the *Royal Nanhai*—a long distance regional trader carrying a more specialized (higher value) cargo—and the *San Diego* galleon, with its large and diverse cargo of storage jars, suggests *KS*' role as a coastal trader targeting domestic, household markets. The close similarity in proportion of jar compositions between *KS* and the burials underlines the likely role of coastal traders in supplying such groups. The absence of *KS*-type earthenware cooking utensils from the burial assemblages also likely reflects the mortuary nature of the Cardamom burials, rather than absence of trade or demand for these items. The various shipwreck assemblages again clearly reveal different contexts and networks. Like the small number of "Angkorian" jars in the burials, the few jar types on the 1600 c. CE *San Diego* that have the SW2 compositional profile (i.e., Si Satchanalai/Singburi) do not necessarily equate with active production at that time.

The stoneware assemblage of the Cardamom Mountain burials demonstrates the close links between upland groups and a larger South China Sea maritime interaction sphere. Upland groups, thought to be harvesting and exchanging forest goods (e.g., timber and benzoin, deer, elephant teeth, and rhinoceros horns (Lockard 2010; Wheatley 1959)), valued both regionally produced ceramics and relatively large volumes of maritime trade wares. This is best documented in Northern Thailand where upland and lowland groups were also closely connected through an inland exchange economy in the 13th–16th c. CE, evident in the diverse stoneware jar and tableware assemblages representing both maritime and

Table 3 NAA results for decorated bowls (underpainted and celadon; cf. Fig. 7 #8, #9) compared to reference results from Si Satchanalai (the likely origin for the Cardamom examples)

	Celadon		Underpainted		
	Card.	Sisatch	Card.	Sisatch ($n = 2$)	
				Avg.	CV
As	< dl	2.00	14.00	2.50	84.85
Ba	400.00	350.00	430.00	485.00	1.46
Ce	61.00	69.00	85.00	111.00	14.01
Cr	41.00	39.00	102.00	74.00	9.56
Cs	12.00	12.00	6.90	13.00	10.88
Eu	0.90	1.30	1.40	1.60	17.68
Fe%	1.26	1.22	2.00	0.68	35.36
Hf	4.20	4.70	8.10	7.20	7.86
K%	2.70	3.00	2.00	2.75	2.57
La	31.40	39.90	43.10	53.60	13.46
Lu	0.36	0.39	0.48	0.52	8.16
Na%	1.30	1.30	0.28	0.46	10.88
Rb	130.00	140.00	140.00	145.00	4.88
Sb	0.50	0.60	2.40	0.65	10.88
Sc	9.82	10.20	16.60	15.40	12.86
Sm	5.15	6.43	6.73	8.81	15.34
Ta	1.10	1.50	1.50	1.60	26.52
Tb	0.60	0.90	0.80	0.85	8.32
Th	13.00	13.00	17.00	17.00	8.32
U	4.10	3.50	3.60	3.50	0.00
Yb	2.10	2.50	2.90	3.55	5.98
Zn	44.00	42.00	57.00	< dl	–

local inland economies (Grave 1995). While intermediaries (e.g., merchant traders) presumably linked inland groups with the maritime economy, as seen in the large number of Chinese and Vietnamese finewares in these burials, adjacent lowland urban elites likely controlled production of stonewares that both emulated exotic types and innovated new ceramic types. A significant difference in the Cardamom burial assemblages is that the stoneware jars exclusively represent a maritime trade origin. Evidence for inland exchange is very limited: a few "Angkorian" jars matched with the Torp Chey production complex.

In sum, the stonewares from the Cardamom burials appear to represent at least two separate production centers (and geochemical precincts) in Thailand, a pattern closely matched in the shipwreck dataset (Table 2). This pattern highlights the link between the burial groups and contemporary coastal traders. The small number of "Angkorian" jars, compositionally attributed to the 14th c. production complex east of Angkor, flags the potential for stoneware jars to circulate after the life of the original production center.

Conclusion

Historians have presented the transition from the premodern to early modern period in Southeast Asia primarily through the lens of maritime trade and coastal entrepôts (Reid 1993). Arguably, the greatest impact of this transition is the cultural transformation behind the production and consumption dynamics of groups in the interior of Southeast Asia, who remain invisible in historical sources. While as yet relatively rare (e.g., Carter and Beavan 2014; Grave 1995; Lape 2003; Lape 2002), archeological research on the likely widespread, smaller unregulated exchanges demonstrated here offers the potential to better understand the broader social, economic, and political dynamics of this period (Stark 2014). Recent syntheses of EMP mainland Southeast Asia offer few insights on Cambodia, instead concentrating on the Thai, Burmese, and Vietnamese states that dominated the EMP political landscape.

Elucidating coastal-inland exchange systems beyond the main and historically well-known entrepôts, and the role of secondary or informal ports, in the mid-15th c. CE (comparable to the better documented role of secondary ports and small coastal villages in the 17th c. CE Cochinchina (Pham 2016: 108)), provides new insights into inland post-Khmer economies. It seems likely that together, the complex articulation between inland and coastal maritime networks shaped and facilitated subsequent, larger-scale economic transformations across the region. What exactly the roles of inland groups were, and how they negotiated the transformations of the early modern period of the following century, is now the challenge and opportunity for future fine-grained, chronologically high-resolution, studies.

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References

Baker C (2003) Ayutthaya rising: from land or sea. J Southeast Asian Stud 34(1):41–62

Barbetti M, Hein D (1989) Palaeomagnetism and high-resolution dating of ceramic kilns in Thailand: a progress report. World Archaeol 21(1):51–70

Beavan N, Halcrow S, McFadgen B, Hamilton D, Buckley B, Sokha T, Shewan L, Sokha O, Fallon S, Miksic J, Armstrong R, O'Reilly DJW, Domett K, Chhem KR (2012a) Radiocarbon dates from jar and coffin burials of the Cardamom Mountains reveal a previously unrecorded mortuary ritual in Cambodia's late-to post-Angkor period (15th–17th centuries AD). Radiocarbon 54:1–22

Beavan N, Sokha T, Zoppi U, McCarthy B, Schilling M, Cort L, Sylvia Fraser L (2012b) Field note: a radiocarbon date for the Koh S'dech shipwreck, Koh Kong Province, Kingdom of Cambodia. In: Freer Sackler Gallery, SEA Ceramics Library. Smithsonian Institution, Washington, DC

Beavan N, Hamilton D, Sokha T, Sayle K (2015) Radiocarbon dates from the highland jar and coffin burial site of Phnom Khnang Peung, Cardamom Mountains, Cambodia. Radiocarbon 57(1):15–31

Bronk Ramsey C (2009) Bayesian analysis of radiocarbon dates. Radiocarbon 51(1):337–360

Bronk Ramsey C (2017) Methods for summarizing radiocarbon datasets. Radiocarbon 59(2):1809–1833

Bronson B (1977) Exchange at the upstream and downstream ends: notes toward a functional model of the coastal state in Southeast Asia. In: Hutterer C (ed) Economic exchange and social interaction in Southeast Asia: perspectives from prehistory, history, and ethnography, vol 13. Michigan Papers on South and Southeast Asia, Ann Arbor, Michigan, pp 39–52

Brown RM (1988) The ceramics of Southeast Asia, their dating and identification, 2nd edn Oxford in Asia studies in ceramics. Oxford University Press, Singapore

Brown R (1996) The Dvaravati Wheels of the Law and the Indianization of South East Asia. E.J. Brill, Leiden

Brown RM (2004) The Ming Gap and shipwreck: ceramics in Southeast Asia. University of California, Los Angeles

Brown RM, Sjostrand S (2002) Maritime archaeology and shipwreck ceramics in Malaysia. Published on the occasion of the exhibition Malaysian Maritime Archaeology by Dept. of Museums & Antiquities in collaboration with Nanhai Marine Archaeology Sdn. Bhd

Carter A (2013) Trade, exchange, and sociopolitical development in iron age (500 BC – AD 500) mainland Southeast Asia: an examination of stone and glass beads from Cambodia and Thailand Anthropology. University of Wisconsin, Madison

Carter AK (2015) Beads, exchange networks and emerging complexity: a case study from Cambodia and Thailand (500 bce–ce 500). Camb Archaeol J 25(04):733–757

Carter A, Beavan N (2014) Glass beads from jar burials of the 15th–17th centuries in the Cardamom Mountains of Cambodia. BEADS: J Socf Bead Researchers 26(1):9–21

Carter AK, Dussubieux L, Beavan N (2016) Glass beads from 15th–17th century CE jar burial sites in Cambodia's Cardamom Mountains. Archaeometry 58(3):401–412

Cartier M (1988) Le commerce de l'Ocean Indien vu de Chine. In: Lombard D, Aubin J (eds) Marchands et hommes d'affaires asiatiques dans l'Ocean Indien et la Mer de Chine 13e-20e siecles. Edit.de l'Ecole des Hautes Etudes en Sciences Soc., Paris, pp 125–127

Cort L (2017) Ceramics in mainland Southeast Asia: Maenam Noi (Singburi) kilns. vol. 2017. Smithsonian Institution, Washington D.C

Diem AI (1998) The significance of Pandanan shipwreck ceramics as evidence of fifteenth century trading relations within Southeast Asia. Bull Orient Ceram Soc Hong Kong 2001(12):28–26

Dunbar E, Cook GT, Naysmith P, Tripney BG, Xu S (2016) AMS 14 C dating at the Scottish Universities Environmental Research Centre (SUERC) radiocarbon dating laboratory. Radiocarbon 58(1):9–23

Evers H-D (1988) Traditional trading networks in Southeast Asia. Archipel 35:89–100

Flecker M (2001) A ninth-century AD Arab or Indian shipwreck in Indonesia: first evidence for direct trade with China. World Archaeol 32(3):335–354

Grave P (1995) Beyond the Mandala: Buddhist landscapes and upland-lowland interaction in Northwest Thailand AD 1200-1650. World Archaeol 27(2):243–365

Grave P, Maccheroni M (2009) Characterizing Asian stoneware jar production at the transition to the Early Modern Period (1550–1650 C.E.). Proceedings of the Scientific Research on Historic Asian Ceramics. Proceedings of the Fourth Forbes Symposium at the Freer Gallery of Art:186–204. Washington D.C., USA

Grave P, Stark M, Ea D, Kealhofer L, Tan BS, Tin T (2015) Differentiating Khmer stoneware production: an NAA pilot study from Siem Reap Province, Cambodia. Archaeometry:n/a-n/a

Green J, Harper R (1987) The maritime archaeology of shipwrecks and ceramics in Southeast Asia. In: Green J, Harper R (eds) Australian Institute for Maritime Archaeology, vol 4. Victorian Archaeology Survey, pp 1–38

Groslier BP (2006) Angkor and Cambodia in the sixteenth century: according to Portuguese and Spanish sources. . Translated by M. Smithies. Orchid Press, Bangkok

Halcrow SE, Harris NJ, Beavan N, Buckley HR (2014) First bioarchaeological evidence of probable scurvy in Southeast Asia: multifactorial etiologies of vitamin C deficiency in a tropical environment. Int J Paleopathol 5:63–71

Hall KR (2016) Commodity flows, diaspora networking, and contested agency in the Eastern Indian Ocean c. 1000–1500. TRaNS: Trans -Reg -Natl Stud SE Asia 4(2):387–417

Hall KR (2018) The Coming of the West: European Cambodian Marketplace Connectivity 1500–1800. In: Smith TO (ed) Cambodia and the West, 1500–2000. Palgrave Macmillan Limited, Basingstoke, pp 7–36

Hendrickson M (2010) Historic routes to Angkor: development of the Khmer road system (ninth to Thirteenth centuries AD) in mainland Southeast Asia.(Research)(Report). Antiquity 84(324):480 (417)

Hendrickson M (2011) A transport geographic perspective on travel and communication in Angkorian Southeast Asia (ninth to fifteenth centuries ad). World Archaeol 43(3):444–457

Hogg AG, Hua Q, Blackwell PG, Niu M, Buck CE, Guilderson TP, Heaton TJ, Palmer JG, Reimer PJ, Reimer RW (2013) SHCal13 southern hemisphere calibration, 0–50,000 years cal BP. Radiocarbon 55(4):1889–1903

Hotchkis MAC, Fink D, Jacobsen GE, Lawson EM, Shying M, Smith AM, Tuniz C, Barbetti M, Grave P, Quan H, Head J (1994) 14C analysis at the ANTARES AMS Centre: dating the log coffins of northwestern Thailand. Nucl Inst Methods Phys Res B 92(92):27–30

Hua Q, Barbetti M, Zoppi U, Fink D, Watanasak M, Jacobsen GE (2004) Radiocarbon in tropical tree rings during the Little Ice Age. Nucl Instrum Methods Phys Res B 223(224):489–494

Junker LL (1993) Craft goods specialization and prestige goods exchange in Philippine chiefdoms of the 15th and 16th centuries. Asian Perspect 32(1):1–36

Junker LL (1998) Integrating history and archaeology in the study of contact period Philippine chiefdoms. Int J Hist Archaeol 2(4):291–320

Lape PV (2002) Historic maps and archaeology as a means of understanding late precolonial settlement in the Banda Islands, Indonesia. Asian Perspect 41(1):43–70

Lape P (2003) A highway and a crossroads: island Southeast Asia and culture contact archaeology. Archaeol Oceania 38:102–109

Li T (2004) The late-eighteenth-and early-nineteenth-century Mekong Delta in the regional trade system. In: Cooke N, Li T (eds) Water frontier: commerce and the Chinese in the lower Mekong region, 1750–1880. Rowman & Littlefield Publishers Inc., Singapore, pp 71–84

Li T (2005) The eighteenth century Mekong Delta and its World of Water Frontier. In: Tran NT, Reid AR (eds) Viet Nam: Borderless Histories (New Perspectives in Se Asian Studies). University of Wisconsin Press, Madison, pp 147–162

Lockard CA (2010) The sea common to all: maritime frontiers, port cities, and Chinese traders in the southeast Asian age of commerce, ca. 1400-1750. J World Hist 21:219–247
Manguin P-Y (1993) The vanishing Jong: insular Southeast Asian fleets in trade and war (fifteenth to seventeenth centuries). In: Reid A (ed) Southeast Asia in the Early Modern Era: trade, power, and belief. Cornell University Press, Ithaca, New York, pp 197–213
Manguin P-Y (2000) City-states and city-state cultures in pre-15th century Southeast Asia. A comparative study of thirty city-state cultures:409–416
Manguin P-Y (2004) The archaeology of early maritime polities of Southeast Asia. Southeast Asia: From Prehistory to History:282–313
Manguin P-Y (2014) Early coastal states of Southeast Asia: Funan and Śrīvijaya. Lost Kingdoms: Hindu-Buddhist Sculpture of Early Southeast Asia:111
Marriner GP, Grave P, Kealhofer L, Stark MT, Ea D, Chhay R, Kaseka P, Suy TB (2018) New dates for old kilns: a revised radiocarbon chronology of stoneware production for Angkorian Cambodia. Radiocarbon 60(3):901–924
Murphy SA, Stark MT (2016) Introduction: transitions from late prehistory to early historic periods in mainland Southeast Asia, c. early to mid-first millennium CE. J SE Asian Stud 47(3):333–340
Orillaneda BC (2016) Maritime trade in the Philippines during the 15th century CE. Moussons. Recherche en sciences humaines sur l'Asie du Sud-Est (27):83–100
Penny D, Hall T, Evans D, Polkinghorne M (2019) Geoarchaeological evidence from Angkor, Cambodia, reveals a gradual decline rather than a catastrophic 15th-century collapse. In: Proceedings of the National Academy of Sciences:201821460
Pham C (2016) European navigation, nautical instructions and charts of the Cochinchinese coast (16th-19th centuries) Moussons. Recherche en sciences humaines sur l'Asie du Sud-Est 27(1):101–129
Ptak R (1998) From Quanzhou to the Sulu zone and beyond: questions related to the early fourteenth century. J SE Asian Stud 29(2):269–294
Reid A (1988) Southeast Asia in the age of commerce 1450–1680: the land below the winds 1. 2 vols. Yale University Press, New Haven
Reid A (1993) Southeast Asia in the Early Modern Era: trade, power, and belief. Cornell University Press, Ithaca
Shaffer LN (2015) Maritime Southeast Asia, 300 BC to AD 1528. Routledge, Abingdon
Sokha T (2013) Discovery of ceramics from the Koh Sdach Shipwreck, Koh Kong province, Cambodia
Stark MT (2006) Early mainland southeast Asian landscapes in the first millennium A.D. Annu Rev Anthropol 35:407–432
Stark MT (2010) From Funan to Angkor. After collapse: the regeneration of complex societies:144
Stark MT (2014) South and Southeast Asia: historical archaeology. In: Encyclopedia of Global Archaeology. Springer, Berlin, pp 6841–6849
Theunissen R, Grave P, Bailey G (2000) Doubts on diffusion: challenging the assumed Indian origin of Iron Age agate and carnelian beads in Southeast Asia. World Archaeol 32(1):84–105
Vickery M, George C, Davidson JS, Lindsay J, Frost M, Ying TY (2004) Cambodia and its Neighbors in the 15th Century. Asia Research Institute, Working Paper Series No 27. National University of Singapore
Wade G (2004) Ming China and Southeast Asia in the 15th century: a reappraisal. Asia Research Institute, National University of Singapore, Singapore
Wade G (2009) An early age of commerce in Southeast Asia, 900-1300 CE. J of Southeast Asian Studies (40(2):221–265
Wallerstein I (1974) The modern world system: capitalist agriculture and the origins of the European world-economy in the sixteenth century. In: Studies in social discontinuity. Academic Press, New York
Wheatley P (1959) Geographical notes on some commodities involved in Sung maritime trade. JMBRAS 32 (2, no. 186)